Attachment 3.10

X-TRACK CALIBRATION ON ORBIT CONTAMINATION SCAN MIRROR MONITORING QMR SPLINTER MEETING

11 MARCH 1992

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CONTAMINATION EFFECTS ON CROSSTRACK CALIBRATION

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- **ASSUMPTIONS:**
  - CONTAMINATION LEVEL (5 YEAR) GSFC MODEL 55-77A THICKNESS
  - CONTAMINANT SPECIES: CARBON AND SILICON OXIDE
  - DEPOSITED AS CONTINUOUS THIN FILM
- SBRC MODELING DOCUMENTED IN "MODIS-N CROSSTRACK RADIOMETRIC CALIBRATION VARIATION AS A FUNCTION OF SCAN MIRROR CONTAMINATION" PL3095-N-00360
- CARBON CONTAMINANT HAS MUCH GREATER EFFECT THAN SILICON OXIDE
- "IF" GSFC AND SBRC MODELING IS CORRECT CONTAMINATION IS A MAJOR PROBLEM.
  NO EVIDENCE OF LANDSAT DEGRADATION DUE TO CONTAMINATION

11/91
91-0908-816

SCAN MIRROR SPECTRAL REFLECTANCE; AOI 37°; CARBON 0, 25A, 50A

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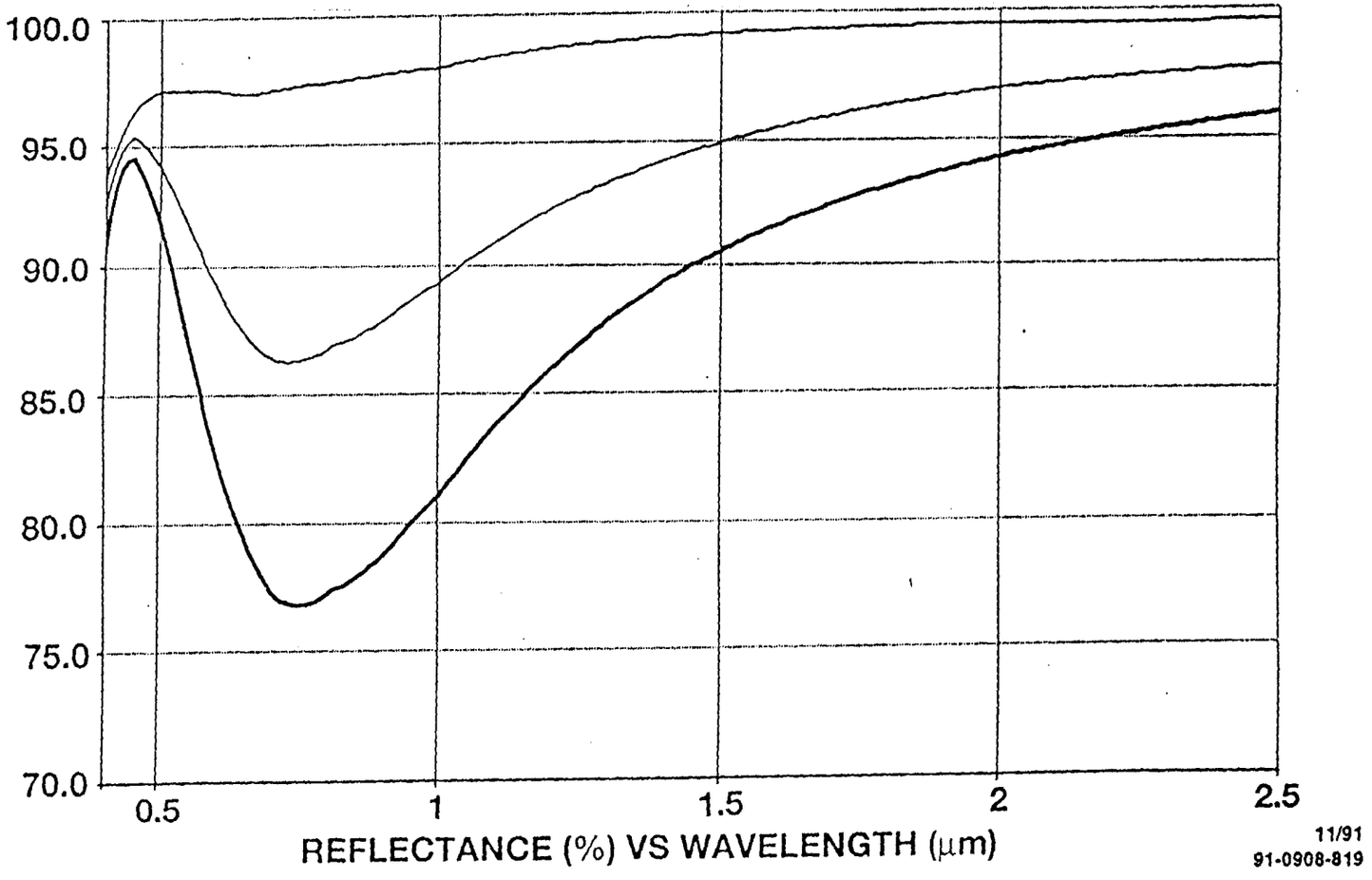

