National Radio Astronomy Observatory
28 July 1986

1

Memorandum

To: D. E. Hogg

From: P. R. Jewell

Subject: Results of 12 m System Tests, 16 - 21 July 1986

Test Participants: R. L. Brown, R. W. Freund, D. E. Hogg, P. R. Jewell, and E. B. Stobie

I. Test Objectives

The system tests, which followed immediately after the end of scheduled observing and before the start of summer shutdown, had the following objectives:

1) Install a total power spectral line scan for the diagnosis of spectral line baseline problems.

2) Test the new digital continuum backend and see that hardware and software are ready for routine service in the fall.

3) Install control and analysis procedures for the North-South Translation stage.

4) Install control and analysis procedures for spectral line beam switching.

5) Install new data-taking and calibration algorithms for spectral line frequency switching.

II. Total Power Spectral Line Data

The total power data-taking mode is needed for the diagnosis of spectral line baseline problems. The primary spectral line observation mode at the 12 m is position switching. The data that is recorded is a quotient given by

$$TR* = \frac{S - R}{R - Z} * \frac{CR - Z}{V - CR} * TC , \qquad (1)$$

where S is the source total power spectrum, R is the reference spectrum, Z is the zero-check array, CR is the reference array during vane calibration, V is the vane array, and TC is the calibration scale factor. The data is stored only as an array of TR*, i.e., the total power data arrays are not kept in any form. Lack of these total power arrays makes it very difficult to track down the source of baseline curvature problems.

During the test session, EBS installed two total power data taking procedures in the FORTH system called TPON and TPOFF. These procedures take total power spectra in the ON and OFF source positions (as set by the thumbwheels) and pass the data to the VAX. POPS/LINE procedures were written to examine and manipulate the data as desired.

a) Results of Total Power Tests

To examine receiver stability and the possibility that reflections from the calibration vane might be introducing baseline curvature, we took a number of total power scans with the vane over the feed and with a large piece of Echosorb "egg carton" absorber over the feed. No substantial difference between the vane and the large absorber were found. However, we were surprised to find that from one scan to the next, even with the same type of absorber over the feed, sizable differences in total power were observed. The difference between two adjacent scans is displayed in Figure 1.

With the total power scan we can experiment with different types of spectral line signal processing. For example, there is reason to believe that under some circumstances, a processing scheme given by

$$TR* = (S - R) * TC/(V - CR) \qquad (2)$$

might produce better baselines than the method described by equation (1). This technique was tried and appears viable. We have no automatic procedure for obtaining the difference (V - CR) at present, so we took total power scans with the vane in and out and post-processed to obtain (V - CR).

No solutions to the baseline problem were uncovered, but a considerable amount of data was taken that has not been fully analyzed yet. With the total power scan procedure, we now have the proper tool to study the problem.

II. Digital Continuum Backend

Over the past year, a new digital continuum backend (DBE) was contructed by RWF and R. H. Hill. The DBE provides the following advantages over the analog standard backend (SBE): simultaneous recording of multiple switch phases (switched power, total power, noise tube signals, and zero values), continuous calibration (at frequencies for which a noise source exists), proper blanking during subreflector transitions, and more flexibility for future expansion (more channels, microprocessor control). The present device is a 2 channel, 4 phase backend. The DBE had been tested twice previously. After each test modifications were made to correct problems or enhance its operations.

The phases of the DBE are defined by the subreflector position and the calibration noise tube state. They are

PH1 = SIG + CAL
PH2 = REF + CAL
PH3 = SIG
PH4 = REF.

Thus,

switched power SP = (PH1 - PH2 + PH3 - PH4)/2,
total power TP = (PH1 + PH2 + PH3 + PH4)/2,
cal signal C = (PH1 + PH2 - PH3 - PH4)/2,

zero level Z = PH1 - PH2 - PH3 + PH4

The cal value is averaged for all the samples in the scan, and the average value CALVAL is used to scale SP, TP, and Z. The exact scale factor is

(TCAL / CALVAL) * EXP(tau * A),

where TCAL is the noise tube temperature, tau is the zenith optical depth, and A is the airmass.

