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LABORATORY CHARACTERIZATION OF TWO RADC 160X244 PLATINUM SILICIDE SENSORS

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Electro-Optics Branch
Mission Avionics Division

April 1987

Final Report for Period 2-11 December 1986

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NOTICE

This technical report has been reviewed and is approved for publication.

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Between 2 Dec and 11 Dec 86, AFWAL/AARI-2 conducted laboratory imaging performance tests on two Rome Air Development Center (RADC) 160x244 Platinum Silicide (PtSi) Sensors. Both cameras were tested using their RS-170 analog composite video outputs. Digital posts were not available for both cameras during the test period. The RADC/NV Digital Image Processor 160x244 was tested with both 100mm, f1.8, 3.4-4.2um and 299mm, f 2.35, 3.4-4.3um germanium lenses. The RADC/AFGL Silicide Infrared Imaging Radiometer was tested with a specially baffled (for reduced internal reflection) 100mm f 1.8 germanium lens. Tests were conducted as part of a comparative evaluation of PtSi versus Mercury-Codmium-Telluride (NgCdTe) technology for imaging applications.

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FOREWORD

This report was prepared by the Electro-Optical Techniques Group, Mission Avionics Division, AF Wright Aeronautical Laboratories' Avionics Laboratory, Wright-Patterson AFB OH.

The following personnel contributed to the design, implementation, and analysis of this test:

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6. Steve DiSalvo, RADC.

This report was submitted by Mr Yasuda in April 1987.

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SECTION 1
INTRODUCTION

Between 2 December and 11 December 1986, AFWAL/AARI-2 conducted laboratory imaging performance tests on two Rome Air Development Center (RADC) 160x244 Platinum Silicide (PtSi) Sensors. Both cameras were tested using their RS-170 analog composite video outputs. Digital ports were not available for both cameras during the test period. In this memo the RADC/NU Digital Image Processor 160x244 will be referred to as the white camera while the RADC/AFGL Silicide Infrared Imaging Radiometer will be referred to as the black camera. The white camera was tested with both 100mm, f1.8, 3.4-4.2um and 299mm, f2.35, 3.4-4.3um germanium lenses. The black camera was tested with a specially baffled (for reduced internal reflection) 100mm f1.8 germanium lens. Tests were conducted as part of a comparative evaluation of PtSi vs Mercury-Cadmium-Telluride (Hg Cd Te) technology for imaging applications.

The following measurements are presented in this report:

1. Field of View (FOV)
2. Minimum Resolvable Temperature (MRT)
3. Modulation Transfer Function (MTF)
4. Signal and Noise
5. Spectral Response
6. Uniformity
7. Blooming

SECTION II

Test Setup

Photographs

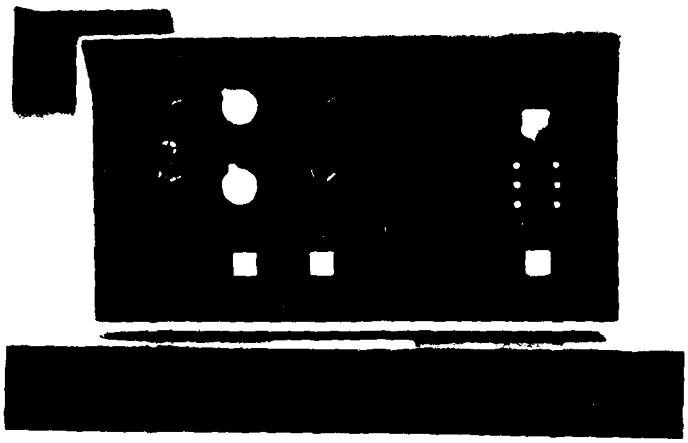


Photo #1. White Camera Electronics

Photo #2. White Camera Receiver

Test Setup
Photographs

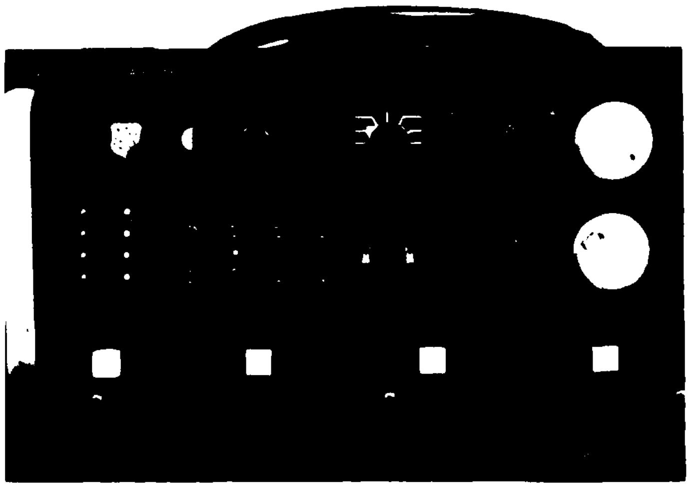


Photo #3. Black Camera Electronics

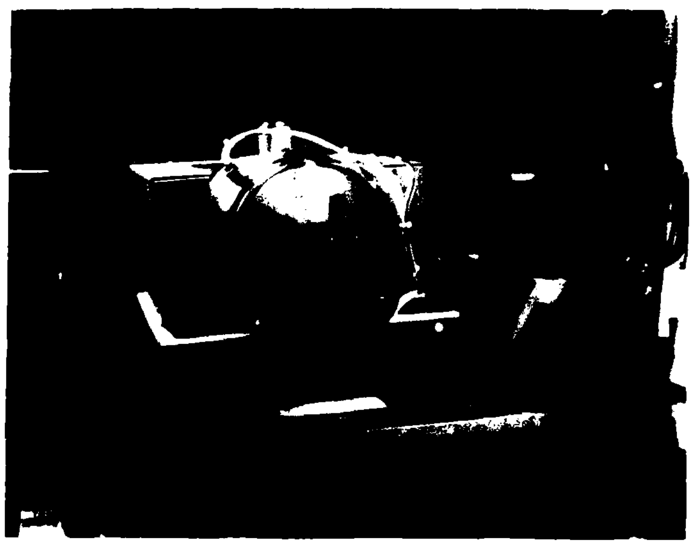


Photo #4. Black Camera Receiver

SECTION III. BLOCK DIAGRAM OF TEST SETUP

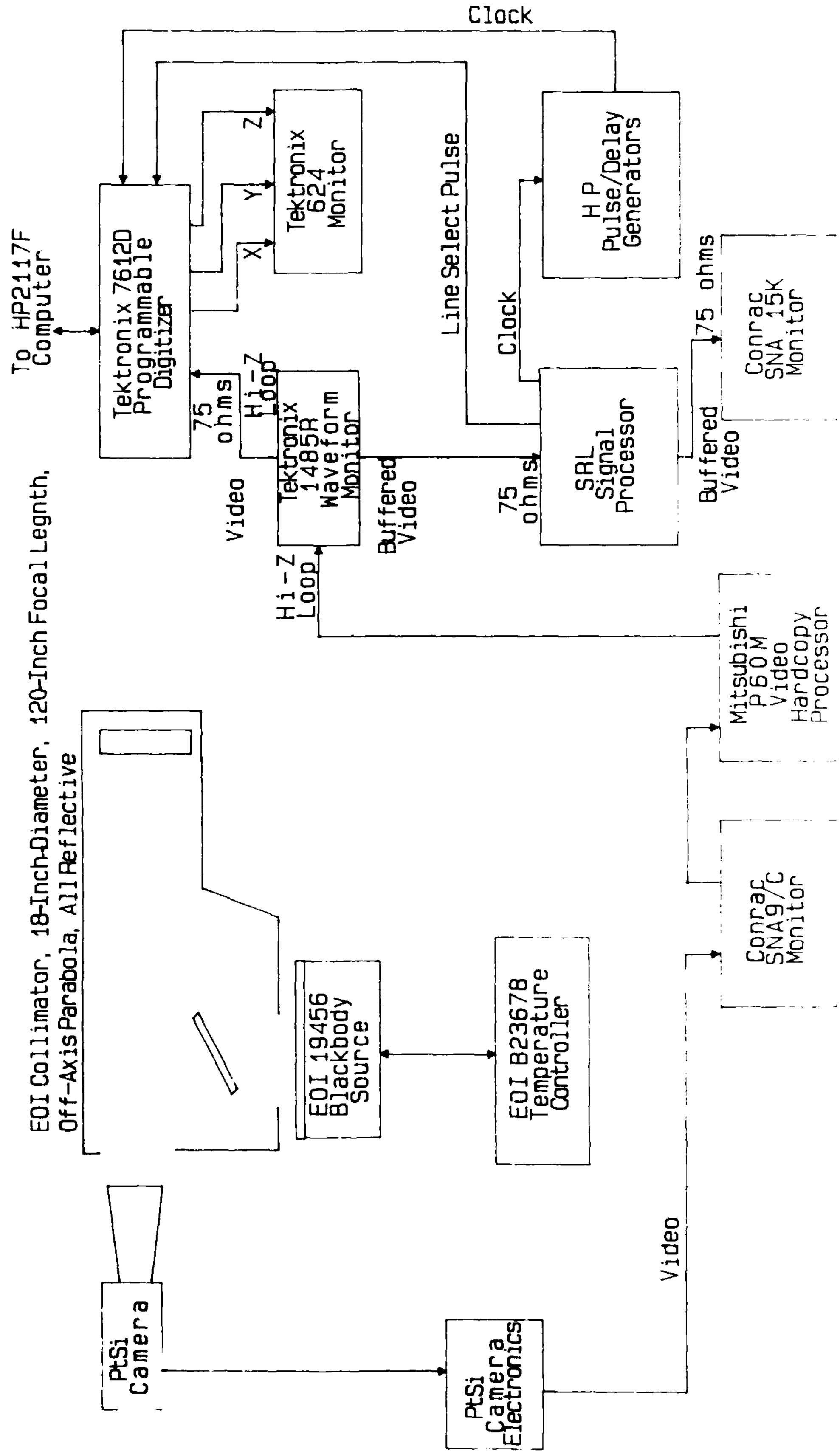


Figure #1. TEST CONFIGURATION

SECTION IV
FIELD OF VIEW (FOV)

1. OBJECTIVE

To determine the horizontal and vertical imagery extents.

2. TEST METHODOLOGY AND PROCEDURES

The sensors were operated in the following mode: White camera - Correct function, Gain = 1, Fine gain = Max, Offset =30% of saturation; Black camera - 3 run, Attenuation = 20 db, offset = 30% of saturation.

A slit pattern was positioned at the collimator focal plane. The FLIR was mounted on a calibrated two-axis rotational translator. The rotational translator was used to angulary slew the FLIR so that the slit image was moved from one edge of the FOV to the other. The angular difference between the two positions was determined to be the FLIR's FOV. An experimenter using a TV monitor determined when the "edge" of the format was reached. This procedure was accomplished for both horizontal and vertical dimensions.

3. RESULTS

TABLE 1. HORIZONTAL AND VERTICAL FOV

	White Camera	Black Camera
100mm, HFOV	7.46°	7.44°
100mm, VFOV	5.55°	5.55°
299mm, HFOV	2.56°	
299mm, VFOV	1.91°	

SECTION V
MINIMUM RESOLVABLE TEMPERATURE (MRT)

1. OBJECTIVE

To determine the FLIR delta temperature sensitivity with respect to angular resolution.

2. TEST METHODOLOGY AND PROCEDURES

The sensors were operated as follows: White camera - Correct function, Gain = 8. Fine gain = Max, Offset = 50% of saturation; Black camera - 3 Run, Attenuation = 0 dbv, Offset = 50% of saturation.

A series of seven-to-one aspect ratio (bar height to bar width) four-bar patterns were used as targets for these MRT tests. The patterns were oriented vertically for the horizontal resolution tests and oriented horizontally for the vertical resolution tests. The patterns were positioned at the center of format. Display contrast and brightness controls were used to adjust for best viewing. One observer was used for these MRT measurements. The test procedures were as follows: a low frequency 4-bar pattern was inserted at the collimator focal plane. The delta temperature was initially adjusted to zero so that the pattern could not be detected by the observer. The delta temperature was slowly incremented upward (hot bars with respect to background) until the 4-bar pattern was just recognizable by the observer. This delta temperature was recorded. The delta temperature was returned to zero degrees and slowly incremented downward (cold bars with respect to background) until the 4-bar pattern was again just recognizable by the observer. An average of the positive and negative delta temperatures was used as the uncorrected MRT. This procedures was repeated for all patterns and orientations. A source-collimator correction factor of 0.94 was used to adjust this MRT data for final results.

HMRT = Horizontal MRT
VMRT = Vertical MRT

3. RESULTS

TABLE 2. HORIZONTAL AND VERTICAL MRT RESULTS

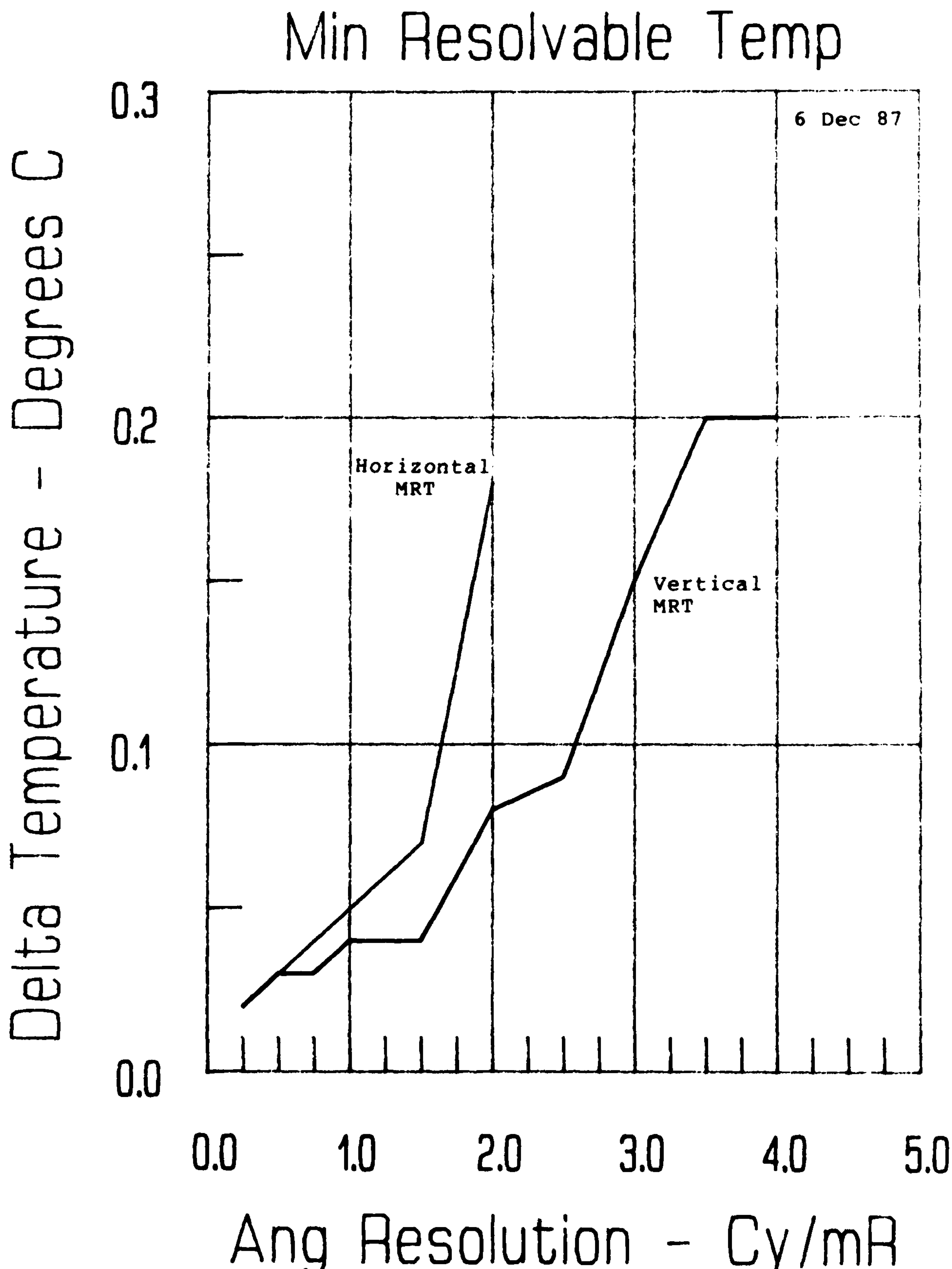
Angular Resolution cy/mr	299mm White Camera HMRT °C	299mm White Camera VMRT °C	100mm White Camera HMRT °C	100mm White Camera VMRT °C	100mm Black Camera HMRT °C	100mm Black Camera VMRT °C
0.25	0.02	0.02	0.02	0.02	0.03	0.03
0.50	0.03	0.03	0.07	0.04	0.05	0.05
0.75	0.04	0.03	–	0.05	–	0.09
1.0	0.05	0.04	–	0.06	–	0.14
1.5	0.07	0.04	–	–	–	–
2.0	0.18	0.08	–	–	–	–
2.5	–	0.09	–	–	–	–
3.0	–	0.15	–	–	–	–
3.5	–	0.20	–	–	–	–
4.0	–	0.20	–	–	–	–
4.5	–	–	–	–	–	–

Using the horizontal FOV data and 160 detectors per line, a design resolution of 1.79 cy/mr for the 299mm lens and 0.61 cy/mr for the 100mm lens can be calculated. These results are reasonably close to the measured horizontal MRT results in Table 2. The vertical design resolution for 244 detectors per vertical FOV is 3.66 cy/mr and 1.26 cy/mr respectively for the 299mm and 100mm lenses. These results also reasonably match the measured vertical MRT cutoff results.

The vertical MRTs are already better than the horizontal MRTs for all except the lowest angular resolution. At the lower resolutions the horizontal and vertical MRTs were about equal, but as resolution increases the larger number of vertical detectors results in a better vertical MRT performance.

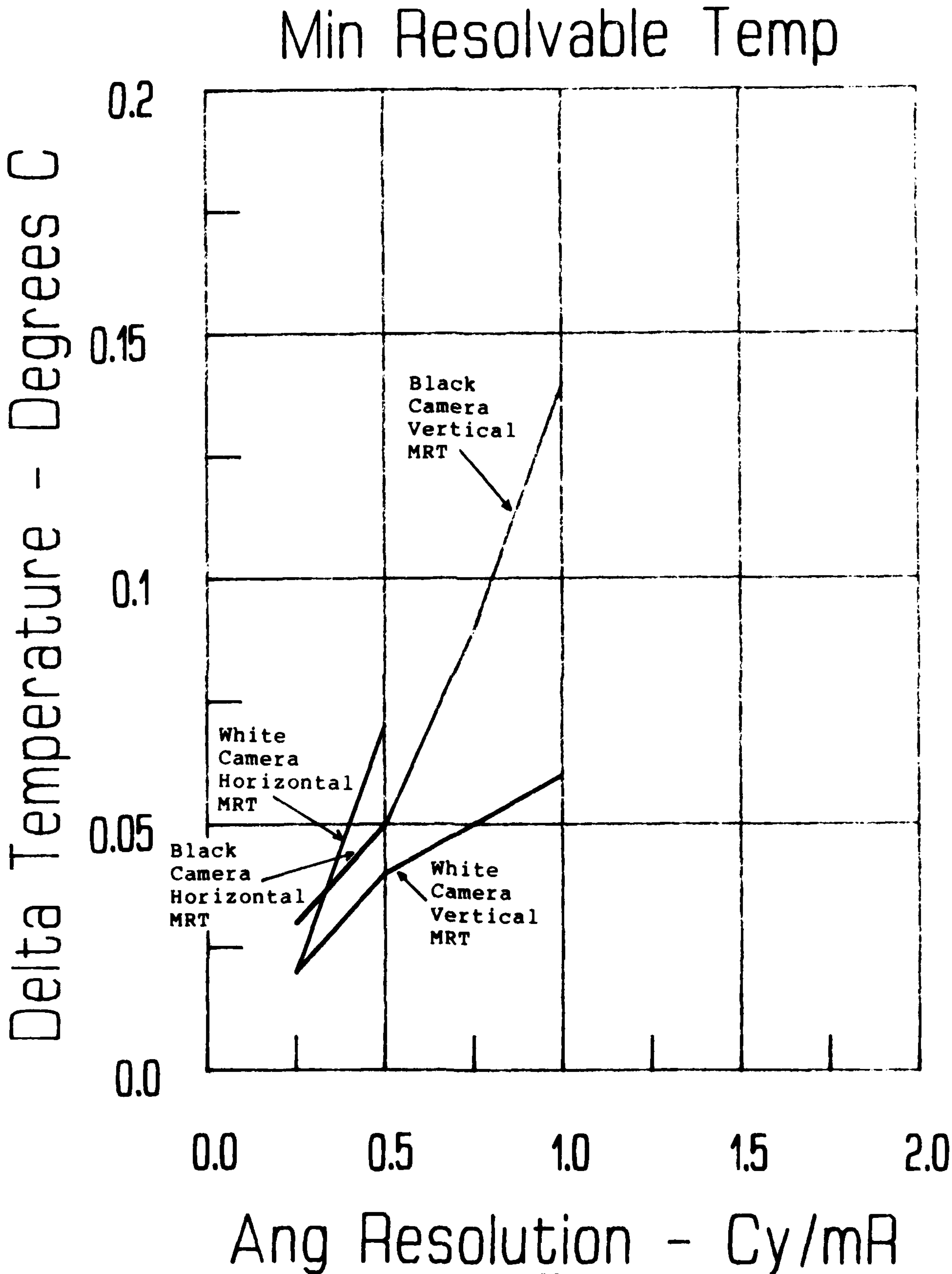
The white camera has a clearly superior vertical MRT over the black camera. The horizontal MRT comparisons are inconclusive since they cross over and only two data points are available for each camera. This cross-over is supported by the MRT and signal-to-noise data. The signal-to-noise for low frequencies is much better for the white camera than the black camera. The MTF, however, appears to be better for the black camera. This combination could explain the cross-over experienced in the horizontal MRT data.

