MODIS Calibration Panel Meeting

Report on the

MODIS-T Instrument Calibration/ Validation

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NASA / Goddard Space Flight Center, Greenbelt, Maryland 20771

Presented:
Monday, 30 September 1991 (PM)

NASA Goddard Space Flight Center
Greenbelt, MD

Presentation Topics

MODIS-T Calibration/ Validation

- MODIS Science Objectives
- Overview of MCST Role
- Instrument
- Calibration
  - Internal
  - Solar
  - Pre-Launch Integrating Sphere
  - Spectral
- Lunar Calibration
- Science Calibration Plan
- Stray Light
- Slater's Questions

List of Sources of Material for Presentation

- Instrument
  Bill Stabnow/721 and Mike Roberto/725

- Calibration
  Bill Eichhorn/713.3

- Lunar Calibration
  Hugh Kieffer/USGS

- Stray Light
  Dennis Evans/ATR

MODIS Science Objectives

Overall Objective

Long-term (15 year) observations

For improved understanding of the global dynamics and

processes occurring

on the surface of the Earth and

in the lower atmosphere

including surface-atmosphere interactions

Exploiting the visible and infrared spectrum and

observation resolutions of 1-2 days and

spatial resolutions of 0.25-1.1 Km.

MODIS Science Objectives

Land Objectives

Studies of the spatial and temporal variability in land surface properties (e.g., vegetation cover and phenology, snow and ice, radiative properties including radiation balance with emphasis on problems such as desertification, regional vegetation stress due to acid rain or drought, and succession or change in vegetation species due to deforestation and anthropogenic effects.

Ocean Objectives

Studies of spatial and temporal variability of oceanic surface properties (e.g., photosynthetic pigments, sea surface temperature, flow visualization, attenuation coefficients and sea ice) with special emphasis on ocean primary productivity.

Atmosphere Objectives

Studies of tropospheric dynamics, climatology and chemistry as obtained through observations of cloud characteristics (height, type, albedo, etc.), aerosols, water vapor, and temperature (including surface termperature).

Overview of MCST Role

Calibration Site Selection

Scenes are being analyzed for homogeneous areas for use in the testing of data.

MODIS-T End-To-End Model

A spreadsheet at-satellite radiance model has been developed from the 5-S code with incorporation from Lowtran-7.

Code 700 has provided a spreadsheet model of at sensor radiances.

Work proceeds in linking the two models to obtain an end-to-end model.

The end-to-end spreadsheet model will be converted to C.

MODIS-T Operational Characteristics

MODIS-T in-orbit scenerios being developed.

Cross-Calibration

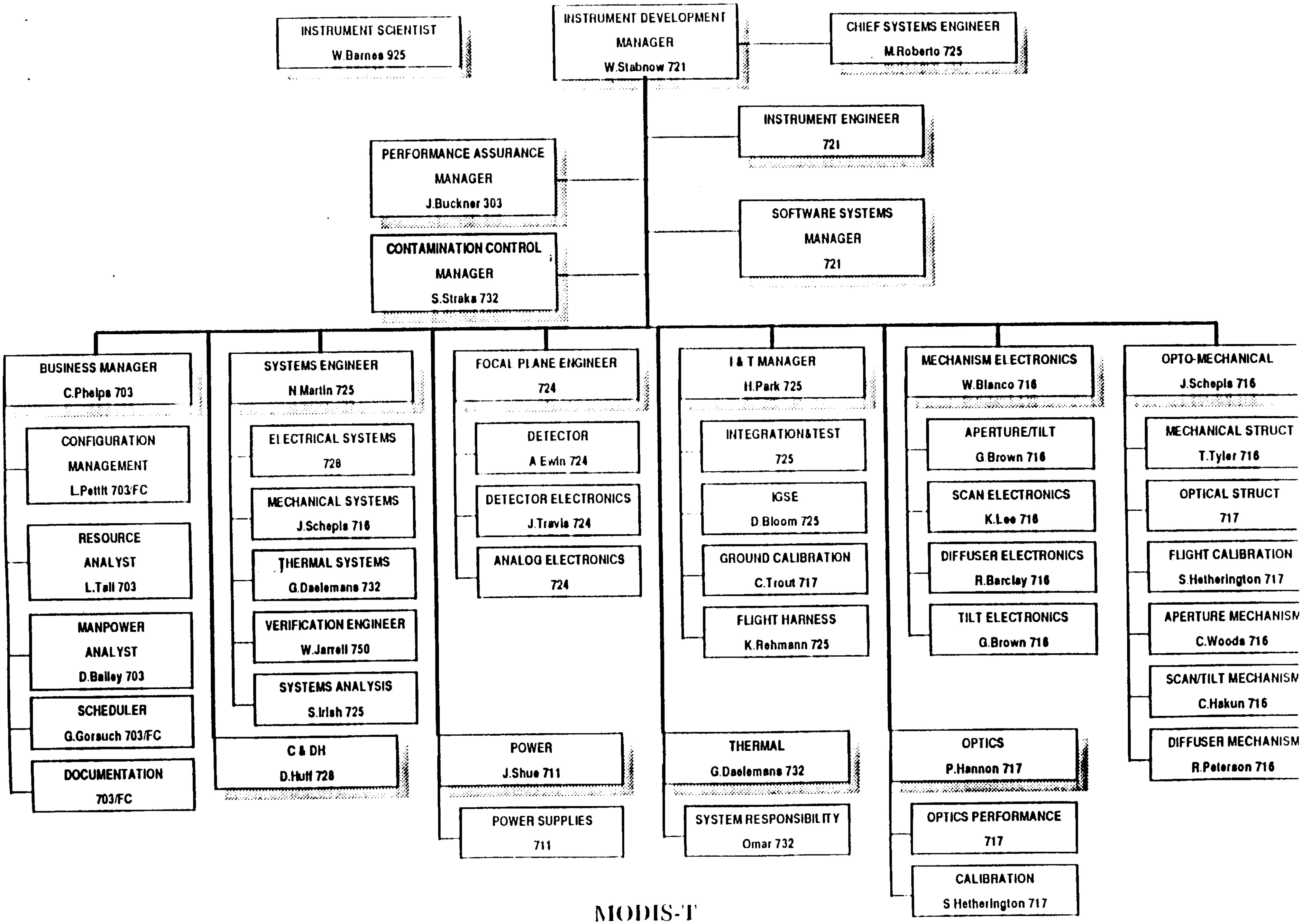
Pre-launch and in-orbit comparisons are being identified.

GSFC MODIS-T

ORGANIZATIONAL MODE

Eos

- MODIS-T INSTRUMENT WILL BE BUILT IN THE IN HOUSE MODE
  - USE A TEAM OF GOVERNMENT AND SUPPORT SERVICE CONTRACTORS
  - VERY LITTLE OF THE INSTRUMENT WILL BE PROCURED



MODIS-T
Organizational Chart
6/5/91

GSFC
MODIS-T

CRITICAL SCIENCE REQUIREMENTS

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Spectral Range	400 To 880nm
Bandwidth	10 To 15nm FWHM (32 Bands)
IFOV	1.1 km At Nadir
Linear Polarization	2.3% Over ± 20° Tilt
Signal to Noise	50 To 900
Dynamic Range	Land and Ocean
Fore/Aft Tilting	+ 67.5 degrees -50 degrees
Line Of Sight Knowledge	Known To ± 90 Arcseconds

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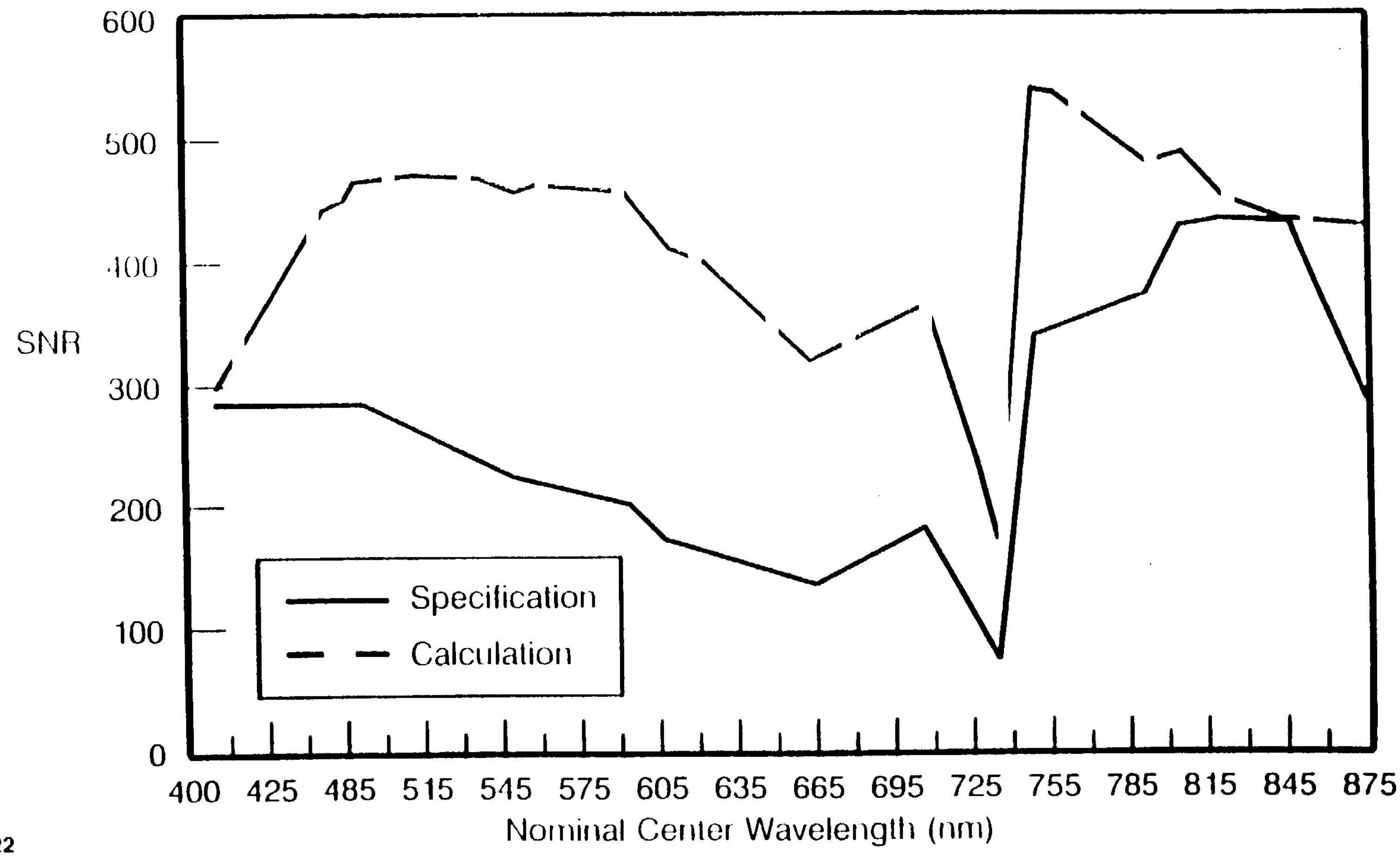
LAND SIGNAL TO NOISE

Eos



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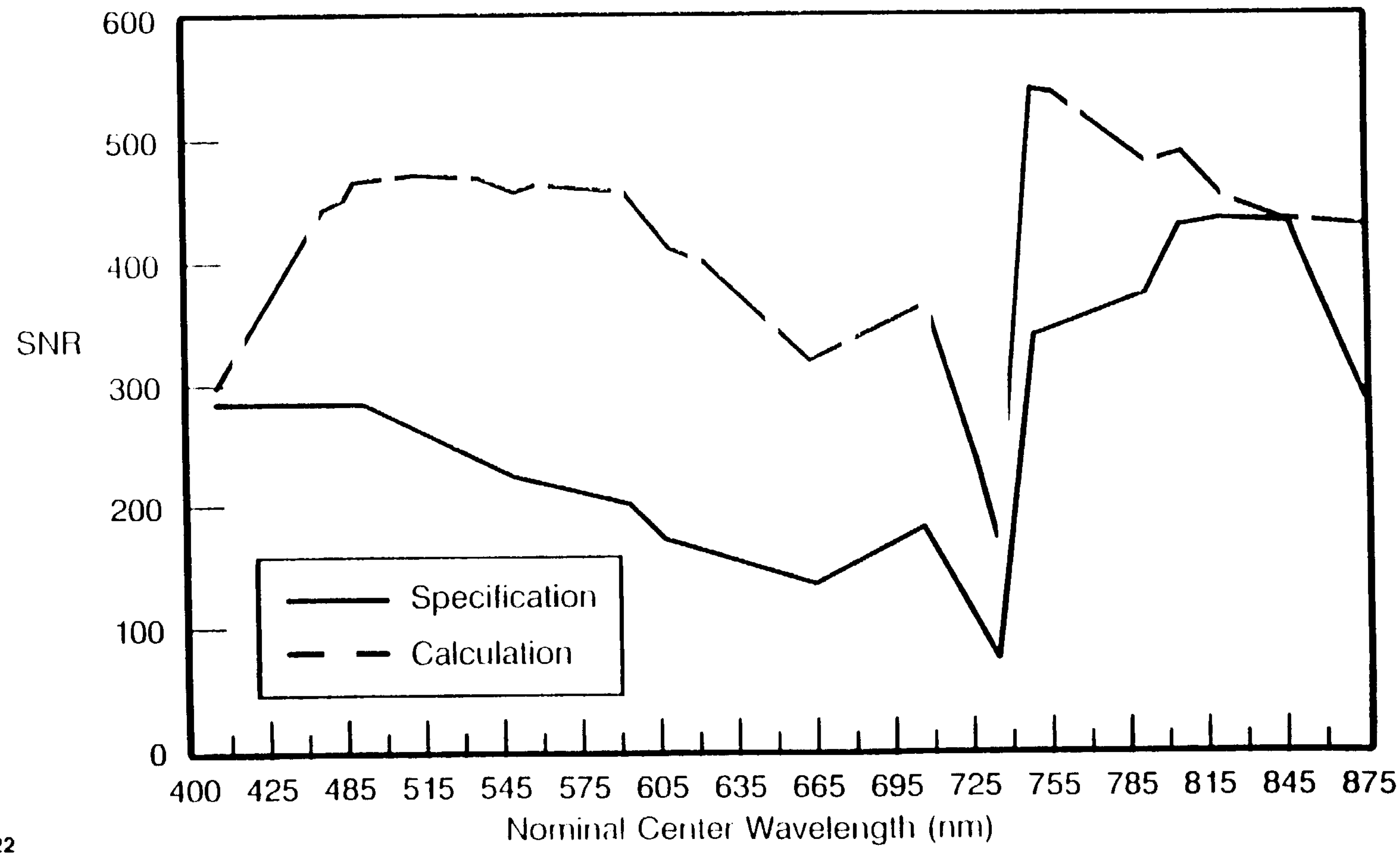
LAND SIGNAL TO NOISE

Eos



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MODIS-T

TOP LEVEL INSTRUMENT PARAMETERS

Eos

Weight	170 kg
Power	130 Watt Average 155 Watt Peak
Data Rate	3.1 Mbps (Day) 0.12 Mbps (Night)
+ 67.5°/-50° Tilt	Tilt The Scan Mirror
Detector	34 x 30 Photodiode/CCD Interline
Major Mechanisms	Single Speed Scan Mirror Tilt Diffuser Wheel
Power Supplies	9 (2 Package With RF Sources)

