MODIS Science Team Meeting, Oct. 1 - 3, 1991. Attachment CC

CALIBRATION

J. YOUNG

6/89
90634-82

CALIBRATION TOPICS

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary

- CALIBRATION REQUIREMENTS
- CALIBRATION STRATEGY
- OBC
  - SOLAR ILLUMINATED DIFFUSER
  - BLACKBODY
  - SRCA
  - MODELING RESULTS
- PREFLIGHT
  - PERFORMANCE/CHARACTERIZATION
  - BTE/GSE
  - CALIBRATION
- REVIEW OF OTHER MAJOR ASPECTS
  - SPECTRAL SHIFTS
  - DIFFUSER SELECTION
  - LUNAR CALIBRATION
- CALIBRATION SUMMARY

6/89
90634-96

Parameter	Phase C/D Require- ment	Predicted	
		Preflight	On-Orbit
Radiometric Calibration			
Below 1.0 µm	5%	4%	3%**
1.1 to 3.0 µm	5%	4%	3%**
Above 3 µm	1%	1%	1%
Reflectance	2%	4%	2%
Spectral Calibration			
Center Wave- length	0.5 nm preflight 1.0 nm on-orbit	0.5 nm	1.0 nm*
Spectral Band- to-Band Stability	0.5% FS 1.0% HS	0.5% FS 1.0% HS	0.5% FS
Geometric Calibration			
Band-to-Band Registration	0.1 IFOV	0.05 IFOV	0.1 IFOV
Diffuser BRDF			
<2.0 µm	1.0%		
2.0 to 2.5 µm	1.5%		

FS = Full Scale HS = Half Scale

* Dependent on good correlation with full aperture ground measurement and SRCA sub-aperture measurements

** Multiple calibration methodologies are required

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

CALIBRATION REQUIREMENTS

9/91
91-0742-6

CALIBRATION STRATEGY
USE MULTIPLE MEASUREMENT/CALIBRATION METHODOLOGIES

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

MODIS-N

PREFLIGHT — USE MULTIPLE METHODS AND CORRELATE

- LOOK FOR TRENDS IN CALIBRATION HISTORY THROUGHOUT PREFLIGHT LIFETIME

INFLIGHT — ONBOARD CALIBRATORS

- RADIOMETRIC, SPATIAL, SPECTRAL AND ONBOARD CALIBRATOR STABILITY MONITORING

INFLIGHT — REMOTE SCENES

- MULTIPLE EARTH SCENES
- LUNAR SCENE

EOS SENSOR CALIBRATION

RECOMMENDED COORDINATED CALIBRATION CAMPAIGN COVERING MULTIPLE EOS SENSORS

- PREFLIGHT CALIBRATION SOURCES
- INFLIGHT EARTH REFERENCE SCENES

RESULT

IT IS BELIEVED THAT 2% ABSOLUTE CALIBRATION IS ACHIEVABLE IF THE CONCEPT OF MULTIPLE MEASUREMENT/CALIBRATION METHODOLOGIES IS FULLY IMPLEMENTED

6/89
90634-98

MULTIPLE OBC ARE FEASIBLE AND WORKABLE

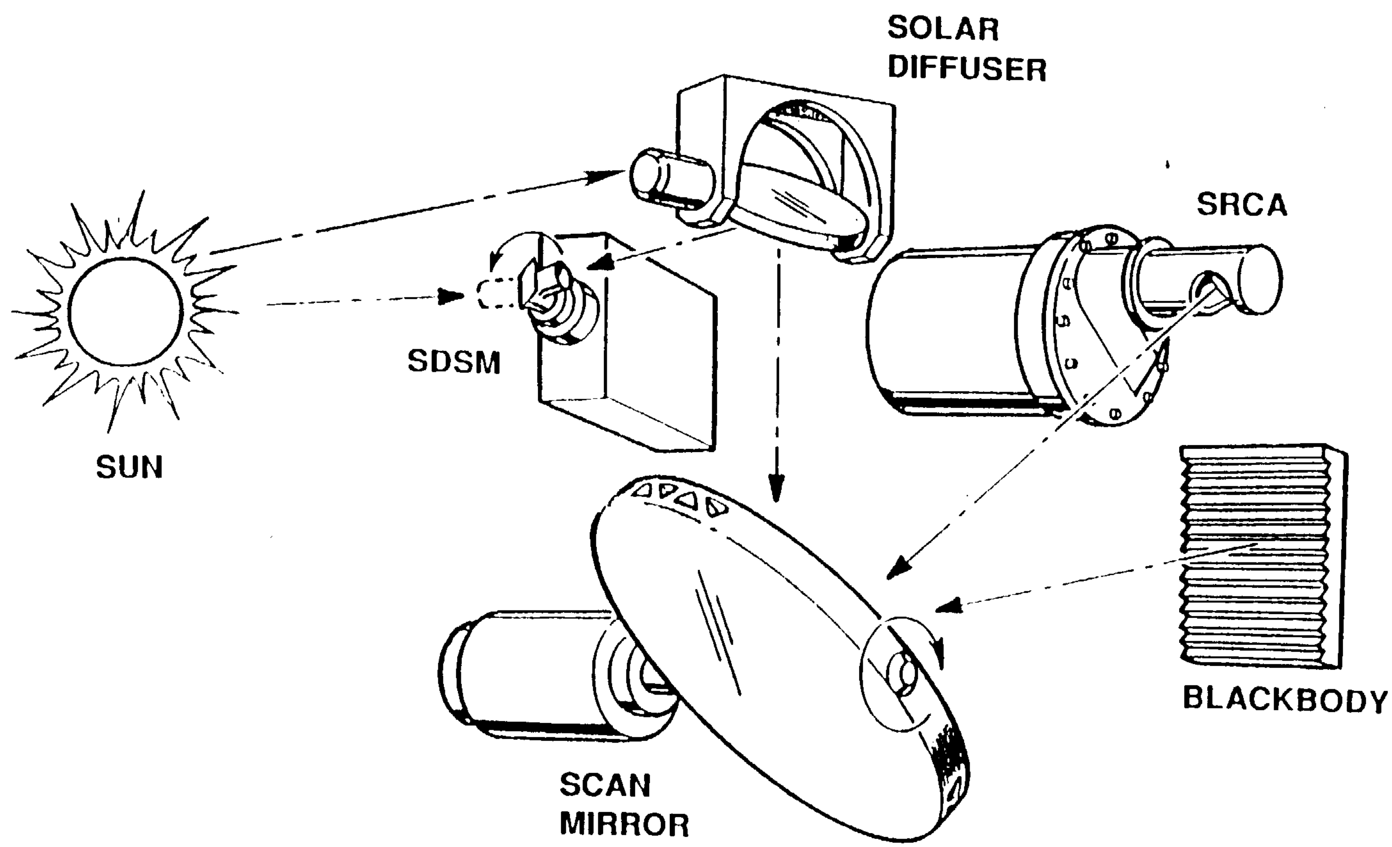
HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary

DC RESTORE	ALL BANDS
BLACKBODY — FULL APERTURE	MWIR/LWIR
SOLAR ILLUMINATED DIFFUSER TWO LEVELS	VIS/NIR/SWIR
~~POLARIZATION CALIBRATOR~~	~~BANDS 17-19~~
SRCA	
RADIOMETRIC CALIBRATION CHECK	VIS/NIR/SWIR
SPATIAL BAND-TO-BAND REGISTRATION	VIS/NIR/SWIR/MWIR/LWIR
SPECTRAL RESPONSE	VIS/NIR/SWIR
DIFFUSER STABILITY MONITOR	VIS/NIR

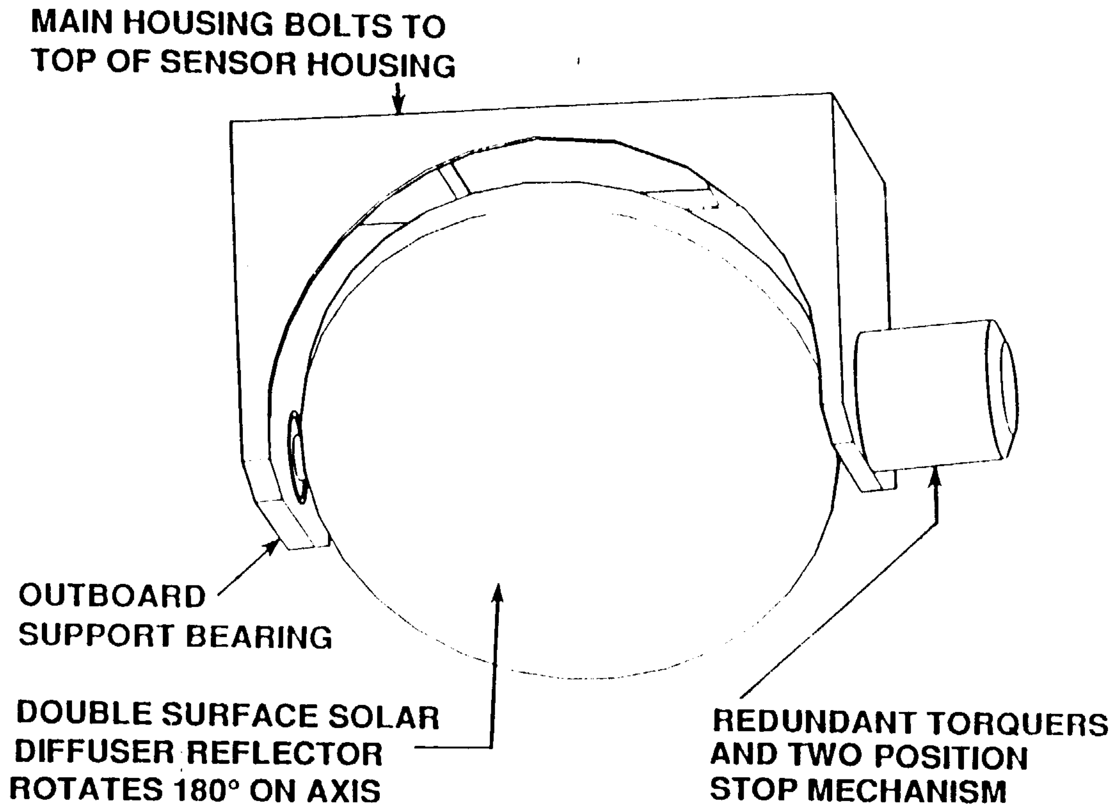
MODIS-N IN-FLIGHT CALIBRATORS

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary



5/91
91-0347-29



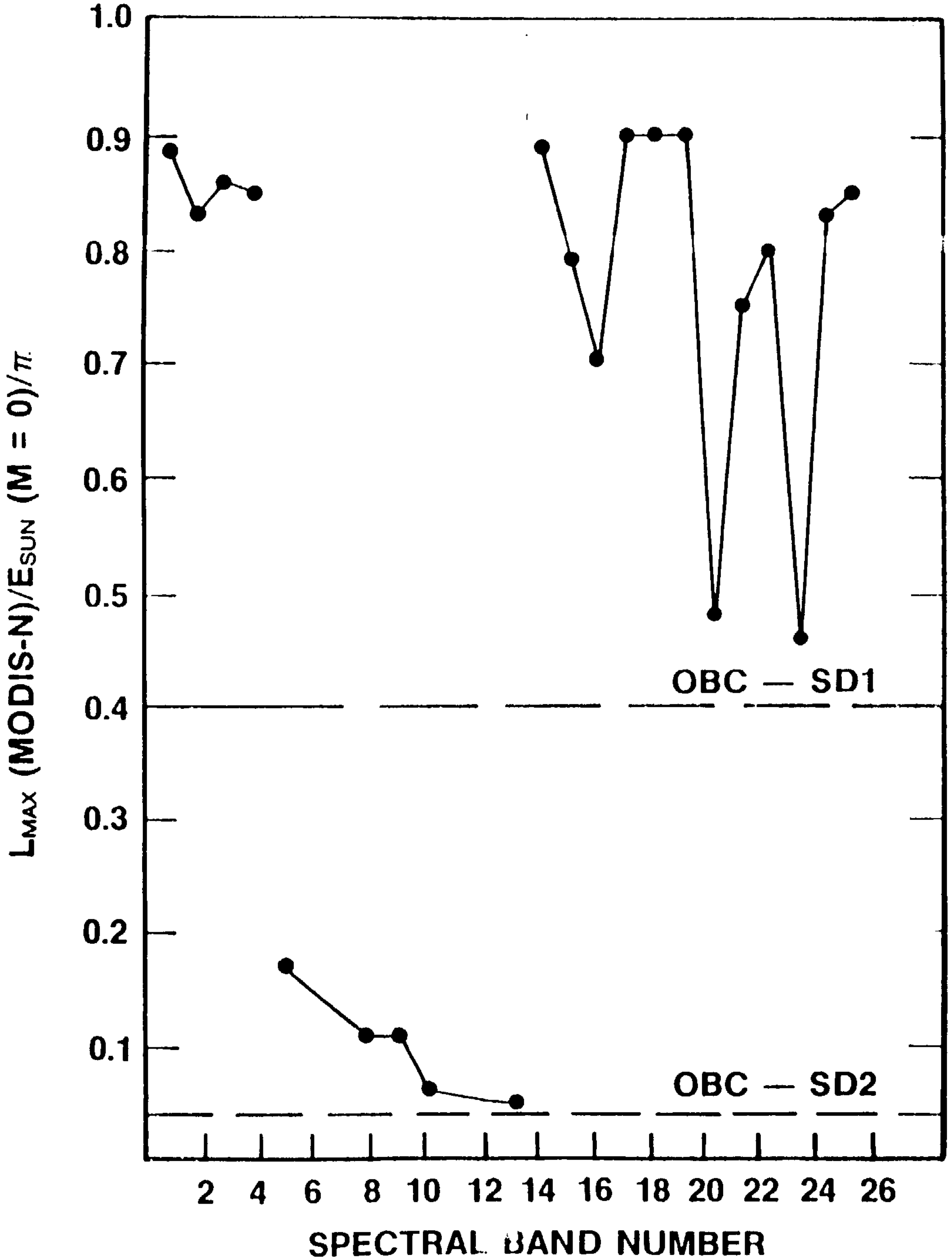
- DOUBLE SIDED
- BRDF's: 0.18/sr, 0.018/sr
- EFFECTIVE ALBEDO: 46%, 4.6%