White Camera - 299mm Lens



Plot #1

100mm Lens



Plot #2

SECTION VI
HORIZONTAL
MODULATION TRANSFER FUNCTION

1. OBJECTIVE

To determine the normalized amplitude modulation response of the FLIR with respect angular resolution. Normally, a slit response will give the system MTF in the scanner direction, however, these cameras use staring arrays with less than 100% fill factors. This results in a better MTF than expected because the fill factor is not taken into account. In the future, square wave response measurements will be used to replace the slit method for staring arrays.

2. TEST METHODOLOGY AND PROCEDURES

The sensors were operated as follows: White camera - Correct functions, Gain = 1, Fine gain = Max, Offset = 30% of saturation; Black camera - 3 Run, Attenuation = 0 db, Offset = 30% of saturation.

A vertical slit pattern of 15.75 microradians in width for the 299mm lens and 66.25 microradians in width for the 100mm lens was positioned at the collimator focal plane and centered both in the imager's format and on a vertical array of detectors. The delta temperature of the slit was set so that a strong video signal was observed on the digitizer. A digitally averaged sample of a horizontal video line through the slit was taken and stored on magnetic tape. The delta temperature was incremented downward and another video sample taken and stored. This procedure was repeated until zero delta temperature was reached.

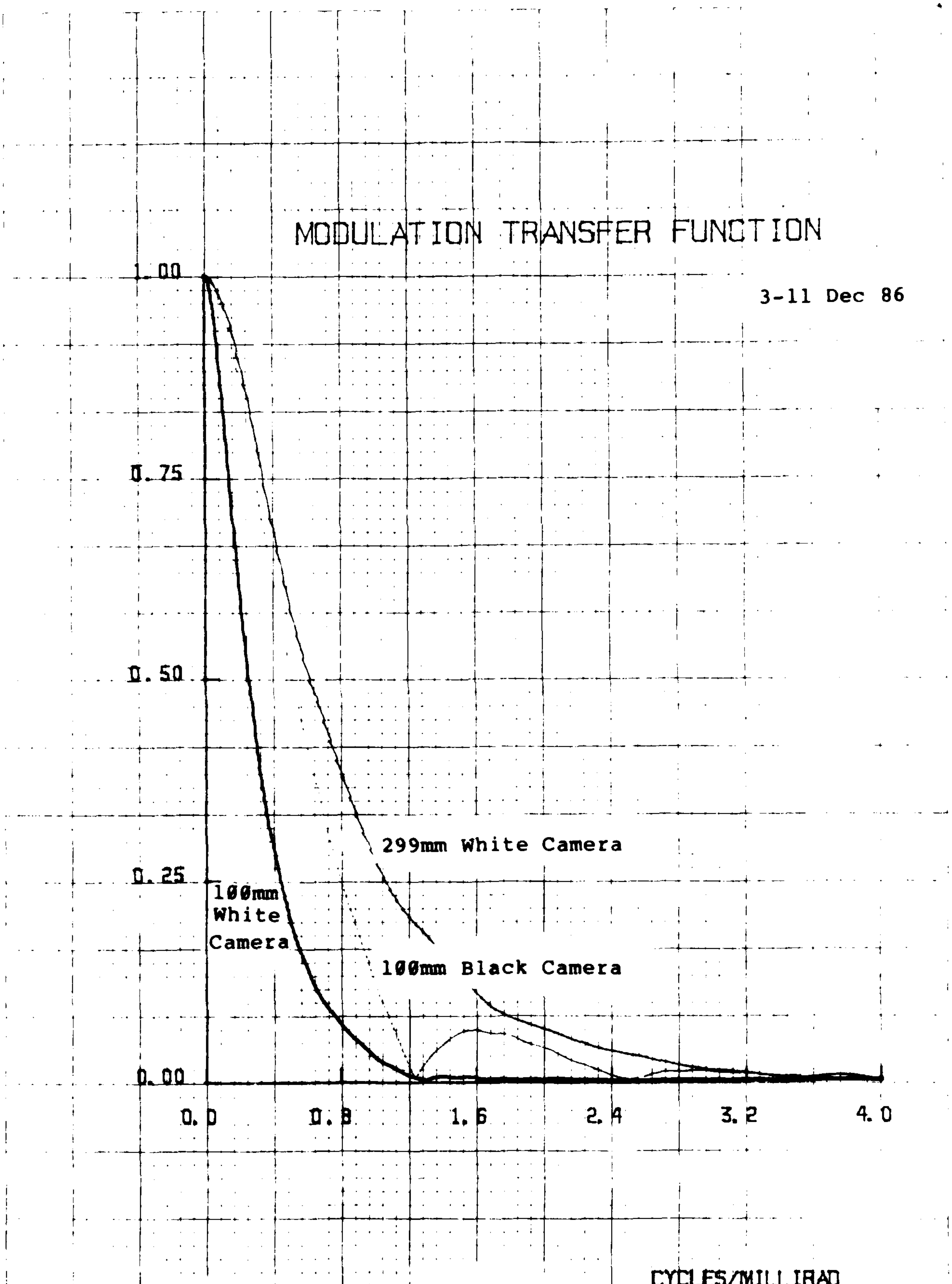
A plot of the peak to peak slit video signal vs. the delta temperature gives an indication of the linear operating range of the sensor with this particular test setup. The maximum peak to peak slit video signal within the linear operating range is selected as the representative sensor line spread function.

The zero delta temperature signal is used as the "background" and is subtracted from the selected video line spread function to remove fixed pattern non-uniformities. A Fourier Transform is performed on the resultant line spread function and the final MTF plotted.

3. RESULTS

To determine the MTF in cy/mr, the active line time (52.6 microseconds) and the horizontal FOVs (44.7 and 130 milliradians) were measured.

The black camera has a significantly better "MTF" than the white camera. Since the detectors are essentially indentical, the difference is probably due primarily to optics and electronics.


MODULATION TRANSFER FUNCTION
3-11 Dec 86
1.00
0.75
0.50
0.25
0.00
299mm White Camera
100mm White Camera
100mm Black Camera
0.0
0.8
1.6
2.4
3.2
4.0
CYCLES/MILLIRAD
Plot #3

SECTION VII
SIGNAL AND NOISE

1. OBJECTIVE

To determine FLIR video signal and noise characteristics as a function of temperature and radiance inputs.

2. TEST METHODOLOGY AND PROCEDURES

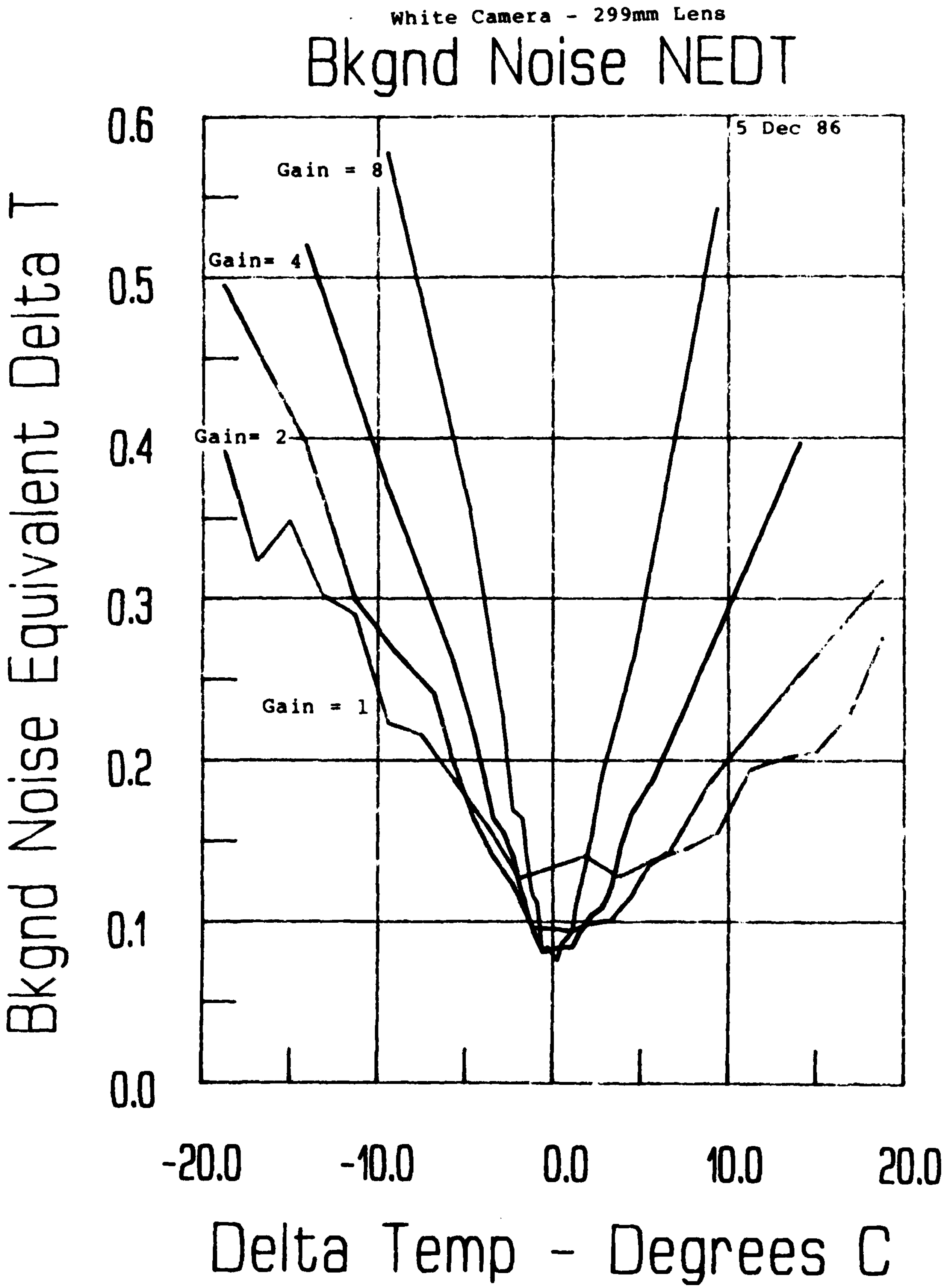
The imagers were set up in the following mode: White camera - Correct function, Gain = 1,2,4,8, Fine gain = Max, Offset = 40% of saturation; Black Camera - 3 Run, Attenuation = 0,10,20, and 30 db, Offset = 40% of saturation.

We inserted 12.0 (for 100mm) and 4.0 (for 299mm) milliradian square aperture patterns at the collimator focal plane and centered in the imager's FOV. The source/pattern delta temperature was set to a selected negative temperature normally determined by the clipping of the signal at the video black level. A video line through the center of the pattern was sampled and stored for later data reduction. Average signal and noise (standard deviation) on a pixel by pixel basis were recorded. The delta temperature was incremented upward to another selected setting and another video sample digitized and stored. This procedure was repeated until the signal began clipping at the high end of the video range. This procedure was repeated for all gain modes.

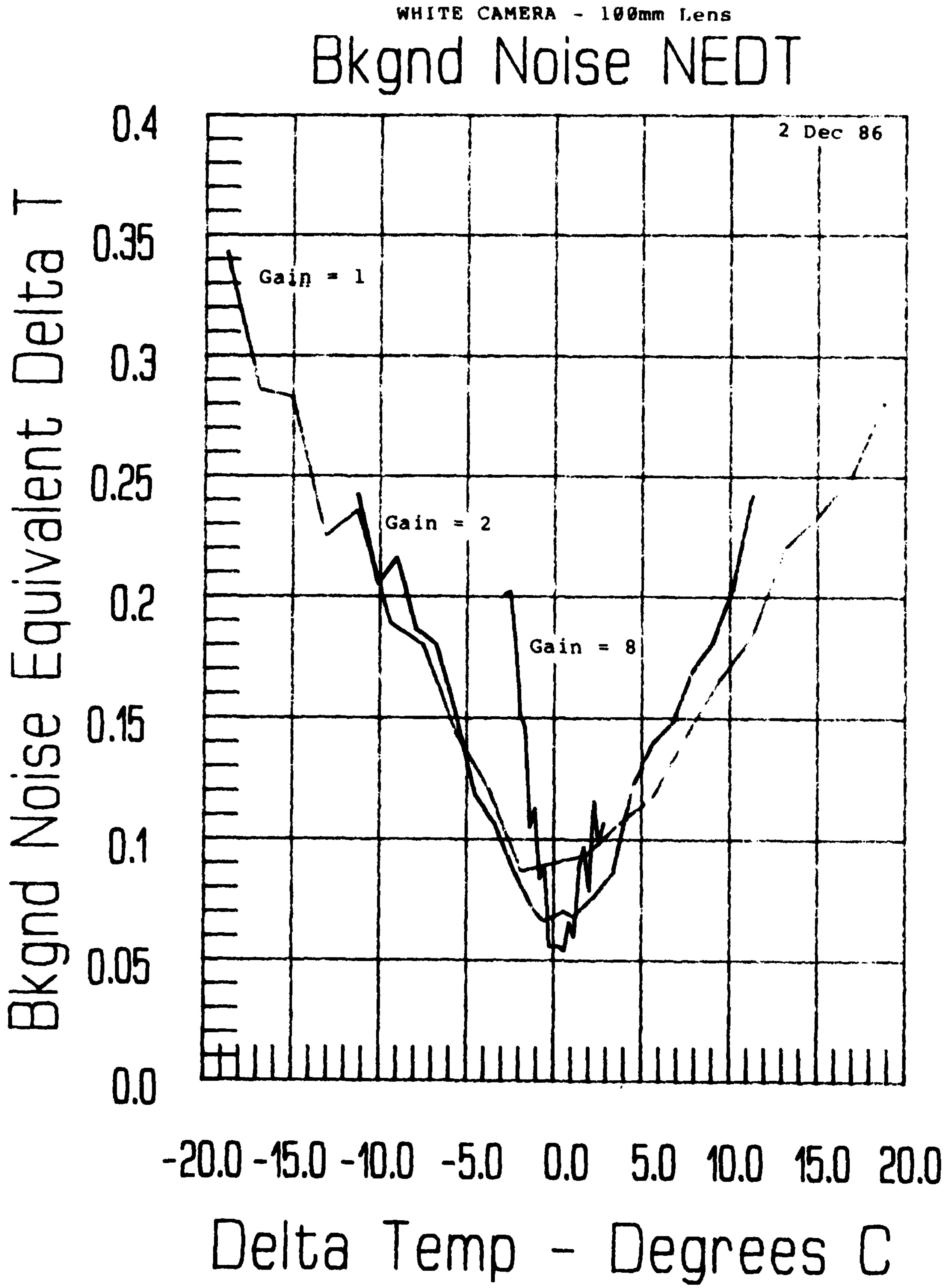
Room ambient temperature ranged between 22°C and 25°C during these tests.

3. RESULTS

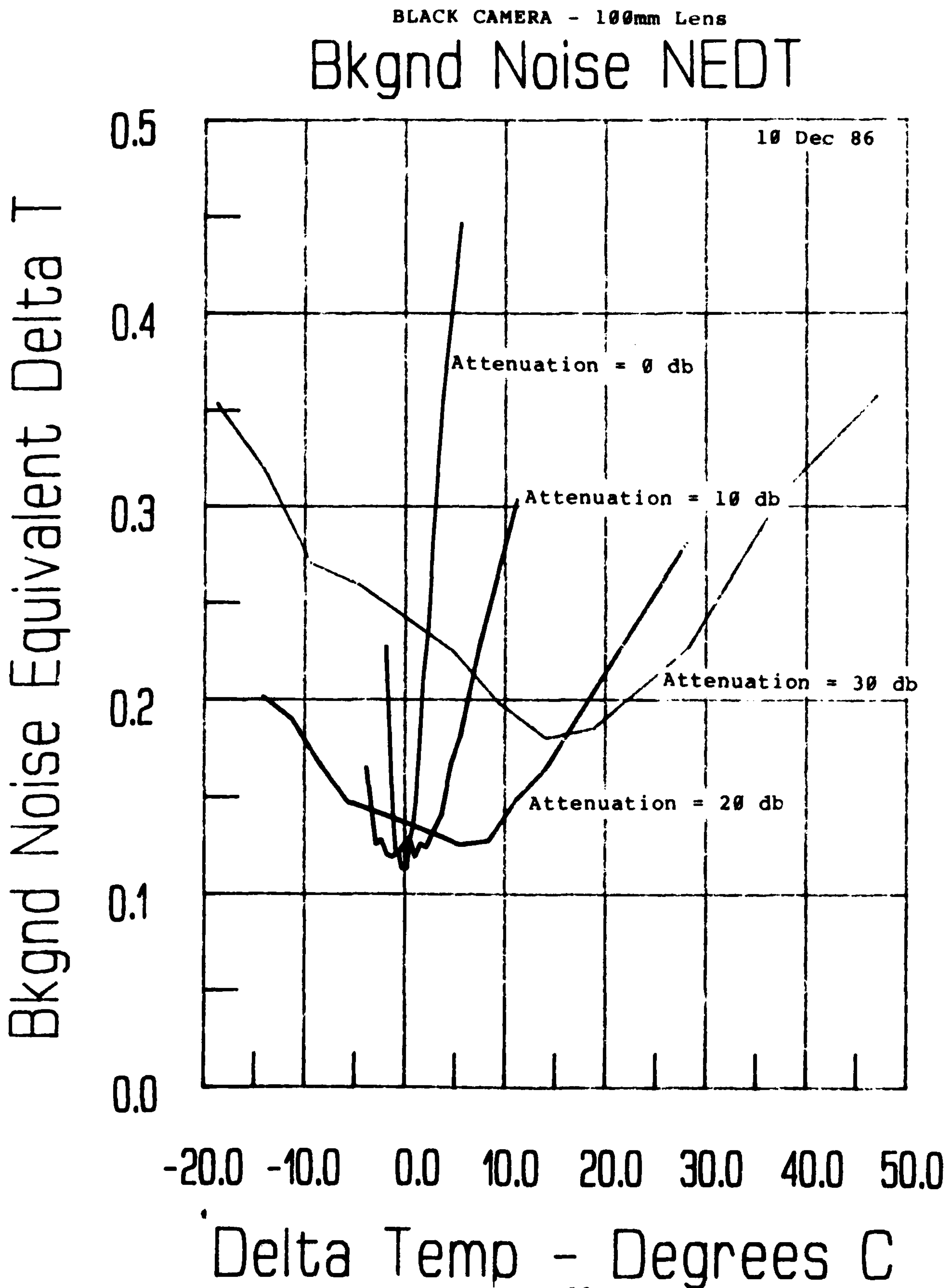
The white camera has a Noise Equivalent Delta Temperature (NEDT) about twice as good as the black camera. Most of this advantage is due to lower white camera noise. The NEDT of the white camera with 299mm lens is about 0.08°C vs 0.05 to 0.06°C for the white camera with 100mm lens. The NEDT variation for the white camera is due to the transmission differences between the lenses.