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91-0908-819

SCAN MIRROR SPECTRAL REFLECTANCE; AOI 37°; CARBON 0, 25A, 50A

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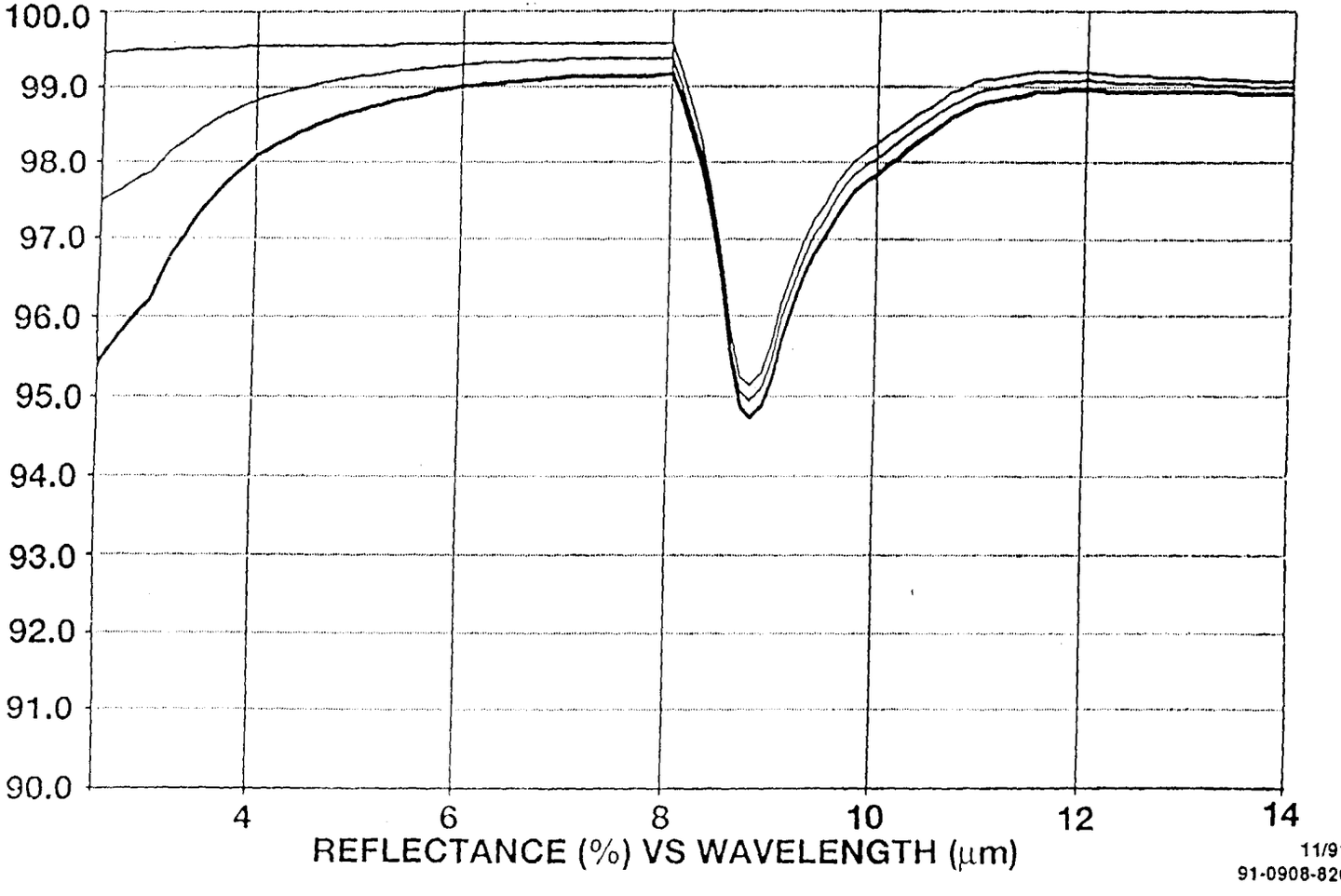

11/91
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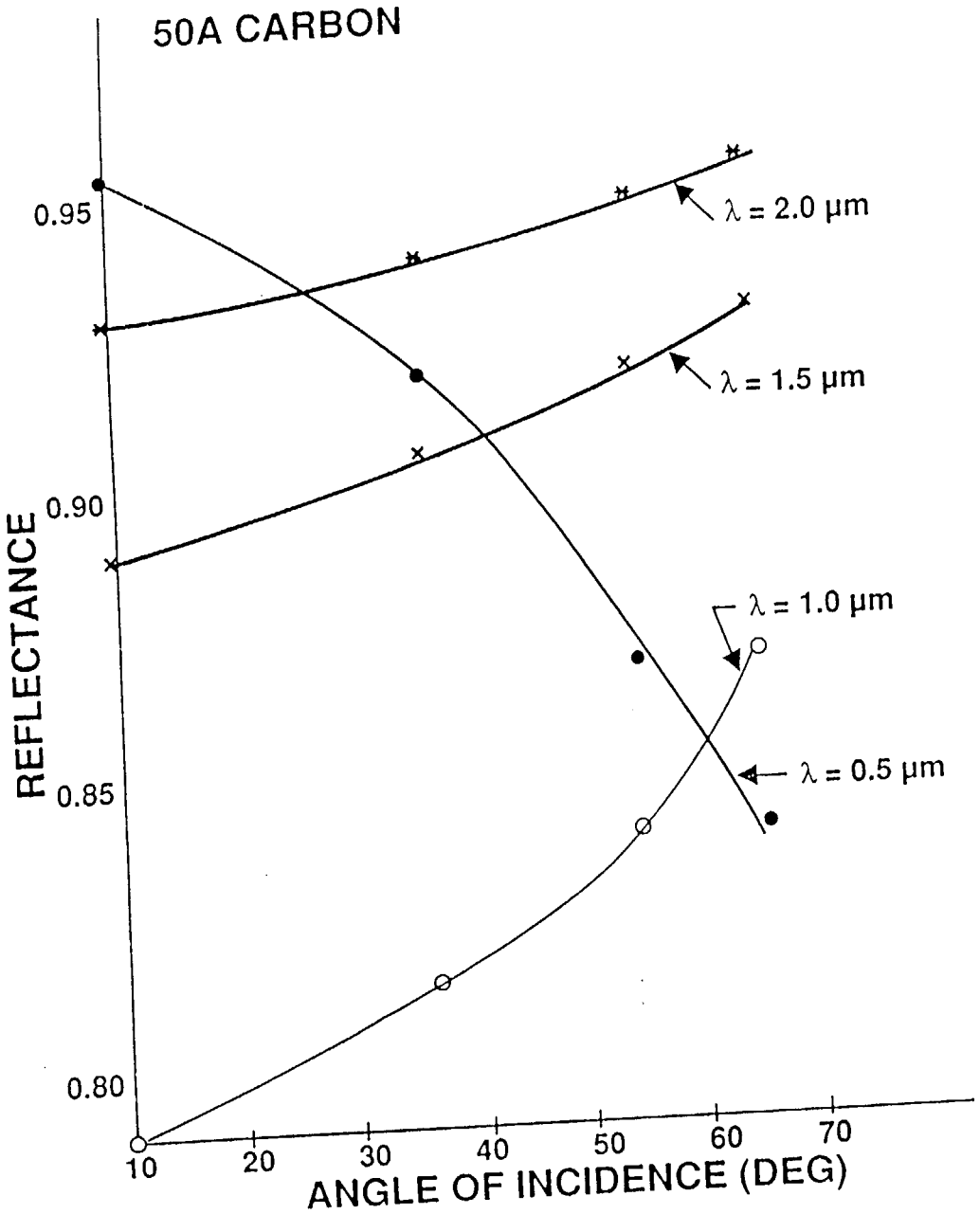

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EFFECT OF 50A CARBON CONTAMINATION ON SCAN MIRROR REFLECTANCE IN VIS/NIR/SWIR REGIONS

