ANOTA

THE MODERATE RESOLUTION IMAGING SPECTRORADIOMETER (MODIS)

CALIBRATION PRESENTATION

September 28, 1993

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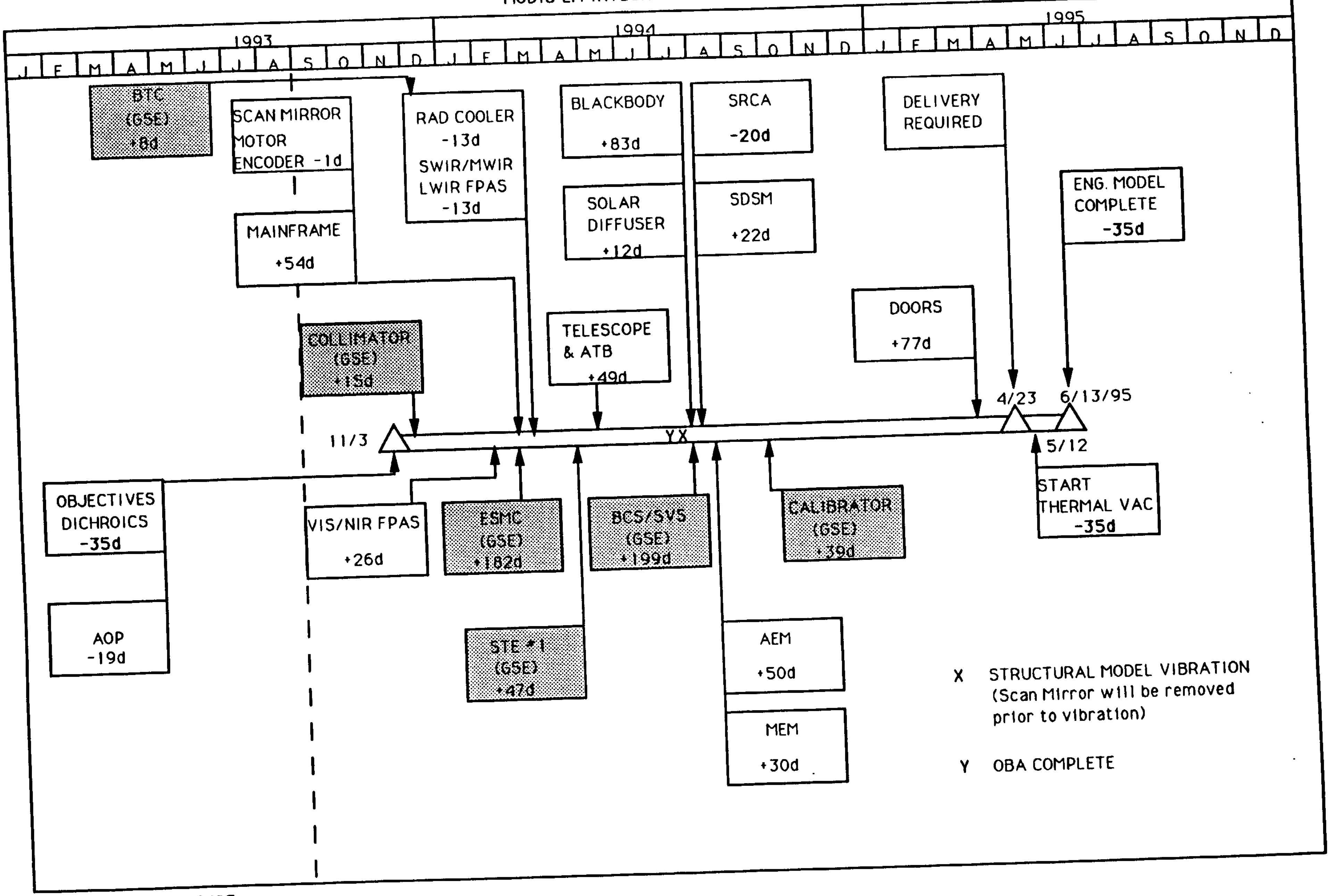
AGENDA

- MODIS CHARACTERIZATION/CALIBRATION METHODOLOGY
- OBC MECHANISMS
- GSE OPTICAL STIMULI
  - MODIS GROUND BASED CALIBRATOR (MGBC)
  - BLACKBODY CALIBRATION SOURCE (BCS)
  - INTEGRATION AND ALIGNMENT COLLIMATOR (IAC)
- TEST FACILITY LAYOUTS
- DEDICATED MODIS CALIBRATED FACILITY
- SYSTEM TEST ALGORITHMS

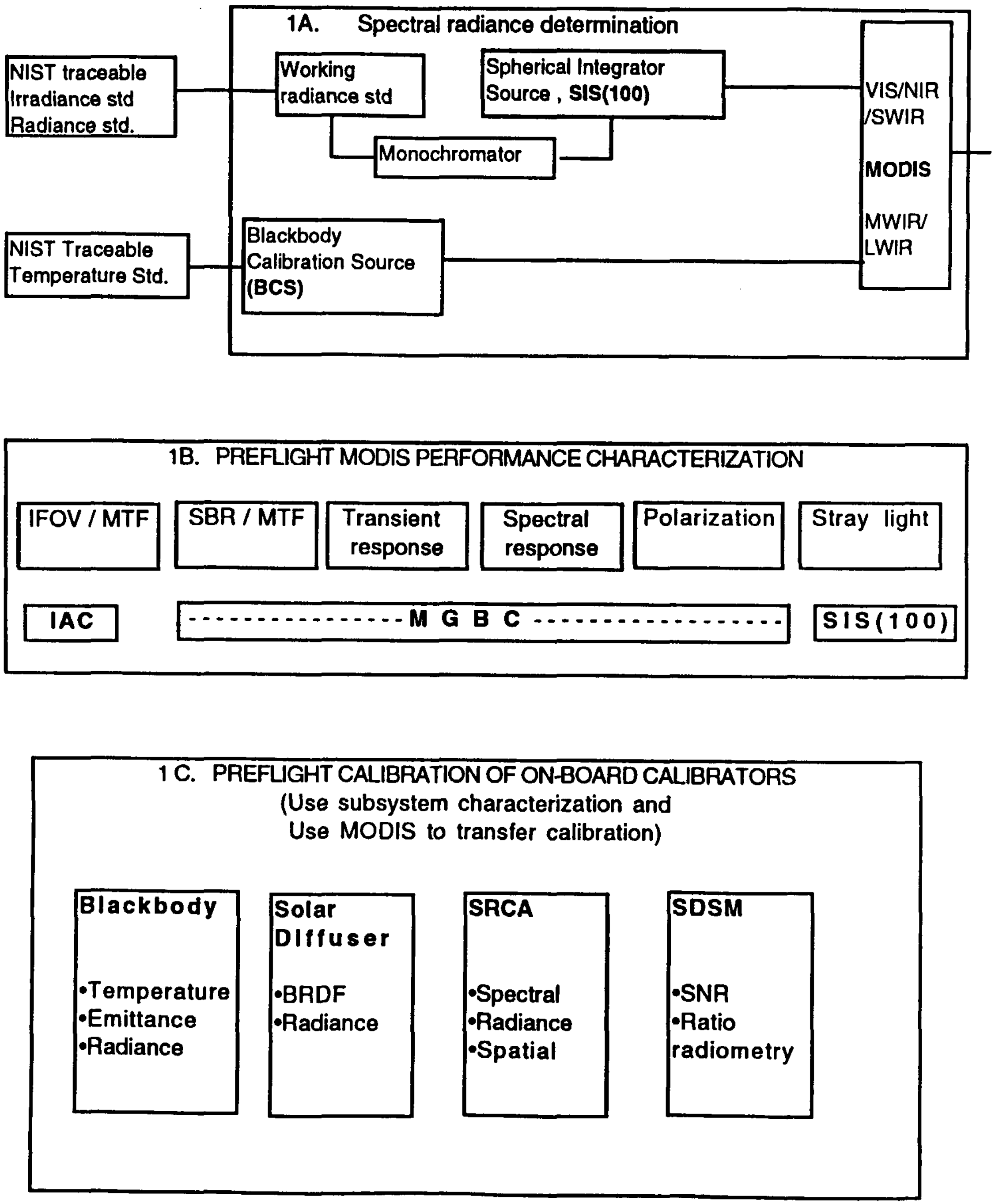
PLANS HAVE BEEN DEFINED FOR THE CALIBRATION OF MODIS

- An approach to calibration has been defined that uses multiple methodologies to achieve high calibration accuracies over a broad spectral range
- The defined plan will allow MODIS to achieve its calibration objectives
- Preflight calibration sources will be used to fully characterize MODIS with links to NIST standards
- A MODIS Calibration Facility will help insure model-to-model uniformity
- Preflight and On-orbit calibration will be linked by the SRCA and the Solar Diffuser
- Extensive on-board calibration capability will help maintain calibration accuracy despite on-orbit environmental changes

MODIS EM INTEGRATION & TEST



STATUS AS OF 8/19/93



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MODIS PREFLIGHT CALIBRATION PLAN

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TEST PARAMETER	SPEC PARA	TEST ENVIRONMENT	Scan mirror status	GSE optical stimuli
Spatial - IFOV	3.3.1	Amb lab	non-scanning	IAC with slits
Response uniformity	3.4.5.4			
Spectral	3.3.3	Amb lab & T/V	non-scanning	MGBC+monochro-mator
wavelength tolerance	3.3.3.2	Amb lab & T/V		
out of band	3.3.3.3	Amb lab		
ripple	3.3.3.4	Amb lab & T/V		
wavelength stability	3.4.7.4	Amb lab & T/V		
wavelength accuracy	3.4.7.5	Amb lab & T/V		
Polarization	3.3.5	Amb lab	non-scanning	MGBC+polarizer prism
MTF	3.4.2	Amb lab & T/V	scanning	MGBC+slits
Transient response	3.4.4	Amb lab	scanning	MGBC+reticles
Radiometric performance	3.4.5	Amb lab & T/V	scanning	SIS (100) & BCS
Dynamic range	3.4.1			
SNR	3.4.1			
System noise meas	3.4.5.5			
Ch to ch uniformity	3.4.5.3.2			
System noise	3.4.5.5			
System crosstalk	3.4.5.3.3	Amb lab	scanning	MGBC+wide slits
Ghosting		Amb lab	scanning	MGBC+full aperture
Geometric performance	3.4.6			
Pointing knowledge	3.4.6.1	Amb lab	non-scanning	MGBC+ptg assy
Alignment change	3.4.6.2	Amb lab	non-scanning	MGBC+ptg assy
Spectral Band Reg.	3.4.6.3	Amb lab & T/V	scanning	MGBC+SBR reticles
Radiometric stability	3.4.7		scanning	
short term	3.4.7.1	Amb lab		SIS(100) & BCS
long term	3.4.7.2	analysis		NA
spectral band to band	3.4.7.3	Amb lab & T/V		SIS(100) & BCS
Stray light	3.4.8	Amb lab	scanning	
Direct sunlight	3.4.8.1	Amb lab		Solar Test Source
Bright target	3.4.8.2	Amb lab		SIS(100)
Dark target	3.4.8.3	Amb lab		SIS(100)
Warm target	3.4.8.4	Amb lab		MGBC-target reticle

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SYSTEM PERFORMANCE TEST MATRIX

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THREE ALTERNATIVES WERE AVAILABLE:
- **Centroid Method**
- **Knife Edge Method**
- **Full Width Half Maximum**

Centroid Method:

$$X1 = \frac{\sum_{Xi}^{Xf} LSF(X) * X * \Delta X}{\sum_{Xi}^{Xf} LSF(X) * \Delta X} \quad \text{and} \quad Y1 = \frac{\sum_{Yi}^{Yf} LSF(Y) * Y * \Delta Y}{\sum_{Yi}^{Yf} LSF(Y) * \Delta Y}$$

Knife Edge Method:

$$\sum_{Xi}^{X2} KER(X) * \Delta X = \sum_{X2}^{Xf} KER(X) * \Delta X$$

$$\sum_{Yi}^{Y2} KER(Y) * \Delta Y = \sum_{Y2}^{Yf} KER(Y) * \Delta Y$$

Full Width Half Maximum (FWHM)

$LSF(XL) = 0.5$ and $LSF(Xu) = 0.5$

$FWHM(X) = Xu - XL$

$X3 = 0.5 * (Xu+XL)$

$LSF(YL) = 0.5$ and $LSF(Yu) = 0.5$

$FWHM(Y) = Yu - YL$

$Y3 = 0.5 * (Yu+YL)$

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MEASUREMENT METHODOLOGY FOR SPECTRAL BAND REGISTRATION

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CENTROID METHODOLOGY SELECTED (1 of 5)

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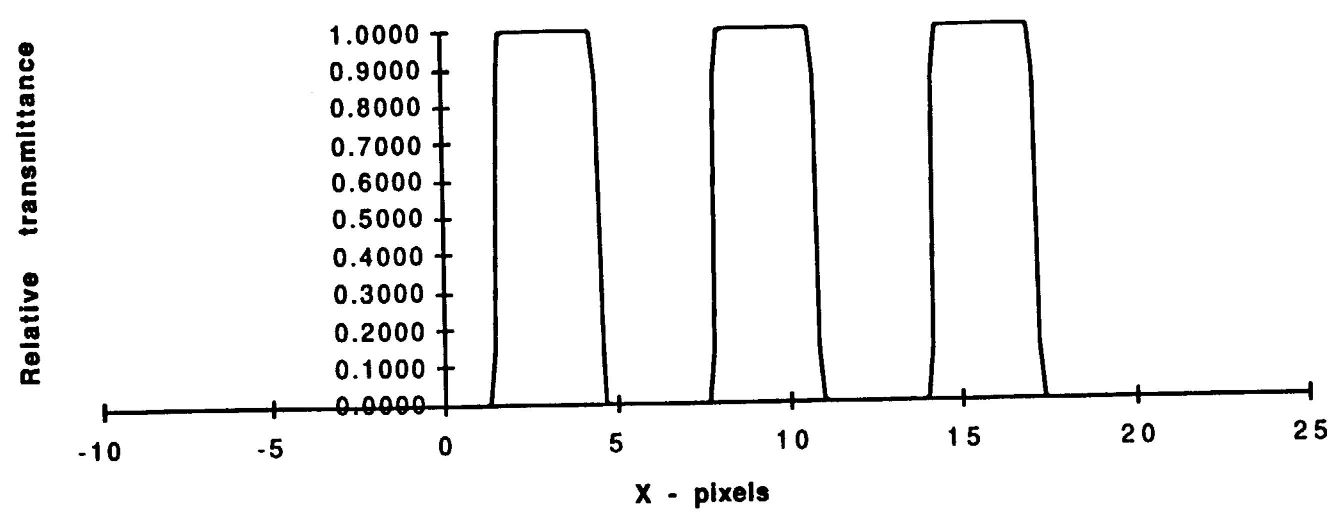
THE FOLLOWING CHARTS ILLUSTRATE THE CENTROID MEASUREMENT AND DATA REDUCTION METHODOLOGY

Figure 1 Reticle aperture transmission function



CENTROID METHODOLOGY SELECTED (2 of 5)

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Figure 2 Optical / detector IFOV

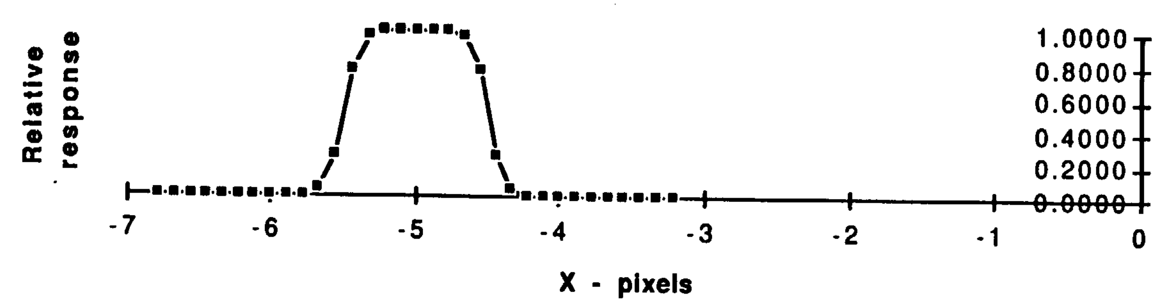
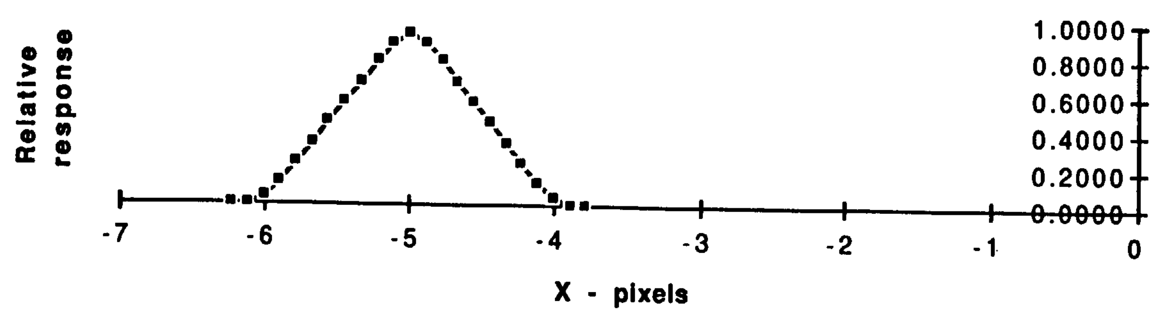


Figure 3 Response - Normalized cross correlation of IFOV and temporal integration



CENTROID METHODOLOGY SELECTED (3 of 5)