White Camera - 299mm Lens
Bkgnd Noise NEDT
5 Dec 86
Gain = 8
Gain= 4
Gain= 2
Gain = 1
Bkgnd Noise Equivalent Delta T
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-20.0
-10.0
0.0
10.0
20.0
Delta Temp - Degrees C

Plot #4

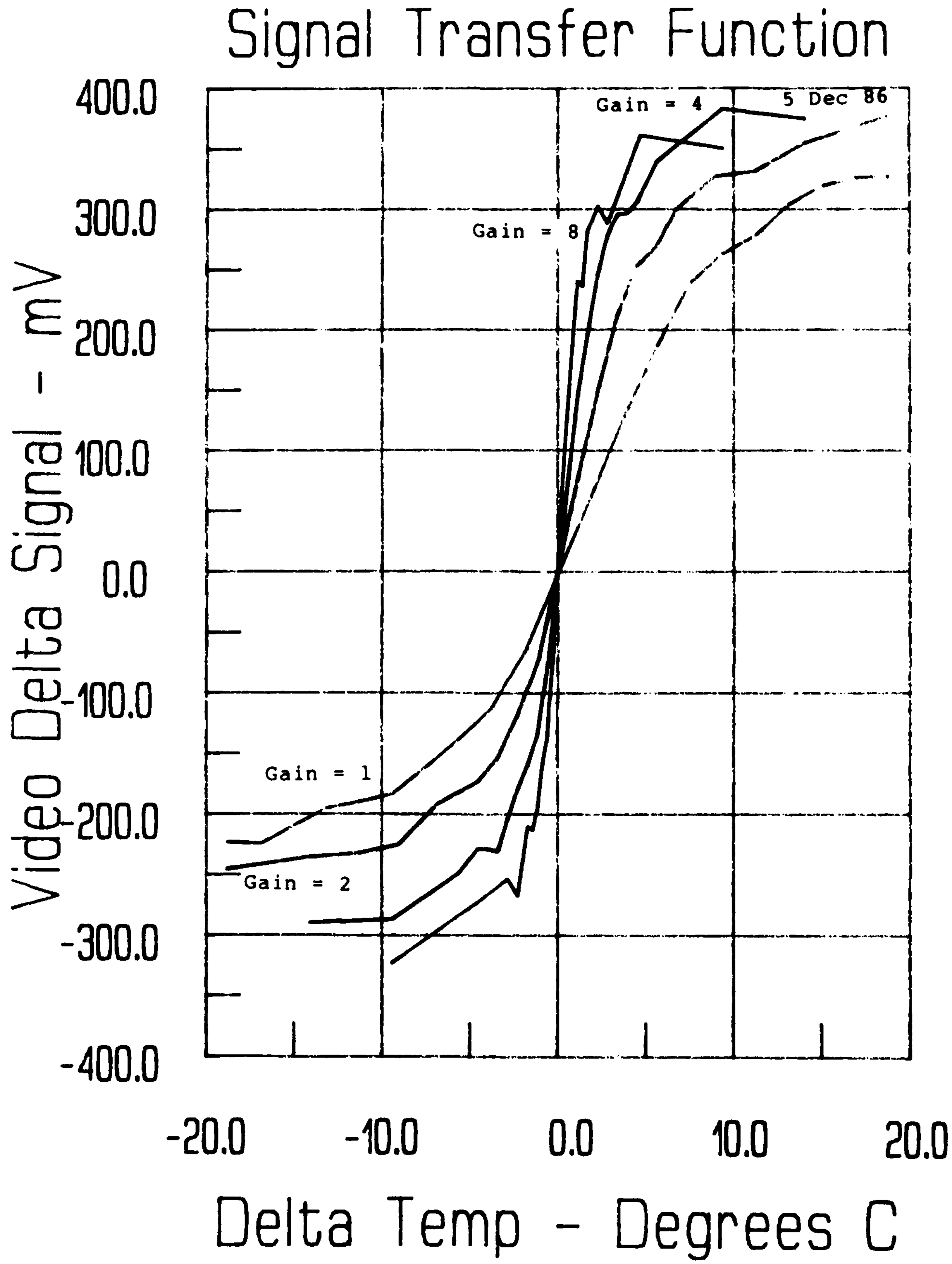

WHITE CAMERA - 100mm Lens
Bkgnd Noise NEDT
2 Dec 86
Gain = 1
Gain = 2
Gain = 8
Bkgnd Noise Equivalent Delta T
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0.0
-20.0 -15.0 -10.0 -5.0 0.0 5.0 10.0 15.0 20.0
Delta Temp - Degrees C

Plot #5


BLACK CAMERA - 100mm Lens
Bkgnd Noise NEDT
10 Dec 86
Attenuation = 0 db
Attenuation = 10 db
Attenuation = 30 db
Attenuation = 20 db
0.5
0.4
0.3
0.2
0.1
0.0
Bkgnd Noise Equivalent Delta T
-20.0 -10.0 0.0 10.0 20.0 30.0 40.0 50.0
Delta Temp - Degrees C

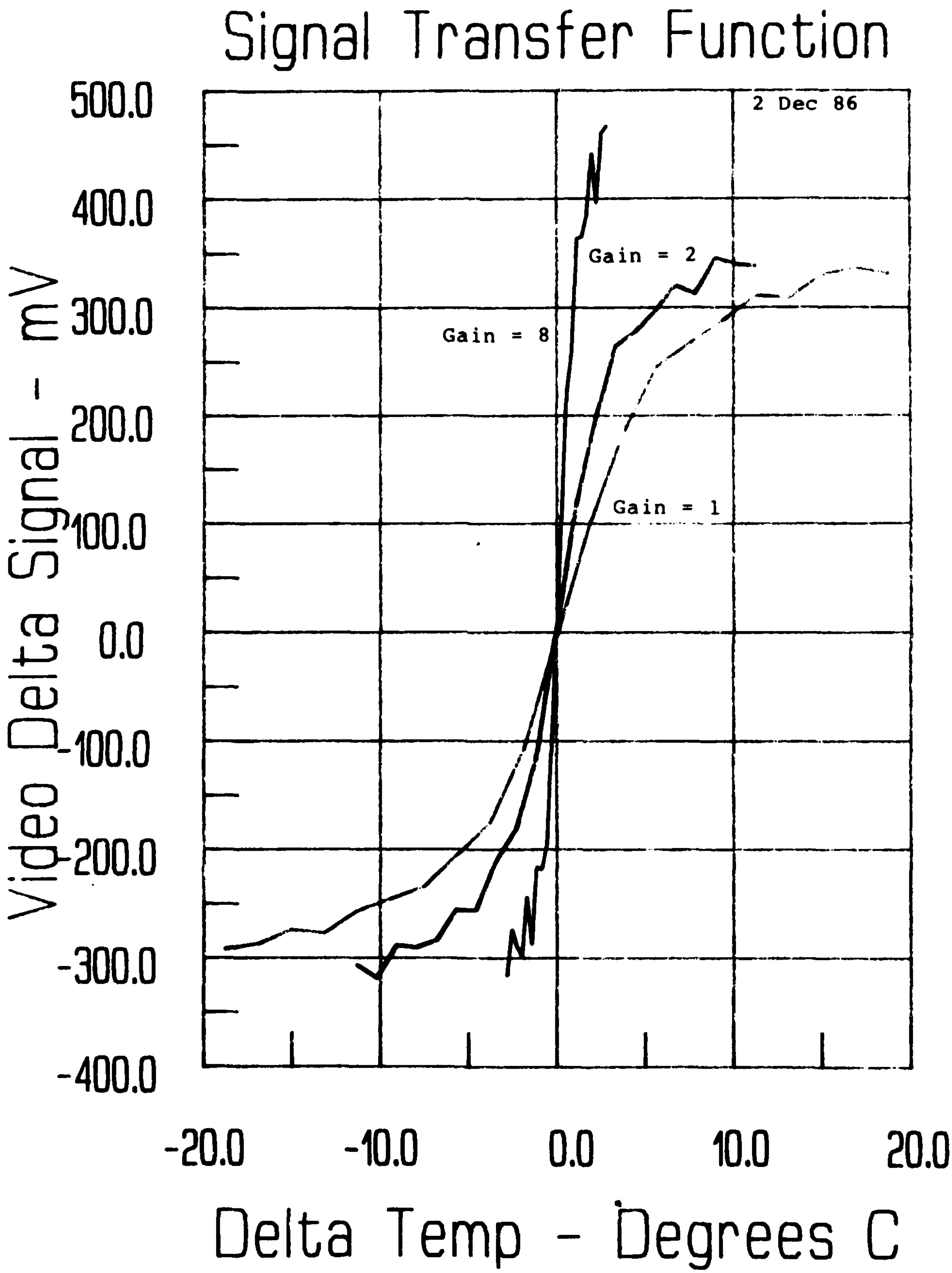
Plot #6

WHITE CAMERA - 299mm Lens



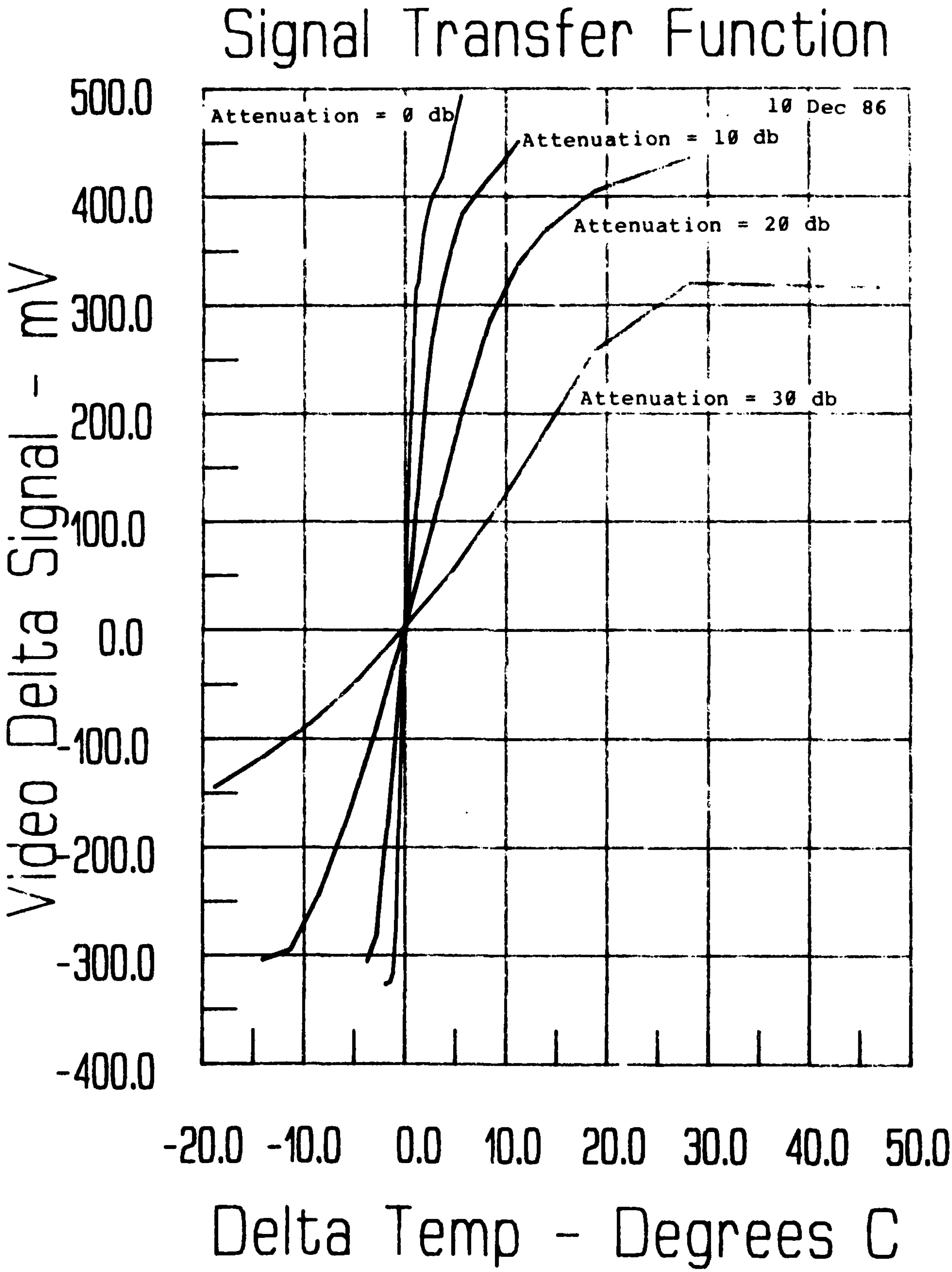
Plot #7

WHITE CAMERA - 100mm Lens



Plot #8

BLACK CAMERA - 100mm Lens



Plot #9

5 Dec 86 BASIC DATA

Room Temp = 22.7 Deg C

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	13.33	22.70	30.55	35.93	2.88	19.77	-111.85	-16.30
2	18.00	22.70	33.17	35.93	3.27	20.68	-83.60	-13.24
3	19.88	22.70	34.26	35.93	3.89	20.27	-65.07	-12.48
4	20.44	22.70	34.59	35.93	5.02	20.00	-53.13	-13.34
5	21.00	22.70	34.92	35.93	6.19	20.36	-33.82	-10.29
6	21.29	22.70	35.09	35.93	7.21	20.67	-29.48	-10.28
7	21.57	22.70	35.26	35.93	9.11	20.00	-21.40	-9.75
8	21.85	22.70	35.43	35.93	9.50	20.70	-16.67	-7.65
9	22.13	22.70	35.59	35.93	16.03	19.76	-8.53	-6.92
10	22.41	22.70	35.76	35.93	19.06	21.43	-3.79	-3.38
11	22.98	22.70	36.10	35.93	18.04	20.10	4.11	3.69
12	23.26	22.70	36.28	35.93	18.58	20.77	7.26	6.50
13	23.54	22.70	36.45	35.93	14.53	20.06	12.94	9.37
14	23.82	22.70	36.62	35.93	11.68	20.11	20.61	11.98
15	24.11	22.70	36.79	35.93	7.07	19.05	33.45	12.42
16	24.39	22.70	36.96	35.93	6.29	20.72	44.81	13.60
17	24.95	22.70	37.31	35.93	5.21	20.71	58.13	14.63
18	25.52	22.70	37.66	35.93	3.93	19.58	73.55	14.75
19	27.40	22.70	38.84	35.93	3.37	20.42	107.18	17.70
20	32.12	22.70	41.90	35.93	3.27	20.21	107.25	17.34

WHITE CAMERA--299mm LENS

TABLE 3. GAIN = 8

5 Dec 86
Room Temp = 22.7 Deg C

BASIC DATA

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-9.40	-322.25	-2.65	324.38	0.08	0.58	34.28	-22.82
2	-4.70	-273.76	17.00	295.53	0.06	0.36	58.25	-18.49
3	-2.82	-252.97	38.36	296.11	0.04	0.23	89.71	-17.33
4	-2.26	-266.85	57.09	328.72	0.04	0.17	118.28	-18.30
5	-1.69	-209.53	71.54	285.85	0.05	0.16	123.84	-13.92
6	-1.41	-212.45	94.61	311.85	0.05	0.14	150.68	-13.73
7	-1.13	-194.96	117.13	316.87	0.05	0.12	172.83	-12.54
8	0.85	-158.32	131.66	294.77	0.05	0.11	187.14	-9.83
9	0.56	-136.74	191.55	333.07	0.07	0.08	242.45	-7.60
10	0.28	-72.33	224.98	302.09	0.07	0.08	256.50	-3.57
11	0.28	74.12	406.40	337.06	0.07	0.08	262.84	3.88
12	0.56	134.93	426.29	296.14	0.08	0.09	239.24	6.85
13	0.85	187.96	504.13	320.95	0.07	0.09	222.18	10.73
14	1.13	240.87	531.10	295.01	0.05	0.09	213.53	14.65
15	1.41	236.58	574.57	342.77	0.04	0.11	167.79	16.46
16	1.69	281.67	583.02	306.12	0.04	0.12	166.47	18.40
17	2.26	302.99	610.05	311.84	0.04	0.15	134.30	20.06
18	2.82	288.86	631.00	346.92	0.04	0.19	102.43	20.45
19	4.70	361.44	662.94	306.28	0.04	0.27	76.90	24.70
20	9.40	350.55	686.68	340.91	0.09	0.54	37.29	24.21

TABLE 3. CONTINUATION

5 Dec 86

Room Temp = 22.8 Deg C

BASIC DATA

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	8.72	22.75	28.10	35.96	3.27	10.70	-88.57	-27.10
2	13.38	22.75	30.58	35.96	3.20	11.23	-89.57	-25.53
3	17.12	22.75	32.66	35.96	3.43	11.42	-72.54	-21.81
4	18.24	22.75	33.31	35.96	3.12	10.94	-73.07	-20.87
5	18.80	22.75	33.63	35.96	3.92	11.01	-58.36	-20.76
6	19.37	22.75	33.96	35.96	4.13	11.09	-55.81	-20.77
7	19.93	22.75	34.29	35.96	4.67	11.20	-43.55	-18.14
8	20.49	22.75	34.62	35.96	4.67	11.09	-38.34	-16.16
9	21.05	22.75	34.95	35.96	5.46	10.73	-29.16	-14.85
10	21.62	22.75	35.29	35.96	7.69	11.24	-17.53	-11.99
11	22.18	22.75	35.62	35.96	9.65	11.05	-8.01	-7.00
12	23.31	22.75	36.31	35.96	10.34	10.93	7.06	6.68
13	23.87	22.75	36.65	35.96	9.54	10.84	15.22	13.40
14	24.44	22.75	37.00	35.96	7.36	11.10	26.60	17.64
15	25.00	22.75	37.34	35.96	5.88	11.42	41.67	21.44
16	25.57	22.75	37.69	35.96	5.24	10.74	53.18	25.94
17	26.13	22.75	38.05	35.96	4.35	10.74	68.09	27.56
18	26.70	22.75	38.40	35.96	3.84	11.30	77.38	26.27
19	27.26	22.75	38.76	35.96	3.65	11.42	83.88	26.82
20	28.40	22.75	39.48	35.96	3.47	11.27	97.94	30.17
21	32.17	22.75	41.94	35.96	3.18	11.40	120.73	33.64
22	36.90	22.75	45.15	35.96	3.21	10.55	116.67	35.53

WHITE CAMERA--299mm LENS

TABLE 4. GAIN = 4

BASIC DATA

5 Dec 86
Room Temp = 22.8 Deg C

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-14.10	-289.96	6.56	295.48	0.16	0.52	20.56	-36.65
2	-9.40	-286.70	19.69	305.35	0.10	0.37	30.50	-34.73
3	-5.64	-249.14	38.20	286.30	0.08	0.26	44.17	-29.54
4	-4.51	-228.28	47.89	275.13	0.06	0.22	50.59	-28.37
5	-3.95	-228.57	57.99	285.51	0.07	0.19	57.89	-27.66
6	-3.38	-230.39	74.77	304.12	0.06	0.16	68.08	-27.53
7	-2.82	-203.45	86.44	288.85	0.06	0.16	72.15	-23.70
8	-2.26	-179.17	100.21	278.34	0.06	0.14	79.42	-21.05
9	-1.69	-159.37	124.46	282.79	0.06	0.11	94.19	-18.72
10	-1.13	-134.87	166.41	300.24	0.06	0.09	119.56	-14.00
11	-0.56	-77.35	222.34	298.65	0.07	0.08	137.14	-7.46
12	0.56	73.02	369.52	295.47	0.08	0.08	129.46	6.86
13	1.13	145.27	451.52	305.21	0.07	0.08	128.78	14.23
14	1.69	195.84	518.85	321.96	0.06	0.10	115.75	20.80
15	2.26	244.90	544.30	298.37	0.05	0.11	108.55	26.96
16	2.82	278.61	568.26	288.62	0.05	0.11	98.80	32.97
17	3.38	296.14	588.99	291.81	0.05	0.12	87.51	36.13
18	3.95	296.94	605.32	307.33	0.05	0.15	75.21	35.18
19	4.51	306.34	617.15	309.78	0.05	0.17	67.89	36.13
20	5.64	339.93	633.19	292.22	0.06	0.19	60.27	40.78
21	9.40	383.36	669.22	284.82	0.08	0.28	40.78	45.83
22	14.10	375.00	693.35	307.31	0.12	0.40	26.60	48.07

TABLE 4. CONTINUATION

5 Dec 86
Room Temp = 22.8 Deg C

BASIC DATA

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	4.13	22.80	25.79	35.99	3.15	6.46	-77.96	-38.02
2	8.77	22.80	28.13	35.99	3.30	6.62	-71.19	-35.52
3	11.56	22.80	29.60	35.99	3.16	6.15	-73.47	-37.74
4	13.80	22.80	30.81	35.99	3.40	6.67	-66.21	-33.75
5	16.04	22.80	32.06	35.99	3.48	6.81	-54.85	-28.05
6	17.17	22.80	32.69	35.99	3.76	6.39	-48.41	-28.53
7	18.29	22.80	33.34	35.99	3.93	6.31	-44.05	-27.43
8	19.42	22.80	33.99	35.99	3.98	6.35	-38.63	-24.22
9	20.54	22.80	34.65	35.99	4.29	6.48	-27.70	-18.35
10	21.67	22.80	35.32	35.99	5.44	6.40	-13.87	-11.79
11	23.92	22.80	36.68	35.99	6.11	6.22	12.24	12.02
12	25.05	22.80	37.37	35.99	5.76	6.42	25.46	22.81
13	26.18	22.80	38.08	35.99	4.94	6.31	42.71	33.42
14	27.31	22.80	38.79	35.99	4.16	6.51	60.79	38.88
15	28.45	22.80	39.51	35.99	3.56	6.52	75.59	41.36
16	29.58	22.80	40.24	35.99	3.51	6.40	85.58	46.99
17	31.84	22.80	41.72	35.99	3.30	6.81	99.33	48.17
18	34.11	22.80	43.24	35.99	3.21	6.39	103.50	51.98
19	36.95	22.80	45.18	35.99	3.22	6.37	110.46	55.79
20	41.70	22.80	48.54	35.99	3.09	6.25	122.07	60.41