C428.006

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MODIS-T

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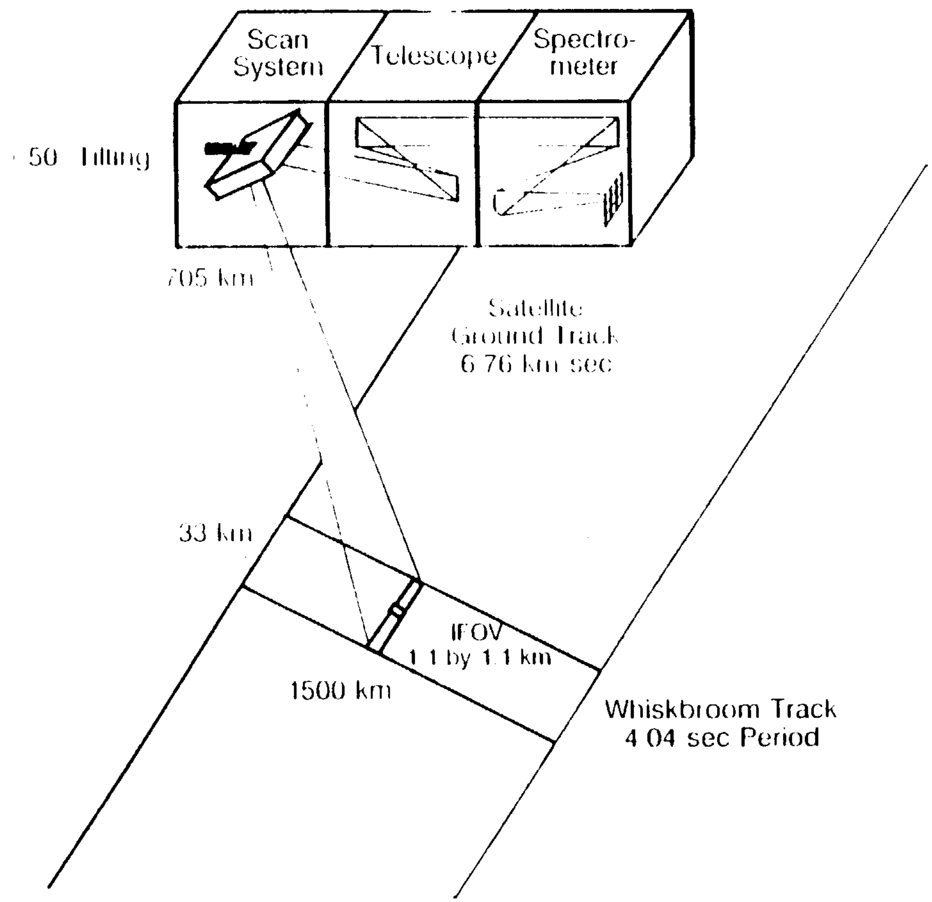
WHISKBROOM SCAN

Eos



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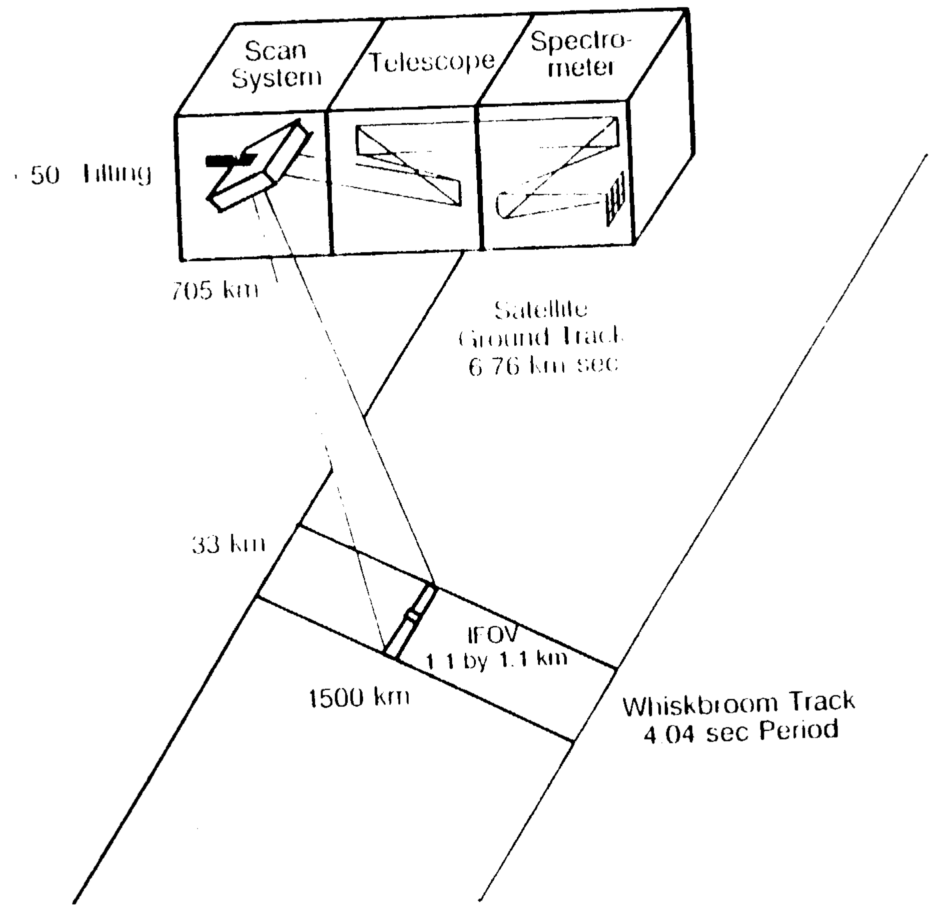
MODIS-T

WHISKBROOM SCAN

Eos



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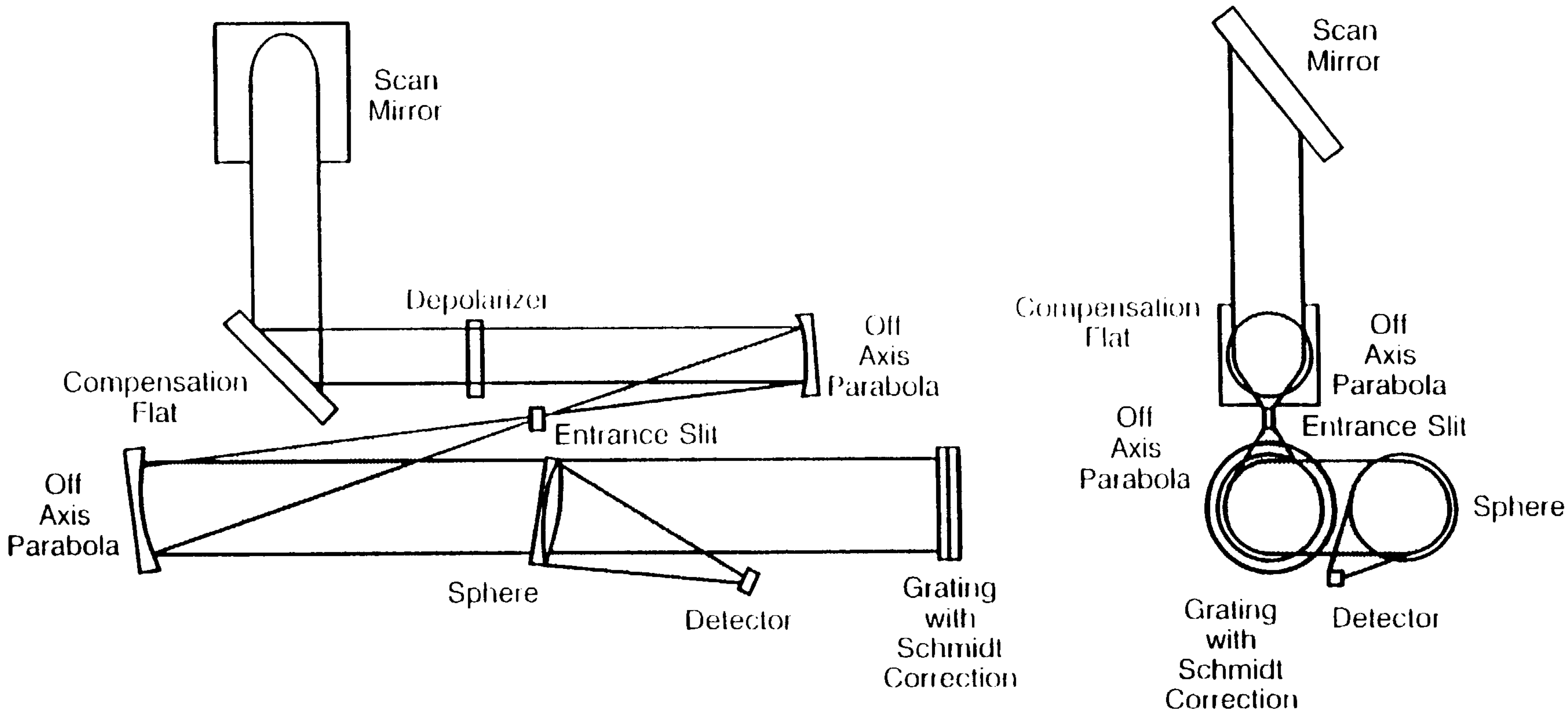
OPTICAL LAYOUT

Eos



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FLIGHT CALIBRATION SYSTEM

Eos

- Use a full aperture diffuser plate at the South Pole.
- Use a solar integrating sphere.

  Can be used from South Pole to North Pole for instrument stability monitoring.

  Three different flux levels.

  Helium RF sources mounted to the integrating sphere provides 5 spectral lines for instrument spectral calibration.

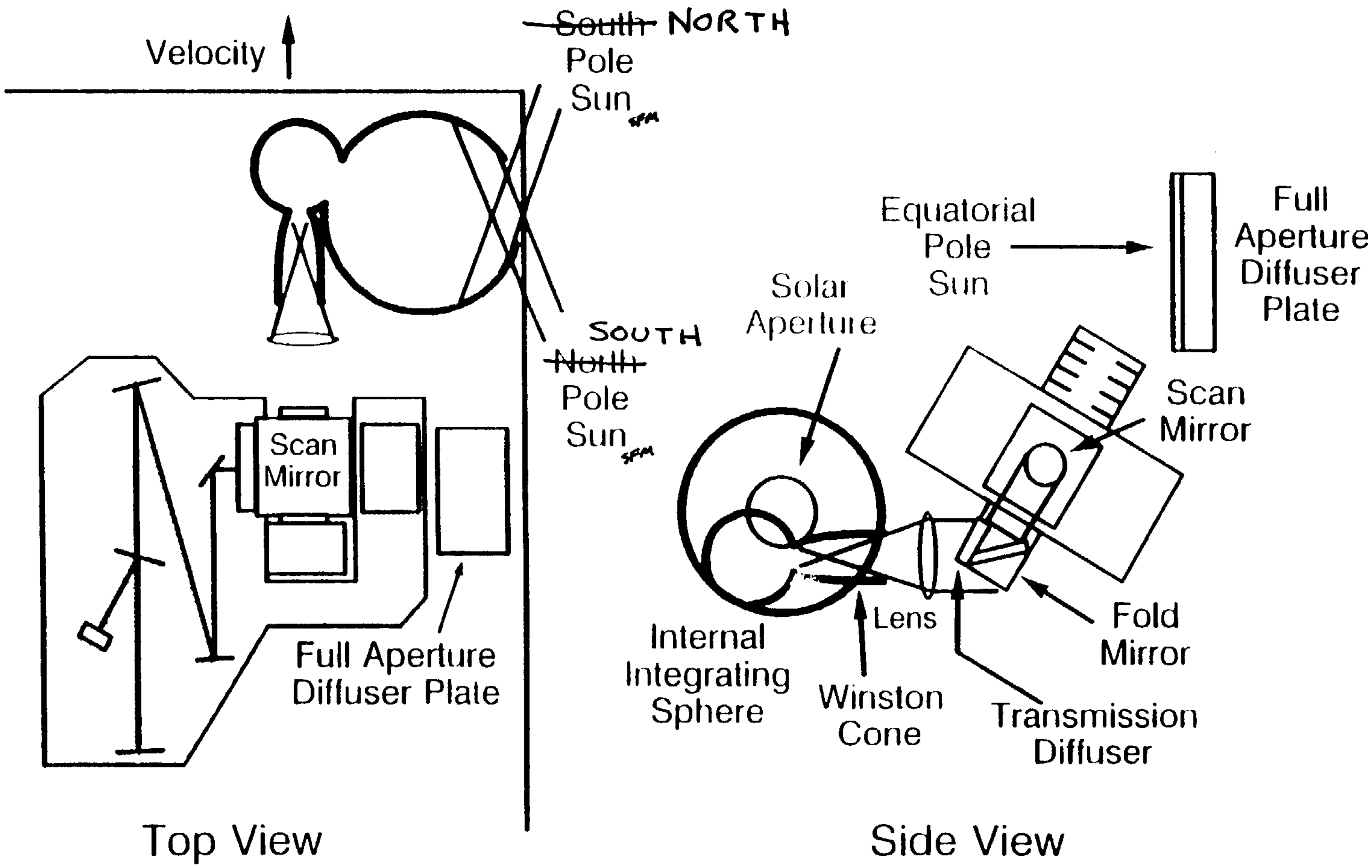
  Can be seen by the instrument on the back scan over -30°/+20° tilts.

  Images the solar integrating sphere on to a small diffuser plate located under the scan mirror.

GSFC MODIS-T

FLIGHT CALIBRATION SYSTEM

Eos



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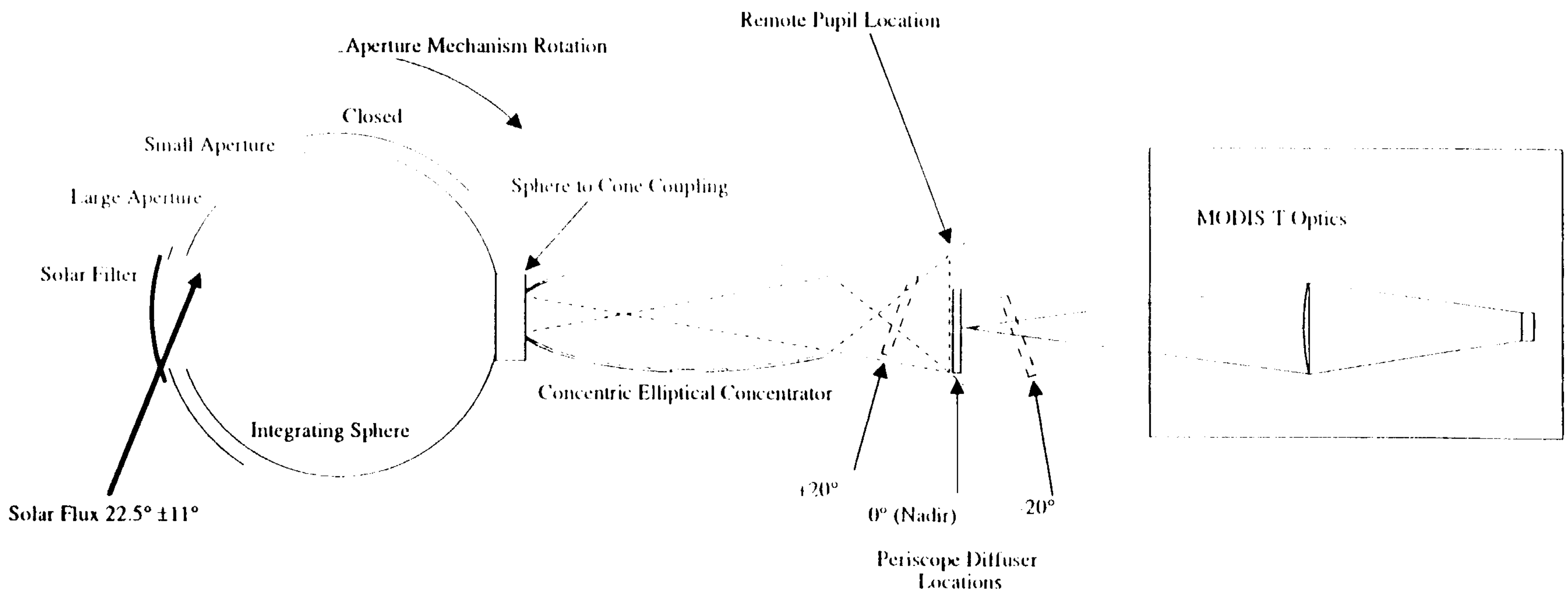
Internal Calibration

On each scan, the MODIS-T detectors view an integrating sphere which is illuminated by the sun. The radiance level of the solar illuminated sphere is monitored by two silicon photodiodes. A dark target is also viewed during each scan, so these two targets allow the gain and offset of the instrument to be determined for each scan. The linearity of the system can be checked by using three apertures which allow the level of illumination to be controlled. The gain and/or offset may also be functions of such variables as the detector temperature monitored by thermistors.

