Task Assignment 110
August 1984

LANDSAT INSTRUMENTS CHARACTERIZATION
GSFC ATR – Dr. J. Barker
SAR Task Leader – Dr. Y. Lee

Task Objective:

The objective of this task is to provide analytical and programming support for both Landsat-4 and -5 Thematic Mapper (TM) and Multispectral Scanner (MSS) instrument characterization, with emphasis on the radiometric performance.

Work Performed:

The following work was performed in the areas indicated.

150 Spectrometry

Several studies have been performed using Landsat-4 and -5 simultaneous overpath data 40608-15472 and 50014-15465 over Pensacola, FL. The overlap region of these two scenes has been determined visually on the IAT and then sampled into 32 x 32 segments. The mean and standard deviation (SD) for each segment have been calculated. For different ground features, they are expected to have a SD close to zero with different mean values. Some structures are shown in the plots of SD versus mean for each band and each sensor. An example is shown in Fig. 2. The plots of reflective bands versus thermal band also show some structures, and an example is shown in Fig. 3, that will help ground feature classification. In general, the plots of the means of Landsat-4 versus Landsat-5 lie on the diagonal line. Some of the data (an example is shown in Fig. 4) lie out of the diagonal line, which indicates a possible bidirectional observation effect occurs. Further studies will be performed.

210 CALDUMP and CALFILE Tapes Processing

In addition to editing the five .FCL files on CALDUMP tapes into seven 1000 minor frame (MF) .CAL files, program LEE.FOR has been modified to use information from start of shutter obscuration extracted from program START.FOR to create seven 200 MF .CAL files that can be run through the current TRAPP program for TM sensor characterization. The 200 MF .CAL files contain 148 MFs of calibration pulse data where the center of calibration pulses has been set in the middle of the region, and 52 MFs of background data collected separately from region before and after dark current (DC) restoration. The location of start of shutter obscuration has been determined for both Landsat-4 and -5 by using the algorithm described in the last monthly report. The results of Landsat-4 scene 40392-18152 over San Francisco, CA, and Landsat-5 scene 50014-15465 over Pensacola, FL, are listed in Tables 1 and 2. The relative starting location of calibration pulse region and two different background regions, with respect to the start of shutter obscuration for both forward and reverse scans, are listed in Table 3. All in-orbit data obtained up to now will be preprocessed in this manner to meet the requirement of the current TRAPP run. A new algorithm has been proposed to utilize more data out of the

CALDUMP tape to cover further study of TM characteristics. A 150 MF calibration pulse region is proposed to be collected to produce information of calibration pulse, light leak of Landsat-5, and three backgrounds. It was also suggested that two 28-MF regions and one 256-MF region of background data, which can be used to study coherent noises, DC restoration, forward/reverse differences, and odd/even differences, be collected simultaneously. The scope of the proposed CALDUMP tape preprocessing is shown in Fig. 1. It was proposed that image data covering 18 28-MF regions will be collected, which should provide more scene statistics than the present procedure.

310 Bright-Target Saturation

Because more background data can be collected from the present CALDUMP tapes, the study of bright-target saturation effect shown on scene 40392-18152 can be continued. Data collected after the start of shutter obscuration have been sampled every 10 MFs, which produce about 70 average background data along each scan line. A threshold value of 200 has been set in band 1 to produce the bright-target boundary. Twelve scan lines have been chosen for this study. Each of them has a different distance between bright-target boundary and the background data that covers the bright-target saturation effect up to about 7000 MFs. A good example of bright-target saturation is shown in Fig. 5. Due to the saturation, the detector lost its sensitivity after coming out of a bright cloud then tries to regain its sensitivity. At the same time, the detector gains sensitivity due to excess ions filled in the detector, which causes the overshot in the mid region of the spectrum. A mathematical modeling of the data will be performed to extract the recovery time constants. Before performing the mathematical modeling of the bright-target saturation, scan-correlated shifts and DC restoration effects needed to be removed. The scan-correlated shifts have been successfully removed as shown in Figs. 6-9. The DC restoration effects on the spectrum are also shown in Figs. 8-10. The expanded plot of Fig. 11 shows the difference between scans with and without bright-target saturation. The increased DN value with increased MF location for the scans without bright-target saturation is due to the DC restoration, which should be corrected. Fig. 12 shows there is no bright-target saturation in bands on a cold focal plane.

620 Tapes and Output Organization

Task personnel organized material in Bldg. 16W (Rms 55 and 14) under the supervision of the ATR.

800 Data Processing

Task personnel processed three CALDUMP tapes, three CALFILE tapes, and 10 BRU tapes.

900 Multispectral Scanner Subsystem (MSS) Coherent Noise Analysis

The following Landsat scenes were entered into the Interactive Digital Image Manipulation System (IDIMS):

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Platform	Path	Row	Date	Scene ID
Landsat 4	20	39	March 31, 1984	4062415465
Landsat 5	20	39	April 24, 1984	5005415465
Landsat 4	27	28	March 16, 1984	4060916261
Landsat 5	27	28	March 16, 1984	5001516224

Each scene was examined for candidate areas of relatively uniform radiance to do an analysis of the coherent noise in the data. A 512 x 512 pixel subimage containing water was extracted from the March 31 and April 24 images. To do coherent noise analysis, an area with relatively uniform radiance with at least six lines and 170 samples must be located in the scene. No such area could be located in the Landsat-4 and -5 scenes acquired on March 16. As a result, no subareas were extracted from these scenes.

A complete analysis of the coherent noise was performed using the March 31 and April 24 subimages. One 6 x 179 study area was located in water in the March 31 data, and two such areas were located in the April 24 data. For each study site, the mean and standard deviation was calculated for each band and for each image channel (i.e., detector output). The latter gives a measure of the image noise without striping.

To compute the coherent noise, the following procedure was instituted as a series of batch jobs on the IDIMS image processing system:

1) The data were normalized by making the mean of the bands equal 25.0 by using the function LINEAR.

2) The normalized bands were combined using the function UNITE.

3) The normalized data were resequenced into the time domain using the function RESEQ.

4) A sample of 4096 pixels from the resequenced output was Fourier transformed using the function CFFT1G.

5) The magnitude of the Fourier transform was calculated using MAG.

6) A histogram-like plot of the magnitude was generated using PLOT.

7) A line plot of the magnitude was generated on the Versatec by using the function GRNDSPOG to form an Earth Resources Inventory System (ERIS) file and by using the ERIS funcion VARPLOT to plot the contents of the file.

The SAR analyst created tables of the coherent noise peaks observed in each Landsat-4 and -5 study site. The data were listed in terms of cycles per 4096 samples, cycles per pixel, and kHz. In addition, the magnitude of the noise peaks as observed in the Fourier magnitude plots were listed. This information was delivered to the NASA project scientist.

Areas of 210 lines were extract from both images and segmented into 24 sample areas corresponding to the data from the 24 detectors (i.e., 35 scans per detector). Means, variances, and counts of radiance numbers were generated for the detectors and delivered to the NASA project scientist.