WHITE CAMERA--299mm LENS
TABLE 5. GAIN = 2

5 Dec 86 BASIC DATA

Room Temp = 22.8 Deg C

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-18.80	-245.40	24.75	269.18	0.24	0.49	13.05	-48.32
2	-14.10	-235.20	33.16	267.39	0.20	0.40	16.68	-44.95
3	-11.28	-232.21	43.79	275.04	0.15	0.30	20.59	-47.47
4	-9.02	-224.96	56.73	280.72	0.14	0.27	24.93	-42.52
5	-6.77	-191.12	71.85	262.00	0.12	0.24	28.24	-35.32
6	-5.64	-182.17	86.78	267.98	0.12	0.20	32.30	-34.76
7	-4.51	-173.00	106.44	278.47	0.10	0.16	38.34	-32.93
8	-3.38	-153.82	129.40	282.25	0.09	0.14	45.45	-29.02
9	-2.26	-118.92	150.29	268.25	0.08	0.12	52.71	-21.64
10	-1.13	-75.45	193.15	267.63	0.08	0.10	66.89	-12.70
11	1.13	74.76	373.10	297.36	0.09	0.09	66.28	12.13
12	2.26	146.51	432.27	284.80	0.09	0.10	64.94	24.03
13	3.38	210.86	492.67	280.84	0.08	0.10	62.31	37.22
14	4.51	253.14	540.23	286.12	0.07	0.12	56.10	46.32
15	5.64	269.48	574.58	304.12	0.07	0.14	47.78	51.31
16	6.77	300.54	590.48	288.97	0.08	0.14	44.41	58.25
17	9.02	328.26	618.92	289.69	0.09	0.19	36.38	61.30
18	11.28	332.19	638.87	305.71	0.11	0.22	29.45	65.69
19	14.10	355.18	655.66	299.51	0.13	0.25	25.19	70.42
20	18.80	377.29	674.79	296.53	0.15	0.31	20.07	76.57

TABLE 5. CONTINUATION

5 Dec 86 BASIC DATA

Room Temp = 23.0 Deg C

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	4.33	23.00	25.89	36.12	3.36	4.68	-66.42	-47.68
2	6.19	23.00	26.81	36.12	3.26	4.28	-68.79	-52.43
3	8.04	23.00	27.75	36.12	3.11	4.86	-67.37	-43.12
4	9.90	23.00	28.72	36.12	3.48	4.48	-56.13	-43.54
5	11.76	23.00	29.71	36.12	3.13	4.88	-60.62	-38.87
6	13.63	23.00	30.72	36.12	3.67	4.36	-49.91	-42.08
7	15.50	23.00	31.75	36.12	3.31	4.62	-48.75	-34.88
8	17.37	23.00	32.81	36.12	3.47	4.59	-39.72	-30.06
9	19.24	23.00	33.89	36.12	3.91	4.77	-28.67	-23.53
10	21.12	23.00	34.99	36.12	4.54	4.39	-14.31	-14.81
11	24.88	23.00	37.27	36.12	4.19	4.67	14.86	13.33
12	26.76	23.00	38.44	36.12	4.20	4.38	30.65	29.35
13	28.65	23.00	39.64	36.12	4.07	4.57	45.95	40.99
14	30.53	23.00	40.86	36.12	3.52	4.62	67.97	51.84
15	32.42	23.00	42.10	36.12	3.48	4.35	75.91	60.73
16	34.31	23.00	43.37	36.12	3.42	4.81	81.61	57.95
17	36.21	23.00	44.66	36.12	3.15	4.68	96.61	65.15
18	38.10	23.00	45.98	36.12	3.14	4.39	101.90	72.87
19	40.00	23.00	47.32	36.12	2.93	4.42	111.40	73.88
20	41.89	23.00	48.69	36.12	3.23	4.79	101.21	68.23

WHITE CAMERA--299mm LENS

TABLE 6. GAIN = 1

5 Dec 86 BASIC DATA

Room Temp = 23.0 Deg C

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-18.80	-223.31	65.32	288.45	0.28	0.39	11.88	-54.77
2	-16.92	-224.47	73.74	298.05	0.25	0.32	13.27	-58.97
3	-15.04	-209.48	78.72	288.03	0.22	0.35	13.93	-51.36
4	-13.16	-195.09	85.10	280.02	0.23	0.30	14.82	-48.65
5	-11.28	-189.84	97.93	287.59	0.19	0.29	16.83	-46.28
6	-9.40	-183.33	114.57	297.72	0.19	0.22	19.50	-45.50
7	-7.52	-161.17	127.01	288.01	0.15	0.22	21.43	-40.12
8	-5.64	-137.99	143.96	281.78	0.14	0.19	24.47	-33.90
9	-3.76	-112.22	177.93	289.99	0.13	0.16	29.85	-25.73
10	-1.88	-65.03	230.84	295.69	0.13	0.13	34.59	-14.55
11	1.88	62.33	348.10	285.60	0.13	0.14	33.15	14.04
12	3.76	128.57	423.17	294.43	0.12	0.13	34.19	29.97
13	5.64	187.16	489.09	301.75	0.12	0.14	33.19	43.26
14	7.52	239.50	525.93	286.26	0.11	0.15	31.85	58.29
15	9.40	264.08	562.46	298.21	0.12	0.15	28.09	67.06
16	11.28	278.94	586.29	307.18	0.14	0.19	24.73	66.82
17	13.16	304.77	600.93	295.99	0.14	0.20	23.16	76.39
18	15.04	319.86	615.59	295.56	0.15	0.21	21.27	83.83
19	16.92	326.53	627.15	300.44	0.15	0.23	19.30	87.07
20	18.80	326.97	637.08	309.94	0.19	0.28	17.39	80.01

TABLE 6. CONTINUATION

2 Dec 86

Room Temp = 23.7 Deg C

BASIC DATA

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	20.88	23.70	34.85	36.54	3.49	22.52	-90.49	-14.03
2	21.16	23.70	35.01	36.54	3.63	21.91	-75.56	-12.53
3	21.44	23.70	35.18	36.54	3.52	23.51	-82.55	-12.37
4	21.72	23.70	35.35	36.54	4.07	23.05	-73.55	-12.97
5	22.00	23.70	35.52	36.54	4.16	21.06	-58.84	-11.61
6	22.29	23.70	35.69	36.54	5.01	21.52	-57.43	-13.37
7	22.57	23.70	35.86	36.54	5.73	21.70	-37.84	-9.98
8	22.85	23.70	36.03	36.54	7.87	21.75	-27.79	-10.06
9	23.13	23.70	36.20	36.54	12.59	30.89	-15.60	-6.36
10	23.41	23.70	36.37	36.54	12.53	20.19	-8.06	-5.00
11	23.98	23.70	36.71	36.54	20.02	22.30	5.56	4.99
12	24.26	23.70	36.89	36.54	16.36	21.48	13.61	10.36
13	24.54	23.70	37.06	36.54	9.68	20.22	26.89	12.88
14	24.82	23.70	37.23	36.54	9.12	19.39	39.81	18.73
15	25.11	23.70	37.41	36.54	5.92	22.70	61.56	16.06
16	25.39	23.70	37.58	36.54	4.95	21.99	77.50	17.46
17	25.67	23.70	37.76	36.54	4.43	17.59	99.48	25.07
18	25.95	23.70	37.93	36.54	3.96	20.27	99.87	19.52
19	26.24	23.70	38.11	36.54	3.81	17.85	120.89	25.78
20	26.52	23.70	38.29	36.54	3.80	17.63	122.68	26.44

WHITE CAMERA--100mm LENS

TABLE 7. GAIN = 8

2 Dec 86

Room Temp = 23.7 Deg C

BASIC DATA

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-2.82	-315.97	20.99	335.73	0.03	0.20	112.05	-19.61
2	-2.54	-274.56	22.52	295.85	0.03	0.20	108.18	-17.49
3	-2.26	-290.87	28.79	318.43	0.03	0.18	128.93	-17.30
4	-1.97	-299.10	35.66	333.53	0.03	0.15	151.52	-18.07
5	-1.69	-244.52	39.94	283.23	0.03	0.15	144.51	-16.11
6	-1.41	-287.71	57.27	343.75	0.02	0.11	204.05	-18.41
7	-1.13	-216.71	63.10	278.58	0.03	0.11	192.11	-13.65
8	-0.85	-218.70	96.77	314.25	0.03	0.08	258.51	-13.37
9	-0.56	-196.38	134.28	329.42	0.04	0.09	348.19	-8.33
10	-0.28	-100.99	157.37	257.13	0.03	0.06	358.13	-6.01
11	0.28	111.34	372.16	259.59	0.05	0.06	394.84	5.25
12	0.56	222.65	481.19	257.30	0.04	0.05	394.77	11.66
13	0.85	260.33	558.82	297.26	0.03	0.07	307.72	16.42
14	1.13	363.13	569.56	205.21	0.03	0.06	321.92	23.97
15	1.41	364.58	604.49	238.68	0.02	0.09	258.57	21.98
16	1.69	383.92	620.15	235.00	0.02	0.10	226.90	24.08
17	1.97	441.04	630.62	188.35	0.02	0.08	223.42	34.38
18	2.26	395.78	646.08	249.06	0.02	0.12	175.44	27.09
19	2.54	460.10	651.21	189.87	0.02	0.10	181.29	35.65
20	2.82	466.11	660.35	193.01	0.02	0.11	165.29	36.55

TABLE 7. CONTINUATION

2 Dec 86
Room Temp = 23.6 Deg C

BASIC DATA

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	12.36	23.60	30.03	36.48	3.48	6.60	-88.34	-46.54
2	13.48	23.60	30.64	36.48	3.27	6.42	-97.48	-49.63
3	14.60	23.60	31.25	36.48	3.42	6.90	-84.18	-41.75
4	15.72	23.60	31.88	36.48	3.66	6.84	-79.39	-42.44
5	16.84	23.60	32.51	36.48	3.37	7.55	-84.17	-37.57
6	17.97	23.60	33.15	36.48	3.68	6.90	-69.49	-37.03
7	19.09	23.60	33.80	36.48	3.55	6.67	-72.03	-38.29
8	20.21	23.60	34.46	36.48	3.84	6.56	-54.60	-31.98
9	21.34	23.60	35.12	36.48	4.65	6.91	-38.86	-26.14
10	22.47	23.60	35.80	36.48	6.35	7.16	-18.28	-16.23
11	23.03	23.60	36.14	36.48	6.31	6.56	-8.85	-8.52
12	24.16	23.60	36.82	36.48	6.68	7.21	8.69	8.05
13	24.72	23.60	37.17	36.48	6.10	7.08	19.27	16.60
14	25.85	23.60	37.87	36.48	4.79	6.69	41.40	29.64
15	26.98	23.60	38.58	36.48	4.20	6.70	63.22	39.57
16	28.11	23.60	39.30	36.48	3.77	7.54	73.79	36.93
17	29.24	23.60	40.02	36.48	3.48	7.39	85.43	40.23
18	30.38	23.60	40.76	36.48	3.64	7.00	88.26	45.82
19	31.51	23.60	41.50	36.48	3.25	6.73	96.31	46.48
20	32.64	23.60	42.25	36.48	3.52	6.95	98.35	49.82
21	33.78	23.60	43.01	36.48	3.57	6.82	95.14	49.89
22	34.91	23.60	43.78	36.48	3.32	7.26	101.99	46.62

WHITE CAMERA--100mm LENS
TABLE 8. GAIN = 2

2 Dec 86

Room Temp = 23.6 Deg C

BASIC DATA

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-11.28	-307.23	25.81	331.85	0.13	0.24	27.24	-58.23
2	-10.15	-318.76	31.03	348.60	0.10	0.20	31.40	-62.54
3	-9.02	-288.14	33.27	320.23	0.11	0.22	31.93	-52.90
4	-7.90	-290.31	40.71	329.84	0.10	0.19	36.77	-52.93
5	-6.77	-283.59	49.61	332.02	0.08	0.18	41.90	-48.52
6	-5.64	-255.49	58.90	313.21	0.08	0.15	45.30	-46.22
7	-4.51	-255.46	81.59	335.86	0.06	0.12	56.62	-47.81
8	-3.38	-209.90	101.62	310.34	0.06	0.11	62.03	-39.03
9	-2.26	-180.75	142.25	321.82	0.06	0.09	80.12	-30.67
10	-1.13	-116.10	212.58	327.51	0.06	0.07	102.93	-17.16
11	-0.56	-55.89	253.76	308.46	0.06	0.07	99.09	-8.68
12	0.56	58.08	376.84	317.58	0.06	0.07	102.98	8.35
13	1.13	117.59	436.95	318.18	0.06	0.07	104.25	17.78
14	2.26	198.29	530.16	330.69	0.05	0.08	87.90	34.00
15	3.38	265.30	572.39	305.90	0.05	0.09	78.40	47.43
16	4.51	278.32	604.61	325.11	0.06	0.12	61.69	46.70
17	5.64	297.20	623.57	325.19	0.07	0.14	52.69	51.48
18	6.77	320.84	638.50	316.48	0.08	0.15	47.41	57.51
19	7.90	312.83	650.59	336.58	0.08	0.17	39.62	59.20
20	9.02	346.11	660.26	312.97	0.09	0.18	38.35	62.85
21	10.15	340.09	669.54	328.27	0.11	0.20	33.50	62.49
22	11.28	338.38	675.48	335.92	0.11	0.24	30.00	59.96

TABLE 8. CONTINUATION

2 Dec 86 BASIC DATA

Room Temp = 23.6 Deg C

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	4.93	23.60	26.19	36.48	3.64	5.35	-80.44	-54.75
2	6.79	23.60	27.11	36.48	3.58	4.87	-80.42	-59.16
3	8.64	23.60	28.06	36.48	3.36	5.18	-81.81	-53.11
4	10.50	23.60	29.03	36.48	3.61	4.75	-77.09	-58.51
5	12.36	23.60	30.03	36.48	3.72	5.38	-69.19	-47.86
6	14.23	23.60	31.05	36.48	3.51	4.95	-70.32	-49.77
7	16.09	23.60	32.09	36.48	3.63	5.64	-64.84	-41.80
8	17.97	23.60	33.15	36.48	4.04	5.24	-50.96	-39.25
9	19.84	23.60	34.24	36.48	4.35	5.66	-40.50	-31.09
10	21.72	23.60	35.35	36.48	4.77	5.05	-22.85	-21.57
11	25.48	23.60	37.64	36.48	4.71	4.94	21.08	20.10
12	27.36	23.60	38.82	36.48	4.34	5.16	41.93	35.30
13	29.24	23.60	40.04	36.48	3.77	5.12	64.97	47.82
14	31.13	23.60	41.25	36.48	3.42	5.06	77.83	52.56
15	33.02	23.60	42.50	36.48	3.54	5.08	81.09	56.54
16	34.91	23.60	43.78	36.48	3.35	5.07	92.61	61.21
17	36.81	23.60	45.08	36.48	3.27	5.18	94.03	59.45
18	38.70	23.60	46.40	36.48	3.50	5.12	94.18	64.40
19	40.60	23.60	47.75	36.48	3.56	4.97	94.42	67.55
20	42.49	23.60	49.12	36.48	3.34	4.93	98.89	66.99

WHITE CAMERA--100mm LENS

TABLE 9. GAIN = 1

2 Dec 86 BASIC DATA

Room Temp = 23.6 Deg C

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-18.80	-292.81	38.79	330.87	0.23	0.34	15.57	-64.01
2	-16.92	-287.90	43.15	330.31	0.21	0.29	17.02	-67.39
3	-15.04	-274.97	47.05	321.29	0.18	0.28	18.28	-63.00
4	-13.16	-278.14	55.70	333.11	0.17	0.22	21.14	-65.91
5	-11.28	-257.29	63.04	319.60	0.16	0.24	22.81	-55.66
6	-9.40	-246.47	76.99	322.73	0.13	0.19	26.22	-57.45
7	-7.52	-235.60	97.38	332.25	0.12	0.18	31.33	-49.68
8	-5.64	-205.83	119.67	324.77	0.11	0.14	36.49	-43.90
9	-3.76	-176.11	154.33	329.71	0.09	0.12	46.84	-34.88
10	-1.88	-108.90	207.46	315.63	0.08	0.09	57.93	-22.18
11	1.88	99.29	425.97	325.96	0.09	0.09	52.81	20.57
12	3.76	182.13	512.61	329.76	0.09	0.11	48.44	38.19
13	5.64	244.97	560.33	314.63	0.09	0.12	43.43	54.47
14	7.52	266.10	596.33	329.50	0.10	0.14	35.39	61.60
15	9.40	287.05	616.88	329.11	0.12	0.17	30.54	65.59
16	11.28	310.30	633.10	322.07	0.12	0.18	27.51	72.21
17	13.16	307.85	646.84	338.25	0.14	0.22	23.39	71.06
18	15.04	329.69	656.74	326.32	0.16	0.23	21.92	75.18
19	16.92	335.79	667.18	330.67	0.18	0.25	19.85	77.69
20	18.80	330.39	674.58	343.46	0.19	0.28	17.57	78.44

TABLE 9. CONTINUATION

10 Dec 86 BASIC DATA

Room Temp = 22.6 Deg C

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	20.72	22.60	34.75	35.87	1.84	39.47	-177.41	-8.28
2	21.19	22.60	35.03	35.87	3.29	40.32	-98.86	-8.07
3	21.47	22.60	35.20	35.87	12.46	39.09	-25.41	-8.10
4	21.75	22.60	35.37	35.87	33.09	39.27	-8.36	-7.04
5	22.03	22.60	35.53	35.87	36.15	38.90	-5.03	-4.67
6	22.31	22.60	35.70	35.87	37.99	39.45	-2.60	-2.50
7	22.88	22.60	36.04	35.87	36.66	40.44	2.75	2.49
8	23.16	22.60	36.21	35.87	31.10	39.88	5.66	4.42
9	23.44	22.60	36.39	35.87	22.63	37.44	10.47	6.33
10	23.72	22.60	36.56	35.87	16.28	41.01	19.34	7.68
11	24.01	22.60	36.73	35.87	10.25	38.17	31.36	8.42
12	24.48	22.60	37.02	35.87	6.81	41.10	53.57	8.88
13	24.95	22.60	37.31	35.87	5.08	38.79	76.01	9.95
14	25.42	22.60	37.60	35.87	4.37	40.36	91.97	9.95
15	26.36	22.60	38.19	35.87	3.06	39.45	136.56	10.59
16	28.25	22.60	39.38	35.87	2.67	39.01	184.93	12.64

BLACK CAMERA--100mm LENS

TABLE 10. ATTENUATION = 0db

10 Dec 86 BASIC DATA

Room Temp = 22.6 Deg C

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-1.88	-326.84	-55.50	275.14	0.01	0.23	173.85	-11.70
2	-1.41	-325.25	-54.70	274.35	0.01	0.17	230.68	-11.37
3	-1.13	-316.47	-41.72	278.54	0.04	0.14	280.55	-10.91
4	-0.85	-276.63	29.28	309.71	0.10	0.12	326.98	-7.62
5	-0.56	-181.77	81.08	266.66	0.11	0.12	322.29	-4.84
6	-0.28	-98.61	188.47	290.88	0.11	0.11	349.67	-2.55
7	0.28	100.84	377.93	280.89	0.10	0.11	357.58	2.61
8	0.56	176.07	450.24	277.97	0.10	0.13	312.18	4.92
9	0.85	236.92	545.81	312.69	0.08	0.13	280.04	7.66
10	1.13	314.95	583.89	272.75	0.06	0.15	279.21	10.09
11	1.41	321.53	617.20	299.47	0.04	0.17	228.04	11.50
12	1.88	365.04	655.41	294.17	0.04	0.21	194.17	12.39
13	2.35	386.13	675.86	293.52	0.03	0.24	164.31	13.96
14	2.82	401.45	693.71	296.06	0.03	0.28	142.36	13.99
15	3.76	417.75	719.65	305.69	0.03	0.36	111.10	14.93
16	5.64	493.01	755.57	266.36	0.03	0.45	87.41	17.83

TABLE [illegible]. CONTINUATION

10 Dec 86 BASIC DATA
Room Temp = 22.8 Deg C

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	19.04	22.80	33.77	35.99	2.32	13.38	-131.39	-22.82
2	19.98	22.80	34.32	35.99	8.71	12.44	-32.33	-22.63
3	20.54	22.80	34.65	35.99	11.40	12.61	-19.53	-17.66
4	21.10	22.80	34.98	35.99	12.16	12.44	-14.47	-14.14
5	21.67	22.80	35.32	35.99	11.72	12.56	-10.17	-9.49
6	22.23	22.80	35.65	35.99	12.82	12.63	-4.58	-4.66
7	23.36	22.80	36.34	35.99	11.75	12.92	4.82	4.38
8	23.92	22.80	36.68	35.99	11.81	12.04	9.66	9.48
9	24.49	22.80	37.03	35.99	10.87	13.20	16.34	13.46
10	25.05	22.80	37.37	35.99	10.32	12.91	22.80	18.23
11	25.62	22.80	37.72	35.99	7.52	12.84	36.91	21.60
12	26.56	22.80	38.31	35.99	4.70	12.10	68.39	26.58
13	27.50	22.80	38.91	35.99	3.48	12.61	102.24	28.23
14	28.45	22.80	39.51	35.99	3.15	12.43	122.09	30.95
15	30.33	22.80	40.73	35.99	2.45	12.37	166.47	33.00
16	34.11	22.80	43.24	35.99	2.92	12.18	154.60	37.09