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

FULL APERTURE SOLAR DIFFUSER PROVIDES ACCURATE AND STABLE RADIOMETRIC CALIBRATION

5/91
91-0343-31

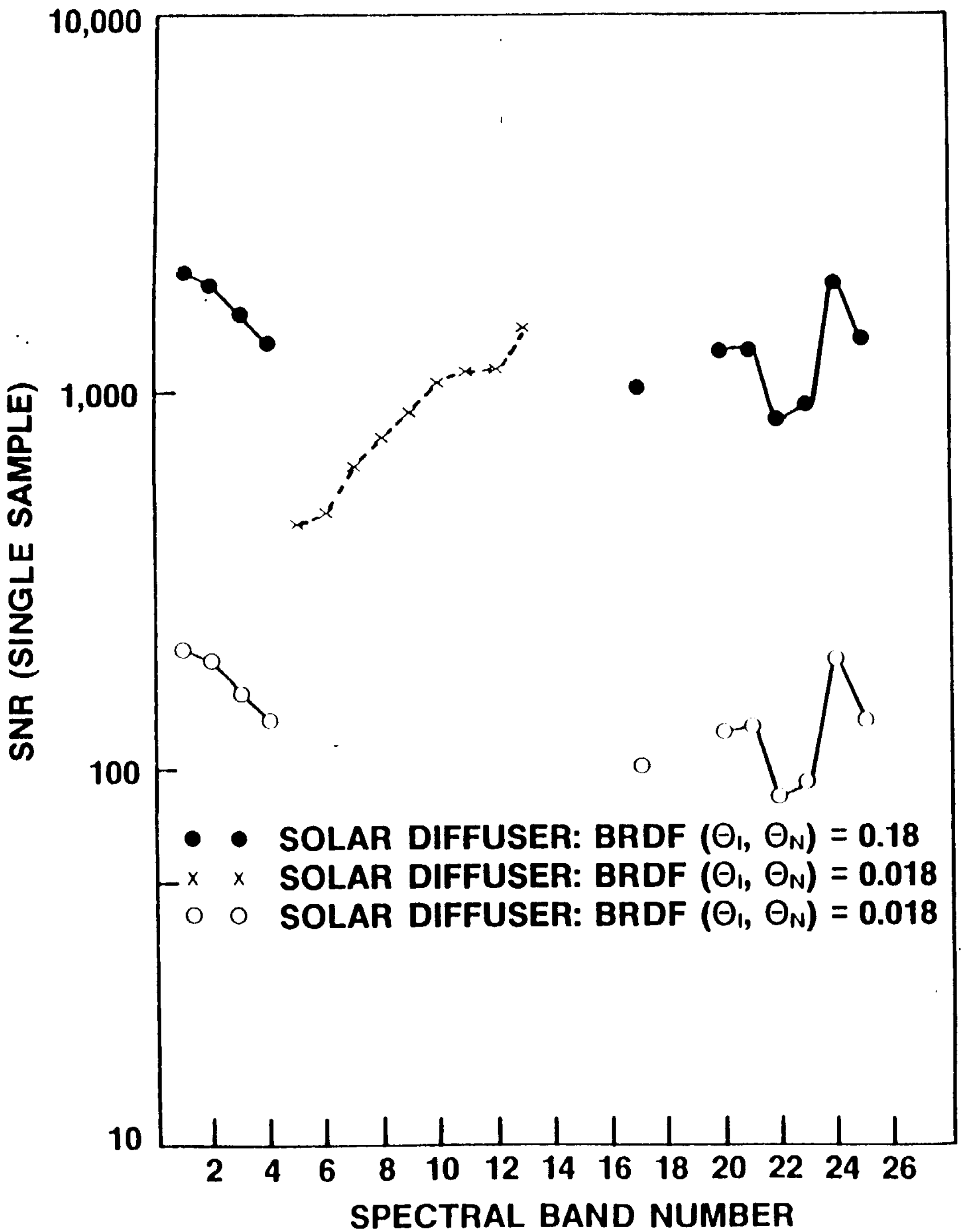


HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

TWO SOLAR DIFFUSERS NEEDED TO MATCH VIS/NIR AND SWIR ALBEDO LEVELS

6/89
90634-86

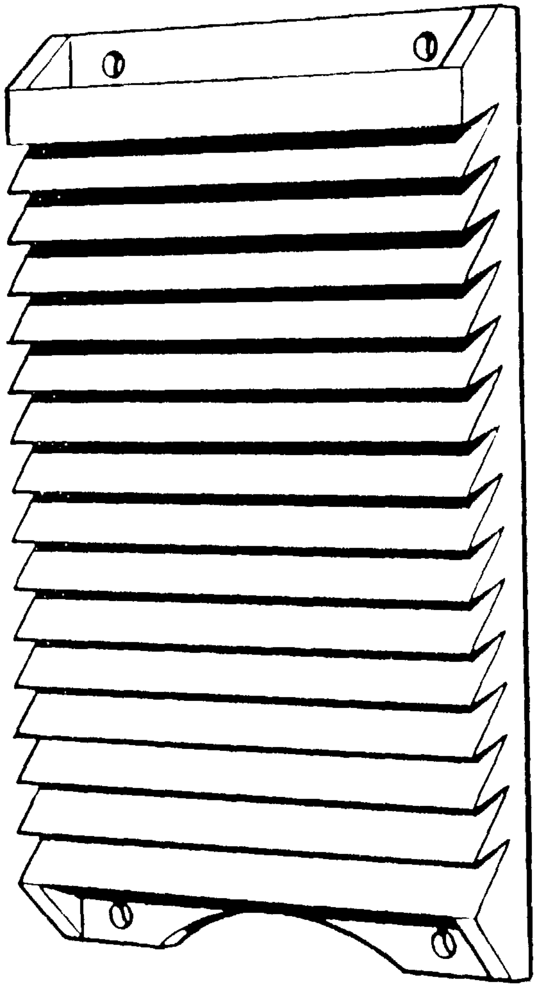


HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

TWO SOLAR DIFFUSERS PERMIT ADEQUATE SNRS FOR RADIOMETRIC CALIBRATION

6/89
90634-89



- 25° V-GROVE HALF ANGLE
- ALUMINUM STRUCTURE
- AMBIENT TEMPERATURE
- EMISSIVITY ≥ 0.992

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

V-GROVE BLACKBODY DESIGN OFFERS HIGH EMISSIVITY

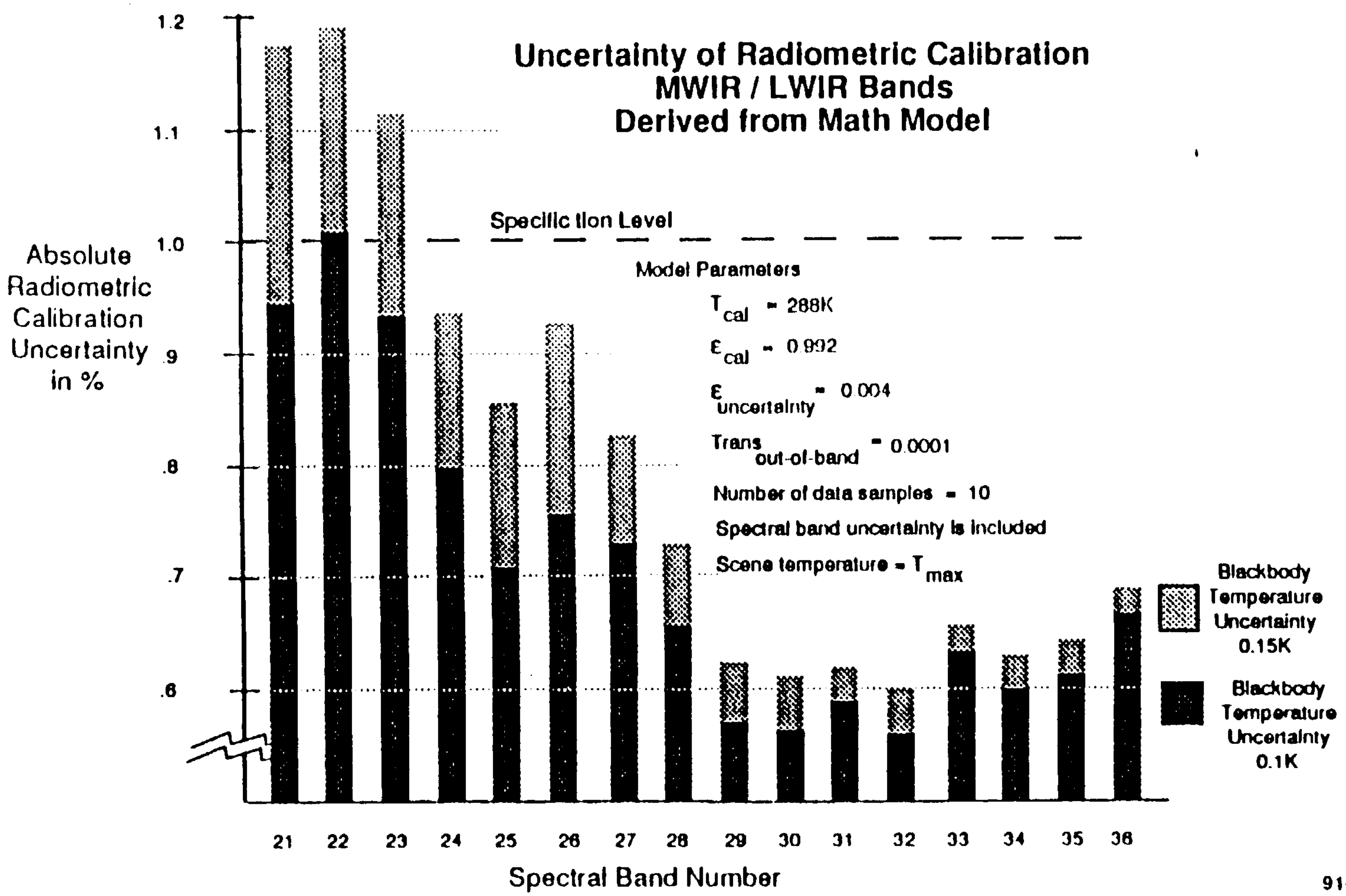
5/91
91-0347-30

ON ORBIT RADIOMETRIC CALIBRATION MODEL FOR MWIR/LWIR

- PARAMETRIC MODELING — MODEL VARIABLES
  - SCENE - TEMPERATURE
  - SENSOR - SPECTRAL SHIFT, OUT OF BAND TRANSMITTANCE, NEΔT
  - OBC-BB - TEMPERATURE AND EMISSIVITY AND THEIR UNCERTAINTY
  - SPURIOUS SOURCES - DIRECT AND INDIRECT SOLAR ILLUMINATION, SENSOR INTERIOR CAVITY EMISSION
- MODEL SNAPSHOT
  - SCENE - NOMINAL TEMPERATURE FOR EACH BAND
  - SENSOR - SPECTRAL SHIFT 0.01 TO 0.05 μm, Toob = 0.001, SOW NEΔT SET
  - OBC-BB - T_{BB} = 320K; ε_{BB} = 0.99
    T_{BB_UNC} = 0.25K; ε_{BB_UNC} = 0.006
  - SPURIOUS SOURCES - NO DIRECT SUNLIGHT: INDIRECT ρ = 0.06 WITH Ω = 1 sr; SENSOR CAVITY: ε = 1.0, T = 300K, Ω = 2 sr
- TEMPERATURE UNCERTAINTY:
  - RSS-0.30K TO 0.56K

ACCURACY PREDICTION FOR MWIR AND LWIR BANDS

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary



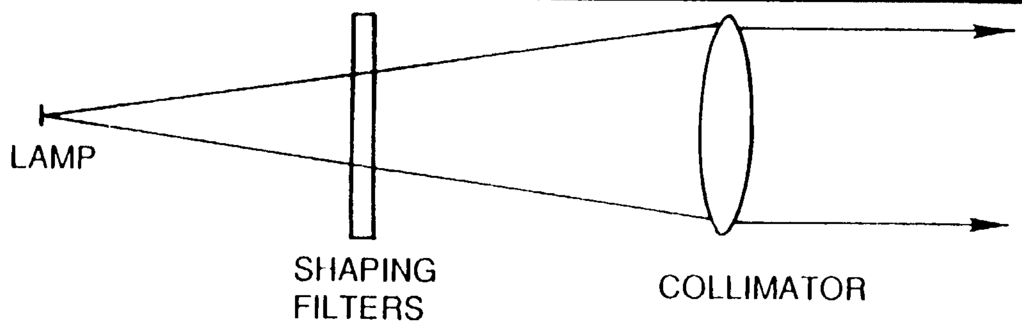
SRCA — PRIMARY FUNCTIONS

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary

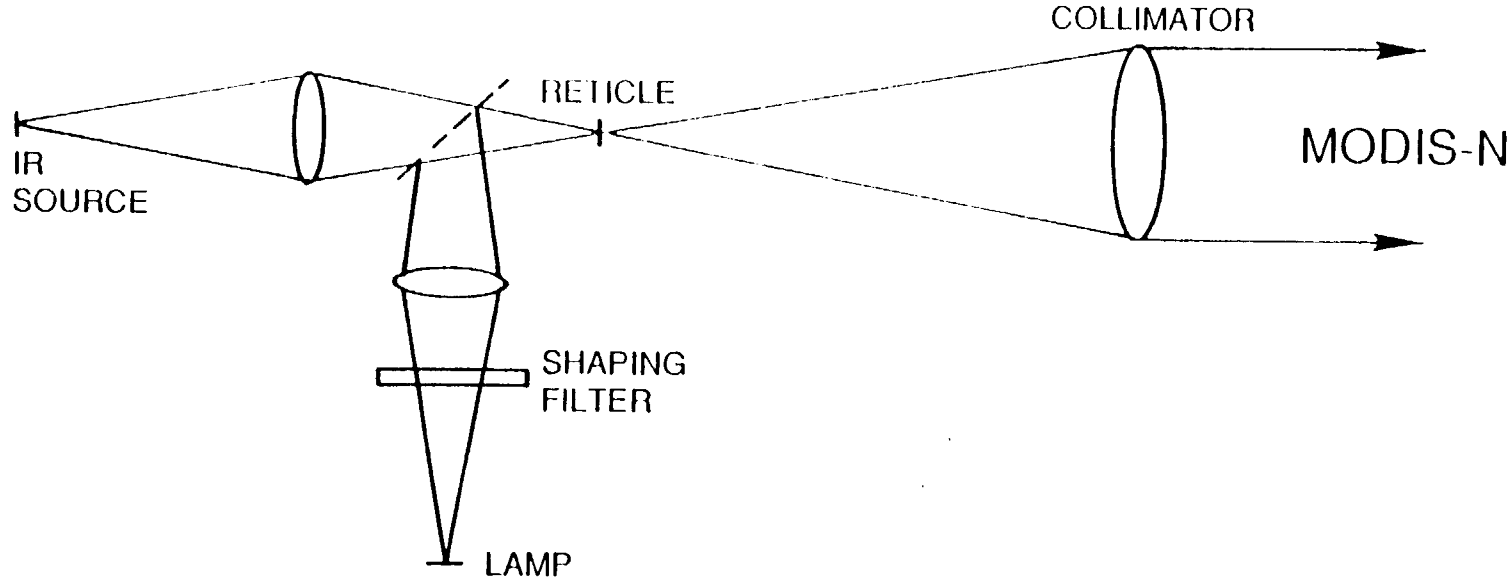
• RADIOMETRIC CALIBRATION CHECK	VIS/NIR/SWIR
• SPATIAL BAND-TO-BAND REGISTRATION	VIS/NIR/SWIR/ MWIR/LWIR
• MONOCHROMATOR SPECTRAL CALIBRATOR	VIS/NIR/SWIR
• SOLAR ILLUMINATED DIFFUSER STABILITY MONITOR	VIS/NIR

7/89
90634-101A

CONCEPTUAL SIMPLICITY OF INDIVIDUAL SRCA FUNCTIONS (1)