The data are recorded in the order PH1, PH2, PH3, PH4. These are completely raw numbers, and have not been scaled in any way. POPS/CONDAR procedures have been written which convert the stored data to a scan containing calibrated switched power, total power, cal values, and zeroes.

a) Digital Backend Test Results -- Hardware

The digital backend performed excellently. All problems noted in earlier test sessions were fixed. The only hardware item worth further consideration is the blanking technique. The blanking of the DBE begins when the pulse to move the subreflector is issued. The length of the blanking is determined by thumbwheel settings on the DBE chassis. The subreflector solenoids appear to have a long time constant and appreciable motion does not occur until about 10 ms after the pulse is issued. RWF and PRJ estimated that the subreflector moved about 6" in the first few milliseconds. This long time constant may mean that we could obtain improved signal-to-noise by delaying the start of blanking for a few milliseconds. The capability to set this delay from the chassis panel might be useful. Improving the response time of the subreflector would be the best solution to the problem.

The switch rate of the subreflector is 4 Hz as driven by the DBE. This means that each switch phase is 125 ms long. RLB and PRJ measured the optimum blanking time (i.e., the blanking time which produced the maximum source antenna temperature) and found it to be 40 ms. Thus, about 32 % of the switch phase is blanked.

Detailed comparisons between the DBE and the SBE were made. Excellent agreement -- within 5 % -- was obtained. Curiously, we obtained improved source intensity with the SBE when external blanking was turned off entirely. This suggests that there may be some problem with SBE blanking.

b) Software

Since the DBE data are recorded as raw voltages, signal processing and calibration must be done in the analysis system. A set of POPS/CONDAR procedures were written by EBS to rearrange and calibrate the data. Switched power, total power, noise tube signals, and "zero" levels can be displayed. The calibration method is to scale by the quantity TC / CALVAL, where TC is the noise tube temperature and CALVAL is the average signal (in volts) produced by the noise tube. Procedures were written to stack data that are analagous to the existing C1 and C2 procedures for the SBE. The only difference is that each scan of the DBE is weighted by the RMS of the zero level points.

Since the DBE takes data in an entirely different manner than the SBE, all the continuum data taking and analysis routines must be rewritten. A few software problems were encountered that must be cleared up before the fall observing season.

1) Flags should be written to the CONDAR header that specify i) which backend is in use, and ii) whether the noise tube is firing during observations.

2) FORTH and CONDAR routines are needed for TIPS, FOCALIZES, AND FIVE-POINTS. It would be nice to use the same procedures as with the SBE, but with branches according to the DBE/SBE flag.

3) Fix the "AVG" and "ONS" verbs to work with the DBE.

4) Find out why the 'SYNTAX' error message occurs in the POPS routines.

5) Find out why the integration time counts negative when phase lock instability occurs.

III. North-South Translation Stage

The original objectives in this project were to

a) Calibrate the mechanical movement of the N-S stage and check computer control of the stage.

b) Calibrate the "plate scale" of the N-S movement on the sky ("/mm).

c) Develop a N-S "FOCALIZE" routine analagous to the axial FOCALIZE currently in use.

d) Develop a POPS routine for analyzing the focalize.

Items (a), (b), and (c) were addressed in the test session with some success. The N-S stage could be controlled by the computer but a disturbing mechanical instability was noted. The zero point of the LED readout drifted with time and the stage moved spontaneously when the telescope was being driven in elevation. Electronics and/or mechanical problems in the stage are indicated. The drift was measured by EBS and is included as Table 1.

The plate scale was measured by DEH to be 32.7"/mm. The calibration curve is displayed in Figure 2. As shown by the figure, the device is quite linear.