BLACK CAMERA--100mm LENS
TABLE 11. ATTENUATION = 10db

10 Dec 86 BASIC DATA
Room Temp = 22.8 Deg C

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-3.76	-305.37	-36.39	270.66	0.03	0.16	81.22	-31.79
2	-2.82	-281.57	-5.93	277.32	0.09	0.12	99.85	-26.22
3	-2.26	-222.61	51.14	275.43	0.12	0.13	98.67	-18.52
4	-1.69	-175.90	105.34	282.92	0.12	0.12	103.96	-14.30
5	-1.13	-119.23	157.43	278.34	0.11	0.12	105.70	-9.81
6	-0.56	-58.79	208.94	269.41	0.12	0.12	104.24	-4.62
7	0.56	56.60	333.28	278.36	0.12	0.13	100.35	4.58
8	1.13	114.14	395.73	283.27	0.12	0.12	101.18	9.57
9	1.69	177.63	448.30	272.34	0.10	0.13	104.98	14.69
10	2.26	235.31	501.52	267.89	0.10	0.12	104.30	20.14
11	2.82	277.45	551.53	275.76	0.08	0.13	98.39	26.36
12	3.76	321.70	603.10	283.08	0.05	0.14	85.56	35.04
13	4.70	356.06	635.05	280.67	0.05	0.17	75.76	38.48
14	5.64	384.69	655.75	272.74	0.05	0.18	68.21	42.43
15	7.52	408.04	686.33	279.97	0.05	0.23	54.26	45.78
16	11.28	451.87	727.59	277.40	0.07	0.30	40.06	51.01

TABLE 11. CONTINUATION

10 Dec 86
Room Temp = 22.8 Deg C

BASIC DATA

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	8.77	22.80	28.13	35.99	1.46	4.33	-208.38	-70.29
2	11.56	22.80	29.60	35.99	2.68	4.96	-110.09	-59.36
3	14.36	22.80	31.12	35.99	3.94	4.81	-61.83	-50.64
4	17.17	22.80	32.69	35.99	4.58	4.49	-37.63	-38.39
5	19.98	22.80	34.32	35.99	4.08	4.59	-22.30	-19.81
6	25.62	22.80	37.72	35.99	4.37	4.54	22.30	21.48
7	28.45	22.80	39.51	35.99	3.77	4.41	53.00	45.30
8	31.28	22.80	41.34	35.99	2.25	4.31	127.38	66.51
9	34.11	22.80	43.24	35.99	1.76	4.49	192.81	75.46
10	36.95	22.80	45.18	35.99	1.55	4.30	239.09	86.13
11	41.70	22.80	48.54	35.99	0.93	4.38	436.97	92.57
22	51.20	22.80	55.72	35.99	0.90	4.36	483.69	100.19

BLACK CAMERA--100mm LENS
TABLE 12. ATTENUATION = 20db

10 Dec 86
Room Temp = 22.8 Deg C

BASIC DATA

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-14.10	-304.15	-22.60	282.25	0.07	0.20	21.57	-94.19
2	-11.28	-294.12	-19.66	275.76	0.10	0.19	26.13	-73.89
3	-8.46	-243.33	32.94	276.97	0.14	0.17	28.76	-55.40
4	-5.64	-172.48	106.23	279.41	0.15	0.15	30.58	-38.00
5	-2.82	-91.02	186.51	278.23	0.13	0.14	32.28	-20.95
6	2.82	97.55	376.63	279.78	0.13	0.13	34.59	21.88
7	5.64	199.65	482.18	283.24	0.11	0.12	35.40	48.69
8	8.46	286.49	568.41	282.62	0.07	0.13	33.86	83.38
9	11.28	338.66	620.36	282.40	0.06	0.15	30.02	99.37
10	14.10	370.29	652.38	282.80	0.06	0.16	26.26	114.59
11	18.80	405.46	687.44	282.68	0.04	0.20	21.57	128.07
12	28.20	436.34	719.11	283.46	0.06	0.28	15.47	138.75

TABLE 12. CONTINUATION

10 Dec 86 BASIC DATA
Room Temp = 23.0 Deg C

DATA SETS	ABS TGT TEMP DEG C	ABS BKG TEMP DEG C	ABS TGT 8-12 RAD W/M2SR	ABS BKG 8-12 RAD W/M2SR	TARGET NOISE MV	BKGND NOISE MV	DS/TN RATIO	DS/BN RATIO
1	4.33	23.00	25.89	36.12	2.83	2.70	-50.84	-53.23
2	8.97	23.00	28.23	36.12	2.64	2.64	-44.18	-44.20
3	13.63	23.00	30.72	36.12	2.25	2.45	-38.04	-34.85
4	18.30	23.00	33.34	36.12	2.51	2.51	-18.10	-18.14
5	27.70	23.00	39.03	36.12	2.69	2.62	20.35	20.92
6	32.42	23.00	42.10	36.12	2.61	2.48	44.92	47.43
7	37.15	23.00	45.32	36.12	2.23	2.40	84.48	78.41
8	41.89	23.00	48.69	36.12	1.86	2.54	139.30	101.74
9	51.40	23.00	55.88	36.12	1.61	2.57	199.85	124.97
10	60.94	23.00	63.68	36.12	1.61	2.[illegible]	197.69	122.42
11	70.50	23.00	72.10	36.12	1.62	2.41	915.73	131.52

BLACK CAMERA--100mm LENS
TABLE 13. ATTENUATION = 30db

10 Dec 86 BASIC DATA
Room Temp = 23.0 Deg C

DATA SETS	DELTA T DEG C	DELTA SIGNAL MV	PORCH TARGET MV	PORCH BKGND MV	TARGET NOISE NEDT	BKGND NOISE NEDT	GAIN DES/ DEG C	SNR2 DS/NQ2 RATIO
1	-18.80	-143.73	130.91	277.55	0.37	0.35	7.65	-51.99
2	-14.10	-116.49	157.74	277.14	0.32	0.32	8.26	-44.19
3	-9.40	-85.49	188.29	276.69	0.25	0.27	9.09	-36.34
4	-4.70	-45.45	230.02	278.38	0.26	0.26	9.67	-18.12
5	4.70	54.84	329.54	277.61	0.23	0.22	11.67	20.63
6	9.40	117.41	392.00	277.50	0.21	0.20	12.49	46.12
7	14.10	188.22	464.05	278.75	0.17	0.18	13.35	81.27
8	18.80	258.48	533.91	278.34	0.13	0.18	13.75	116.19
9	28.20	321.38	596.16	277.69	0.14	0.23	11.40	149.85
10	37.60	318.96	595.69	279.64	0.19	0.31	8.48	147.19
11	47.00	317.17	595.13	280.88	0.24	0.36	6.75	154.38

TABLE 13. CONTINUATION

SECTION VIII
VIDEO SPECTRAL RESPONSE

1. OBJECTIVE

To determine the FLIR normalized spectral characteristics.

2. TEST METHODOLOGY AND PROCEDURES

The sensors were operated in the following mode: White camera - Correct function, Gain = 1, Fine gain = Max, Offset = 30% of saturation, 100mm lens; Black camera - 3 Run, Attenuation = 30 db, Offset = 2.5% of saturation, 100mm lens.

A high-temperature blackbody source with a circular variable spectral filter (CVSF) was positioned in the collimator focal plane. A slit image of the CVSF was presented to the sensor. A blackbody source temperature was then selected which was within the linear portion of the signal transfer curve and at the same time, provided a sufficiently strong video signal for analysis.

After the blackbody source temperature was selected and set, the CVSF was incremented through its various wavelength settings and a video sample of the slit signal digitized and stored for each wavelength.

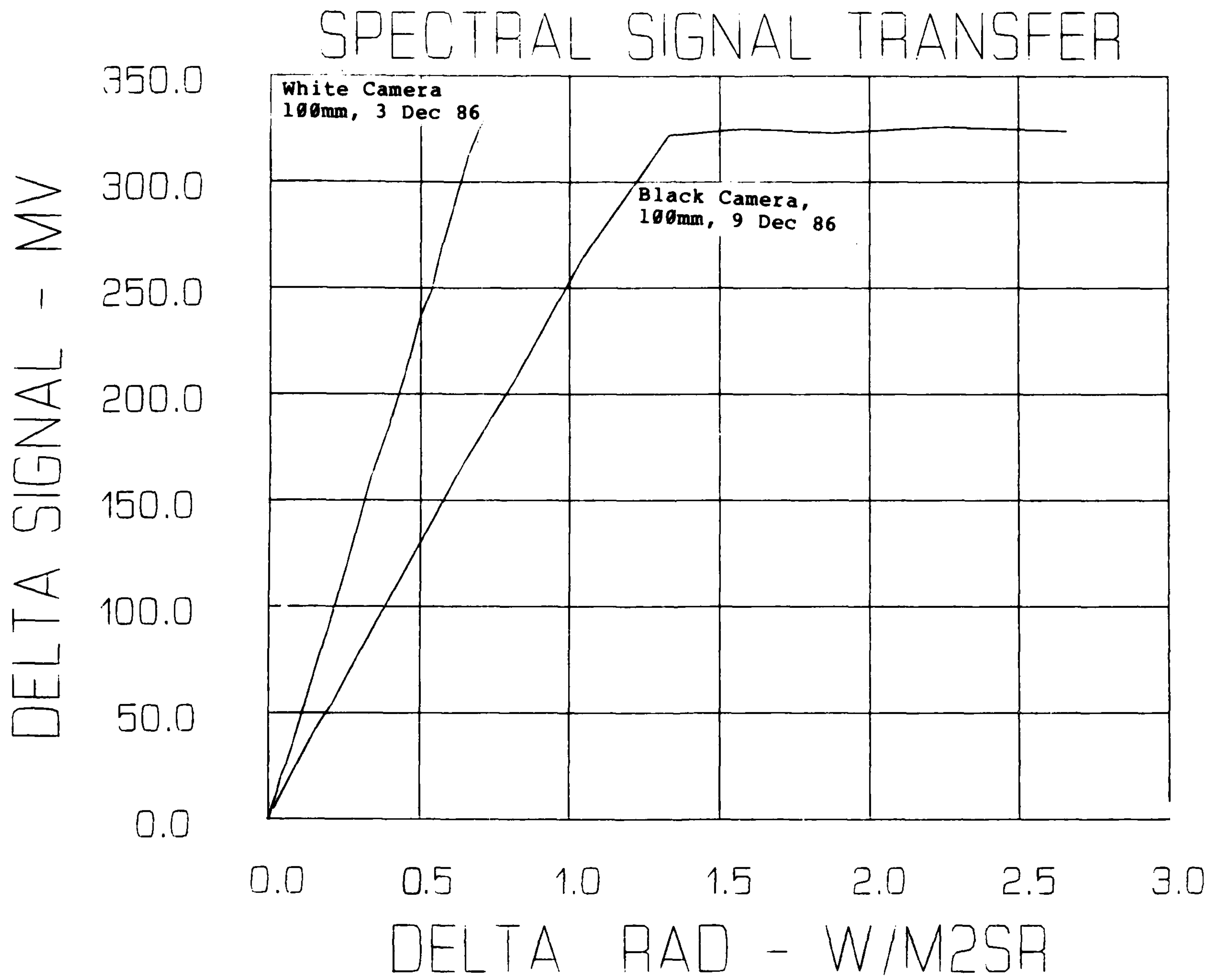
Spectral radiance of the blackbody source CVSF collimator combination were calculated for each wavelength to determine the final Normalized Spectral Response values.

Two CVSF filters had to be used to cover the 3-5.5 micrometer range. They overlap between 4.16 and 4.58 micrometers.

3. RESULTS

The Spectral Signal Transfer curves indicate the linearity of the sensors for these tests.

The Spectral Response curves for both the black and white cameras are very similar. The dip in both curves at 4.25 micrometers is due to the atmospheric CO_2 absorption band.


SPECTRAL SIGNAL TRANSFER
White Camera
1ØØmm, 3 Dec 86
Black Camera,
1ØØmm, 9 Dec 86
DELTA SIGNAL - MV
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
DELTA RAD - W/M2SR

Plot #11

WHITE CAMERA, 100mm, 3 DEC 86

TABLE 14A
RELATIVE SPECTRAL RESPONSE

WAVELENGTH - MICRONS	SPECTRAL RESPONSE
3.27	0.03
3.40	0.00
3.53	0.35
3.66	1.00
3.79	0.91
3.91	0.78
4.04	0.63
4.16	0.53
4.28	0.04
4.40	0.23
4.52	0.23
4.58	0.21
4.16	0.46
4.27	0.26
4.48	0.24
4.70	0.19
4.93	0.10
5.15	0.01
5.39	0.00

TABLE 14B
RELATIVE SPECTRAL RESPONSE

BLACK CAMERA, 100mm, 9 DEC 86

WAVELENGTH - MICRONS	SPECTRAL RESPONSE
3.27	0.00
3.40	0.01
3.53	0.65
3.66	1.00
3.79	0.93
3.91	0.85
4.04	0.71
4.16	0.61
4.28	0.04
4.40	0.29
4.52	0.27
4.58	0.25
4.16	0.39
4.27	0.18
4.48	0.28
4.70	0.19
4.93	0.10
5.15	0.00
5.39	0.00

WHITE CAMERA, 100mm, 3 DEC 86

TABLE 15A

SPECTRAL SIGNAL TRANSFER

DELTA RAD - W/M2SR	DELTA SIGNAL - MV
0.00	0.00
0.03	12.90
0.04	19.40
0.06	25.00
0.08	34.60
0.11	48.20
0.15	67.70
0.20	90.46
0.26	120.00
0.34	162.00
0.40	186.00
0.45	207.00
0.50	236.00
0.54	250.00
0.57	265.00
0.61	287.00
0.66	312.00
0.71	329.00

TABLE 15B

SPECTRAL SIGNAL TRANSFER

BLACK CAMERA, 100mm, 9 DEC 86

DELTA RAD - W/M2SR	DELTA SIGNAL - MV
0.00	0.00
0.15	40.50
0.21	53.90
0.29	75.00
0.39	101.00
0.51	132.00
0.64	166.00
0.82	207.00
1.04	263.00
1.33	322.00
1.57	325.00
1.87	323.00
2.24	326.00
2.66	324.00

SECTION IX
UNIFORMITY

1. OBJECTIVE

To determine the video uniformity of the sensors under various background temperature conditions.

2. TEST METHODOLOGY AND PROCEDURES

The sensors were operated in the following modes: White camera - Gain = 8, Fine gain = Max, 100mm and 299mm lens; Black camera - 3 Run, Attenuation = 0 db, 100mm lens.

A unifrom blackbody source 7 inches square was used to "cap" the camera's lens by placing the source in front of the aperture. Camera focus was kept at infinity. The blackbody source was first set at ambient room temperature. Background subtraction was used for both cameras at this ambient temperature. No background subtraction was used for other blackbody source temperatures. A single horizontal line halfway down the format was digitized and stored as a typical representation of the sensor horizontal uniformity. Vertical uniformity was obtained by sampling one point at the center of each horizontal line for one entire field. This procedure was repeated for all background temperatures.

Room ambient temperatures ranged from about 22 to 23° during these tests.

3. RESULTS

When background subtraction is used, the uniformity is very good; however, without the background subtraction, just the opposite is true. The white camera is very non-uniform, with variations up to 600mv. This equivalent to several degrees celsius variation at the selected gain setting. The non-uniformities were similar for both the 100mm and 299mm lenses. The black camera has much less non-uniformity possibly because of the specially baffled 100mm lens which was designed to reduce flare. An estimate of the non-uniformity as a function of temperature can be made by looking at the signal and noise data and using the temperature gain data to correct voltage to temperature. Plots with temperature non-uniformities were not made because of some non-linearity in the signal transfer data.

UNIFORMITY

Photo #5 - White Camera, 100mm Lens, 22°C Source Temperature, Background Subtraction, Maximum Gain

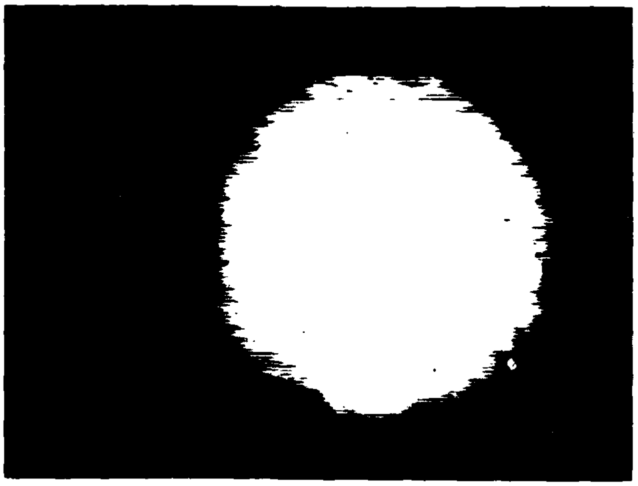


Photo #6 - White Camera, 100mm Lens, 45°C Source Temperature, No Background Subtraction, Maximum Gain

UNIFORMITY

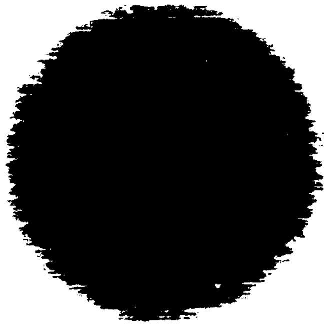
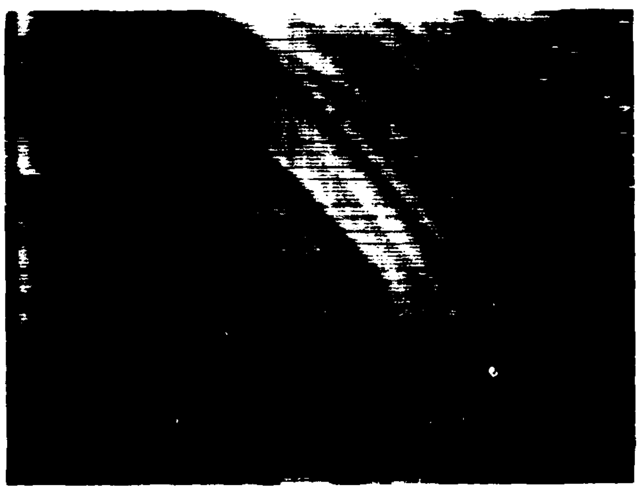


Photo #7 - White Camera, 100mm Lens, 5°C Source Temperature, No Background Subtraction, Maximum Gain



Photo#8 Black Camera, 100mm Lens, 22°C Source Temperature, No Background Subtraction, Maximum Gain

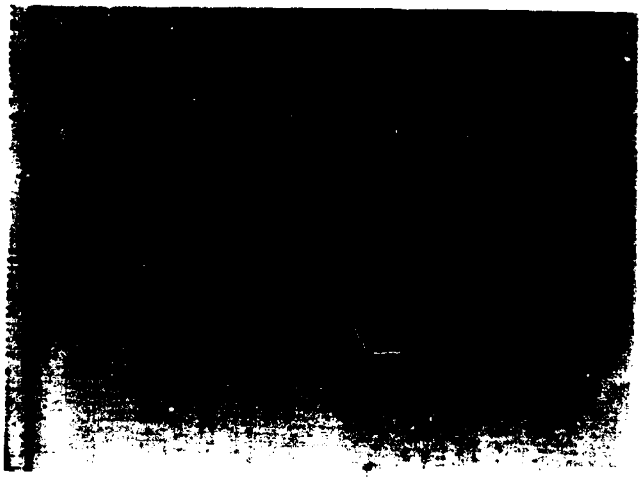


Photo #9 - Black Camera, 100mm Lens, 45°C Source Temperature, Background Subtraction, Maximum Gain

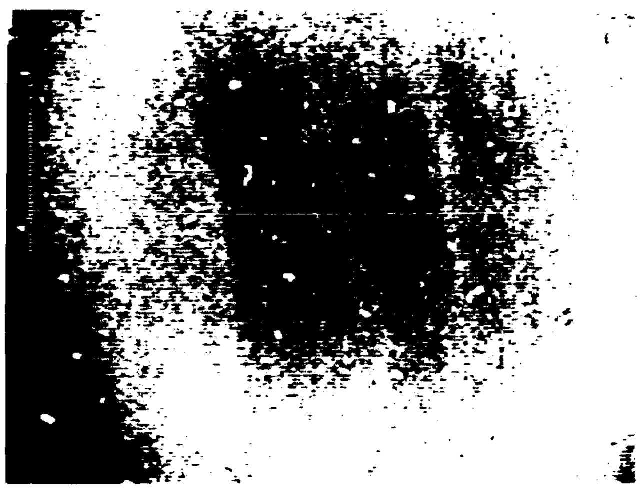


Photo #10 - Black Camera, 100mm Lens, 35°C Source Temperature No Background Subtraction, Maximum Gain