MODIS-N

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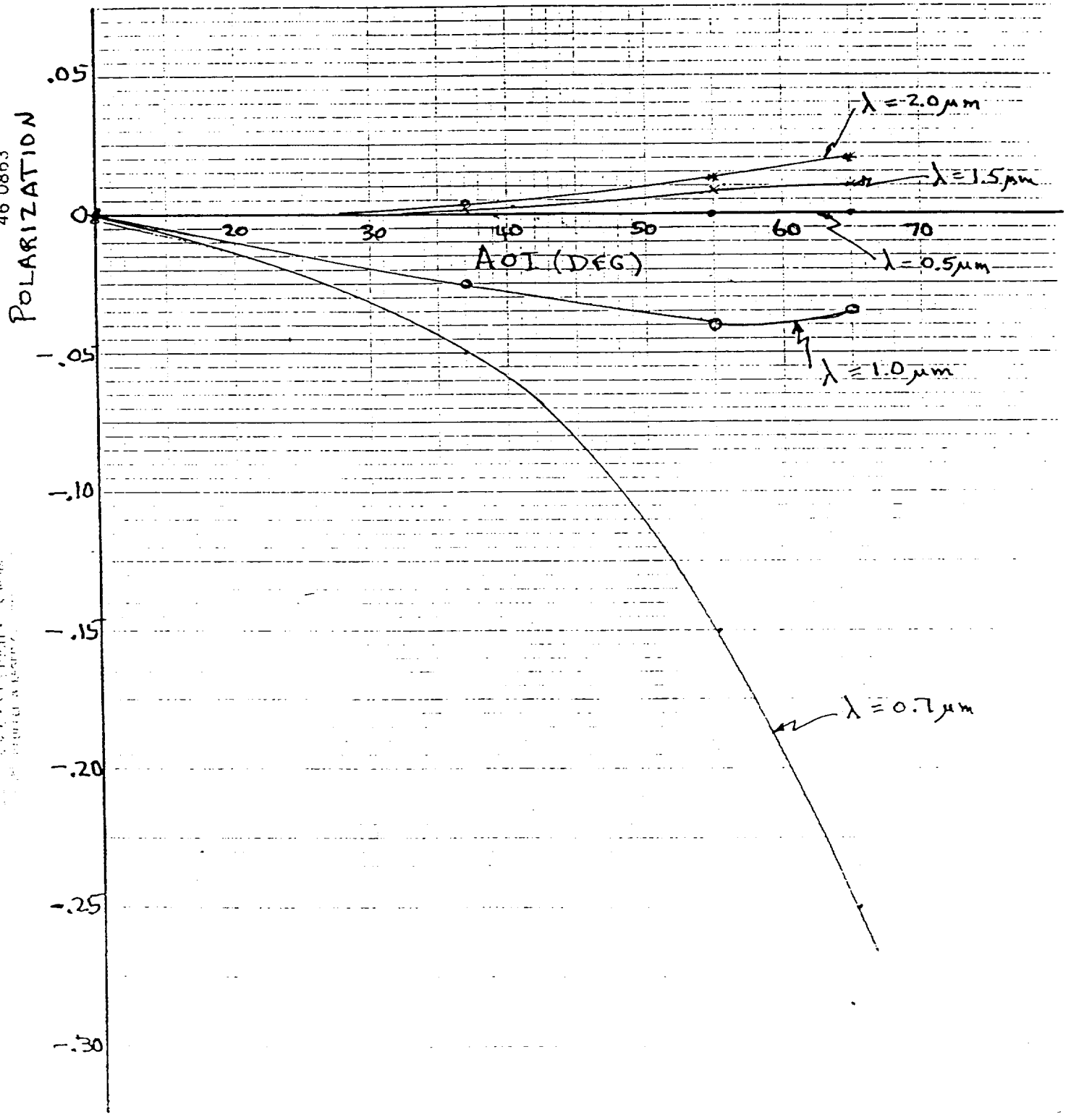
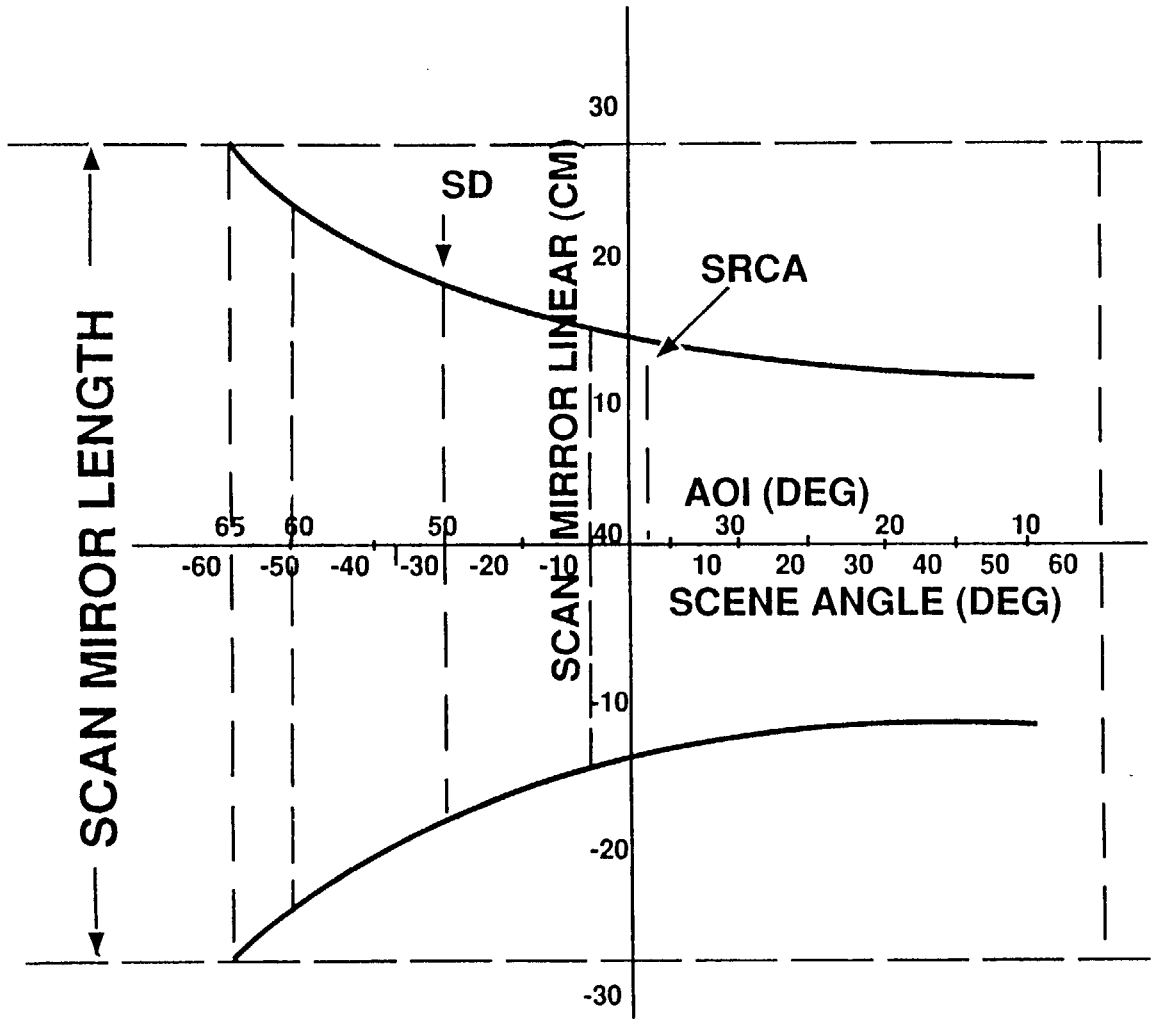
91-0908-821