Polaroid prints were made of enhancements of band 4 over water for both Landsat-4 and -5 to visually show that the Lansat-5 data has less coherent noise than the Landsat-4 data.

Significant Accomplishments:

On their own initiative and time, task personnel conducted the studies by using the Landsat-4 and -5 coincident data. The results are of interest in the fields of image classification and bidirectional observation.

Problem Areas:

None.

Schedule Conformance:

Work is proceeding as planned.

Work Planned for Next Month:

150 Spectrometry

Task personnel will perform studies by use of pure pixels.

310 Bright Target Saturation

Task personnel will remove scan-correlated shifts and DC restoration effects and perform mathematical modeling to obtain a bright target saturation time constant.

350 Droop

Task personnel will develop a correction algorithm for removal of DC restoration.

Deliverables Submitted:

Plots: Standard deviation versus mean for each band and each sensor
Originator: Y. P. Lee

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Plots:	**Mean of reflective bands versus mean of thermal band**
Originator:	**Y. P. Lee**
Plots:	**Mean of Landsat-4 versus mean of Landsat-5 for each band**
Originator:	**Y. P. Lee**
Plots:	**Average background versus distance from bright target boundary**
Originator:	**Y. P. Lee**
Listings:	**Statistics for Landsat-4 and -5 data for bands and detectors**
Originator:	**W. Hallada**
Listings:	**Observed coherent noise peaks in Landsat-4 and -5 data**
Originator:	**W. Hallada**
Graphics:	**Plots of the magnitude of the Fourier transformed data for Landsat-4 and -5**
Originator:	**W. Hallada**
Graphics:	**Polaroid prints of band 4 for Landsat-4 and -5**
Originator:	**W. Hallada**

Computer Utilization:

The estimated computer time used this month is as follows:

Minutes	Computer
1236 (wall clock)	HP-3000 (IDIMS)
120 (wall clock)	HP-3000 (ERRSAC)

Table 1

24-AUG-1984 10:00

LANDSAT-4 START OF SHUTTER OBSCURATION

CHANNEL	FORWARD	REVERSE
1	6452	6464
2	6448	6468
3	6444	6472
4	6440	6476
5	6436	6480
6	6432	6484
7	6428	6488
8	6424	6492
9	6420	6496
10	6416	6496
11	6412	6500
12	6408	6504
13	6404	6508
14	6400	6512
15	6396	6516
16	6396	6520

Table 2 24-AUG-1984 10:00

LANDSAT-5 START OF SHUTTER OBSCURATION

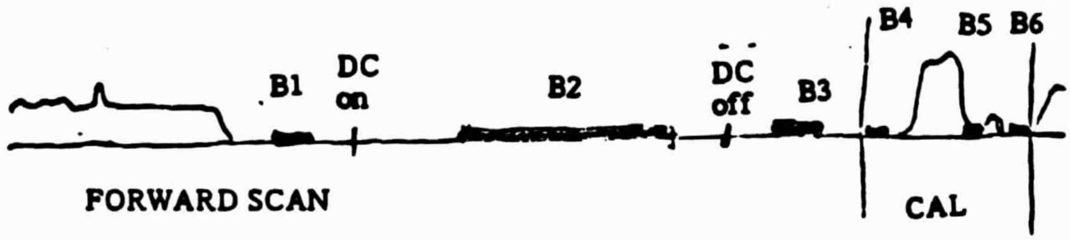
CHANNEL	FORWARD	REVERSE
1	6496	6432
2	6492	6436
3	6488	6440
4	6484	6444
5	6480	6448
[illegible]	6476	6452
7	6476	6456
8	6472	6460
9	6468	6460
10	6464	6464
11	6460	6468
12	6456	6472
13	6452	6476
14	6448	6480
15	6444	6484
16	6440	6488

Table 3

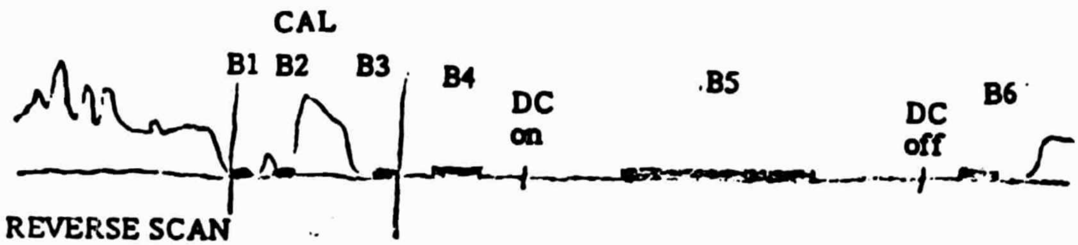
Relative Location of Start of Calibration Pulse Region and Start of Two Different Background Regions

	CAL	B-BDC	B-ADC
FWD	612	16	472
REV	24	228	684

CALDUMP TAPE PREPROCESSING



CAL region	150 mf		
B1	28 mf	B4	14 mf
B2	256 mf	B5	10 mf
B3	28 mf	B6	14 mf
total	512 mf		



CAL region	150 mf		
B4	28 mf	B1	14 mf
B5	256 mf	B2	10 mf
B6	28 mf	B3	14 mf
total	512 mf		