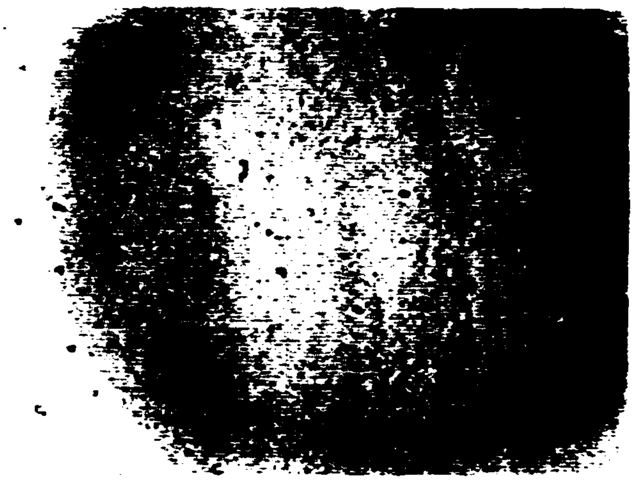
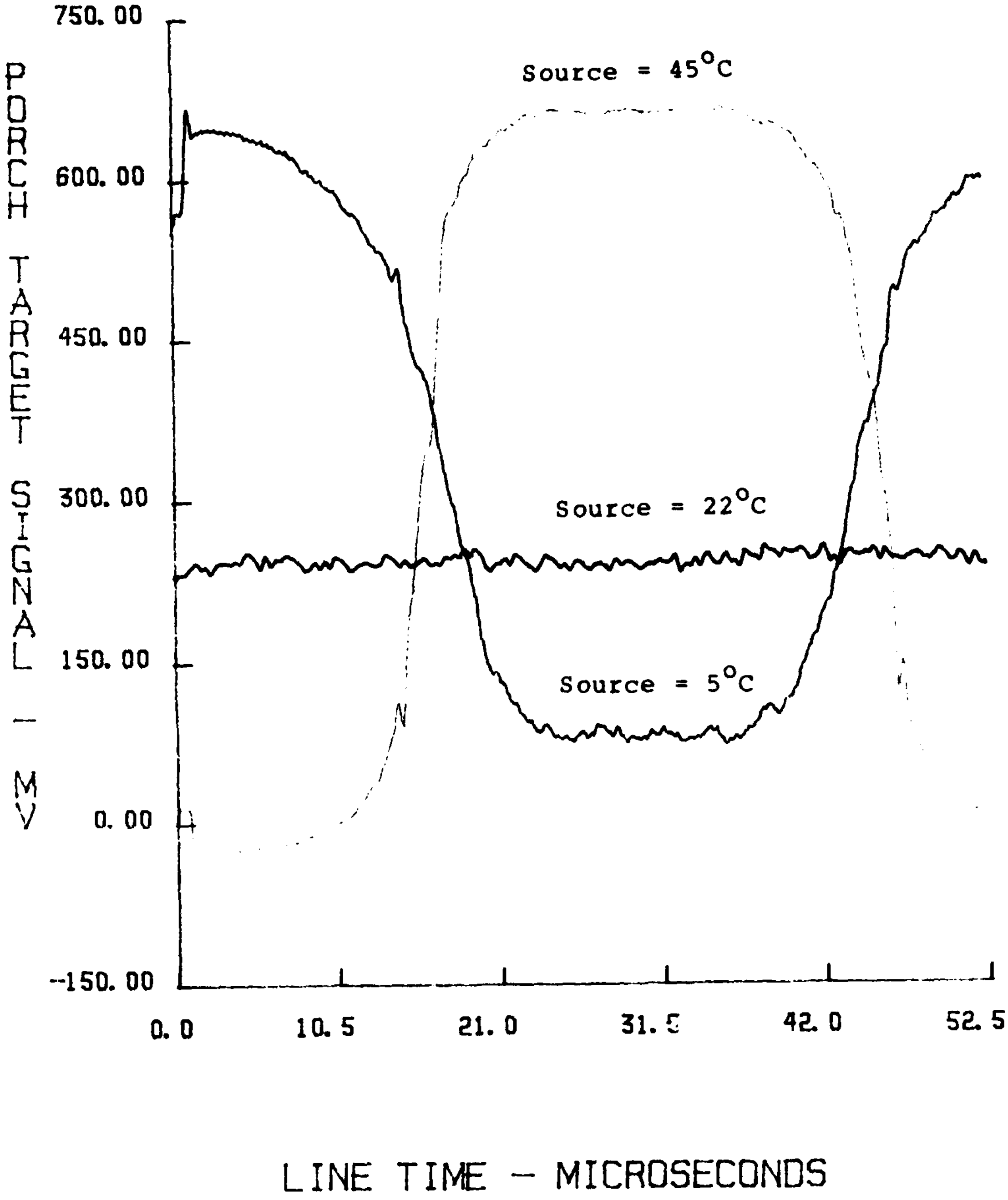


Photo #11 - Black Camera, 100mm Lens, 5 °C Source Temperature
No Background Subtraction, Maximum Gain

HORIZONTAL VIDEO UNIFORMITY

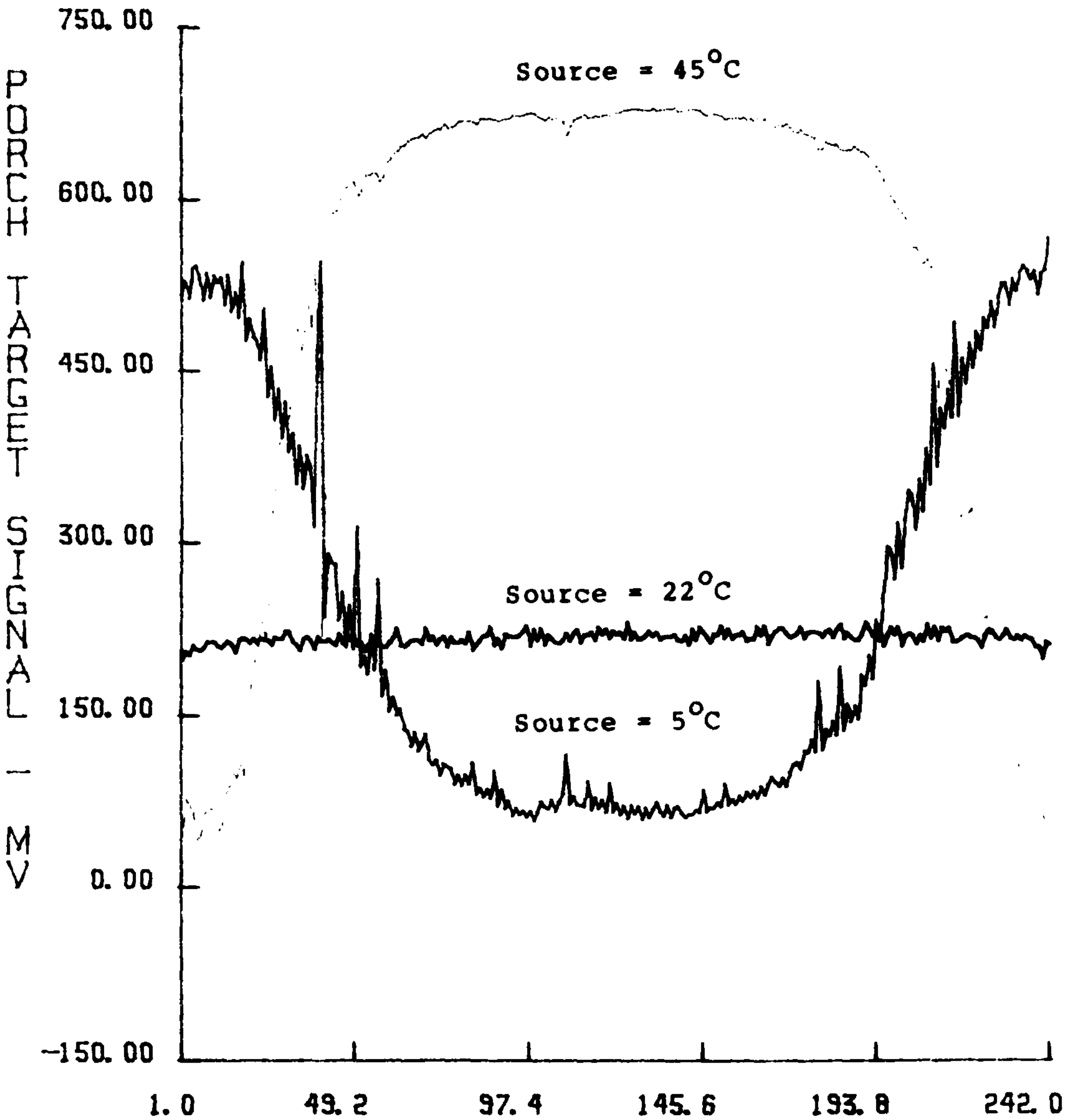
White Camera, 299mm Lens, Maximum Gain, 5 Dec 86



Plot #12

VERTICAL VIDEO UNIFORMITY

White Camera, 299mm Lens, Maximum Gain, 5 Dec 86

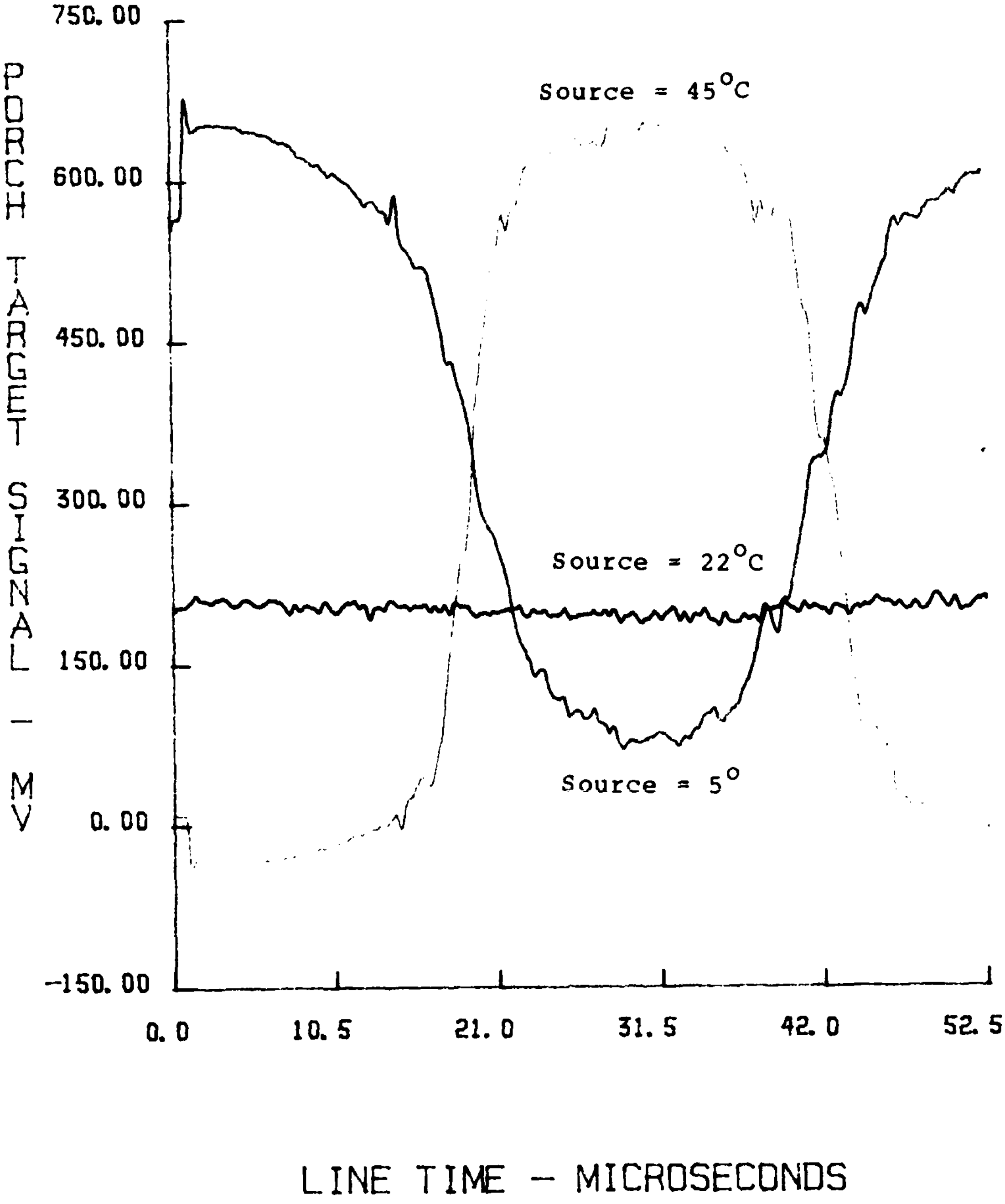


ONE FIELD - SCAN LINES

Plot #13

HORIZONTAL VIDEO UNIFORMITY

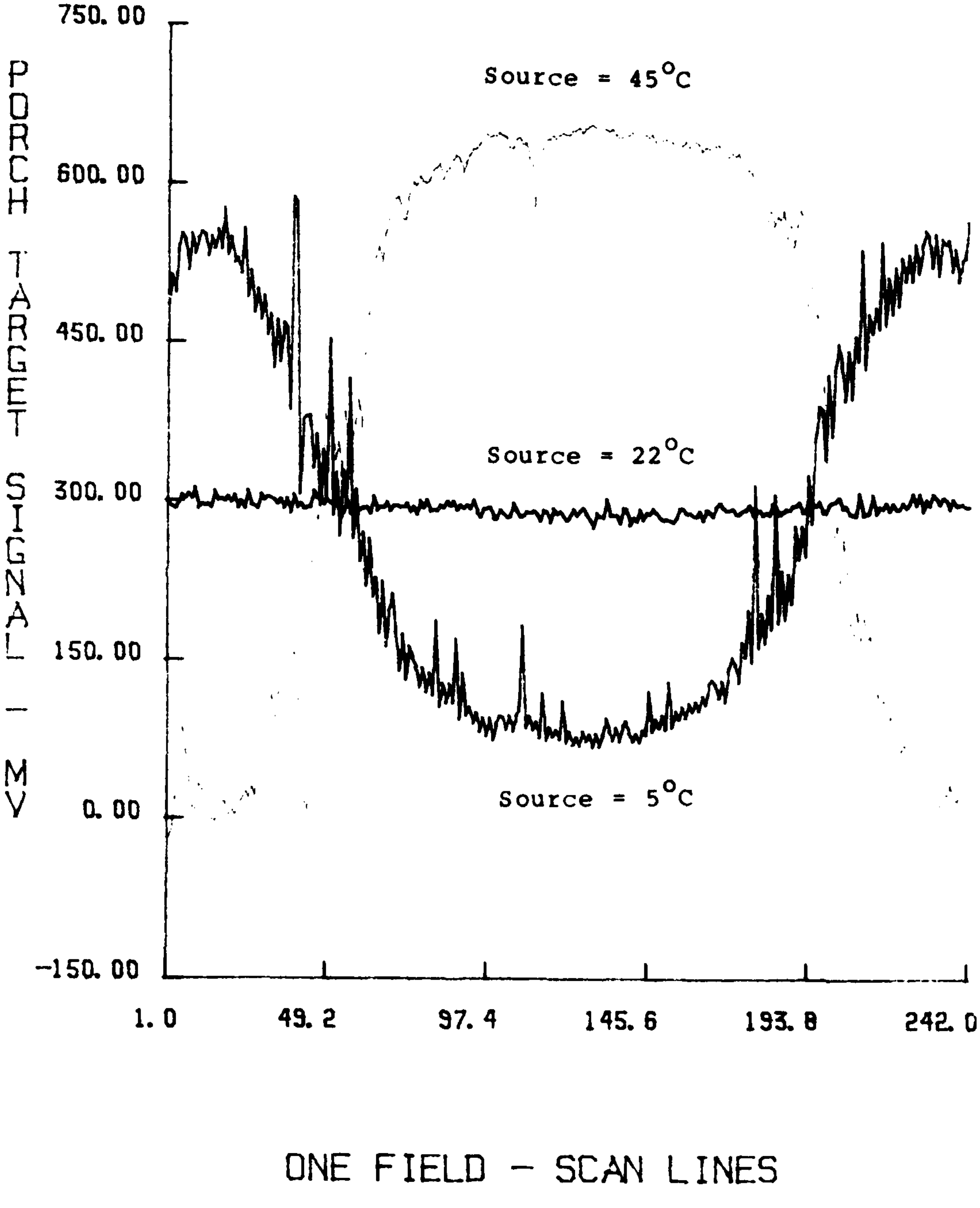
White Camera, 100mm Lens, Maximum Gain, 4 Dec 86



Plot #14

VERTICAL VIDEO UNIFORMITY

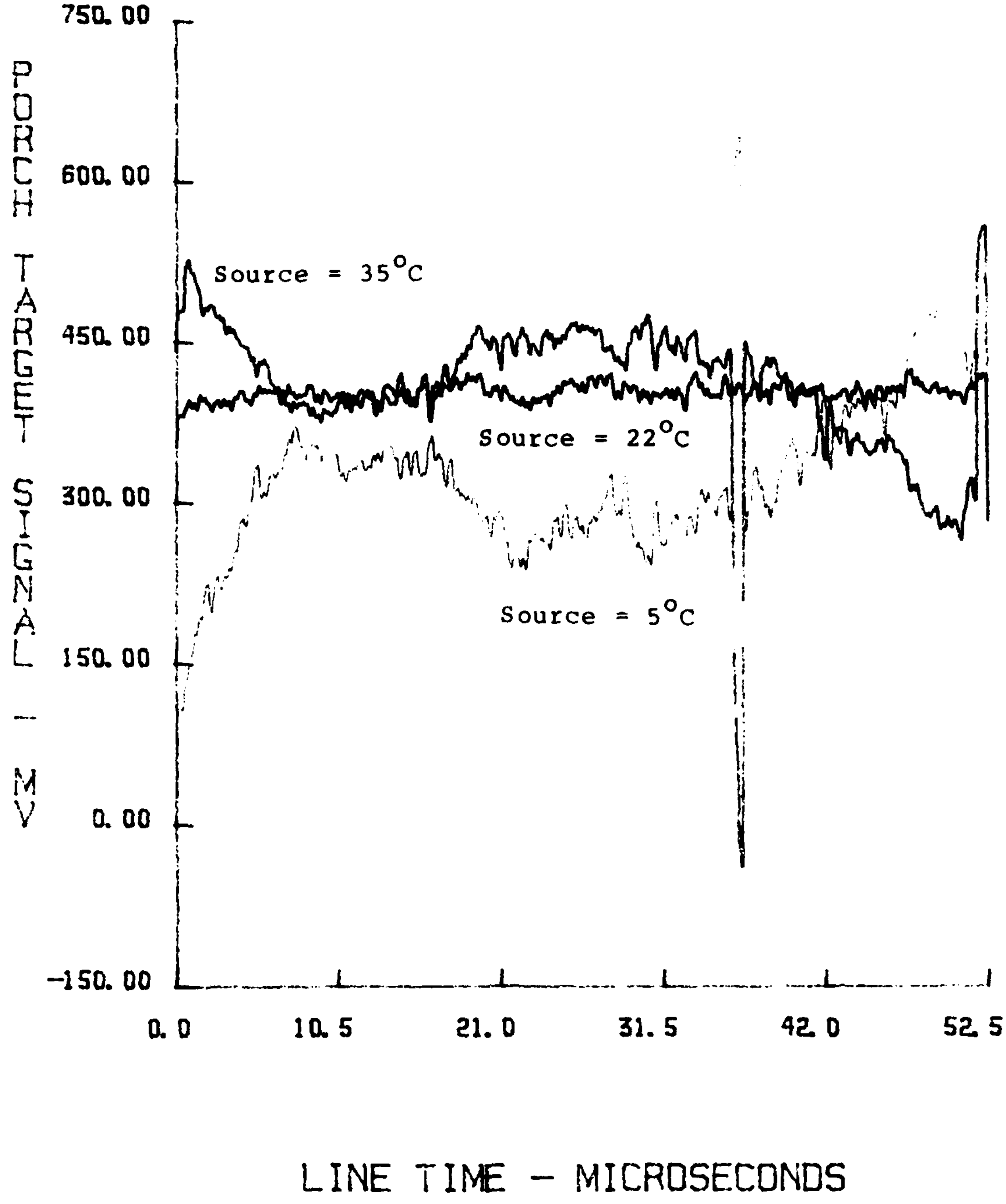
White Camera, 100mm Lens, Maximum Gain, 4 Dec 86