Figure 27 Polarization as a function of AOI for selected wavelengths in VIS/NIR/SWIR
Contaminant: Carbon 50A





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WITH ON ORBIT CONTAMINATION CROSS TRACK CALIBRATION DEPENDENT UPON ρ VS. AOI

MODIS-N

GSFC SBRC

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ON ORBIT MONITORING METHODS

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- MODIFY SRCA (INCLUDING ADDITIONAL DETECTORS)
- LAMPS (W/O OPTICS) LOCATED IN SCAN MIRROR CAVITY
  - USE MODIS-N SYSTEM DETECTORS
  - SNR MODEL GENERATED
- POSSIBLE USE OF SOLAR SOURCE
  - SDSM TYPE DETECTION
  - METHOD OF USING SUN - NOT KNOWN
- GROUND TRUTH USING UNDER FLIGHTS
  - SIMILAR TO AVHRR

EVALUATION OF CONTAMINATION METHODOLOGY

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EVALUATION MATRICES					
PERCEIVED REQUIRED CALIBRATION DATA IMPORTANCE					
SCAN MIRROR	VIS	NIR	SWIR	MWIR	LWIR
SPATIAL	LOW	LOW	LOW	LOW	LOW
SPECTRAL	HIGH	HIGH	MODERATE	LOW	LOW
ANG OF INC	HIGH	HIGH	MODERATE	LOW	LOW
POLARIZATION	MODERATE	MODERATE	LOW	LOW	LOW
DIFFICULTIES ASSOCIATED WITH STRAWMAN MEASUREMENT METHOD					
SCAN MIRROR	VIS	NIR	SWIR	MWIR	LWIR
SPATIAL	HIGH	HIGH	HIGH	HIGH	HIGH
SPECTRAL	MODERATE	MODERATE	HIGH	HIGH	HIGH
ANG OF INC	MODERATE	MODERATE	HIGH	HIGH	HIGH
POLARIZATION	HIGH	HIGH	HIGH	HIGH	HIGH

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RADIOMETRIC/POLARIMETRIC PERFORMANCE STRONGLY DEPENDENT UPON:

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- CONTAMINANT TYPE - N,K
- CONTAMINANT THICKNESS
- FORMATION - CONTINUOUS FILM VS "CLUMPS"
- CROSSTACK ANGLE - AOI
- SPECTRAL LOCATION

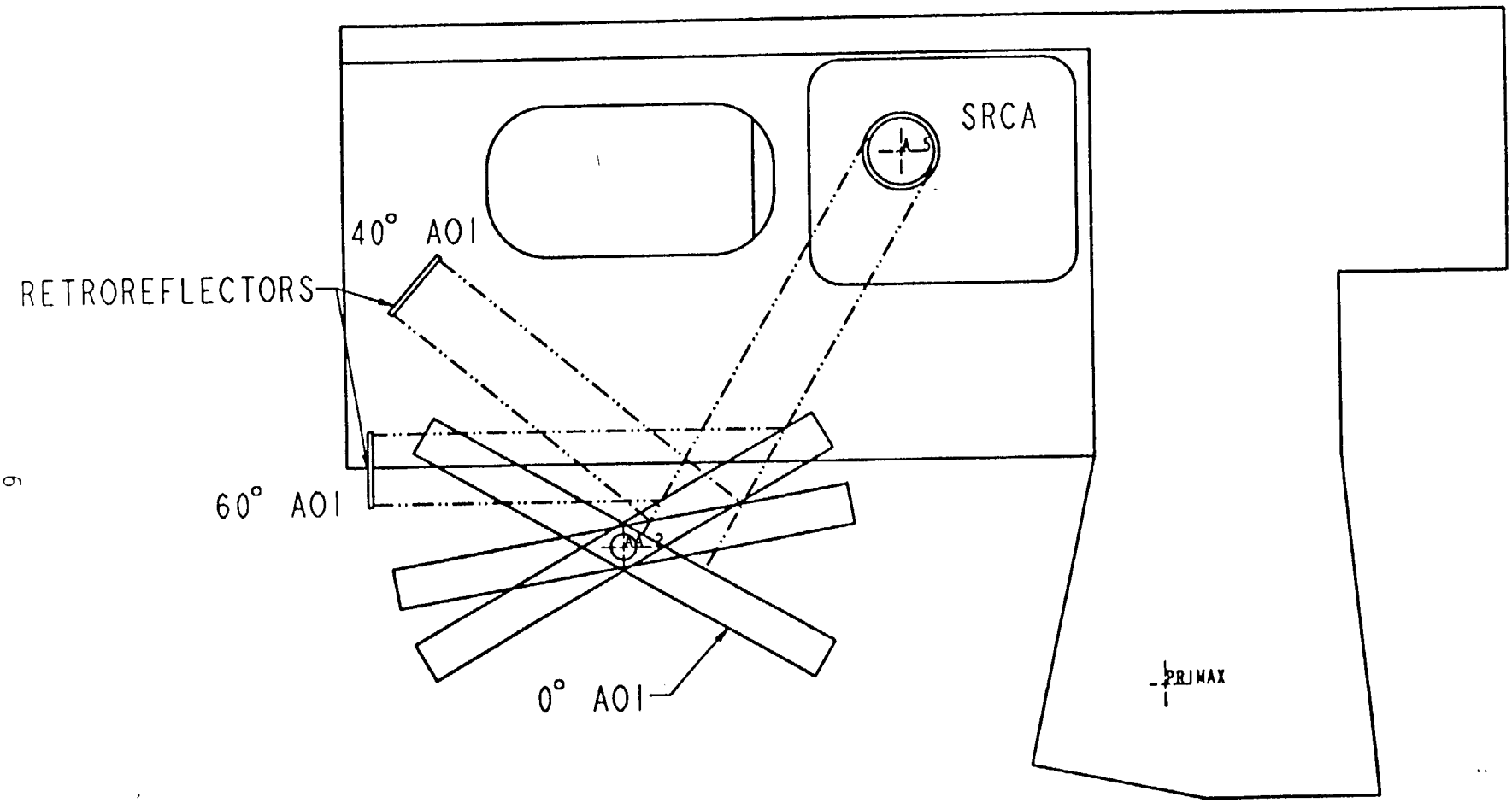

Figure 3 Use of modified SRCA to achieve scan mirror reflectance measurement at AOI: 0°, 40°, 60°.