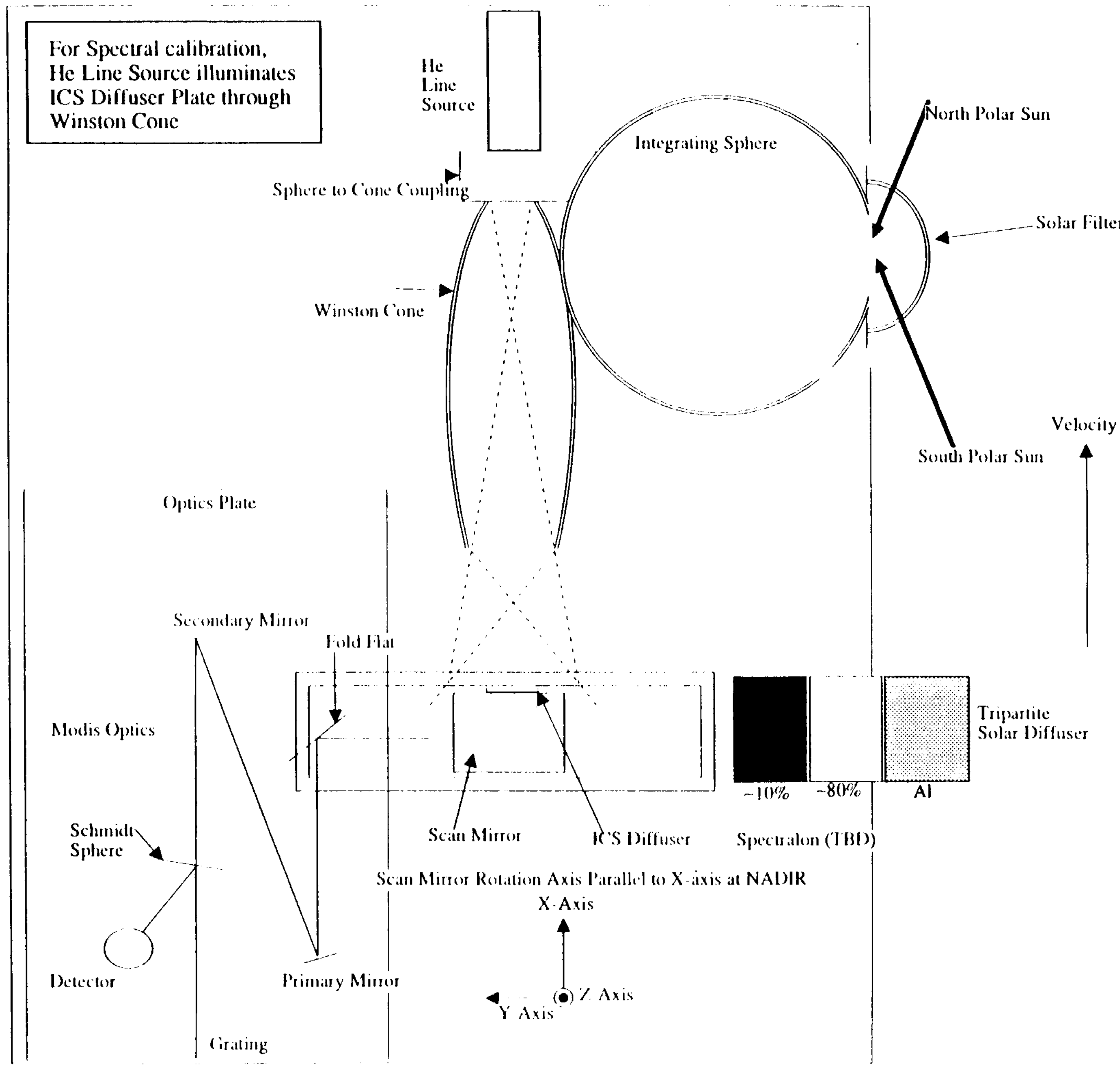
This method of calibration is a secondary method since the entire optical path of the instrument is not tested. To insure the method's stability over time, it is periodically compared to a primary method of calibration.

In addition to measuring the sensor gain, the zero offset must also be determined. Under routine operating conditions, the zero offset will be measured by scanning across an internal dark target. Two other methods of measuring the zero offset include deep space looks and views of the darkside of the Earth. These latter two approaches require the instrument to be placed in non-routine modes of operation. The deep space looks occur only when MODIS-T is tilting by 50^{o} or more so it will seldom be used. In addition, only a portion of the scan mirror will be sampled, although the portion sampled will be different from that sampled by normal operations when the internal dark target is used. The darkside of the Earth is not normally viewed since no data is taken at these times. The zeros measured by using the internal dark target, deep space, and the darkside of the Earth should all agree if the instrument is behaving correctly.

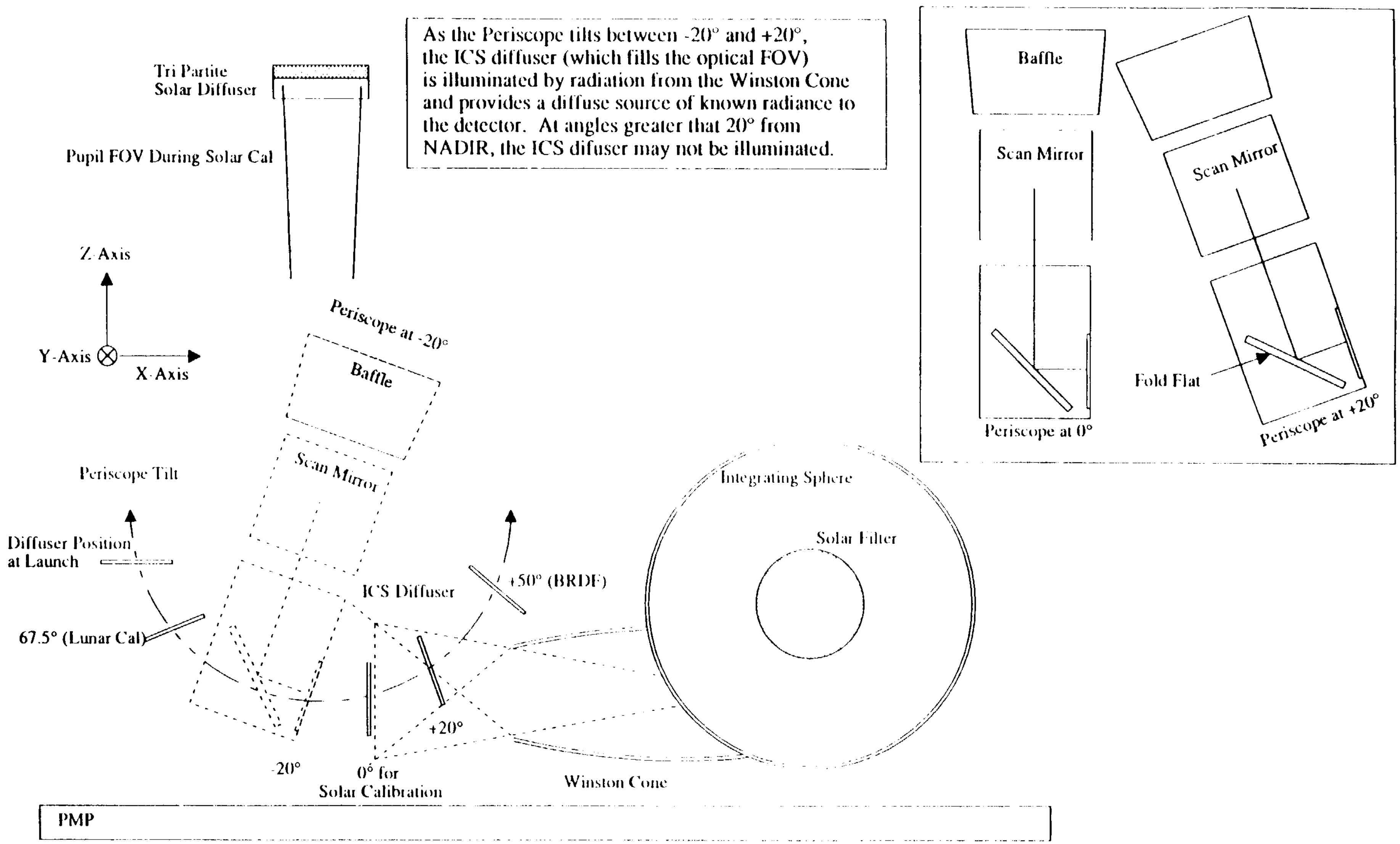
MODIS-T Optical System Sees
25 Frames of ICS Diffuser data during
each 180° of scan mirror rotation. The
ICS Diffuser always fills the optical system FOV



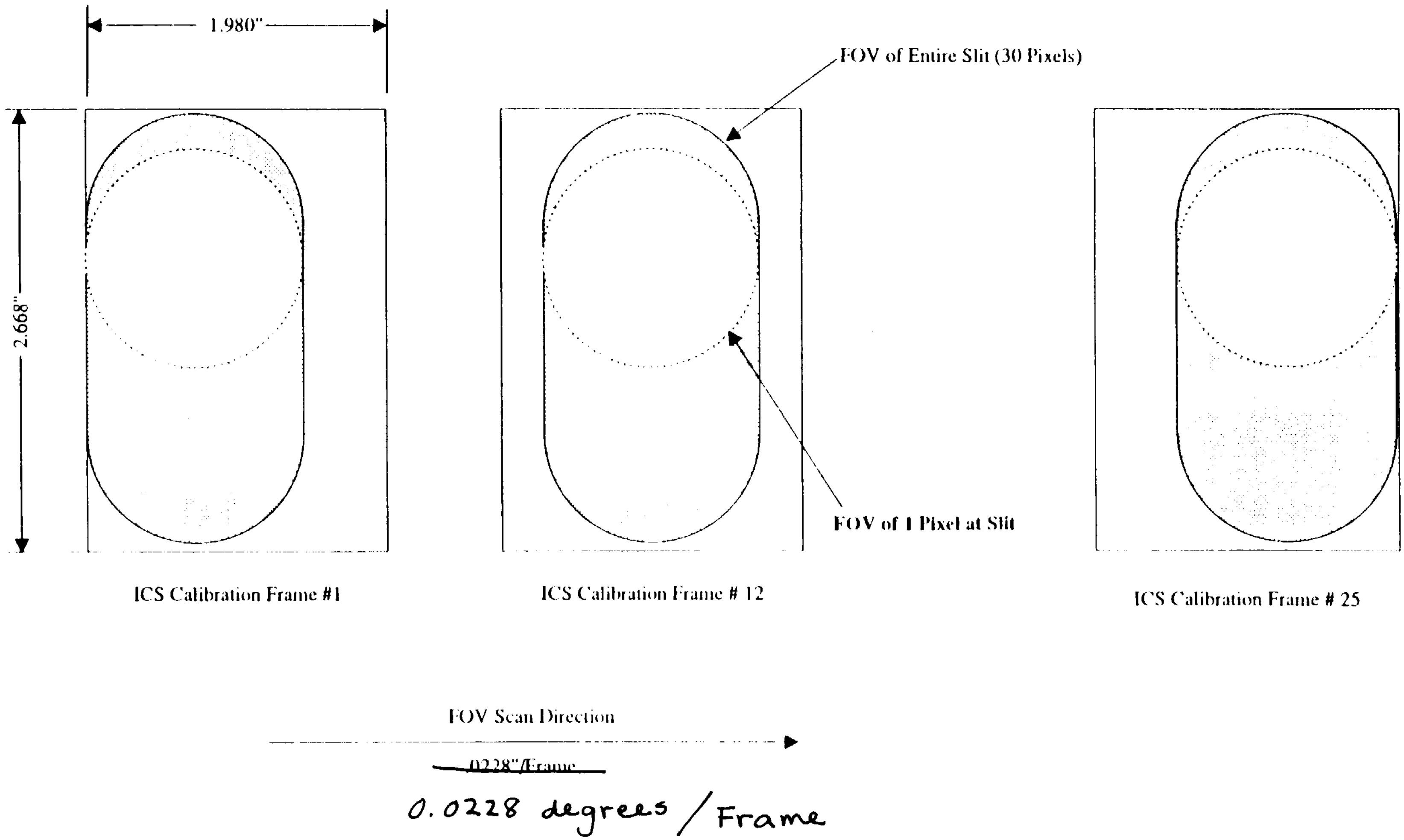
MODIS-T Internal Calibration System Concept