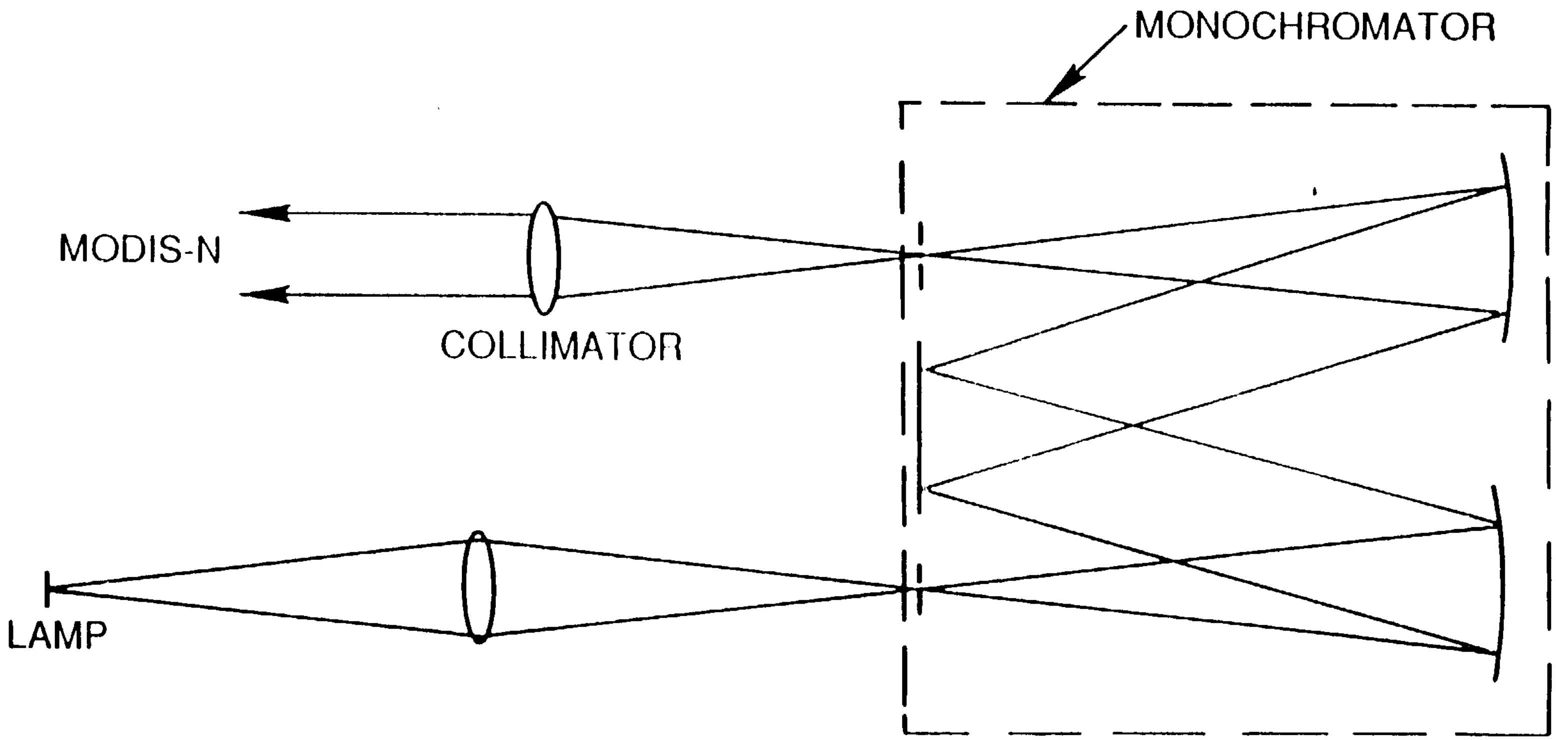
RADIOMETRIC CALIBRATION CHECK



SPATIAL BAND TO BAND REGISTRATION

7/89
90634-101B

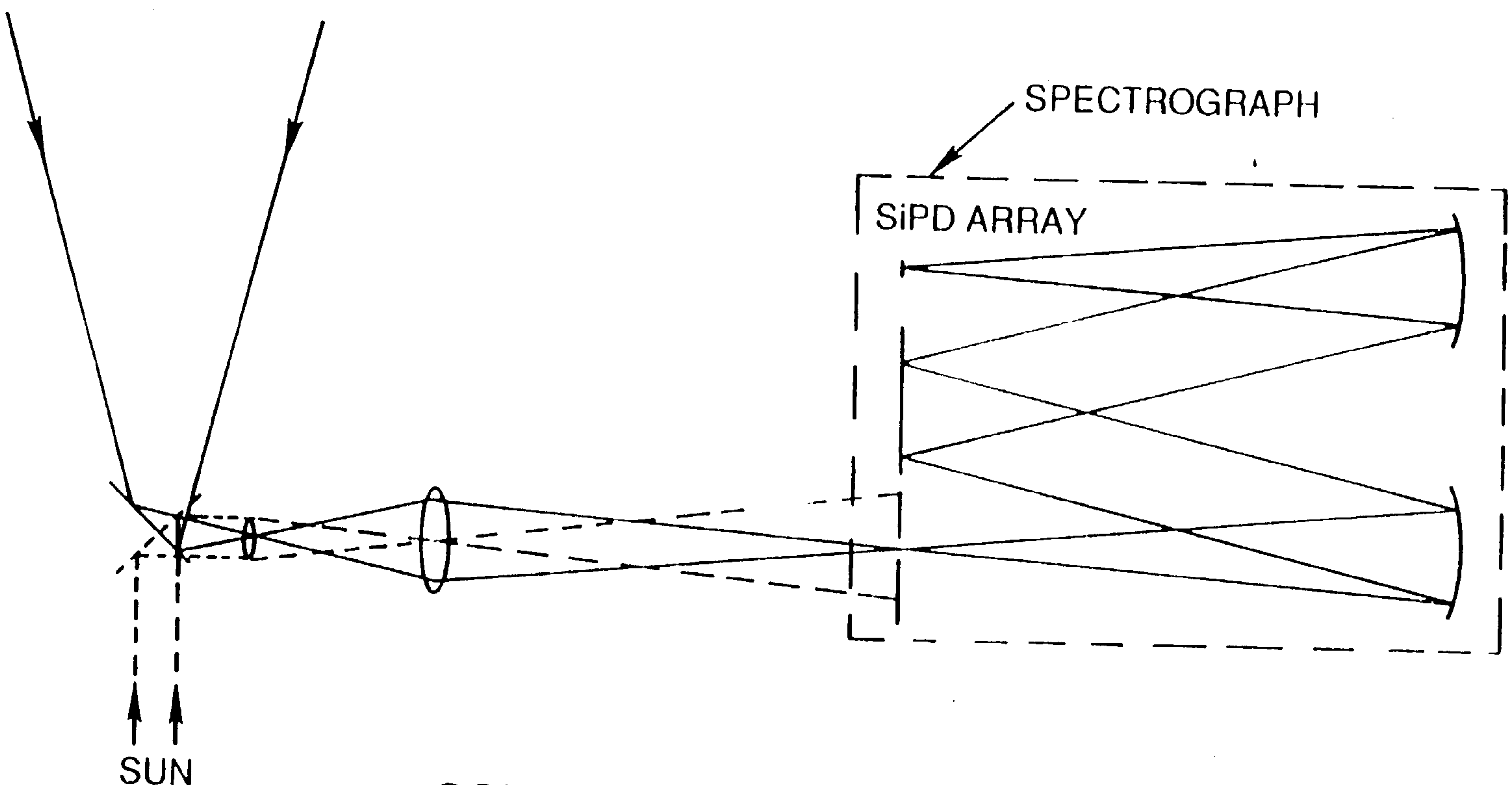
CONCEPTUAL SIMPLICITY OF INDIVIDUAL SRCA FUNCTIONS (2)



MONOCHROMATOR SPECTRAL CALIBRATOR

7/89
90634-101C

CONCEPTUAL SIMPLICITY OF INDIVIDUAL SRCA FUNCTIONS (3)

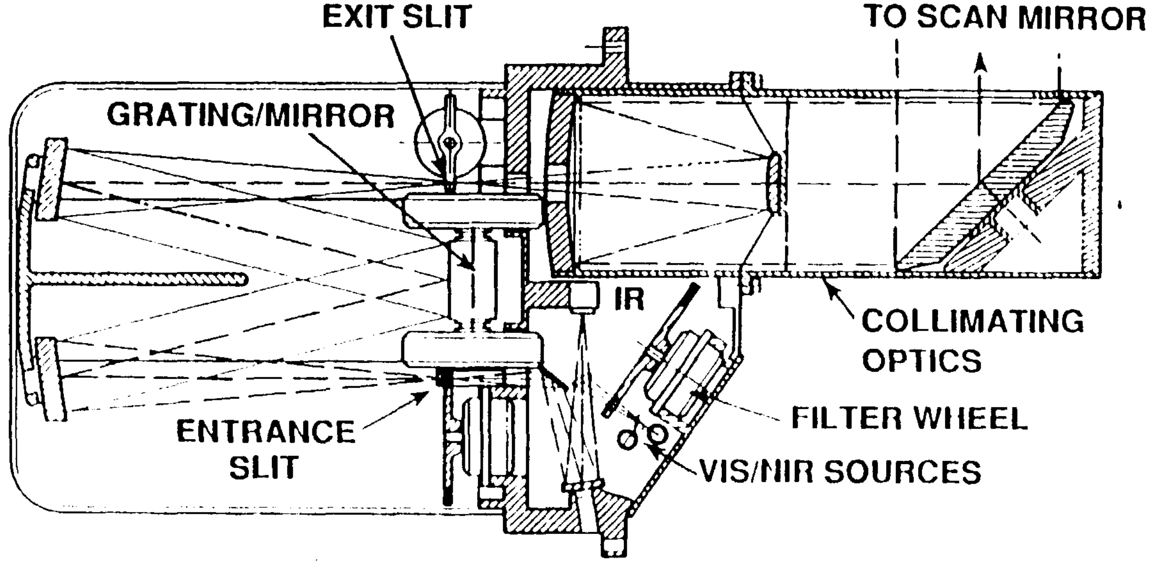


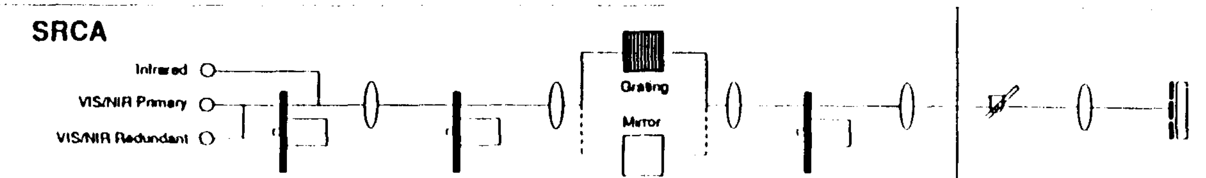
SOLAR DIFFUSER STABILITY MONITOR

7/89
90634-101D

SPECTRORADIOMETRIC CALIBRATION ASSEMBLY (SRCA)

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary



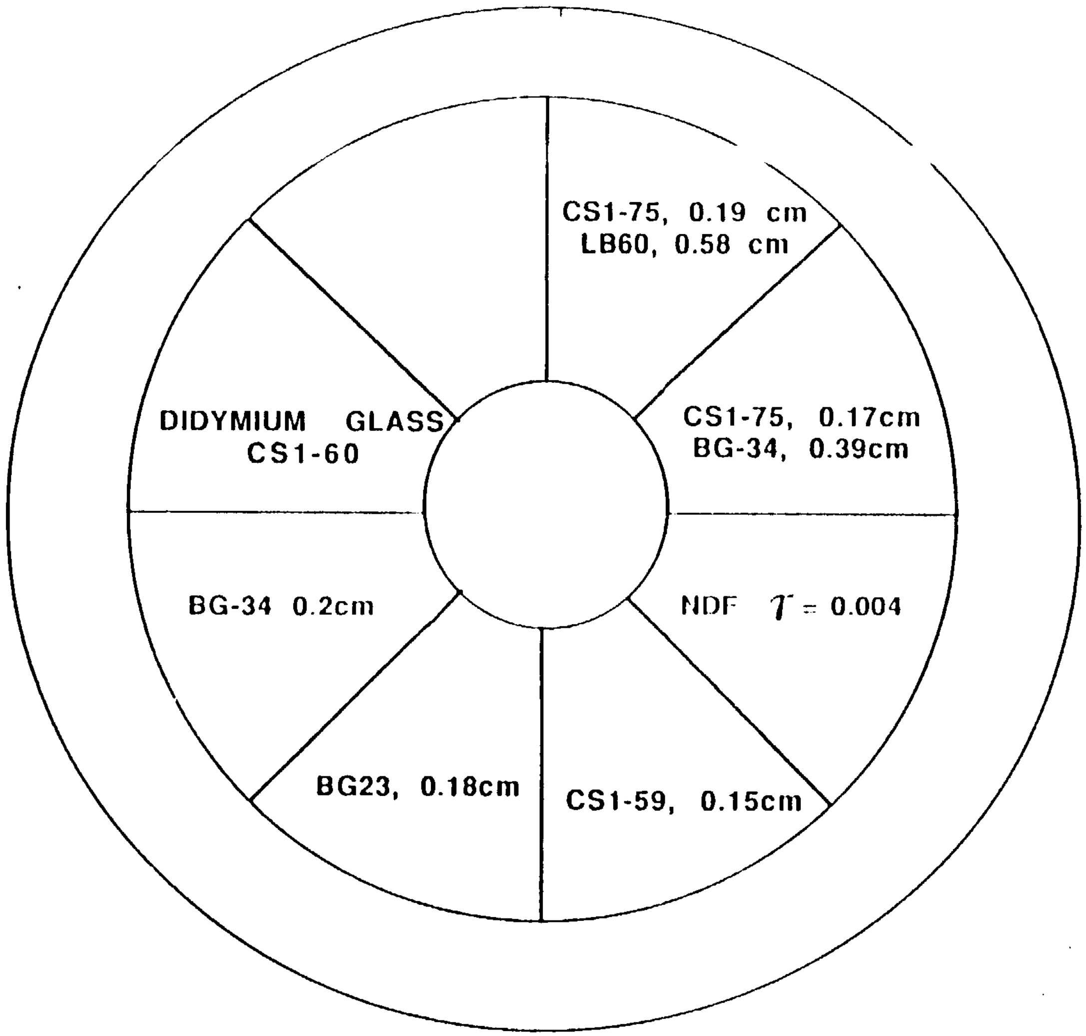


Operating Mode	Sources	Filter Wheel	Relay Optics	Entrance Slit	Collimating Optics	Grating/ Mirror	Focusing Optics	Exit Slit	Collimating Optics	Scan Mirror Assembly	Telescope / Aft Optics	Filters / Detectors
Radiometric Check	VIS/NIR		X	Open	X	Mirror	X	Open	X	X	X	X
Spectral Calibration	VIS/NIR	Spectral Shaping Filters	X	Entrance Slit / Filters	X	Grating	X	Exit Slit / Photodiode	X	X	X	X
Spatial Registration	VIS/NIR & IR		X	Open	X	Mirror	X	Reticle Pattern	X	X	X	X
Self Calibration	VIS/NIR	Didymium Glass	X	Entrance Slit / Filters	X	Grating	X	Photodiode / Exit Slit	X			

5/91
91-0347-33

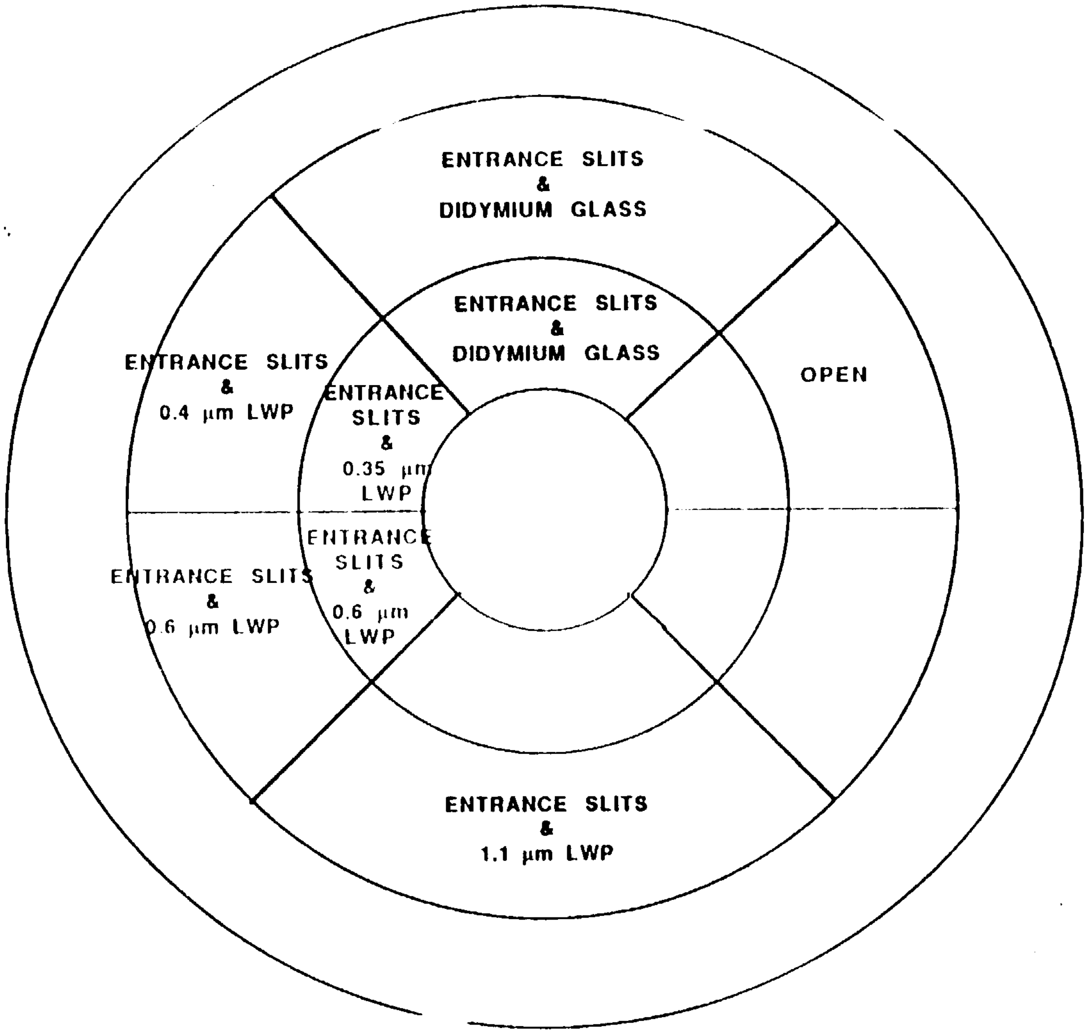
HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary



VIS/NIR/SWIR SOURCE ASSEMBLY- FILTER WHEEL

6/89
90634-88

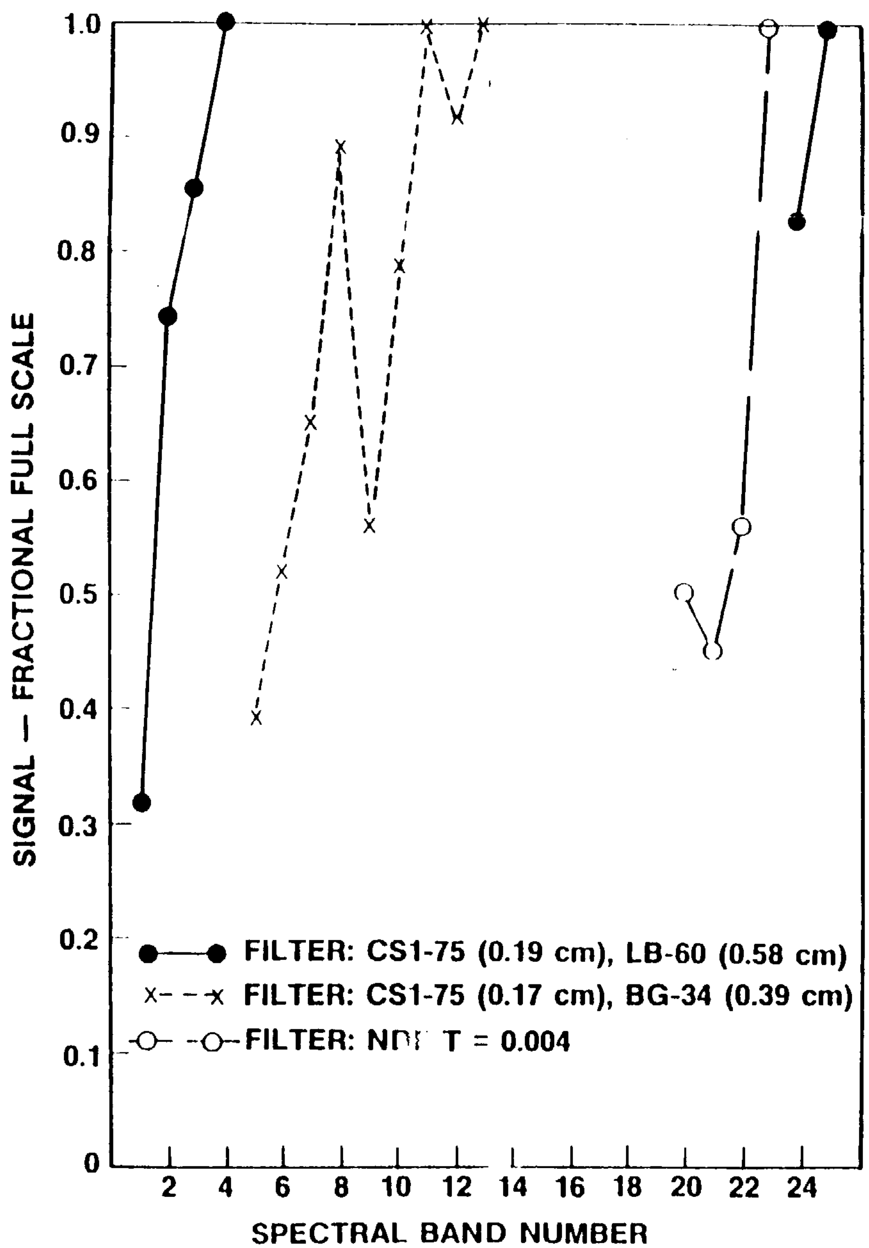


HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

ENTRANCE PLANE MECHANISM

6/89
90634-87

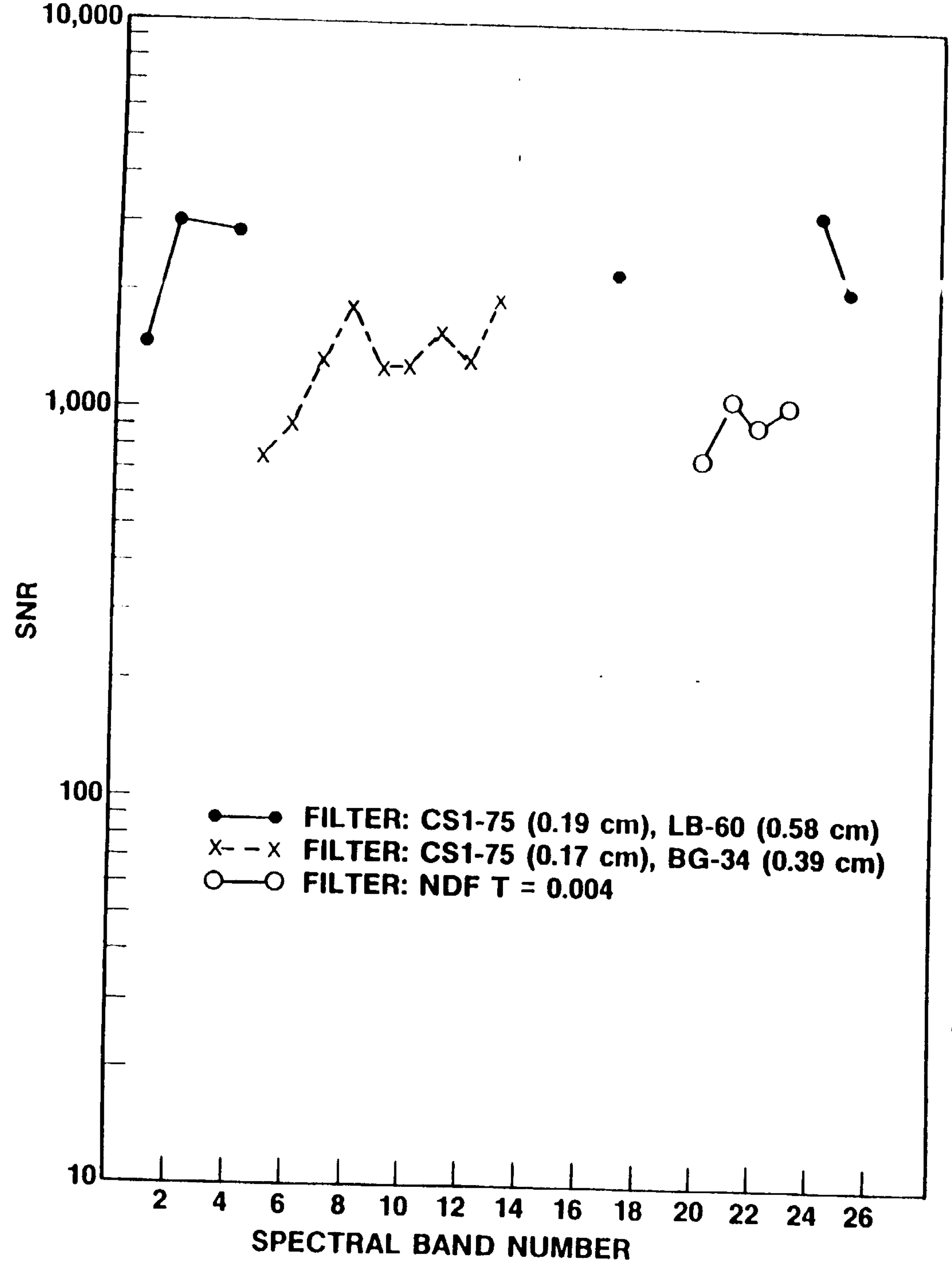


HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

FILTERS SHAPE SRCA RADIANCE FOR ON-BOARD RADIOMETRIC CALIBRATION AND SPATIAL REGISTRATION VIS/NIR/SWIR

6/89
90634-90



HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

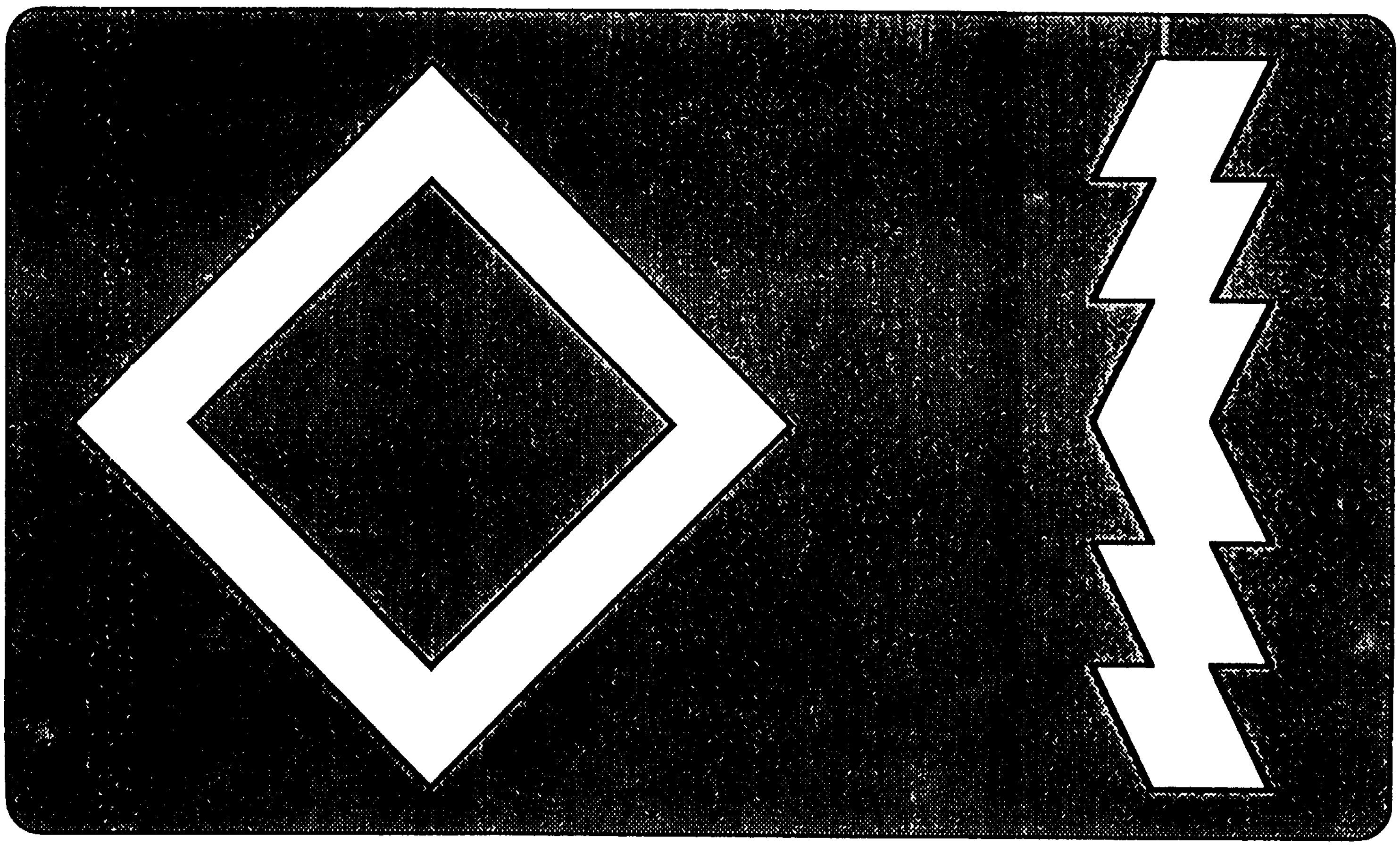
SHAPED RADIANCES YIELD HIGH SNRs FOR CALIBRATION VIS/NIR/SWIR

6/89
90634-91

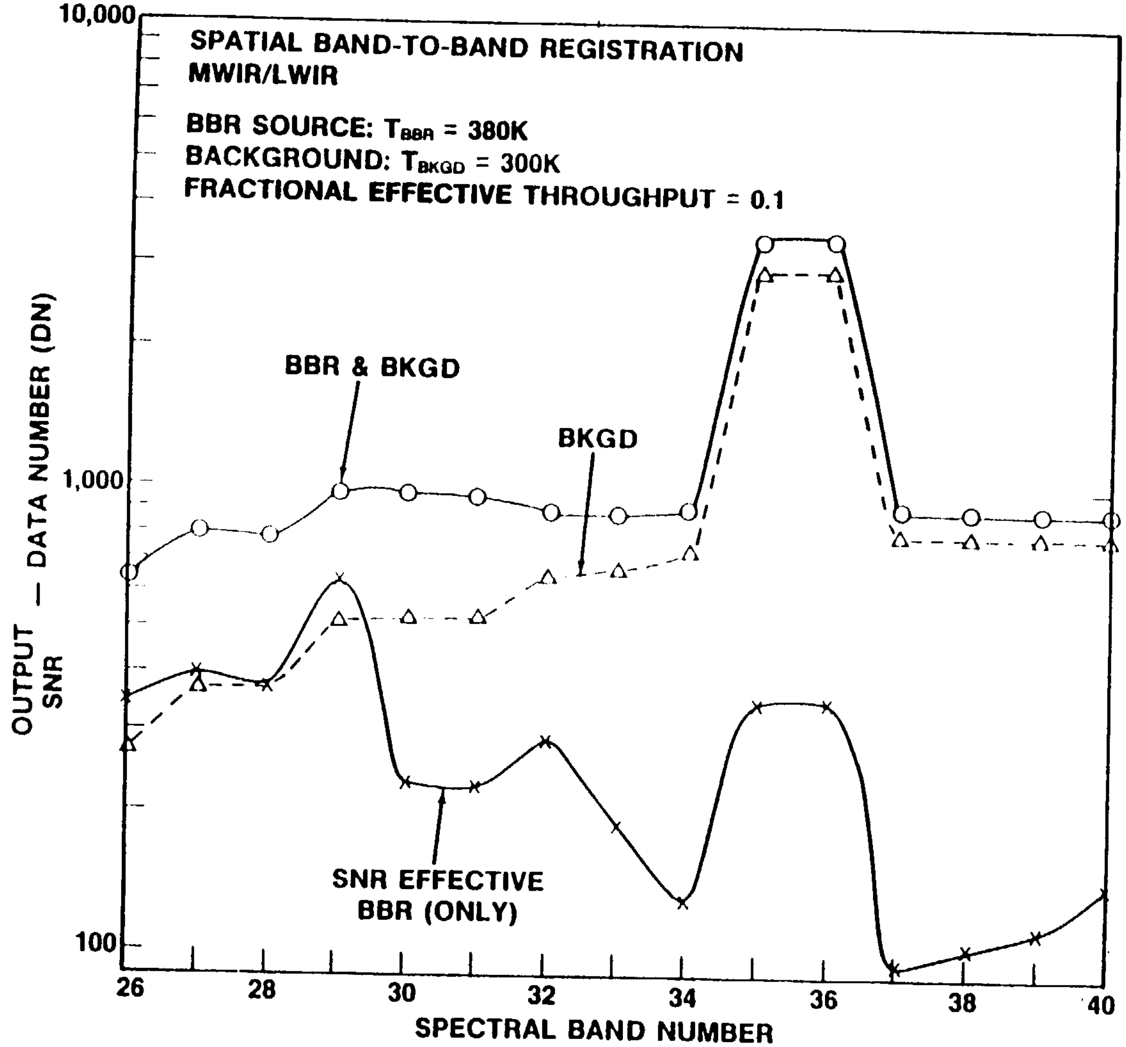
SPATIAL BAND-TO-BAND REGISTRATION RETICLE PATTERN CONCEPTS

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary



7/89
90634-109



HUGHES

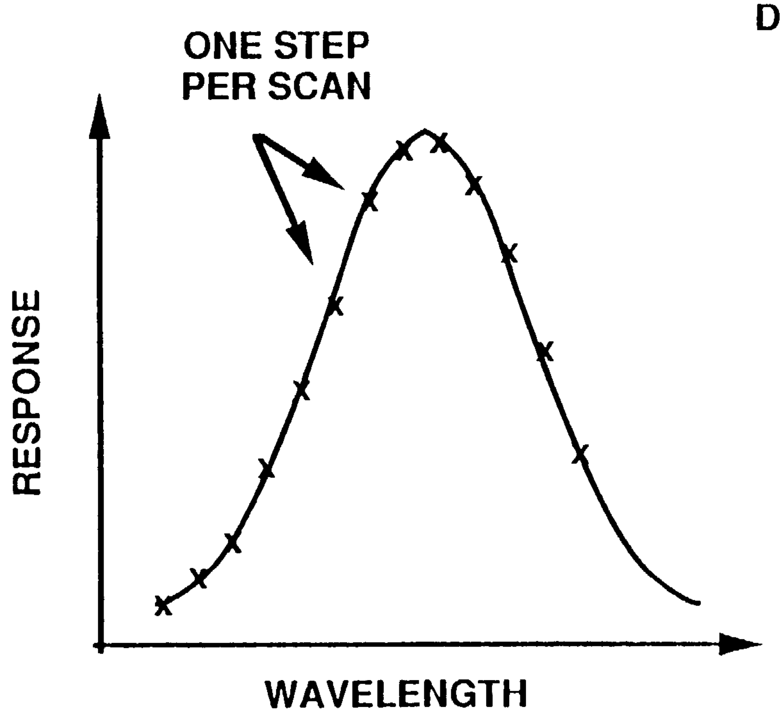
SANTA BARBARA RESEARCH CENTER
a subsidiary