SRCA HARDWARE MODIFICATIONS

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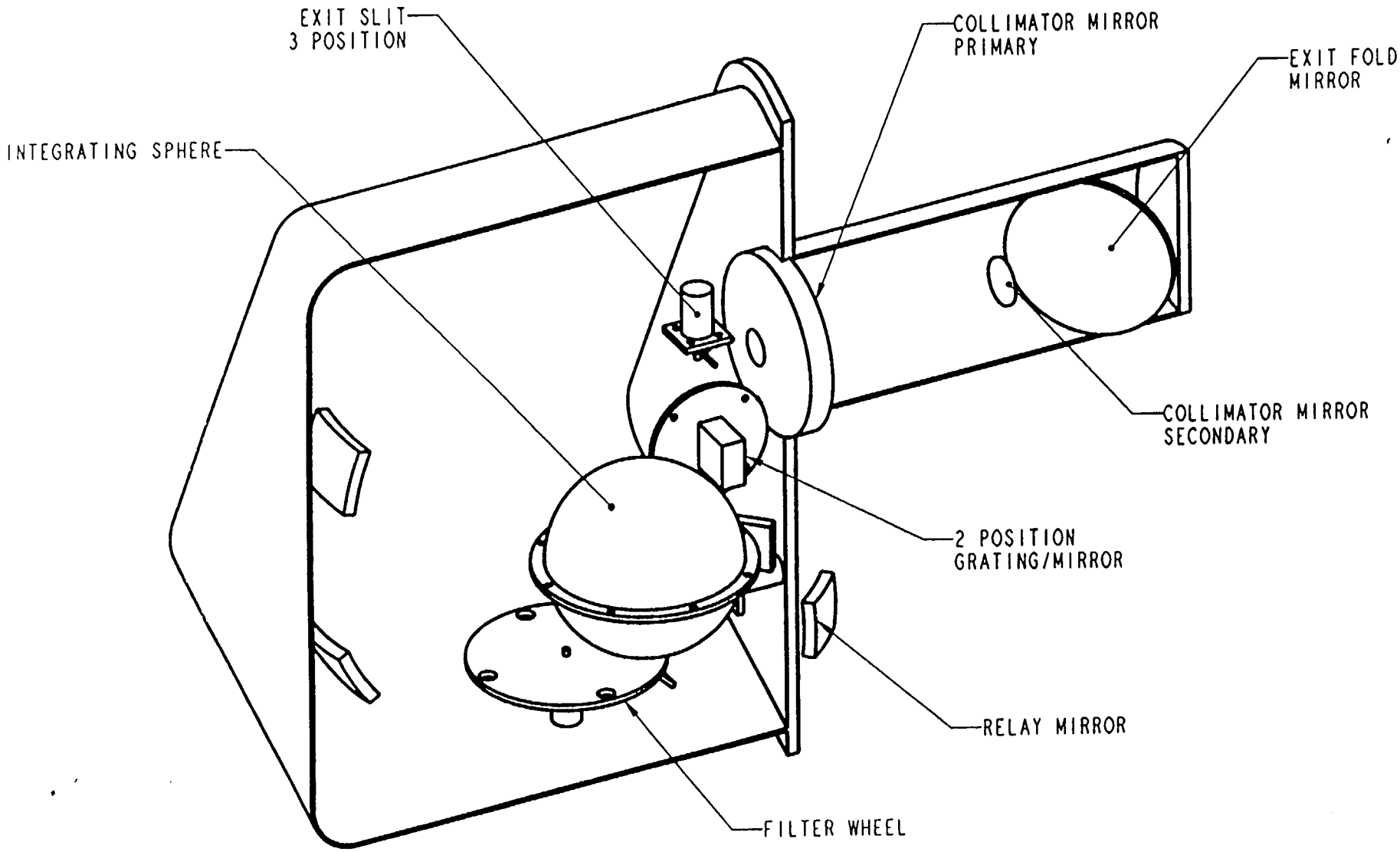
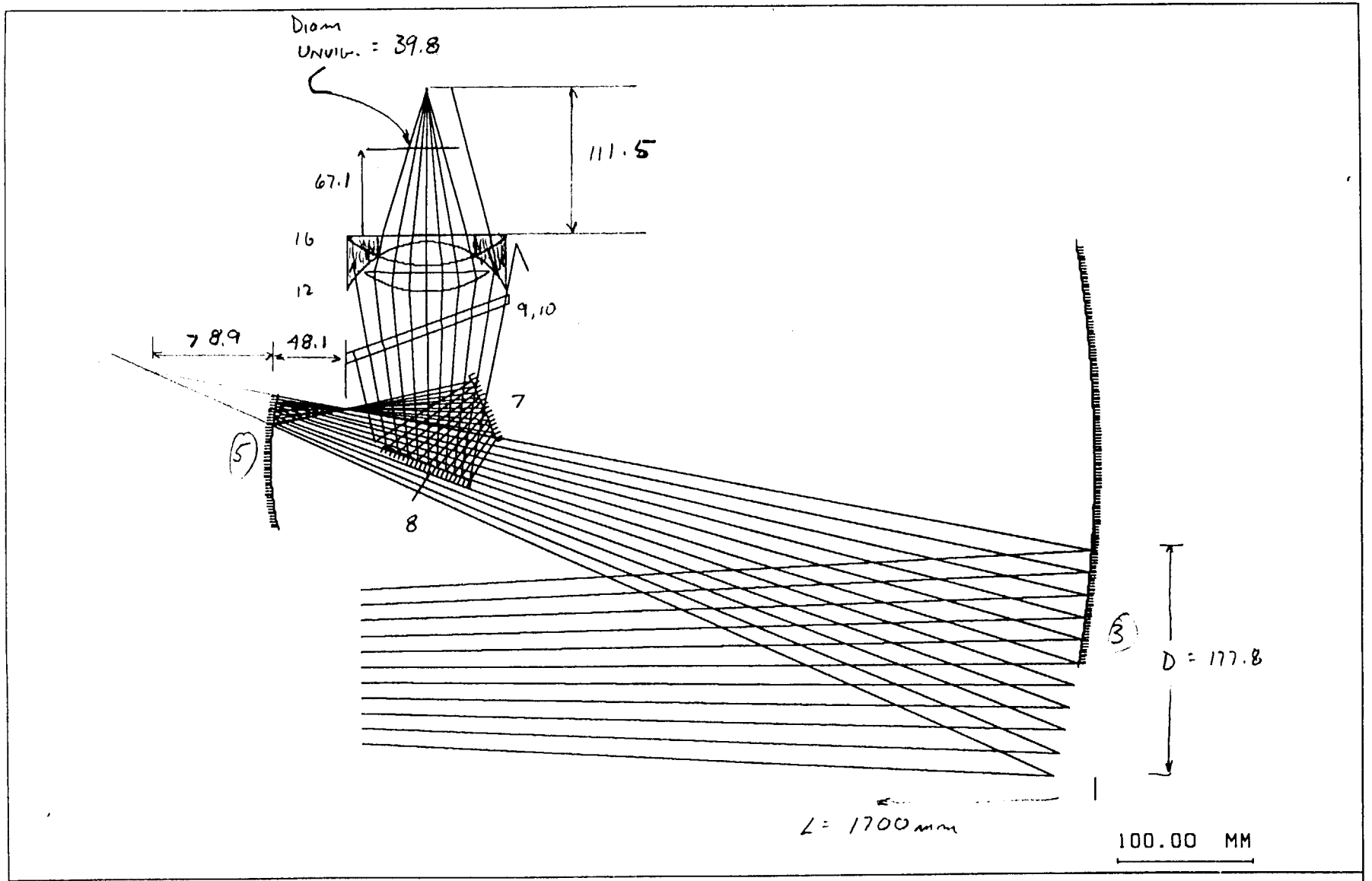
- TWO RETROREFLECTORS
- Si DETECTOR AT EXIT SLITS
- SET OF ORTHOGONAL POLARIZERS/ORDER FILTERS
- TILTABLE FOLD MIRROR - SELF CALBIRATION