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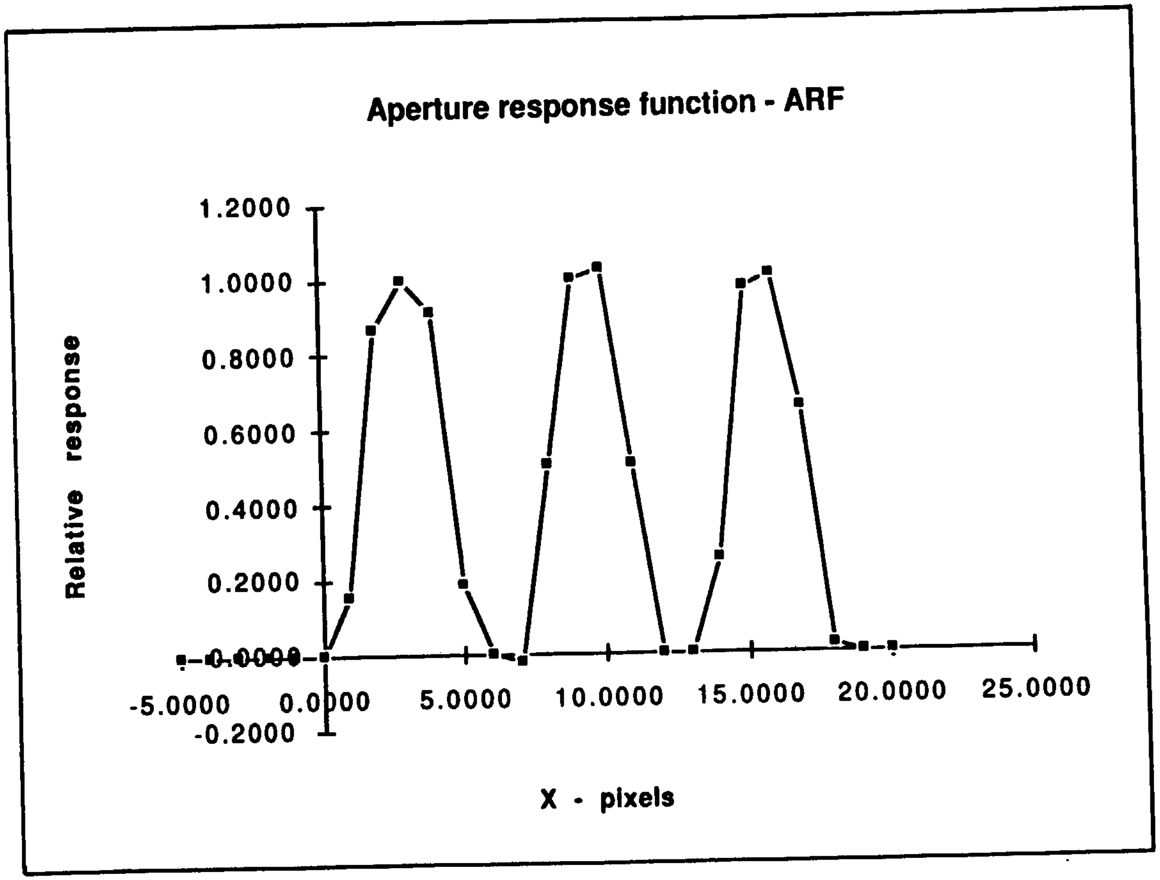

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CENTROID METHODOLOGY SELECTED (4 of 5)

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Figure 4 Aperture response function (ARF)- Normalized cross correlation of response and reticle aperture

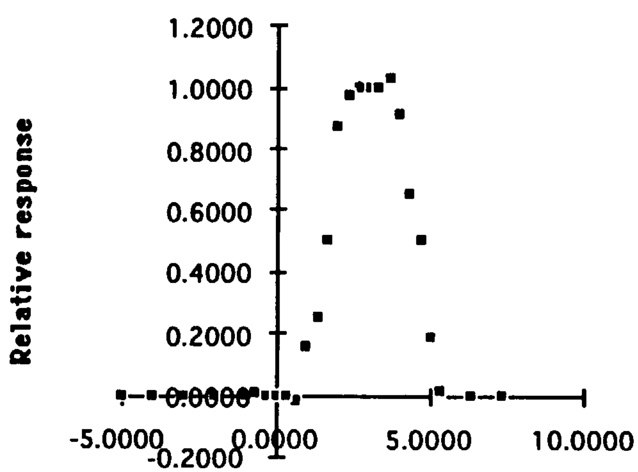
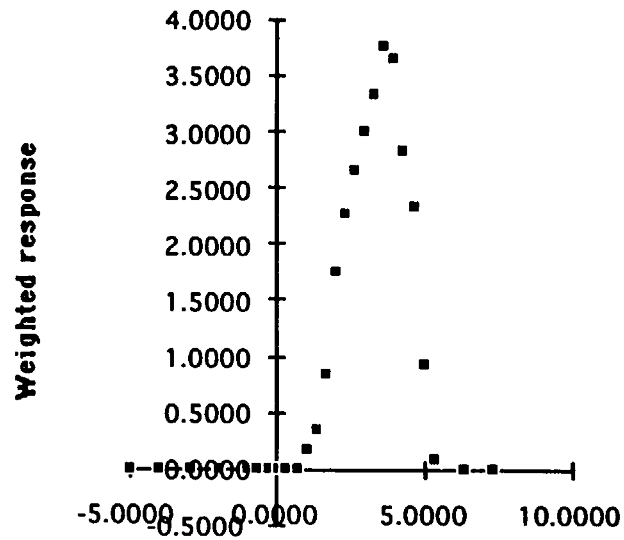


Figure 5 illustrates Xshifted * ARF1s weighted data



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CENTROID METHODOLOGY SELECTED (5 of 5)

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Figure 1 Optical / detector fov

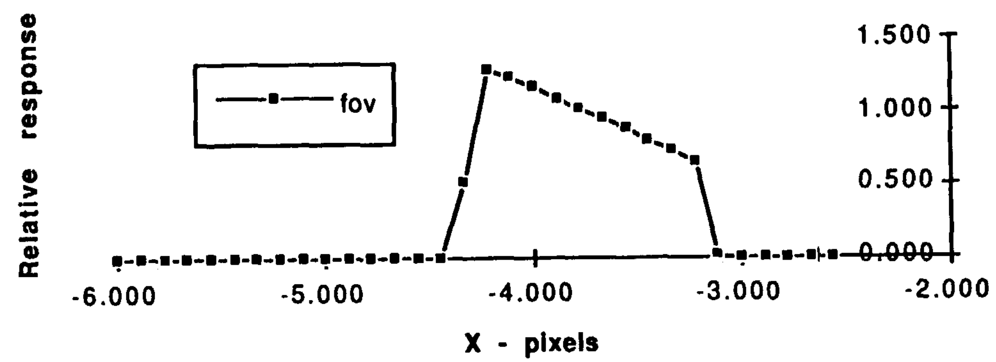
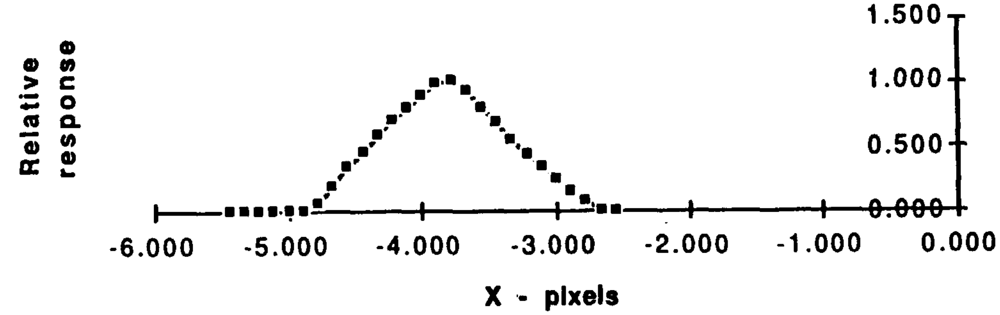


Figure 2 Response - Normalized cross correlation of fov and temporal integration



CENTROID RETRIEVAL UNCERTAINTY ESTIMATE

	Asymmetrical fov function			Symmetrical fov function		
XpkeCtr	3 IFOV	1 IFOV	2 IFOV	3 IFOV	1 IFOV	2 IFOV
0.0000	0.0370	0.0370	0.0370	0.0004	0.0008	-0.0003
0.0667	0.0380	0.0540	0.0330	0.0014	0.0170	-0.0046
0.1333	0.0360	0.0190	0.0450	-0.0018	-0.0180	0.0074
0.2000	0.0370	0.0560	0.0300	0.0013	0.0177	-0.0065
0.2667	0.0360	0.0200	0.0410	-0.0011	-0.0173	0.0037
0.3333	0.0380	0.0380	0.0380	0.0000	0.0007	-0.0003
0.4000	0.0390	0.0540	0.0330	0.0013	0.0170	-0.0046
0.4667	0.0350	0.0190	0.0440	-0.0018	-0.0185	0.0073
0.5333	0.0400	0.0560	0.0310	0.0013	0.0178	-0.0064
0.6000	0.0360	0.0210	0.0410	-0.0012	-0.0173	0.0041
0.6667	0.0370	0.0370	0.0370	0.0004	0.0006	-0.0004
average=	0.0372	0.0374	0.0373	0.0000	0.0000	-0.0001
stddev=	0.0015	0.0158	0.0051	0.0013	0.0157	0.0051

CALIBRATOR RETICLE PATTERN FOR TRANSIENT RESPONSE (NEW MEASUREMENT CONCEPT)

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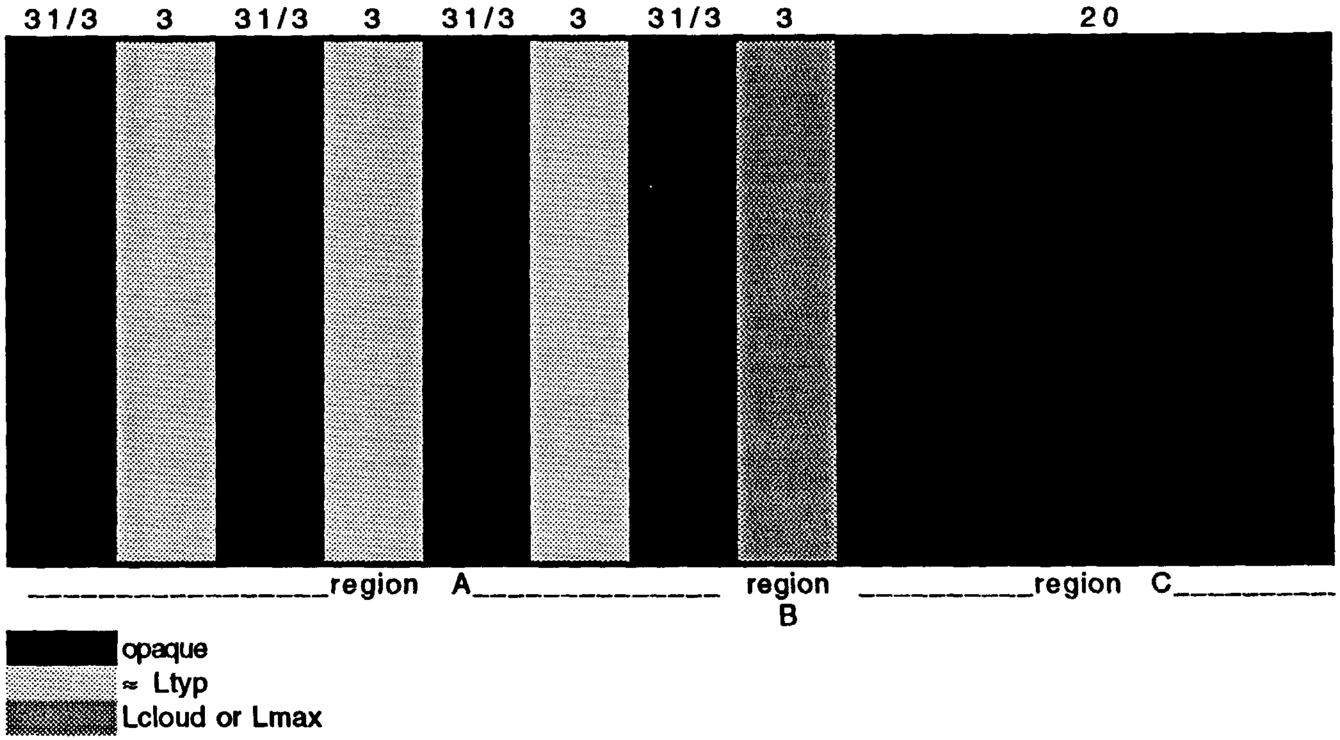

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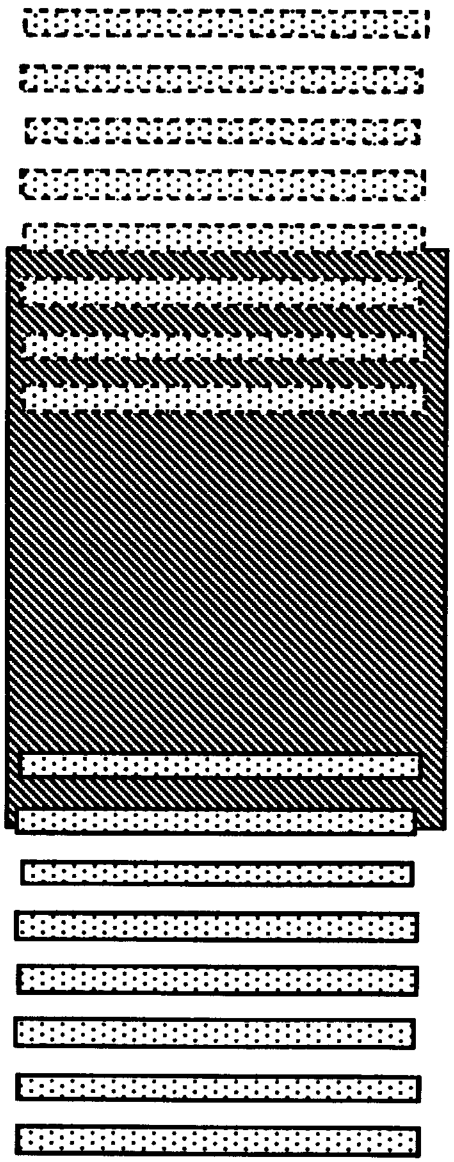

Solid FPA sketch is FPA at one instant in time and the dotted FPA represents a later time. The region with the diagonal pattern represents the MGBC illuminated region.

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MODIS FPA BEING SCANNED ACROSS MGBC ILLUMINATED REGION

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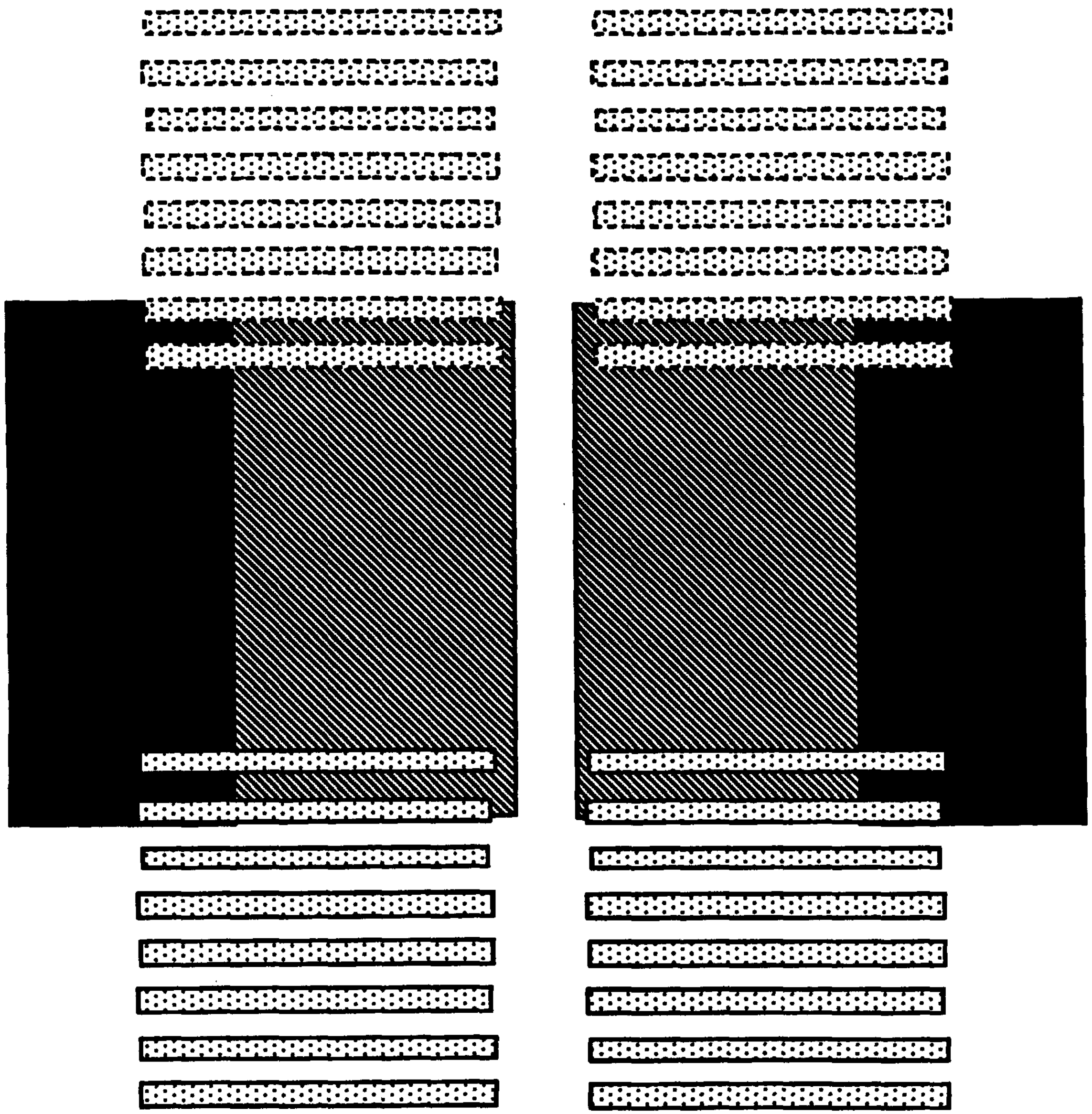
Solid FPA sketch represents the projected FPA at one instant in time and the dotted FPA is at a later time. The region with diagonal pattern represents the MGBC illuminated region. The black region represents the masking of a portion of the along track illuminated region.