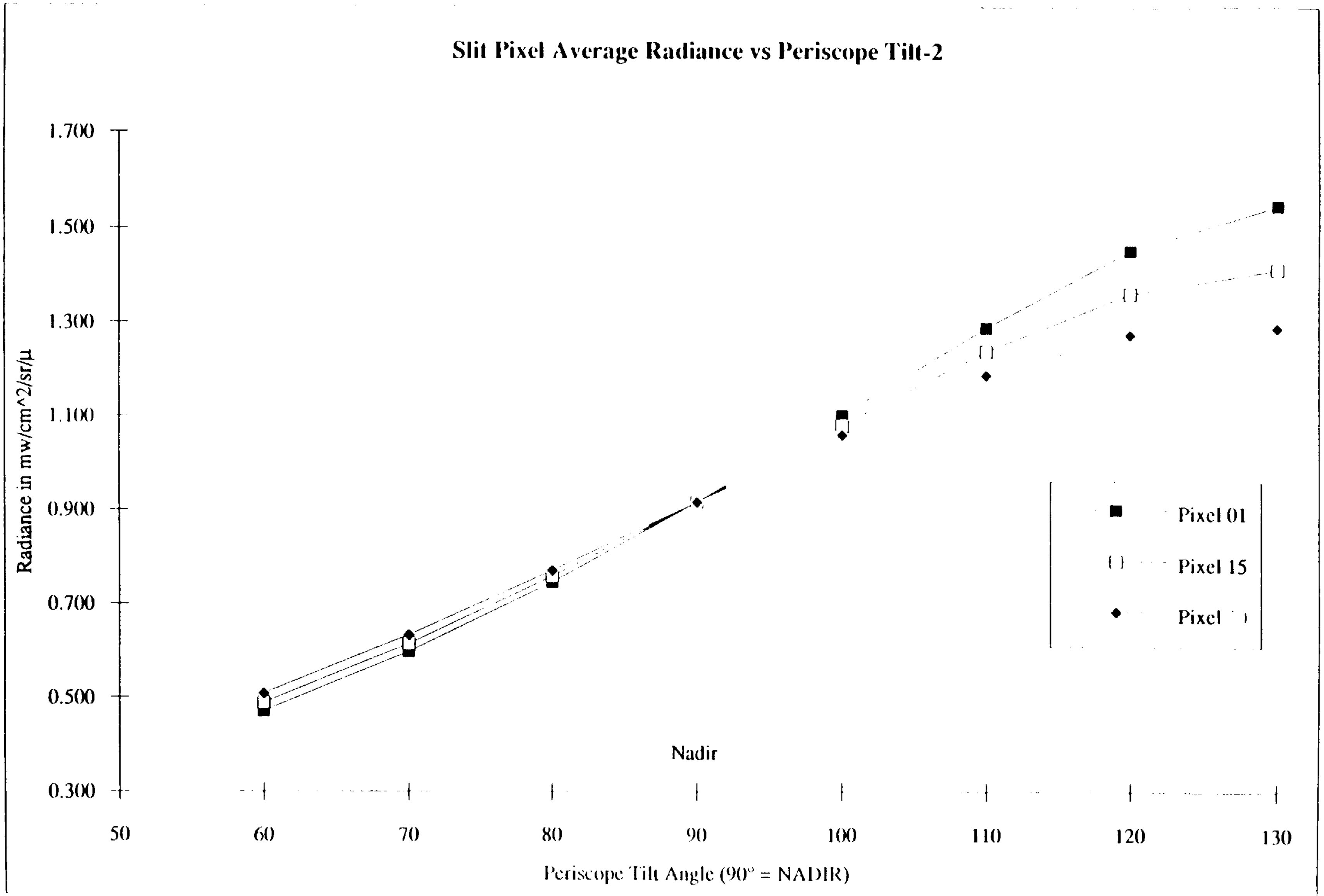
MODIS-T Calibration System Top View



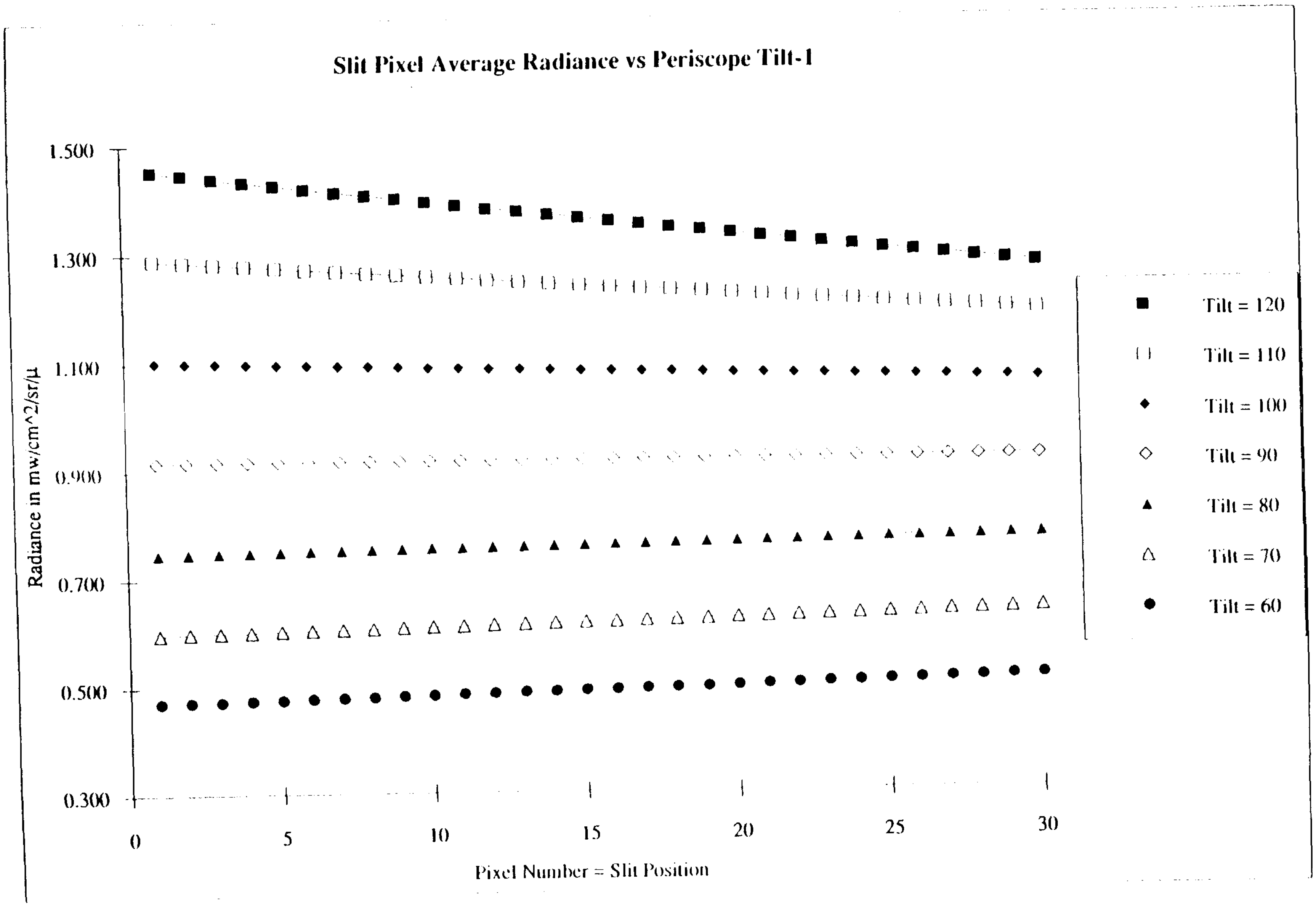
MODIS-T Calibration Concept Showing Periscope tilt and various diffuser locations

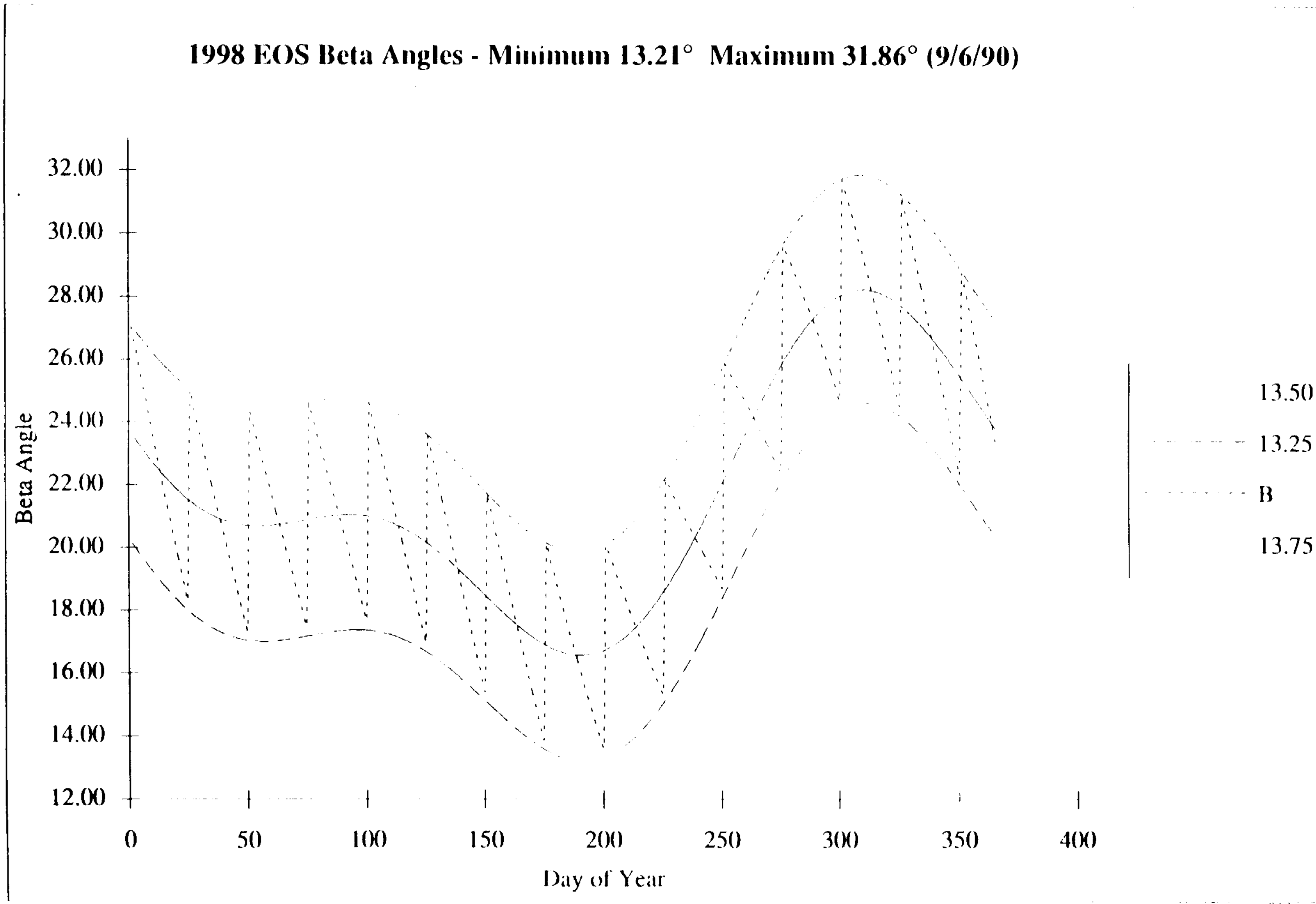


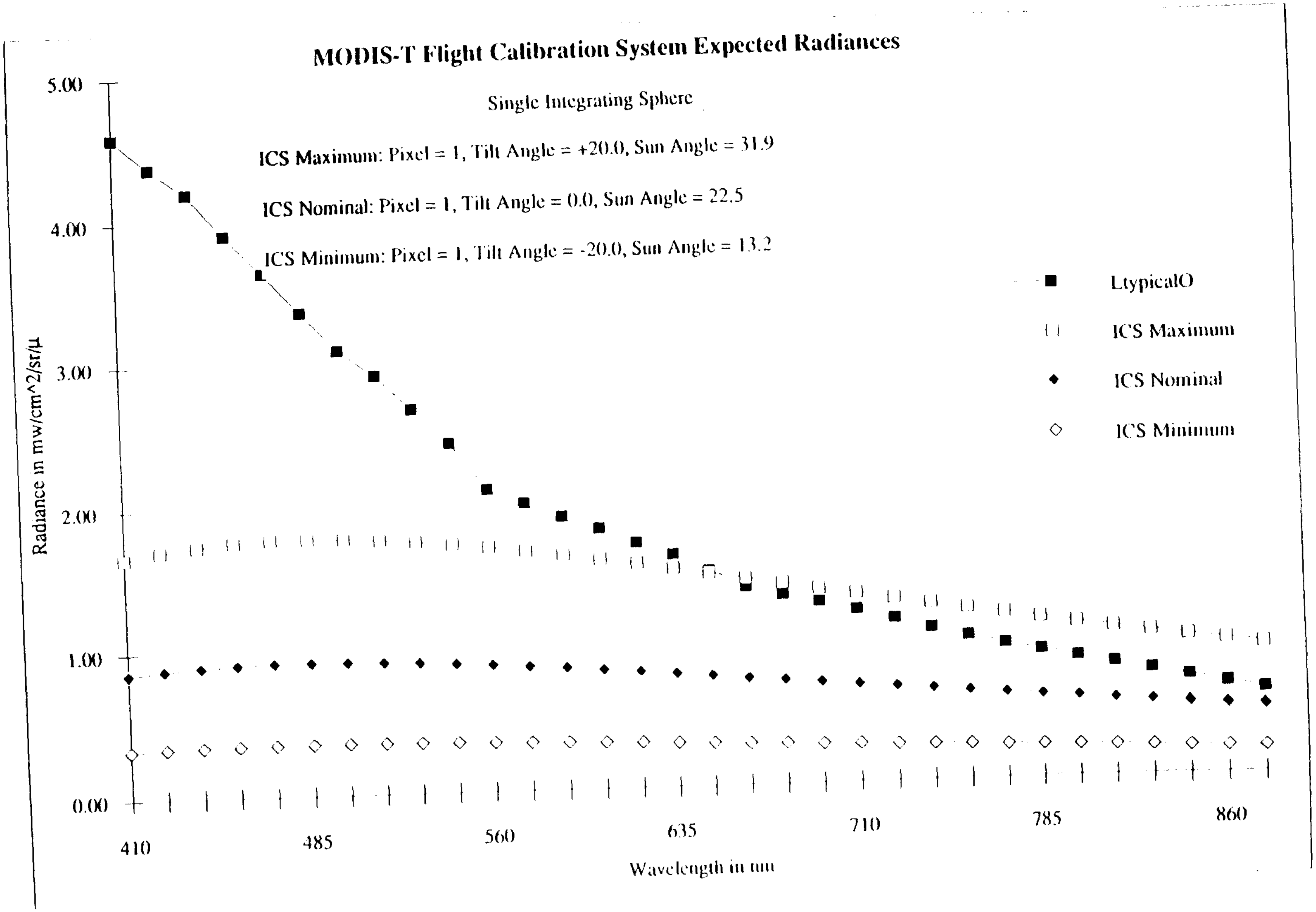
MODIS-T ICS Diffuser



Slit Pixel Average Radiance vs Periscope Tilt-2
1.700
1.500
1.300
1.100
0.900
0.700
0.500
0.300
Radiance in mw/cm^2/sr/μ
Nadir
50
60
70
80
90
100
110
120
130
Periscope Tilt Angle (90° = NADIR)
Pixel 01
Pixel 15
Pixel


Slit Pixel Average Radiance vs Periscope Tilt-1
1.500
1.300
1.100
0.900
0.700
0.500
0.300
Radiance in mw/cm^2/sr/μ
0
5
10
15
20
25
30
Pixel Number = Slit Position
Tilt = 120
Tilt = 110
Tilt = 100
Tilt = 90
Tilt = 80
Tilt = 70
Tilt = 60


1998 EOS Beta Angles - Minimum 13.21° Maximum 31.86° (9/6/90)
Beta Angle
32.00
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
0
50
100
150
200
250
300
350
400
Day of Year
13.50
13.25
B
13.75