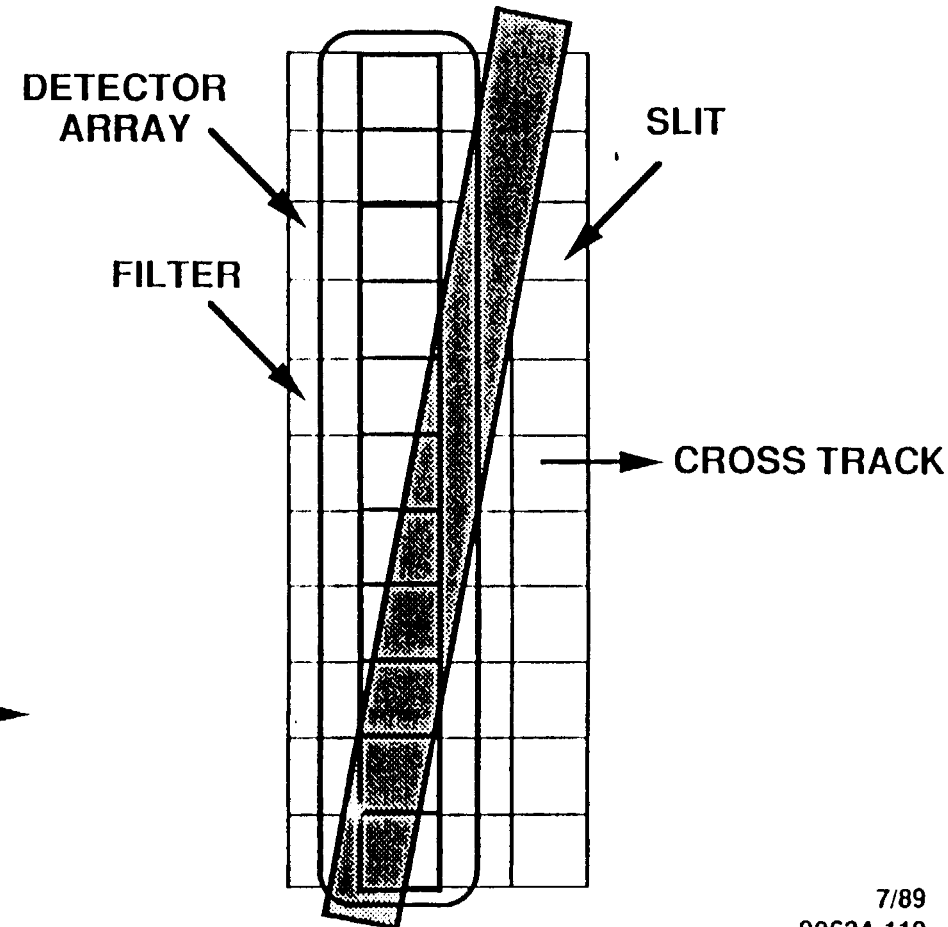
MWIR/LWIR 0.1 PIXEL ON-BOARD REGISTRATION MEASUREMENT ACHIEVABLE

6/89
90634-85

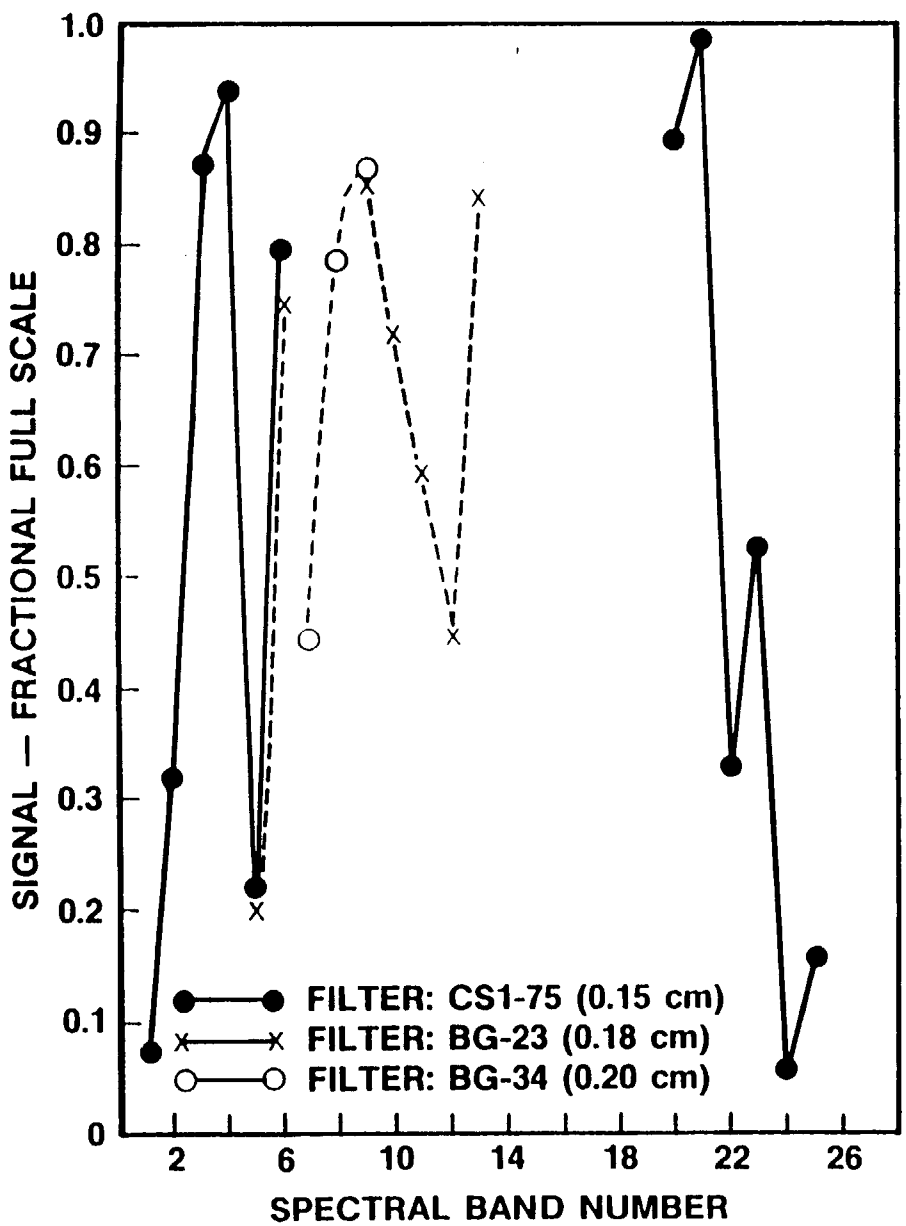
RELATIVE SPECTRAL RESPONSE MEASUREMENT CONCEPT

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary





7/89
90634-110



HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

FILTERS SHAPE SRCA RADIANCE FOR ON-BOARD SPECTRAL CALIBRATION

6/89
90634-92

MODIS-N FAR FIELD RESPONSE MEASUREMENT

HUGHES

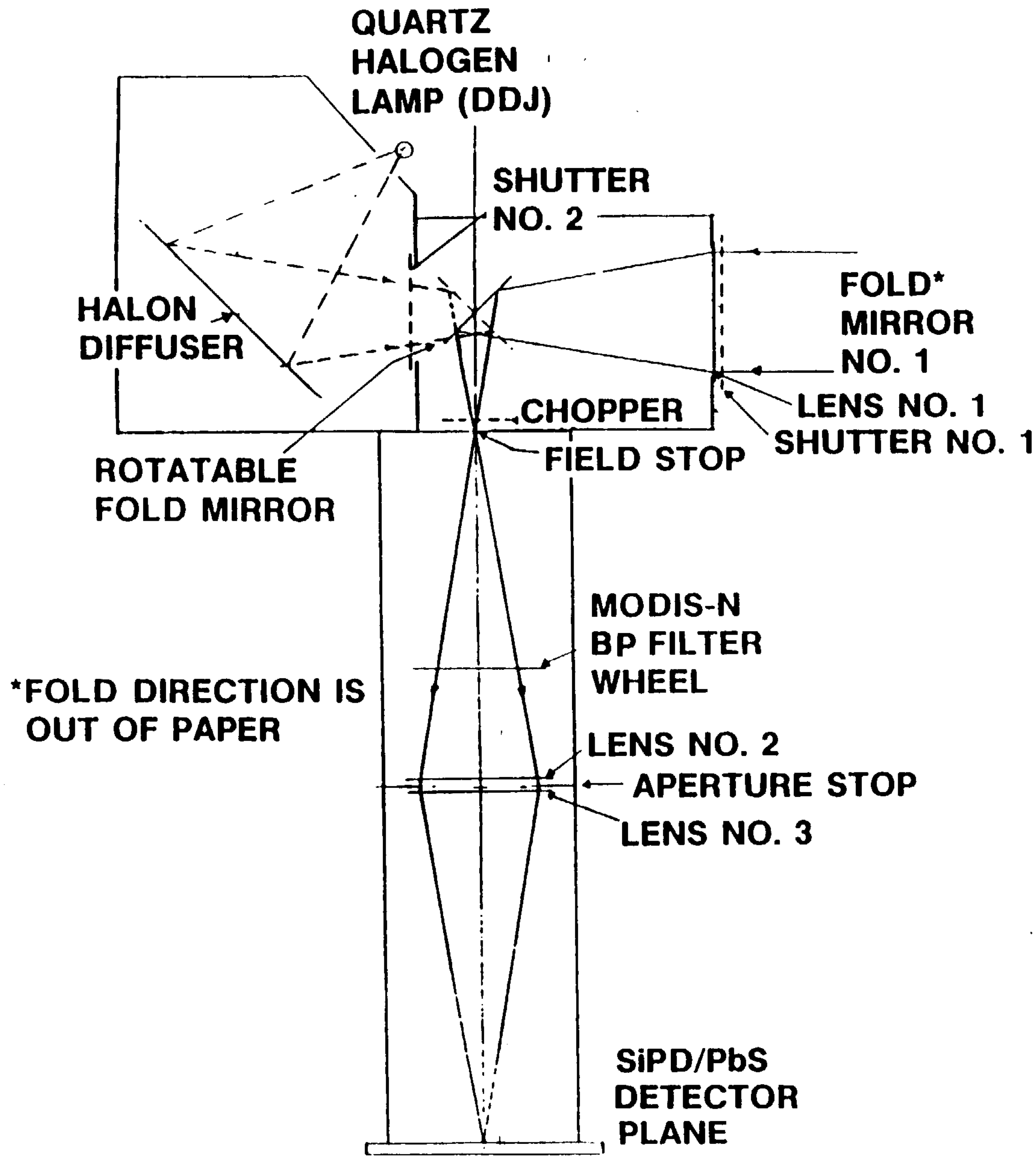
SANTA BARBARA RESEARCH CENTER
a subsidiary

- CALIBRATION SOURCE DOES NOT SIMULATE EARTH (TYPICALLY)
- MODIS-N OPENING (AT APERTURE DOOR) WILL BE DIVIDED INTO THREE SECTIONS
- EARTH SIMULATION IS ATTAINABLE WITH SIS (48)

SUMMARY OF FAR FIELD SPURIOUS RESPONSE CONFIGURATIONS

SOURCE	CONFIGURATION	DISTANCE SOURCE TO MODIS-N	EFFECTIVE SOLID ANGLE (SR)
EARTH	ON ORBIT	705 km	$\Pi \sin^2 (64.2) = 2.55$
SIS (48)	FAR CONDITION	960 INCHES	$\Pi \sin^2 ([Atn(9/960)] = 0.00028$
SIS (48)	NEAR CONDITION	8 INCHES	$\Pi \sin^2 [Atn(9/8)] = 1.75$
SIS (48)	NEAR (IDEAL) CONDITION	4.34 INCHES	$\Pi \sin^2 [Atn(9/4.34)] = 2.55$

- POTENTIAL SCATTERED (REENTRANT) ENERGY CAN CONTAMINATE MEASUREMENT
- SIS (48) RADIANCE MONITOR



HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

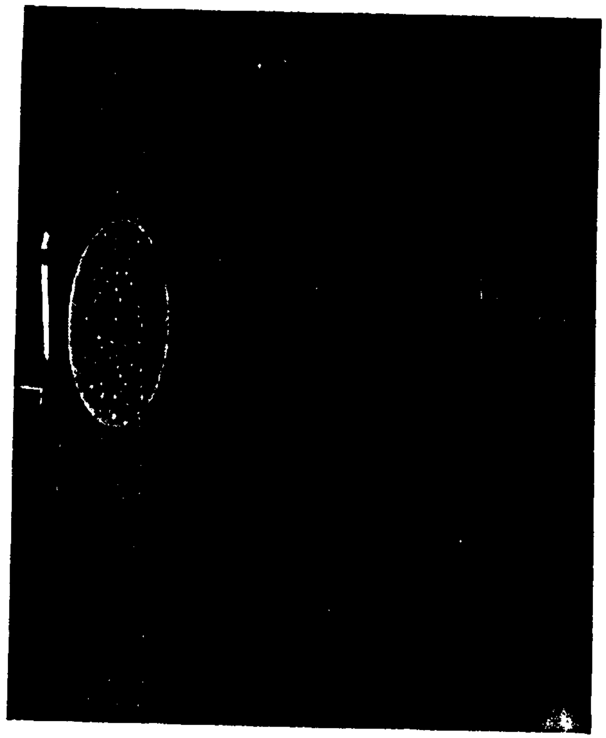
OPTICAL SCHEMATIC OF SIS(48) MONITORING SYSTEM

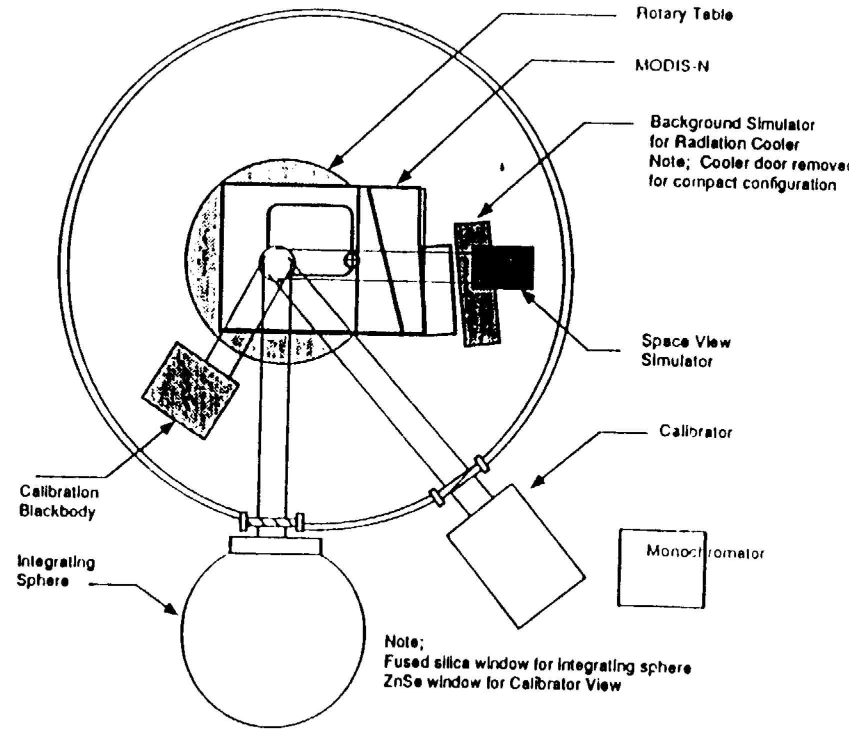
6/89
90634-112G

MODIS-N PRE-FLIGHT CALIBRATION HARDWARE AND TEST EXPERIENCE BASED ON TM

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary





- INTEGRATING SPHERE FOR VIS/NIR/SWIR RADIOMETRIC CALIBRATION
- THERMAL VACUUM CHAMBER TEST CONFIGURATION

5/91
91-0347-37

MODIS-N CALIBRATION UNCERTAINTY ESTIMATE

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

SIS RADIOMETRIC CALIBRATION UNCERTAINTY

Irradiance/radiance standards	0.5%
Transfer to working standard	1.0%
Halon diffuser	0.5%
Monochromator comparator	
Scattered light	1.0%
Wavelength calibration	0.3%
Nonuniform response	1.0%
Geometric factors	1.0%
SIS	
Current control	0.5%
Nonuniformity	0.5%
SNR	
Standard lamp usage	
Orientation	0.3%
Diffuser to lamp	0.5%
Current	0.5%
Linearity	1.5%
RSS total	2.8%

MODIS-N REFLECTANCE BANDS CALIBRATION ACCURACY ESTIMATE

SIS calibration	2.8%
Chamber window	1.0%
SNR	0.5%
Nonuniformity	0.5%
Stray light after correction	1.0%
Polarization	0.5%
Spectral effects	
In-band	0.5%
Out of band	1.0%
RSS total	3.4%
Margin	2.0%
Total	3.9%
Requirement	5.0%

SPECTRAL BAND SHIFTS ARE A MAJOR CONCERN

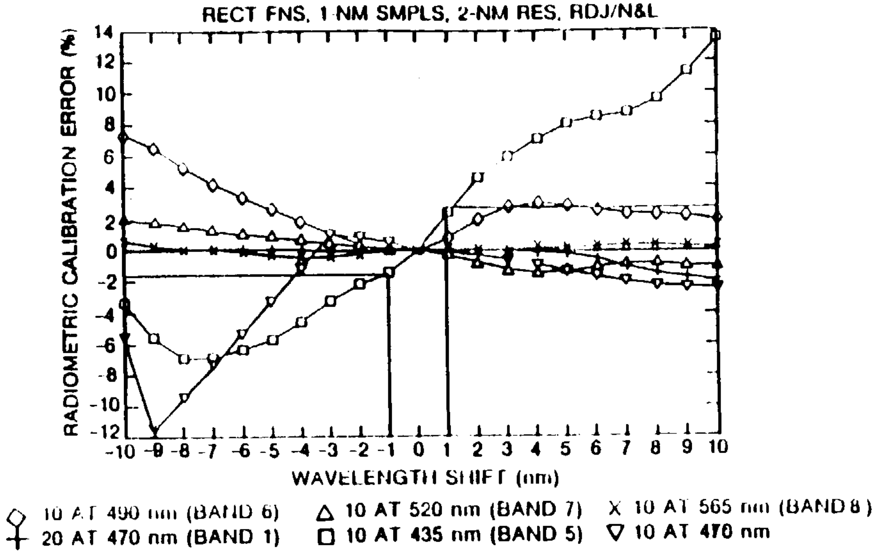
HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary

- PAST INSTRUMENTS
  - MSS BAND 3 LONG WAVELENGTH EDGE SHIFTED 9 nm
  - MSS BANDS HAD RADIOMETRIC CALIBRATION SHIFT FROM -10 TO 12% AIR TO VACUUM
  - SPOT HAS HAD EFFECTS IN 3 TO 27% DOMAIN
  - SPECTRAL PROPERTIES OF BAND PASS FILTERS HAVE BEEN SENSITIVE TO ABSORBED WATER
  - ABSORBED/DESORBED WATER EFFECTS ARE REVERSIBLE WITH VARIABLE TIME CONSTANTS