A N-S FOCALIZE routine was implemented by EBS. The routine executed and appeared to change the pointing properly. The temperatures at the different N-S settings didn't look right, but the observations were taken in poor weather. We will need to repeat the test in better weather to know if the routine is working or not.

IV. Spectral Line Beam Switching

This test was surprisingly successful. EBS developed an algorithm for taking data similar to the continuum OFF-ON-ON-OFF technique. The multiplexer SIG/REF signal was used to drive the subreflector; no blanking of the signal during subreflector movement was applied. The beam throw was 4'.

The baselines were amazingly flat (Figure 3). Even filter bank birdies, such as those seen commonly in the 2 MHz filters, were considerably surpressed. This result confirms a suggestion made for a long time by J. Payne that beam switching might cure many of the baseline and birdie problems that have plagued us. Of course, the astronomical circumstances must be amenable to the beam throw limitations of the subreflector. This good result gives strong impetus to the continued development of a fast beam switcher with a long throw. Despite not applying any blanking, the signal-to-noise ratio with the beam switching data appeared to be comparable to or even better than with ordinary beam switching. We have yet to implement a calibration technique for beam switched data. To be dimensionally correct, we should multiply the measured (S - R) by TC/(VANE - SKY). Since the baselines are flat the way they are, it seems unwise to multiply by a curvy array. We therefore recommend that the calibration be done by a channel-average of the array TC/(VANE - SKY).

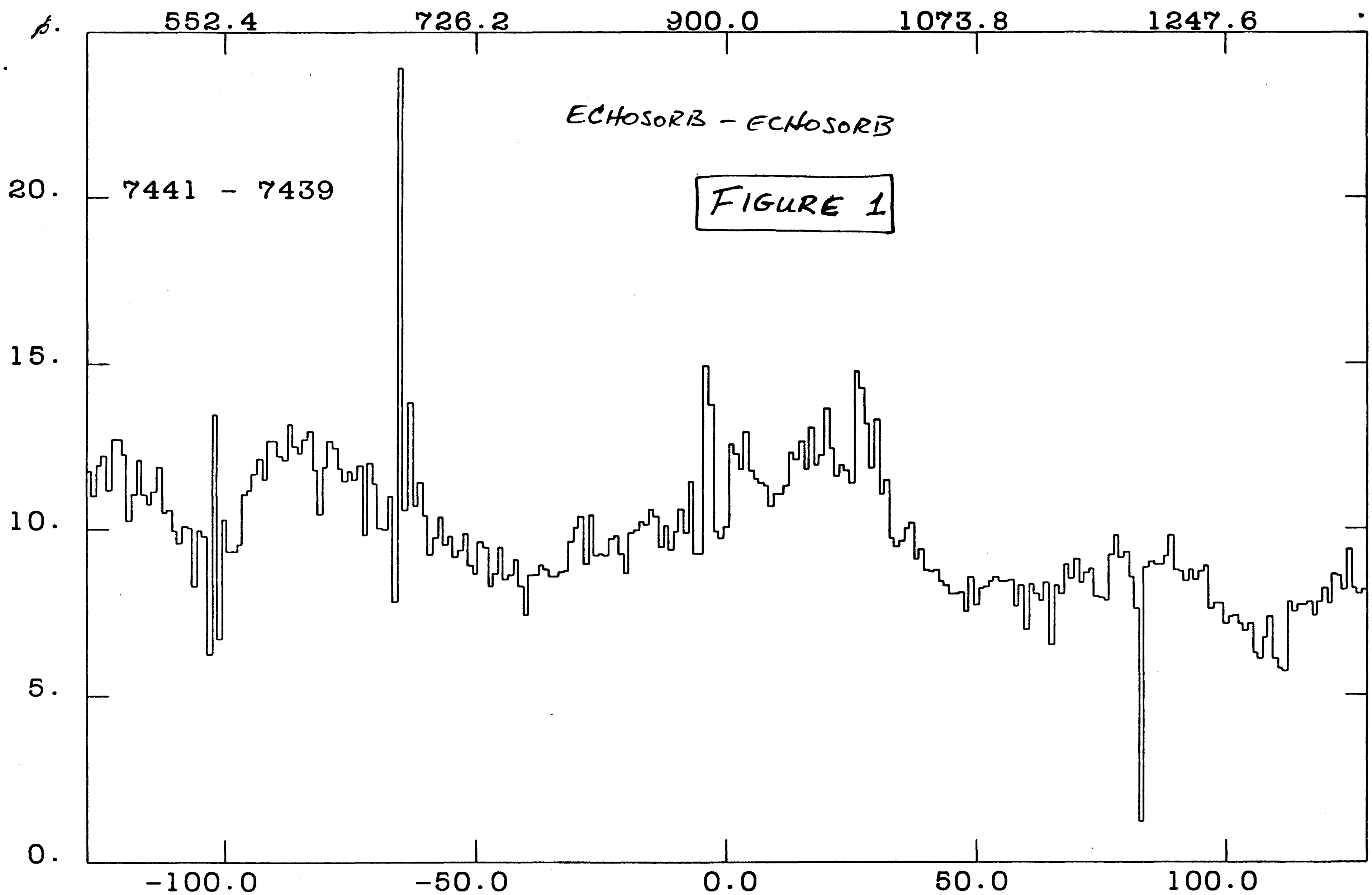
When the beam-switching technique was first tested, we found that a few records had very bad baselines. RLB and DEH suggested that the problem arose with an unequal number of S or R measurements, caused by data lost from phase lock or wind loading error conditions. This effect was confirmed by turning the integrate disable and pointing tolerance check off. EBS installed a counter for each S and R measurement and then normalized by that counter at the completion of the record. This cured the problem. The similarity of the baseline curvature with that seen commonly in ordinary position switched data suggested that the same effect may be occurring in our long-standing baseline problems. We were not able to confirm this so far, however. This effect could be occurring in frequency switched data, as well. EBS installed the counter in the frequency switched FORTH code, but we were unable to test it.