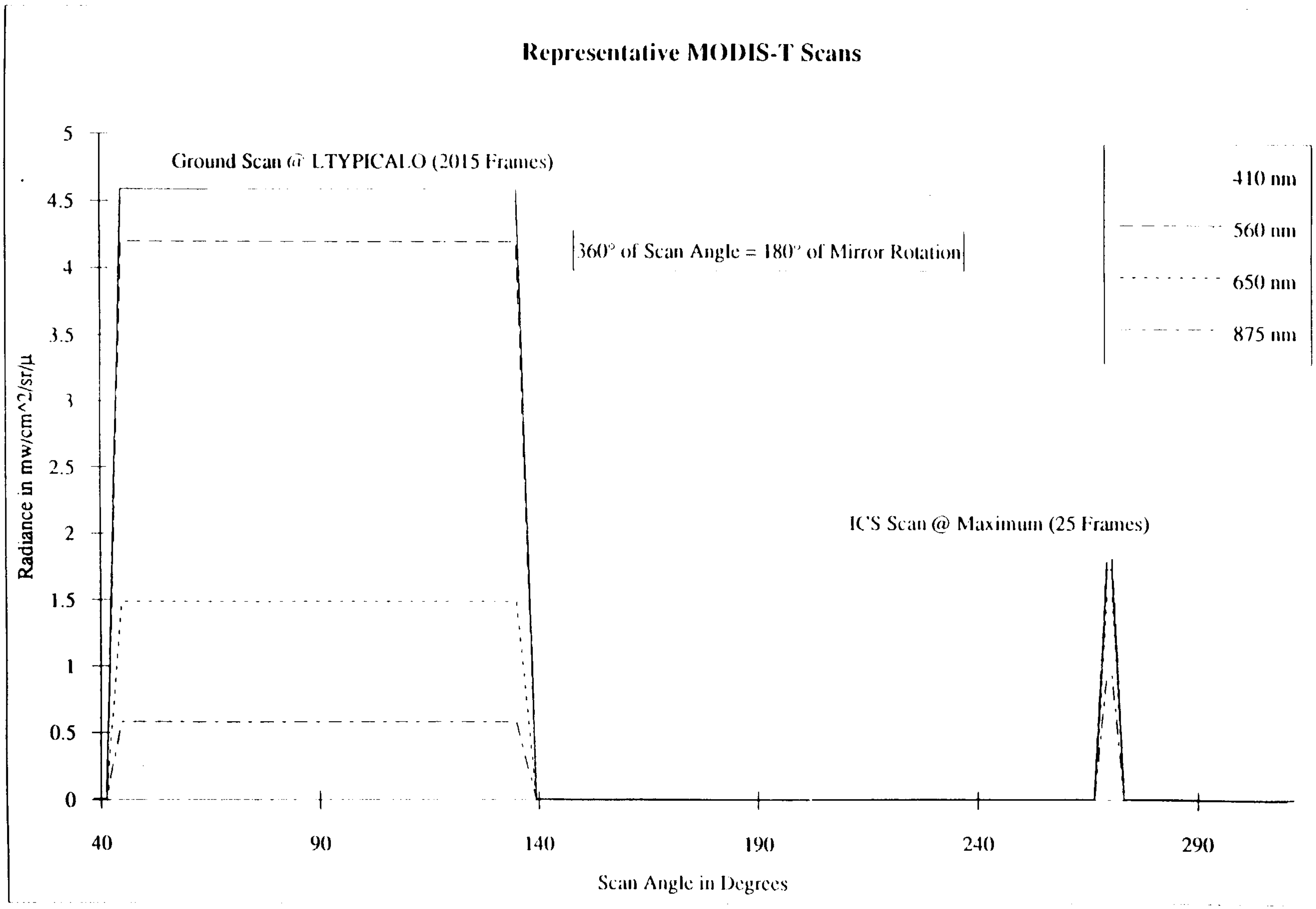

MODIS-T Flight Calibration System Expected Radiances
Single Integrating Sphere
ICS Maximum: Pixel = 1, Tilt Angle = +20.0, Sun Angle = 31.9
ICS Nominal: Pixel = 1, Tilt Angle = 0.0, Sun Angle = 22.5
ICS Minimum: Pixel = 1, Tilt Angle = -20.0, Sun Angle = 13.2
LtypicalO
ICS Maximum
ICS Nominal
ICS Minimum
Radiance in mw/cm^2/sr/µ
5.00
4.00
3.00
2.00
1.00
0.00
410
485
560
635
710
785
860
Wavelength in nm

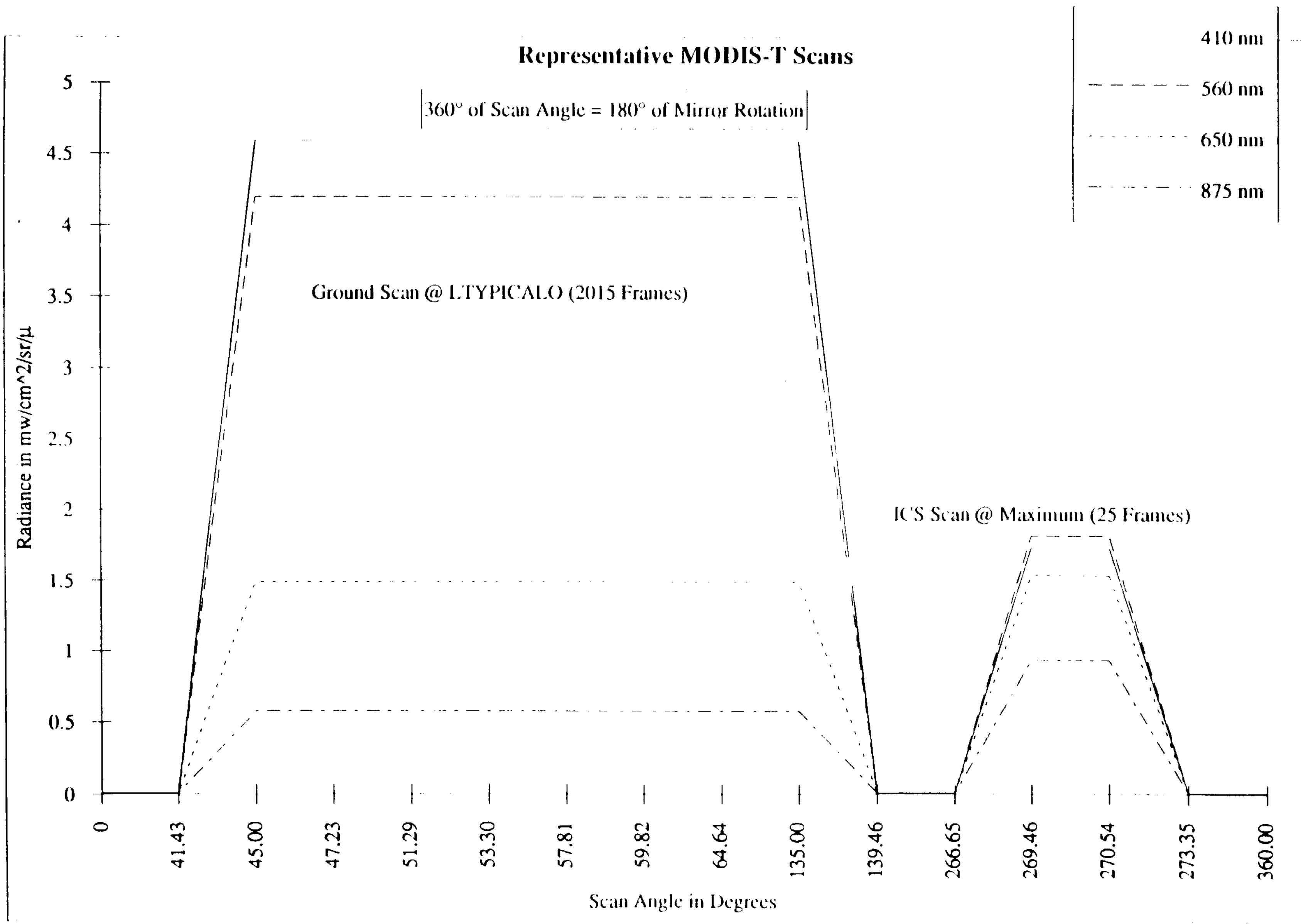
MODIS-T Internal Calibration System Flux and S/N

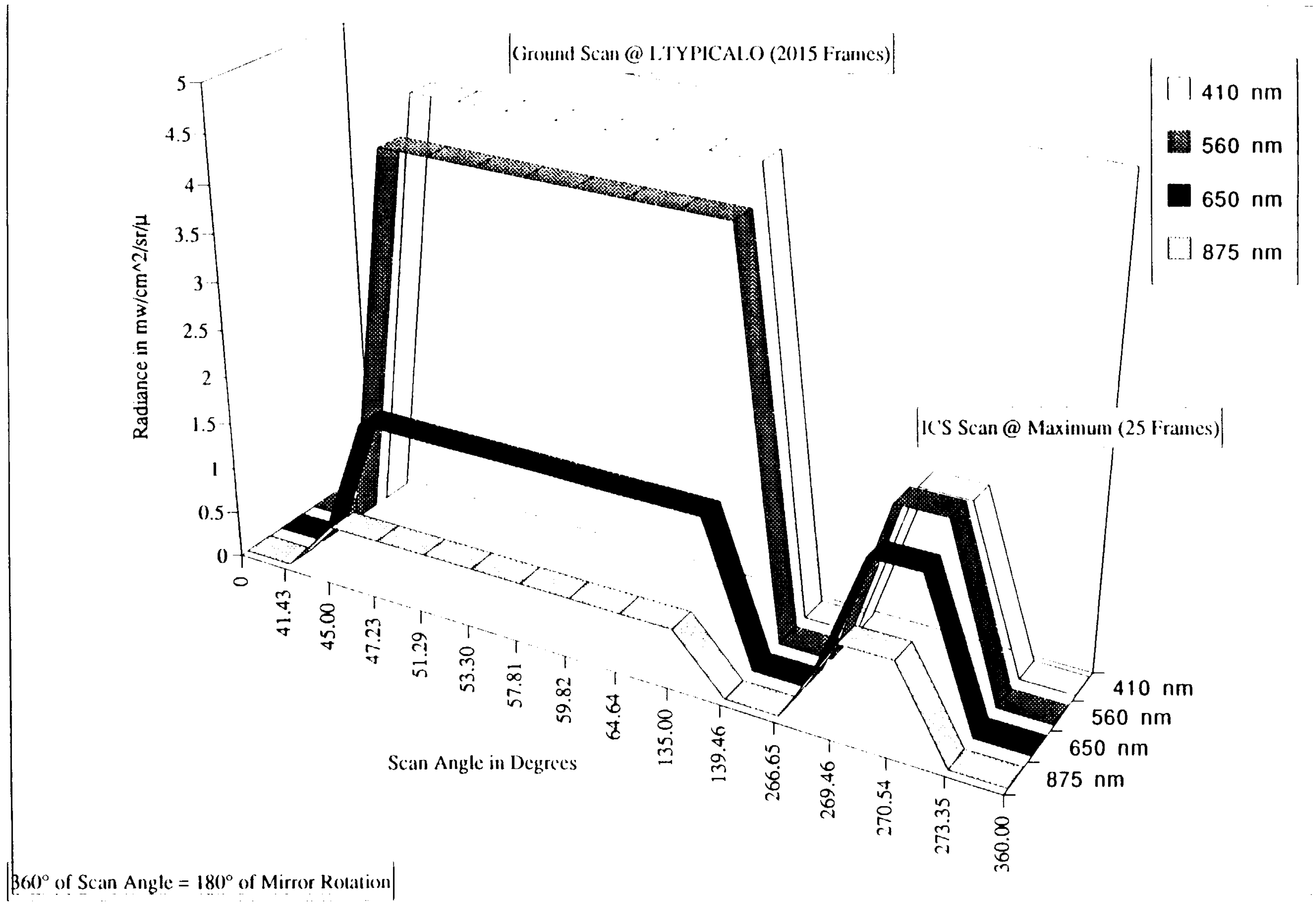
Single Integrating Sphere				ICS Nominal Pixel = 1 Tilt Angle = 0.0 Sun Angle = 22.5		ICS Maximum Pixel = 1 Tilt Angle = +20.0 Sun Angle = 31.9		ICS Minimum Pixel = 1 Tilt Angle = -20.0 Sun Angle = 13.2	
Band	Wavelength (nm)	LTYPICALO mw/cm^2 /sr/µ	LTYPICALO S/N (SPEC)	Internal Calibrator (ICS) mw/cm^2/sr/µ	ICS S/N	Internal Calibrator (ICS) mw/cm^2/sr/µ	ICS S/N	Internal Calibrator (ICS) mw/cm^2/sr/µ	ICS S/N
1	410	4.59	820	0.855	153	1.663	297	0.333	60
2	425	4.38	859	0.879	172	1.709	335	0.342	67
3	440	4.20	838	0.897	179	1.743	348	0.349	70
4	455	3.91	826	0.908	192	1.766	373	0.354	75
5	470	3.64	814	0.915	205	1.778	398	0.356	80
6	485	3.36	802	0.916	219	1.781	425	0.357	85
7	500	3.09	786	0.914	232	1.776	452	0.356	91
8	515	2.91	770	0.908	240	1.764	467	0.353	94
9	530	2.67	754	0.898	254	1.746	493	0.350	99
10	545	2.43	752	0.886	274	1.722	533	0.345	107
11	560	2.10	750	0.872	311	1.694	605	0.339	121
12	575	2.00	736	0.855	315	1.663	612	0.333	123
13	590	1.90	724	0.838	319	1.628	620	0.326	124
14	605	1.81	711	0.819	322	1.591	625	0.319	125
15	620	1.70	699	0.799	328	1.553	638	0.311	128
16	635	1.61	661	0.778	320	1.513	621	0.303	124
17	650	1.49	616	0.757	313	1.472	608	0.295	122
18	665	1.37	571	0.736	307	1.430	596	0.287	119
19	680	1.31	558	0.714	304	1.388	591	0.278	118
20	695	1.25	546	0.693	303	1.346	588	0.270	118
21	710	1.19	535	0.671	302	1.305	587	0.261	118
22	725	1.12	522	0.650	303	1.264	589	0.253	118
23	740	1.05	508	0.629	304	1.223	592	0.245	119
24	755	0.99	495	0.609	304	1.183	591	0.237	119
25	770	0.93	490	0.588	310	1.144	603	0.229	121
26	785	0.88	472	0.569	305	1.105	593	0.221	119
27	800	0.83	454	0.549	301	1.068	584	0.214	117
28	815	0.78	435	0.531	296	1.032	575	0.207	115
29	830	0.73	417	0.512	293	0.996	569	0.200	114
30	845	0.68	398	0.495	290	0.962	563	0.193	113
31	860	0.63	380	0.478	288	0.928	560	0.186	112
32	875	0.58	317	0.461	252	0.896	490	0.180	98