Figure 1

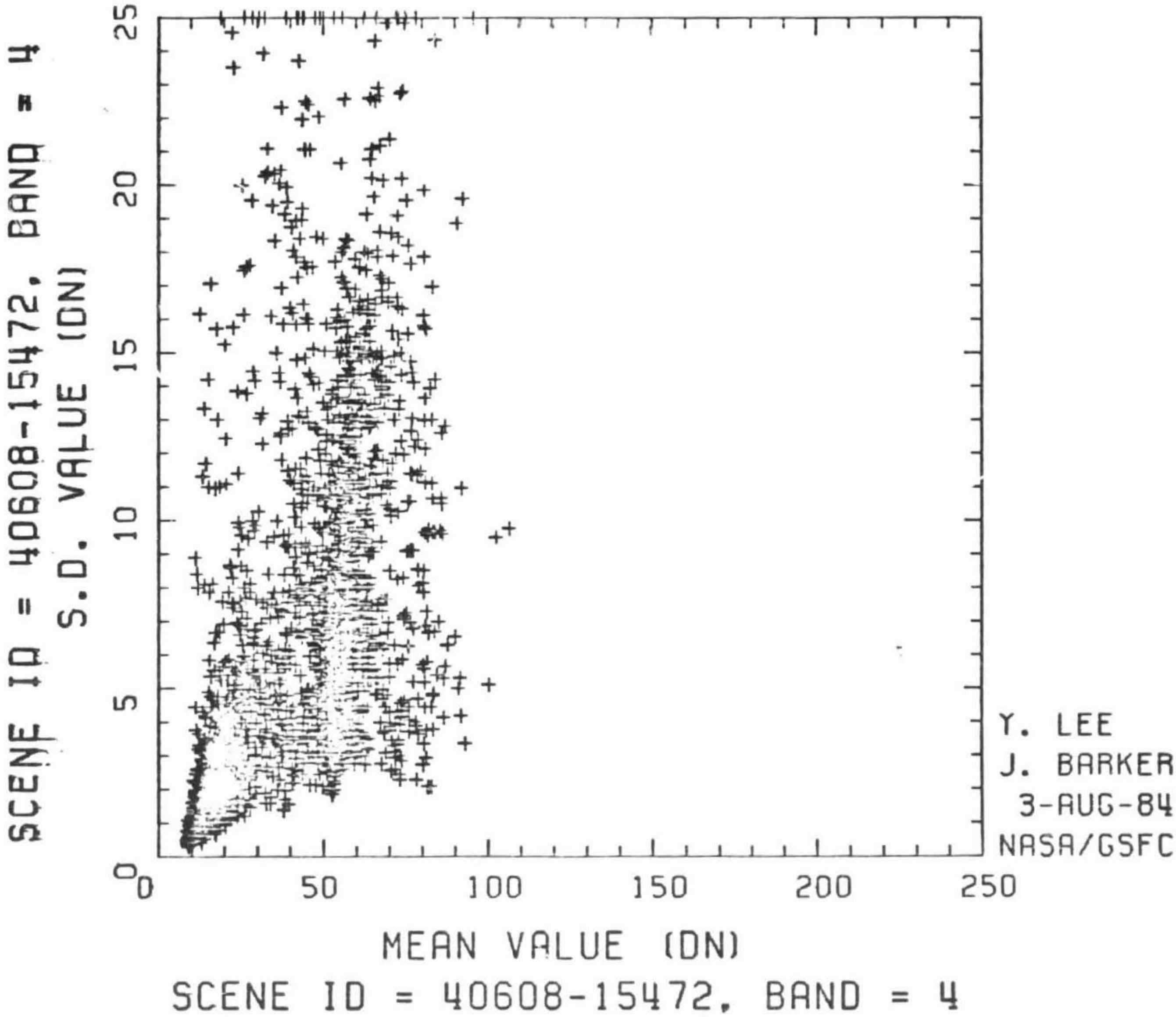


Figure 2 – Standard Deviation vs. Mean Value of Landsat-4 Band 4

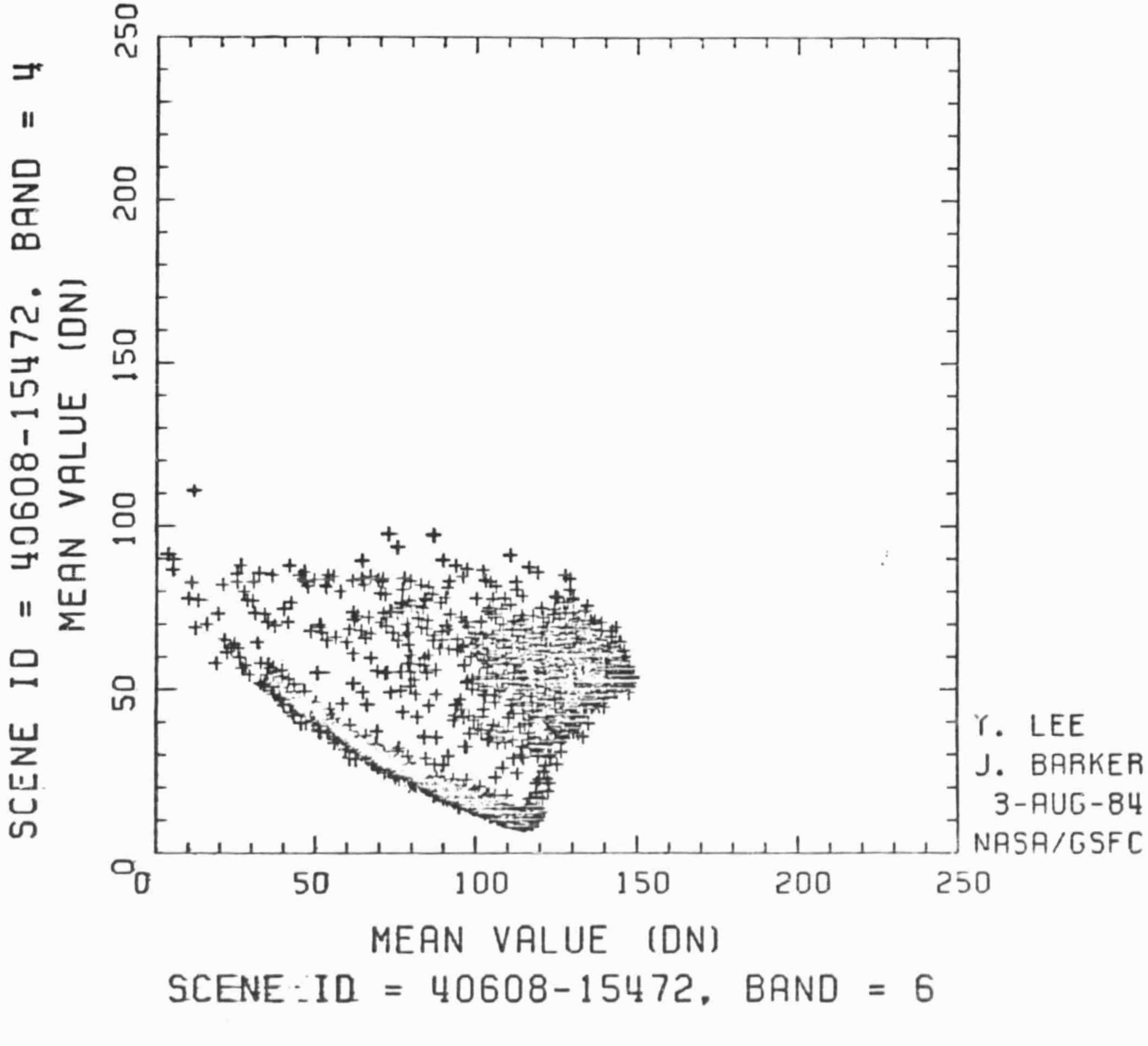


Figure 3 – Mean Value of Band 4 vs. Mean Value of Band 6 of Landsat–4