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TWO CONFIGURATIONS OF MODIS FPA BEING SCANNED ACROSS MGBC ILLUMINATED REGION

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SRCA (CUTAWAY)

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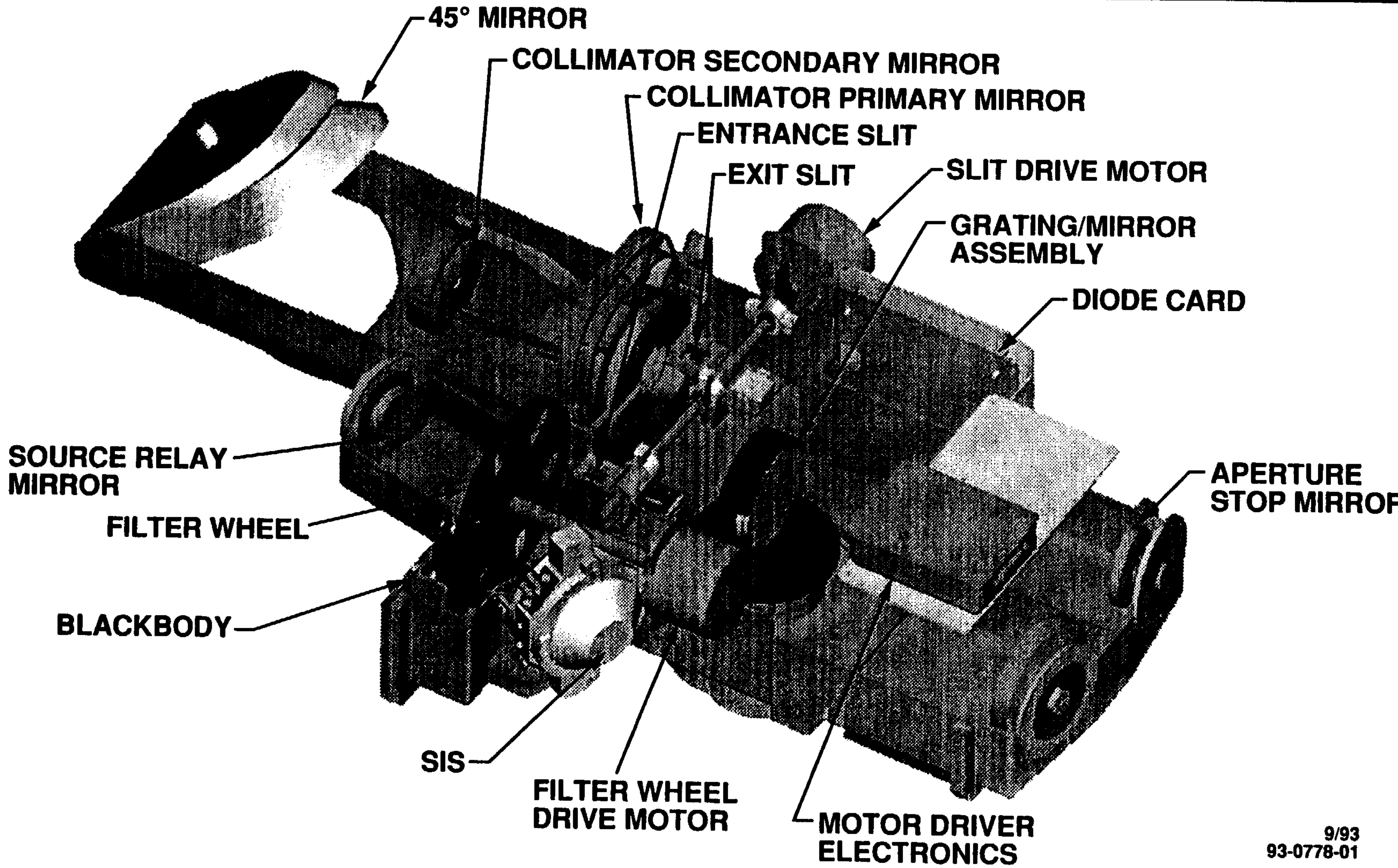

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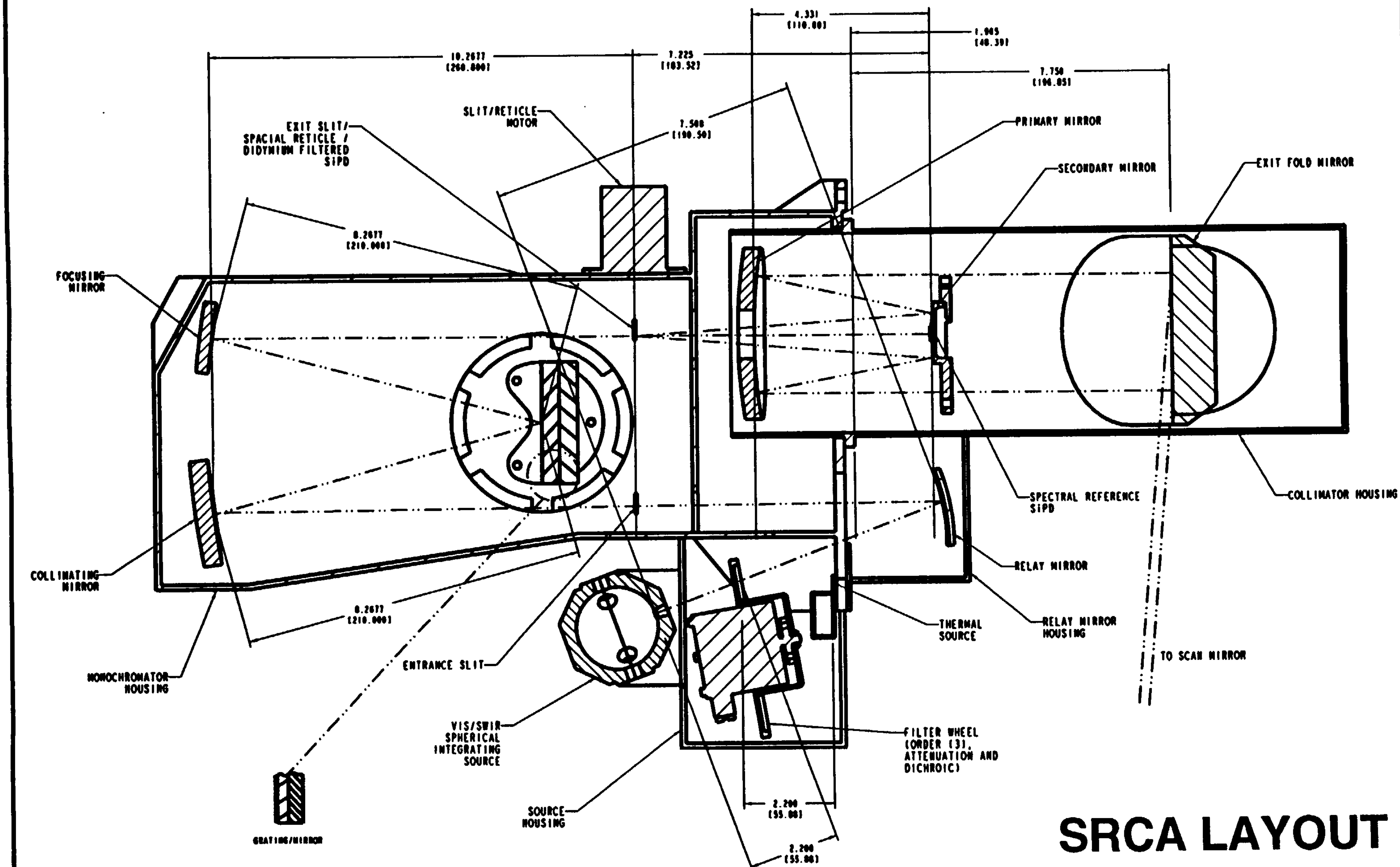
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[190.50]
SLIT/RETICLE
MOTOR
EXIT SLIT/
SPACIAL RETICLE /
DIDYMIUM FILTERED
SiPD
PRIMARY MIRROR
SECONDARY MIRROR
EXIT FOLD MIRROR
8.2677
[210.000]
FOCUSING
MIRROR
COLLIMATING
MIRROR
SPECTRAL REFERENCE
SiPD
COLLIMATOR HOUSING
RELAY MIRROR
RELAY MIRROR
HOUSING
THERMAL
SOURCE
8.2677
[210.000]
MONOCHROMATOR
HOUSING
ENTRANCE SLIT
TO SCAN MIRROR
VIS/SWIR
SPHERICAL
INTEGRATING
SOURCE
FILTER WHEEL
(ORDER (3),
ATTENUATION AND
DICHROIC)
SOURCE
HOUSING
GRATING/MIRROR
2.200
[55.88]
2.200
[55.88]

SRCA LAYOUT

SRCA CALIBRATION SELECTION BLOCK DIAGRAM

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a. SRCA SPECTRAL CALIBRATION

- SiPD feedback √ / Constant current √
- SIS√
- IR source
- Filter wheel: Order filter √ / ND filter / ITO beam combiner / Open
- Relay mirror√
- Entrance slits √ / Open
- Collimating mirror√
- Grating √ / Mirror
- Condensing mirror√
- Didymium / SiPD √
- Reference SiPD √
- Exit slits √ / Open / SBR reticle
- SRCA collimator √

b. SRCA RADIOMETRIC CALIBRATION

- SiPD feedback √ / Constant current√
- SIS √
- IR source
- Filter wheel: Order filter / ND filter √ / ITO beam combiner / Open √
- Relay mirror √
- Entrance slit / Open √
- Collimating mirror √
- Grating / Mirror√
- Condensing mirror √
- Didymium / SiPD
- Reference SiPD
- Exit slit / Open √ / SBR reticle
- SRCA collimator √

c. SRCA SPECTRAL BAND CALIBRATION

- SiPD feedback √ / Constant current √
- SIS √
- IR source √
- Filter wheel: Order filter / No filter / ITO beam combiner √ / Open
- Relay mirror √
- Entrance slit / Open √
- Collimating mirror √
- Grating / Mirror √
- Condensing mirror √
- Didymium / SiPD
- Reference SiPD
- Exit slit / Open / SBR reticle √
- SRCA collimator √

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SRCA SIS RADIANCE PROBLEM HAS BEEN SOLVED

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- ORIGINAL SUSPICION THAT LOW RADIANCE VALUES WERE DUE TO SPECTRALON CONTAMINATION WERE FALSE

- QUARTZ-HALOGEN LAMP COLOR TEMPERATURE VALUES HAVE BEEN TESTED AS 2700K NOT 2900K AS ADVERTISED

- ANALYTICAL MODELLING NOW TRACKS EMPIRICAL RESULTS WELL

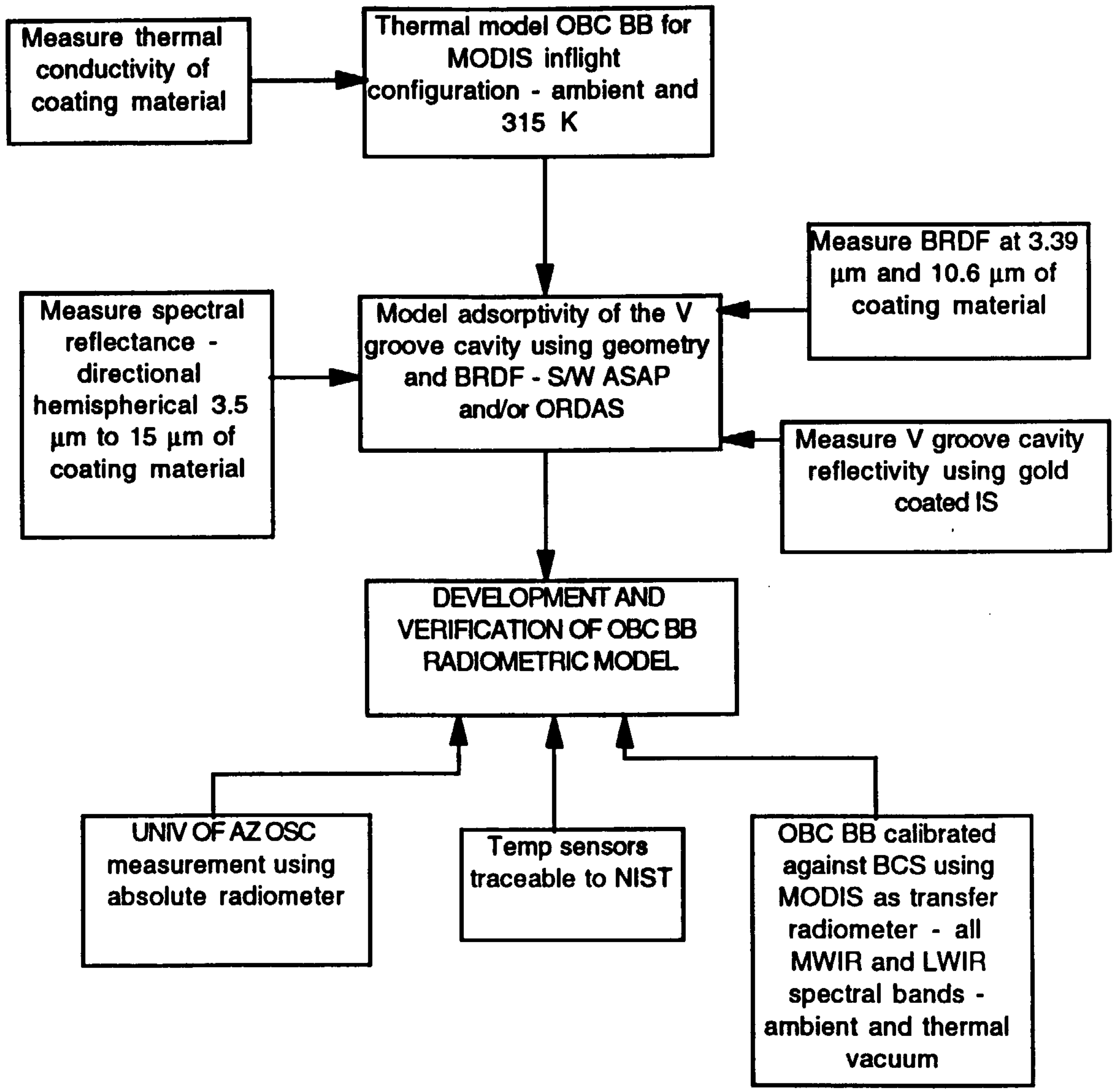
- SEVERAL DESIGN MODIFICATIONS HAVE BEEN MADE:

  -REARRANGEMENT OF LAMP HEAT SINKS TO EXPOSE ADDITIONAL SURFACE OF LAMP

  -REDUCTION OF SPHERE INSIDE DIAMETER TO BOTH REDUCE SURFACE AREA AND INCREASE REFLECTIONS FROM THICKER WALLS

  -ADD REFLECTIVE COATING TO OUTSIDE OF SPHERE

  -SPHERICAL COUNTERBORING OF SPECTRALON TO PRODUCE REFLECTING SOCKETS AT LAMP MOUNT POSITIONS



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DEVELOPMENT AND VERIFICATION FLOW OF OBC BLACKBODY RADIOMETRIC MODEL

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TOTAL INTEGRATED REFLECTANCE FOR BLACK ANODIZED ALUMINUM SURFACE

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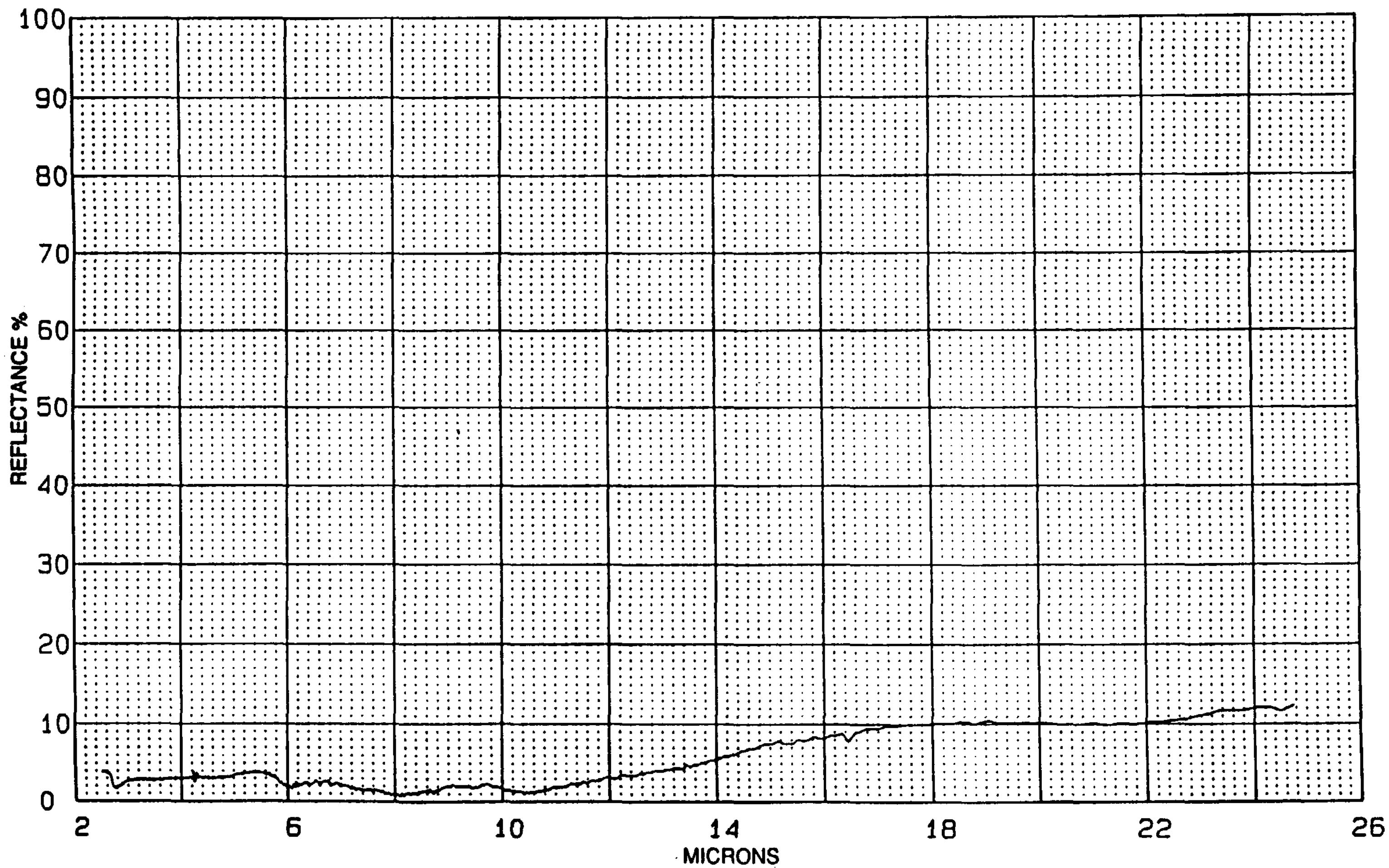