MODIS-T Sample Radiance Calculation

Modis-T Solar Calibration System Single Integrating Sphere w/ Concentric Elliptical Concentrat				
Angle Of Incidence	deg	22.5000	0.383	3.1416
Incident Flux	mw/cm^2-µ	200.0000		0.9900
First Integrating Sphere			Area (cm^2)	
First Sphere Diameter	in	10.0000	2026.830	1.0000
Initial Area in Percent of Total			0.300	0.3000
Ent Port Diameter	in	4.0000	81.073	0.0400
Exit Port Diameter (Dex)	in	1.5000	11.401	0.0056
Detector 1	in	0.3937	0.785	0.00[illegible]
Detector 2	in	0.3937	0.785	0.00[illegible]
Detector 3	in	0.3937	0.785	0.0004
Detector 4	in	0.3937	0.785	0.0004
Initial Reflectivity (Rho0)		0.9800	SFi	0.3472
Reflectivity (Rho1)		0.9900	1-Rho*SFi-Rho0*Fo	0.0597
Effeciency at Exit Port		0.0923	Efficency	0.0933
Solar Filter Transmission (Ts)		0.9800		
Flux In	mw/µ	6080.9724		
Flux Out of Exit Port	mw/µ	561.4662		
Flux into Si Det	mw/µ	39.0735		
Exit Port Brighiness	mw/cm^2-sr-µ	15.6760		
Sphere Wall Brighiness (ExRad)		15.6760		
Second Integrating Sphere (NOT USED)			Dual Sphere Flag	0
Second Sphere Diameter	in		0.0000	2.2500
Ent Port Diameter	in			2.2500
Exit Port Diameter	in		0.0000	1.5000
Det 1	in			0.3937
Det 2	in			
Line1	in			
Line2	in			
Reflectivity				0.9900
Sphere Eff at Exit Port				
Sphere Eff at Entrance Port				
Flux into Sphere	mw/µ			
Flux Out First Order	mw/µ			
Actual Flux Out (Using Trout Formula)	mw/µ			
Exit Port/Sphere Wall Brighiness	mw/cm^2-sr-µ			
Concentric Elliptical Concentrator			Area (cm^2)	
Sphere Exit Port Diameter	in	1.5000	11.401	
Flux Available to CEC at Sphere Exit	mw/µ	561.4662		
Exit Port Brightness (ExRad)		15.6760		
CEC Small Aperture (SmAp) (Asmap)	in	1.5000	11.401	
CEC Length	in	11.6472		
CEC Large Aperture	in	3.2178		
Remote Pupil Diameter	in	5.0000		
Rem. Pupil Distance from Large Aperture	in	4.4000		
CEC Separation Distance (Sep)	in	*0.4000*		0.4000
Flat Reflectance (Rflat)	%	*1.0000*		
Flux into CEC (CECFlux)	mw/µ	*437.1277*	437.128	
CEC Coupling Coef		*0.7785*		
Flux Into CEC	mw/µ	*437.1277*		
CEC Reflectivity		*0.9800*	Area (cm^2)	
Flux Into Remote Pupil (RPFlux)	mw/µ	*428.3851*	126.677	
Remote Pupil Size (Diameter)	in	*5.0000*	126.677	
Remote Pupil X Location				
Remote Pupil Y Location				
Irradiance at Pupil Location	mw/cm^2-µ	*3.3817*		
Diffuser Screen			Area (cm^2)	
Sec Diffuser Reflectivity (Rsd)		0.9800		
Sec Diffuser Height	in	2.6680	34.081	
Sec Diffuser Width	in	1.9800		
Periscope Tilt Angle	deg	90.0000		
Sec Diffuser Angle from Horizontal	deg	0.0000		
Sec Diffuser angle re Cone Axis (Ad)		90.0000		
Sec Diffuser Center X Location RE Pupil		0.9000		
Sec Diffuser Center Y Location RE Pupil		-1.0000		
Flux Cone Height at Diffuser		5.3645	145.822	
Irradiance at Diffuser Location	mw/cm^2-µ	*2.9377*		
Flux Incident onto Diffuser	mw/µ	100.1219		
Secondary Diffuser Brightness	mw/cm^2-sr-µ	*0.9164*	0.5183	1.2867
Solar Diffuser Brightness @ 100%	mw/cm^2-sr-µ	*63.6620*		
Ratio		*0.0144*	0.0081	0.0202
Solar Diffuser Brightness @ 5%	mw/cm^2-sr-µ	*3.1513*	0.0094	


Representative MODIS-T Scans
Ground Scan @ LTYPICALO (2015 Frames)
360° of Scan Angle = 180° of Mirror Rotation
410 nm
560 nm
650 nm
875 nm
ICS Scan @ Maximum (25 Frames)
Radiance in mw/cm^2/sr/μ
Scan Angle in Degrees
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
40
90
140
190
240
290


Representative MODIS-T Scans
360° of Scan Angle = 180° of Mirror Rotation
410 nm
560 nm
650 nm
875 nm
Ground Scan @ LTYPICALO (2015 Frames)
ICS Scan @ Maximum (25 Frames)
Radiance in mw/cm^2/sr/µ
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
41.43
45.00
47.23
51.29
53.30
57.81
59.82
64.64
135.00
139.46
266.65
269.46
270.54
273.35
360.00
Scan Angle in Degrees



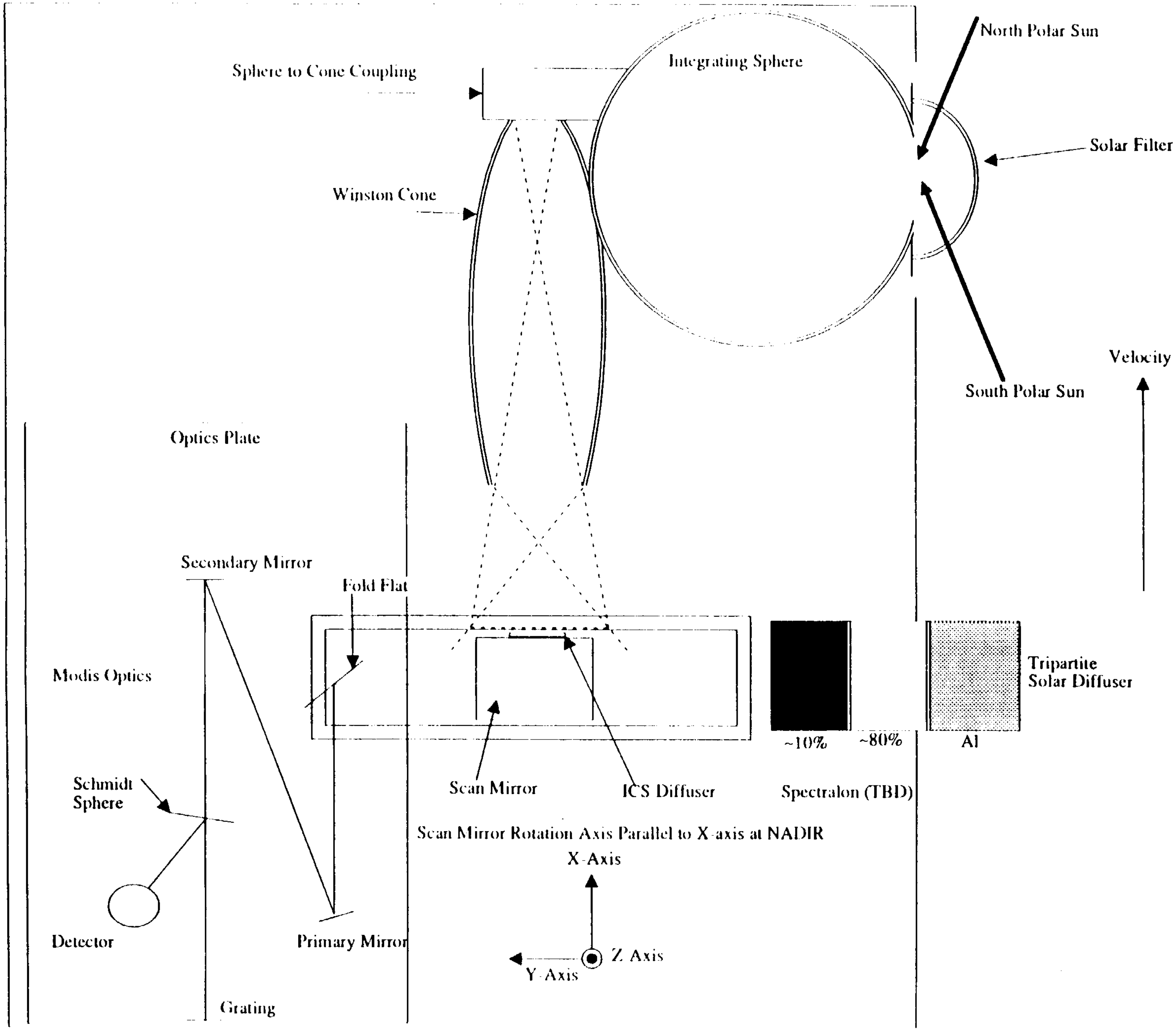
Ground Scan @ LTYPICALO (2015 Frames)
ICS Scan @ Maximum (25 Frames)
410 nm
560 nm
650 nm
875 nm
Radiance in mw/cm^2/sr/μ
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
41.43
45.00
47.23
51.29
53.30
57.81
59.82
64.64
135.00
139.46
266.65
269.46
270.54
273.35
360.00
Scan Angle in Degrees
410 nm
560 nm
650 nm
875 nm
360° of Scan Angle = 180° of Mirror Rotation

Solar Calibration

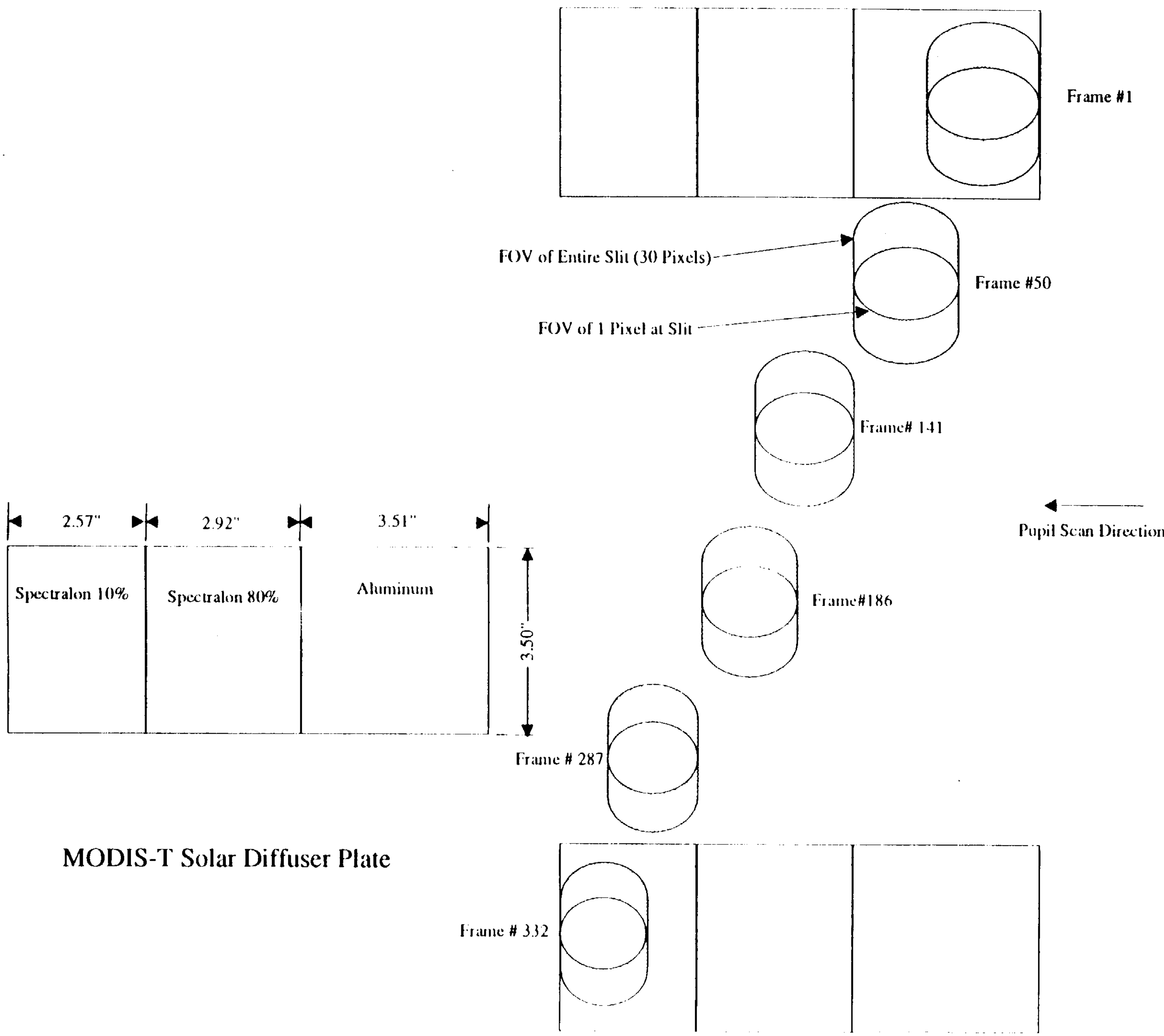
A deployable solar diffuser plate is part of the MODIS–T design. The diffusing plate will be deployed on an arm about 50 cm in length when the satellite is crossing the equator. Assuming the material in the diffusing plate maintains its characteristics, the plate provides a stable repeatable source. The diffuser plate consists of three separate sections - two sections are composed of Spectralon (~10% and ~80% reflectance) and one section is composed of roughened aluminum. The aluminum will be used to provide a stable source over time to check the degradation of the Spectralon panels.

Since the diffuser plate is subject to contamination and other changes with time, particularly if exposed to solar ultraviolet radiation, under normal conditions it will be stowed in a protective opaque housing. The frequency of deployment will be kept to a minimum, perhaps once per month, to assure that a stable repeatable source is available over the five years of the mission. When the diffuser is deployed, it will cover part of the Earth as seen by the instrument. Thus, the data collection procedure remains the same as when it is not deployed and the only requirement in the data processing is to recognize the instrument mode and analyze the data properly.

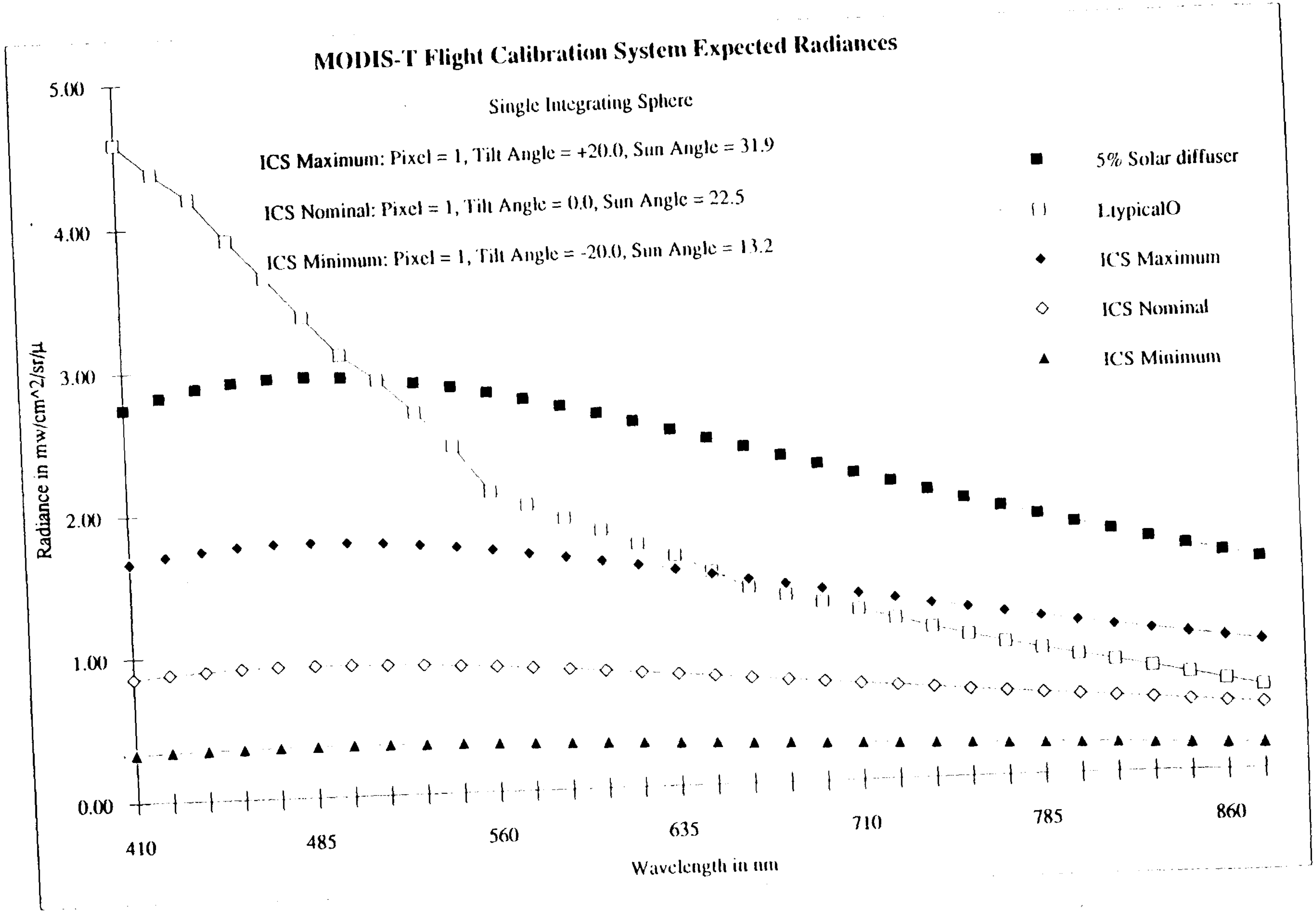
This method of calibration is a primary method of calibration since the entire optical path of the instrument is monitored.