V. Frequency Switching Tests

We had no time to try any new frequency switching techniques. If time allows, we will try some of these tests in the startup period at the end of Summer Shutdown.

Copies to:

R. L. Brown
R. W. Freund
J. M. Payne
E. B. Stobie



DATE 7-19-86 FREQ= 86243.35 SYN=1.86984627 FB=1000 SB=1
SOURCE: TEST :00. 7440 SECOND TIME= 2.0 TS= 1200. DV= 3.48

N-S POINTING JULY 20, 1986 ON JUPITER

FIGURE 2

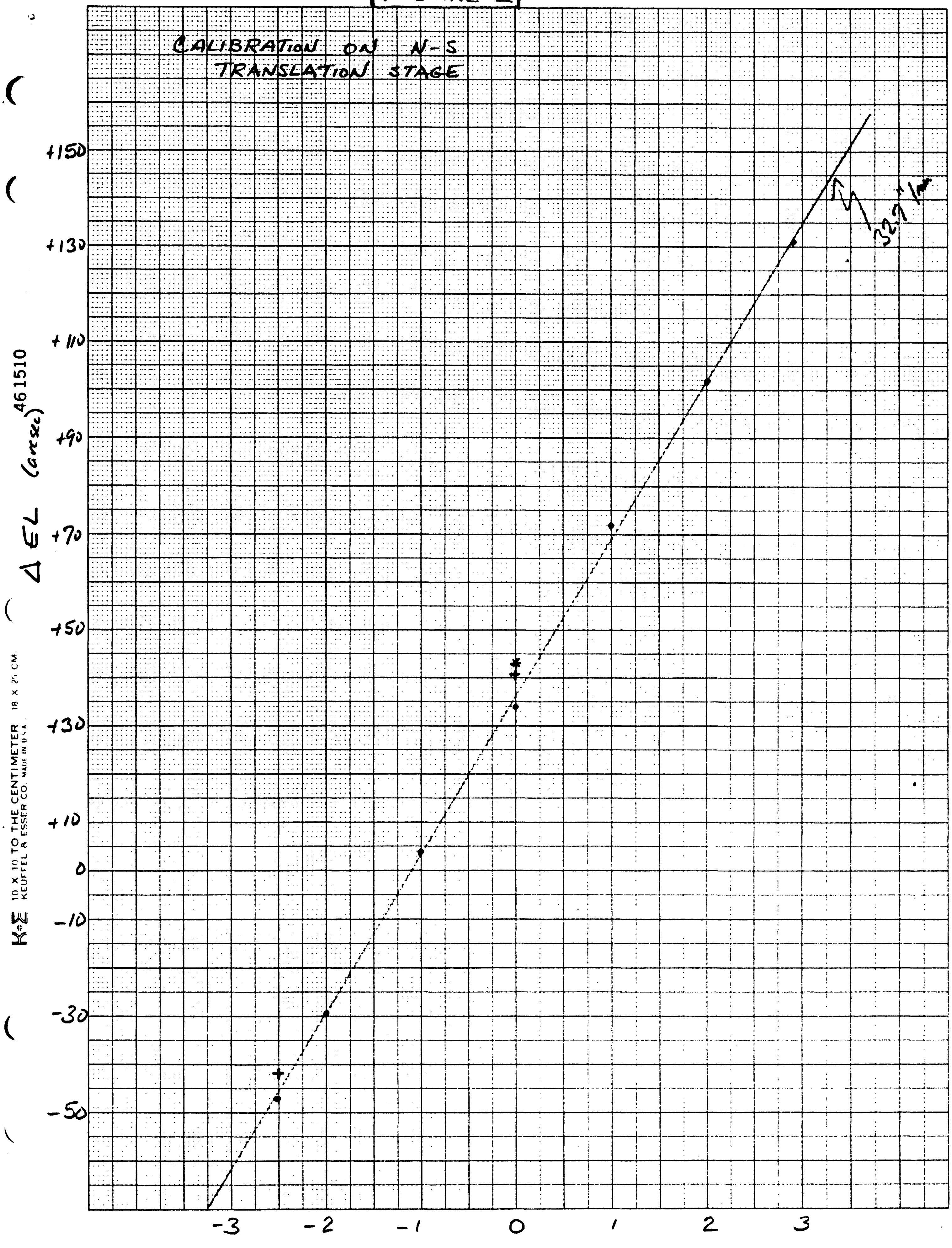


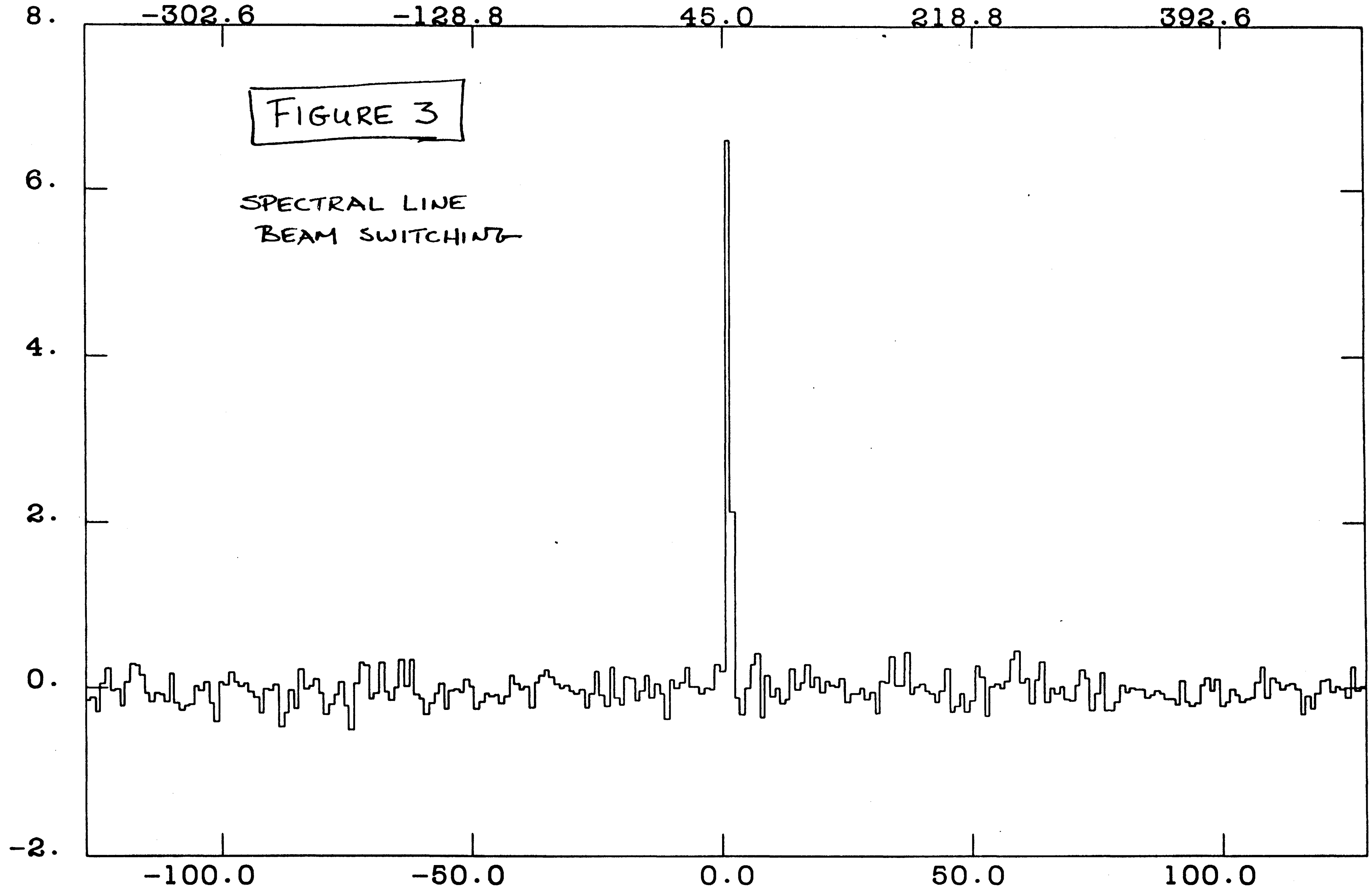
TABLE 1

NORTH - SOUTH TRANSLATION STAGE MEASUREMENTS
21 JULY 86 EBS

	tolerance: 300		tolerance: 99		tolerance: 50	
Commanded	Meter	FORTH	Meter	FORTH	Meter	FORTH
-3000	-3003	-3000	-2971	-2947	-2970	-3001
-2000	-1985	-2043	-1988	-2023	-1987	-2013
-1000	-992	-969	-993	-1062	-993	-1014
0	-3	-32	-5	-14	-4	4
1000	987	991	987	946	987	933
2000	1980	1971	1981	1923	1981	2015
3000	2977	3021	2975	2918	2973	3006
-3000	-2970	-3010	-2971	-2956	-2968	-2942
-2000	-1977	-2028	-1988	-2047	-1976	-2012
-1000	-983	-955	-965	-994	-983	-1044
0	-6	24	-4	-28	3	26
1000	998	1040	987	972	997	966
2000	1991	1962	1980	2020	1991	2030
3000	2980	2962	2973	2952	2973	2992

Manual Setting

Meter	FORTH
0	34
1002	996
2000	2006
3001	3001
2000	1978
1000	966
0	-57
-1001	-1022
-2004	-2038
-3003	-3009



)ATE 7-20-86 FREQ= 86243.35 SYN=1.87522370 FB=1000 SB=1
;OURCE: MIRA 4 SCANS 7887-7887 TIME= 2.0 TS= 1133. DV= 3.48