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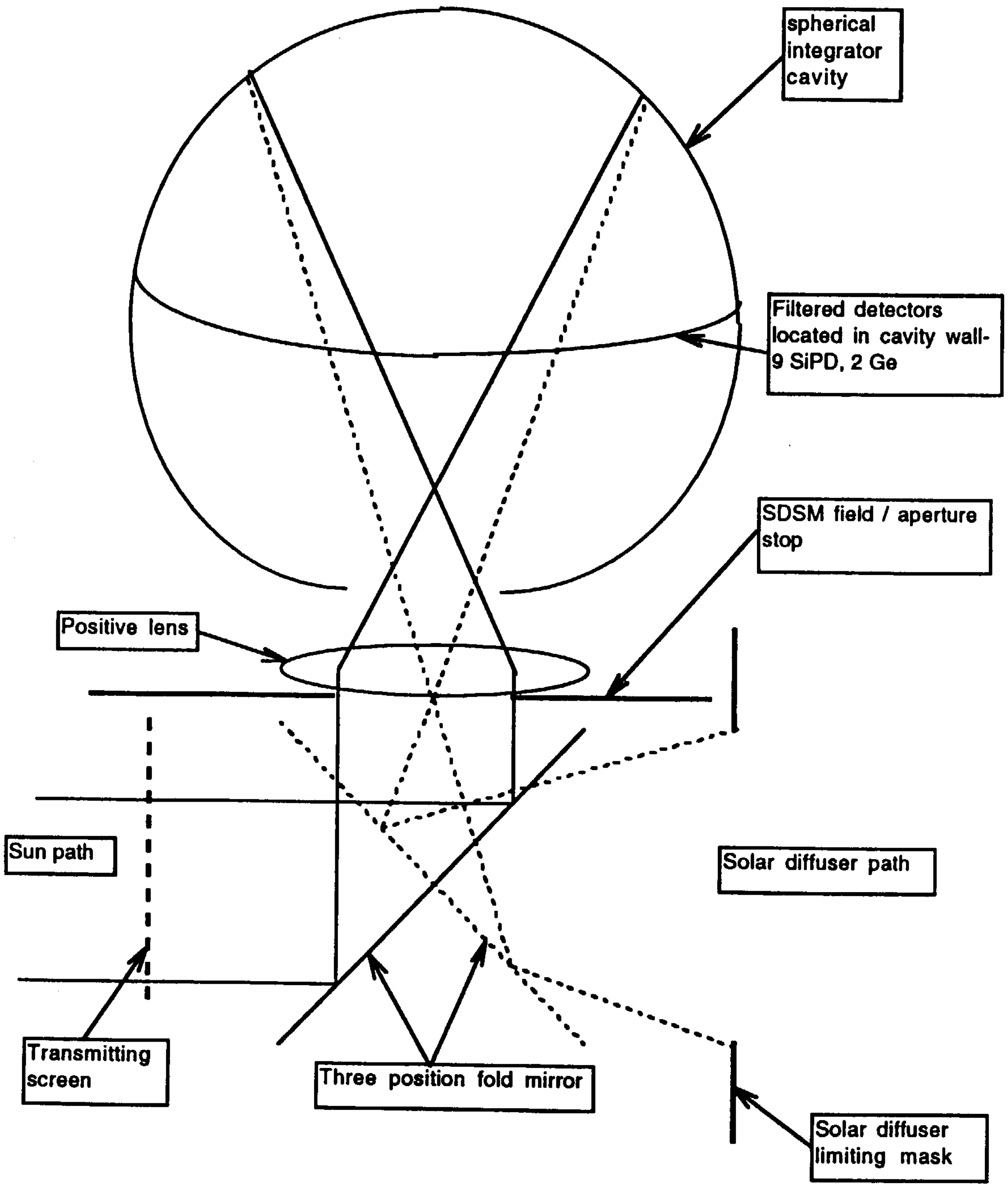

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SDSM GENERAL CONFIGURATION

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SDSM (CUTAWAY)

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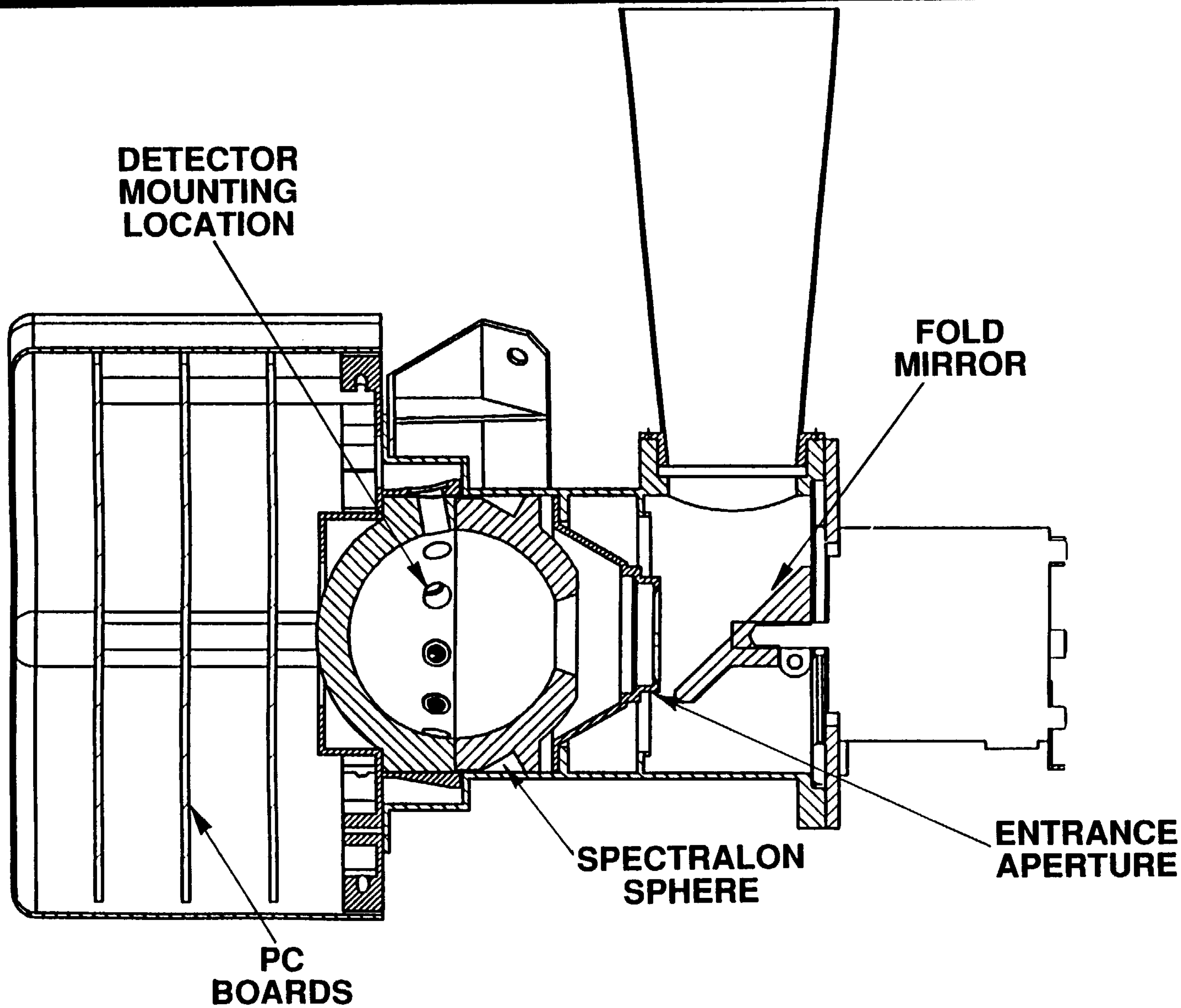
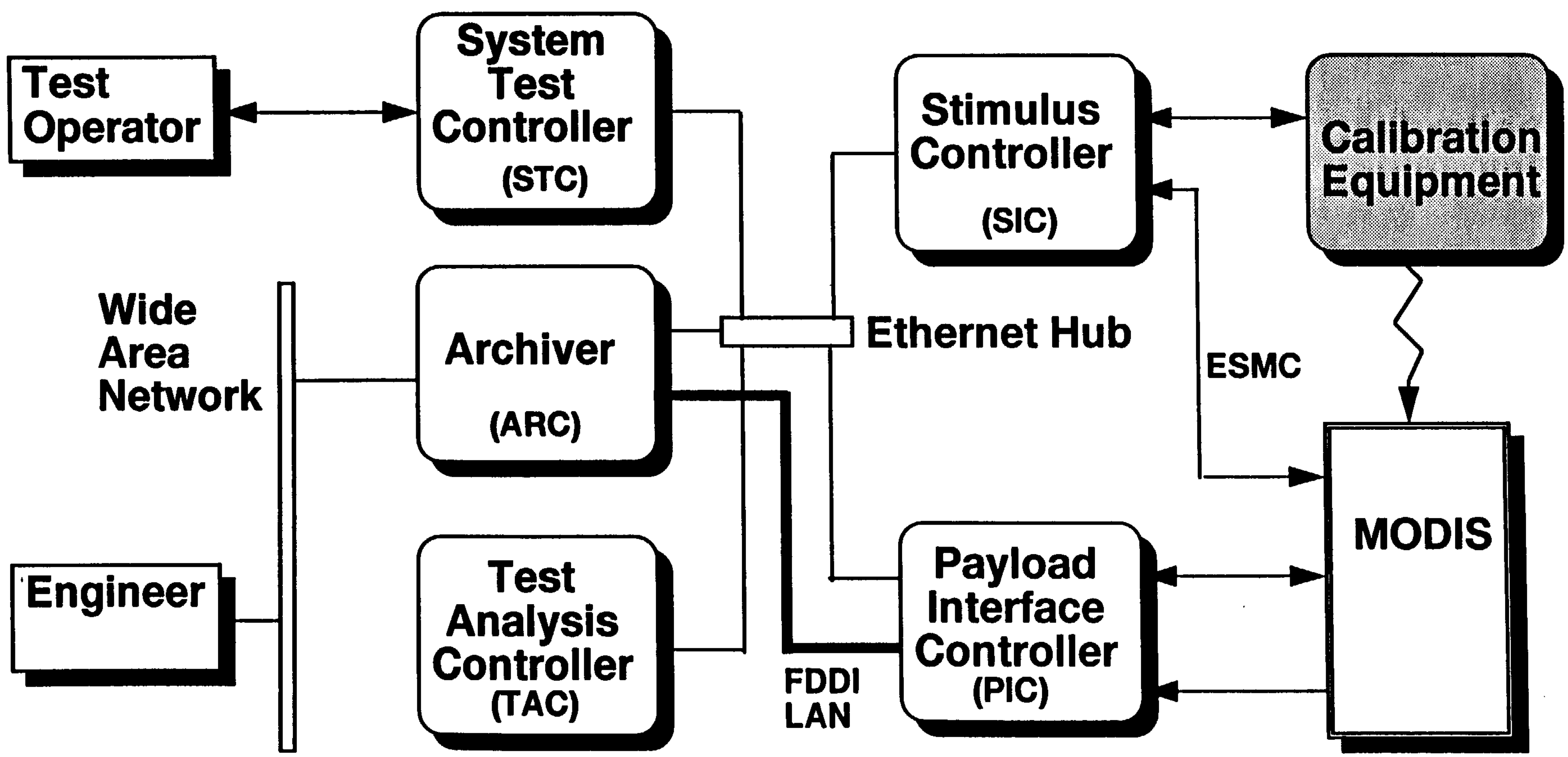


ALL MODIS STIMULUS IS PROVIDED BY THE GSE STIMULUS AND CALIBRATION EQUIPMENT



MGBC FUNCTIONAL FLOW DIAGRAM

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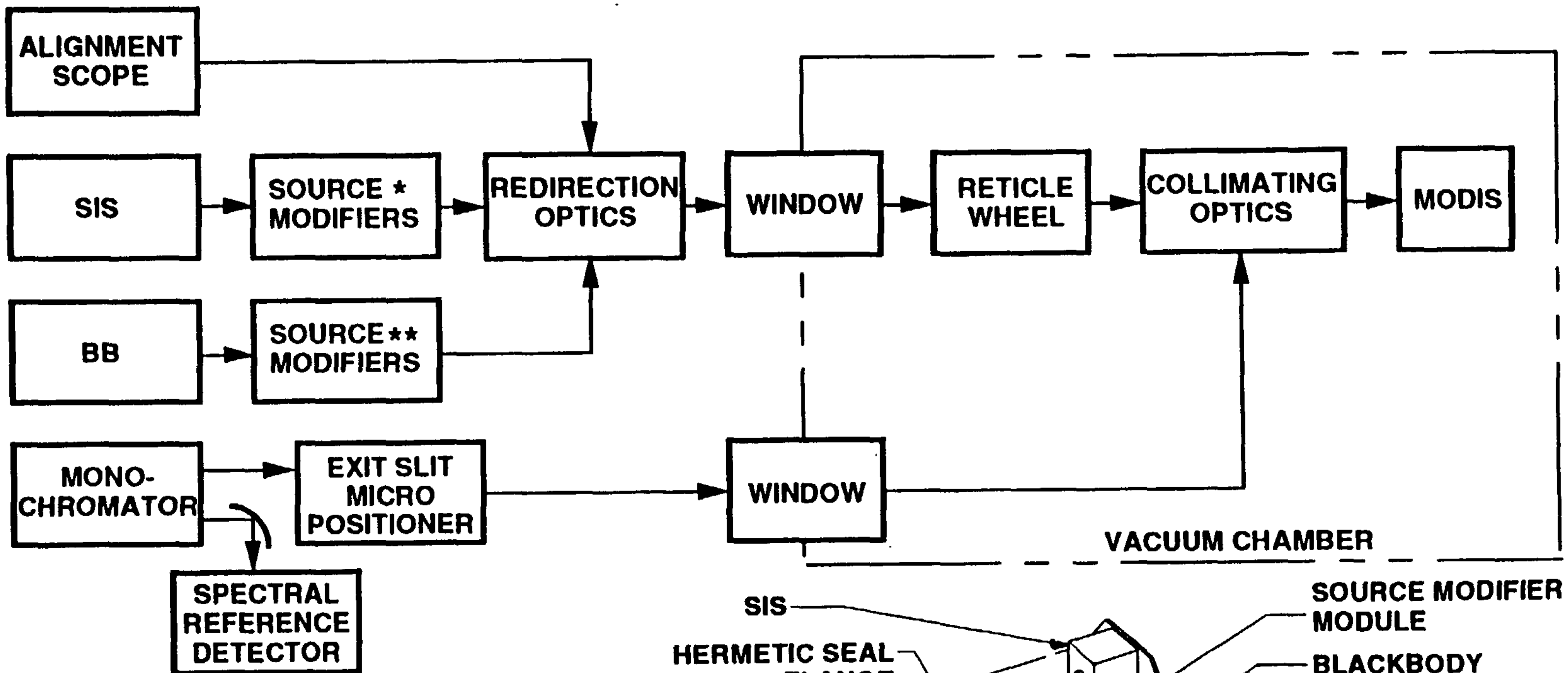
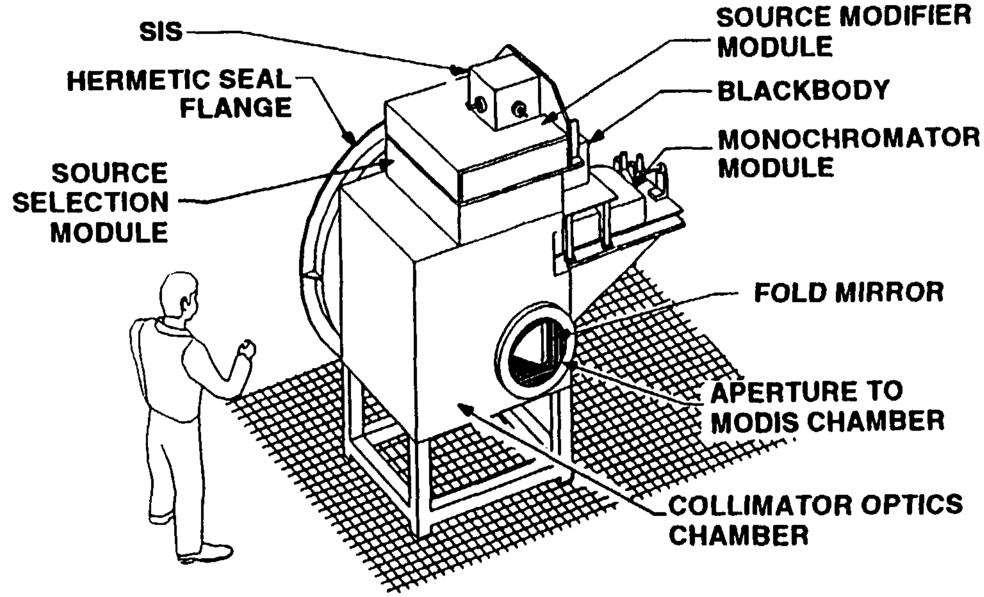