EXIT SLIT
3 POSITION
COLLIMATOR MIRROR
PRIMARY
EXIT FOLD
MIRROR
INTEGRATING SPHERE
COLLIMATOR MIRROR
SECONDARY
2 POSITION
GRATING/MIRROR
RELAY MIRROR
FILTER WHEEL



NEW BASELINE VIS OBJ. SCALE: 0.25 JWF 6-MAR-92

Save, (Y)es or (N)o <Yes> ?

Contam 2

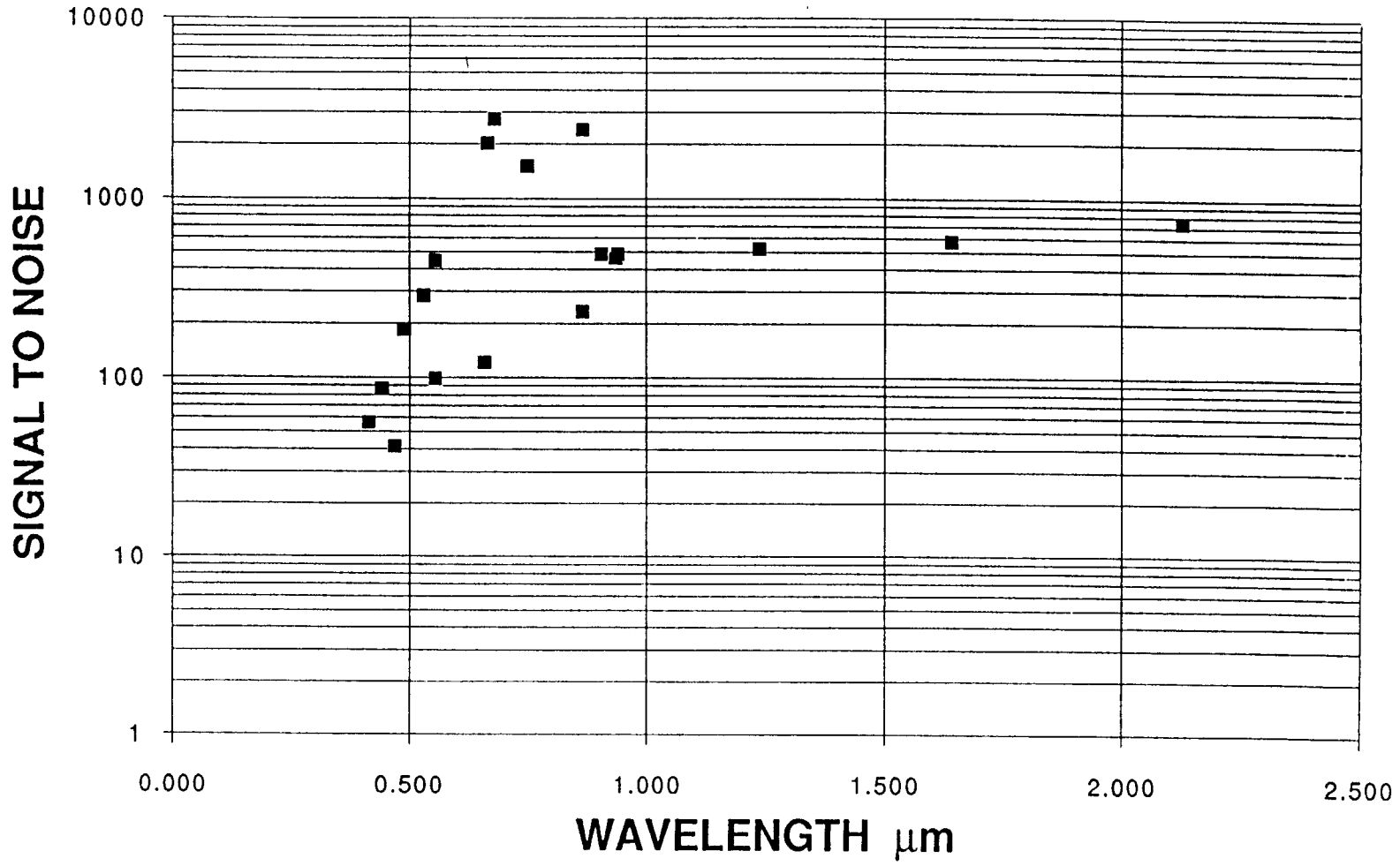
THIS IS A REVIEW OF THE POSSIBILITY OF USING A LAMP
IN THE SCAN MIRROR CAVITY TO MONITOR CONTAMINATION
THE EQUATIONS TO BE USED INCLUDE:
Ffs=K*Emiss w*L*Ωent*Fdet/(4*Pl*Lmax*(Ω*A)modis)
Emiss w=(0.7641-.0000875*Temp)*EXP(-(.759-.0001488*Temp)*Wln)
L=11905.7/(Wln^5*(EXP(14388/Temp/Wln)-1)
K=Pe*Conv eff/(∑Emiss w*L*ΔWln) where ∑Emiss w*L*ΔWln = SUM_Lw_wln
Note: ∑ is taken over .4 to 5.0 micrometers