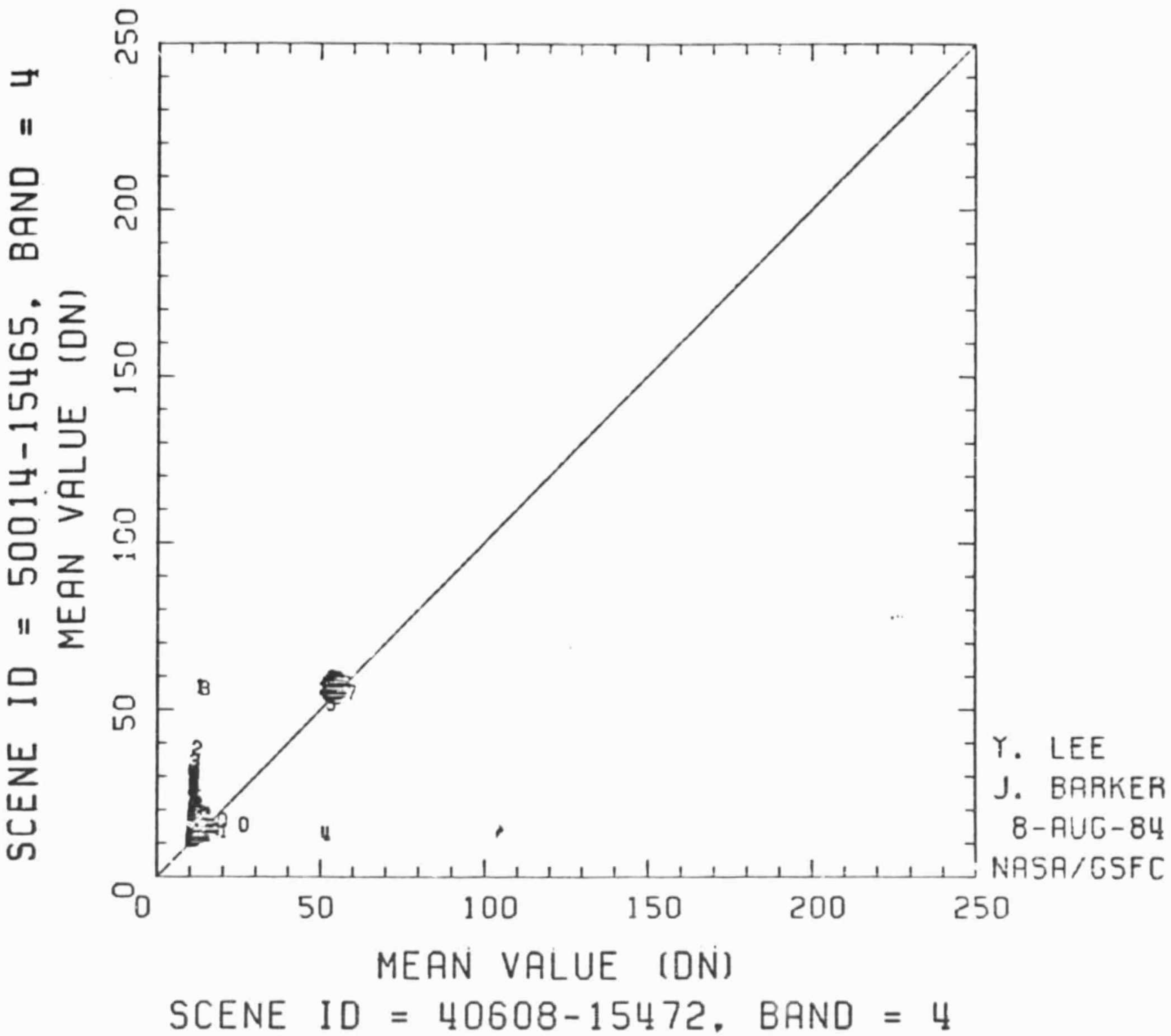


Figure 4 – Mean Value of Landsat-4 vs. Mean Value of Landsat-5 for Band 4

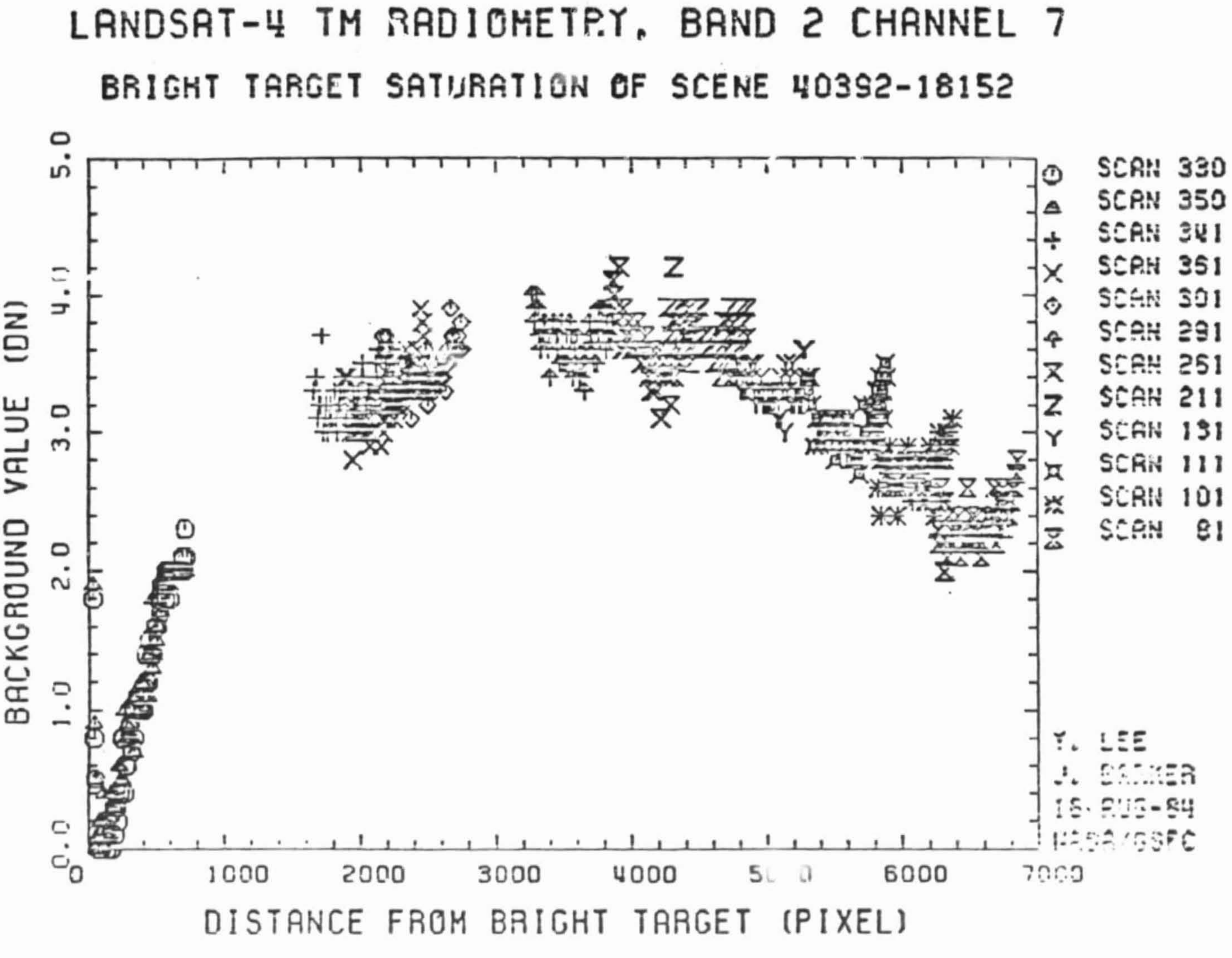


Figure 5 – Example of Bright-Target Saturation