* POLARIZER
NEUTRAL DENSITY FILTERS
SPECTRAL SHAPING FILTERS

** SPECTRAL SHAPING FILTERS



COMPLETE PERSPECTIVE OF CALIBRATOR

MGBC OPTICAL SCHEMATIC DRAWING

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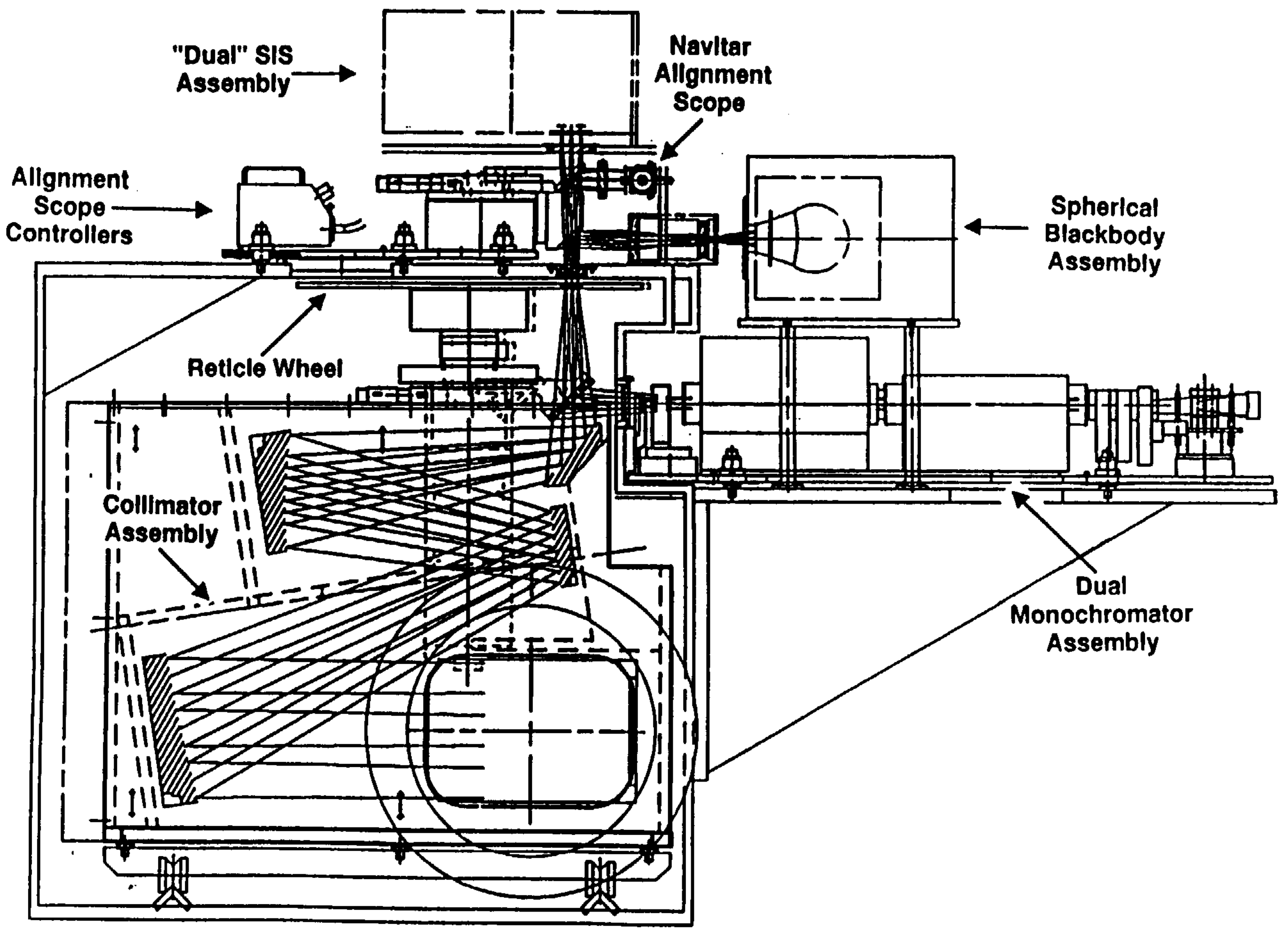

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MODIS GROUND BASED CALIBRATOR PROGRESS

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- **Purchase order placed with Tinsley Corp.**
    - **PDR scheduled for September 28**
- **MGBC Reticle Wheel Assembly Drawings complete. Fourteen reticles and one open space; five spares.**
- **MGBC Dual SIS Assembly and Spherical Blackbody Assembly Source Drawings are complete.**
- **MGBC Polarization Assembly design and layout complete; final tolerances being defined.**
- **MGBC Alignment Assembly design complete; procurement started.**

RETICLE PATTERNS SHAPE THE OPTICAL STIMULI FOR MOST MODIS TESTS

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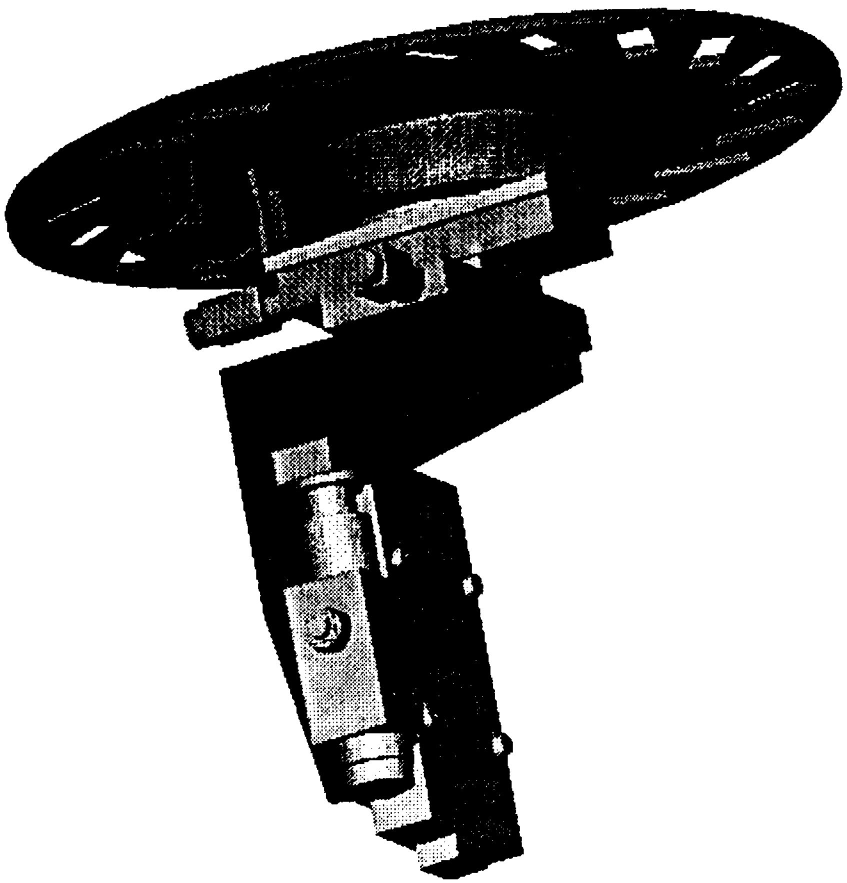
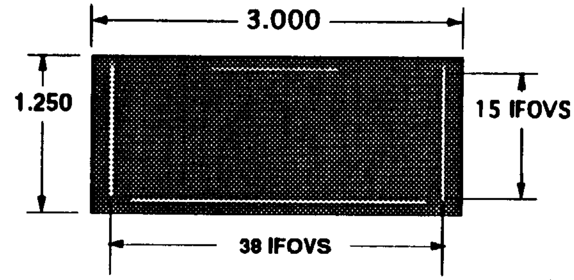
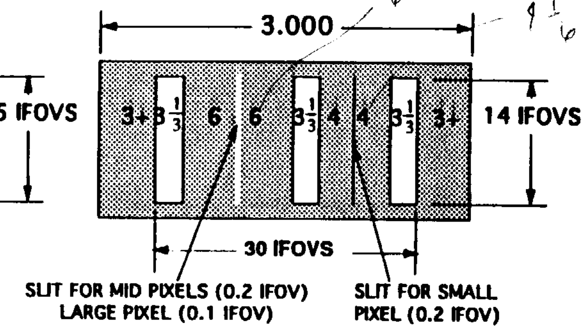


- 18 RETICLES COVER ALL TESTS
- 4 MOTORIZED STAGES PROVIDE TABLE ROTATION, AND X,Y,Z MOTION

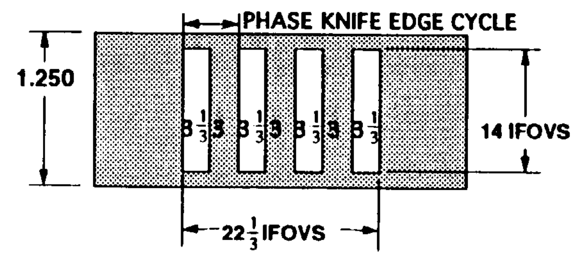
IFOV



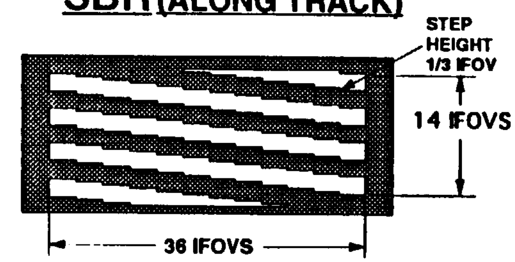
MTF



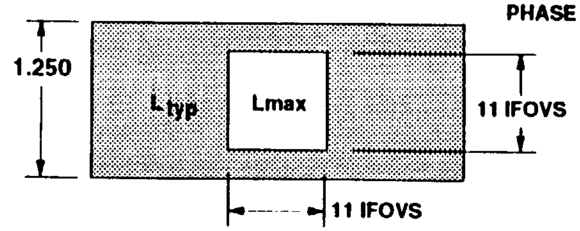
SBR (ALONG SCAN)



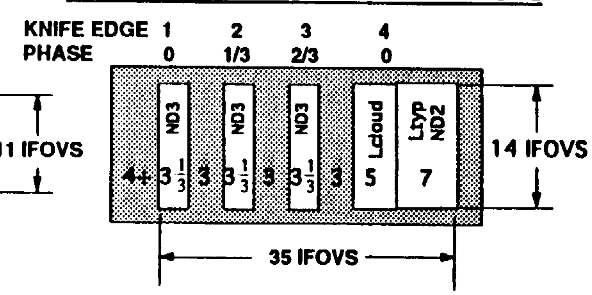
SBR (ALONG TRACK)



STRAY LIGHT



TRANSIENT RESPONSE



INTEGRATION AND ALIGNMENT COLLIMATOR DESIGNS NEARLY COMPLETE

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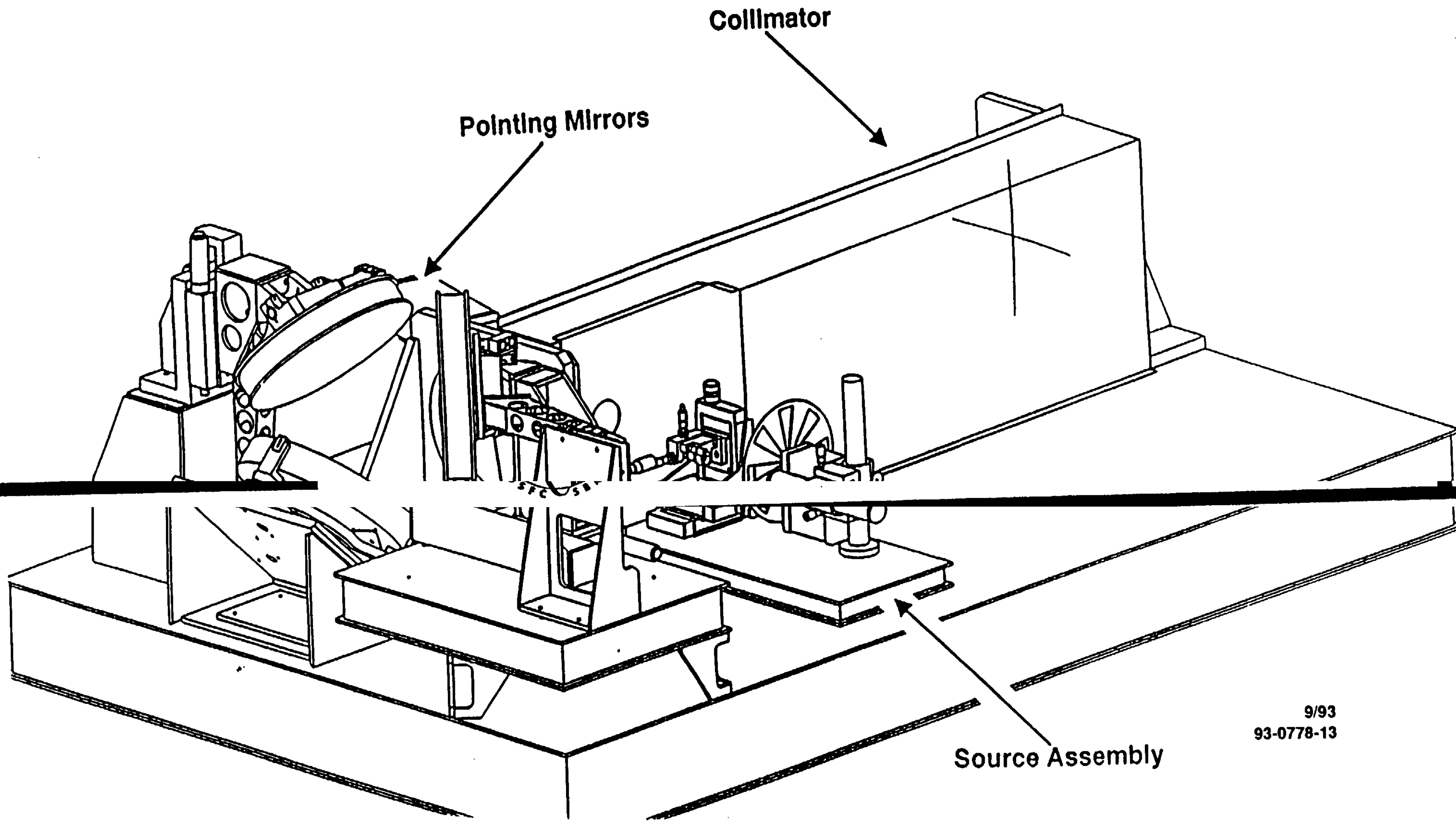

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BLACKBODY CALIBRATION SOURCE AND SPACE VIEW SOURCE PROGRESS

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- A Internal CDR was held at SBRC on August 19, 1993.
- Blackbody procurement is complete.
- Assembly of the BCS & SVS has started.
- Efforts on software development for computer control of the blackbody system is progressing to near completion.
- Projected delivery is December 1993.

BCS/SVS FLOWDOWN AND DERIVED REQUIREMENTS

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	BCS		SVS	
	Requirements	Predicted Performance	Requirements	Predicted Performance
• Radiometric error L_{typ}	< 0.42 , < 0.15%	0.33, .08%	< L_{typ}*error/10	pass*
• Radiometric error 0.3 L_{typ}	< 0.84%	0.68%	NA	NA
• Effective cavity emittance	> 0.999	0.9997	>0.999	0.9997
• Temperature uncertainty	< ± 0.04 K	± 0.04 K	< ± 0.04 (300 K)	± 0.04
			< 85 K (cold)	< 85 K
• Temperature uniformity	< 0.1 K	0.08 K	< 85 K	< 85 K
• Temperature stability	± 0.02 K (6 min.)	± 0.01 K	floats	floats
• Temperature repeatability	± 0.1 K	± 0.1 K	floats	floats
• Temperature control	± 0.01 K	± 0.01 K	floats	floats
• Temp. transition time	< 30 min (10°)	< 30 min	TBR	< 4 hr
• Temperature range	170-340 K (vac)	meets req	<85 to 300 K	meets req.
	300-380 K (amb)	meets req.		

* Band 24 slightly out of tolerance. BCS+SVS total error still in spec

BCS/SVS MECHANICAL DESIGN

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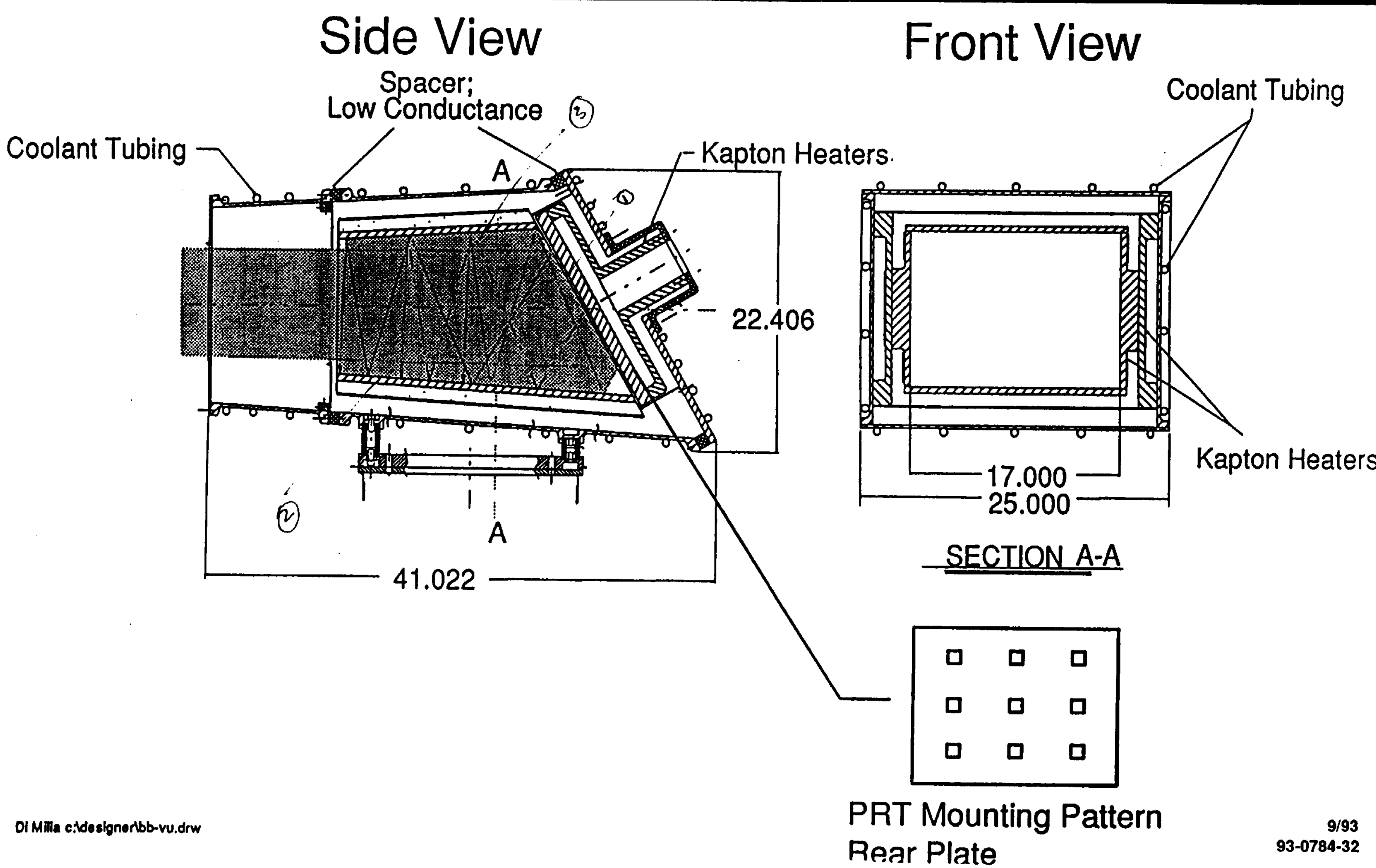

Di Milla c:\designer\bb-vu.drw

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CAVITY TEMPERATURE GRADIENTS MEET REQUIREMENTS DURING OPERATION IN VACUUM