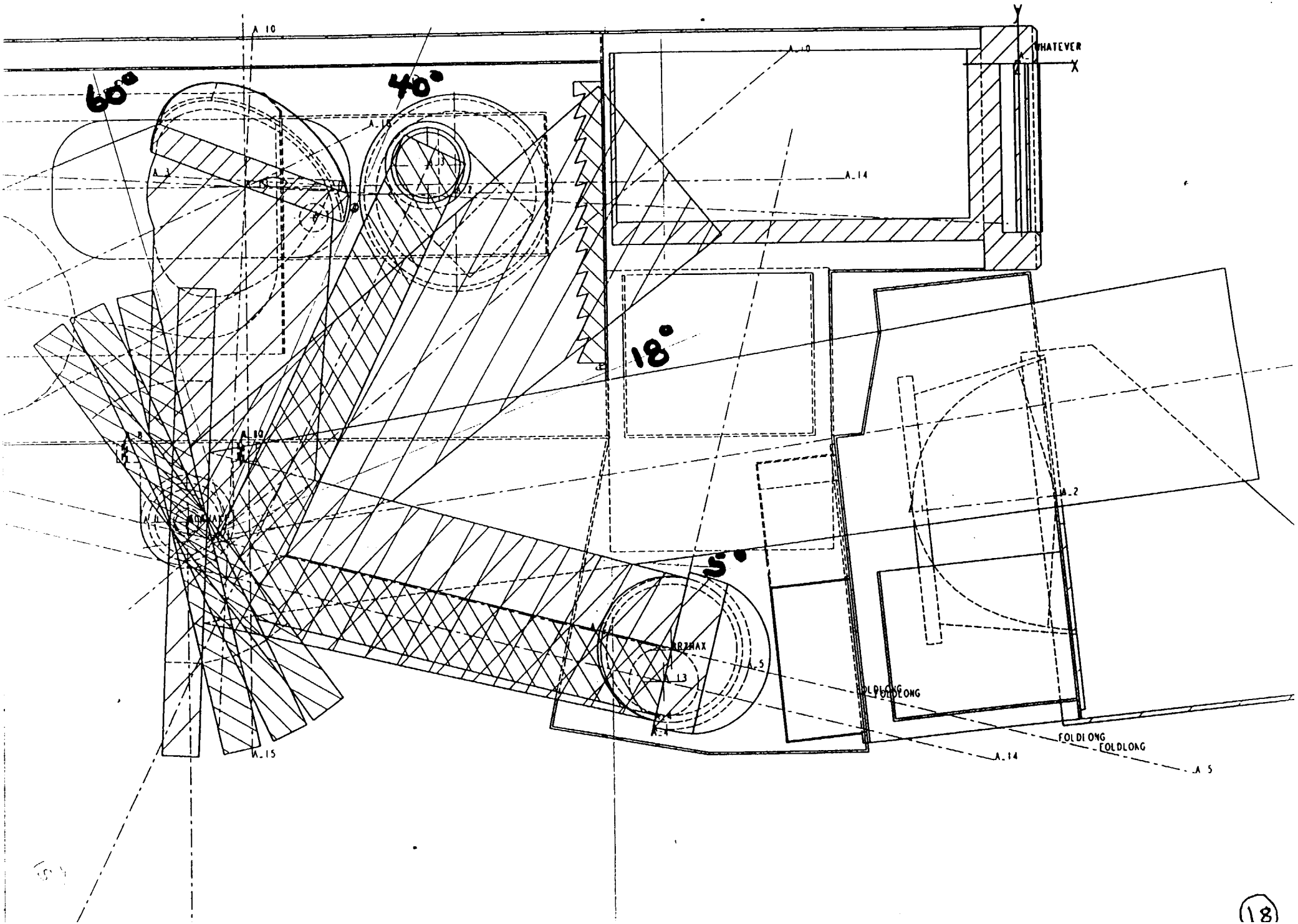
WLN	Emiss	L	Lw	WLN	Emiss	L	Lw
0.4	0.445	5.88856	2.62145	3.6	0.160	6.84628	1.09449
0.5	0.431	22.10912	9.53245	3.7	0.155	6.27378	0.97138
0.6	0.418	45.16769	18.86088	3.8	0.150	5.75868	0.86354
0.7	0.404	66.78879	27.01086	3.9	0.145	5.29439	0.76891
0.8	0.392	81.95196	32.09927	4	0.141	4.87513	0.68572
0.9	0.379	89.73013	34.03885	4.1	0.136	4.49588	0.61246
1	0.367	91.38956	33.57639	4.2	0.132	4.15223	0.54783
1.1	0.356	88.78897	31.59347	4.3	0.128	3.84032	0.49072
1.2	0.345	83.60308	28.81120	4.4	0.124	3.55674	0.44017
1.3	0.334	77.08799	25.72922	4.5	0.120	3.29853	0.39535
1.4	0.323	70.09183	22.65730	4.6	0.116	3.06304	0.35557
1.5	0.313	63.14326	19.76827	4.7	0.112	2.84795	0.32018
1.6	0.303	56.54579	17.14521	4.8	0.109	2.65120	0.28868
1.7	0.294	50.45433	14.81637	4.9	0.105	2.47098	0.26058
1.8	0.284	44.93049	12.77866	5	0.102	2.30566	0.23549
1.9	0.275	39.98010	11.01258				
2	0.267	35.57765	9.49124			SUM_Lw_wln	41.57503
2.1	0.258	31.68165	8.18568				
2.2	0.250	28.24400	7.06763				
2.3	0.242	25.21552	6.11106				
2.4	0.235	22.54901	5.29269				
2.5	0.227	20.20081	4.59218				
2.6	0.220	18.13148	3.99194				
2.7	0.213	16.30593	3.47694				
2.8	0.207	14.69325	3.03438				
2.9	0.200	13.26637	2.65342				
3	0.194	12.00174	2.32487				
3.1	0.188	10.87889	2.04098				
3.2	0.182	9.88005	1.79521				
3.3	0.176	8.98985	1.58201				
3.4	0.170	8.19494	1.39670				
3.5	0.165	7.48376	1.23532				
3.6	0.160	6.84628	1.09449				