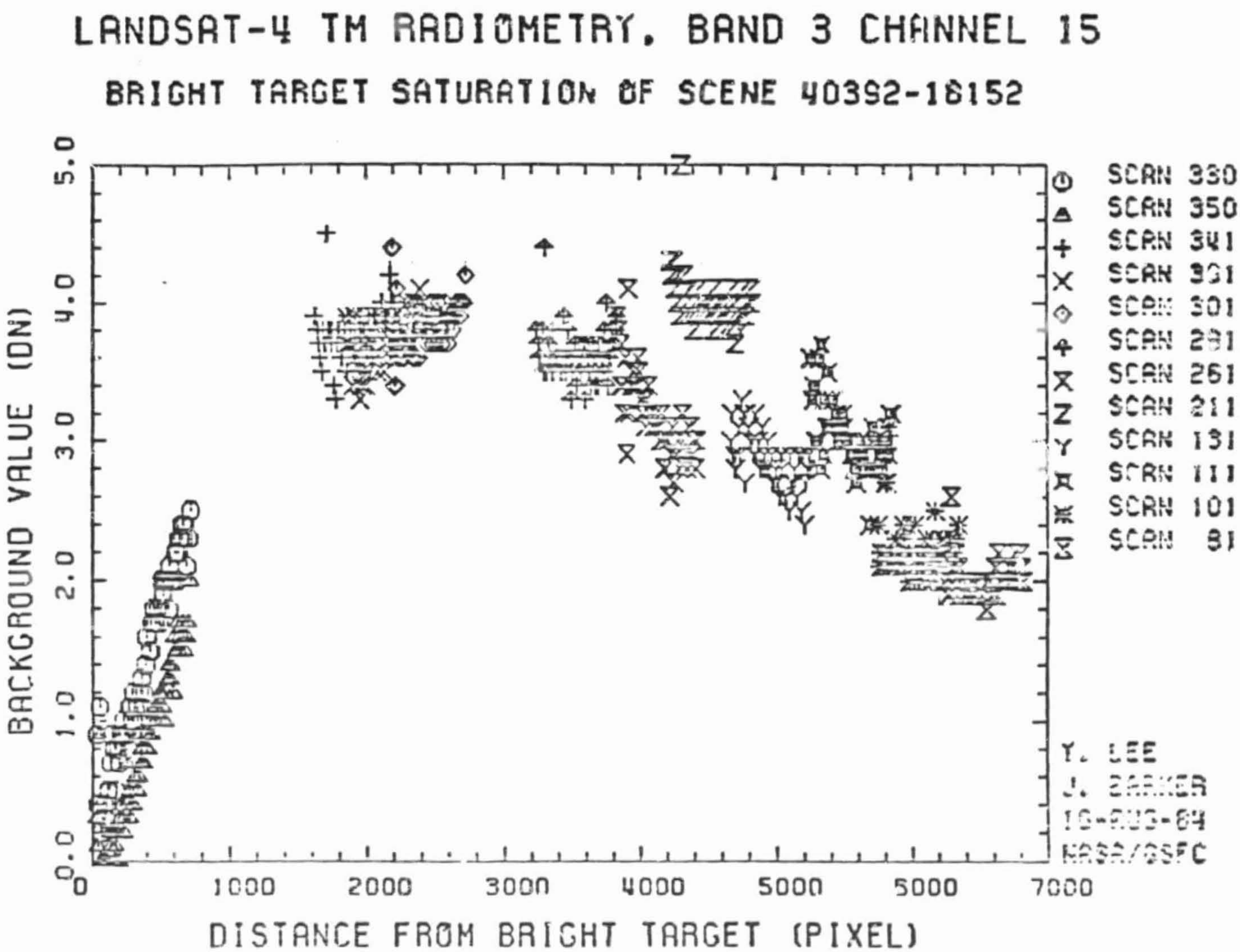


Figure 6 – Bright-Target Saturation Coupling With Scan Correlated Shifts

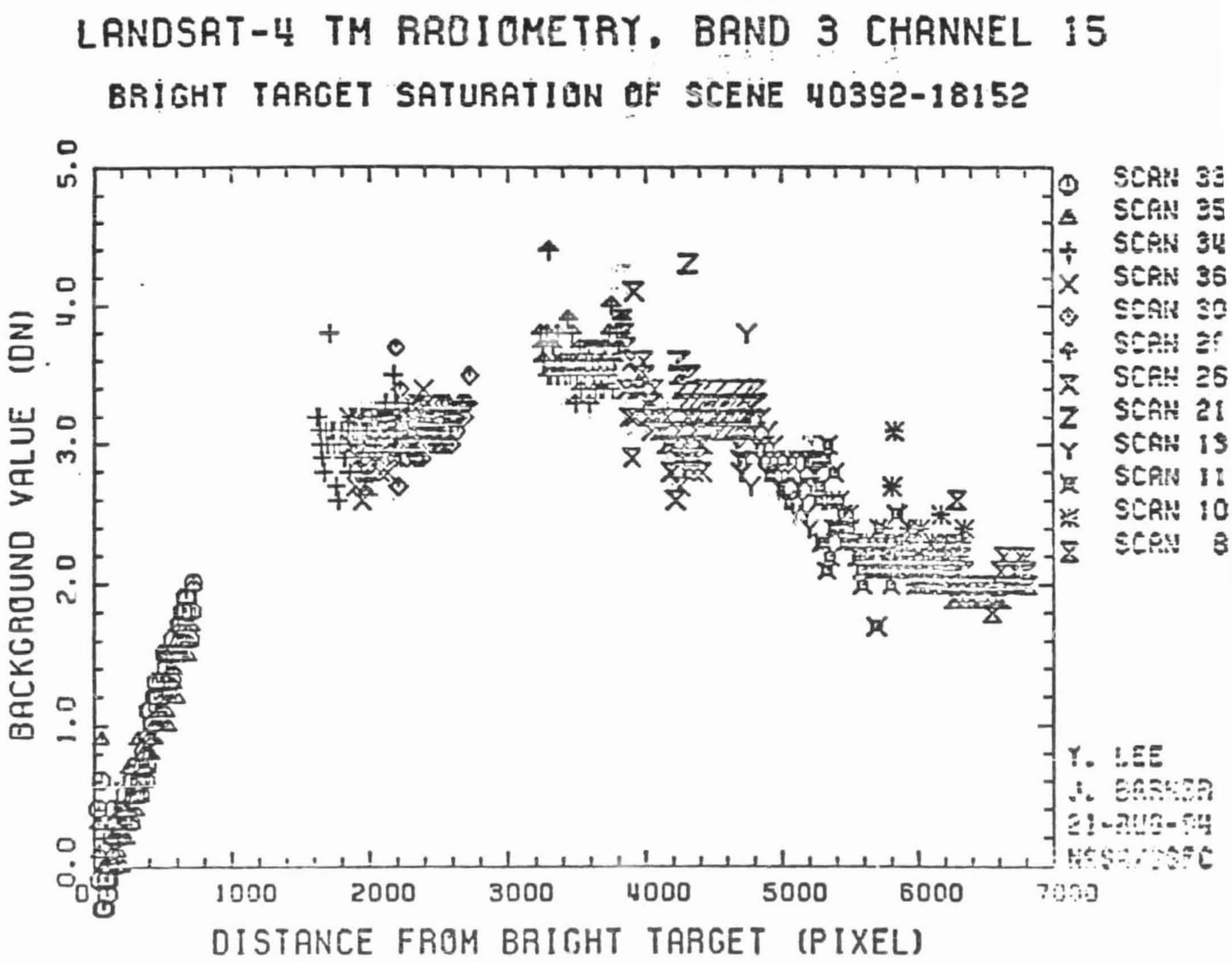


Figure 7 – Bright–Target Saturation Alone – After Scan Correlated Shifts Correction