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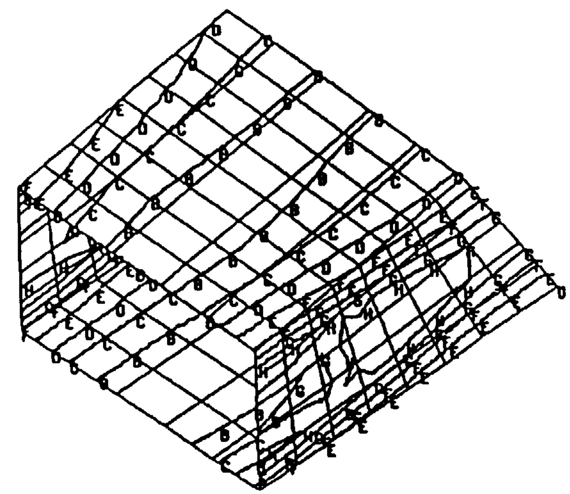
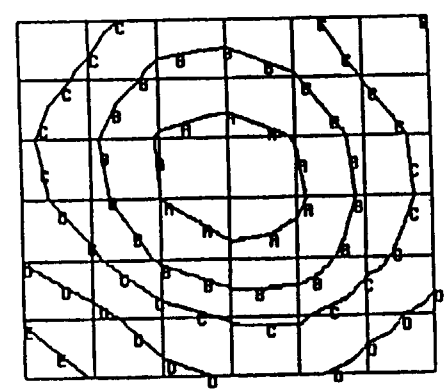
Thermal Gradients at 170 K

	Flowed Down Requirements	Analytical Prediction
1st Bounce	±.04K	±.03K
2nd Bounce	±.05K	±.03K
3rd Bounce	±.10K	±.03K
4th Bounce	±.25K	±.05K



20 mK per isotherm line



CINDA Model

- 1543 nodes
- 3686 linear conductors
- 386 radiative conductors

- **Thermal performance targets can be met for operation in vacuum.**
- **Analysis remaining for laboratory (in air) operation.**

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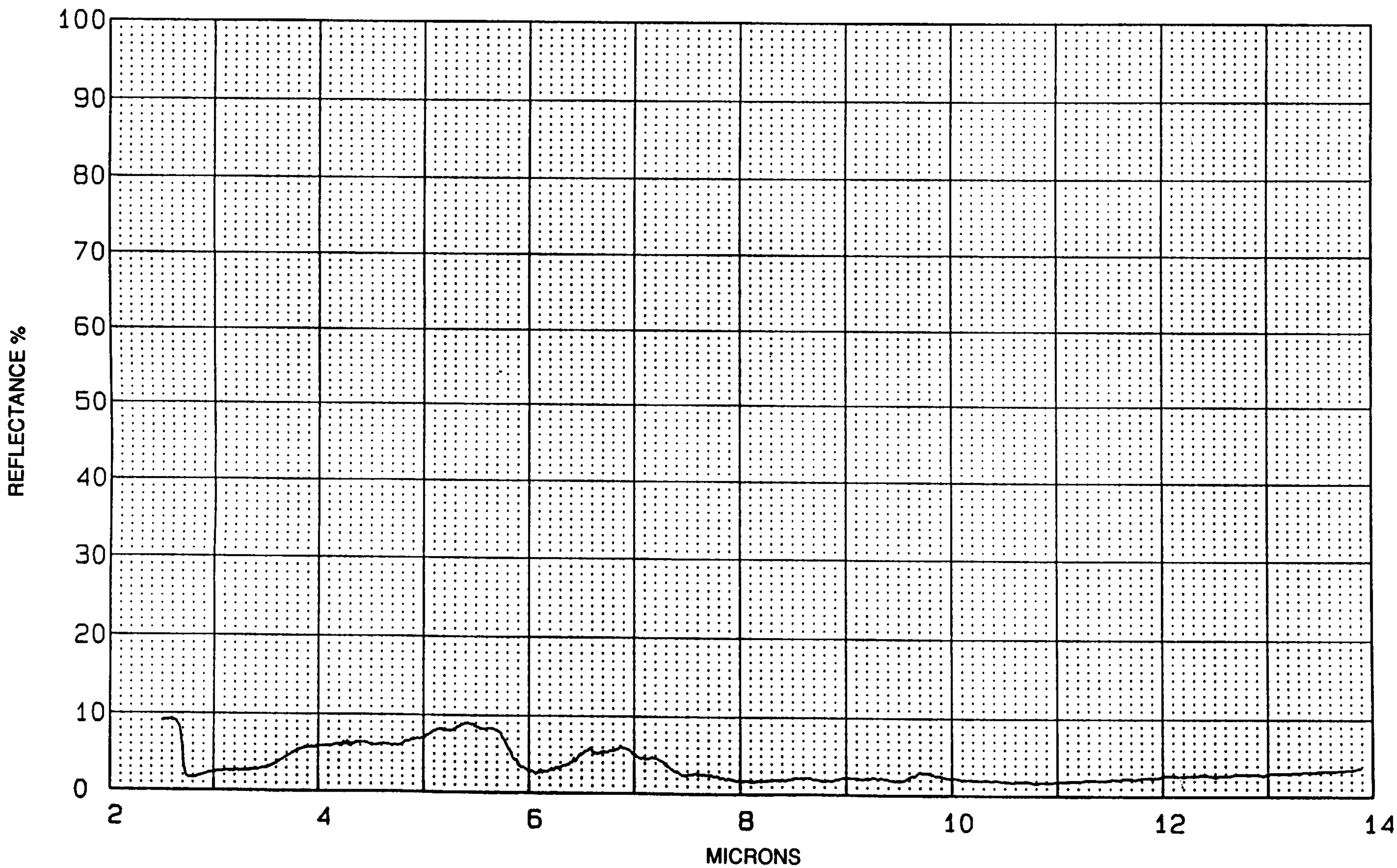
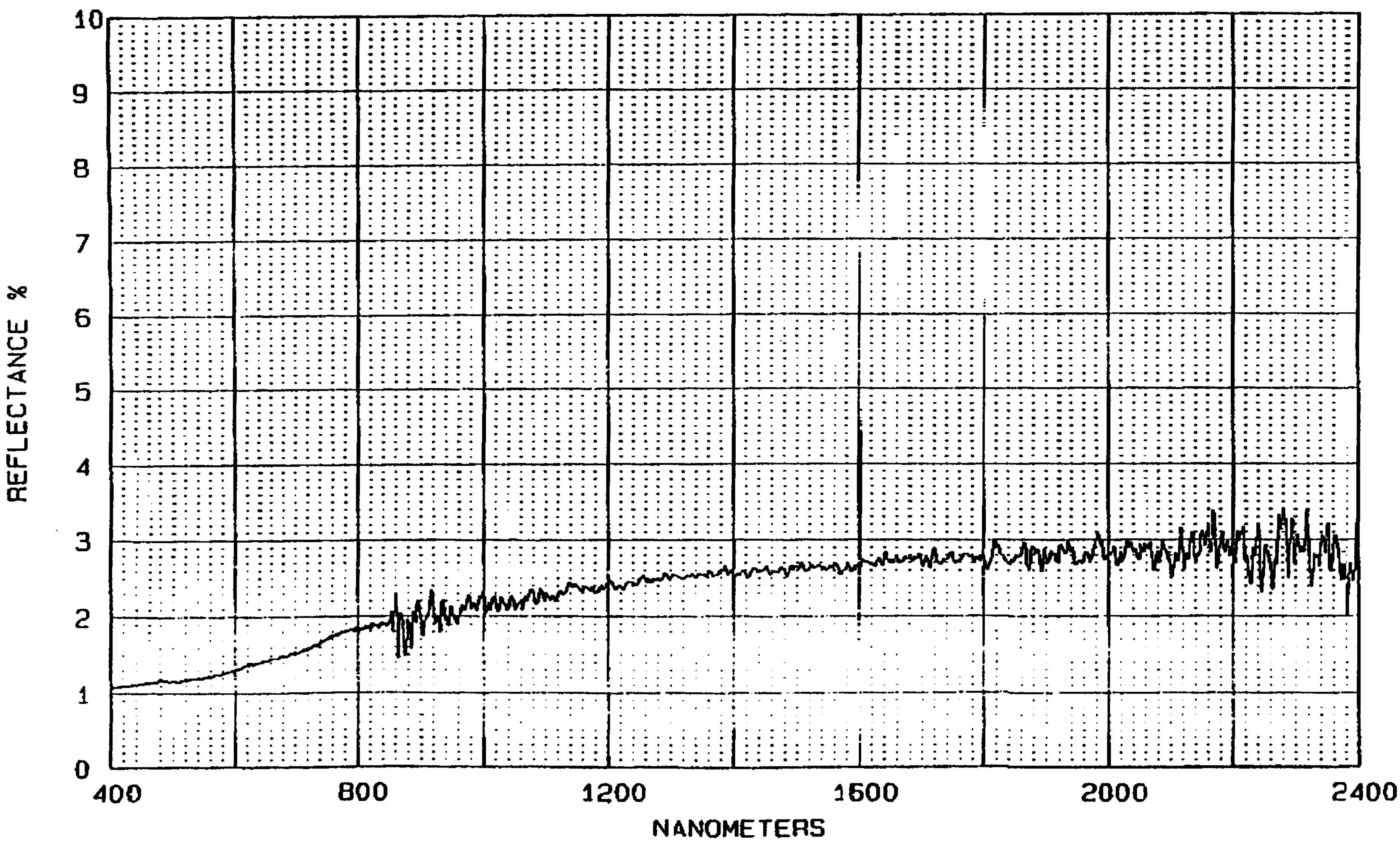
PROJECT	RE	GLA	PART	SERIAL	MATERIAL	POLAR	AOI	FILENAME
MODIS	DIMILIA	VKC7	ANAPLEX	2	12 IN AL	N/A	12	RU930609.P01
SIDE 1 ANAPLEX ANODIZE (POLISHED)								



PROJECT	RE	GLA	PART	SERIAL	MATERIAL	POLAR	AOI	FILENAME
MODIS	DI MILIA	VKC7	ANODIZE	ANAPLEX	ALUMINUM	N/A	12	RA930828.H01
	VISIBLE NIR REFLECTANCE OF ANAPLEX ANODIZE							



PROPOSED GSE AMBIENT TEST TOPOLOGY

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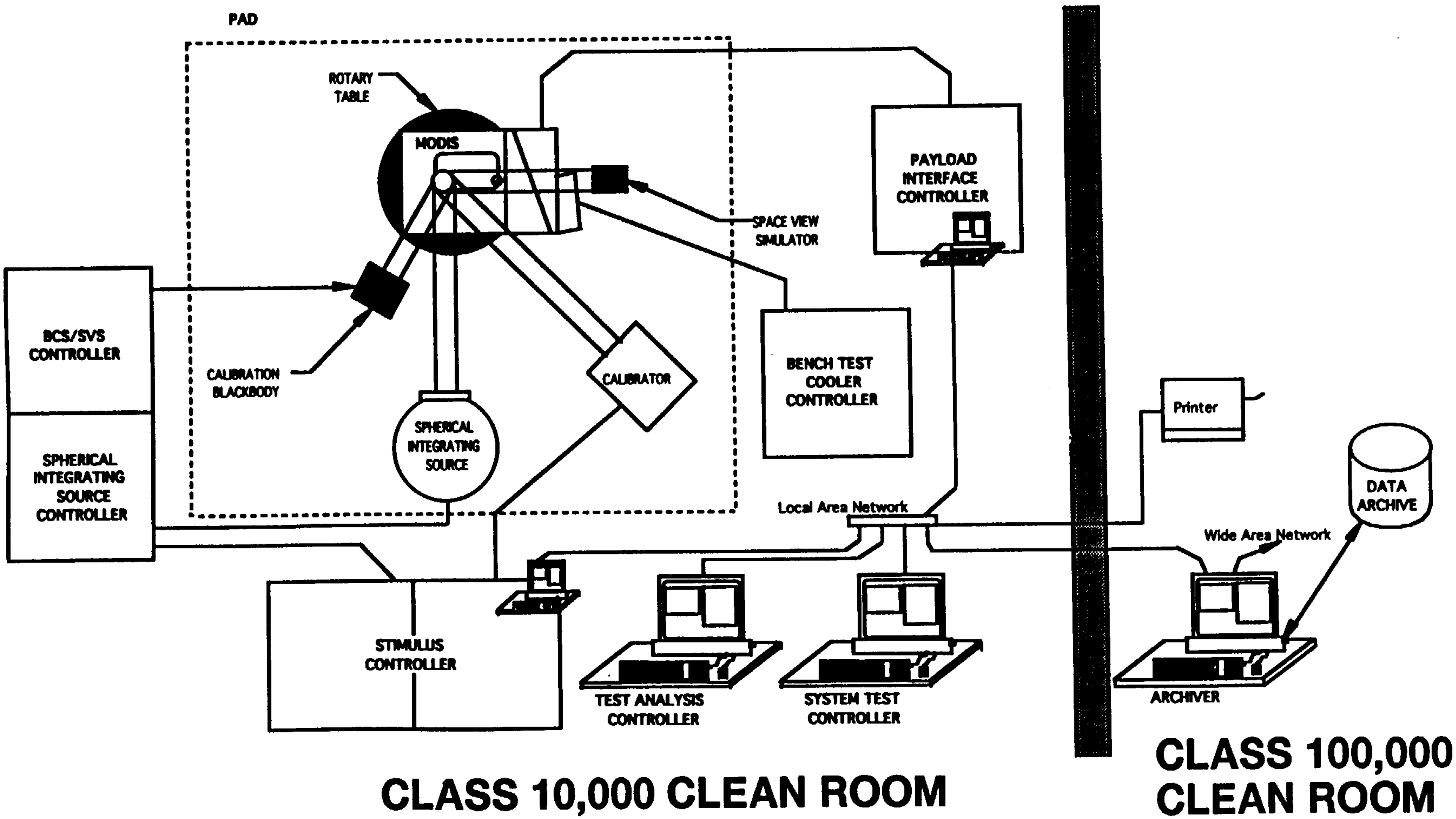

B32 CLASS 10,000 CLEAN ROOM PROPOSED MODIS TEST LAYOUT

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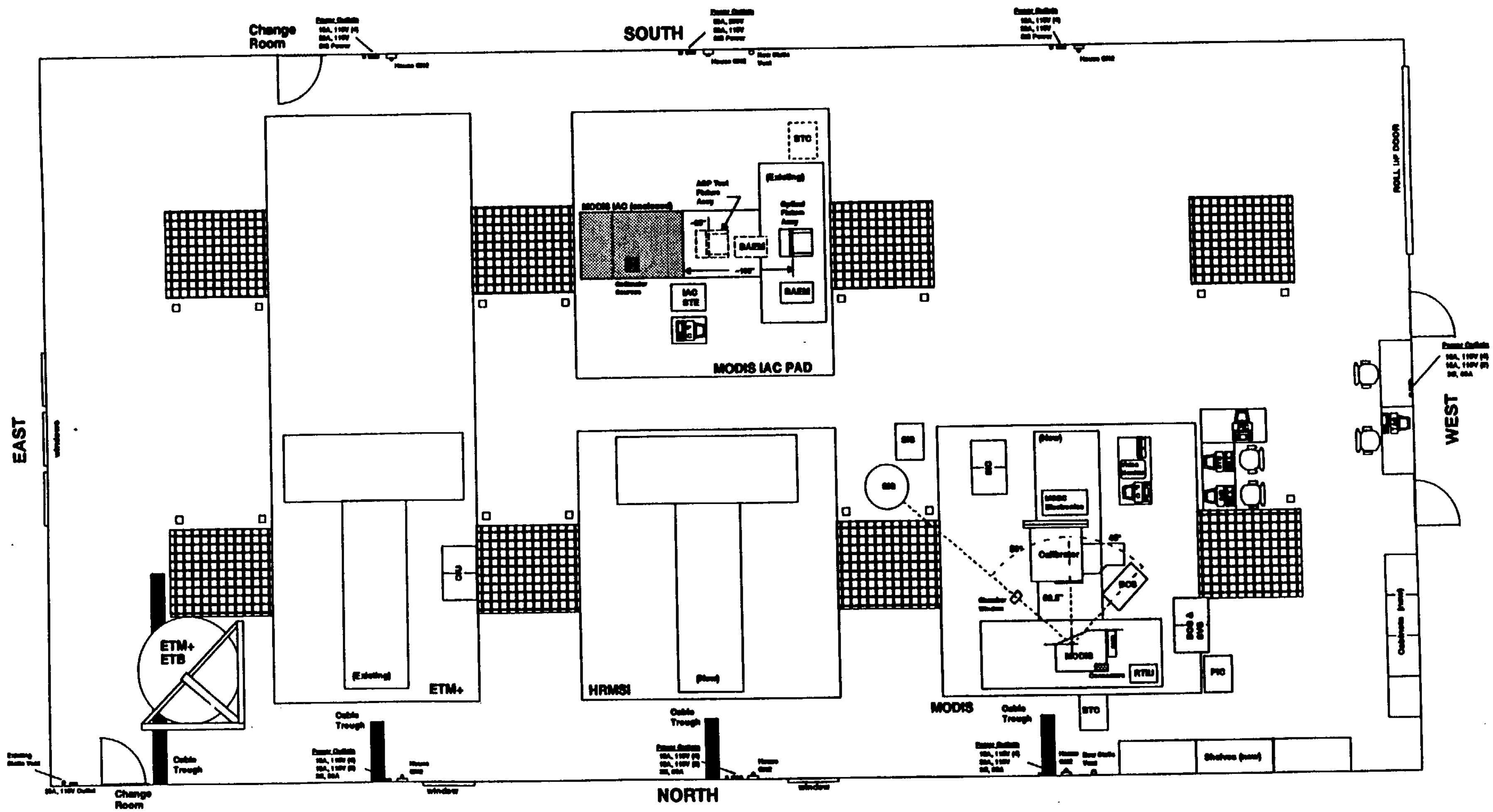