Contam 2

	POWER Pe=	18.600							
	Conv eff=	0.600							
	Temp(K)=	2950.0	Ffs=	K*Emiss_w*L*PI()*Dent^2/4/Zlamp_ent^2*Fdet/(4*PI()					
				Lmax(IFOV/705000)^2*PI()*Dent^2/4)					
	K=	0.2684		SNR_lamp=	Ffs*SNR_syst				
	Fdet=	(IFOV/705000*Fsyst)^2/(PI()*(Zlamp_fpa/Frat_lamp)^2/4)							
Band	LMAX	SNR	IFOV	Wln	Emiss _w	L	Fdet	Ffs	SNR
		syst							lamp
1.	0.0685	4053.	250	0.659	0.410	58.528	0.000015	0.030	122
2.	0.0285	2317.	250	0.865	0.384	87.793	0.000015	0.102	236
3.	0.0593	4090.	500	0.470	0.435	16.163	0.000059	0.010	42
4.	0.0518	4079.	500	0.555	0.424	34.500	0.000059	0.024	99
5.	0.0068	1511.	500	1.240	0.340	81.101	0.000059	0.349	528
6.	0.0070	2917.	500	1.640	0.299	54.043	0.000059	0.199	580
7.	0.0022	2444.	500	2.130	0.256	30.604	0.000059	0.306	749
8.	0.0175	3431.	1000	0.415	0.443	7.612	0.000234	0.017	57
9.	0.0133	2660.	1000	0.443	0.439	11.543	0.000234	0.033	87
10.	0.0101	2525.	1000	0.490	0.433	20.044	0.000234	0.074	186
11.	0.0082	2216.	1000	0.531	0.427	28.926	0.000234	0.130	287
12.	0.0064	2286.	1000	0.555	0.424	34.500	0.000234	0.196	449
13.	0.0032	3077.	1000	0.667	0.409	60.219	0.000234	0.662	2036
14.	0.0031	3875.	1000	0.681	0.407	63.090	0.000234	0.712	2761
15.	0.0026	1529.	1000	0.750	0.398	75.311	0.000234	0.992	1517
16.	0.0016	1333.	1000	0.865	0.384	87.793	0.000234	1.811	2414
17.	0.0185	3083.	1000	0.905	0.379	89.943	0.000234	0.158	488
18.	0.0256	4063.	1000	0.936	0.375	90.937	0.000234	0.115	466
19.	0.0189	3150.	1000	0.940	0.375	91.026	0.000234	0.155	489
	Fsyst=	38.000		LAMP IMAGING					
	Dent=	17.780		Zpm_lamp	69.635	.=(1/Fpm-1/Zlamp_ent)^(-1)			
	Frat_syst=	2.137		Zsm_lamp=	4.813	.=(1/Fsm-1/(Zpm_sm-Zpm_lamp))^(-1)			
	Zlamp_ent	170.000		Zobj_lamp=	13.478	.=(1/Fobj-1/(Zsm_obj-Zsm_lamp))^(-1)			
	Fpm=	49.400		Zlamp_fpa=	3.978	.=Zobj_lamp-Fobj			
	Zpm_sm=	61.750							
	Fsm=	12.350		Frat_lamp=	1.001	.=(Zep_obj-Zobj_lamp)/Dep_obj			
	Zsm_obj=	37.000							
	Fobj=	9.500							
	Zep_sm=	15.438	.=(1/Fsm-1/(Fpm+Fsm))^(-1)						
	Dep_sm=	4.445	.=Dent*Zep_sm/Zpm_sm						
	Zep_obj=	16.982	.=(1/Fobj-1/(Zsm_obj-Zep_sm))^(-1)						
	Dep_obj=	3.501	.=Dep_sm*Zep_obj/(Zsm_obj-Zep_sm)						

CONTAMINATION MEASUREMENT - SNR




60°
40°
18°
5°
WHATEVER
A_10
A_14
A_15
A_13
A_12
A_11
A_9
A_8
A_2
A_5
A_4
RR2MAX
FOLDLONG
FOLDLONG
FOLDLONG
FOLDLONG

ALL METHODS HAVE LIMITATIONS

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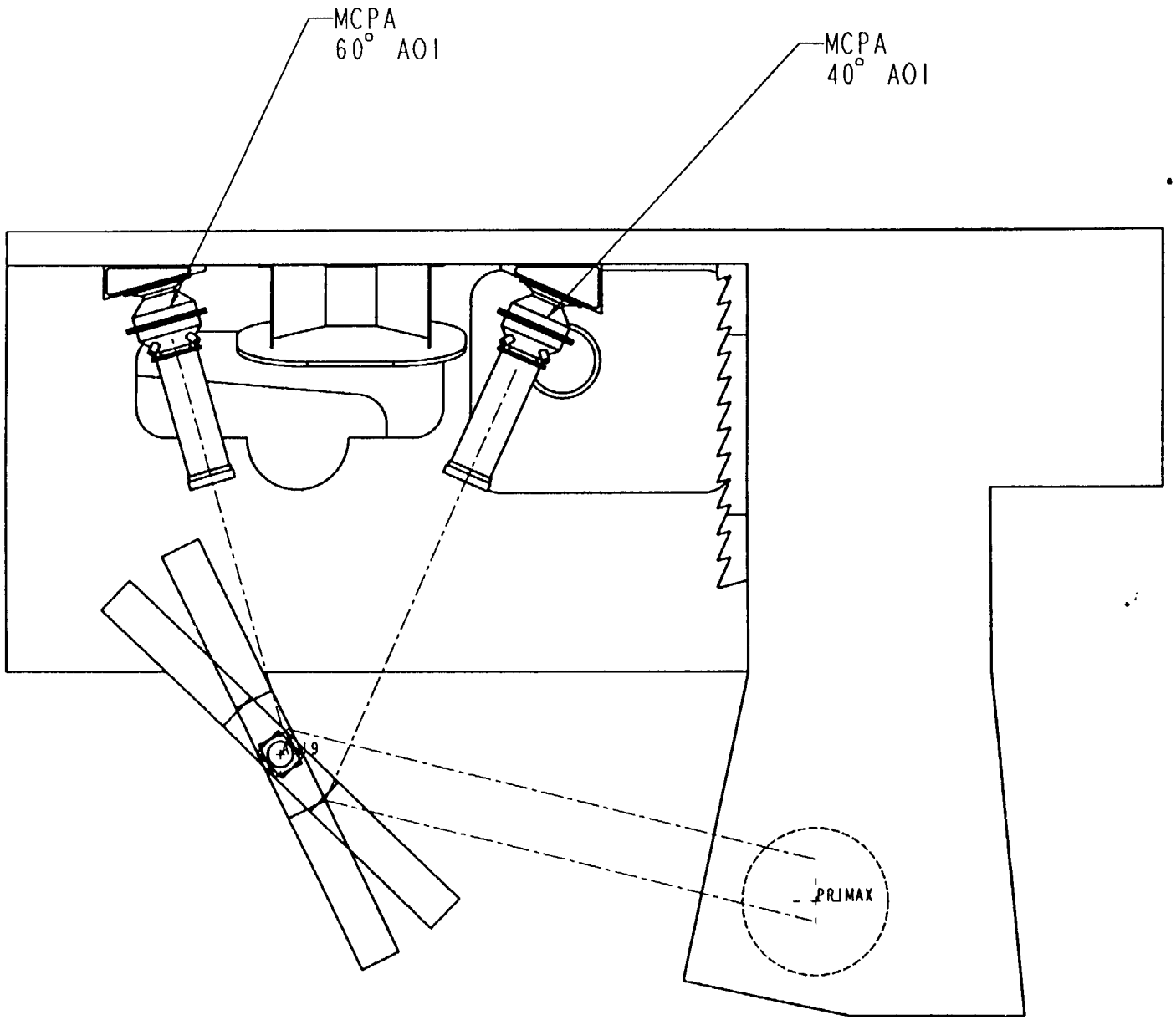
- ELEMENTS OTHER THAN SCAN MIRROR CAN BE CONTAMINATED
- LAMP METHOD CAN COVER MORE SPECRAL RANGE BUT DOES NOT HAVE POLARIZATION CAPABILITY
- MODIS DETECTOR VIEWS LAMP ENERGY THROUGH A RANGE OF SCAN MIRROR AOI AND SPATIAL AREAS

  MAY BE ASSET AND/OR LIABILITY


MCPA
60° AOI
MCPA
40° AOI
PRIMAX

PROPOSED CONFIGURATION FOR MIRROR POLARIZATION CALIBRATOR ASSEMBLY (MCPA)