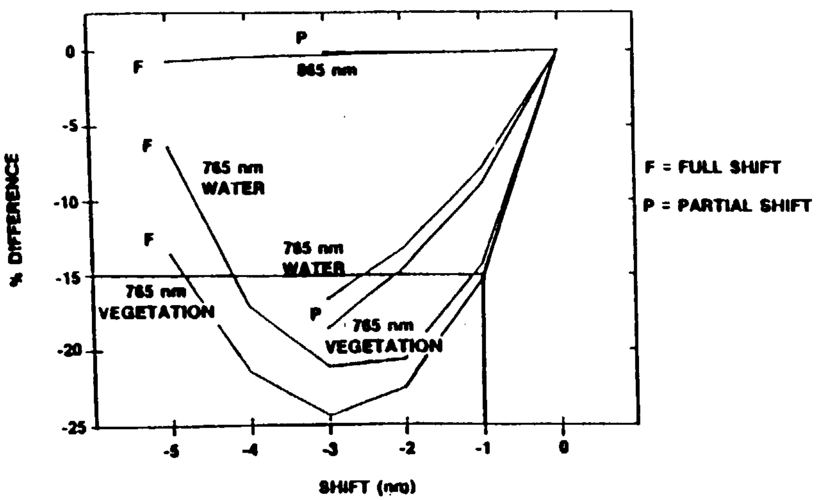
SPECTRAL BAND SHIFTS ARE A MAJOR CONCERN (CONT)

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary

- SOLAR ILLUMINATED DIFFUSER (OBC)
  - SPECTRAL VARIATIONS OF SOLAR IRRADIANCE CAUSED BY FRAUNHOFER LINES
  - VARIATIONS ARE PREDOMINANTLY IN THE REGION OF 0.4 TO 0.68 μm
  - BAND-DEPENDENT WITH VARIATION <0.5% TO 4% FOR 2 nm SHIFT
- EARTH/ATMOSPHERIC SCENES
  - BAND 12 (765 nm) HAS 25% VARIATION OF MODELED REFLECTANCE FOR A 5 nm SHIFT
  - SOME BANDS ARE INSENSITIVE TO SHIFTS



RADIOMETRIC ERROR ASSOCIATED WITH SOLAR SPECTRAL STRUCTURE



RADIOMETRIC ERROR ASSOCIATED WITH GROUND SPECTRAL SIGNATURES

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

RADIOMETRIC ERROR ASSOCIATED WITH SPECTRAL SIGNATURES

9/91
91-0742-1

MODIS-N SPECTRAL SHIFTS AND THEIR EFFECTS WILL BE MINIMIZED

- MINIMIZING THE EFFECTS OF SPECTRAL SHIFTS WILL BE DONE VIA A MULTIPLE APPROACH
- STATE OF THE ART OPTICAL FILTERS WILL BE MANUFACTURED TO MINIMIZE SPECTRAL INSTABILITY : $\Delta\lambda < 2$ nm
- OBC SRCA WILL BE USED TO CHARACTERIZE MODIS-N SPECTRAL BANDS (λ <1.0 μm) SHIFTS ON ORBIT
- SPECTRAL BANDS (λ > 1.0 μm) WILL NOT BE CHARACTERIZED ON ORBIT
  - Optical filters sealed in vacuum detector dewar
    - Filters not subjected to air-vacuum cycling
    - Detector - filter combination is well temperature controlled
- SOLAR ILLUMINATED DIFFUSER WILL BE USED TO CALIBRATE MODIS-N REFLECTANCE BANDS ON ORBIT

OBC — DIFFUSER SELECTION CRITERIA

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

BRDF:	0.18 sr^{-1} AND 0.018 sr^{-1}
STABILITY:	EFFECTS OF RADIATION BELTS EFFECTS OF SOLAR ULTRAVIOLET IRRADIATION EFFECTS OF CONTAMINATION
DURABILITY:	LAUNCH VIBRATION AND SHOCK LOADS
POLARIZATION:	DEGREE OF POLARIZATION FOR REFLECTED COMPONENT
CANDIDATE MATERIALS:	HALON WITH CARBON FILLER CROSSED CYLINDRICAL LENS REFLECTOR ARRAYS WITH EVAPORATED NDF LAYERS GROUND METAL SURFACES WITH EVAPORATED THIN FILMS OVERCOAT YB 71 WHITE PAINT
PRELIMINARY SELECTION:	YB 71 WHITE PAINT

9/91
91-0742-5

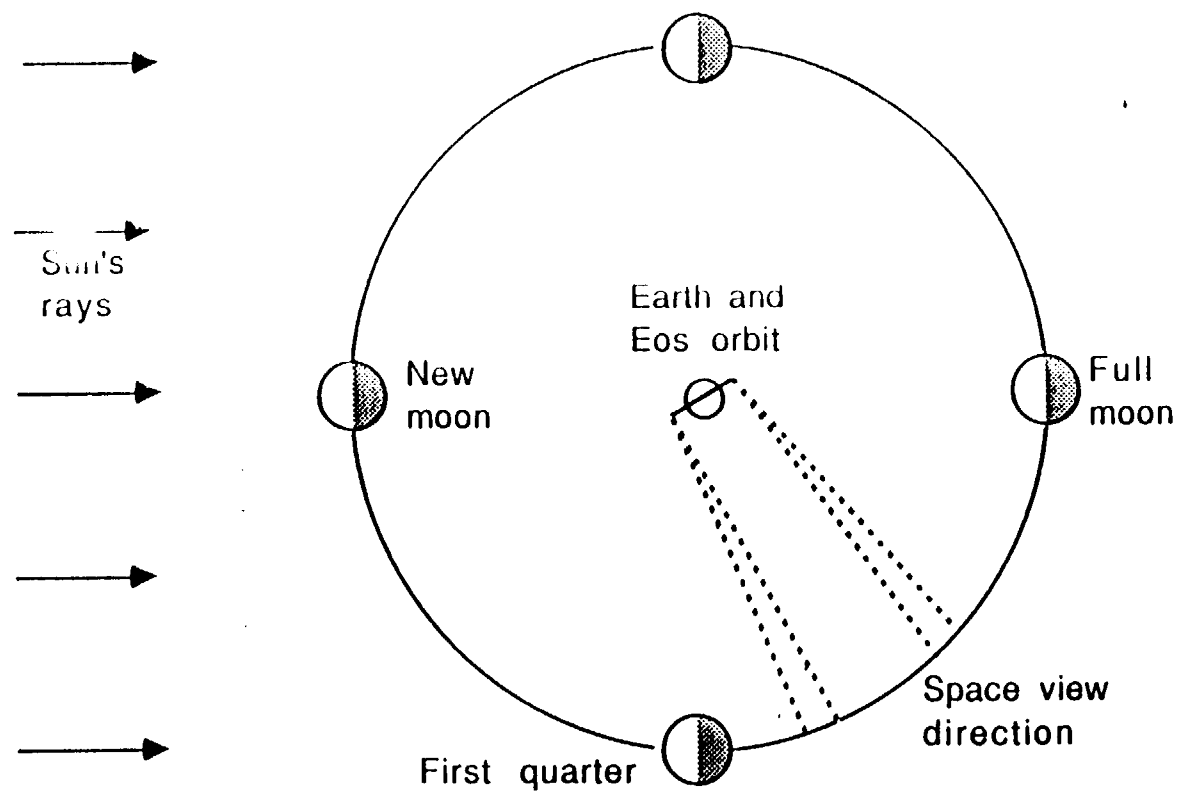
LUNAR VIEW AVAILABLE THROUGH SPACE-VIEW PORT

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary

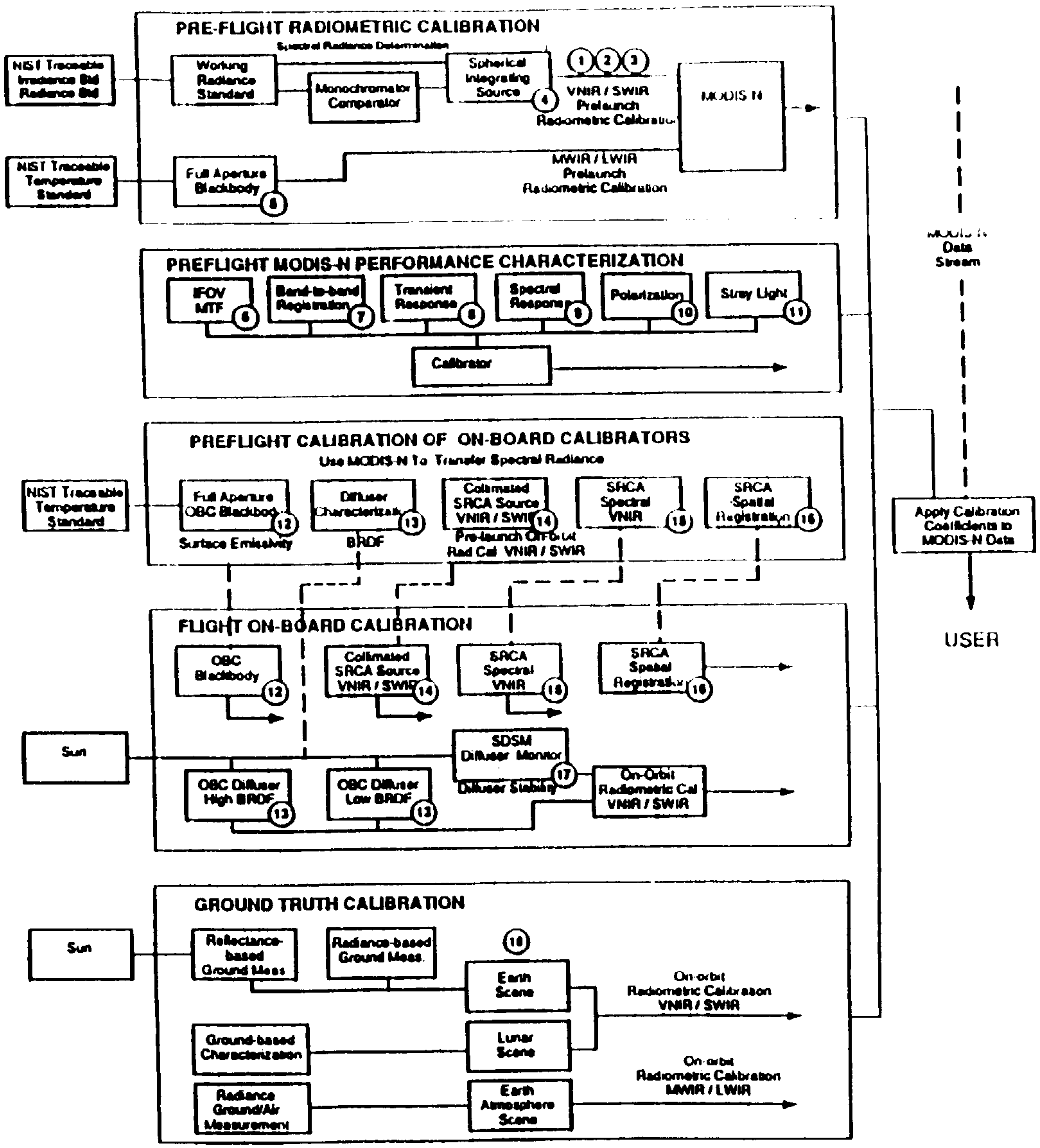
- THE MOON IS VISIBLE AT PREDICTABLE TIMES THROUGH THE MODIS-N DC-RESTORE SPACE-VIEW PORT
- SIMPLE ELECTRONIC GATING WILL PREVENT LUNAR INTERFERENCE WITH DC RESTORE FUNCTION AND ALLOW ACQUISITION OF LUNAR RADIANCE DATA FOR CALIBRATION STABILITY CHECKS
- LUNAR VIEWING CONDITIONS:
    - MOON PHASE WILL BE BETWEEN FIRST QUARTER AND FULL
    - MOON VISIBLE IN SPACE-VIEW PORT 4 - 6 TIMES PER YEAR, NOT AT EVEN INTERVALS
    - WHEN IN VIEW, MOON VISIBLE APPROXIMATELY A DAY FOR PART OF EACH ORBIT
    - MOON SAMPLED 5 TO 20 TIMES EACH SCAN

GEOMETRY FOR LUNAR VIEW THROUGH SPACE PORT

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary



7/89
90634-HF



MODIS-N CALIBRATION MANAGEMENT PLAN BLOCK DIAGRAM COVERING PREFLIGHT AND ON-ORBIT ACTIVITIES INCLUDING MATH MODEL INDEX

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

MODIS-N CALIBRATION MANAGEMENT PLAN

9/91
91-0742-4

Model	Purpose	Model Number
Transfer spectral radiance/irradiance to spherical integrator source (SIS) via monochromator comparator – multiple methodologies	Source calibration, VIS/NIR/SWIR	1a, 2a, 3a 1b, 2b, 3b
SIS – MODIS-N	Instrument calibration, VIS/NIR/SWIR	4a, 4b
Full aperture blackbody – MODIS-N	Instrument calibration, MWIR/LWIR	5
MTF/IFOV – calibrator (phased reticles) – MODIS-N	Instrument characterization, all bands	6
Band-to-band registration – calibrator and phased reticle (CT/AT) – MODIS-N	Instrument characterization, all bands	7
Transient response – calibrator – MODIS-N	Instrument characterization, all bands	8
Spectral response – monochromator – MODIS-N	Instrument characterization, all bands	9
Polarization – calibrator – MODIS-N	Instrument characterization, all bands	10
Stray light response/calibrator/SIS/large aperture IR source – MODIS-N	Instrument characterization, all bands	11a, 11b
OBC blackbody – MODIS-N	Instrument calibration, MWIR/LWIR	12
OBC diffuser calibration	BRDF 0.4-2.40 µm, angle	13a
OBC solar-illuminated diffuser – MODIS-N	Instrument calibration, VIS/NIR/SWIR	13b
SRCA – filtered incandescent source – MODIS-N	Calibration transfer, VIS/NIR/SWIR	14a
SRCA – filtered incandescent source – MODIS-N	Instrument calibration check, VIS/NIR/SWIR	14b
Wavelength calibration – SRCA monochromator	λ calibration, VIS/NIR	15a
Spectral response – SRCA – MODIS-N	Instrument characterization, VIS/NIR	15b
Band-to-band spatial registration – OBC SRCA – MODIS-N	Instrument characterization, all bands	16
Diffuser – sun – solar illuminated diffuser stability monitor	Diffuser stability check, 0.43-0.90 µm	17
Ground truth – Earth/lunar/atmosphere – MODIS-N – several major models	Instrument calibration	18

HUGHES

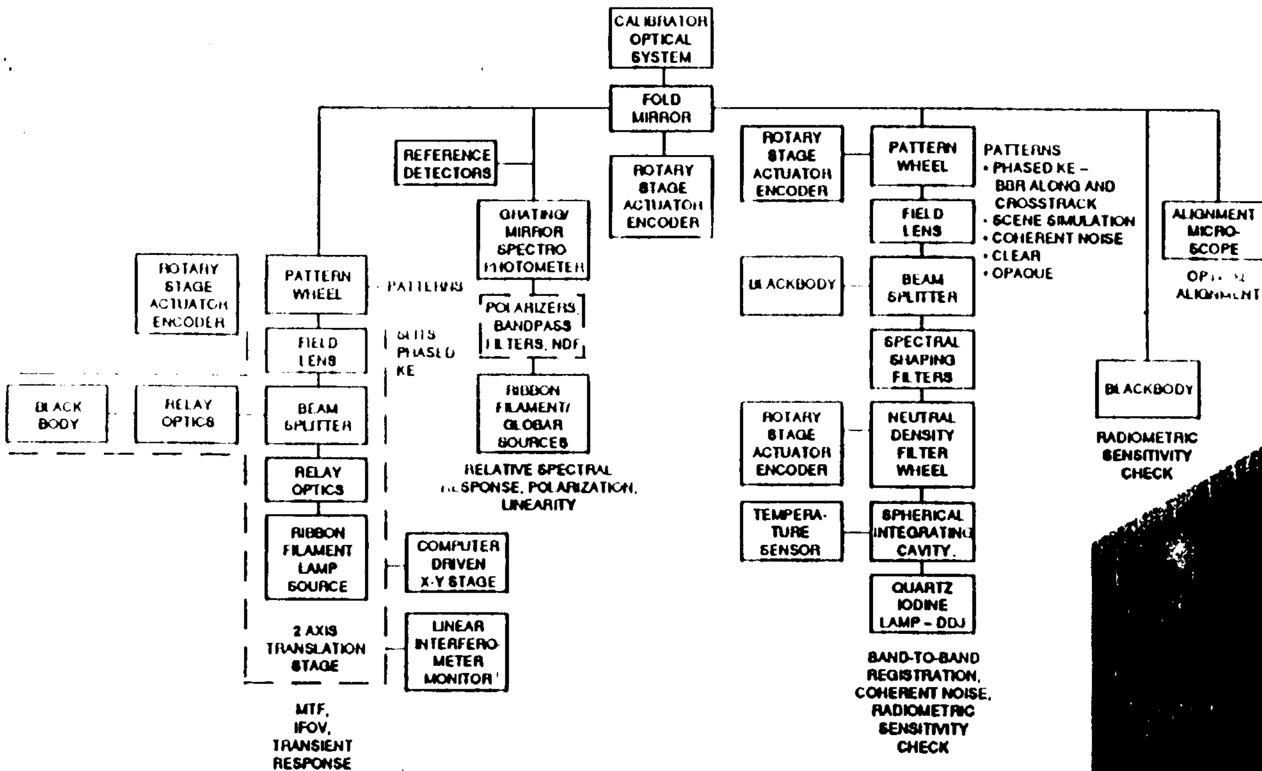
SANTA BARBARA RESEARCH CENTER
a subsidiary