EXPANDED VIEW INTEGRATION AND ALIGNMENT LAYOUT

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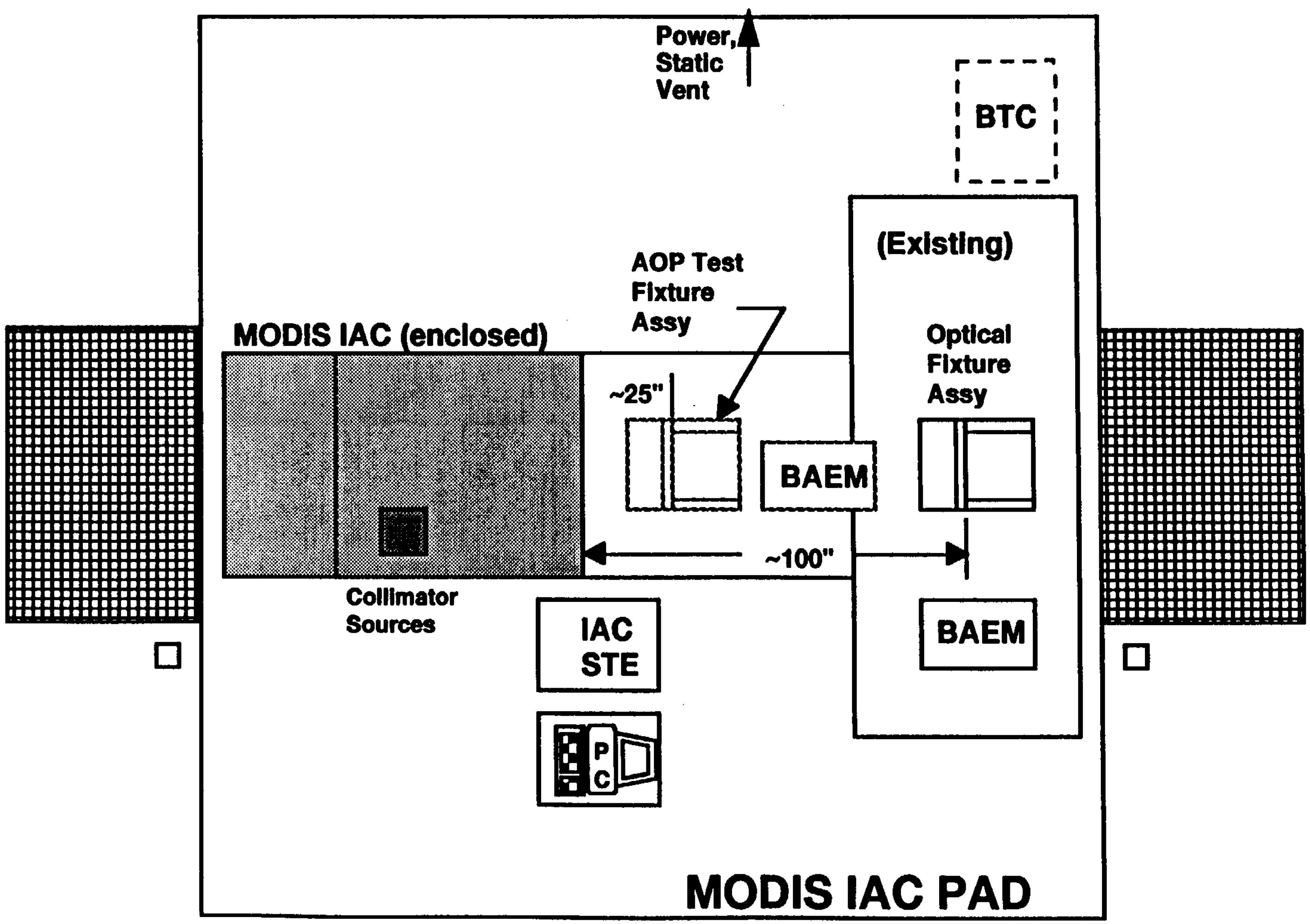

EXPANDED VIEW SYSTEM AMBIENT TESTING LAYOUT

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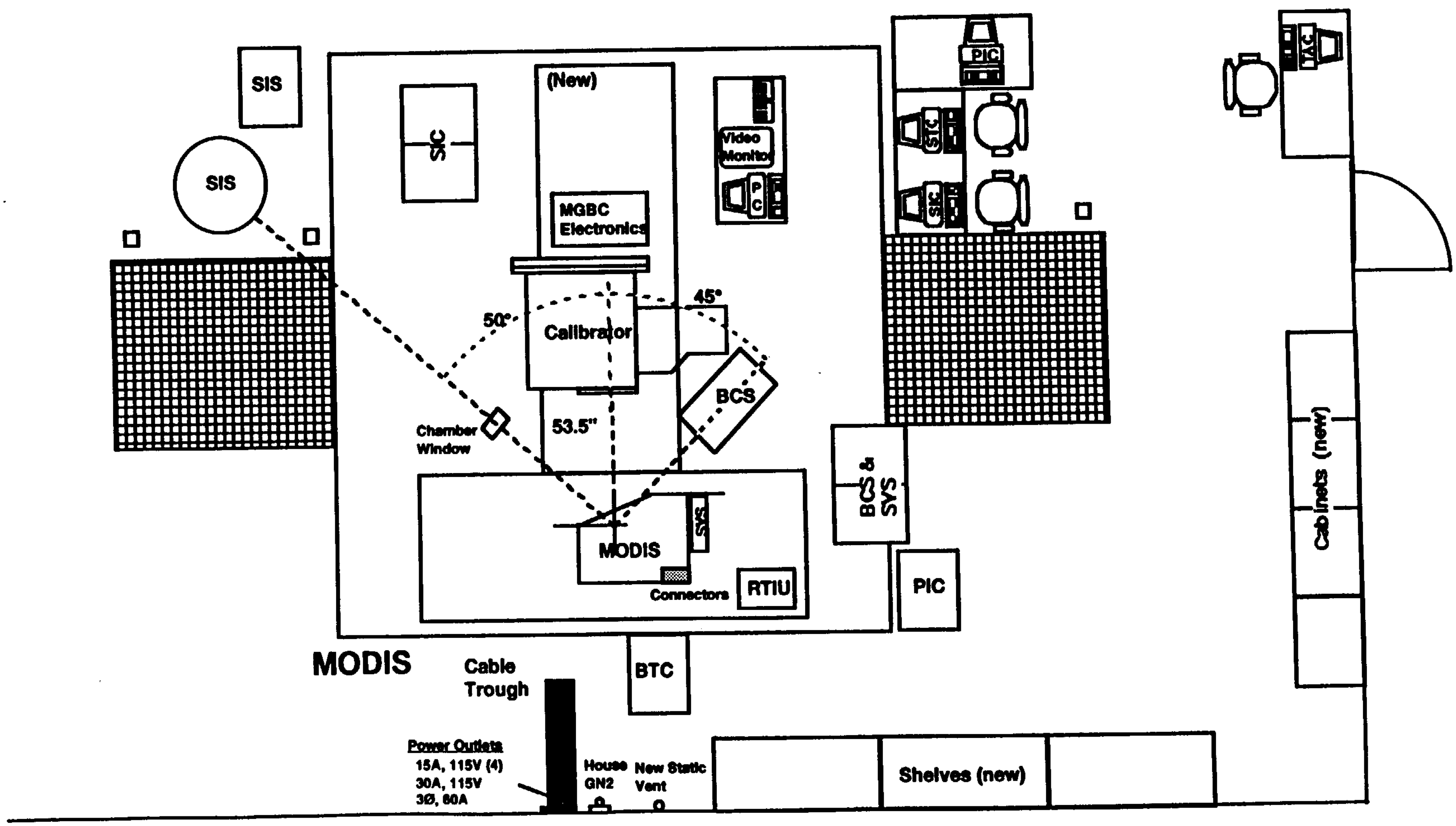

DEDICATED MODIS CALIBRATION FACILITY PROGRESS

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- Preliminary design completed
  - Studies have focused on mechanical interface of Calibrator and MODIS
  - Rugged platform provides vibration stability
  - Alignment may be re-established between the MGBC and MODIS following pump down
- Instrumenting similar HAC chamber for vibration data
- Blackbody Calibration Source mounting details being defined
- SBS cold head cryopumps perturbations being analyzed
- Analysis of induced jitter at reticle image on MODIS focal plane underway
- Completion of development specification planned in October

MODIS DEDICATED CALIBRATION FACILITY PROPOSED LAYOUT

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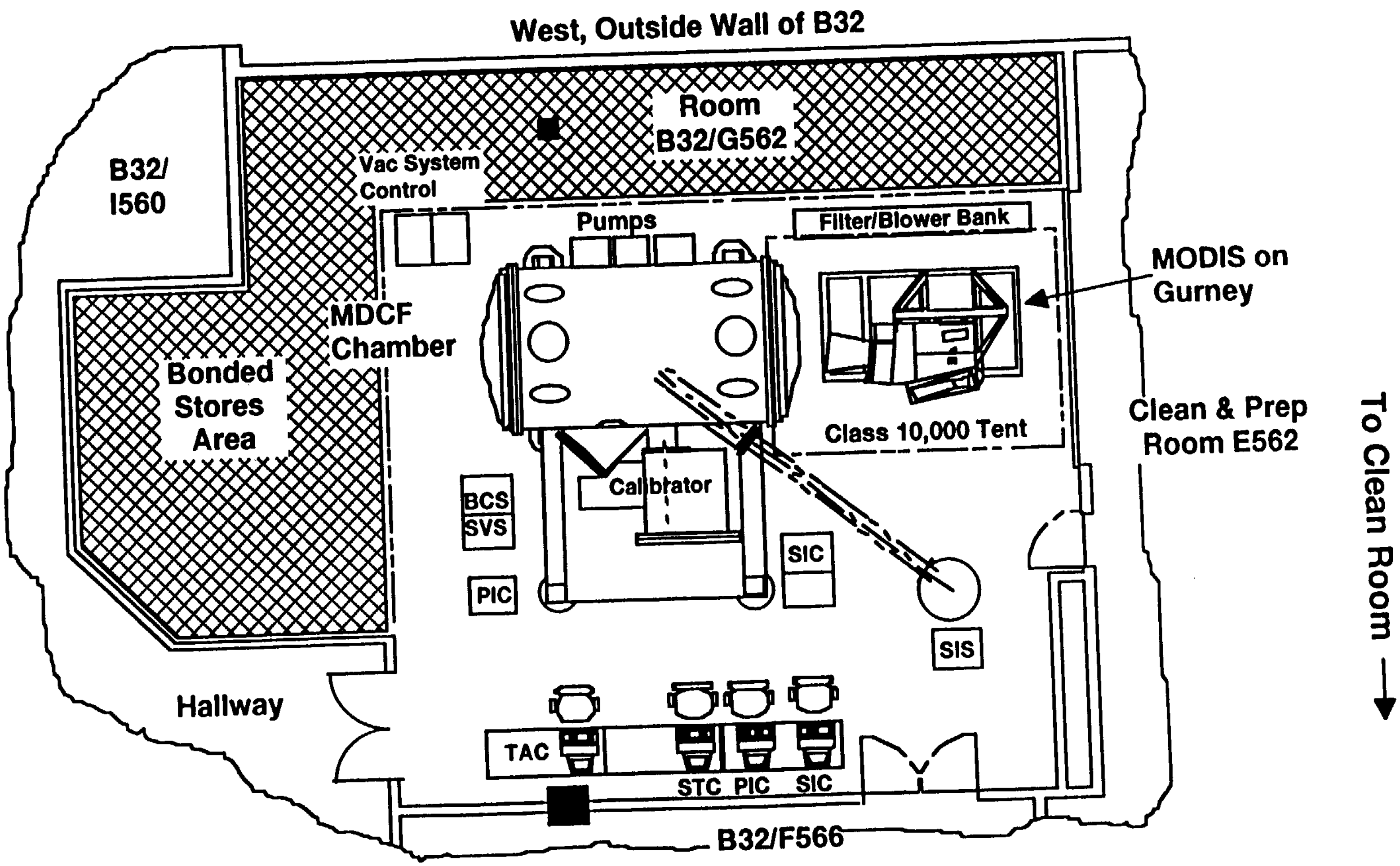

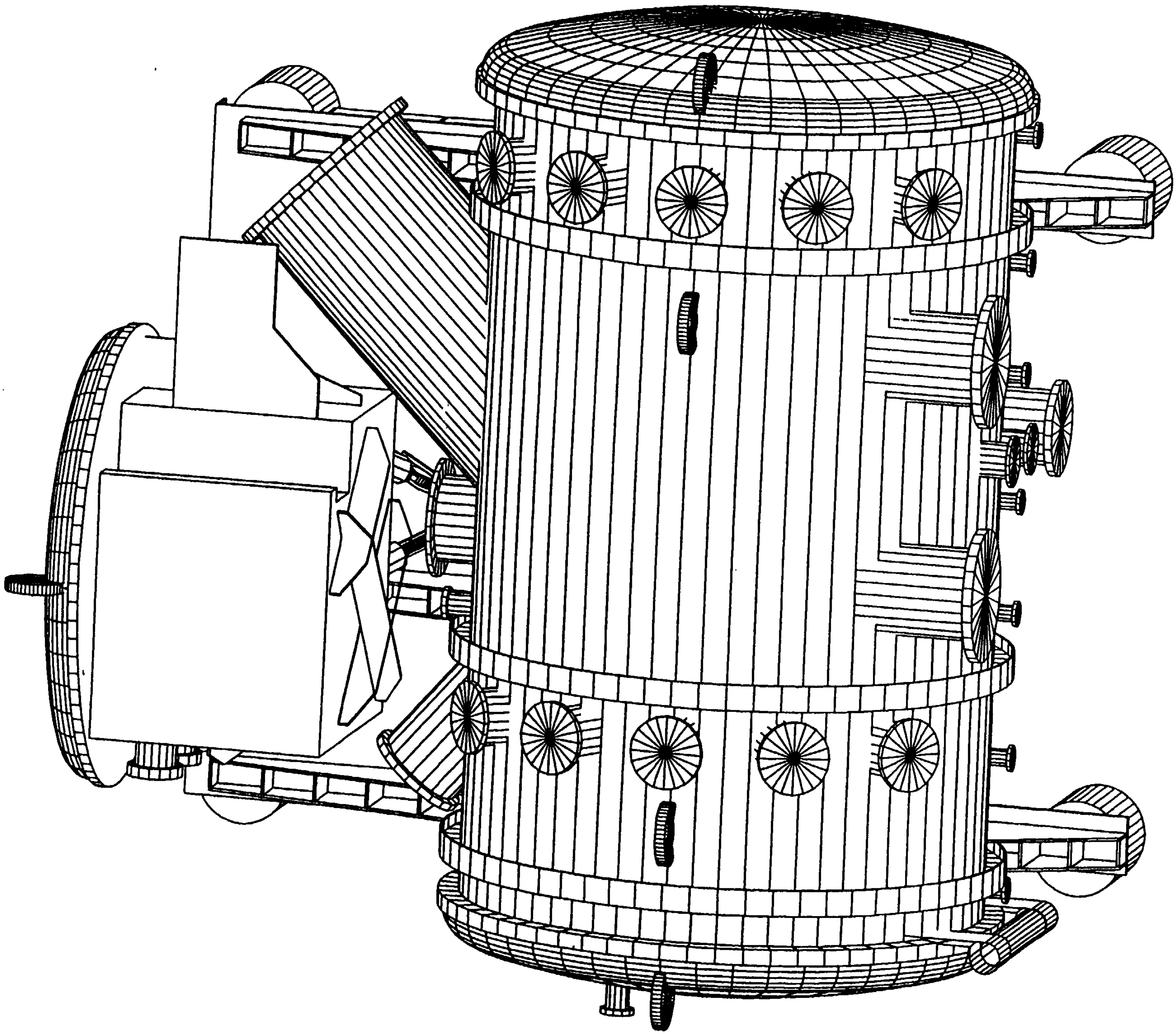

SYSTEM TEST ALGORITHMS (AGENDA FOR 9/8/93)

- ALGORITHM MATRIX/STATUS
- DISCUSSION OF 5 ALGORITHMS
  - RADIOMETRIC PERFORMANCE/ACCURACY (PARTIALLY COMPLETE)
    - CHARGE SUBTRACTION/INITIAL GAINS, OFFSETS/LINEARITY
  - SNR
  - IFOV
  - MTF
  - BAND TO BAND REGISTRATION
- OOB CALCULATION

SPEC	SBRC 151759 PAR #	SBRC 151868/9 APPENDIX	% COMPLETE
OPTICAL PERFORMANCE	3.3		
IFOV	3.3.1	D	100
FOV	3.3.2	D	80
SPECTRAL BANDS	3.3.3		
WL, OOB, RIPPLE	3.3.3.2-4	C	10
SENSITIVITY	3.3.4	G	50
INSTRUMENT POLARIZATION INSENSITIVITY	3.3.5	O	10
SYSTEM PERFORMANCE	3.4		
DYNAMIC RANGE	3.4.1	F, G	50
MTF	3.4.2	M	100
MINIMUM QUANTIZING RESOLUTION	3.4.3	Elec Ver.	10
TRANSIENT RESPONSE	3.4.4	N	50
RADIOMETRIC PERFORMANCE	3.4.5		
ABSOLUTE RADIOMETRIC ACCURACY	3.4.5.2	K	50
RELATIVE RADIOMETRIC ACCURACY	3.4.5.3		
RMS DEVIATION	3.4.5.3.1	F, G	10
CHAN TO CHAN UNIFORMITY	3.4.5.3.2	F, G	10
CROSSTALK AND PATTERN NOISE	3.4.5.3.3	I, L	10
UNIFORMITY ACROSS IFOV	3.4.5.3.4	D	10
GEOMETRIC PERFORMANCE	3.4.6		
POINTING, ALIGNMENT, SPECTRAL BAND REGISTRATION	3.4.6.1-3	P, Q	75
RADIOMETRIC AMP, STABILITY AND REPEATABILITY	3.4.7	H	10
STRAY LIGHT	3.4.8		
BRIGHT, DARK, WARM TARGETS	3.4.8.2-4	E	75
IN-FLIGHT CALIBRATION	3.4.9		
IN-FLIGHT RADIOMETRIC CALIBRATION	3.4.9.1	S	10
IN-FLIGHT WAVELENGTH CALIBRATION	3.4.9.2	J	10
IN-FLIGHT REFLECTANCE CALIBRATION	3.4.9.3	R	10
IN-FLIGHT LUNAR CALIBRATION	3.4.9.4	T	10
IN-FLIGHT ELECTRONICS CALIBRATION	3.4.9.5	U	10
COMMAND, CONTROL, COMMUNICATION, AND TELEMETRY	3.5		
COMMAND AND CONTROL FUNCTIONS	3.5.1	B	20
INSTRUMENT DATA STREAM	3.5.2	A	90
INSTRUMENT HEALTH AND STATUS MONITORING	3.5.3	V	20

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ALGORITHM DEVELOPMENT HAS SHOWN EXCELLENT PROGRESS

MODIS
GSFC SBRC

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93-0784-44

INITIAL APPROACH ALGORITHM FOR WAVELENGTH CALIBRATION DEVELOPED

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- CHANGES IN NUMEROUS MONOCHROMATOR PARAMETERS WILL RESULT IN SHIFT IN SRCA SPECTRAL OUTPUT, $\Delta\lambda_{SRCA}$
- ALL CHANGES IN SRCA SPECTRAL PERFORMANCE ACCOUNTED FOR BY MEASURED CHANGE IN CENTROID GRATING ANGLES FOR DIDYMIUM BANDS, $\Delta\lambda_{SRCA} \alpha \ \Delta\theta_{didym}$
- DIDYMIUM BANDS' CENTROIDS MEASURED IN SAME MANNER AS MODIS W/ SIMILAR ERRORS
- MEASURED SPECTRAL CHANGES IN MODIS BANDS ARE CORRECTED FOR CHANGES IN SRCA SPECTRAL OUTPUT. DIFFERENCES IN GRATING ANGLE & DIFFRACTION ORDER BETWEEN MODIS AND DIDYMIUM MEASUREMENT MUST BE TAKEN INTO ACCOUNT.