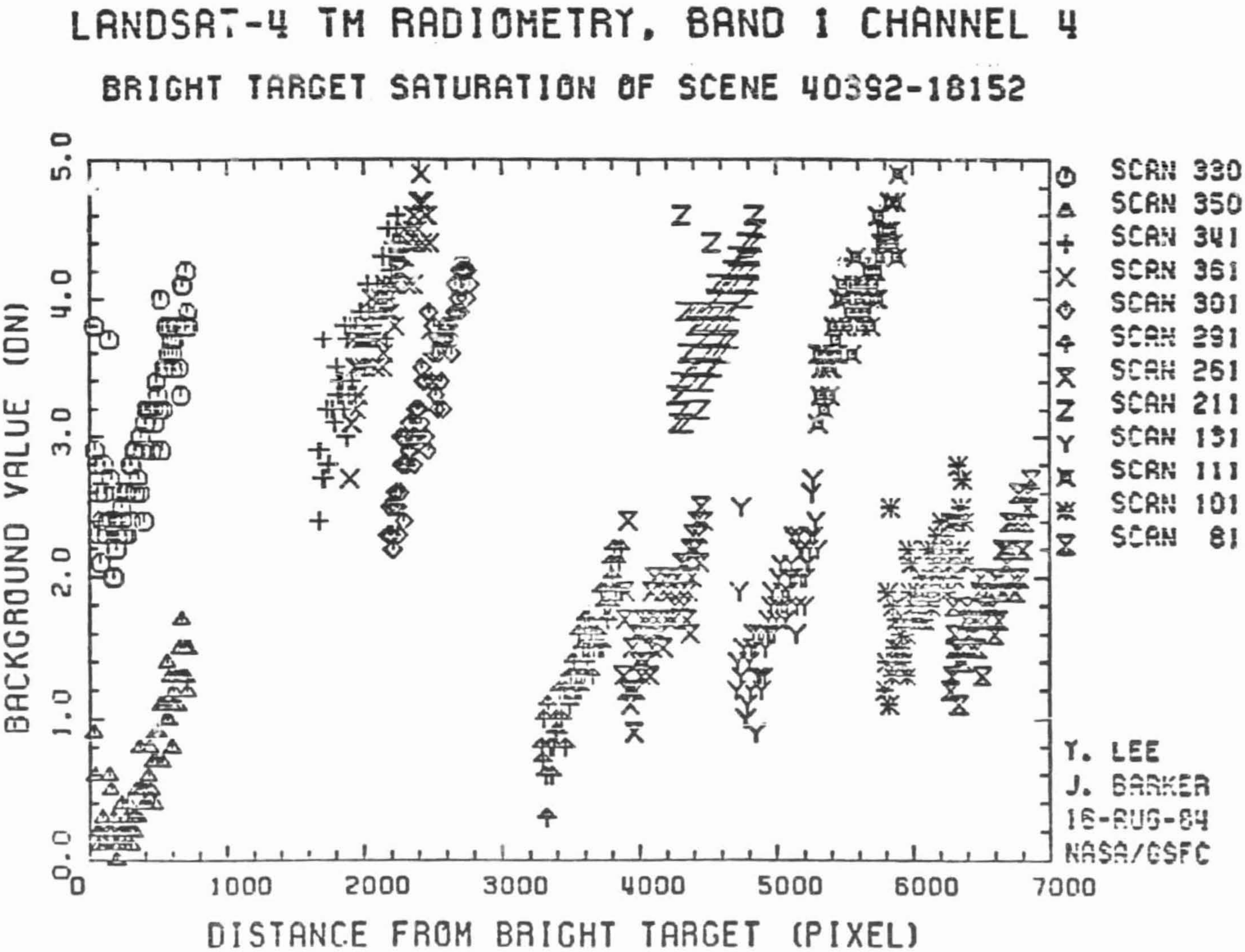


Figure 8 – Bright-Target Saturation and Scan Correlative Shifts + DC Restoration

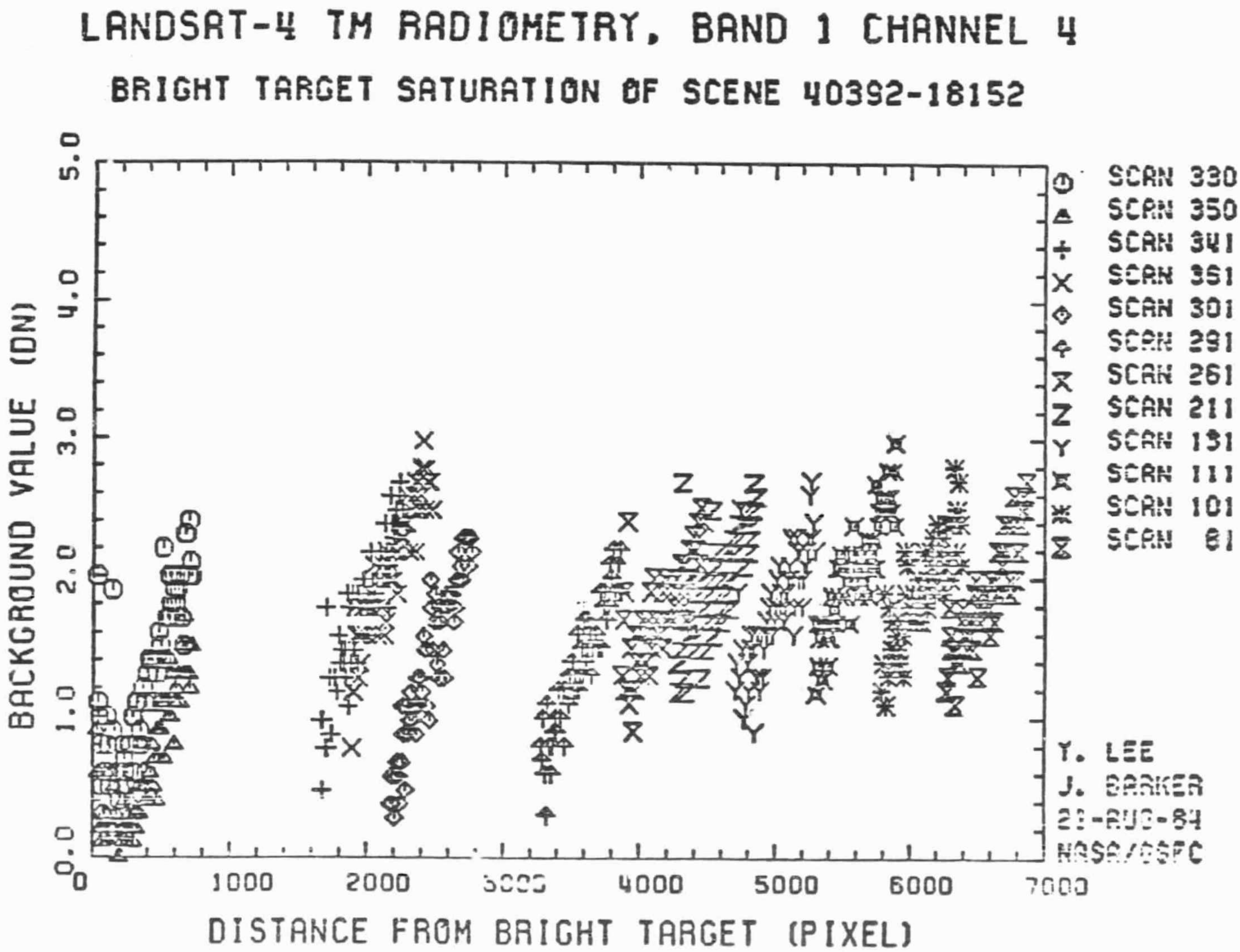


Figure 9 –Bright–Target Saturation and DC Resotration
After Scan Correlated Shifts Correction