Plot #15

HORIZONTAL VIDEO UNIFORMITY

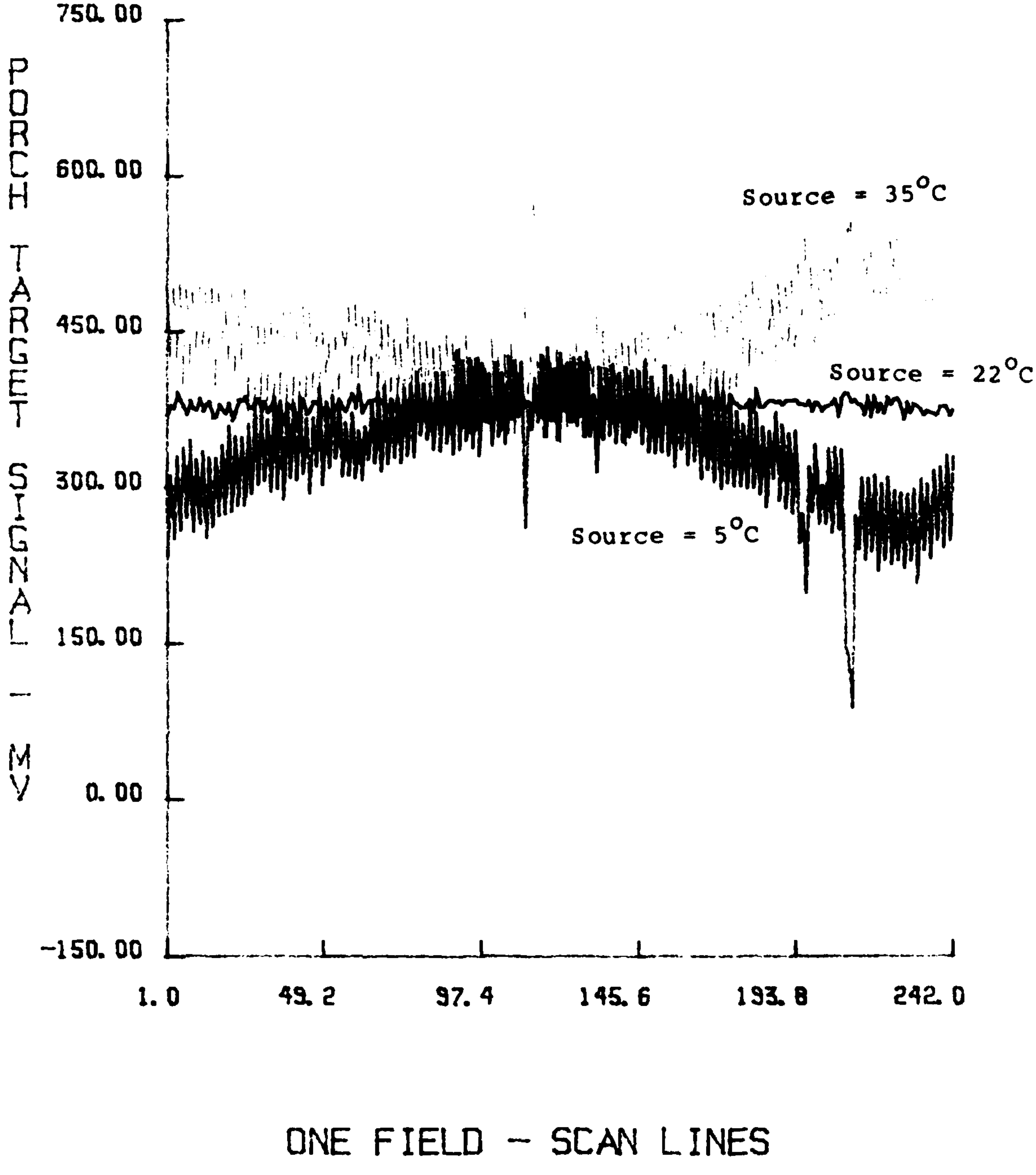
Black Camera, 100mm Lens, Maximum Gain, 12 Dec 86



Plot #16

VERTICAL VIDEO UNIFORMITY

Black Camera, 100mm Lens, Maximum Gain, 12 Dec 86



Plot #17

SECTION X
BLOOMING

1. OBJECTIVE

To determine the amount of image spread from high-temperature targets.

2. TEST METHODOLOGY AND PROCEDURES

The sensors were operated in the following modes: White camera - Gain = 8 and 1, Fine gain = Max and Min, 100mm lens; Black camera - 3 Run, Attenuation = 0 db, 100mm lens.

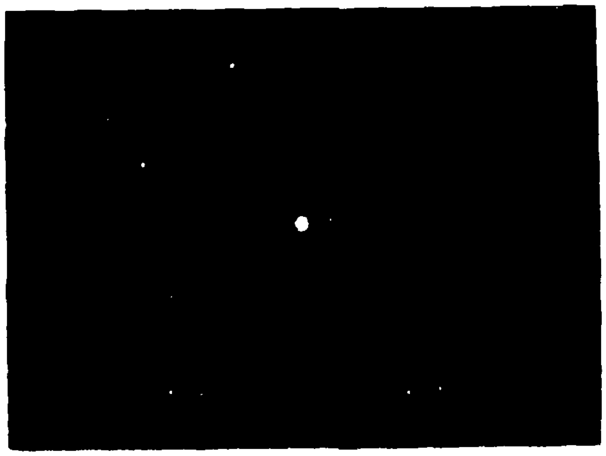
A 1.65 milliradian circular aperture target was placed in the collimator focal plane and centered in the sensor's FOV. The blackbody source temperature was set to 50°C (room temperature was approximately 22°C) and a horizontal scan line through the center of the image digitized and stored. A vertical sample (one field) through the center of the image was also acquired and stored. The source temperature was incremented upward and the procedure repeated.

3. RESULTS

As can be seen in the photos and plots, image spread is quite substantial. According to RADC most of the spread is due to optical flare. Vertical blooming appears somewhat worse than the horizontal blooming for both cameras.

BLOOMING

1.65 Milliradian Circular Aperture Pattern



Photo#12 - White Camera 100mm Lens, Minimum Gain, $100^{\circ}C$ Source Temperature

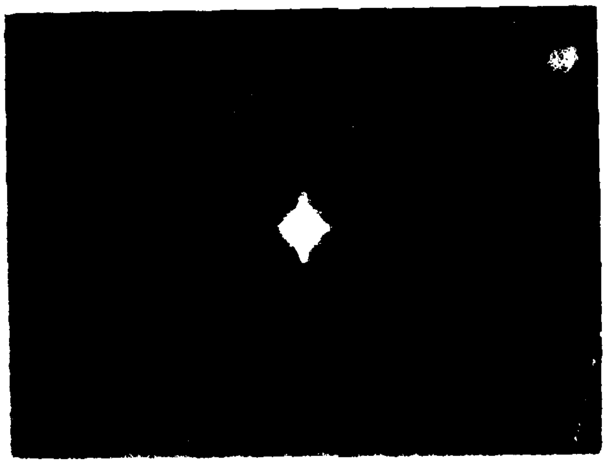


Photo #13 - White Camera, 100mm Lens, Minimum Gain, $500^{\circ}C$ Source Temperature

BLOOMING

1.65 Milliradian Circular Aperture Pattern

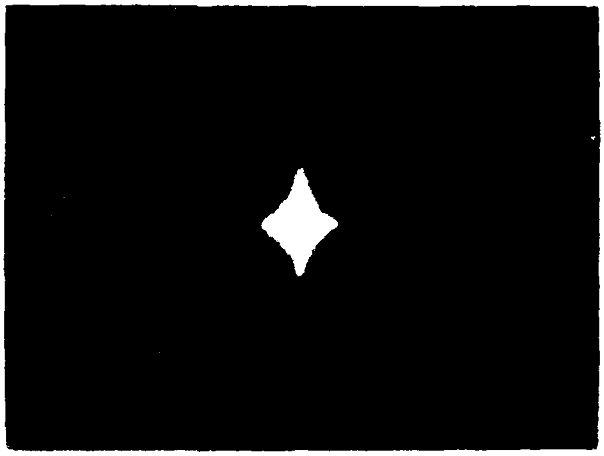


Photo #14 - White Camera, 100mm Lens, Minimum Gain, 800°C Source Temperature

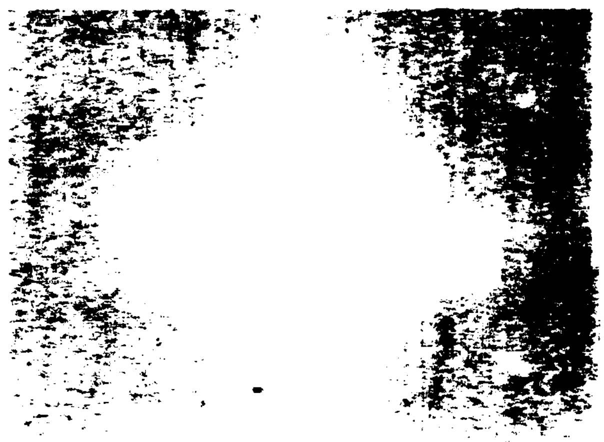


Photo #15 - White Camera, 100mm Lens, Maximum Gain, 500°C Source Temperature

BLOOMING

1.65 Milliradian Circular Aperture Pattern

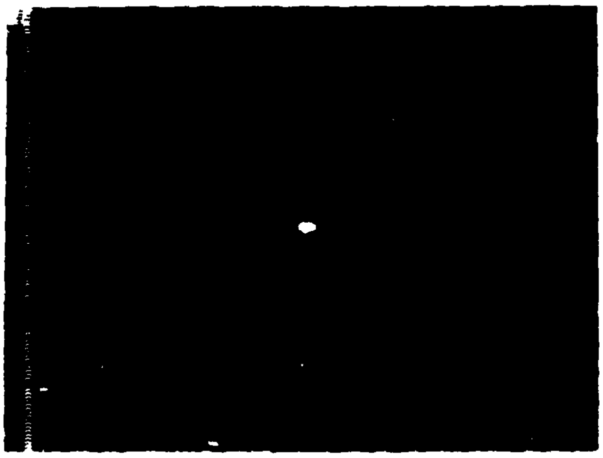


Photo #16 - Black Camera, 100mm Lens, Maximum Gain, 50°C Source Temperature

Photo #17 - Black Camera, 100mm Lens, Maximum Gain, 250° Source Temperature

BLOOMING

1.65 Milliradian Circular Aperture Pattern

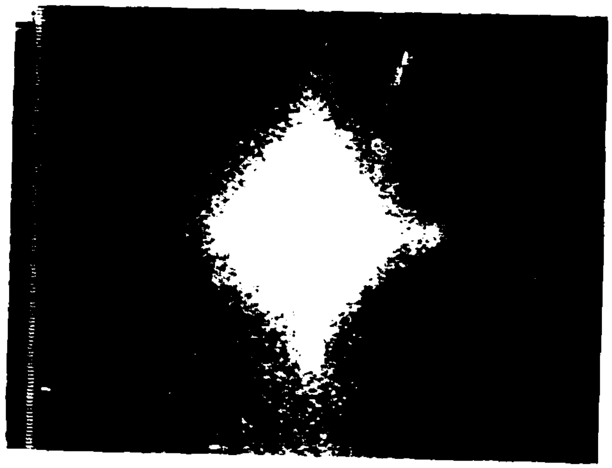
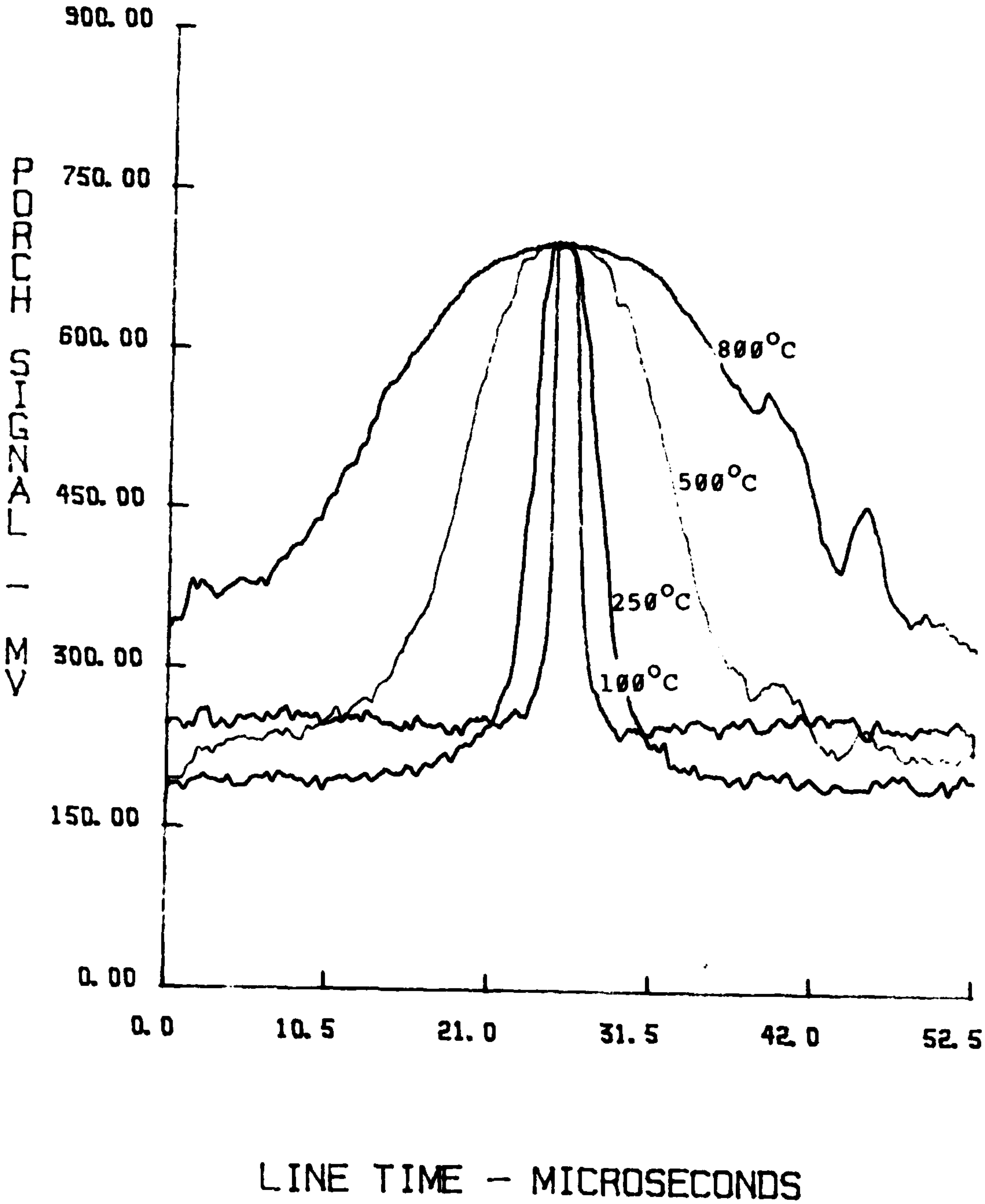


Photo #18 - Black Camera, 100mm Lens, Maximum Gain, 500°C Source Temperature

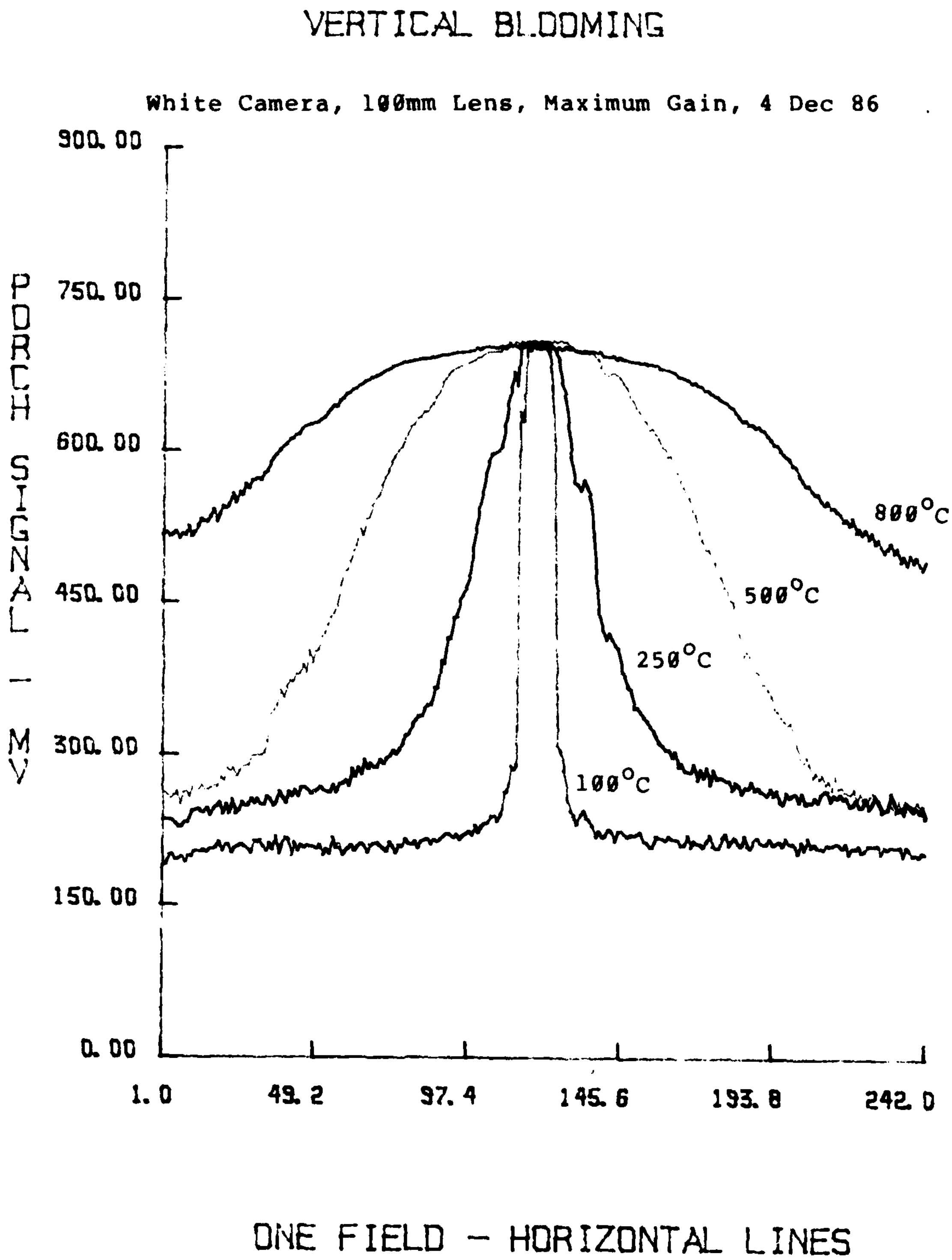
Photo #19 - Black Camera, 100mm Lens, Maximum Gain, 800°C Source Temperature

HORIZONTAL BLOOMING

White Camera, 100mm Lens, Maximum Gain, 4 Dec 86



Plot #18

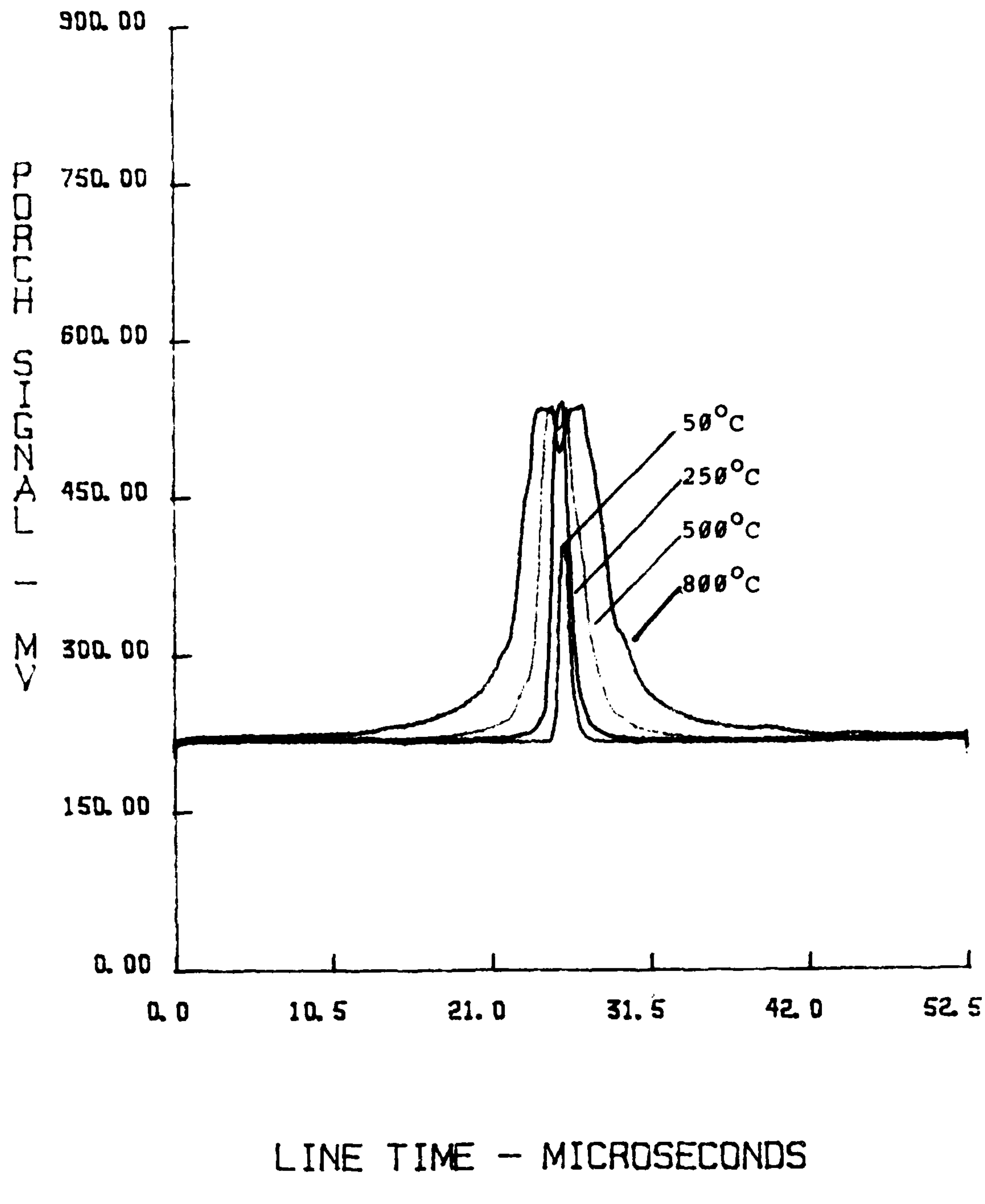


VERTICAL BLOOMING
White Camera, 100mm Lens, Maximum Gain, 4 Dec 86
PORCH SIGNAL - MV
900.00
750.00
600.00
450.00
300.00
150.00
0.00
1.0
49.2
97.4
145.6
193.8
242.0
800°C
500°C
250°C
100°C
ONE FIELD - HORIZONTAL LINES