$$\Delta\lambda_{MODIS} = \Delta\lambda_{\text{Measured}} - \Delta\lambda_{SRCA}$$

- $\Delta\lambda_{MODIS} = 2A\cos(\beta)\,[\cos(\theta_{MODIS})\,\Delta\theta_{MODIS}/M_{MODIS} - \cos(\theta_{didym})\,\Delta\theta_{didym}/M_{didym}$ $+ \Delta\theta_{didym}\{\sin(\theta_{didym})\,(\theta_{MODIS}-\theta_{didym})/M_{didym} + \cos(\theta_{didym})\,(M_{MODIS}-M_{didym})/M_{didym}\text{^}2\}]$

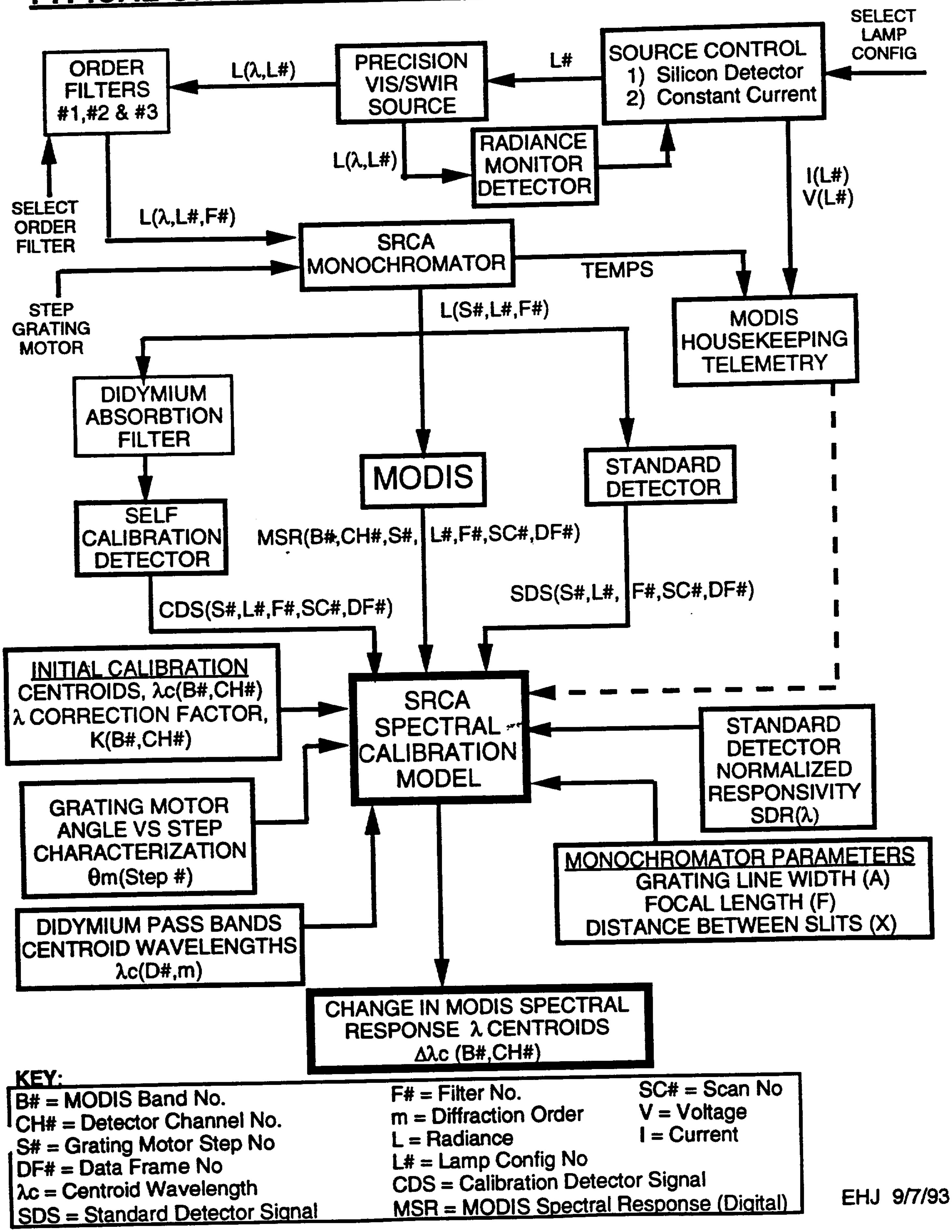
  (DEFININTIONS: A-Grating ruling spacing; ß- Czerny Turner half included angle; M- Diffraction Order; θ- Centroid grating angle)

- CHANGES IN MONOCHROMATOR GEOMETRY AFFECTING ANGLE OF INCIDENCE & ANGLE OF DIFFRACTION ARE DETERMINED FROM SOLUTION OF FOUR SIMULTANEOUS EQNS OBTAINED FROM SEVERAL DIDYMIUM MEASUREMENTS:

$$\lambda\,(\theta_{didym});\ \Delta\lambda/\Delta\theta_{didym};\ \Delta(\Delta\lambda)/\Delta\theta_{didym}\text{^}2;\ \Delta\theta_{didym}/\Delta M_{didym}$$

- TIME & GRATING ANGLE DEPENDENT UNCERTAINTIES ARE MINIMIZED BY SPACING DIDYMIUM CENTROID MEASUREMENTS THROUGHOUT GRATING'S ANGULAR RANGE & TIME INTERVAL (REPEATED EACH RADIANCE LEVEL) REQUIRED FOR MODIS SPECTRAL CALIBRATION

TYPICAL ON-ORBIT SPECTRAL CALIBRATION FLOW



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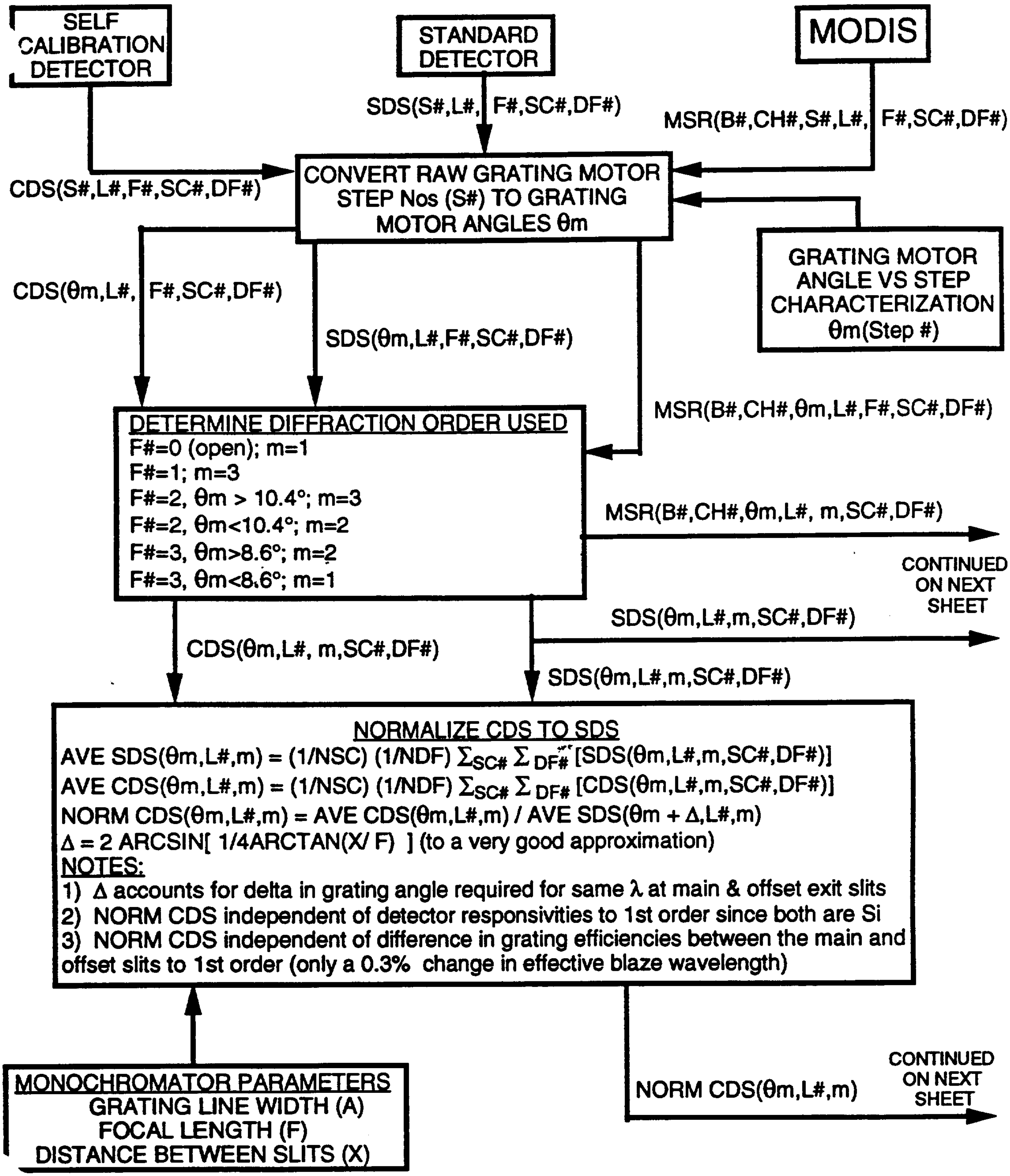
SPECTRAL CALIBRATION ALGORITHM FLOW



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CALCULATE TOTAL AVERAGE MSR NORMALIZED TO SDS

$$\text{NORM MSR}(B\#,CH\#,\theta m,L\#,m,SC\#,DF\#) = \frac{\text{MSR}(B\#,CH\#,\theta m,L\#,m,SC\#,DF\#)}{\text{SDS}(\theta m,L\#,m,SC\#,DF\#)}$$

$$\text{TOTAL AVE MSR}(B\#,CH\#,\theta m,L\#,m,) = (1/NSC)(1/NDF)\,\Sigma_{SC\#}\Sigma_{DF\#}\,[\text{NORM MSR}(B\#,CH\#,\theta m,L\#,m,SC\#,DF\#)]$$

SDS(θm,L#,m,SC#,DF#)

CONTINUED FROM PREVIOUS SHEET

MSR(B#,CH#,θm,L#,F#,SC#,DF#)

TOTAL AVE MSR(B#,CH#,θm,L#, m)

CONTINUED ON NEXT SHEET

ß (L#); OFFSET (L#)

DETERMINE

1) GRATING MOTOR ANGULAR OFFSET, $\theta_{offset}(L\#)$
2) CZERNY TURNER HALF INCLUDED ANGLE, ß (L#)

BY SIMULTANEOUSLY SOLVING FOLLOWING EQNS

Eqs 1-3: $\lambda c(D\#,m) = (A/m)\,\{\text{Sin}[\beta-\bar{\theta}m(L\#,m,D\#)-\theta_{offset}(L\#)] - \text{Sin}[\beta+\bar{\theta}m(L\#,m,D\#)+\theta_{offset}(L\#)+\delta]\}$

$$\delta = \text{ARC TAN}(X/F)$$

Eq 4: $\dfrac{\lambda c(D2,m=2) - \lambda c(D3,m=2)}{\bar{\theta}m(L\#,m=2,D2) - \bar{\theta}m(L\#,m=2,D3)} = \partial\lambda/\partial\theta m|_{@\theta m=?}$

Eq 5: $\dfrac{(m=3) - (m=2)}{\bar{\theta}m(L\#,m=3,D3) - \bar{\theta}m(L\#,m=2,D3)} = \partial m/\partial\theta m|_{@\theta m=?}$

MONOCHROMATOR PARAMETERS

GRATING LINE WIDTH (A)
FOCAL LENGTH (F)
DISTANCE BETWEEN SLITS (X)

$\bar{\theta}m(L\#,m,D\#)$

DIDYMIUM PASS BANDS CENTROID WAVELENGTHS
$\lambda c(D\#,m)$

CONTINUED FROM PREVIOUS SHEET

NORM CDS(θm,L#,m)

DETERMINECENTROID GRATING MOTOR ANGLES $\bar{\theta}m$ FOR DIDYMIUM PASS BANDS

$$\bar{\theta}m(L\#,m,D\#) = \frac{\Sigma_{\theta m}[\text{Norm CDS}(\theta m,L\#,m) * (\theta m)]}{\Sigma_{\theta m}[\text{Norm CDS}(\theta m,L\#,m)]}$$

DIDYMIUM PASS BANDS	DIFFRACTION ORDER	θm RANGE
D2	3	9.5° - 10.2°
D3	2	6.8° - 7.4°
D3	3	10.6° - 11.4°

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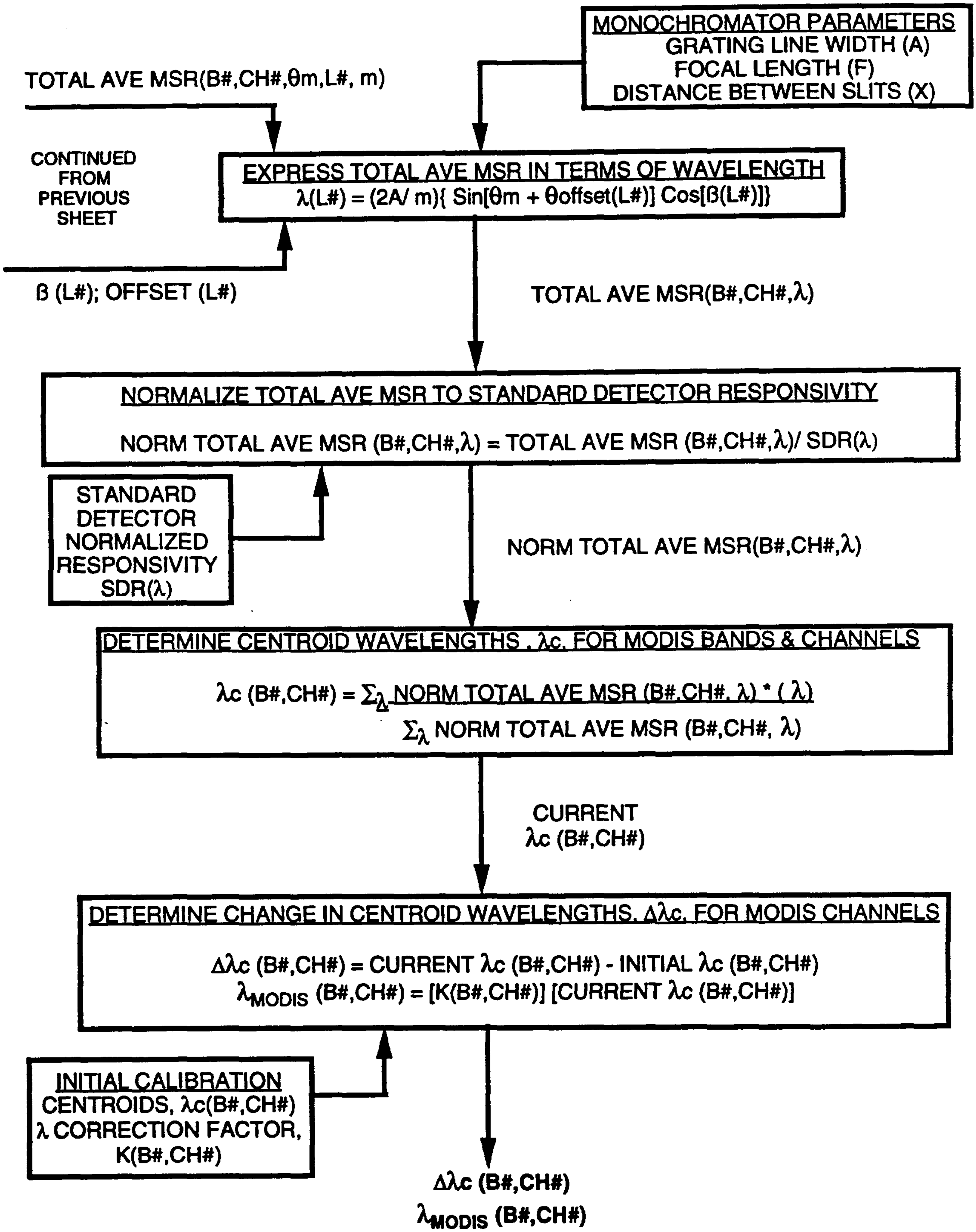
MONOCHROMATOR PARAMETERS
GRATING LINE WIDTH (A)
FOCAL LENGTH (F)
DISTANCE BETWEEN SLITS (X)
TOTAL AVE MSR(B#,CH#,θm,L#, m)
CONTINUED FROM PREVIOUS SHEET
EXPRESS TOTAL AVE MSR IN TERMS OF WAVELENGTH
λ(L#) = (2A/ m){ Sin[θm + θoffset(L#)] Cos[β(L#)]}
β (L#); OFFSET (L#)
TOTAL AVE MSR(B#,CH#,λ)
NORMALIZE TOTAL AVE MSR TO STANDARD DETECTOR RESPONSIVITY
NORM TOTAL AVE MSR (B#,CH#,λ) = TOTAL AVE MSR (B#,CH#,λ)/ SDR(λ)
STANDARD DETECTOR NORMALIZED RESPONSIVITY SDR(λ)
NORM TOTAL AVE MSR(B#,CH#,λ)
DETERMINE CENTROID WAVELENGTHS , λc, FOR MODIS BANDS & CHANNELS
λc (B#,CH#) = Σλ NORM TOTAL AVE MSR (B#,CH#, λ) * (λ) / Σλ NORM TOTAL AVE MSR (B#,CH#, λ)
CURRENT λc (B#,CH#)
DETERMINE CHANGE IN CENTROID WAVELENGTHS, Δλc, FOR MODIS CHANNELS
Δλc (B#,CH#) = CURRENT λc (B#,CH#) - INITIAL λc (B#,CH#)
λMODIS (B#,CH#) = [K(B#,CH#)] [CURRENT λc (B#,CH#)]
INITIAL CALIBRATION CENTROIDS, λc(B#,CH#) λ CORRECTION FACTOR, K(B#,CH#)
Δλc (B#,CH#)
λMODIS (B#,CH#)

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