LANDSAT-4 TM RADIOMETRY, BAND 4 CHANNEL 2

BRIGHT TARGET SATURATION OF SCENE 40392-18152

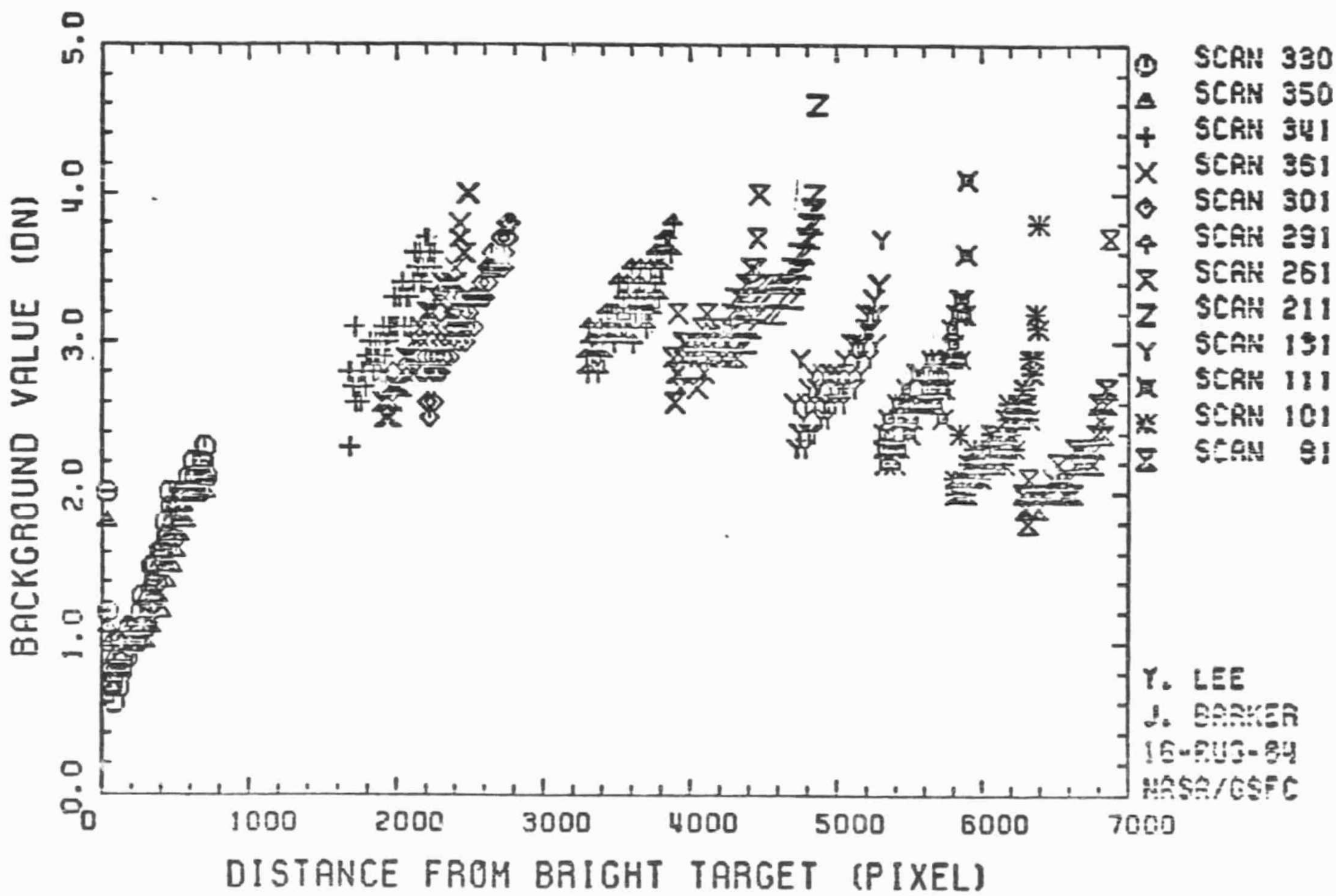


Figure 10 – Bright-Target Saturation and DC REstoration

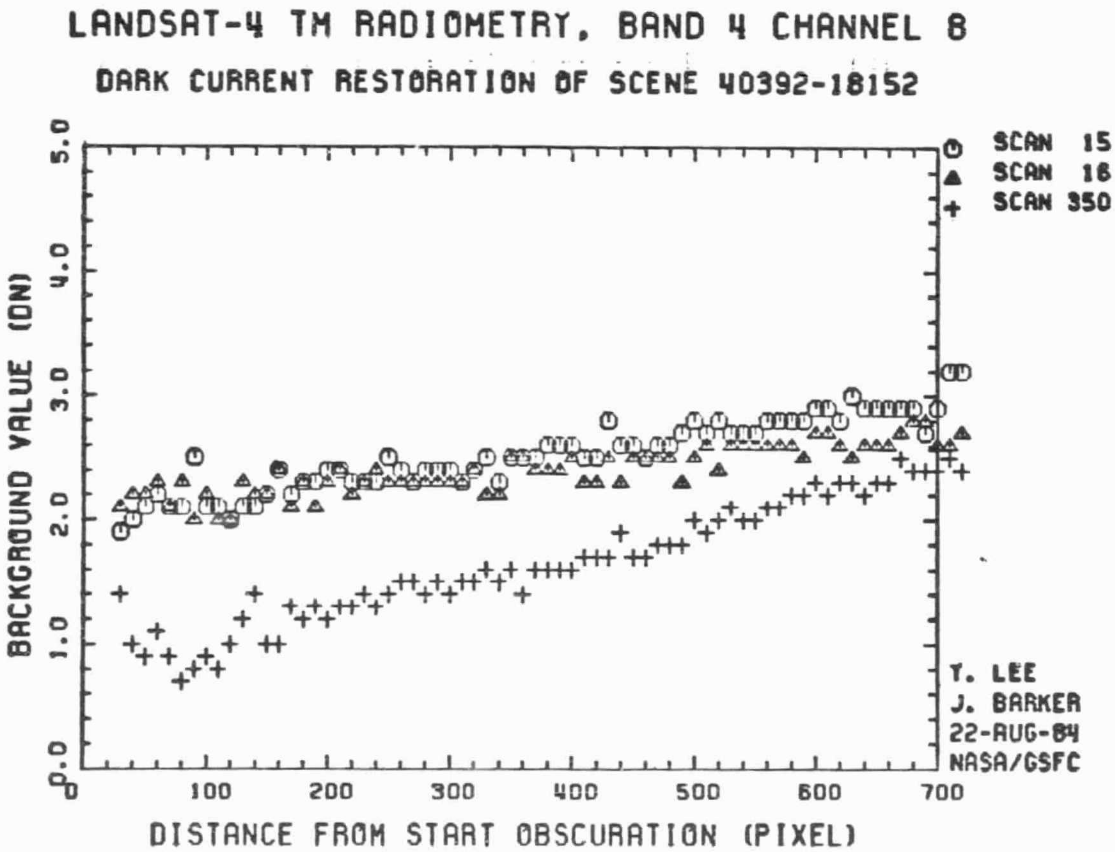


Figure 11 – Scans 15 and 16 Without Bright-Target Saturation,
Scan 350 With Bright Target Saturation

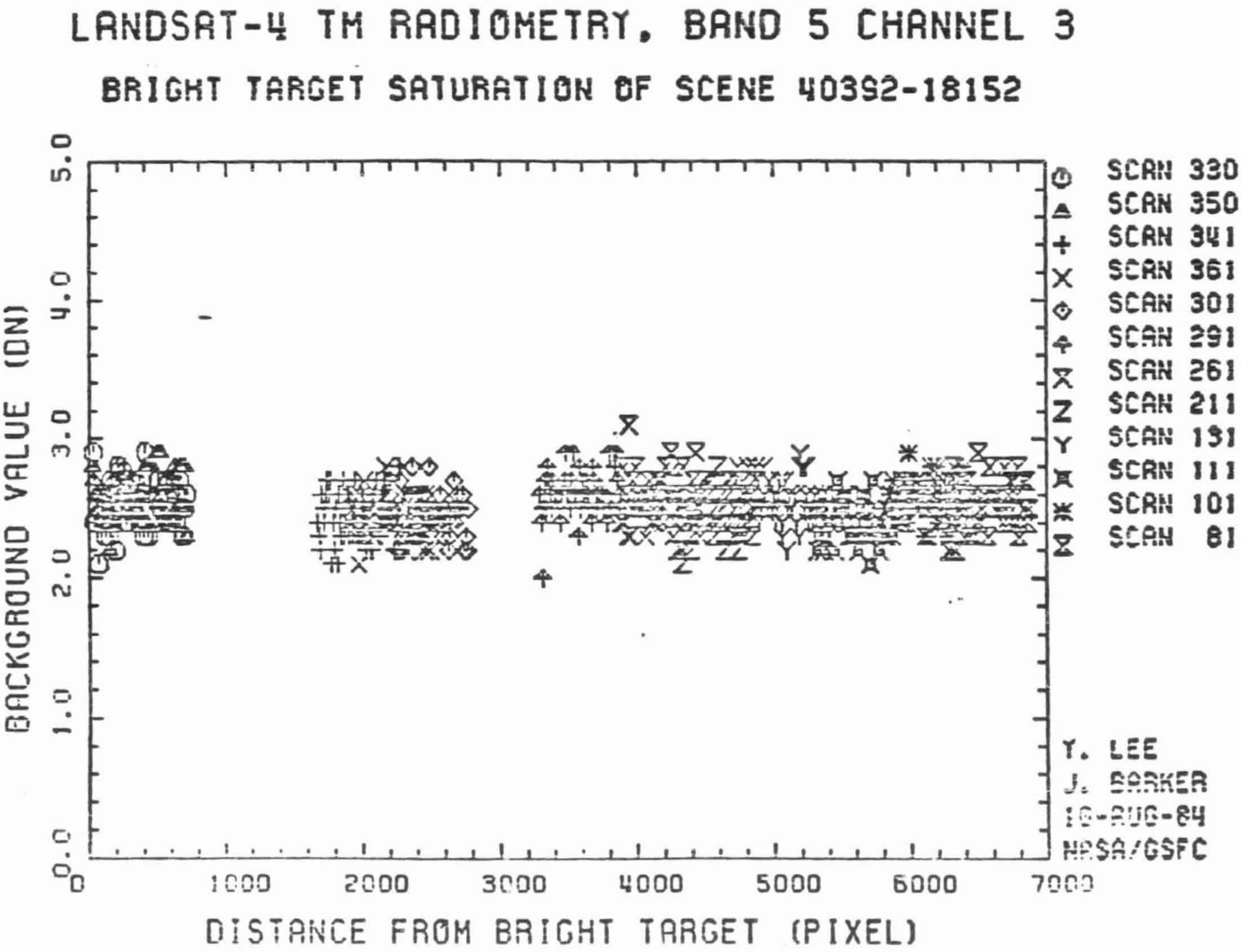

LANDSAT-4 TM RADIOMETRY, BAND 5 CHANNEL 3
BRIGHT TARGET SATURATION OF SCENE 40392-18152
BACKGROUND VALUE (DN)
DISTANCE FROM BRIGHT TARGET (PIXEL)
0.0
1.0
2.0
3.0
4.0
5.0
0
1000
2000
3000
4000
5000
6000
7000
SCAN 330
SCAN 350
SCAN 341
SCAN 361
SCAN 301
SCAN 291
SCAN 261
SCAN 211
SCAN 131
SCAN 111
SCAN 101
SCAN 81
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Figure 12