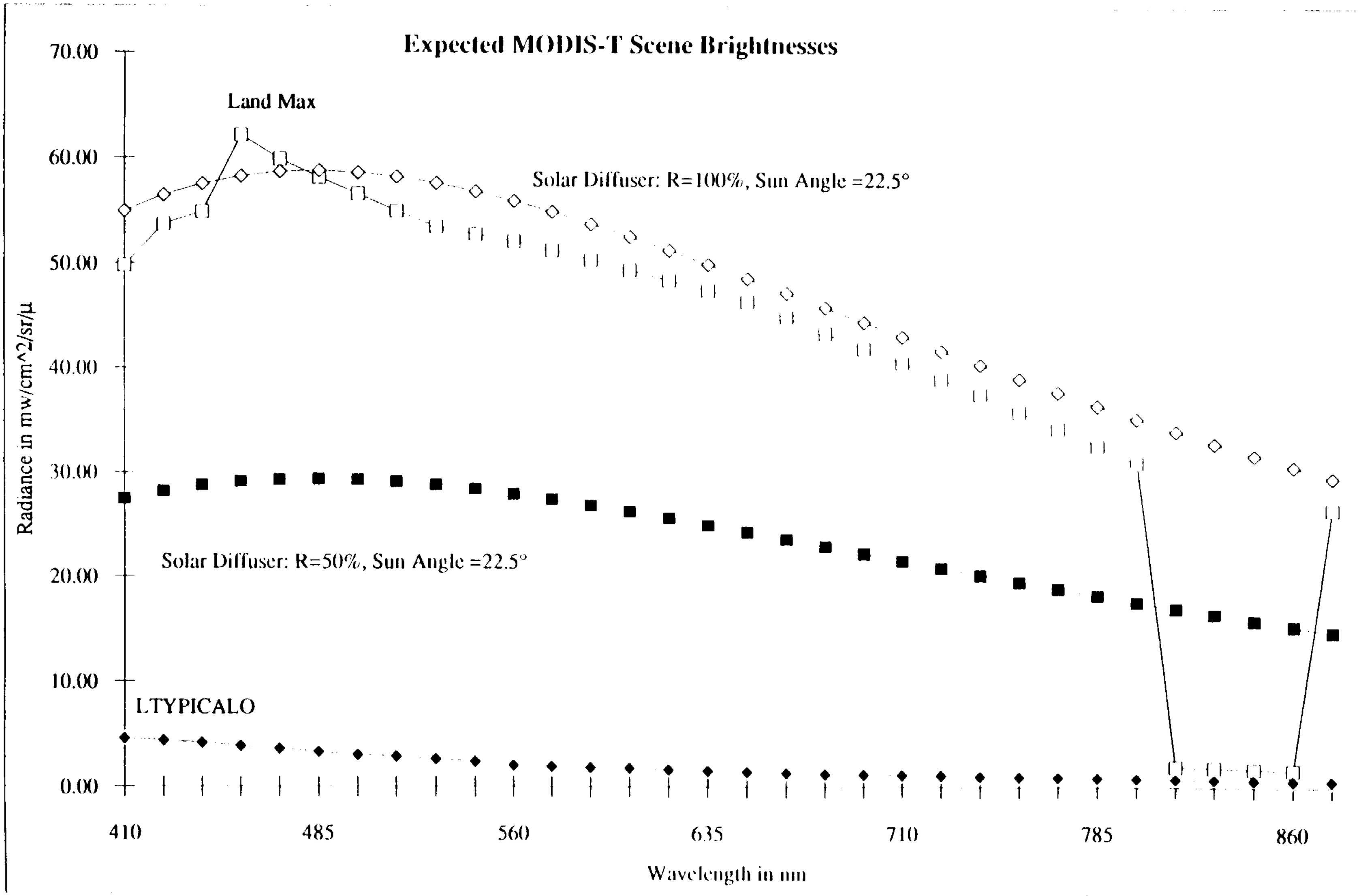
MODIS-T Calibration System Top View



MODIS-T Solar Diffuser Plate

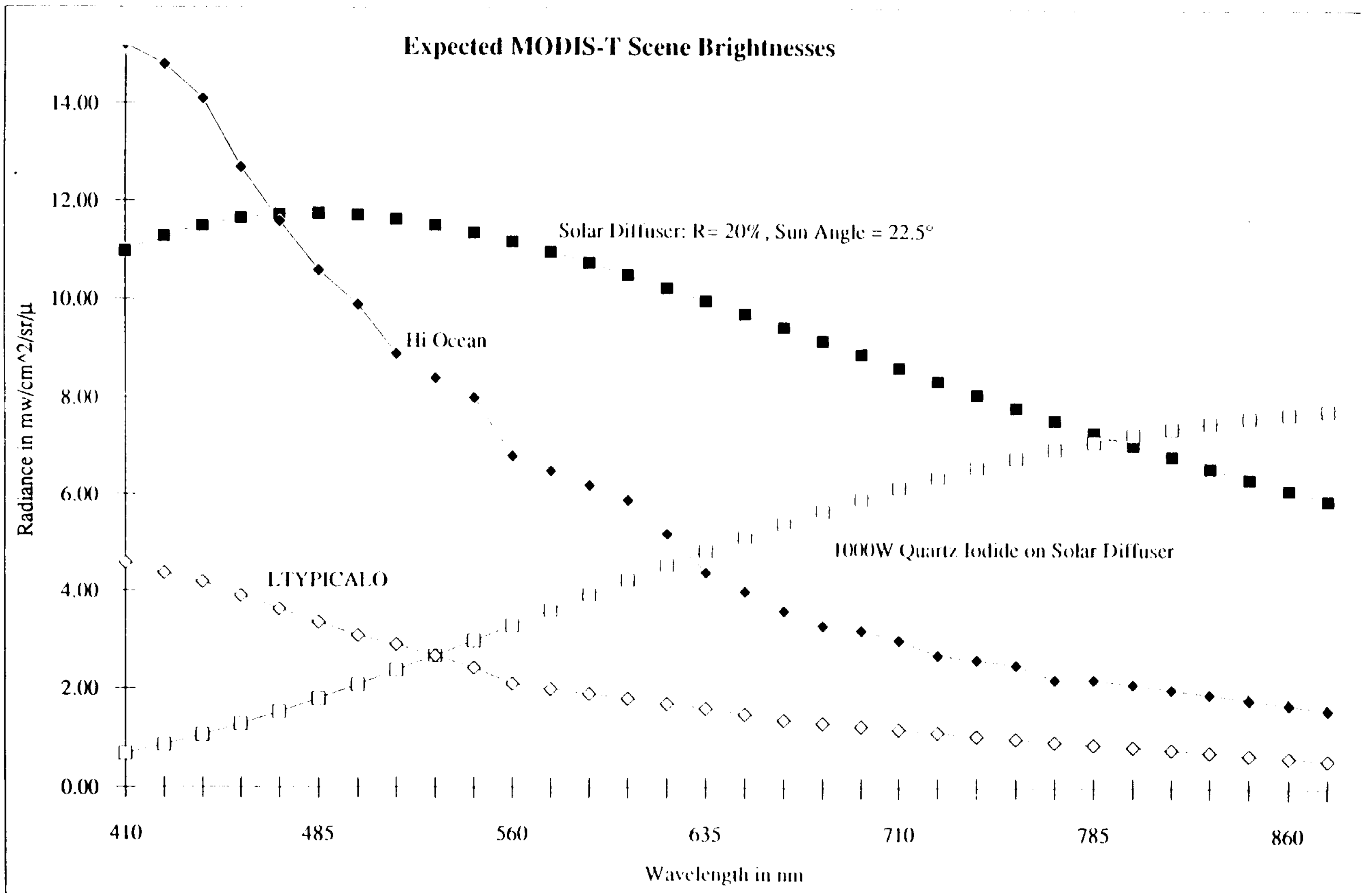


MODIS-T Flight Calibration System Expected Radiances
Single Integrating Sphere
ICS Maximum: Pixel = 1, Tilt Angle = +20.0, Sun Angle = 31.9
ICS Nominal: Pixel = 1, Tilt Angle = 0.0, Sun Angle = 22.5
ICS Minimum: Pixel = 1, Tilt Angle = -20.0, Sun Angle = 13.2
5% Solar diffuser
LtypicalO
ICS Maximum
ICS Nominal
ICS Minimum
Radiance in mw/cm^2/sr/μ
5.00
4.00
3.00
2.00
1.00
0.00
410
485
560
635
710
785
860
Wavelength in nm



Expected MODIS-T Scene Brightnesses
Land Max
Solar Diffuser: R=100%, Sun Angle =22.5°
Solar Diffuser: R=50%, Sun Angle =22.5°
LTYPICALO
Radiance in mw/cm^2/sr/μ
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
410
485
560
635
710
785
860
Wavelength in nm

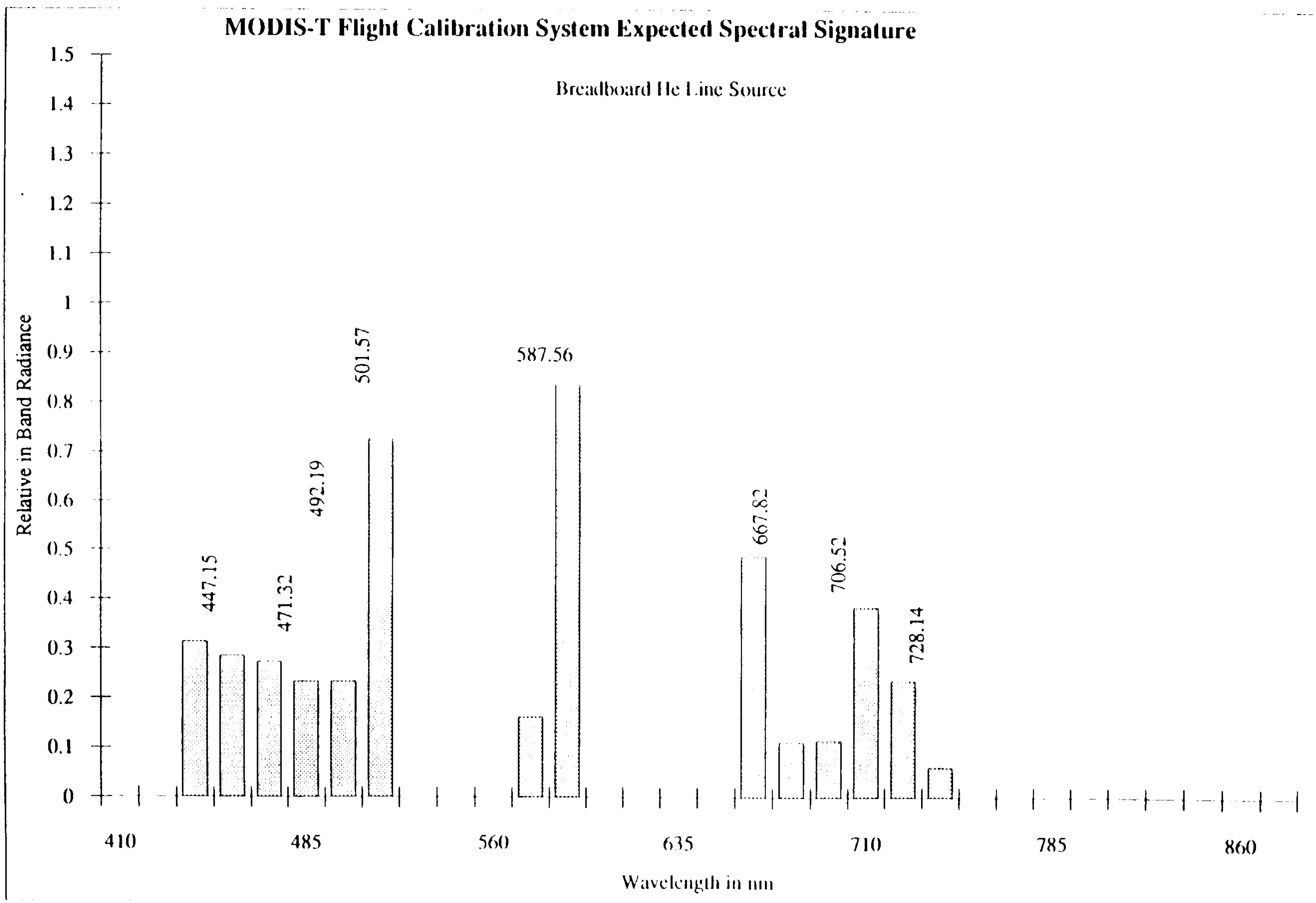
Pre-Launch Integrating Sphere Calibration



Expected MODIS-T Scene Brightnesses
Radiance in mw/cm^2/sr/μ
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
410
485
560
635
710
785
860
Wavelength in nm
Solar Diffuser: R= 20% , Sun Angle = 22.5°
Hi Ocean
LTYPICALO
1000W Quartz Iodide on Solar Diffuser

Spectral Calibration

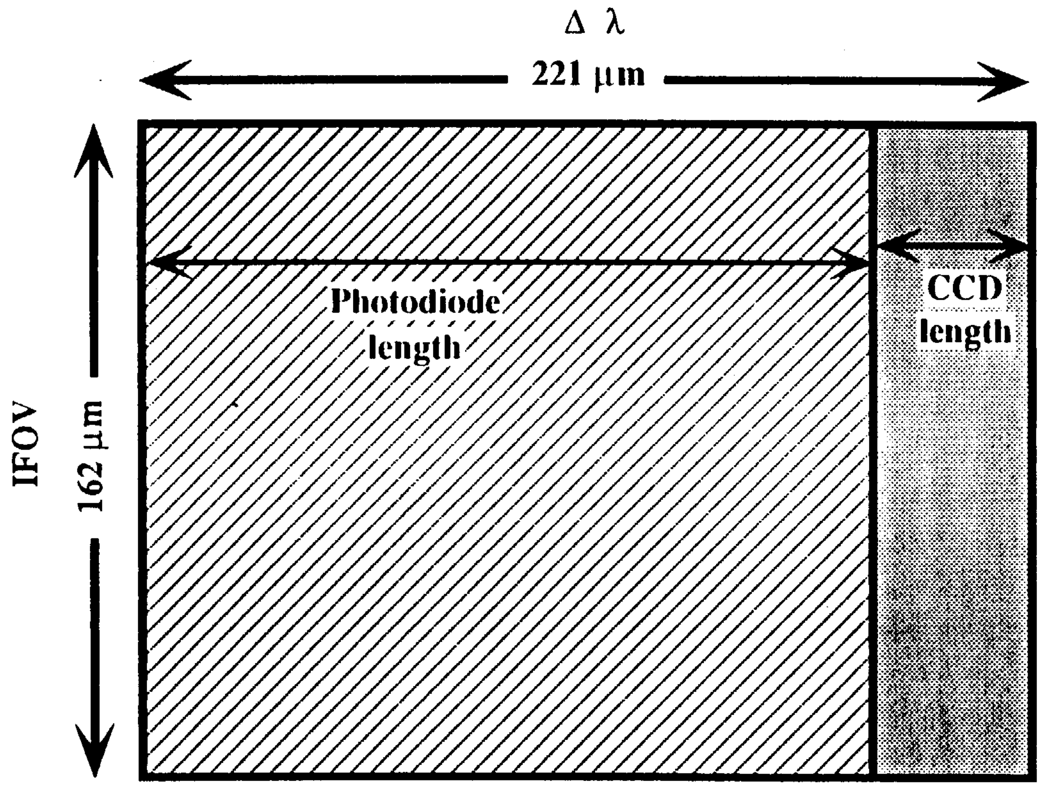
An internal spectral line source will be used to provide in-orbit spectral calibration. The assembly consists of an incandescent lamp source which illuminates a double pass grating spectrometer that provides a light source of known wavelength to the detectors.