PERFORMANCE CHARACTERIZATION AND CALIBRATION MATH MODEL

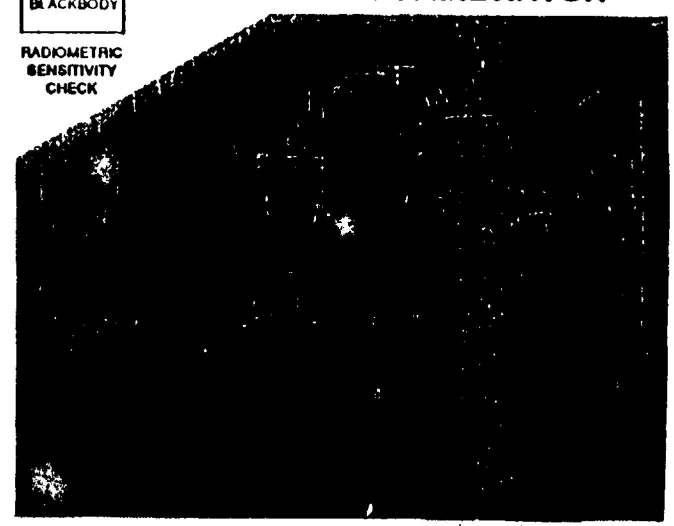
9/91
91-0742-3

MODIS-N CALIBRATOR WILL BE USED TO CONDUCT A BATTERY OF TESTS

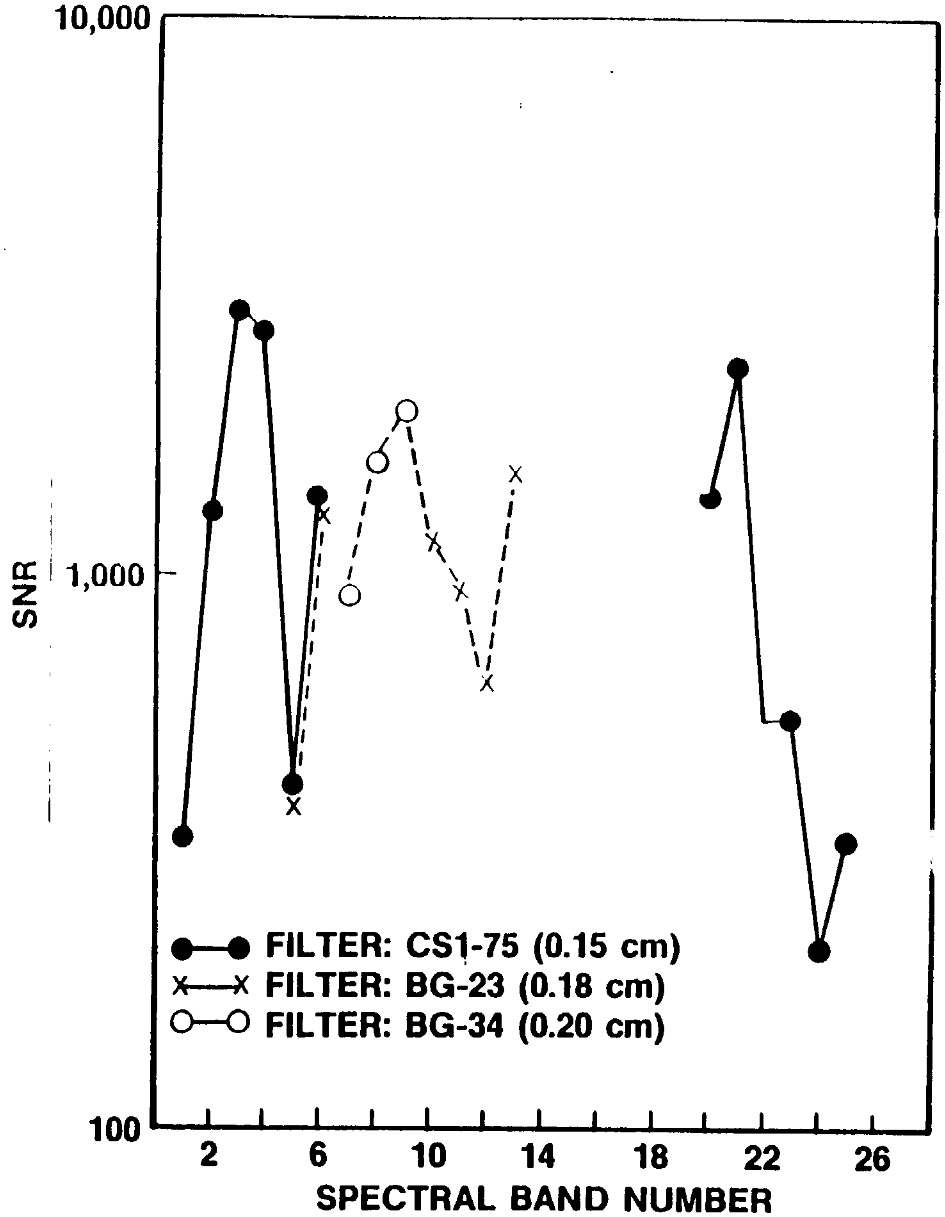
HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary



TM CALIBRATOR



5/91
91-0347-36



HUGHES

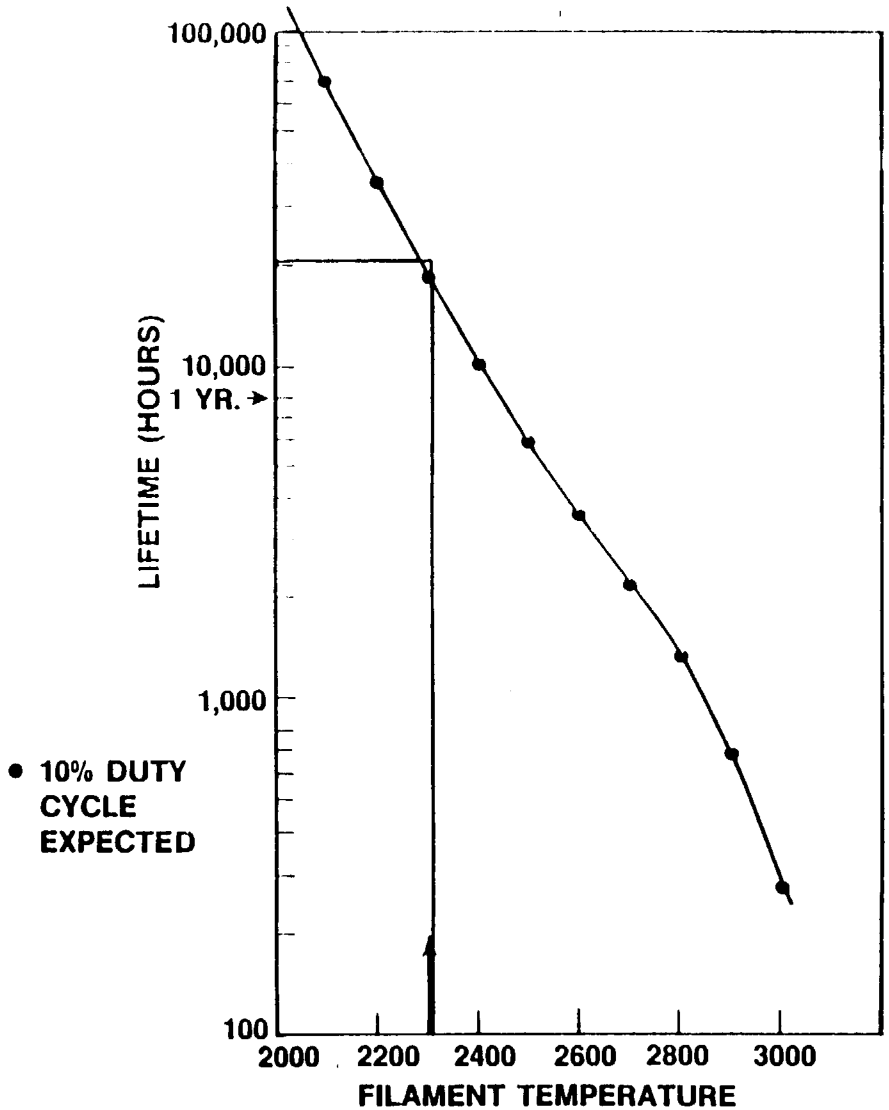
SANTA BARBARA RESEARCH CENTER

a subsidiary

SHAPED RADIANCES YIELD HIGH SNRs FOR SPECTRAL CALIBRATION

6/89

90634-93

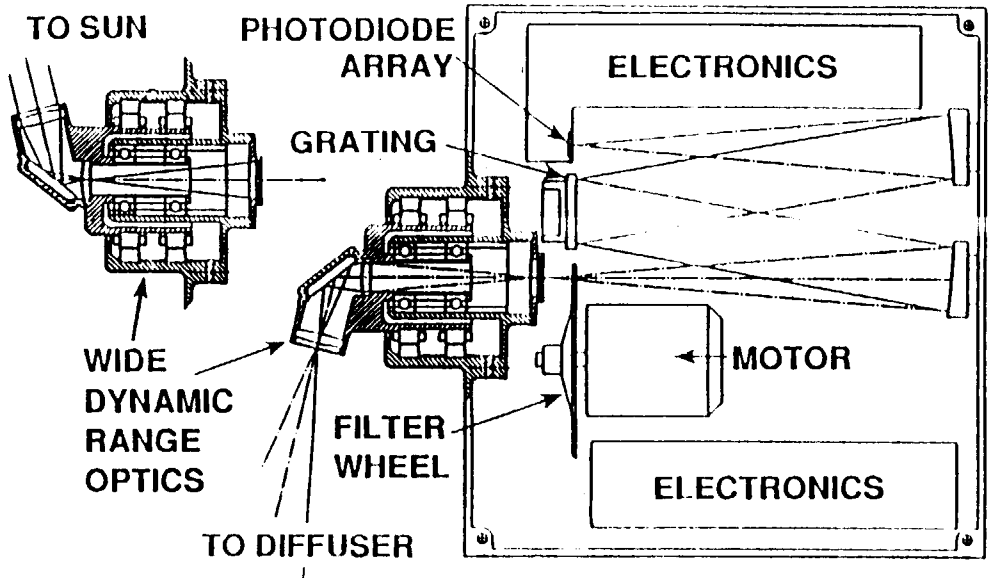


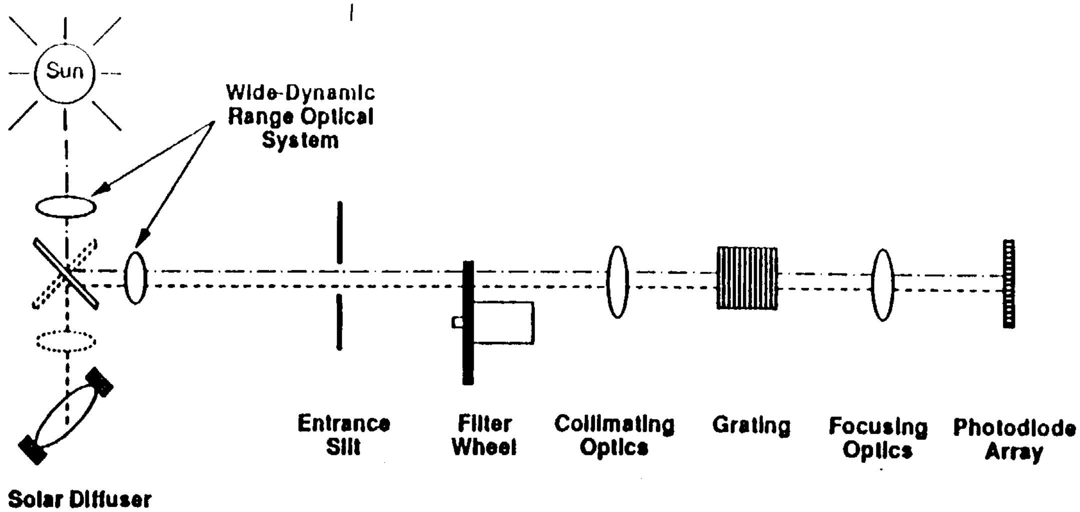
HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

INCANDESCENT SOURCE EXPECTED TO HAVE LIFETIME GREATER THAN 10,000 HOURS

6/89
90634-94





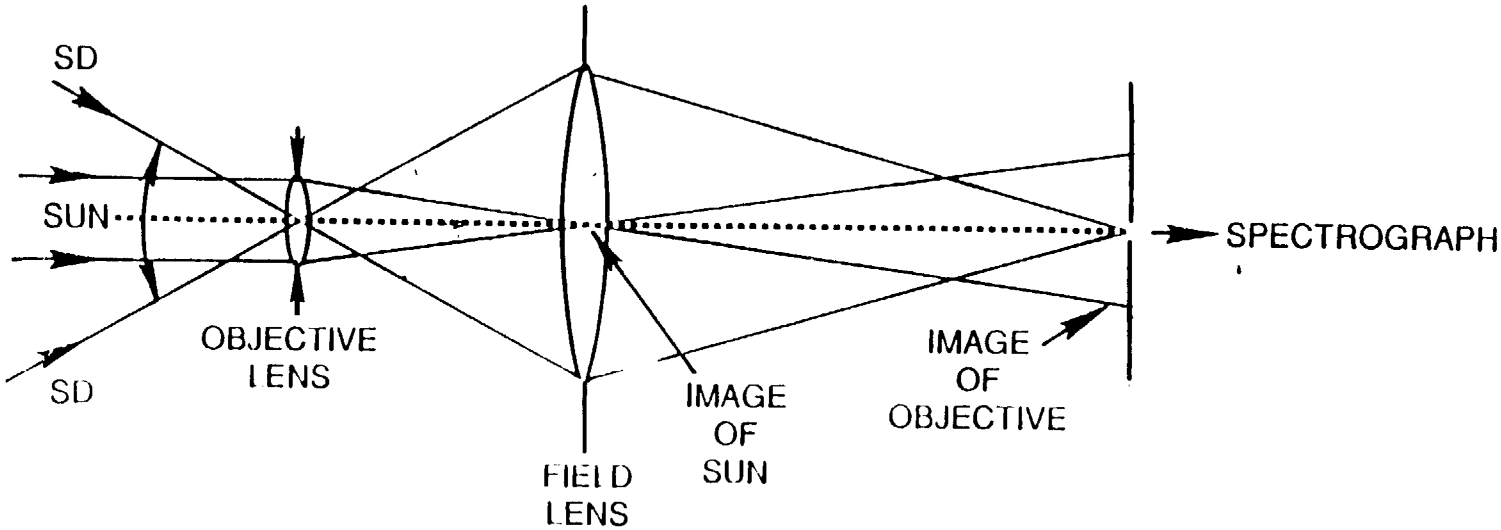
- **Solar Diffuser Reflectance Monitored Using Sun as Reference**

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary

SOLAR DIFFUSER STABILITY MONITOR (SDSM) ALTERNATELY VIEWS SUN AND DIFFUSER

5/91
91-0343-32

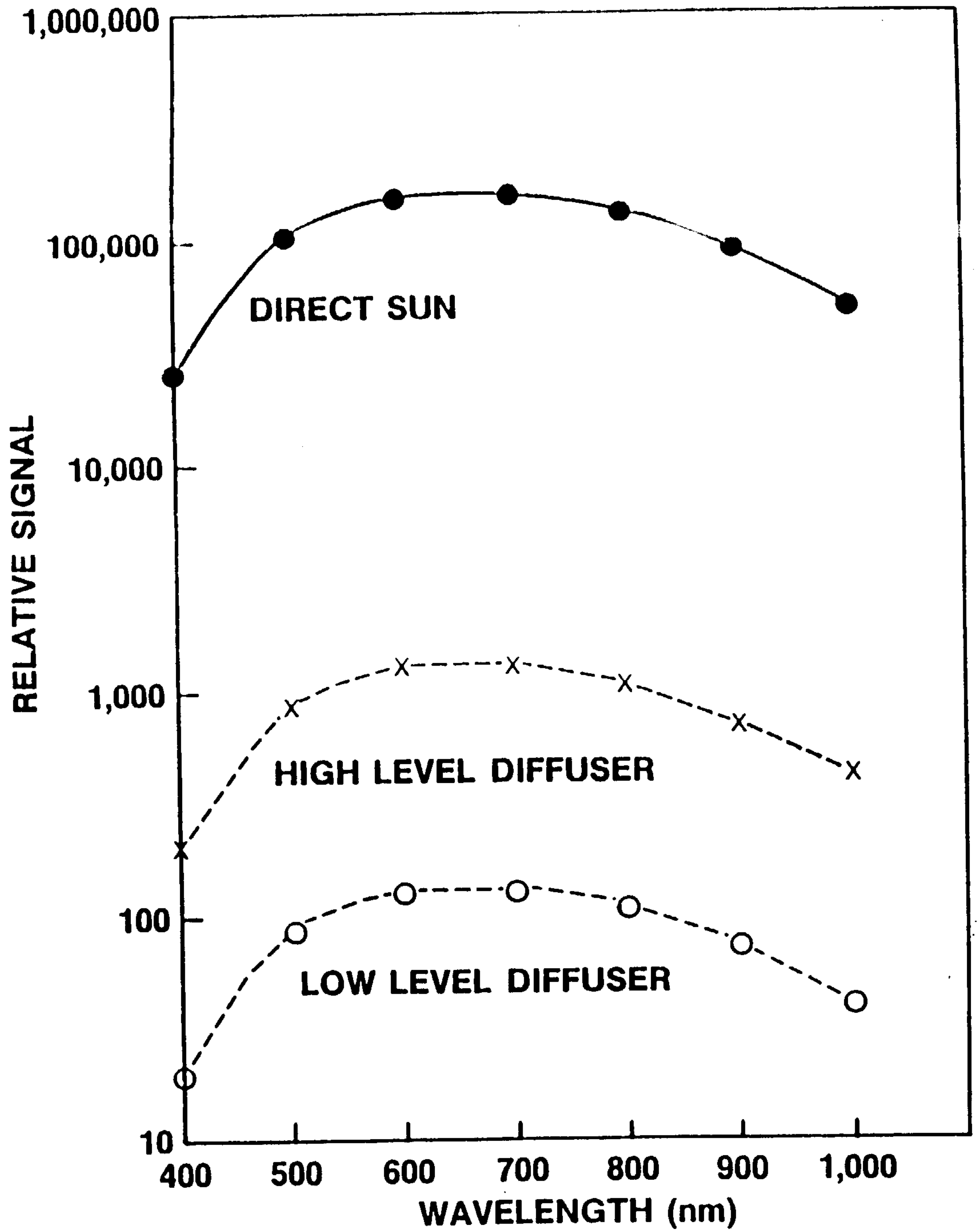
WIDE DYNAMIC RANGE OPTICAL SYSTEM



$$\frac{P_{SUN}}{P_{SD}} = \frac{4\ (f/\#)^2_{SD}}{\pi \cdot \mathrm{BRDF} \cdot \mathrm{COS}\ (\phi_i)} \approx 90$$