Plot #19

HORIZONTAL BLOOMING

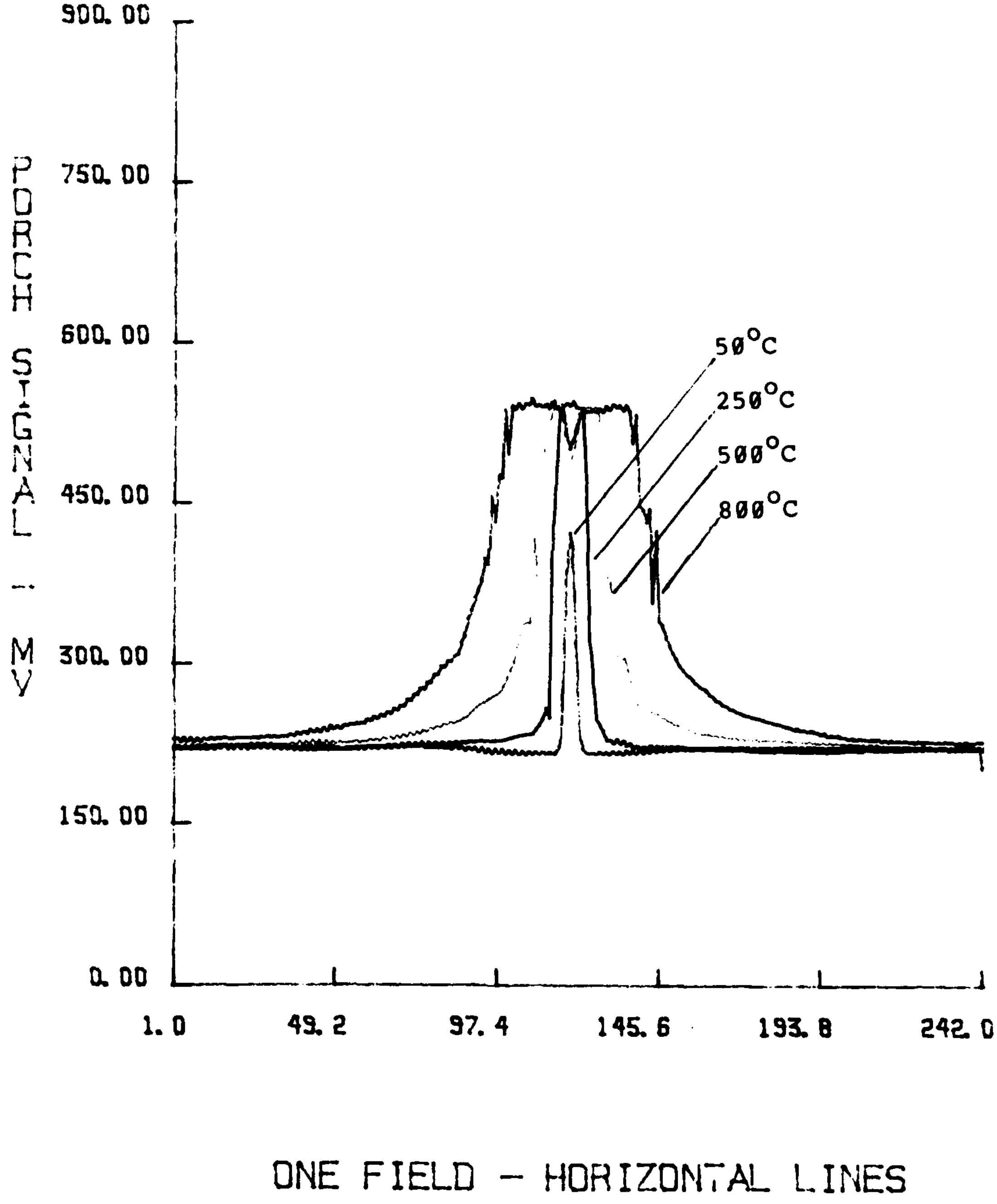
White Camera, 100mm Lens, Minimum Gain, 4 Dec 86



Plot #20

VERTICAL BLOOMING

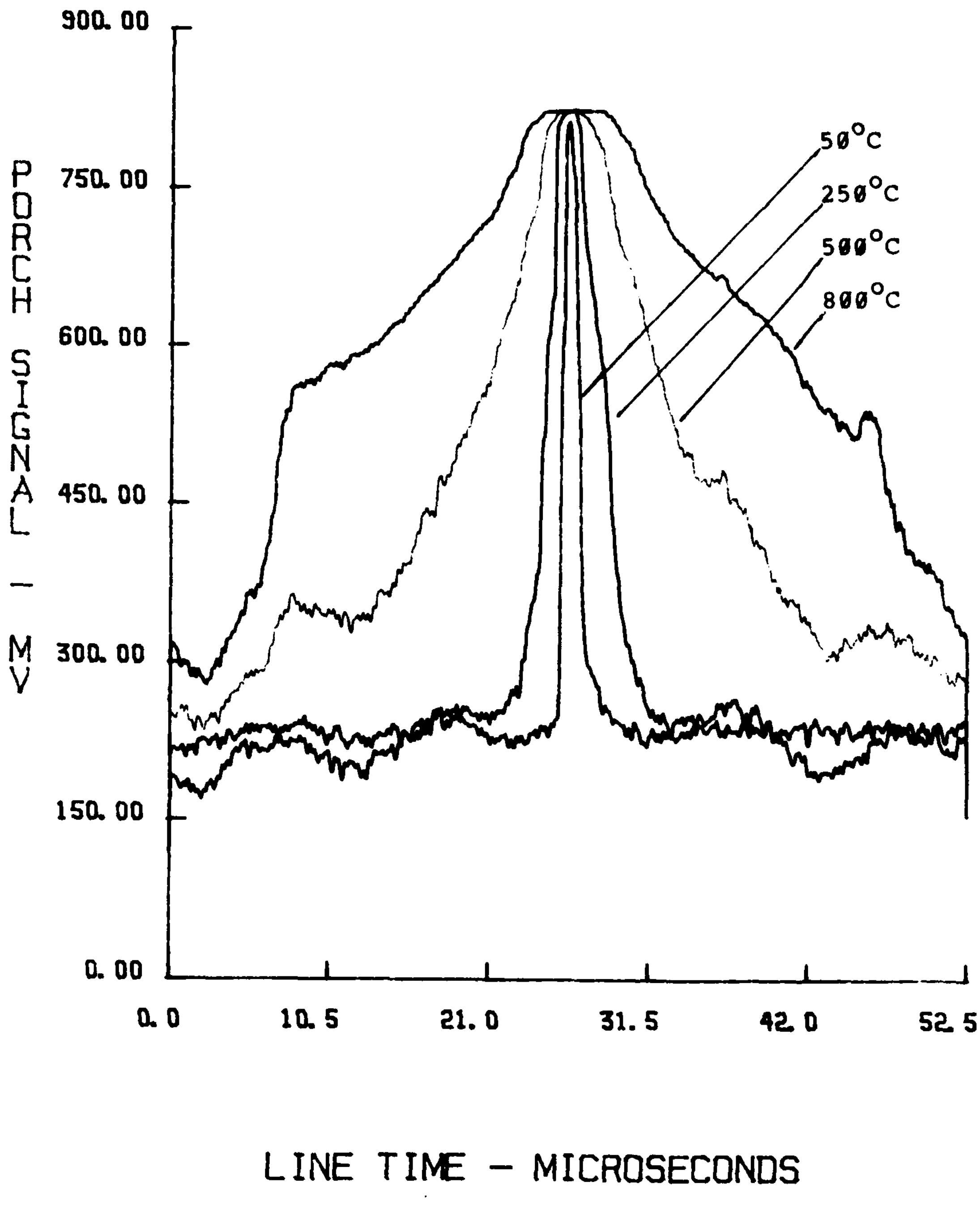
White Camera, 100mm Lens, Minimum Gain, 4 Dec 86



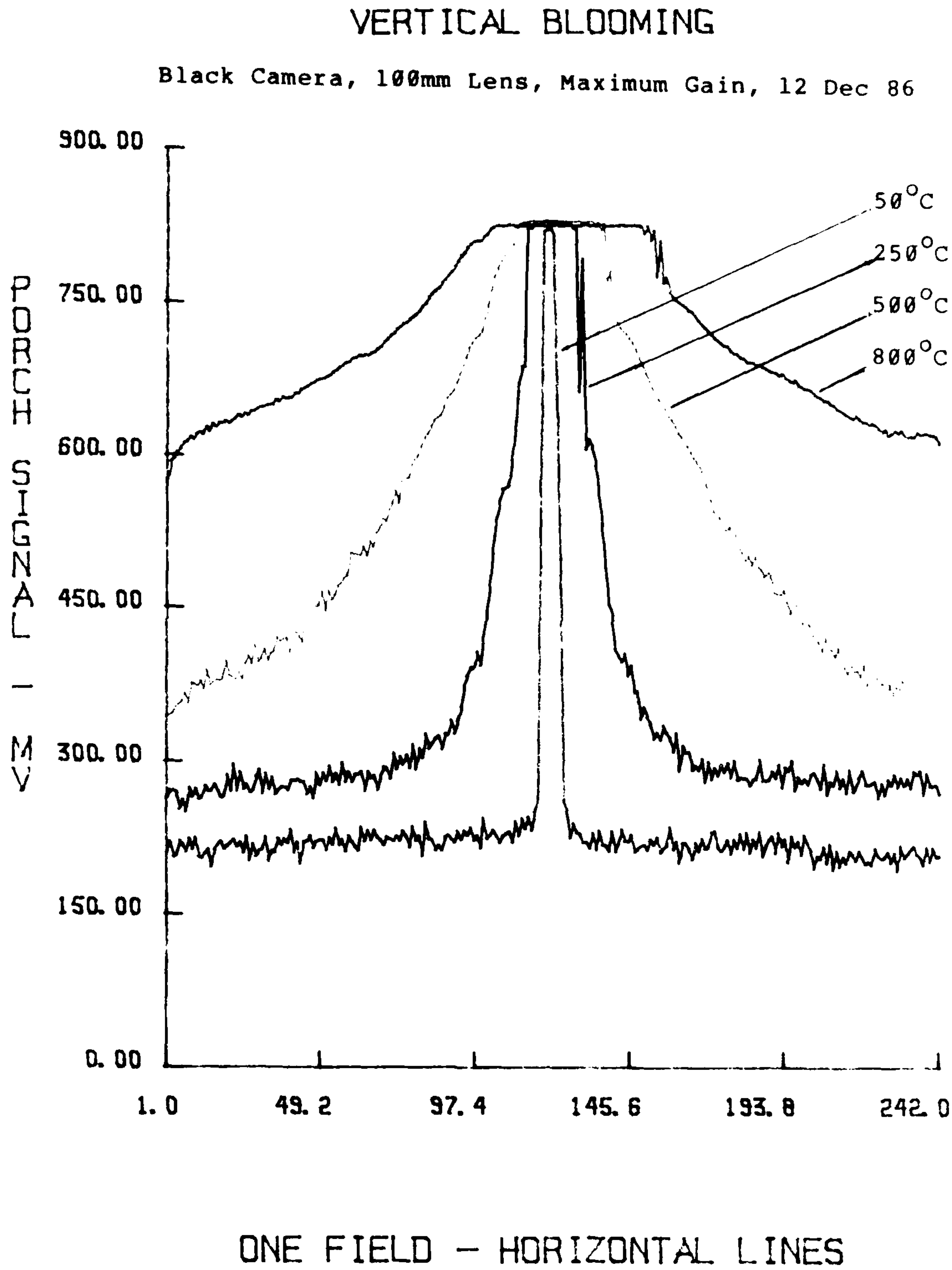
Plot #21

HORIZONTAL BLOOMING

Black Camera, 100mm Lens, Maximum Gain, 12 Dec 86



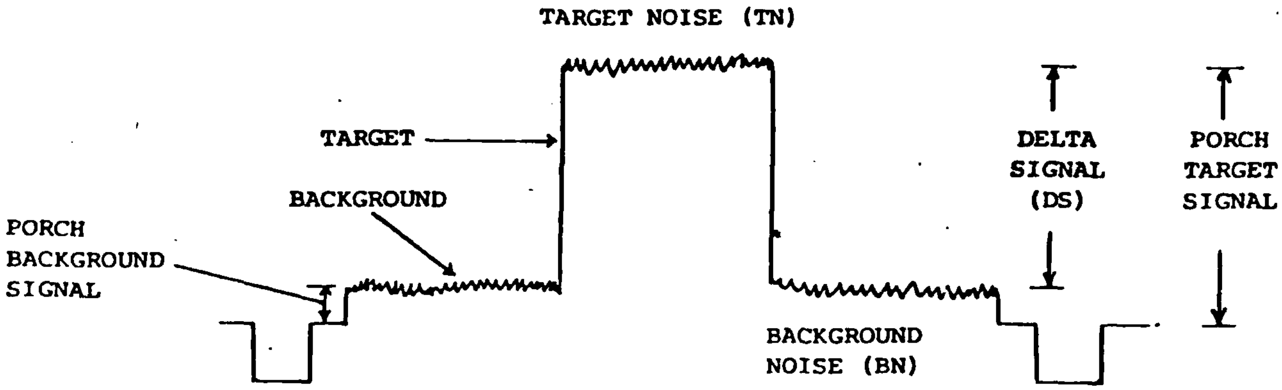
Plot #22


VERTICAL BLOOMING
Black Camera, 100mm Lens, Maximum Gain, 12 Dec 86
900.00
750.00
600.00
450.00
300.00
150.00
0.00
PORCH SIGNAL - MV
50°C
250°C
500°C
800°C
1.0
49.2
97.4
145.6
193.8
242.0
ONE FIELD - HORIZONTAL LINES

Plot #23

Appendix A

DEFINITION OF TERMS



HORIZONTAL VIDEO LINE

The signals, temperatures, and radiances for all non-incremental data are always referenced to the background and can thus be considered "cummulative" or "large signal" data. Incremental data are referenced only to adjacent data points and can thus be considered "incremental" or "small signal" data.

BASIC DATA

1. Porch Target Signal = PTS

2. Porch Background Signal = PBS

3. Delta Signal = DS = ΔS - PTS-PBS

4. Target Noise = TN

5. Background Noise = BN

6. $NQ1 = (TN^2 + BN^2)^{1/2}$

7. $NQ2 = \left(\frac{TN^2 + BN^2}{2}\right)^{1/2}$

8. $SNRT = \frac{DS}{TN}$

9. $SNRB = \frac{DS}{BN}$

10. $SNR1 = \frac{DS}{NQ1}$

11. $SNR2 = \frac{DS}{NQ2}$

12. Target Temperature = TT

BASIC DATA (Cont'd)

13. Background Temperature = BT

14. Delta Temperature = ΔT = TT-BT

15. SNRT Temperature Sensitivity = DS/TN/ΔT

16. SNRB Temperature Sensitivity = DS/BN/ΔT

17. SNR1 Temperature Sensitivity = DS/NQ1/ΔT

18. SNR2 Temperature Sensitivity = DS/NQ2/ΔT

19. Temperature Gain = DS/ΔT

AVERAGED INCREMENTAL DATA

1. Incremental Delta Temperature = $\Delta\Delta T$

$$\Delta\Delta T_{12} = \Delta T_2 - \Delta T_1$$

2. Average Delta Temperature = $A\Delta T$

$$A\Delta T_{12} = \frac{\Delta T_1 + \Delta T_2}{2}$$

3. Incremental SNRT = ΔSNRT

$$\Delta SNRT_{12} = SNRT_2 - SNRT_1$$

4. Incremental SNRB = ΔSNRB

$$\Delta SNRB_{12} = SNRB_2 - SNRB_1$$

5. Incremental SNR1 = ΔSNR1

$$\Delta SNR1_{12} = SNR2_2 - SNR1_1$$

6. Incremental SNR2 = ΔSNR2

$$\Delta SNR2_{12} = SNR2_2 - SNR2_1$$

7. Incremental SNRT Temperature Sensitivity = ΔSNRT/$\Delta\Delta T$

8. Incremental SNRB Temperature Sensitivity = ΔSNRB/$\Delta\Delta T$

9. Incremental SNR1 Temperature Sensitivity = ΔSNR1/$\Delta\Delta T$

10. Incremental SNR2 Temperature Sensitivity = ΔSNR2/$\Delta\Delta T$

AVERAGED INCREMENTAL DATA (Cont'd)

11. Incremental Delta Signal = $\Delta\Delta S$

$$\Delta\Delta S_{12} = \Delta S_2 - \Delta S_1$$

12. Incremental Gain = $\Delta\Delta S/\Delta\Delta T$

13. Average Porch Target Signal = APTS

$$APTS_{12} = \frac{PTS_1 + PTS_2}{2}$$

SENSOR SPECTRALLY CORRECTED RADIANCE DATA

The purpose of "correcting" radiance values with the sensor's spectral response is to factor out the spectral radiance dependency of the sensor. The sensor's response can be plotted as a function of "neutral" radiance.

The "correction" for the 8-12 micrometer spectral band is accomplished as follows: a hypothetical, spectrally neutral detector has a constant relative spectral response of SR, across the 8-12 micrometer band. The integrated spectral response, ISR_1 of this detector is given by the equation:

$$ISR_1(\lambda) = \int_8^{12} SR_1(\lambda)d\lambda \qquad \text{where } \lambda = \text{wavelength}$$

since SR_1 is wavelength independent

$ISR_1 = 4SR_1$.

The sensor under test has an integrated spectral response, ISR_2 of

$$ISR_2(\lambda) = \int_8^{12} SR_2(\lambda)d\lambda$$

where $SR_2(\lambda)$ = sensor spectral response.

A correction factor (CF) which normalizes ISR_2 with respect to ISR_1 is obtained by:

$$CF = \frac{ISR_1}{ISR_2(\lambda)}$$

The sensor normalized spectral response, NSR_2 is obtained as follows:

$NSR_2(\lambda) = SR_2(\lambda) * CF$ at each wavelength.

NSR_2 is, in turn, used to obtain the corrected spectral radiance CSRAD of the blackbody source.

$CSRAD(\lambda) = SRAD(\lambda) * NSR_2(\lambda)$ at each wavelength

where $SRAD(\lambda)$ = spectral radiance of blackbody source.

The integral of CSRAD across the 8-12 micrometer band results in the sensor spectrally corrected radiance.

1. Porch Target Radiance (Spectrally Weighted) = PTRW
2. Porch Background Radiance (Spectrally Weighted) = PBRW
3. Delta Radiance = DRAD = PTRW-PBRW
4. Average Delta Radiance = ADRAD

$$ADRAD_1 = \frac{DRAD_2 + DRAD_1}{2}$$

5. Incremental Delta Radiance = DDRAD

$$DDRAD_1 = DRAD_2 - DRAD_1$$

6. Incremental Radiance Gain = DGain - DDS/DDRAD
7. SNRT Radiance Sensitivity = DS/TN/DRAD
8. SNRB Radiance Sensitivity = DS/BN/DRAD
9. SNR1 Radiance Sensitivity = DS/NQ1/DRAD
10. SNR2 Radiance Sensitivity = DS/NQ2/DRAD