MODIS-T Flight Calibration System Expected Spectral Signature
Breadboard He Line Source
Relative in Band Radiance
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
447.15
471.32
492.19
501.57
587.56
667.82
706.52
728.14
410
485
560
635
710
785
860
Wavelength in nm

He Line Source Spectral Characteristics

Source Wavelength	Relative Line Strength	MODIS-T Spectral Band	% of in-band Energy	Normalized in-band Radiance	MODIS-T Spectral Band	Total in-band Radiance Relative to Peak
447.148	0.601	440	52.35	0.314	440	0.314
		455	47.65	0.286	455	0.286
471.315	0.300	470	91.23	0.273	470	0.273
		485	8.77	0.026	485	0.234
492.193	0.400	485	52.05	0.208		
		500	47.95	0.192	500	0.728
501.568	0.599	500	89.55	0.536		
		515	10.45	0.063	515	0.063
587.562	1.000	575	16.25	0.163	575	0.163
		590	83.75	0.837	590	0.837
667.815	0.601	665	81.23	0.488	665	0.488
		680	18.77	0.113	680	0.113
706.519	0.500	695	23.21	0.116	695	0.116
		710	76.79	0.384	710	0.384
728.135	0.300	725	79.10	0.237	725	0.237
		740	20.90	0.063	740	0.063

Schematic diagram of the Band 1 MODIS-T detector



Lunar Calibration

When MODIS-T tilts by 50° or more, it is capable of viewing deep space. At such times it is also cable of viewing the full moon. The moon is a relatively stable radiation source, which potentially allows it to be used for calibration.

Only six of the 32 detector are exposed to lunar radiation when the moon is viewed and the intensity of the source is low compared to the Earth, so the signal-to-noise ratio may not be high. The moon is a relatively stable radiation source, which potentially allows it to be used for calibration. The intensity of the lunar disk will vary during the year as the Earth-Sun distance changes and will also vary with the lunar libration angle. Given the precise illumination and observation geometry, a high spatial resolution model of the spectral radiance from the moon will be calculated. This radiometric image will then be transforms to match the resolution and orientation of MODIS-T. Periodically then, MODIS-T will be exposed to a stable radiometric source, allowing the long-term stability of the instrument to be monitored. Hugh Kieffer of the USGS-Flagstaff is the principal investigator for lunar calibration.

This method of calibration is a primary method of calibration since the entire optical path of the instrument is monitored.

MODIS-T Science Calibration/ Characterization Plan Outline and Responsibilities

Introduction	Barker, Petroy
Pre-Launch Calibration/Characterization Methodology	GSFC Code 700
In-Orbit Radiometric Calibration/Characterization Methodology	
Instrument-Based Calibration	
Internal sources	GSFC Code 700
External solar	Guenther, Barker, Geller, Hoyt, Mecherikunnel
External lunar	Kieffer, Hoyt
Instrument Cross-Comparison	
Cross-Sensor/within platform	Ungar, R.Muller
Cross-Platform In-Orbit	Ungar
Target Related/Aircraft	Abel, Guenther, King, Brown, Ungar
Target-Based Calibration	
Target Related/Ground Reflectance	Slater et al., Markham
Bio-Optical Oceans	Evans, Esaias
Image-Related	
Radiometric Rectification	Hall, Barker
Class-Specific Scene Equalization	Barker, Markham, Burelbach
In-Orbit Geometric Calibration	GSFC Code 700
In-Orbit Spectral Calibration	GSFC Code 700
Offical MODIS-T/MCST Calibration Algorithm	Barker, Petroy
Algorithm Sensitivity/Simulation Studies	Barker, Markham, Ungar, Justice, Townsend, Esaias, King

Preliminary Stray Light Report for MODIS-T

Dennis Evans, Advanced Technology and Research Corporation (ATR)

- **Basic Assumptions:**

  1) All stray light hitting the slit between the primary mirror and the secondary mirror will make it to the detector.
  2) All stray scatter sources after the slit will be minimal.
  3) All optical surfaces will have a roughtness of 40 A rms.
  4) All structural surfaces are covered with Chemglaze Z306 (black paint).

  NOTE: The effect of the solar diffuser panel on the scatter level has not yet been studied.

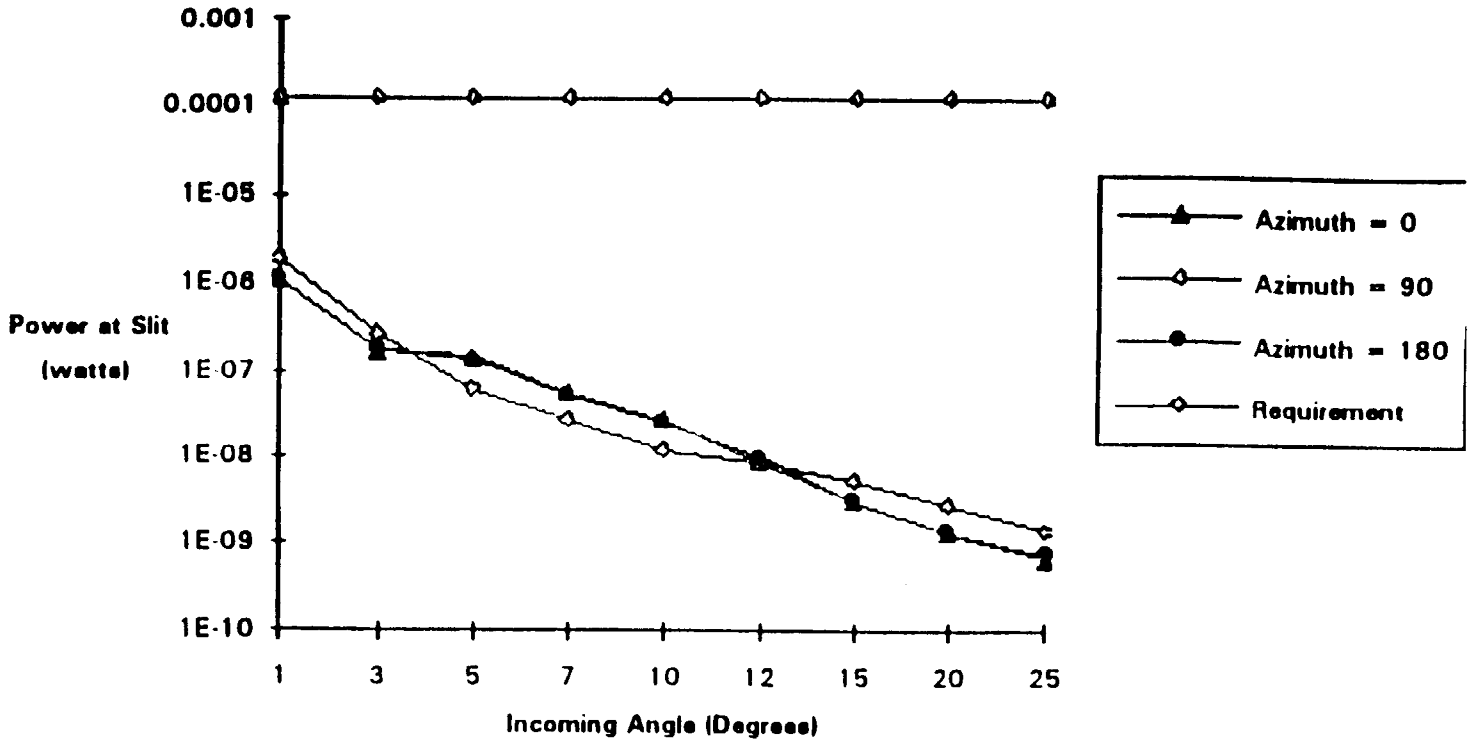
- **Model:**

  Arizona's Paraxial Analysis of Radiation Transfer/Paraxial Analysis of Diffracted Energy (APART/PADE) - a deterministic stray radiation analysis program.

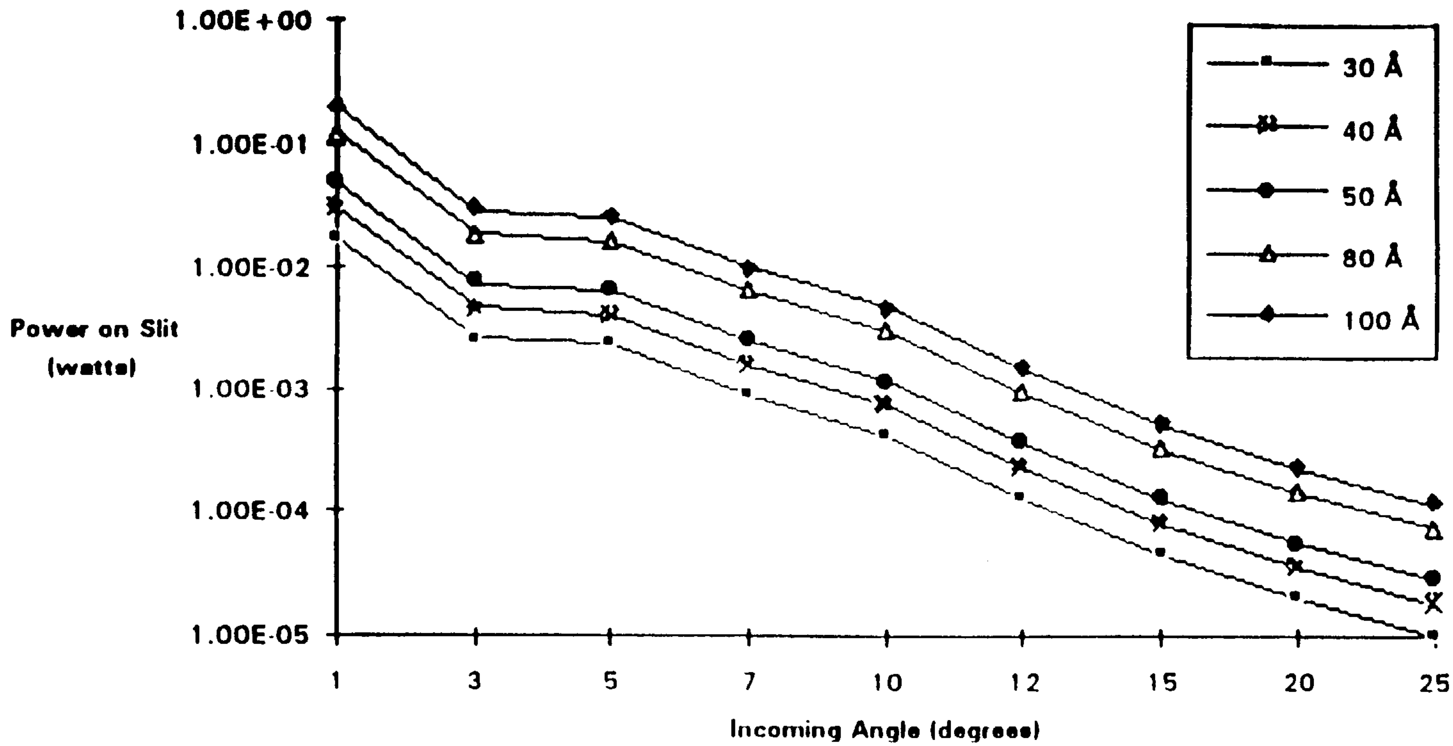
- **Results:**

  1) MODIS-T meets its stray light specifications (2 to 5 orders of magnitude lower than specs).
  2) The optical elements are the predominant stray light contributors - primarily the effects of surface roughness.

Normalized Power Hitting the Slit from a Scattering Point Source



Power on Slit vs. Surface Roughness of Optical Elements



Summary of P. Slater's MODIS-T Calibration Questions (April, 1991) (1 of 4)

(answered originally in May 2nd letters from T. Magner)

1) Intensity of 2-sphere Solar Calibrating System
2) UV stability of internal IS surface
3) Photodiode loss of sensitivity in orbit
4) Solar diffuser material

Paraphrasing of Slater's MODIS-T Questions (2 of 4)

with updating of answers

1) **Is internal calibrator solar throughput adequate with 2 spheres?**

Current plans (see spreadsheet output) call for
using only one 0.98 reflectance sphere,
with 78% efficient IS-to-cone coupler
with 98% efficient CEC Winston cone, and
with original focusing lens removed.

Maximum expected solar radiance from the IS is
less than typical expected at-satellite radiance from ocean
for wavelengths below about 640nm, and
more than typical above 640 nm (see Figure)

Maximum expected solar radiance from the IS is
about a factor of six less than maximum (see Figure)

Paraphrasing of Slater's MODIS-T Questions (2 of 4)

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Paraphrasing of Slater's MODIS-T Questions (3 of 4)

with updating of answers

2) Is UV-degradation of solar illuminated IS Labsphere surface a problem?

Current plans call for
- an IS coating of
  - either a stable paint, or
  - 100% pure Spectralon, and
- a UV blocking filter as one element of the IS aperture mechanism
  - with an open aperture on the aperture mechanism
    - to occasionally check for degradation of the filter.

3) Will the photo-diode monitors in the IS degrade in orbit?

Relative and absolute stability of photodiodes
- expected to be high on time scale of months
  - e.g. between pre-launch and in-orbit calibrations
    - and between orbits

Paraphrasing of Slater's MODIS-T Questions (4 of 4)

with updating of answers

4) What material is planned for solar diffuser?

Three sections are planned for solar panel

5-20% reflectance doped Spectralon

100% reflectance pure Spectralon

non-Lambertian roughened aluminum

(Expected to be UV resistant)

MCST Feedback Sheet

Questions ? **Concerns ?**

Suggestions ? **Actions for Next Meeting?**

Name: **Date:**

For E-mail correspondence address GSFCmail:JBarker, JHarnden, or HGeller.
For updates on the latest events and available documents, CHECK MCST.BB bulletin board on GSFCmail.