- **VARIABLE VIGNETTING DUE TO DIFFRACTION: < ½%**
- **NONUNIFORM SENSITIVITY OF SPECTRORADIOMETER: CHARACTERIZE**
- **VARIABLE ILLUMINATION ANGLES: CHARACTERIZE**

7/89
90634-94A



HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

SOLAR ILLUMINATED DIFFUSER MONITOR RELATIVE SIGNAL AS A FUNCTION OF MEASUREMENT MODE

6/89
90634-111

Type of Calibration	Source	Mechanism	Aperture	Spectral Bands	Usage Frequency (Max)	Other Comments
DC restore	Space		Full	All	Once per scan line	
Radiometric	Sun	Solar illuminated diffuser	Full	VIS/NIR/SWIR less 8 through 16	Once per orbit	BRDF = 0.18 sr^{-1}
Radiometric	Sun	Solar illuminated diffuser	Full	VIS/NIR/SWIR	Once per orbit	BRDF = 0.18 sr^{-1}
Radiometric	Blackbody	Blackbody	Full	MWIR/LWIR	Once per scan line	
Radiometric	Incandescent source	SRCA spectrally shaped collimator	Partial	VIS/NIR/SWIR	Available any time during orbit	
Spatial Registration	Incandescent source and IR source	SRCA	Partial	VIS/NIR/SWIR MWIR/LWIR	Available any time during orbit	
Spectral (MODIS-N)	Incandescent source	SRCA grating monochromator	Partial	VIS/NIR	Available any time during orbit	Grating is rotated to produce λ scan
Spectral (monochromator)	Incandescent source	SRCA grating monochromator and filter	Full	$0.40\ \mu m \leq \lambda \leq 1.00\ \mu m$	Available any time during orbit	Grating is rotated to produce λ scan
Diffuser stability monitor	Sun	SDSM grating spectrograph and fold mirror	Full	$0.40\ \mu m \leq \lambda \leq 0.90\ \mu m$	Available once per orbit	High BRDF diffuser
Diffuser stability monitor	Sun	SDSM grating spectrograph and fold mirror	Full	$0.40\ \mu m \leq \lambda \leq 0.90\ \mu m$	Available once per orbit	Low BRDF diffuser

HUGHES

SANTA BARBARA RESEARCH CENTER

a subsidiary

MODIS-N IN-FLIGHT CALIBRATION CAPABILITY

5/91

91-0347-34

GSE/BTE FUNCTIONS

- SIMULATE INTERFACE BETWEEN MODIS-N AND HOST SPACECRAFT
- PROVIDE OPTICAL STIMULI FOR PERFORMANCE TESTING AND CALIBRATION
- PROCESS HIGH RATE DATA STREAM
- MONITOR, CONTROL AND RECORD TEST CONFIGURATIONS AND OPERATIONAL CONDITIONS
- PROVIDE COOLING OF SWIR, MWIR, AND LWIR FOCAL PLANES FOR LABORATORY AMBIENT TESTS
- PROVIDE RADIATIVE HEAT SINKS FOR THERMAL VACUUM TESTS
- PROVIDE SPECIAL TOOLS AND FIXTURES FOR ALIGNMENT AND HANDLING

FUNCTIONAL/ PERFORMANCE PARAMETER	Ambient	Vacuum	MODIS-N Calibrator	Reticles	Slit source	Grating Monochromator	Payload Stimulus Control Console	Spherical Integrator Source	Blackbody FAIRS	Large-Aperture IR Source LAIRS	DC Restore Source	Alignment Test Set	Bench Cooler	Space Background Simulator	Payload Interface Control Console	Computer	High Data Rate Recorder	TEST PHASE*
Command and Power																		1, 2, 4, 5, 6
Command Verification	X	X													X	X		
Power Profile	X	X													X	X		
Turn On Transients	X	X													X	X		
Operational Transients	X	X													X	X		
Power Supply Transients	X	X													X	X		
Power Supply Ripple	X	X													X	X		
Spectral Coverage																		1, 2, 3, 4, 5
In-Band Shape	X	X	X			X					X		X	X	X	X		
Out of Band	X	X	X			X					X		X	X	X			
Spatial Coverage (IFOV)																		1, 2, 3
Cross Track	X		X	X	X						X			X	X	X		
Along Track	X		X	X	X						X			X	X	X		
Far Field Spurious	X		X					X	X	X	X		X		X	X		4
Radiometric Performance																		3, 4, 5, 6
Gain	X	X	X				X	X	X		X		X	X	X	X	X	
Offset	X	X	X				X	X	X		X		X	X	X	X	X	
Signal Versus Radiance	X	X	X				X	X	X		X		X	X	X	X	X	
Linearity	X	X	X				X	X	X		X		X	X	X	X	X	
SNR	X	X	X				X	X	X		X		X	X	X	X	X	
On Board Calibrator		X	X				X	X	X		X		X	X	X	X		
Spectral Matching		X	X													X	X	
Coherent Noise	X	X	X				X	X			X		X	X	X	X	X	
Scan Modulation	X	X						X	X		X		X	X	X		X	
Band-to-Band Stability	X	X		X				X	X		X		X	X	X			
MTF (Sine Wave)																		1, 2, 3, 4, 5, 6
Along Track	X	X	X	X			X				X		X	X	X	X		
Cross Track	X	X	X	X			X				X		X	X	X	X		
Transient Response																		1, 4
Rise Time	X	X	X	X			X				X		X		X	X		
Overshoot/Undershoot	X	X	X	X			X				X		X		X	X		
Polarization Sensitivity	X					X					X		X		X			1, 3
Spectral Band Registration																		3, 4, 5
Along Track	X	X	X	X			X				X		X	X	X	X	X	
Crosstrack	X	X	X	X			X				X		X	X	X	X	X	
Alignment Reference	X											X						3, 6

*Test Phase
1. Subsystem checkout
2. Subsystem integration
3. Optical alignment and performance (performed during subsystem integration and prior to Phase 4)
4. Ambient environmental bench tests
5. Thermal vacuum environmental tests
6. Instrument/spacecraft integration tests

HUGHES

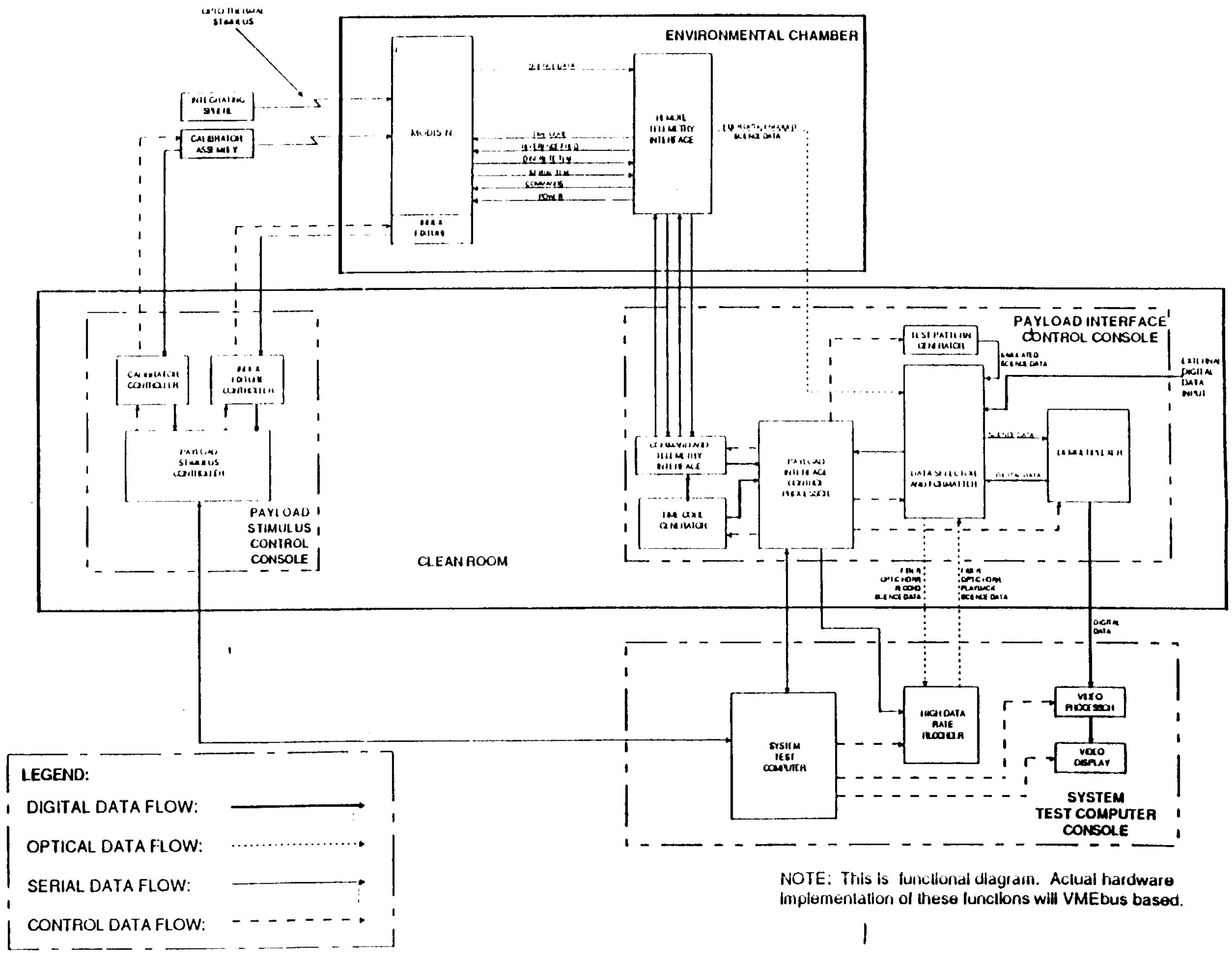
SANTA BARBARA RESEARCH CENTER
a subsidiary

PERFORMANCE VERIFICATION MATRIX

9/91
91-0742-8

PRP90-1051

006-58



NOTE: This is functional diagram. Actual hardware implementation of these functions will VMEbus based.

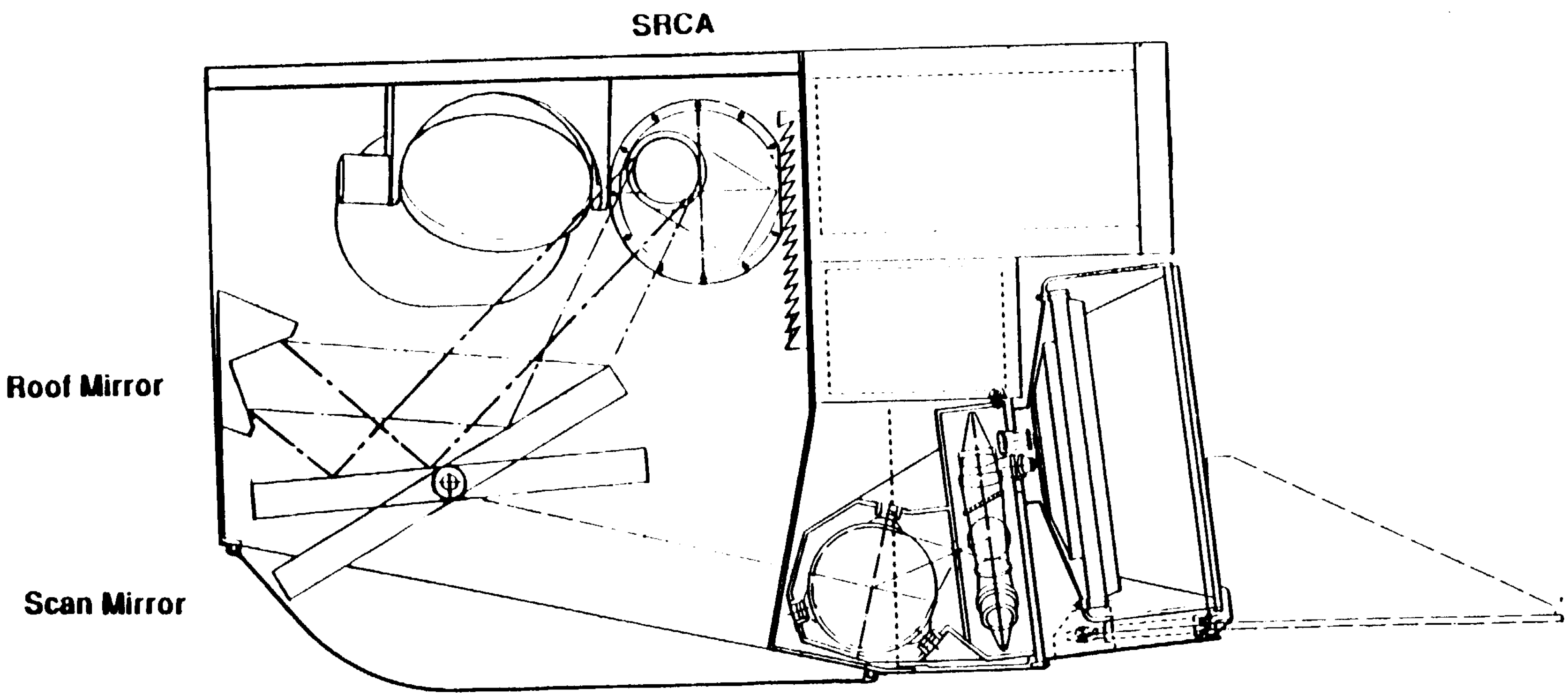
Figure 3-10. MODIS-N System Test Equipment Functional Diagram.

SANTA BARBARA RESEARCH CENTER

SCAN MIRROR REFLECTANCE CHARACTERIZATION

HUGHES
SANTA BARBARA RESEARCH CENTER
a subsidiary

METHOD A - ROOF MIRROR



CONCEPTUAL DESIGN FOR REFLECTANCE CHECK ACROSS THE SURFACE OF THE SCAN MIRROR

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

- Concern: Non-Uniform Contamination of the Scan Mirror On-Orbit
- Status: Baseline design for On-Orbit calibration sources does not provide information over the length of the Scan Mirror.
- Conceptual Solution: Characterize Spectral Reflectance of Scan Mirror across its length.
- Two Methods: Both use the SRCA Monochromator (VIS/NIR) with the following modifications:

  1) The collimator fold mirror must be capable of being tilted in small steps, in the scan direction, with a stepper motor.

  2a) A Reflecting Roof Mirror must be located within the scan cavity in a location near the end or the Earth Scan. The Scan Mirror is viewed at large angles of incidence.

  3a) A Silicon Photodiode must be added at the end of the SRCA exit slit to sense the Reflected Energy from the Scan Mirror and Roof Mirror.

  4a) Vignetting due to beam translation needs to be characterized.

  2b) The Scan Mirror is viewed at Normal Incidence. (No additional optics required.)

  3b) A Silicon Photodiode must be added at the side of the SRCA exit slit to sense the reflected energy from the Scan Mirror.

  Either or both methods can be implemented.

- Action Needed: If the pursuit of this concept is of interest to GSFC, we'd be happy to respond to a request for proposal.

SCAN MIRROR REFLECTANCE CHARACTERIZATION

METHOD B - NORMAL INCIDENCE

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary