UNIVERSITY OF CALIFORNIA

LICK OBSERVATORY TECHNICAL REPORTS

No. 2

SCANNER DATA REDUCTION SYSTEM

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Santa Cruz, California
December, 1972
APPENDED 1976

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FIGURES

TABLE

Second Printing (1976)

Since this report was printed, a number of additional notes have been written explaining and elaborating the Data Reduction System. In order to preserve this information and make it available if needed, the notes are included in Appendix E. They have not been edited, and apologies are offered herewith to the writers who have had no chance to revise their work.

Lloyd Robinson 1976

E-1 "Things which should be in the SDRS manual but aren't"

E-2 Further changes to SDRS - 1973

E-3 New improved Scrunch 1973

E-4 Revisions to Scanner Data Reduction System, Jack Baldwin, David Burstein 1974

E-5 Batch Flux, Alan Koski 1975

I. INTRODUCTION

The Scanner Data Reduction System (SDRS) is a collection of computer programs which will convert Image-Tube Scanner data into spectra on linear wavelength and intensity scales. These programs will run on the Lick Observatory PDP-8I computers. The raw data collected by the Image-Tube Scanner system are stored on a magnetic tape containing a series of scans of the program star and sky, standard star and sky, and the sky alone, all of which are on a distorted wavelength scale and have not been corrected for atmospheric extinction, scanner sensitivity as a function of wavelength, or paired pulses. The SDRS programs allow the user to combine these scans into one scan in which each channel, corresponding to a particular wavelength, contains the ratio of counting rates of the program star to the standard star, corrected for extinction and paired pulses and with the sky counting rate subtracted out. A forthcoming extension of the system will allow this ratio of counting rates to be converted to absolute fluxes.

This manual attempts to give, first, a general overview of the system and, second, a user's guide to each individual program. A complete listing of all programs is included as an appendix. The Scanner Data Reduction System is unfortunately rather complicated to use. Before expecting Real Data to flow out of the computer, the budding young data reducer is urged to (1) read this manual all the way through, and (2) set aside two or three hours for experimenting on the computer.

II. AN OVERVIEW OF THE SYSTEM

1. The General Course of Events

The SDRS programs perform the following operations on Image-Tube Scanner data:

(1) calibrate the non-linear wavelength scale.

(2) correct for paired pulses.

(3) subtract the sky background.

(4) correct for atmospheric extinction.

(5) add together all of the scans for a given object.

(6) find the counting rate for each channel.

(7) divide by the spectrum of a smooth standard source (either a standard star or a quartz lamp).

(8) if dividing by a stellar spectrum, remove the effects of any absorption lines.

(9) transform to a linear wavelength scale.

In order for all of the above to actually happen, the following input data are essential:

(1) program star scans.

(2) standard star and/or quartz lamp scans.

(3) neon-argon lamp scan.

(4) a log of the contents of each scan on the raw data tapes; including object name, declination, hour angle, dwell time, and which slit the object is in. This may be either in hand-written form or stored on the raw data tape.

If it is planned to eventually transform the data to a linear $F\nu$ scale, the prudent observer will have obtained scans of both the standard star and the quartz lamp. The intensity calibration programs now in development will be able to work either from

[Program Star]/[Standard Star]

or from the combination of

[Program Star]/Quartz Lamp]

and

[Standard Star]/Quartz Lamp].

If the first option is used, the quartz lamp spectrum is still required in the "LINE ZAPPER" program (see below). If the quartz lamp spectrum goes to zero anywhere, various disasters can happen, so it is best to add together three different scans of the lamp, taken at grating settings around 2800, 3000 and 3200.

The general flow of data through the SDRS program is:

Raw Data Tapes → Scratch Area, SDRS Tape

Scratch Area, SDRS Tape → Reduced Data Tape

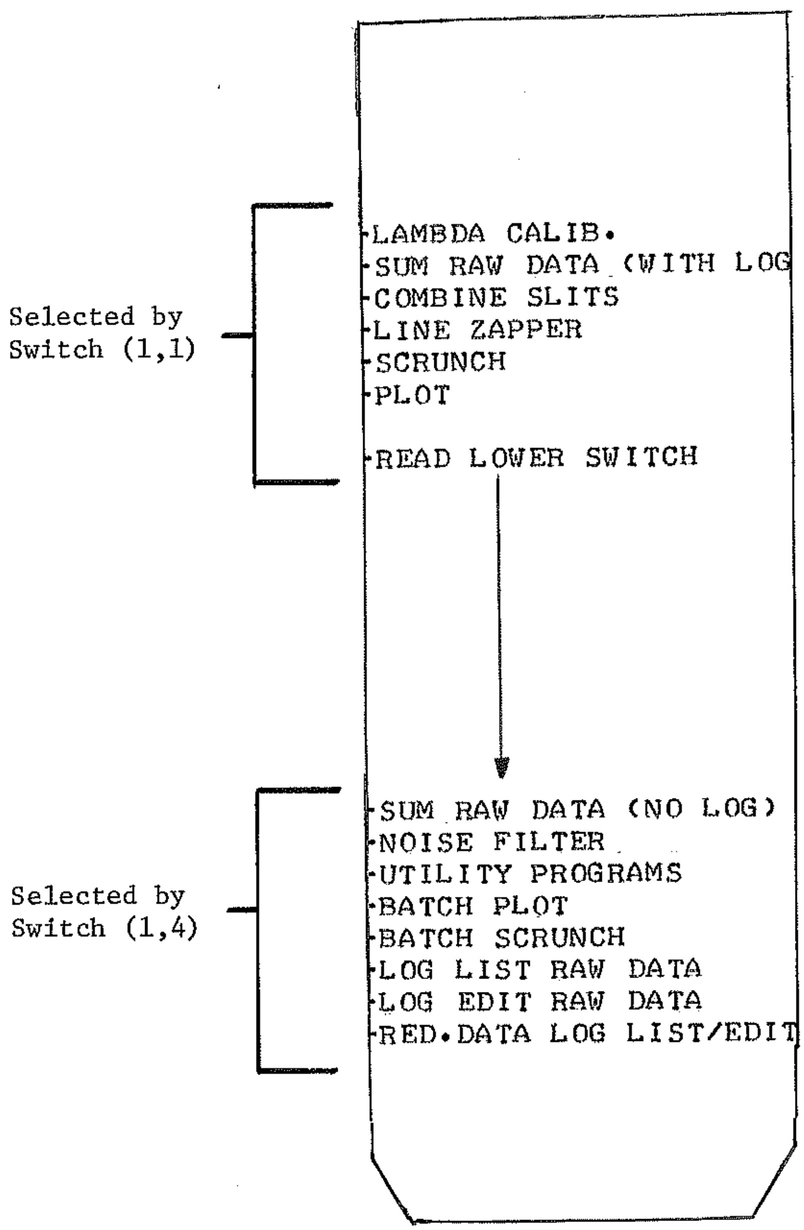
So in addition to the SDRS tape (the one with the programs on it), you will need a blank tape to store the reduced data on.

The first six programs are meant to be used in the order in which they appear on the selector switch (see Fig. 1). The wavelength calibration comes first, because it is necessary to know the wavelength corresponding to each channel in order to know the atmospheric extinction coefficient at each channel. The next program adds up all of the data for each object, correcting for paired pulses, sky background, and extinction, and saves it on the scratch area of the SDRS tape, but still keeps separate the output from the two spectrograph slits. This completes the phase of transferring data from the raw data tapes to the SDRS tape.

It is next necessary to divide by a smooth continuum source to remove discontinuities in the spectrum caused by changes in sensitivity across the face of the image tubes. The flow of data is now from the SDRS tape scratch area to the Reduced Data Tape; the second tape drive, which was first used to input data from the Raw Data Tapes, is now used to output data into the Reduced Data Tape.

Figure 1

SDRS Label for Computer Switch Panel



A slight complication now arises - the scanner can be used to observe either stellar objects, where the star is scanned alternately in the left and right spectrograph slits, or to observe extended objects filling both slits where the scanner alternately looks at the nebula in both slits and then the sky at some offset position in both slits. The first type of observing procedure will be called the "stellar mode", the second the "nebular mode". If the data have been obtained in the stellar mode, which is the usual case, the data from the two slits can now be combined. For the nebular mode data, this step should be bypassed (see "Using the Programs").

The final operation is to transform the data to a linear wavelength scale, using the calibration found with the first program. There is a net squeezing of the data to any scale desired; generally 2.50, 1.25 or .625 Å/channel, depending on the grating dispersion (see Section III.5). Channels toward the red end of the spectrum will contain zeros, except that the last three channels will contain information about the wavelength range of the scan and a scale factor for the data. The scale factor is an exponent -- the contents of the data channels should be multiplied by $10^{(\text{scale factor})}$ to obtain the ratio of counting rates of the program star to the continuum source.

2. Summary of the SDRS Programs

To reduce data for stellar objects to a plot on a linear wavelength scale, programs 1-6 are generally used in order. The other programs represent various options and frills.

The programs presently available are:

(1) LAMBDA CALIBRATION: calculates the function necessary to convert from channel number to λ. The actual conversion is performed later, in SCRUNCH.

(2) SUM RAW DATA (WITH LOG): sums all scans of a single object, subtracts sky, applies deadtime and extinction corrections for data with labels written by the LOG I.D. routine at the telescope.

(3) COMBINE SLITS: adds together data taken in the left and right slits after dividing by a calibration spectrum.

(4) LINE ZAPPER: removes absorption lines introduced by the calibration spectrum.

(5) SCRUNCH: transforms scans to a linear wavelength scale.

(6) PLOT: CRT or Calcomp plot of data from tape.

(7) SUM RAW DATA (NO LOG): same as (2), except declination, slit, dwell, and hour angle have to be typed in by hand.

(8) NOISE FILTER: applies either a low-pass noise filter or a Gaussian smoothing to reduced data.

(9) UTILITY PROGRAMS: programs which didn't fit in anywhere else; used for moving scans from place to place on tape, adding, subtracting, and dividing scans, etc.

(10) BATCH PLOT: automatic Calcomp plotting of any number of scans from one DECTAPE.

(11) BATCH SCRUNCH: automatic scrunching of any number of scans from one DECTAPE.

(12) LOG LIST RAW DATA: dumps out log information from up to 20 raw data tapes.

(13) LOG EDIT RAW DATA: allows altering of log information on raw data tapes.

(14) REDUCED DATA LOG LIST/EDIT: choice of listing or editing identifying information on Reduced Data Tape.

3. Data Storage Format on DECTAPE

A probable source of confusion is the system of numbering scans stored on tape. The term "scan" is applied to spectra of two different lengths - 2048 channels or 4096 channels.

4096 channel scans always contain information from both spectrograph slits - the raw data tapes and the partially processed data stored on the SDRS tape are in this format.

Since only 2048 different wavelengths are actually observed, the reduced data will come out in 2048 channel scans.

When the programs ask for "scan no.", some are referring to 4096 ch. scans and others are referring to 2048 ch. scans. Table 1 is provided to keep you from going astray. Programs asking for 2048 ch. scan input can alway operate on $\frac{1}{2}$ of a 4096 ch. scan. The margin of the log sheets (see Fig. 2) provides a conversion table between the numbering systems for 2048 ch. scans and 4096 ch. scans.

4. The Extinction and Wavelength Tables

Two tables are stored on the disk for use by the system. They occupy disk records 17-25. Neither can be wiped out by any SDRS program.

The Extinction Table (disk records 18-25) contains the atmospheric extinction coefficient for each channel of raw data. It is loaded during execution of the SUM RAW DATA program if the question "NEW EXT. TBL.?" is answered "Y". The program finds the wavelength of each channel from the calibration determined in the LAMBDA CALIB. program, and then the extinction coefficient as a function of wavelength is approximated by a fourth order polynomial $k(\lambda) = f(x)$, $x = 1/(\lambda-2900)$ with coefficients C_0 through C_4 equal to 3.2488E-2, 2.7062E2, 3.2827E5, -2.4503E8, and 4.8804E10 respectively. The Extinction Table needs to be reloaded only when starting to reduce data taken at a new grating setting.

The Lambda Table (disk record 17) contains 100 times the wavelength of every fourth channel of raw data. It is also computed from the calibration found in the LAMBDA CALIB. program, and is loaded from the SCRUNCH or BATCH SCRUNCH programs if the question "NEW LAMBDA TBL.?" is answered "Y". The Lambda Table should only be reloaded when starting to reduce data taken at a new grating setting.

TABLE 1

PROGRAM INPUT/OUTPUT SUMMARY

PROGRAM	INPUT			OUTPUT				REMARKS
	2048 CH. SCAN	4096 CH. SCAN	TAPE UNIT	2048 CH. SCAN	4096 CH. SCAN	TAPE UNIT	CALCOMP	
λ CALIBRATION		X	7					OUTPUT ONTO SPECIAL TABLE, UNIT 8.
SUM RAW DATA		X	7		X	8		
COMBINE SLITS		X	8	X		7,8		
LINE ZAPPER	X		7,8	X		7,8		
SCRUNCH	X		7,8	X		7,8		
PLOT	X		7,8				X	or CRT OUTPUT
BATCH PLOT	X		7				X	
NOISE FILTER	X		7,8	X		7,8	X	
UTILITY PROGRAMS	X		7,8	X		7,8		

LOG SHEET
(Figure 2)

TAPE: ____________

4096 SCAN #	2048 SCAN #	OBJECT	FROM TAPE	DATE OBSERVED	DIVIDED BY	λ(0)	SCRUNCH	LINE ZAP	FLUX CAL.	λ CAL. #	NOTES
0	0										SDRS PROGRAMS
	1										AND TABLES
1	2										
	3										
2	4										
	5										
3	6										
	7										
4	8										
	9										
5	10										
	11										
6	12										
	13										
7	14										
	15										
8	16										
	17										
9	18										
	19										
10	20										
	21										
11	22										
	23										
12	24										
	25										
13	26										
	27										
14	28										
	29										
15	30										
	31										
16	32										
	33										
17	34										
	35										

Neither of these tables is loaded automatically, and if they are not properly loaded in when required, program execution will proceed with no warning given and will lead to sometimes plausible, but usually wrong, results!

5. Negative Scan Numbers

Entering a negative scan # when a program wants to read a scan from tape usually gets you back to the calling program, but sometimes just causes that step in the program to be skipped.

Asking the program to save a negative scan # always causes a step to be skipped, with nothing saved on tape.

6. Using the Programs

It is assumed that the potential user knows how to operate the computer hardware and has some slight experience with LICK FOCAL. SDRS requires the teletype, disk, two DECTAPE drives, the CRT and the Calcomp plotter. For best results, they should all be turned on. Keep an eye peeled on the CRT; important messages are liable to flash up on the screen at any time. To get going, bootstrap the SDRS Tape on Unit 8 and type "GO". The CRT will display "SCANNER DATA REDUCTION SYSTEM", "SELECT DESIRED SUBROUTINE AND PRESS START". This message will always be displayed when the system is waiting for a new program to be selected. Control can always be returned to this calling program by stopping execution with "Control - C" and then typing "GO" (Return). Set switches (1,1) and (1,4) on the switch panel to the desired program, then press the green "START" button (switch 3,8).

Mount the data tape containing the neon scan on Unit 7 and use the LAMBDA CALIBRATION program to obtain the coefficients for a power series λ = f (channel #). These coefficients will be stored in a special table on the SDRS tape (so Unit 8 must be on "WRITE ENABLE"). This special table (the Lambda Calibration Table) automatically stores the coefficients comprising each new calibration under a different number. The program types out that calibration number. Separate sets of coefficients are stored for the left and right slits, but under the same calibration number. This calibration can be recalled at any time in the future when a program asks for "CALIB. NO.:"; where appropriate you will also be asked to specify whether left slit calibration, right slit calibration, or the average of both slits.

Now use the SUM RAW DATA program to go through all of your raw data tapes, converting the series of scans for each object into one scan per object with sky subtracted, which will be stored on the "scratch" area on the back of the SDRS tape. Be sure to also do this for a continuum source, preferably for both a standard star and a sum of quartz lamp scans (at enough different grating settings to get a relatively smooth spectrum).

We now arrive at a three-way fork in the road, depending on whether the data were obtained in the "stellar" or "nebular" modes, and, in the case of the stellar mode, whether it is worth doubling the processing time to get a slightly more accurate wavelength scale. The three types of reduction will be described separately in the following paragraphs.

Stellar Mode: The normal reduction procedure for a stellar object involves using COMBINE SLITS as the third program. COMBINE SLITS accepts data in 4096 channel format from the scratch area of the SDRS tape. The data are divided by the continuum spectrum (standard star or quartz lamp), and then the two slits are added together. Output is a 2048 channel scan, onto Unit 7; the raw data tape formerly on Unit 7 must be replaced by a Reduced Data Tape before this operation. The scan written onto the Reduced Data Tape will contain, for each channel, the ratio of counting rates of the program star to the continuum source. Use COMBINE SLITS on all data taken at the same grating setting before moving on to the next step.

The remaining programs will normally read data from the Reduced Data Tape and then write their output back onto the same spot. If the continuum source is a star, it is necessary to use the LINE ZAPPER program to remove the effects of any stellar absorption lines. LINE ZAPPER requires a scan of [Standard Star]/[Quartz], from which the line profiles are measured. Then, one by one, the scans containing [Program Star]/[Standard Star] are read in, the effects of the line profiles are removed, and the data are rewritten onto the Reduced Data Tape. This should be done for all program stars observed at the same grating setting before moving on to the next step. If the continuum source is a quartz lamp, LINE ZAPPER should be bypassed.

Finally, the data should be put onto a linear wavelength scale, using SCRUNCH or, more conveniently, BATCH SCRUNCH. The program will ask if a "NEW LAMBDA TABLE" is desired. Answer "Y" (yes); the program will ask for "SLIT <L,R,B>:" (answer "B" = both slits averaged together), and for the number of the calibration found in the LAMBDA CALIB. program. If the BATCH SCRUNCH is used, the data must be on Unit 7; you can just type in the scan numbers, write enable Unit 7, and take a coffee break. The SCRUNCH programs require ten minutes per scan.

Nebular Mode: This method of reduction is used for observations of an extended object which filled both spectrograph slits. The LAMBDA CALIB. and SUM RAW DATA programs are used as described above (but be sure to use slit codes "B" and "S" when they are required in SUM RAW DATA; see Section III.2).

Since the two slits will have received data from different parts of the nebula, it will generally not be correct to combine channels. Instead, the summed data for each slit must separately be pulled from the scratch area of the SDRS tape and divided by a continuum source (standard star or quartz lamp for the same slit also taken from the scratch area of the SDRS tape), and the result must then be saved on the Reduced Data Tape on Unit 7 (the raw data tape formerly on Unit 7 must be removed before this step). This division is accomplished by using the UTILITY PROGRAMS package options C (clear buffer), A (add scan from Unit 8 to buffer), D (divide buffer by scan from Unit 8), and S (save buffer on Unit 7). This should be done for all objects observed at the same grating setting before moving on to the next step. Please note that SUM RAW DATA puts scans on the scratch area of the SDRS tape under 4096 channel format, but that the UTILITY PROGRAMS read in scans under the 2048 channel format, so that conversion of scan numbers is required (see Fig. 2 for conversion chart).

The remaining programs will normally read data from the Reduced Data Tape, modify it, and then write it back onto the same spot on the Reduced Data Tape. If the continuum source is a star it is necessary to use the LINE ZAPPER program to remove the effects of any stellar absorption lines. LINE ZAPPER should be used separately for left and right slit data (see Section III.4).

The data can then be put onto a linear wavelength scale, using SCRUNCH or BATCH SCRUNCH. When the program asks "NEW LAMBDA TABLE?" answer "Y" (yes). The program will then ask for "SLIT <L,R,B>:" (answer L = left slit or R = right slit as appropriate), and for the number of the calibration found in the LAMBDA CALIB. program. If BATCH SCRUNCH is used, all of the right slit data should be scrunched, then a new lambda table for the left slit should be loaded and the left slit data scrunched.

Stellar Mode, More Accurate Wavelength Scale: Because the wavelength calibrations for the left and right slits are in general slightly different (due to pincushion distortion and, possibly, a tilted spectrograph slit), adding together uncalibrated data for the two slits, as is done in the normal reduction technique, can lead to some uncertainties (of up to a few Å) in the wavelength scale and to a degradation in the spectral resolution. A better, but slower, way to reduce the data is to "scrunch" the data for the two slits separately, and then add together the results.

As a start, the data should be reduced exactly as described above for the "nebular mode". This will result in the left and right slits both on linear, but slightly displaced, wavelength scales. The data for the two slits must be shifted so that the wavelength scales line up, and then the two slits must be added together. This is accomplished by again calling the UTILITY PROGRAMS, and using the options "C" (clear buffer), "A" (add), "SD" (shift data to align), "A" (add in the other slit), and "S" (save on Reduced Data Tape). The SD option shifts data by x channels, where x can be computed from $x = \Delta\lambda/1.25$ for first order spectra, or $x = \Delta\lambda/.625$ for second order spectra. $\Delta\lambda$ can be found from the starting wavelengths typed out during SCRUNCH or BATCH SCRUNCH.

III. A USER'S GUIDE TO INDIVIDUAL PROGRAMS

1. Lambda Calibration

This program will find, for each slit, a polynomial giving one hundred times the wavelength of each channel as a function of channel number. A choice of third or fifth order polynomials, determined by a least squares fit, is provided. The fifth order polynomial, which should be used with caution, will in many cases give a more accurate wavelength determination. The program finds a separate set of polynomial coefficients for each slit; these coefficients are then stored on the SDRS tape and assigned a specific "calibration number"

(1-85) by which they may be recalled at any future time. The program does not do anything about actually converting the data to a linear wavelength scale; this is done later in the SCRUNCH program using the calibration found in the present program.

The calibration is first determined for the right slit, and then most of the process is repeated for the left slit. The program normally expects to read in and display scans of the neon lamp and, if necessary, the night sky, after which the user will identify 5 well-spaced emission lines in the spectrum. The program will then proceed to identify all of the emission lines in the spectrum and make a polynomial fit to these. If a neon scan isn't available, or if the program seems to be making a wrong identification, the user is given the opportunity of "bailing out" at several points. The bail-out routine allows the user to identify all of the emission lines by hand. This program requires about 10 minutes, and there are periods of a few minutes during which it computes with no output to indicate normal operation.

INPUT: raw data tape on Unit 7 (set on "WRITE LOCK")

OUTPUT: polynomial coefficients onto Unit 8 (set on "WRITE ENABLE")

OPERATION: Once the program has been called from switches (1,1) and (3,8), the CRT asks "NEON COMP SCAN NO (-1 IF NONE):". If no neon scan is available type -1 to get into the bail-out routine (see below). Otherwise, type in the appropriate neon scan number. The neon scan will be read from tape and displayed on the CRT screen. The CRT will then ask "TYPE -1 IF SKY LINES ARE NEEDED:". Sky lines are necessary if the scan extends to the blue of 5850 Å, otherwise hit the return key. If -1 is entered, the CRT asks for scans with the sky in the right, and then the left slit (they can be the same). A summary of instructions will then be displayed; press the "ALT MODE" key to continue.

The program will next spend several minutes locating all of the peaks in the neon and sky spectra for the right slit. During this time, the neon scan will be displayed on the bottom half of the CRT screen, and the sky scan (if used) will be on the upper half of the screen. The spectra will be divided by a horizontal line with two vertical hash marks on it. When the peak finding is completed, the joystick marker will be displayed and you will be asked to mark five lines, using the joystick. The horizontal part of the marker must be in the upper half of the screen when marking sky lines, and in the lower half when marking neon lines. As each line is marked, the CRT asks "LA = "; type in the wavelength in Angstroms. If the peak finding routine has not picked up the line or if the marker is too far from the line center, the marker will just reappear; try again or go on to another line. Important: of 5 lines, one should be near each end outside of the hash marks, and three should be between the hash marks. After the fifth wavelength has been typed in, the marker will reappear; press button (3,11) without moving the joystick to go to the next step.

A linear fit will be made to the three central points, after which the residuals [λ(calculated) $-\lambda$(observed)] vs. [channel number] will be displayed. These should look like a cubic. The CRT will ask "OK?"; if the answer is "N" (no), you will be given a choice of repeating the line identifications or going to the bail-out routine. If things are OK the program will identify all usable lines from an internal wavelength table and display them on the residual plot. You will again be asked if things look OK, with the same choices in case they don't. The program will fit a cubic equation to the residuals and plot the result. The CRT then asks if you want to fit a fifth order equation to the residuals from the third order polynomial, and does so if desired. The final option is whether to type out the residuals of the

Fig. 3. Neon-Argon Lamp Spectrum

(GS = Grating Setting)

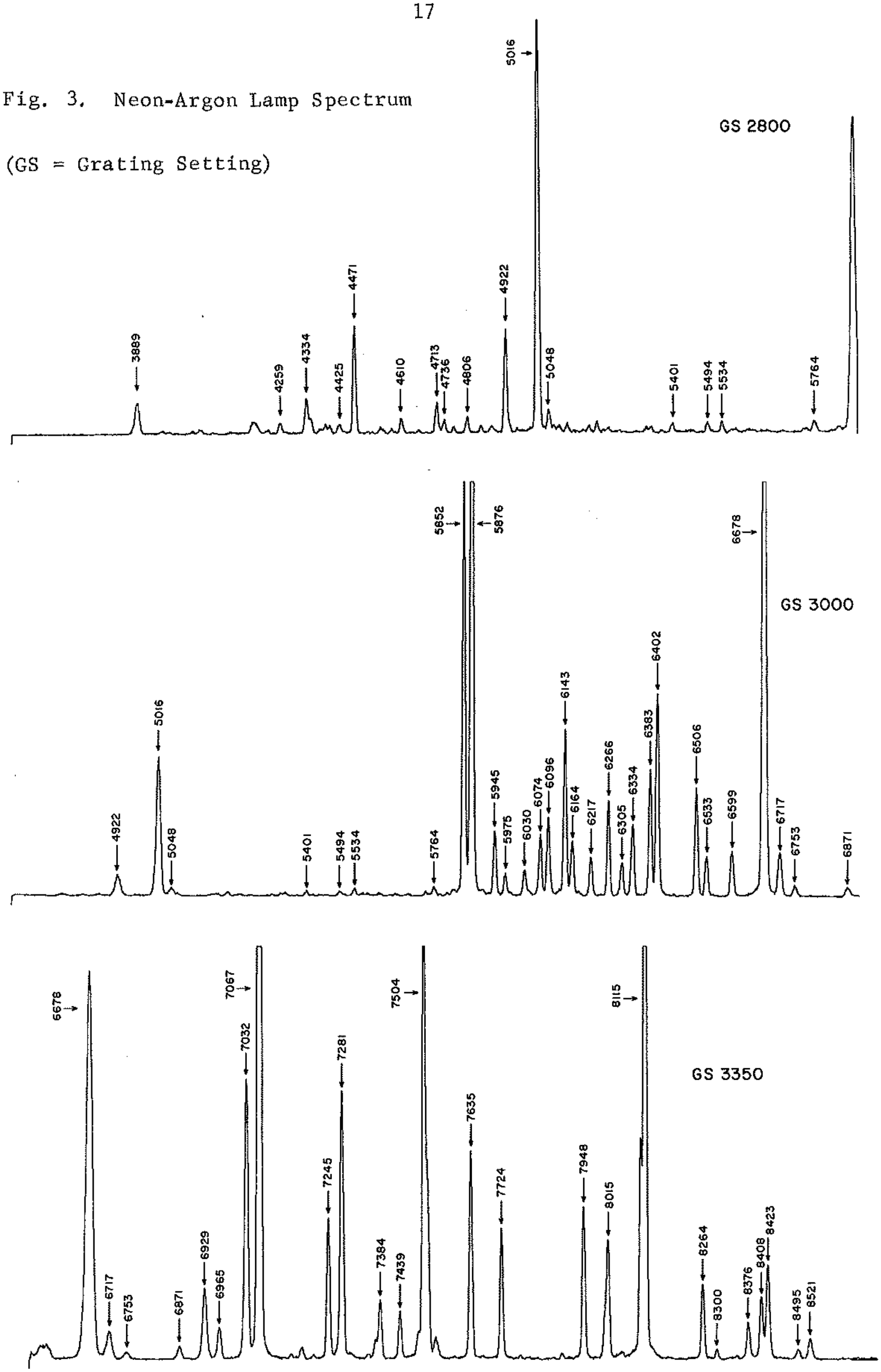
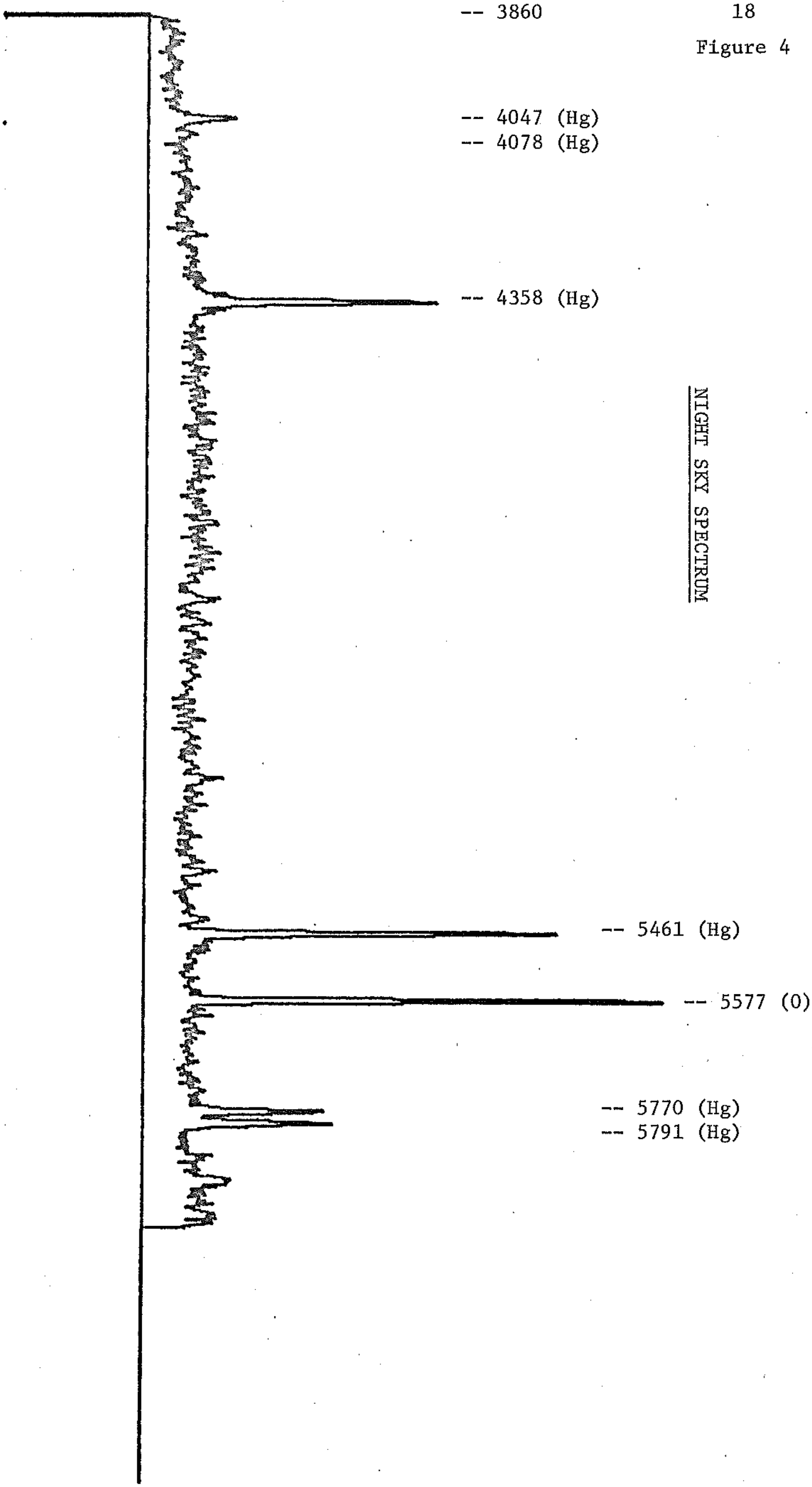


Figure 4


-- 3860
-- 4047 (Hg)
-- 4078 (Hg)
-- 4358 (Hg)
NIGHT SKY SPECTRUM
-- 5461 (Hg)
-- 5577 (0)
-- 5770 (Hg)
-- 5791 (Hg)

total polynomial fit. The coefficients are stored on tape #8 as calibrations 1 → 85*. The program then loops back and repeats for the left slit, bypassing the step of identifying five lines by hand.

THE BAIL-OUT ROUTINE: in case of disaster, the bail-out routine allows you to identify all lines by hand, using the joystick to mark lines on the CRT display and then asking for the wavelength to be typed in. The "Complete Bail Out" (called for the case of no neon scan) asks for two comparison spectra in each slit. If just one spectrum is available for a slit, enter the same scan number twice.

2. Sum Raw Data

This program will add up all of the scans for a given object, subtracting the sky background and correcting for paired pulses and atmospheric extinction. If it is used with data for which no log labels were stored on tape at the telescope, a table of declination, scan number, slit, dwell, and hour angle must be typed in. The LOG-LIST RAW DATA program can be used to check if labels are on the raw data tapes. The data from the left and right slits are not combined in this program.

INPUT: raw data tape on Unit 7 (set to "WRITE LOCK")

OUTPUT: onto the scratch area of the SDRS tape on Unit 8 (set to "WRITE ENABLE"), in 4096 channel format in the order: right slit, left slit.

OPERATION: This program is called by either SUM RAW DATA (WITH LOG) or SUM RAW DATA (NO LOG). In either case, it first asks "NEW EXT. TBL.? (Y OR N):". The extinction table (see Section II.4) must always be loaded when starting

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*Note: After calibration number 85 has been used, the program automatically reinitializes to calibration 1, and previous calibrations will be written over.

Coefficients are stored in a normalized integer format for maximum precision; the numbers typed out by the program have been multiplied by: CØ, 10; C1, 20000; C2, 8×10^7; C3, 10^{11}; C4, 10^{14}; C5, 10^{17}.

to reduce data from a new grating setting; type "Y" and the teletype will ask "CALIB. NO.:", referring to the calibration found in the LAMBDA CALIBRATION program. Entering a zero here will lead to a zero extinction correction. The table does not need to be reloaded as long as you continue to reduce data taken at the grating setting for which it is already loaded (type "N"). To return to the calling program, type "-2".

WITH LOG: The program will now ask which scan numbers should be processed; enter -1 as the last scan number. If 100 is added to a scan number, you will be asked to change to a new raw data tape before that scan is processed.

NO LOG: In this case, you will be asked for the object's declination in the format DEG. MIN (i.e. 15.20 = 15°20'). Then fill in the table of scan number, slit code, dwell, and hour angle.

Scan number:	add 100 to scan number to change raw data tapes. enter -1 to signal end of data input. enter -2 to bail out.
Slit code:	R = star in right slit, sky in left slit. L = star in left slit, sky in right slit. B = nebula in both slits. S = sky in both slits. Q = quartz lamp in both slits.
Dwell:	in minutes
H. A.:	hour angle in format HR. MIN (i.e. 3^h13^m = 3.13).

IN CASE OF ERROR: start entering -2 at every opportunity. Further processing will be curtailed.

STORING THE OUTPUT: The CRT will display the output for each slit broken up into four segments at different offsets, with the shortest wavelength segment at the bottom. The slits will be plotted one on top of the other. The teletype will ask which scan on the back part of the SDRS/scratch tape the output should be stored as; scans 1-17 are available. Entering a negative scan number will cause the output to be thrown away. The program will then loop back to its start.

SAMPLE I/O:

WITH LOG LABELS:

```
     SUM RAW DATA

     NEW EXT. TBL.? (Y OR N):Y
     CALIB. NO.:35

     SCAN #S
     :4
     :5
*___:-1
     STORE AS SCAN NO.:10

     NEW EXT. TBL.? (Y OR N):N

     SCAN #S
     :6
     :7
     :8
*___:-1
     STORE AS SCAN NO.:11

     NEW EXT. TBL.? (Y OR N):-2
```

WITHOUT LOG LABELS:

```
     SUM RAW DATA

     NEW EXT. TBL.? (Y OR N):Y
     CALIB. NO.:35
     DEC:28.43
     SCAN #   SLIT   DWELL   H.A.

     :4       :L     :1      :2.11
     :5       :R     :1      :2.09
*___:-1
     STORE AS SCAN NO.:10

     NEW EXT. TBL.? (Y OR N):N
     DEC:10.30
     SCAN #   SLIT   DWELL   H.A.

     :6       :L     :2      :1.43
     :7       :R     :4      :1.39
     :8       :L     :2      :1.34
*___:-1
     STORE AS SCAN NO.:11

     NEW EXT. TBL.? (Y OR N):-2
```

*program reads in data, does the reduction.

---

3. Combine Slits

This program is meant for data taken in the "stellar mode" (see Section II.1). It first divides the data by a continuum source (if desired), and then adds together the left and right slit data and saves it on tape.

INPUT: 4096 channel scans, normally from SDRS/Scratch Tape on Unit 8.

OUTPUT: 2048 channel scans, normally onto the Reduced Data Tape on Unit 7 (set to "WRITE ENABLE").

OPERATION: The CRT will ask for the program star scan number (enter -1 to return to calling program) and tape unit, and then "DIVIDE BY SCAN # (OR 'NONE', OR 'SAME'):". A response of "NONE" will cause the two slits to be added together without normalization. If a scan number is entered, the CRT will also ask which tape unit. "SAME" can be used when looping back through the program and dividing by the same continuum source each time (but a scan number must be specified the first time around).

The data are read in and combined, and the result is displayed on the CRT in four offset segments, with the shortest wavelength segment at the bottom. The teletype will then ask "SAVE AS SCAN #:", "UNIT":. Entering a negative scan number will cause the result to be thrown away. The program always loops back to the start.

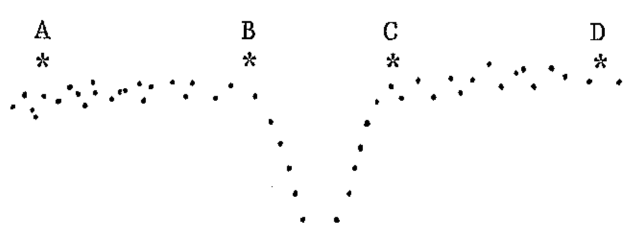
WARNING: This program is normally used just after SUM RAW DATA, where raw data tapes are on Unit 7. Be sure to put a REDUCED DATA TAPE on Unit 7 before using this program.

4. Line Zapper

This program will remove the effects of any absorption lines in the continuum source used for normalization. A scan is constructed such that when it is divided into a scan from the Reduced Data Tape, the absorption line profiles will be removed, but all other parts of the spectrum will remain unchanged. This dummy scan has most of its channels equal to 1, but has an upside-down absorption line profile where there are lines to be removed.

INPUT, OUTPUT: 2048 channel scans, normally from the Reduced Data Tape on Unit 7.

OPERATION: To construct the dummy scan, read in a scan of the standard star divided by the quartz lamp. The spectrum will be displayed, and lines can be marked with the joystick. As each line is marked, it will be displayed on a larger scale and you will be asked to mark four continuum points.



The continuum in the ranges A-B and C-D will be extrapolated across B-C, and the line profile will be found in the range B-C. The points may be marked in any order. When no more lines remain to be marked, press button (3,11) without moving the joystick to proceed to the next step.

Once the dummy scan has been built up, the program will ask for program star scan numbers, read in the scan, remove the lines, display the result, and allow you to save the result on tape. It will then loop back and ask for the next program star. This loop will continue until the program is asked to read in a negative scan number, at which time control is returned to the calling program. A bad result can be thrown away by trying to save it as a negative scan number.

5. Scrunch, Batch Scrunch

These programs transform scans onto a linear wavelength scale, using the coefficients saved on the SDRS tape by the LAMBDA CALIB. program. SCRUNCH will transform one scan at a time and allow you to save the output anywhere on tape. BATCH SCRUNCH will automatically transform many scans, writing the output scan back on top of the input scan.

The output of SCRUNCH can be on any desired wavelength scale, but the following are recommended:

Grating Dispersion (Å/mm)	Wavelength Scale (Å/channel)
0-68	.625
68-135	1.25
135-270	2.50

There is a net squeeze so that channels toward the end of the scan are set to zero, except that channels 2045 through 2047 contain respectively the scale factor exponent, 100*(λ of last channel), and 100*(λ of blue edge of first channel). SCRUNCH requires about ten minutes per scan.

INPUT, OUTPUT: 2048 channel scans, from either tape unit for SCRUNCH, from tape Unit 7 for BATCH SCRUNCH.

OPERATION: I/O is mostly self-explanatory. The spectrum is displayed in four segments at different offsets, with the lower wavelengths near the bottom. The program will ask (on either CRT or the teletype) "NEW LAMBDA TBL.?". The Lambda Table (see Section II.4) must be loaded before using SCRUNCH, but once it is in, it doesn't need to be reloaded except when you start to scrunch data taken at a new grating setting. If you type "Y" (yes), indicating you want to load a new table, the program will ask "SLIT <L,R,B>:", meaning is the table to use the left slit calibration, the right slit calibration, or the average of the two. The program will also ask for the calibration number.

6. Plot

INPUT: 2048 channel scans from either tape drive.

OUTPUT: plots on the CRT or CALCOMP, on linear or semi-log scales.

OPERATION: The program asks for:

"SCAN:" --- enter scan number, or -1 to return to calling program.

"UNIT:" --- tape unit 7 or 8.

"SCALE:" --- This sets the y scale. The data will be divided by the scale before plotting. Full scale deflection is 1024. The scale may be any positive number. If Ø is entered, the scale will automatically be set so that the largest value is 500. If the plot is to be sent to the CRT or is to be plotted on an x scale of .5 points per channel on the Calcomp, the scale will be multiplied by 1.25.

LOG SCALE: if switch (2,1) is in the up position, the data will be converted to 10000* $\log_{10}$.

"OFFSET:" --- the spectrum will be moved up or down by this many units after scaling. The offset must be in the range -8,000,000 to +1024.

"CRT (Y OR N):" --- if "Y", the plot will come out on the CRT. If "N", the plot is on the Calcomp after you answer the following questions.

"POINTS PER CHAN:" --- This sets the x scale on the Calcomp.
.5 = each point plotted is the sum of two channels.
1 = plot each channel as one point.
2 = plot each channel as two adjacent points.
etc.

"DOTS? (Y OR N):" --- plot dots or leave the pen down.

"NEW PAGE?:" --- "Y" = advance the Calcomp one page before plotting.

SAMPLE TELETYPE I/O:

```
PLOT
SCAN:3 UNIT:7 SCALE:Ø =    14.21   OFFSET:1ØØ CRT? (Y OR N):Y
SCAN:3 UNIT:7 SCALE:2Ø OFFSET:1ØØ CRT? (Y OR N):N
POINTS PER CHAN:.5 DOTS? (Y OR N):N NEW PAGE?:N
SCAN:3 UNIT:7 SCALE:1ØØØ
LOG SCALE (SW. 2,1)  OFFSET:-3ØØØØ CRT? (Y OR N):N
POINTS PER CHAN:1 DOTS? (Y OR N):N NEW PAGE?:N
SCAN:-1
```

BATCH PLOT: Up to a whole tape can be automatically dumped out on the Calcomp using this routine. Input parameters are the same as for plot, except the scale is always set automatically.

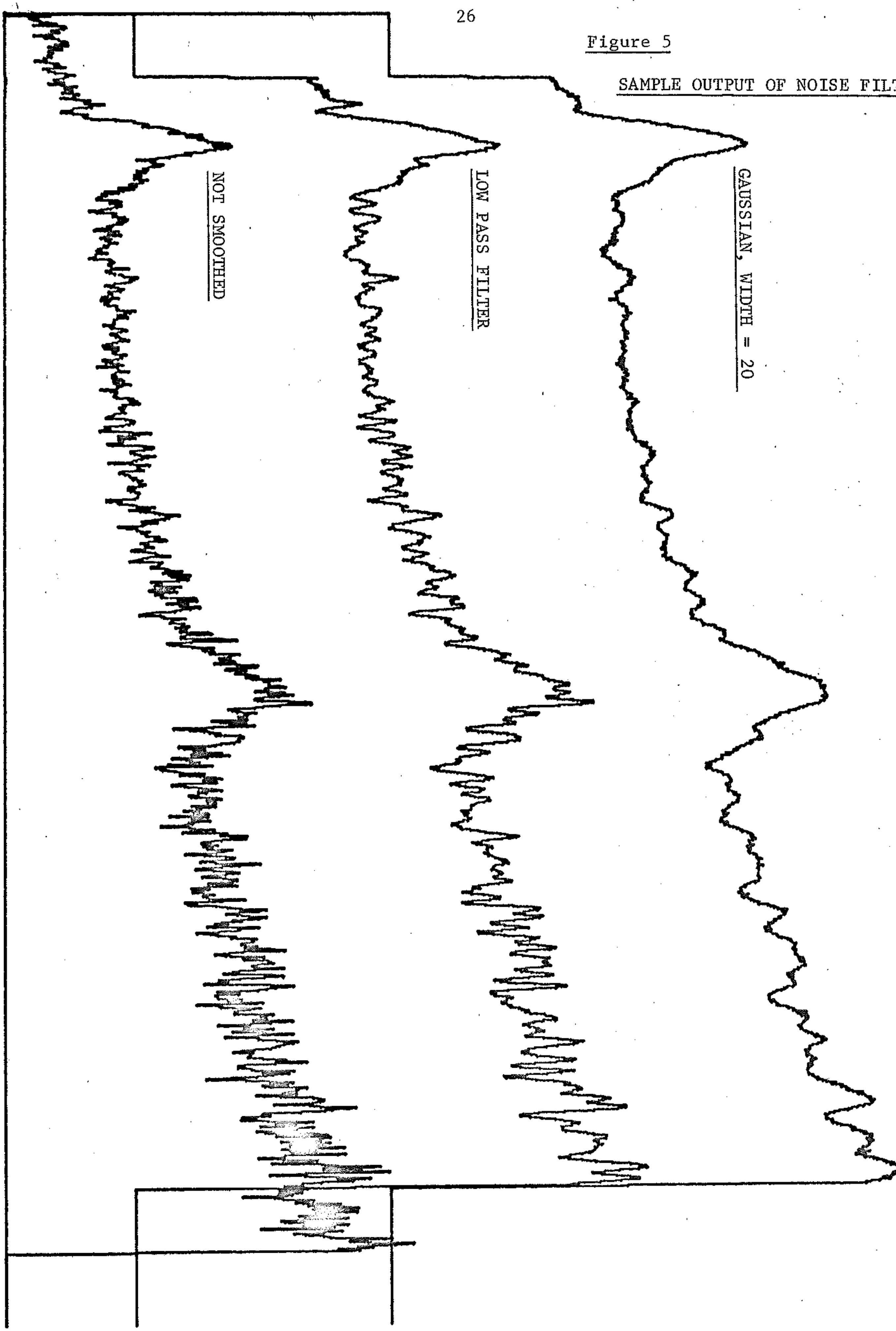
7. Noise Filter

This program smooths the spectrum by convolving it with either a Gaussian function of specified width or a low-pass filtering function. The program asks for "SCAN:" and "UNIT:" (tape unit), then for "<G>AUSS or <F>OURIER:" (enter "G" or "F", fourier refers to the low-pass filter). If a Gaussian is selected, the program asks "WIDTH:", meaning full-width, at half maximum of the Gaussian function desired (in channels, not Angstroms!).

The results are displayed, after which the output may be stored on tape (scan # = -1 to bypass this step) or plotted on the Calcomp. (see "PLOT" write-up for information about Calcomp plotting parameters).

Figure 5

SAMPLE OUTPUT OF NOISE FILTER



SAMPLE I/O:

```
NOISE FILTER

SCAN:29  UNIT:7
G(AUSS) OR F(OURIER)?:G   WIDTH:20
SAVE AS SCAN:-1
CALCOMP? (Y OR N):Y SCALE:0 =    82.91   OFFSET:300
POINTS PER CHAN:.5 DOTS? (Y OR N):N NEW PAGE?:N
CALCOMP? (Y OR N):N
```

8. Utility Programs

This is a catch-all for little goodies that didn't fit in anywhere else.

INPUT, OUTPUT: 2048 ch. scans, tape Unit 7 or 8. Data are read in from tape and stored on disk in a "buffer" area, where it can be operated upon according to which option is selected. The buffer is automatically cleared when the program is first called, but it is not cleared at any other time unless option "C" is specified.

OPTIONS:

Code	Function
C	clear the buffer.
A	get a scan from tape and add it to the buffer contents.
M	(minus) get a scan from tape and subtract it from the buffer contents.
D	get a scan from tape and divide it into the buffer contents.
F	fix up bad points. Displays the scan record by record. Picking off a point with the crosshairs + switch 3,11 causes the point to be set equal to its neighbor. Pressing 3,11 without moving the joystick causes the next section of the scan to be displayed. Press both 3,11 and 3,12 to fix up lots of points in a row -- CRT asks "L, M OR R?" L,R = set all points to left or right of cursor to Ø. M = mark a second position, set all points between the two positions equal to the point next to the first position.
S	save buffer contents on tape.
P	plot on CRT.
Q	quit; return to calling program.
SD	shift data; move the scan to right or left by any number of channels (to the nearest thousandth).

SAMPLE I/O:

```
UTILITY PROGRAMS
OPTION:A SCAN #:2  UNIT:8
OPTION:D SCAN #:4  UNIT:8
OPTION:S SCAN #:15  UNIT:7
OPTION:C
OPTION:A SCAN #:4  UNIT:7
OPTION:SD  ENTER X:-3.125
OPTION:A SCAN #:5  UNIT:7
OPTION:S SCAN #:4  UNIT:7
OPTION:Q
```

9. Log List Raw Data

While taking data at the telescope, the observer has the option of storing "LOG I.D." information on the raw data tapes. This information includes object name, R.A., dec., hour angle, P.S.T., dwell time, slit, grating setting, and comments. This program will dump that data out in tabular form, for as many as 20 tapes.

INPUT: 4096 channel scans from raw data tapes on Unit 7.

OPERATION: The program first reads in the log information from all data tapes, and then dumps it out by teletype (a slow, noisy process). The program will ask for tape number and date, and then it will read in whatever tape is on Unit 7. It then loops back and asks you to enter the next tape number and date. The loop continues until -1 is entered as the tape number; the log is then typed out.

To speed up the tape reading, both tape drives may be used as Unit 7, but with only one of them turned on to "REMOTE" at a time. The SDRS tape must be back on Unit 8 before the log is typed out.

10. Log Edit Raw Data

This program allows you to alter the log information stored on the raw data tapes.

INPUT, OUTPUT: 4096 channel scans from a raw data tape on Unit 7 (set on "WRITE ENABLE").

OPERATION: The teletype will ask for "SCAN NO:", then read in the old log information for the specified scan on Unit 7. You will then be asked to fill in the log fields. To not change a particular field, just press the "ALT MODE" key and the existing entry will be saved.

After the new log data have been typed in, the teletype will ask "ALL OK (Y OR N):"; if the answer is "Y" (yes) the altered log data will be stored on tape, otherwise the tape will not be written on.

11. Reduced Data Log List/Edit

The following identifying information is stored on the Reduced Data Tape:

Object Name
Scale Factor Exponent
Standard Star Name

These fields may be listed or altered using this program.

INPUT, OUTPUT: 2048 channel scans on Unit 7.

OPERATION: You will be asked to specify "LIST" or "EDIT". If listing, you will be asked for the first and last scan numbers (they can be the same) to be listed. If editing, you will be asked which scan, and then you must re-enter all of the information. The information is stored on the tape during the process of normalizing the spectrum by a scan of a continuum source (in either COMBINE SLITS or UTILITY PROGRAMS). The contents of the Object Name and Standard Star Name fields come indirectly from the log information on the raw data tapes; these fields will be blank if the raw data tapes were read using SUM RAW DATA (NO LABELS).

Acknowledgements

This system is the result of long hours of work by several people. Joe Wampler was the over-all director. Large sections of programming were contributed by Dave Burstein, Tom Ewing, Joe Wampler, and the author. As each program was completed and turned out not to work, it was usually Lloyd Robinson who gleefully pointed out our mistakes.

This work has been supported, in part, by funds from NSF grant GP-29684, and NASA grant NGR 05-061-006.

And finally, an IMPORTANT MESSAGE: if the program fails in the middle of some long winter night, don't phone the author. He suffers from total amnesia between the hours of 7 PM and 9 AM.

Appendix A. Special Numbers Stored with Various Types of Scans

The data stored on Dectape by SDRS are logically divided into "records" of 512 doubleword channels, but it is physically divided into "blocks" of 129 words. Each record requires 1024 words for data, but occupies 8 blocks totalling 1032 words, so that there are 8 "spare" words per record. 2048 channel scans occupy four records for a total of 32 spare words; 4096 channel scans occupy 8 records for a total of 64 spare words. These extra words are used to store identifying information about the scan as follows:

<u>Raw Data Tape</u> (4096 channel, or 8 record, format)

I = integer format (loaded onto disk with X PUT)

P = packed ASCII character format (loaded onto disk with X CODI)

BLOCK	WORD 121	122	123	124	125	126	127	128
7	SCAN NO. (I)	DWELL (SECONDS) (I)	HOUR ANGLE HR (I)	MIN (I)	SLIT (I)	N A M E (P)		
15	CONTINUATION OF NAME (P)			RIGHT ASCENSION DEG (I)	MIN (I)	SEC (I)	DECLINATION DEG (I)	10*MIN
23	P.S.T. HR (I)	MIN (I)	GRATING SETTING (I)	B L A N K				
31	B L A N K							
39	C O M M E N T S (P)							
47	C O N T I N U A T I O N O F C O M M E N T S (P)							
55	C O N T I N U A T I O N O F C O M M E N T S (P)							
63	C O N T I N U A T I O N O F C O M M E N T S (P)							

Note that the 129 words in a DECTAPE block are numbered 0-128, and that the 64 blocks in a scan are numbered 0-63.

<u>SDRS/Scratch Tape</u>: (4096 channel, 8 record format)

F = floating point format (loaded onto disk with X STOR)

P = packed ASCII character format (loaded onto disk with X CODI)

BLOCK	WORD 121	122	123	124	125	126	127	128
7	TOTAL DWELL, RIGHT SLIT (F)					N A M E (P)		
15	CONTINUATION OF NAME (P)							
39	TOTAL DWELL, LEFT SLIT (F)					N A M E (SAME AS BLOCK 7) (P)		
47	CONTINUATION OF NAME (SAME AS BLOCK 15) (P)							

Note: other fields may contain leftover information from raw data tape.

<u>Reduced Data Tape</u>: (2048 channel, or 4-record, format)

I = integer format (loaded onto disk with X PUT)

P = packed character format (loaded onto disk with X CODI)

BLOCK	121	122	123	124	125	126	127	128
7	SCALE FACTOR (I)	FLUX CAL FLAG (I)			FLAG (=4095) (I)	N A M E (P)		
15	CONTINUATION OF NAME (P)							
31	S T A N D A R D S T A R N A M E (P)							

Flux calibration flag: = 1000 if scan is on an F_ν scale.
= 0 otherwise.

If a scan on the Reduced Data Tape has been through the SCRUNCH program, the last three channels of the fourth record contain the following:

Channel 509: scale factor exponent
Channel 510: 100*(λ of last data channel)
Channel 511: 100*(λ of first data channel)

Appendix B. Teletype I/O for a Typical Data Reduction in the Stellar Mode.

(all user responses are underlined)

```
*G

SCAN  11
AVE CT    59.96

SCAN  14
AVE CT   166.91

SAVE ON TAPE
<R> CALIB #=  45
COEFFICIENTS ARE:
 5167270
 1416556
 3563580
-1354907
TYPE RESID(Y/N)?:N

SCAN  11
AVE CT    61.27

SCAN  15
AVE CT   107.98

SAVE ON TAPE
<L> CALIB #=  45
COEFFICIENTS ARE:
 5164698
 1417352
 3594501
-1373306
TYPE RESID(Y/N)?:N
```

LAMBDA CALIBRATION

```
SUM RAW DATA

NEW EXT. TBL.? (Y OR N):Y
CALIB. NO.:45
DEC:43.14
SCAN #  SLIT  DWELL  H.A.

:12     :,    :2     :2.21
:13     :R    :2     :2.19
:-1
BAD CODE FOR SLIT TYPE, SCAN 12.  TRY AGAIN:L
STORE AS SCAN NO.:1
```

SUM RAW DATA (NO LABELS)

```
NEW EXT. TBL.? (Y OR N):N
DEC:Ø
SCAN #   SLIT   DWELL   H.A.

:14      :Q      :2
:1Ø4     :Q      :1 CHANGE TAPE, THEN HIT RETURN:

:6      :Q      :1
:-1
STORE AS SCAN NO.:4

NEW EXT. TBL.? (Y OR N):-2
```

SUM RAW DATA (NO LABELS)

```
COMBINE CHANNELS
SCAN    1 DIVIDED BY SCAN    3
SAVE AS SCAN:Ø   UNIT:7
SCAN    2 DIVIDED BY SCAN    3
SAVE AS SCAN:1   UNIT:7
SCAN    3 DIVIDED BY SCAN    4
SAVE AS SCAN:2   UNIT:7
```

COMBINE CHANNELS

```
LINE ZAPPER
STANDARD STAR SCAN #:2  UNIT:7
PROGRAM STAR SCAN #:Ø  UNIT:7
SAVE AS SCAN:Ø UNIT:7
PROGRAM STAR SCAN #:1  UNIT:7
SAVE AS SCAN:1 UNIT:7
PROGRAM STAR SCAN #:-1
```

LINE ZAPPER

```
SCRUNCH

SCAN # (UNIT 7)
(-1 TO END)
:Ø
:1
:-1
LAMBDA SCALE (ANG/CHAN):1.25
NEW LAMBDA TABLE? <Y/N>:Y SLIT? <L,R,B>:B = BOTH
CALIB. NO.:42

SCAN    Ø
SCRUNCH
LAMBDA OF 1ST CHAN. =   4149.97

SCAN    1
SCRUNCH
LAMBDA OF 1ST CHAN. =   4149.97*G
```

BATCH SCRUNCH

Appendix C. SDRS Tape and Disk Utilization.

1. Focal System: SCN72-Q (LICK FOCAL by Lloyd Robinson).

2. Overlays: (called by X NAME (n))

n	Contents
1	X FILT, X DTIM, X TINC, X DMUL
2	X LOGB, X SHOV
3	X POLY, X FLIP
4	EDIR (tape editing routines, includes X TWRT, X TRED).
5	TTTT (Tom's Trustworthy Transfer Trips for packed characters).
6	X TYCO, X DICO, X MPUT

3. Blocks 90, 91: Fourier coefficients for NOISE FILTER.

4. Focal Programs:

Program #	Contents
0	Reserved for more overlays.
1	Calling program (X CALL (1,1)), label writing (X CALL (1,30)).
2	LAMBDA CALIBRATION
3	" "
4	" "
5	" "
6	" "
7	" "
8	" "
9	" "
10	Subroutines to generate Lambda Table, Extinction Table.
11	SUM RAW DATA
12	" " "
13	" " "
14	COMBINE SLITS
15	SCRUNCH
16	"
17	UTILITY PROGRAMS
18	" "
19	NOISE FILTER

Program #	Contents
20	PLOT
21	"
22	UTILITY PROGRAMS
23	LINE ZAPPER
24	" "
25	(empty)
26	No program. Wavelength calibration storage (right slit).
27	No program. Wavelength calibration storage (left slit).
28	No program. Wavelength table for LAMBDA CALIBRATION.
29	LAMBDA CALIBRATION
30	REDUCED DATA LOG LIST/EDIT
31	RAW DATA LOG EDIT
32	RAW DATA LOG LIST
33	" " " "

5. LAMBDA CALIBRATION Program Disk Utilization:

Disk Record	Contents
0	List of channel numbers of peaks.
1-4	Input data; Neon scan.
5	Peak channel # vs. λ , running account.
6	Clear record.
7	Linear fit residuals.
8	Cubic fit curve.
9	Peak chan. # vs. λ , final fit + λ-calibration coefficient.
10-13	Input data; Sky.
14,15	Neon scans after X FORM.
26,27	Sky scans after X FORM.

Appendix D. Program Listings

```
*X WHAT(5)

1:
FILT,TINC,DMUL,DTIM(PPUL)
2:
SHOV, LOGB(*10000)    P
3:
POLY, FLIP     P
4:
ETAP  JUNE 8/72.
5:
 TTTT DEC 72
6:
 TTTP DEC 72*


*W
C:LICK FOCAL SCN72-Q  H:@@

01.01 C-DEC.4/72.

02.10 X CALL(1,1)
*
```

```
        X CALL(1)
*W
C:LICK FOCAL SCN72-Q  M(FU

01.10 X SWIT(-1)
01.20 F J=1,50;S A=A

02.10 E
02.15 X STAT(330,800,2)
02.20 T "  SCANNER DATA"!"REDUCTION SYSTEM"
02.25 X STAT(180,600,1)
02.30 T "SELECT DESIRED SUBROUTINE, THEN PRESS START"
02.40 S D=FSWIT(3,8)
02.50 IF (D)2.4,2.4;S D=FSWIT(1,1);X GO(3,D+10)

03.10 X CALL(2,131);  C-LAMBDA CALIB.
03.11 X CALL(11,11);  C-SUM RAW DATA WITH LOG
03.12 X CALL(14,138); C-COMBINE SLITS
03.13 X CALL(23,138); C-LINE ZAPPER
03.14 X CALL(15,133); C-SCRUNCH
03.15 X CALL(20,138); C-PLOT
03.16 G 5.1
03.17 S D=FSWIT(1,4); C-READ LOWER SWITCH
03.18 X GO(4,D+10)

04.10 X CALL(11,138); C-SUM RAW DATA (NO LOG)
04.11 X CALL(19,138); C-NOISE FILTER
04.12 X CALL(17,7);   C-UTILITY PROGRAMS
04.13 X CALL(20,10);  C-BATCH PLOT
04.14 X CALL(15,6);   C-BATCH SCRUNCH
04.15 X CALL(33,10);  C-LOG LIST RAW DATA
04.16 X CALL(31,133); C-LOG EDIT RAW DATA
04.17 X CALL(30,10);  C-REDUCED DATA LOG
04.18 C                       LIST/EDIT

05.10 X STAT(-1);T !"PROGRAM NOT AVAILABLE";G 1.1

30.10 T !!!!!;W 3
30.20 T !!!!!!!!!;W 4
30.30 T !!!!!
*
```

```
 X CALL(2)
*W
C:LICK FOCAL SCN72-Q  OZJ6

01.01 X CALL(1,1)
01.03 X SWIT(-1)
01.04 E
01.05 X STAT(200,750,2);F J=0,50;S K=0
01.06 T "WAVELENGTH CALIBRATION";S RB=101;X STAT(200,500,1.5)
01.10 A !"NEON COMPARISON SCAN NO(-1 IF NONE)"R;I (R)1.9;S AB=0;S RN=R
01.15 S RI=0;S SK=0
01.20 F K=0,3;X MGET(R*8+K,1,7);X SAV(K+1+9*SK,1)
01.25 X SWIT(-1);D 2
01.30 X STAT(99,800,1);A "TYPE -1 IF SKY LINES ARE NEEDED"SY
01.32 I (SY)3.1
01.35 X SWIT(-1);X STAT(150,900,1.5);F J=0,50;S K=0
01.37 T "WHEN MARKER APPEARS, PLEASE IDENTIFY 5 LINES---"
01.40 T !"2 NEAR EITHER SIDE OF SCREEN; 3 INSIDE HASH MARKS."
01.50 T !"KEEP HORIZONTAL MARK IN APPROPRIATE PART OF SCREEN."
01.60 A !!"PRESS 'ALT MODE' TO CONTINUE"G
01.62 X SWIT(-1);S SK=0;D 5
01.63 I (SY)1.66,1.7
01.66 S SK=1;D 5
01.70 X CLER(0);X SAV(5);X SAV(6);X CRT(1,0,0,0,8,512)
01.75 X STAT(300,500,.5);T "1";X STAT(700,500,.5);T "1"
01.80 X CALL(3,132)
01.90 X CALL(9,2)

02.10 F J=0,1,1;D 8
02.20 D 5

03.10 T !"SCAN WITH SKY LINES IN";A !"<R> SLIT"R;S RS=R;S SK=1
03.15 A !"<L> SLIT"RT;D 1.2
03.20 D 2.1
03.30 G 1.35

05.10 S D=FPEAK(0,<14+SK*12>*100,1023)/480;X PULL(14+SK*12,1)
05.12 X PULL(15+SK*12);I (2-D)5.3;S D=2
05.30 X CRT(D,1024,0,1,8,SK*542)

08.10 X PULL(J*2+SK*9+1,1);X PULL(J*2+SK*9+2)
08.20 X FORM(1);X FORM(2);X SAV(J+14+SK*12,1)
*
```

```
 X CALL(3)
*W
C:LICK FOCAL SCN72-Q  OJMZ

01.01 X CALL(1,1)
01.04 X STAT(-1);S Q=0
01.05 S K=1;T !!%3"SCAN"RN;S RB=101;G 1.2
01.10 T !!%3"SCAN"RS
01.20 S CN=0;F J=1,20,2000;S CN=CN+FCHAN(J,RB)
01.30 S CN=CN/100;S C0=0;S N=0;F J=1,20,2000;D 5
01.40 S CT=C0*<1.2-Q>/N;T !%7.02"AVE CT"CT;T

02.01 S WL=10
02.03 I (2000-WL)2.89;I (FCHAN<WL,RB>-CT)2.06,2.1,2.1
02.06 S WL=WL+5;G 2.03
02.10 S Y=FCHAN(WL,RB);S WL=WL+1;S Y1=FCHAN(WL,RB)
02.14 I (Y-Y1)2.1;S XP=WL-1;S XT=XP
02.15 S Y2=FCHAN(XP,RB);S Y3=FPEAK(XP,RB,XP+10)
02.16 I (Y3-Y2)2.2,2.2;S WL=XP
02.18 D 2.1
02.19 I (Y1-Y3)2.1;S XP=WL;I (XP-XT-4)2.15
02.20 S YT=FCHAN(XP,RB);S YF=(YT+CT)/5;I (CT-YF)2.21,2.21;S YF=CT
02.21 S YA=(FCHAN<XP-1,RB>+FCHAN<XP,RB>+FCHAN<XP+1,RB>)/3
02.24 S S=0;S S1=0;S XD=0;F J=XP-10,XP+10;D 3
02.25 I (XD-7)2.45;S PK=S/S1;I (2.5-FABS<PK-XP>)2.45
02.30 D 4
02.45 S WL=XP+11;S WT=WL;S Z=0
02.50 D 2.1
02.51 I (Y1-CT)2.06;I (Y1-Y)2.6;S Z=Z+1;I (Z-4)2.6;G 2.03
02.60 G 2.5
02.89 I (-SK)2.9,2.96
02.90 I (Q)2.96;S Q=-1;S RB=1001;S KS=K;G 1.1
02.96 S KC=K;I (LJ)2.97;X CALL(6,7)
02.97 X END(0)

03.10 S A=FCHAN(J,RB)-YF;I (A)3.3,3.3;S S=S+J*A
03.20 S S1=S1+A;S XD=XD+1;R
03.30 I (J-XP)3.4,3.4;S J=XP+11;R
03.40 S S=0;S S1=0;S XD=0

04.10 S XC(K)=PK*100;S K=K+1

05.10 I (FCHAN(J,RB)-2*CN)5.2;R
05.20 S C0=C0+FCHAN(J,RB);S N=N+1
*
```

```
 X CALL(4)
*W
C:LICK FOCAL SCN72-Q  O<J*

01.01 X CALL(1,1)
01.10 X PULL(5);S KC=FCHAN(511);X CLER(0);X CLER(1)
01.15 S XX=0;S X=0;S XY=0;S Y=0;S N=0
01.25 X PULL(5);F J=0,2,510;D 2
01.30 S D=N*XX-X↑2;S Z0=(Y*XX-X*XY)/D;S Z1=(N*XY-Y*X)/D
01.40 X CLER(1);F J=0,2,510;D 3
01.50 X SAV(7,1);X CLER(0);X SWIT(-1);X CRT(1,0,0,0,8,512)
01.55 F J=0,2,KC-1;D 5
01.57 X STAT(100,900,1);A "OK?-<Y>ES OR <N>O"OK
01.58 I (OK-0Y)1.7
01.60 X STAT(-1);X CALL(5,7)
01.70 A !"<R>EPEAT I.D. OR <B>AIL OUT?"BA;G 6.05

02.10 S CH=FCHAN(J)/100;I (-CH)2.2;S J=511;R
02.20 I (600-CH)2.3,2.3;R
02.30 I (CH-1400)2.4,2.4;R
02.40 S N=N+1;S X=X+CH;S XX=XX+CH↑2;S AM=FCHAN(J+1)/100
02.50 S Y=Y+AM;S XY=XY+CH*AM

03.10 S CH=FCHAN(J)/100;I (-CH)3.2;S J=511;R
03.20 S V=FCHAN(J+1)/100;S RE=(Z0+Z1*CH-V)*2.5+512
03.30 X EDIT(J,1,CH*100);X EDIT(J+1,1,RE)

05.10 S U=FCHAN(J,1)/200;S V=FCHAN(J+1,1);X STAT(U,V,0);T "."

06.05 X PULL(0);X SAV(5);I (BA-0R)6.1;G 6.35
06.10 X SWIT(-1);X STAT(200,800,2);F J=0,50;S K=0
06.15 T "BAIL OUT"!!,"MARK ALL USABLE LINES"
06.20 A !"TYPE 'G' TO GO"G;X SWIT(-1)
06.30 X PULL(0);X EDIT(499,0,1);X SAV(5)
06.35 X SWIT(-1);S Q=FCHAN(509);S SK=0;D 7
06.40 I (Q)6.5,6.5;S SK=1;D 7
06.50 X CLER(0);X CRT(1,0,0,0,8,512)
06.60 X CALL(6,2)

07.10 S D=FPEAK(0,<14+SK*12>*100,1023)/480;X PULL(14+SK*12,1)
07.20 X PULL(15+SK*12);I (2-D)7.4;S D=2
07.40 X CRT(D,1024,0,1,8,SK*542)
*
```

```
 X CALL(5)
*W
C:LICK FOCAL SCN72-Q  O/K[

01.01 X CALL(1,1)

07.01 S X1=0;S X2=0;S X3=0;S X4=0;S X5=0;S X6=0;S Y0=0;S Y1=0;S Y2=0
07.02 S Y3=0;S N=0
07.03 X PULL(7);F J=0,2,KC;S X=FCHAN(J)/100;S Y=FCHAN(J+1)-512;D 8
07.04 DO 9
07.05 S C(1)=Z0*1000-800*B(1);S C(2)=Z1*2.E6-B(2)*1.6*1.E6
07.06 S C(3)=-B(3)*6.4*1.E9;S C(4)=-B(4)*8.E12
07.07 X STAT(-1);X PULL(5);I (-FCHAN<499>)7.1
07.09 X CALL(7,7)
07.10 X CLER(0);X SAV(8);X PUTN(64,0,2,512,4)
07.11 F J=1,4;X STOR(72,4*J+300;B<J>*2)
07.13 X NAME(3);X PULL(8);X POLY(72,304,3,0,0,0)
07.14 X SWIT(-1);F J=1,4;S D(J)=C(J)
07.15 X CRT(1,0,0,0,5,512);X PULL(7);F J=0,2,KC-1;D 10
07.20 X CALL(8,130)

08.01 S Y=Y/2;IF (-X)8.2;S J=KC+1;R
08.20 S XS=X*X;S XC=XS*X;S XF=XC*X;S XV=XF*X;S X1=X1+X;S X2=X2+XS
08.30 S X3=X3+XC;S X4=X4+XF;S X5=X5+XV;S X6=X6+XV*X;S Y0=Y0+Y
08.40 S Y1=Y1+Y*X;S Y2=Y2+Y*XS;S Y3=Y3+Y*XC;S N=N+1

09.01 S A1=X2-X1*X1/N;S A2=(X3-X2*X1/N)/A1;S A3=(X4-X3*X1/N)/A1
09.02 S A4=(A2*X1-X2)/N;S C1=(Y1-X1*Y0/N)/A1;S A5=(A3*X1-X3)/N
09.03 S C2=(-C1*X1+Y0)/N;S A6=A4*X2-A2*X3+X4
09.04 S A7=-(A5*X2-A3*X3+X5)/A6;S A8=(Y2-C2*X2-C1*X3)/A6
09.05 S A9=-A7*A2-A3;S D1=-A8*A2+C1;S D2=A7*A4+A5;S D3=A8*A4+C2
09.06 S B(4)=(Y3-D3*X3-D1*X4-A8*X5)/(D2*X3+A9*X4+A7*X5+X6)
09.07 S B3=B(4);S B(3)=B3*A7+A8;S B(2)=B3*A9+D1;S B(1)=B3*D2+D3

10.10 S U=FCHAN(J)/200;S V=FCHAN(J+1);X STAT(U,V,0);T "."
*
```

```
 X CALL(6)
*W
C:LICK FOCAL SCN72-Q  O&JR

Ø1.Ø1 X CALL(1,1)

Ø2.Ø4 E
Ø2.Ø5 X CLER(1)
Ø2.1Ø X PULL(5);S SK=FCHAN(5Ø9);S KC=FCHAN(511);S KS=KC
Ø2.15 S BA=FCHAN(499);I (-SK)2.2,2.3,2.3
Ø2.2Ø S KS=FCHAN(5Ø8)
Ø2.3Ø S U=512;S V=5ØØ;S I=Ø
Ø2.4Ø S D=FSWIT(3,11,U,V);S M1=FITR(D/1Ø24);S O1=D-1Ø24*M1
Ø2.41 I (M1-U)2.5,2.8,2.5
Ø2.5Ø S M2=M1*2;I (SK)2.7,2.7;I (O1-512)2.7,2.7,2.6
Ø2.6Ø S P=1;F J=KS,2,KC-1;D 3
Ø2.65 S U=M1;S V=5ØØ;G 2.4
Ø2.7Ø S P=Ø;F J=Ø,2,KS-1;D 3
Ø2.72 G 2.65
Ø2.8Ø F J=499,51Ø;S K=FCHAN(J);X EDIT(J,1,K)
Ø2.85 X EDIT(511,1,I);X SAV(9,1);X SAV(5,1);X CALL(4,138)

Ø3.1Ø S XC=FCHAN(J);I (FABS<M2-XC/1ØØ>-8)3.2,3.2;R
Ø3.2Ø X STAT(XC/2ØØ,5+542*P,.5);T "↑";I (-BA)3.3,3.4,3.4
Ø3.3Ø X STAT(-1);T !%7"PK="XC,"  ";G 3.45
Ø3.4Ø X STAT(25+1ØØ*I,512,1)
Ø3.45 A "LA="LA;I (-LA)3.5;R
Ø3.5Ø X EDIT(I,1,XC);X EDIT(I+1,1,LA*1ØØ);S I=I+2;S J=511;R

Ø4.1Ø X CLER(Ø);X CLER(1);F J=2,2,KC*2-1;X EDIT(J-2,Ø,XC<J/2>)
Ø4.2Ø S KC=KC*2-2;I (SK)4.3,4.3;S KS=KS*2-2;X EDIT(5Ø9,Ø,SK)
Ø4.25 X EDIT(5Ø8,Ø,KS);X EDIT(5Ø1,Ø,RS);X EDIT(5Ø2,Ø,RT)
Ø4.3Ø X EDIT(511,Ø,KC);X EDIT(51Ø,Ø,RI);X EDIT(5ØØ,Ø,RN)
Ø4.4Ø X EDIT(499,Ø,AB);X EDIT(5Ø5,Ø,AB);X SAV(5);X SAV(Ø)

Ø7.1Ø D 4
Ø7.15 I (-AB)2.Ø4;I (-RI)7.2;G 2.Ø4
Ø7.2Ø E
Ø7.3Ø X PULL(9,1);F J=2ØØ,2Ø3;S C(J-2ØØ)=FCHAN(J,1)
Ø7.4Ø X PULL(Ø);F J=2ØØ,2Ø3;X EDIT(J,Ø,C<J-2ØØ>)
Ø7.5Ø X SAV(Ø);X CALL(7,135)
*
```

```
 X CALL(7)
*W
C:LICK FOCAL SCN72-Q  OOMB

01.01 X CALL(1,1)
01.07 E
01.08 X PULL(0);X MGET(2,1);S A=FCHAN(200);S B=FCHAN(201)
01.10 S C=FCHAN(202);S D=FCHAN(203)
01.11 S KC=FCHAN(511);S SK=FCHAN(509);S Z=2;I (-SK)1.12;G 1.14
01.12 S KS=FCHAN(508);G 1.15
01.14 S KS=KC
01.15 S AQ=A/10+5.E3;S AL=A/10+2.01*1.E5;F J=0,55;D 2
01.16 F J=S1,56;D 5
01.18 S KQ=0;S ST=S1
01.20 F K=KQ,2,KS-1;S L=FCHAN(K)/100;D 3
01.23 S KQ=KA+2;I (KS-KQ)1.25;I (S2-ST)1.25;G 1.2
01.25 I (KS-KC)1.3,1.4,1.3
01.30 F J=100,109;D 2
01.31 F J=S1,110;D 5
01.33 S KQ=KS;S ST=S1
01.35 F K=KQ,2,KC-1;S L=FCHAN(K)/100;D 3
01.37 S KQ=KA+2;I (KC-KQ)1.4;I (S2-ST)1.4;G 1.35
01.40 F J=0,125;X EDIT(J,0,0)
01.45 F J=0,2,Z-1;X EDIT(J,0,XC<J+2>);X EDIT(J+1,0,LA<J+3>)
01.50 X EDIT(511,0,Z-2);X EDIT(499,0,1);X SAV(5);X SAV(9)
01.70 E
01.80 X CALL(4,138)

02.10 I (FCHAN<J,1>-AQ)2.2,2.2;S S1=J;S J=511
02.20 R

03.10 D 6.1
03.20 S P=0;F S=ST,S2;D 4
03.30 I (-P)3.4;S KA=K;S K=511;R
03.40 S ST=SA+1;S K=511;R

04.10 I (FABS<FCHAN(S,1)-W>-1000)4.2;R
04.20 S XC(Z)=FCHAN(K);S LA(Z+1)=FCHAN(S,1)
04.30 S KA=K;S Z=Z+2;S SA=S;S P=1;S S=200

05.10 I (FCHAN<J,1>-AL)5.2,5.2;S S2=J-1;S J=511
05.20 R

06.10 S W=A*.1+B*5.E-5*L+C*1.25*1.E-8*L*L+D*1.E-11*(L↑3)

07.10 X PULL(0);F J=1,4;X EDIT(J+199,0,C(J))
07.20 X SAV(0);G 1.07
*
```

```
 X CALL(8)
*W
C:LICK FOCAL SCN72-Q  O-GS

01.01 X CALL(1,1)
01.02 X STAT(100,900,1);A "FIFTH ORDER FIT?-<Y>ES OR <N>0"TH;S IN=3
01.03 I (TH-0Y)1.04;X CALL(29,2)
01.04 X STAT(-1);X PULL(5);S RI=FCHAN(510)
01.05 T !!"SAVE ON TAPE";X MGET(0);S CZ=FCHAN(0)
01.10 I (85-CZ)1.8
01.15 I (-RI)1.5;S CZ=CZ+1;T !"<R>"
01.20 X EDIT(0,0,CZ);T %3" CALIB #="CZ
01.30 S C=6*CZ;F J=1,6;X EDIT(C-6+J,0,C(J))
01.40 T !"COEFFICIENTS ARE:";F J=C-5,C+IN-5;T !%7,FCHAN(J)
01.45 X MSAV(0);G 1.7
01.50 X MGET(1);T !"<L>"
01.54 D 1.2
01.58 D 1.3
01.60 D 1.4
01.65 X MSAV(1)
01.70 A !"TYPE RESID(Y/N)?"RD;I (RD-0Y)3.7,3.1,3.7
01.80 T !"FULL, REINITIALIZED!";S CZ=1;G 1.1

03.10 T !!"CALC VS MEAS RESID";X PULL(5,1);S C(1)=FCHAN(6*CZ-5)
03.15 F J=2,6;S C(J)=FCHAN(6*CZ-6+J)
03.20 F I=0,2,KC-1;S J=FCHAN(I,1)/100;S RW=FCHAN(I+1,1)/100;D 6
03.70 I (-RI)1.01;G 7.1

06.10 S W1=C(1)*.1+C(2)*J*5.E-5+C(3)*1.25*1.E-8*J*J+C(4)*(J↑3)*1.E-11
06.15 S W=C(5)*(J↑4)*1.E-14+C(6)*(J↑5)*1.E-17+W1
06.20 T !%7.02"CH"J," W="W/100," RW="RW
06.30 S RS=RW-W/100;T %7" RS="RS*100

07.10 X PULL(9);I (-FCHAN<505>)7.8;F J=1,4;X EDIT(199+J,0,D(J))
07.20 X SAV(9)
07.30 E
07.40 X PULL(5);S R=FCHAN(500);S SK=0;S RI=1;S RN=R
07.50 F K=0,3;X MGET(R*8+K+4,1,7);X SAV(K+1+9*SK,1)
07.60 I (FCHAN<509>)7.7,7.7;S R=FCHAN(502);S SK=1;S RS=R;D 7.5
07.70 X CALL(3,132)
07.80 E
07.81 X CALL(9,9)
*
```

```
 X CALL(9)
*W
C:LICK FOCAL SCN72-Q  08E0

01.01 X CALL(1,1)

02.10 X SWIT(-1);X STAT(200,600,1.5);F J=0,50;S K=0
02.15 T "COMPLETE BAIL OUT ROUTINE"
02.16 A !!"1ST COMPARISON SCAN IN <R> SLIT"RN;S R=RN
02.17 A !"2ND COMPARISON SCAN"RS;S SK=0;S RI=0
02.20 F K=0,3;X MGET(R*8+K,1,7);X SAV(K+1+9*SK,1)
02.25 F J=0,1,1;D 8
02.26 X SWIT(-1);I (-RI)2.28;I (RS-RN)2.27,2.3,2.27
02.27 S SK=1;S R=RS;D 2.2
02.28 D 2.25
02.30 D 5
02.31 I (SK)2.4,2.4;S SK=0;D 5
02.35 S SK=1
02.40 X CLER(0);X SAV(5);X SAV(6);X CRT(1,0,0,0,8,512)
02.50 S AB=1;X CALL(3,132)

05.10 S D=FPEAK(0,<14+SK*12>*100,1023)/480;X PULL(14+SK*12,1)
05.20 X PULL(15+SK*12);I (2-D)5.3;S D=2
05.30 X CRT(D,1024,0,1,8,SK*542)

06.05 X CLER(0);X SAV(8);X PUTN(64,0,2,512,4)
06.06 F J=0,5;X STOR(72,4*J+300;B(J)*2*<.01↑J>)
06.07 X NAME(3);X PULL(8);X POLY(72,300,5)
06.08 X CRT(1,0,0,0,5,512)
06.10 X STAT(-1);F J=0,5;S H(J)=T(J)-.01*B(J)*(.01↑J)
06.20 S C(1)=H*1000;S C(2)=H(1)*2.E6;S C(3)=H(2)*8.E9
06.30 S C(4)=H(3)*1.E13;S C(5)=H(4)*1.E16;S C(6)=H(5)*1.E19
06.40 X CALL(8,132)

08.10 X PULL(J*2+SK*9+1,1);X PULL(J*2+SK*9+2)
08.20 X FORM(1);X FORM(2);X SAV(J+14+SK*12,1)

09.10 X SWIT(-1);X STAT(200,600,1);F J=0,50;S K=0
09.20 A "IST COMP SCAN IN <L> SLIT"R;S RN=R;S SK=0;D 9.9
09.30 A !"2ND COMP SCAN"RS;S R=RS;S SK=1;D 9.9
09.40 S RI=1;G 2.25
09.90 F K=0,3;X MGET(R*8+K+4,1,7);X SAV(K+1+9*SK,1)
*
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```
 X FILE(10)

B=11710*W
C:LICK FOCAL SCN72-Q  OHJ\

01.01 X CALL(1,1)

02.05 D 7
02.10 D 4;I (-OOPS)2.9;X PUTN(8,0,2,512,4)
02.15 X NAME(3);F J=0,5;X STOR(40,4*J;C(J))
02.20 X PULL(1);X POLY(40,0,5);X SAV(17);X END(0)
02.90 D 5.2;X CALL(14,175)

03.10 D 7;D 4;I (-OOPS)3.9
03.15 X CLER(0);X SAV(6);X PUTN(48,512,2000,512)
03.20 S C(0)=C(0)-2.9E5
03.25 D 2.15;F K=1,4;D 6
03.80 X END(0)
03.90 I (1-OOPS)3.95;D 5.3;T !"ZEROS LOADED INTO EXTINCTION TABLE"
03.91 X END(0)
03.95 D 5.2;X CALL(11,150)

04.10 X STAT(-1);A !"CALIB. NO."CN;I (CN)4.9,4.8;I (85-CN)4.9
04.20 X MGET(S1);X MGET(S2,1);S SF(0)=10;S SF(1)=2.E4;S SF(2)=8.E7
04.30 S SF(3)=1.E11;S SF(4)=1.E14;S SF(5)=1.E17
04.40 F J=0,5;S CH=6*CN-5+J;S C(J)=(FCHAN(CH)+FCHAN(CH,1))/(2*SF(J))
04.50 X CLER(0);F J=1,4;X SAV(J);X PUTN(8*J,0,512*(J-1),512,1)
04.70 S OOPS=0;R
04.80 S OOPS=1;R
04.90 S OOPS=2;R

05.20 T "IMPOSSIBLE!"
05.30 X CLER(0);F J=18,25;X SAV(J)
05.40 X OUT(6);X DIVD(0,0,1,3);X SAV(J)

06.10 X PULL(K);X POLY(40,0,5);S D=FITR(FPEAK(0,0,511)/4000+1)
06.15 X DIVD(0,0,1,D);X SAV(K);X PULL(6);X DIVD(K);S C(0)=133.07031
06.20 S C(1)=13.53109/D;S C(2)=.2003604/D↑2;S C(3)=-.1825613E-2/D↑3
06.25 S C(4)=.4438725E-5/D↑4;F J=0,4;X STOR(41,4*J;C(J))
06.30 X POLY(41,0,4);X SAV(K+17);X SAV(K+21)

07.10 S S1=0;S S2=1
 *
```

```
 X CALL(11)
*W
C:LICK FOCAL SCN72-Q  07F\

01.05 X CALL(1,1)
01.10 E
01.20 X STAT(-1);T !!"SUM RAW DATA"
01.22 D 7;A !!"NEW EXT. TBL.? (Y OR N)"T1;I (T1-0Y)2.1,1.26,2.1
01.26 X CALL(10,3)

02.10 I (T1)1.05;I (-LB)11.2
02.11 X CLER(0);F J=9,16;X SAV(J);X PUTN(8*J+7,121,0,8)
02.13 A !"DEC"D
02.15 S DC=(FITR(D)+<D-FITR(D)>/.6)*.0174533
02.40 X CALL(12,168)

04.10 X PULL(9);S SC=FPEAK(0,900,4095)/200+1
04.21 X SWIT(-1);F J=0,1;F K=9,12;D 10.5
04.22 A !"STORE AS SCAN NO."RS;I (RS)1.22,5.2
04.24 F J=0,1;X STOR(79+32*J,121;TT(J))
04.26 X NAME(0);X MPUT(72,64*RS,64);X MGET(0);G 1.22

05.20 T "SCAN 0 NOT ALLOWED";G 4.22

07.10 X SWIT(-1);X STAT(100,700,1);F Q=1,50;S A=A
07.20 T "PROGRAM TO SUM SCANS; SUBTRACT SKY;
07.30 T !"CORRECT FOR DEADTIME AND EXTINCTION."!;I (-LB)7.95
07.40 T !"ENTER DEC, H.A. IN FORMAT:  DEG.MIN, HR.MIN"
07.50 T !"ADD 100 TO SCAN # IF SCAN IS ON ANOTHER TAPE."
07.60 T !"ENTER -1 AS SCAN # TO PROCESS SCANS."
07.65 T !"... -2 TO BAIL OUT."
07.70 T !"ENTER DWELL TIME IN MINUTES."
07.75 T !"SLIT CODE:"
07.76 T !"L=LEFT"!"R=RIGHT"!"B=BOTH"!"S=SKY"
07.77 T !"Q=QUARTZ OR OTHER CALIB."
07.90 X STAT(-1);R
07.95 D 7.5;D 7.6;D 7.65;G 7.9

10.50 X PULL(K+4*J);X CRT(SC,0,0,0,20,(K-9)*256)

11.10 E
11.15 S LB=1;G 1.2
11.20 T !!"SCAN #S";S N=0
11.25 A !S(N);S N=N+1;I (S(N-1)+1)1.2,11.3,11.25
11.30 S N=N-2;I (N)1.05;X CALL(13,2)
11.35 G 4.1
*
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```
 X CALL(12)
*W
C:LICK FOCAL SCN72-Q  O#M\

01.01 X CALL(1,1)
01.40 X NAME(1);F J=Ø,1;S TT(J)=Ø
01.50 T !"SCAN #  SLIT  DWELL  H.A."!

Ø2.Ø5 S N=Ø
Ø2.1Ø A !,R(N);I (R(N))3.1;D 11.3;A S(N)
Ø2.15 D 11.3;A DT(N);I (S(N)-ØQ)2.2,2.3
Ø2.2Ø D 11.3;A H(N)
Ø2.3Ø I (99-R(N))3.4;S N=N+1;G 2.1

Ø3.1Ø I (-2-R(N))3.2;X CALL(11,14Ø)
Ø3.2Ø F J=Ø,N-1;D 4
Ø3.3Ø X END(Ø)
Ø3.4Ø D 3.2;S J=N;S R(J)=R(J)-1ØØ;D 3.5;D 4;G 2.Ø5
Ø3.5Ø A "CHANGE TAPE, THEN HIT RETURN"DY

Ø4.1Ø I (N)4.45,4.45
Ø4.2Ø S Q=H(J);S HA=(FITR(Q)+<Q-FITR(Q)>/.6)*.261799
Ø4.22 S SZ=1/(.6Ø6548*FSIN(DC)+.795Ø48*FCOS(DC)*FCOS(HA))
Ø4.24 S Z=SZ-.ØØ18167*(SZ-1)-.ØØ2875*<(SZ-1)↑2>
Ø4.26 S Z=Z-.ØØØ8Ø83*<(SZ-1)↑3>
Ø4.3Ø I (S(J)-ØL)4.32,4.5
Ø4.32 I (S(J)-ØR)4.34,4.6
Ø4.34 I (S(J)-ØB)4.36,4.7
Ø4.36 I (S(J)-ØS)4.38,4.8
Ø4.38 I (S(J)-ØQ)4.4,4.9
Ø4.4Ø T %2.Ø !"BAD CODE FOR SLIT TYPE, SCAN"R(J);A ".  TRY AGAIN"S(J)
Ø4.42 I (-S(J))4.3
Ø4.45 S J=N;R
Ø4.5Ø F K=Ø,3;D 1Ø;D 11.2
Ø4.54 F K=4,7;D 1Ø;D 11.1
Ø4.58 R
Ø4.6Ø F K=Ø,3;D 1Ø;D 11.1
Ø4.64 F K=4,7;D 1Ø;D 11.2
Ø4.68 R
Ø4.7Ø F K=Ø,7;D 1Ø;D 11.1
Ø4.78 R
Ø4.8Ø F K=Ø,7;D 1Ø;D 11.2
Ø4.88 R
Ø4.9Ø F K=Ø,7;D 1Ø.1;D 11.1

1Ø.1Ø X MGET(8*R(J)+K,Ø,7);X DTIM(DT(J)*6Ø,149)
1Ø.2Ø X PULL(K+18,1);X TINC(256*Z)

11.1Ø X IN(K+9);X SAV(K+9);S TT(K/4)=TT(K/4)+6Ø*DT(J)/4
11.2Ø X SAV(K+1);X PULL(K+9);X OUT(K+1);X SAV(K+9)
11.3Ø T "   "
*
```

```
 X CALL(13)
*W
C:LICK FOCAL SCN72-Q  O<LD

01.01 X CALL(1,1)

02.10 X NAME(0);F J=72,32,104;X MTAK(J,64*S(0),32,7)
02.15 S A1=FTAK(87,127);S A2=FTAK(87,128)/10;D 12
02.20 X CLER(0);F J=9,16;X SAV(J)
02.35 S DC=A1*.0174533;F J=0,1;S TT(J)=0
02.40 F J=0,N;D 3;X NAME(0)
02.45 I (N+50-J)1.01
02.50 X END(0)

03.10 I (S(J)-100)3.2;S S(J)=S(J)-100
03.15 A !"CHANGE TAPE, THEN HIT RETURN"DY
03.20 X MTAK(8,64*S(J),64,7);S DT=FTAK(15,122);X NAME(1)
03.25 S SL=FTAK(15,125);I (SL-25)3.3;S SL=FITR(SL/10)-1
03.30 I (SL-0Q)3.32,3.9
03.32 S A1=FTAK(15,123);S A2=FTAK(15,124);D 12;S HA=A1*.261799
03.34 S SZ=1/(.606548*FSIN(DC)+.795048*FCOS(DC)*FCOS(HA))
03.36 S Z=SZ-.0018167*(SZ-1)-.002875*(SZ-1)↑2;S Z=Z-.0008083*(SZ-1)↑3
03.40 I (SL-0B)3.46,3.7;I (SL-0L)3.46,3.5;I (SL-0R)3.46,3.6
03.42 I (SL-0S)3.46,3.8
03.46 T !"BAD LABEL, SCAN"%2,S(J)
03.48 S J=N+100;R
03.50 F K=0,3;D 10;D 11.2
03.54 F K=4,7;D 10;D 11.1
03.58 R
03.60 F K=0,3;D 10;D 11.1
03.64 F K=4,7;D 10;D 11.2
03.68 R
03.70 F K=0,7;D 10;D 11.1
03.78 R
03.80 F K=0,7;D 10;D 11.2
03.88 R
03.90 F K=0,7;D 10.1;D 11.1

10.10 X PULL(K+1);X DTIM(DT,149)
10.20 X PULL(K+18,1);X TINC(256*Z)

11.10 X IN(K+9);X SAV(K+9);S TT(K/4)=TT(K/4)+DT/4
11.20 X SAV(K+1);X PULL(K+9);X OUT(K+1);X SAV(K+9)

12.05 S A1=A1-FITR(A1/2048)*4096;S A2=A2-FITR(A2/2048)*4096
12.10 I (-A1*A2)12.2;I (A2-A1)12.2;S A2=-A2
12.20 S A1=A1+A2/60
*
```

```
 X CALL(14)
*W
C:LICK FOCAL SCN72-Q  O>FØ

Ø1.Ø1 X CALL(1,1)
Ø1.1Ø E
Ø1.15 X STAT(-1)
Ø1.2Ø T !!"COMBINE SLITS";X NAME(Ø)
Ø1.25 X STAT(1ØØ,5ØØ,1);F J=1,5Ø;S J=J
Ø1.3Ø A !!"PROGRAM STAR SCAN #"P;I (P)1.Ø1;A " UNIT"U1
Ø1.5Ø A !"DIVIDE BY SCAN # (OR 'NONE', OR 'SAME')"S;I (S)1.3
Ø1.55 I (S-ØNONE)1.6,3.1;I (S-ØSAME)1.6,2.3
Ø1.6Ø A " UNIT"U2
Ø1.7Ø S S1=S

Ø2.2Ø X MTAK(72,64*S,64,U2);S K=9
Ø2.22 D 4.1;S NO=<FITR(N1/2ØØØØ)+1>*1Ø;I (4Ø95-N1)2.25;S NO=1
Ø2.25 F J=9,16;X PULL(J);X DIVD(Ø,Ø,1,NO);X SAV(J)
Ø2.3Ø D 5;F J=1,8;X PULL(J);X DIVD(J+8,Ø,4Ø95*R1(J/5));X SAV(J)
Ø2.4Ø T " DIVIDED BY SCAN "S1;G 3.15

Ø3.1Ø X MTAK(8,64*P,64,U1);D 1.15;T %2,!"SCAN "P
Ø3.15 S K=1;D 4.1;X SWIT(-1);S SC=N1/1ØØ+1
Ø3.2Ø F J=1,4;X PULL(J);X IN(J+4);X CRT(SC,Ø,Ø,Ø,2Ø,<J-1>*256);X SAV(J)
Ø3.25 X CLER(Ø);F J=Ø,3;X CRT(1Ø,Ø,Ø,Ø,1Ø,J*256)
Ø3.3Ø A !"SAVE AS SCAN"R;I (R)1.25;D 1.6
Ø3.4Ø X MPUT(8,32*R,32,U2)
Ø3.45 T "";G 1.25

Ø4.1Ø X PULL(K);S N1=FPEAK(Ø,K*1ØØ,4Ø95)

Ø5.1Ø D 3.1;F J=Ø,1;D 6
Ø5.15 S Z=R2(Ø);I (R1(1)-R1(Ø))5.2;S Z=R2(1)
Ø5.2Ø F J=Ø,1;D 7
Ø5.3Ø F J=Ø,2;S D=FTAK(79,126+J);X PUT(39,121+J,D)
Ø5.35 F J=Ø,2;S D=FTAK(87,121+J);X PUT(39,124+J,D)
Ø5.4Ø X STOR(15,121;Ø);X PUT(15,121,Z);X PUT(15,125,-1)

Ø6.1Ø S R1(J)=FASK(79+32*J,121)/(819Ø*NO*FASK(15+32*J,121))
Ø6.2Ø S R2(J)=.4342945*FLOG(R1(J));S R2(J)=FITR(R2(J))

Ø7.1Ø I (Z)7.2;S R1(J)=R1(J)/1Ø↑Z;R
Ø7.2Ø S R1(J)=R1(J)*1Ø↑(-Z)
 *
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```
 X FILE(15)

B=11751*W
C:LICK FOCAL SCN72-Q  0)F

01.01 X CALL(1,2)
01.05 E
01.10 X SWIT(-1);F J=0,20;X STAT(100,900,1);S ST=0
01.20 T !"SCRUNCH"!
01.30 A !"SCAN NO."O;I (O)1.01;A " UNIT"U
01.45 A !"LAMBDA SCALE (ANG/CHAN)"Z2;S Z2=100*Z2;S Z1=Z2/2
01.47 A !"NEW LAMBDA TABLE? <Y/N>"LC;X STAT(-1);I (LC-25)1.9
01.48 A "SLIT? <L,R,B>"SL;I (0B-SL)1.5;T "= BOTH";X CALL(10,2)
01.49 G 1.9
01.50 I (0L-SL)1.6;T "= LEFT";S S1=1;S S2=1;X CALL(10,266)
01.55 G 1.9
01.60 T "= RIGHT";S S1=0;S S2=0;X CALL(10,266)
01.90 I (BP-0Y)11.1,6.2,11.1

03.10 X PULL(1);S SC=FPEAK(0,100,2047)/200+1;D 3.15
03.15 X CLER(1);F J=0,3;D 3.2
03.20 X PULL(J+1);X CRT(SC,0,0,0,20,J*256);X CRT(SC,0,0,1,10,J*256)

06.10 X STAT(-1);D 1.2;T !!"SCAN # (UNIT 7)"!"(-1 TO END)";S VV=0;S U=7
06.12 S BP=25
06.15 A !R(VV);I (R(VV))1.45;S VV=VV+1;G 6.15
06.20 S VV=-1
06.30 S VV=VV+1;S O=R(VV);I (-O)11.1,11.1;Q

11.10 X NAME(0);X SWIT(-1);X MTAK(8,32*O,32,U)
11.11 F J=1,4;X PULL(J);X SAV(J+4)
11.12 D 3.1;T %2.0 !!"SCAN "O
11.20 X CALL(16,132)

15.20 X EDIT(2046,100,W);X EDIT(2047,100,W1)
15.22 S D=FTAK(15,121);I (D-2048)15.23;S D=D-4096
15.23 X EDIT(2045,100,D);X SAV(4);D 3.15
15.25 T %7.02 !"LAMBDA OF 1ST CHAN. ="W1/100
15.27 I (BP-0Y)15.28,15.3
15.28 A !"SAVE AS SCAN"O;I (O)1.01;A " UNIT"U
15.30 X MPUT(8,32*O,32,U);X SWIT(-1);I (BP-0Y)15.4,6.3
15.40 X CALL(1,2)
*
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```
 X CALL(16)
*W
C:LICK FOCAL SCN72-Q  OIIV

Ø1.Ø1 X CALL(1,1)
Ø1.Ø4 T !"SCRUNCH TO ",%5.Ø3,Z2/1ØØ," ANG/CHAN"
Ø1.Ø8 X CLER(Ø);F J=1,4;X SAV(J)
Ø1.1Ø S L1=Ø;S N=Ø;S L2=63;S L=Ø
Ø1.2Ø X SAV(N/512+1);X PULL(17);F B=L1,L2;S LAMB(B-L1)=FCHAN(B)
Ø1.3Ø S M=LAMB(1)-LAMB(Ø);S W=LAMB(Ø)-M*.625;S W1=W
Ø1.4Ø X PULL(5,1);X PULL(1);S TØ=Ø;S T=LAMB(Ø)-M;S JØ=Ø
Ø1.5Ø S K=Ø;S P=1;F N=Ø,2Ø35;D 2
Ø1.9Ø X SWIT(-1);X CALL(15,15)

Ø2.1Ø S W=W+Z2;I (W-LAMB(K-L1))2.4,2.4;S T=LAMB(K-L1);S K=K+1
Ø2.2Ø I (K-L2)2.3,2.3;I (K-512)2.25;S N=2Ø48;R
Ø2.25 S L1=L2+1;S L2=L2+64;D 1.2
Ø2.3Ø S M=LAMB(K-L1)-T
Ø2.4Ø S J1=4*(K-<LAMB(K-L1)-W>/M)+1
Ø2.5Ø S T1=J1+(J1-JØ)/2;S IØ=FITR(TØ);S I1=FITR(T1)
Ø2.7Ø S Y=(1-TØ+IØ)*FCHAN(IØ-L,5Ø1)+(T1-I1)*FCHAN(I1-L,5Ø1)
Ø2.8Ø IF (I1-IØ-1)2.85,2.9;F I=IØ+1,I1-1;S Y=Y+FCHAN(I-L,5Ø1)
Ø2.83 G 2.9
Ø2.85 S Y=Y-FCHAN(IØ-L,5Ø1)
Ø2.9Ø X EDIT(N,1ØØ,Y/<T1-TØ>);S TØ=T1;S JØ=J1

1Ø.1Ø S R1=FASK(79,121);S R2=4Ø95*NO*FASK(47,121);I (R1*R2)1Ø.12,1Ø.7
1Ø.12 S R1=R1/R2
1Ø.15 S R2=FITR(.4342945*FLOG(R1));I (R2)1Ø.2;S R1=R1/1Ø↑R2;G 1Ø.3
1Ø.2Ø S R1=R1*1Ø↑(-R2)
1Ø.3Ø F J=1,4;X PULL(J);X DIVD(J+8,Ø,4Ø95*R1);X SAV(J)
1Ø.4Ø X STOR(47,121;Ø);X PUT(47,121,R2);D 1Ø.5;X END(Ø)
1Ø.5Ø F K=Ø,1;F J=Ø,2;S D=FTAK(79+8*K,126-5*K+J);X PUT(71,121+3*K+J,D)
1Ø.7Ø S R1=1;S R2=Ø;G 1Ø.3
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```
 X CALL(17)
*W
C:LICK FOCAL SCN72-Q  OLGP

01.01 X CALL(1,1)

06.10 X STAT(300,800,1);X NAME(0)
06.15 T "OPTIONS:"!!"C=CLEAR"!"A=ADD"
06.20 T !"M=MINUS"!"D=DIVIDE BY"!"F=FIXUP"!"S=SAVE"!"P=CRT PLOT"
06.25 T !"Q=QUIT"!"SD=SHIFT DATA"

07.01 X SWIT(-1);X STAT(-1);T !!"UTILITY PROGRAMS";D 6;D 7.9
07.10 X STAT(-1);A !"OPTION"O;I (O-0C)7.2,7.9
07.20 I (O-0A)7.3,7.7
07.30 I (O-0F)7.4,8.5
07.40 I (O-0S)7.42,7.8
07.42 I (O-0M)7.44,8.6
07.44 I (O-0D)7.46,8.7
07.46 I (O-0P)7.5,8.78
07.50 I (O-0Q)7.52,1.01
07.52 I (O-0SD)7.65,10.1
07.65 T "  ????";G 7.1
07.70 D 11;I (R)7.1;X CALL(22,7)
07.78 G 7.1
07.80 D 11;I (R)7.1;F J=1,4;X PULL(J);X SAV(J+4)
07.85 X MPUT(40,32*R,32,U)
07.88 G 7.1
07.90 X PUT(47,125);X CLER(0);F J=1,4;X SAV(J)
07.95 G 7.1

08.50 X CALL(18,2)
08.55 D 6;G 7.1
08.60 D 11;I (R)7.1;X MTAK(40,32*R,32,U)
08.65 F J=1,4;X PULL(J);X OUT(J+4);X SAV(J)
08.68 G 7.1
08.70 D 11;I (R)7.1;X MTAK(72,32*R,32,U);S N1=FPEAK(0,900,2044)
08.72 S NO=<FITR(N1/20000)+1>*10;I (4095-N1)8.74;S NO=1
08.74 F J=9,12;X PULL(J);X DIVD(0,0,1,NO);X SAV(J)
08.76 X PUT(47,125,-1);X CALL(16,10)
08.77 G 7.1
08.78 S R1=1;X SWIT(-1);X CALL(20,3,1)
08.80 X STAT(100,250,1);A "HIT RETURN TO CONTINUE"R;D 6;G 7.1

10.10 X CALL(22,2)
10.13 G 7.1

11.10 A "SCAN #"R;I (R)11.2;A " UNIT"U
11.20 R
*
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```
 X CALL(18)
*W
C:LICK FOCAL SCN72-Q  OJI<

01.01 X CALL(1,1)
01.40 X STAT(100,100);X SWIT(-1);F Z=1,50;S A=A
01.50 T "SWITCH 3,11 TO FIX SINGLE POINTS"!
01.60 T "        3,11 + 3,12 TO ZERO ALL POINTS TO RIGHT OR LEFT OF CURSB
01.65 T ", OR TO FIX UP A STRING OF POINTS <OPTION M>."!
01.70 T "        3,11 WITHOUT MOVING CURSOR TO END"

02.30 X CLER(1);F J=1,4;D 3
02.50 X STAT(-1);X SWIT(-1);X END(0)

03.05 S D=1025*512;S CP=256
03.10 X PULL(J);D 6;D 10;X CRT(SC,0,0,0,20,512);X CRT(SC,0,0,1,8,512)
03.20 D 5.1;S D=FSWIT(3,11,X1,Y1);S D1=FSWIT(3,12);S CP=FITR(D/2048)
03.23 I (-D1)3.5
03.25 I (D-D0)3.3,3.4
03.30 S X=FCHAN(CP+FSGN(50-CP));X EDIT(CP,0,X)
03.35 X SAV(J);G 3.1
03.40 R
03.50 X STAT(200,20,1);A "L, M, OR R?"LR;I (LR-0L)3.55,3.8
03.55 I (LR-0R)3.92,3.6,3.92
03.60 X ERAS(CP,0,H-CP+1)
03.70 G 3.35
03.80 X ERAS(0,0,CP)
03.90 G 3.35
03.92 I (LR-0M)3.1,3.94,3.1
03.94 D 5.1;S D=FSWIT(3,11,X1,Y1);S X=FCHAN(CP-1)
03.95 I (CP-FITR(D/2048))3.96;S CP=FITR(D/2048);S D=D0;S X=FCHAN(X1/2+1)
03.96 F K=CP,FITR(D/2048);X EDIT(K,0,X)
03.98 G 3.35

05.10 S X1=FITR(D/1024);S Y1=D-1024*X1;S D0=D

06.10 S H=511;I (J-3)6.2;I (FTOTL(500,0,9))6.2,6.15,6.2
06.15 S H=508
06.20 S SC=FPEAK(0,0,H)/300+1;I (SC-2048)6.3;S SC=2047
06.30 R

10.10 D 1.4;D 1.5;D 1.6;D 1.65;D 1.7
*
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```
 X CALL(19)
*W
C:LICK FOCAL SCN72-Q  O:OL

Ø1.Ø1 X CALL(1,1)
Ø1.1Ø X STAT(-1);T !"NOISE FILTER"!!
Ø1.15 A "SCAN"S;I (S)1.Ø1;A " UNIT"U
Ø1.2Ø F J=Ø,3;X MGET(4*S+J,Ø,U);X SAV(J+4)
Ø1.3Ø S NC=1Ø23;I (FTOTL(5ØØ,Ø,9))1.4,1.35,1.4
Ø1.35 S L1=FCHAN(511);S L2=FCHAN(51Ø);X ERAS(5Ø9,Ø,3);X SAV(7)
Ø1.37 S DL=6Ø;I (L2-L1-165ØØØ)1.38;S DL=125
Ø1.38 S NC=(L2-L1)/DL-1Ø25
Ø1.4Ø S R1=4;S OF=6ØØ;X SWIT(-1);X CALL(2Ø,394,1)

Ø2.Ø5 A !"G(AUSS) OR F(OURIER)?"GF;I (GF-ØF)2.Ø7,4.1
Ø2.Ø7 I (GF-ØG)6.1,2.1,6.1
Ø2.1Ø A "  WIDTH"W1;I (-W1)3.1;S W1=1;G 3.1
Ø2.15 S R2=2Ø48/(5ØØ*(SC-1))
Ø2.2Ø F J=4,7;X PULL(J);X DIVD(Ø,Ø,R2,1/R2+1);X SAV(J)
Ø2.25 X CLER(Ø);X SAV(8);X NAME(1);F J=4,7;D 5
Ø2.3Ø X PULL(4);S R2=2Ø48/(R2*FPEAK(Ø,4ØØ,1Ø25+NC-W));D 2.2
Ø2.35 X EDIT(511,Ø,L1);X EDIT(51Ø,Ø,L2);X SAV(7);X PULL(6)
Ø2.4Ø X ERAS(NC+1-W,6ØØ,2*W);S OF=1ØØ;X CALL(2Ø,394,1)
Ø2.5Ø X CALL(21,25)

Ø3.1Ø S W=5*W1;I (W-17Ø)3.2;S W=17Ø
Ø3.2Ø S XN=5.72/W1;X CLER(Ø);F S=1,W-1;D 3.8
Ø3.3Ø X EDIT(512-W,Ø,2934579*XN);X CLER(1);X FORM(Ø);X SAV(3);G 2.15
Ø3.8Ø S A=XN*2934579.2*FEXP(-2.772*<S/W1>↑2);D 3.9
Ø3.9Ø X EDIT(512-W-S,Ø,A);X EDIT(512-W+S,Ø,A)

Ø4.1Ø S W=1ØØ;X NAME(4);X CLER(1);X TRED(9Ø,2Ø1,8,323);X SAV(3,1);G 2.15

Ø5.1Ø X PULL(J+1);X PULL(J,1);X FORM(Ø);X PULL(3);X FILT(W)
Ø5.15 X SAV(3);X CLER(1);X FORM(Ø);X DIVD(Ø,1,1,4ØØ);X SAV(J,1)

Ø6.1Ø A !"TYPE EITHER 'G' OR 'F'"GF;I (GF-ØF)2.Ø7,4.1,2.Ø7
*
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```
 X CALL(2Ø)
*W
C:LICK FOCAL SCN72-Q  OYEØ

Ø1.Ø1 X CALL(1,2)
Ø1.1Ø X STAT(-1);T !!"PLOT"
Ø1.2Ø A !"SCAN"S;I (S)1.Ø1;A "UNIT"U;D 22
Ø1.3Ø A "SCALE"SC;I (-FSWIT(2,1))1.31;D 28;G 1.31
Ø1.31 I (-SC)1.32;D 24;T %6.Ø2,"="SC,"  "
Ø1.32 C
Ø1.35 A "OFFSET"OF
Ø1.36 I (-OF)1.37,1.37;D 26
Ø1.37 C
Ø1.4Ø A "CRT? (Y OR N)"CR;I (CR-ØY)1.6,1.5,1.6
Ø1.5Ø X CALL(21,4)
Ø1.51 G 1.2
Ø1.6Ø A !"POINTS PER CHAN"P,"DOTS? (Y OR N)"DT
Ø1.65 S DD=Ø;I (DT-ØY)1.67,1.66,1.67
Ø1.66 S DD=1
Ø1.67 C
Ø1.7Ø A "NEW PAGE?"PG;I (PG-ØY)1.8,1.71,1.8
Ø1.71 X CPEN(Ø,9);F J=1,2*FITR(P);X COMP(1Ø24);X COMP(76)
Ø1.8Ø C
Ø1.85 X CALL(21,7)
Ø1.87 G 1.2

Ø3.Ø5 S OF=4ØØ
Ø3.1Ø D 24;X CALL(21,4,1)
Ø3.2Ø X END(Ø)

Ø6.1Ø S OF=1ØØ;D 24;S P=1;X CALL(21,7,1)
Ø6.2Ø X END(Ø)
Ø6.5Ø D 1.3;D 1.35;D 1.36;D 1.6;D 1.7;X CALL(21,7,1)
Ø6.6Ø X END(Ø)

1Ø.1Ø D 1.1;A !" FIRST AND LAST SCAN #S"S1,S2,"TAPE UNIT"U;D 1.6;D 1.35
1Ø.15 S S=S1
1Ø.2Ø D 1.71;D 22;D 24;D 1.36;X CALL(21,7)
1Ø.3Ø S S=S+1;I (S2-S)1.Ø1,1Ø.2,1Ø.2

22.1Ø S R1=1;F J=Ø,3;X MGET(4*S+J,Ø,U);X SAV(J+1)

24.1Ø X PULL(R1);S SC=FPEAK(Ø,1ØØ*R1,2Ø44)/5ØØ

26.Ø5 S OF=OF*FITR(SC)
26.1Ø X PUTN(72,Ø,-OF-FITR(-OF/4Ø96),512);X PUTN(72,512,-OF/4Ø96,512)
26.2Ø F J=Ø,3;X PULL(J+R1);X OUT(9);X SAV(J+R1)
26.3Ø S OF=Ø

28.1Ø X NAME(2);T !"LOG SCALE (SW. 2,1)  "
28.2Ø F J=Ø,3;X PULL(J+R1);X LOGB(Ø);X SAV(J+R1)
*
```

```
 X CALL(21)
*W
C:LICK FOCAL SCN72-Q  M?E7

01.01 X CALL(1,2)

04.10 D 20;S SW=15;S PP=0;S DD=0
04.20 S SD=SD*2.5;X CRT(SD,1022,0,1,SW,OF,PP,DD)
04.30 X CLER(0);X CLER(1);S SW=5;D 4.2
04.40 X END(0)

07.10 X CPEN(0,9);X COMP(0,-1023);X COMP(0,50);X CPEN(1,9);X ZCOM(0)
07.15 I (P-1)7.5
07.20 F J=0,3;X PULL(J+R1);D 21;X CRT(SD,0,0,0,0,OF,P,DD)
07.25 S Y=FZCOM(0);X COMP(0,OF-Y);F J=1,2*FITR(P);X COMP(-1024)
07.30 X CPEN(0,9);X COMP(0,-OF)
07.40 X END(0)
07.50 D 20;S PP=1;S SW=0;D 4.2;X COMP(2);D 7.25;D 7.3;X END(0)

20.10 F J=0,2,2;D 20.3;D 20.4
20.20 X PULL(9,1);X PULL(11);R
20.30 X PULL(J+R1,1);X PULL(J+R1+1);D 21
20.40 X FORM(1);X FORM(2);X SAV(J+9,1)

21.10 S SD=SC;I (818-SC)21.2;I (SC-.99)21.3;R
21.20 S SD=SC/FITR(SC/800+1);F I=0,1;X DIVD(0,I,1,SC/800+1)
21.25 R
21.30 S SD=100*SC;F I=0,1;X DIVD(0,I,100,1)

25.10 A !"SAVE AS SCAN"S;I (S)25.2;A "UNIT"U
25.15 F J=0,3;X PULL(J+R1);X MSAV(4*S+J,0,U)
25.20 A !"CALCOMP? (Y OR N)"CC;I (CC-0Y)1.01,25.25,1.01
25.25 F J=0,3;X PULL(J+R1);X SAV(J+R1+4)
25.30 S R1=R1+4;X CALL(20,818,1)
25.35 G 25.20
*
```

```
 X CALL(22)
*W
C:LICK FOCAL SCN72-Q  O;EØ

Ø1.1Ø X CALL(1,1)

Ø2.1Ø X STAT(2ØØ,15Ø,1);X NAME(2);T "SHIFT BY X CHANNELS"
Ø2.2Ø T !"X>Ø FOR SHIFT TO LONGER WAVELENGTHS";X STAT(-1)
Ø2.25 F J=1,4;X PULL(J);X SAV(J+4)
Ø2.3Ø A "  ENTER X"X;S X1=FITR(X);S X2=X-X1;S X3=FITR(X1/512)
Ø2.4Ø S X1=X1-512*X3;I (FABS(X3)-4)2.5;S DR=-1;S X3=4;G 2.8
Ø2.5Ø X SHOV(5,2Ø48,X1,4)
Ø2.6Ø I (X2)2.7,2.8;S RØ=8;S DR=-1;S C1=Ø;S C2=511;D 1Ø;G 2.8
Ø2.7Ø S RØ=4;S DR=1;S C1=511;S C2=Ø;D 1Ø
Ø2.8Ø X CLER(Ø);F J=Ø,3;X SAV(J);X SAV(J+9)
Ø2.85 F J=Ø,3;X PULL(4.5-.5*FSGN(X)-X3+J);X SAV(J+12)
Ø2.9Ø F J=Ø,3;X PULL(J+12);X SAV(J+1)
Ø2.95 X NAME(Ø);X END(Ø)

Ø7.7Ø S T1=FTAK(47,121);S JB=FTAK(47,125);X MTAK(4Ø,32*R,32,U)
Ø7.72 S DV=1;I (JB-4Ø95)7.78;I (FTAK(47,125)-4Ø95)7.78
Ø7.74 S DV=2;S T2=FTAK(47,121);S D=T1-T2;X PULL(8,1)
Ø7.75 S Q=1Ø↑FABS(D)
Ø7.76 F J=3,6;S K=J+FSGN(D);X PULL(K);X DIVD(Ø,Ø,Q,1);X SAV(K)
Ø7.78 F J=1,4;X PULL(J);X IN(J+4);X DIVD(Ø,Ø,1,DV);X SAV(J)
Ø7.8Ø I (DV-2)7.9;S T1=(T1+T2+FABS(D))/2;X PUT(47,121,T1)
Ø7.82 I (FCHAN(5Ø8,1))7.9,7.84,7.9
Ø7.84 F J=51Ø,511;S K=FCHAN(J,1);X EDIT(J,Ø,K)
Ø7.86 X EDIT(5Ø9,Ø,T1-4Ø96*FITR(T1/2Ø48));X SAV(4)
Ø7.9Ø X END(Ø)

1Ø.1Ø S X4=FABS(X2);X PULL(RØ,1)
1Ø.2Ø F J=1,4;D 11
1Ø.3Ø D 11.1;X EDIT(C1);D 11.3

11.1Ø X MOVE(.5-DR*.5,51Ø,X2*1ØØØ);X PULL(RØ+DR*J,1)
11.2Ø S D=(1-X4)*FCHAN(C1)+X4*FCHAN(C2,1);X EDIT(C1,Ø,D)
11.3Ø X SAV(RØ+DR*J-DR)
*
```

```
 X CALL(23)
*W
C:LICK FOCAL SCN72-Q  NLEØ@@E9BAX CALL(1,1)

Ø1.Ø1 X CALL(1,1)

Ø2.1Ø E
Ø2.12 X NAME(Ø)
Ø2.15 X STAT(-1);A !!"LINE ZAPPER"!"STANDARD STAR ";D 12;I (S)1.Ø1
Ø2.2Ø X NAME(Ø)
Ø2.23 X SWIT(-1);X CLER(Ø);F J=12,15;X SAV(J);X PUTN(8*J,Ø,1ØØØ,512)
Ø2.25 S OF=1ØØ;S R1=2;X CALL(2Ø,394,1)
Ø2.3Ø X CLER(Ø);X SAV(1);X SAV(6);X STAT(5Ø,95Ø,1);T "MARK LINE"
Ø2.35 S XD=512;S YD=512;D 13;X SWIT(-1);S XC=2*XD
Ø2.37 I (5248ØØ-D)2.4,4.1
Ø2.4Ø S R=FITR(XC/512);S CH=XC-512*R;I (128-CH)2.45;S R=R-1;S CH=CH+512
Ø2.45 X PULL(R+2,1);X PULL(R+2);S S1=FPEAK(CH-128,1ØØ*(R+2),CH+128)
Ø2.55 X PULL(R+3);X CRT(S1/8ØØ+1,256,CH-128,1,15,1ØØ);X STAT(3ØØ,1ØØ,1)
Ø2.57 T "MARK 4 CONTINUUM LIMITS"
Ø2.6Ø S XD=512;S YD=512;F J=Ø,3;D 13;S C(J)=XD/4+512*R+CH-128
Ø2.65 X CALL(24,2)

Ø4.1Ø X STAT(-1);X SWIT(-1);T !"PROGRAM STAR ";D 12;I (S)1.Ø1
Ø4.2Ø F J=2,5;X PULL(J);X DIVD(J+1Ø,Ø,1ØØØ);X SAV(J)
Ø4.3Ø S R1=2;X CALL(2Ø,3)
Ø4.4Ø A !"SAVE AS SCAN"S;I (S)4.1;A "UNIT"U
Ø4.5Ø X MPUT(16,32*S,32,U)
Ø4.6Ø G 4.1

12.1Ø A "SCAN #"S;I (S)12.2;A " UNIT"U
12.15 X MTAK(16,32*S,32,U)
12.2Ø R

13.1Ø S D=FSWIT(3,11,XD,YD);S XD=FITR(D/1Ø24);S YD=D-1Ø24*XD
13.2Ø X STAT(XD-2,YD-5);T "*"
*
```

```
 X CALL(24)
*W
C:LICK FOCAL SCN72-Q  NFI&@@FUF2F J=C(2),C(3);D 5

01.01 X CALL(1,1)

03.10 S M=0;S XX=0;S SX=0;S XY=0;S X2Y=0
03.20 S X3=0;S X4=0;S SY=0
03.30 F J=0,2;F K=J+1,3;D 7
03.35 X PULL(2);X PULL(12,1)
03.40 F J=C(0),C(1);D 5
03.50 F J=C(2),C(3);D 5
03.60 S D=M*XX*X4+2*SX*XX*X3-M*X3↑2-X4*SX↑2-XX↑3
03.70 S A0=SY*XX*X4+SX*X3*X2Y+XX*XY*X3
03.73 S A0=A0-SY*X3↑2-XY*SX*X4-X2Y*XX↑2;S A0=A0/D
03.76 S A1=M*XY*X4+SY*X3*XX+X2Y*SX*XX
03.78 S A1=A1-M*X2Y*X3-SY*SX*X4-XY*XX↑2;S A1=A1/D
03.80 S A2=M*X2Y*XX+XY*SX*XX+SY*SX*X3
03.83 S A2=A2-M*XY*X3-X2Y*SX↑2-SY*XX↑2;S A2=A2/D
03.86 S M=C(1);S M=FCHAN(M,1201)
03.90 F J=C(1),C(2);D 6
03.95 S M=FCHAN(2200,1201);X SWIT(-1);X PULL(14,1)
03.96 X PULL(15);X FORM(1);X FORM(2);X SAV(10,1)
03.97 X PULL(12,1);X PULL(13);X FORM(1);X FORM(2);X PULL(10)
03.98 X CRT(5,1023,0,1,10,110);X CALL(23,2*128+25)

05.10 S NX=J-XC;S M=M+1;S SY=SY+FCHAN(J,200);S SX=SX+NX
05.20 S XY=XY+NX*FCHAN(J,200);S X2Y=X2Y+NX*NX*FCHAN(J,200)
05.30 S XX=XX+NX↑2;S X3=X3+NX↑3;S X4=X4+NX↑4

06.10 S NX=J-XC;S NI=A0+A1*NX+A2*NX↑2
06.30 S AB=NI/FCHAN(J,200);X EDIT(J,1201,AB*1000)

07.10 I (C(K)-C(J))7.2;R
07.20 S T=C(J);S C(J)=C(K);S C(K)=T
*
```

```
 X CALL(29)
*W
C:LICK FOCAL SCN72-Q  O(EØ

Ø1.Ø1 X CALL(1,1)

Ø2.Ø5 X PULL(5);F J=1,4;X EDIT(249+J,Ø,C(J))
Ø2.Ø6 E
Ø2.Ø7 S KC=FCHAN(511);F J=Ø,3;S T(J)=FCHAN(J+25Ø);S D(J+1)=T(J)
Ø2.Ø8 S T=T/1ØØØ;S T(1)=T(1)*5.E-7;S T(2)=T(2)*1.25*1.E-1Ø
Ø2.Ø9 S T(3)=T(3)*1.E-13;X EDIT(Ø,1,1);X EDIT(1,1,912)
Ø2.1Ø X EDIT(2,1,2Ø47ØØ);X EDIT(3,1,112);F J=Ø,2,KC-1;D 3
Ø2.15 S N=5;D 9
Ø2.2Ø X SWIT(-1);F J=Ø,2,KC+3;D 1Ø
Ø2.4Ø S IN=5;X CALL(9,6)

Ø3.1Ø S L=FCHAN(J)/1ØØ;S V=FCHAN(J+1)/1ØØ
Ø3.2Ø S RE=Ø;F K=Ø,3;S RE=RE+T(K)*(L↑K)
Ø3.3Ø X EDIT(J+4,1,L*1ØØ);X EDIT(J+5,1,(RE-V)*2ØØ+512)

Ø4.1Ø I (-R<J>)4.2;R
Ø4.2Ø I (FABS<M>-FABS<X(J+K*N1)>)4.3,4.3;R
Ø4.3Ø S M=X(J+N1*K);S B=J;S C=K

Ø5.1Ø I (J-B)5.2,5.3,5.2
Ø5.2Ø S D=X(J+N1*C);F K=Ø,N1;S X(J+N1*K)=X(J+N1*K)-X(B+N1*K)*D
Ø5.3Ø R

Ø6.1Ø I (1.E-6-FABS(X<J+N1*K>))6.2;R
Ø6.2Ø S B(K)=X(J+N1↑2)

Ø7.1Ø F P=Ø,2*N;S S(P)=XX↑P+S(P)
Ø7.2Ø S Y=Y/2;F R=Ø,N;S X(R+N1↑2)=Y*(XX↑R)+X(R+N1↑2)

Ø9.1Ø S N1=N+1;S I=-1;F J=Ø,N;F K=Ø,N1;S X(J+K*N1)=Ø
Ø9.12 F J=Ø,2*N;S S(J)=Ø
Ø9.15 F J=Ø,2,KC+3;S XX=FCHAN(J,1)/1.E4;S Y=FCHAN(J+1,1)-512;D 7
Ø9.16 F P=Ø,N;F Q=Ø,N;S X(P+Q*N1)=S(P+Q)
Ø9.17 F K=Ø,N;S R(K)=K+1
Ø9.2Ø S M=1.E-6;F J=Ø,N;F K=Ø,N;D 4
Ø9.3Ø S R(B)=Ø;F K=Ø,N1;S X(B+N1*K)=X(B+N1*K)/M
Ø9.35 F J=Ø,N;D 5
Ø9.4Ø S I=I+1;I (I-N)9.2;F J=Ø,N;F K=Ø,N;D 6
Ø9.5Ø R

1Ø.1Ø S U=FCHAN(J,1)/2ØØ;S V=FCHAN(J+1,1);X STAT(U,V,Ø);T "."
*
```

```
 X CALL(30)
*W
C:LICK FOCAL SCN72-Q  M?E0

01.01 C-AUG. 25/72 PUTN.EDIT,STAP,TOTL FIXED.
01.02 C-PROG 16-LIST AND EDIT REDUCED DATA LOG
01.03 X CALL(1,1)

02.10 A "TYPE FIRST, LAST SCANS TO LIST",U,V
02.20 X NAME(6);F J=U,V;D 3
02.30 X NAME(5);F J=U,V;D 4
02.35 T !
02.40 G

03.10 F M=1,4;X MTAK(J*4+M-1,32*J+8*M-1,1,7)

04.10 T !!"SCAN",%2,J;T !"NAME...";X DICO(J*4,126,6,1024,1,121)
04.20 X UNPK(6,1024);D 5
04.30 S M=FTAK(J*4,121);S M=M-FITR(M/2049)*4096;T !"SCALE ",M
04.40 T !"STND...";X DICO(J*4+3,121,6,1024);X UNPK(6,1024);D 5

05.10 F M=1,300;S U=U
05.20 X COTY(12,1024)
05.30 F M=1,30;S U=U

06.10 A !!"ALTER SCAN NO"J;X NAME(6);D 3.1;X NAME(5);T !"NAME...";D 7
06.20 X CODI(J*4,126,6,2000,1,121);A !"SCALE"M;X PUT(J*4,121,M)
06.30 T !"STND...";D 7;X CODI(J*4+3,121,6,2000)
06.40 X NAME(6);F M=1,4;X MPUT(J*4+M-1,32*J+8*M-1,1,7)
06.45 T !
06.50 G

07.10 F M=1,200;S B=B
07.20 X TYCO(20,2000)
07.30 F M=1,30;S B=B
07.40 X PACC(12,2000)

10.10 X STAT(-1);A !!"LIST OR EDIT?"LE;I (LE-0EDIT)2.1,6.1,2.1

31.90 X CALL(1,1)
31.98 W
31.99 X END(0)
*
```

```
 X CALL(31)
*W
C:LICK FOCAL SCN72-Q  0ZE0

01.02 C-PROG 17-EDIT LOG
01.03 X CALL(1,1)
01.05 X STAT(-1)
01.10 A "TYPE SCAN NO",K;X NAME(6);F M=1,8;X MTAK(8*M-1,64*K+8*M-1,1,7)
01.20 T !"HIT 'ALT MODE' KEY TO LEAVE VALUE UNCHANGED."
01.30 X NAME(5)

02.10 S J=FTAK(7,125);A !"SLIT"J;X PUT(7,125,J)
02.13 S J=FTAK(7,123);A !"HA HR"J;X PUT(7,123,J)
02.16 S J=FTAK(7,124);A "MIN"J;X PUT(7,124,J)
02.20 S J=FTAK(7,122);A !"DWELL"J;X PUT(7,122,J)
02.30 T !"NAME...";F M=1,130;S B=B
02.40 S J=FTYCO(20,2000)
02.50 F M=1,30;S B=B
02.60 I (J-2) 2.7;I (J-4)2.3,2.8,2.3
02.70 X PACC(12,2000);X CODI(7,126,6,2000,8,121)
02.80 S J=FTAK(23,121);A !"PST HR"J;X PUT(23,121,J)
02.85 S J=FTAK(23,122);A "MIN"J;X PUT(23,122,J)
02.90 S J=FTAK(15,124);A !"RA HR"J;X PUT(15,124,J)
02.93 S J=FTAK(15,125);A "MIN"J;X PUT(15,125,J)
02.96 S J=FTAK(15,126);A "SEC"J;X PUT(15,126,J)

03.10 S J=FTAK(15,127);A !"DEC DEG"J;X PUT(15,127,J)
03.15 S J=FTAK(15,128)/10;A "MIN"J;X PUT(15,128,J*10)
03.20 S J=FTAK(23,123);A !"GRAT"J;X PUT(23,123,J)
03.30 T !"COM...";F M=1,170;S B=B
03.40 S J=FTYCO(70,2000)
03.50 F M=1,30;S B=B
03.60 I (J-2) 3.7;I (J-4) 3.3,3.8,3.3
03.70 X PACC(64,2000);X CODI(39,121,32,2000,8,121)
03.80 A !!"ALL OK? (Y OR N)"J;I (J-0Y) 4.1,3.9,4.1
03.90 X NAME(6);F M=1,8;X MPUT(8*M-1,64*K+8*M-1,1,7)

04.10 T !;G

31.98 W
31.99 X END(0)
*
```

```
 X CALL(32)
*W
C:LICK FOCAL SCN72-Q  OLE;

01.01 C-PROG 19-LIST LOG (WITH PROG 20)
01.02 X CALL(1,1)

02.10 T "SCAN SLT  HA  DWELL    OBJECT     PST   RGHT ASC   DECLIN   "
 02.15 T "GRAT   COM",!
02.20 S B=10+9*N;S W=0;S L=0
02.30 X DICO(B,W,64,1024,1);X CODI(9,0,64,1024)
02.35 S D=FTAK(9,1);I (D-0) 2.4,5.1
02.39 S R=FTAK(9,0);T !%2,R,"   "
02.40 S M=FTAK(9,4);S J=M;I (J-27) 2.41;S J=FITR(J/10)-1
02.41 I (0B-J) 2.42;T "B";G 2.5
02.42 I (0L-J) 2.43;T "L";G 2.5
02.43 I (0N-J) 2.44;T "N";G 2.5
02.44 I (0Q-J) 2.45;T "Q";G 2.5
02.45 I (0R-J) 2.46;T "R";G 2.5
02.46 T "?"
02.50 S J=FTAK(9,2);T %2,J;S J=FTAK(9,3);T %2,J;T %4,D
02.60 I (27-M) 2.7;I (R-0) 2.7,2.7;S J=FTAK(9,32);I (J-0) 2.65,5.1
 02.65 F J=1,49;T " "
02.67 G 4.3
02.70 T "  ";X DICO(9,5,6,1024);X UNPK(6,1024);F K=1,300;S N=N
02.80 S J=FCOTY(12,1024)
02.85 F K=1,30;S N=N
02.90 F K=1,J;T " "

03.10 S J=FTAK(9,16);T %2,J;S J=FTAK(9,17);T %2,J;S J=FTAK(9,11);T %3,J
 03.20 S J=FTAK(9,12);T %2,J;S J=FTAK(9,13);T %2,J;S J=FTAK(9,14)
03.25 T " ";S J=J-FITR(J/2049)*4096;T %2,J
03.30 S J=FTAK(9,15)/10;T %3.1,J;S J=FTAK(9,18);T %6,J

04.10 S J=FTAK(9,32);I (J-0) 4.2,5.1
04.20 T "   "
04.30 T "YES"

05.10 S L=L+1;I (17-L) 9.1;S W=W+64;I (W-129) 2.3;S B=B+1;S W=W-129;G 22

09.10 X END(0)

31.98 W
31.99 X END(0)
*
```

```
 X CALL(33)
*W
C:LICK FOCAL SCN72-Q  OYNH

01.02 X CALL(1,1)

02.10 X NAME(6);S N=0;T !"USE ALL TAPE DRIVES",!,"DIAL 7, THEN TYPE"
02.15 T !,"NEG TAPE = END."!!"TAPE NO.  DATE (RET=SAME)"
02.20 A !J;X PUT(1,N,J);I (J-0) 2.9;T "         ";F K=1,180;S N=N
02.30 S M=FTYCO(20,2500+20*N)
02.40 F K=1,80;S N=N
02.50 I (M-1) 2.7,2.6;T !"BAD FIRST CHAR.REPEAT";G 2.2
02.60 X MOVV(2500+20*(N-1),2500+20*N,20)
02.70 F K=0,17;F M=1,8;D 8.1
02.80 X CODI(10+9*N,0,1152,1024,1);S N=N+1;I (N-20) 2.2
02.90 T !"PUT SYSTEM TAPE ON 8";S N=0
02.95 X CODI(2,0,400,2500,1);X NAME(5);X DICO(2,0,400,2500,1)

03.10 S J=FTAK(1,N);I (2048-J) 9.1;T !!!!!;F K=1,300;S N=N
03.15 X COTY(20,2500+20*N)
03.20 F K=1,30;S N=N
03.25 T "  TAPE",%2,J,!!;S C=0
03.30 X CALL(32,266,1)

04.10 T !!"COMMENTS";S B=10+9*N;S W=32;S L=0
04.20 S J=FTAK(B,W);I (J-0) 4.3,5.1
04.30 X DICO(B,W,32,1024,1);X UNPK(32,1024);T !%2,L,"-";F K=1,400;S N=N
04.40 X COTY(64,1024)
04.50 F K=1,50;S N=N

05.10 S L=L+1;I (17-L) 6.1;S W=W+64;I (W-129) 4.2;S B=B+1;S W=W-129
05.20 G 4.2

06.10 I (C-0) 9.1;S N=N+1;I (N-21) 3.1;G 9.1

08.10 X MTAK(9,64*K+8*M-1,1,7);X DICO(9,121,8,1024+64*K+8*(M-1))

09.10 T !;I (C-0) 9.2;Q
09.20 G

10.10 X STAT(-1);G 2.1
10.20 X NAME(6);D 2.7;X CODI(10,0,1152,1024,1);X NAME(5)
10.25 S N=0;X CALL(32,266,1)
10.30 S N=0;S C=-1;G 4.1
*
```

April 4, 1973
I-1

Things Which Should be in the SDRS Manual, But Aren't

1. Dwell time entries on the raw data tape log must be in seconds.

2. The REDUCED DATA LOG LIST/EDIT program now allows listing and editing of the wavelength range of the scan.

3. Dave Burstein has made substantial improvements to the LAMBDA CALIBRATION program:

   a. Sky and neon scans no longer need to be on the same data tape. Add 100 to the scan number to get the computer to pause and ask you to change tapes before reading in the scan.

   b. The COMPLETE BAIL-OUT routine (reached by entering - 1 for the neon scan number) now contains an "ABSORPTION OPTION" which allows the user to identify lines not picked up by the peak finding routine. You will be asked for a scan number, the scan will be read in and displayed, and then you should mark first the left, then the right sides of absorption or emission lines using the joystick. Set switch 3, 7 in the up position before marking emission lines, set it in the off position before marking absorption lines. The channel number of the first moment of the area under the line profile will be returned as the line position. When asked "LA=;." enter in wavelength in angstroms, or enter in -1 if particular peak not wanted and program will continue. To exit this routine, mark the same position ~~device~~. twice.

   c. The automatic line identification routine doesn't have very many lines below λ3500 Å. The complete bail out routine should probably be used for scans extending below that wavelength.

4. There are several restrictions or limitations inherent in the SDRS system, partly because of the use of integer arithmetic and partly because of certain mental lapses on my part.

   a. The extinction routine fails at large air masses in the ultra-violet. It never works for an optical depth $\gtrsim 4.4$. Overflows of this type will appear as sudden, very obvious discontinuities in the output.

   b. The deadtime (paired pulse) correction should be of the form: r = r *exp(RT) where r = apparent counting rate, R = correct counting rate, and T = deadtime per count. I'm using R = r/(1-rT) with T = 51 nanoseconds. This gives a 1% error at $AB_\nu \sim 8$.

   c. The final output is claimed to be accurate to only 1%, even if the input data should be better than that. Also, note that everything is normalized to the highest channel in the spectrum, and that the result in any other channel is accurate to only .001 times the result in the highest channel. For example, if a planetary nebula spectrum has an emission line 100 x (continuum level), then the continuum will be accurate to only 10%. Sorry about that! The best way out is to reduce the data twice, removing strong lines the second time so that normalization will be to the continuum level.

5. Ken Nordsieck has a machine language SCRUNCH program near completion. It will have essentially the same I/O, but will run in seconds.

Jack Baldwin

CASSEGRAIN SCANNER COMPARISON LINES
(revised edition)

LINE	OLD** LINE I D	WAVELENGTH	SOURCE	LINE	OLD LINE I D	WAVELENGTH	SOURCE
:3520	none	3520.50	Ne	6334	6334	6334.40	Ne
?3607	none	3607.00	A+He	6383	6383	6383.15	Ne+A
3889	3889	3888.65	He	6402	6402	6402.25	Ne
3949	none	3948.98	A	6506	6506	6506.53	Ne
3965	none	3964.73	He	:6533	6533	6533.00	Ne
4026	none	4026.19	He	6599	6599	6599.00	Ne
4044	none	4044.70	A+A	6678	6678	6678.20	He+Ne
?4190	none	4190.00	A+A	6717	6717	6717.04	Ne
:4260	4259	4260.00	A+A	6871	6871	6871.29	A
*:4334	4334	4334.00	A+A	6929	6929	6929.50	Ne
:4388	none	4387.93	He	6965	6965	6965.43	A
4471	4471	4471.50	He	7032	7032	7032.00	Ne+Ne
4713	4713	4713.00	He+Ne	7065	7067	7065.15	He+A+Ne
4922	4922	4921.93	He	7245	7245	7245.17	Ne
5016	5016	5015.68	He	7281	7281	7281.30	He+A
:5048	5048	5047.74	He	7384	7384	7384.00	A
:5340	none	5340.00	Ne+Ne	7439	7439	7438.90	Ne
- - - - -	- - - -						
:5401	5401	5401.00	Ne	:7506	7504	7506.00	A+A
:5494	5494	5494.00	Ne	7635	7635	7635.11	A
:5764	5764	5764.42	Ne	7724	7724	7723.76	A
5852	5852	5852.50	Ne	7948	7948	7948.10	A+Ne
5876	5876	5876.10	He+Ne	8012	8015	8012.00	A+A
5945	5945	5944.83	Ne	:8111	8115	8111.00	A+A
				or			(if unresolved)
6030	6030	6030.00	Ne	8103	none	8103.70	
6074	6074	6074.34	Ne	+ 8115	none	8115.30	
6096	6096	6096.16	Ne	8264	8264	8264.50	A
6143	6143	6143.06	Ne	8300	8300	8300.32	Ne
6164	6164	6163.59	Ne	:8377	8376	8377.00	Ne+Ne
6217	6217	6217.20	Ne+Ne	8408	8408	8408.30	Ne+A
6266	6266	6266.50	Ne	8424	8423	8424.00	A+Ne
6305	6305	6304.80	Ne	:8495	8495	8495.36	Ne
				8521	8521	8521.44	A

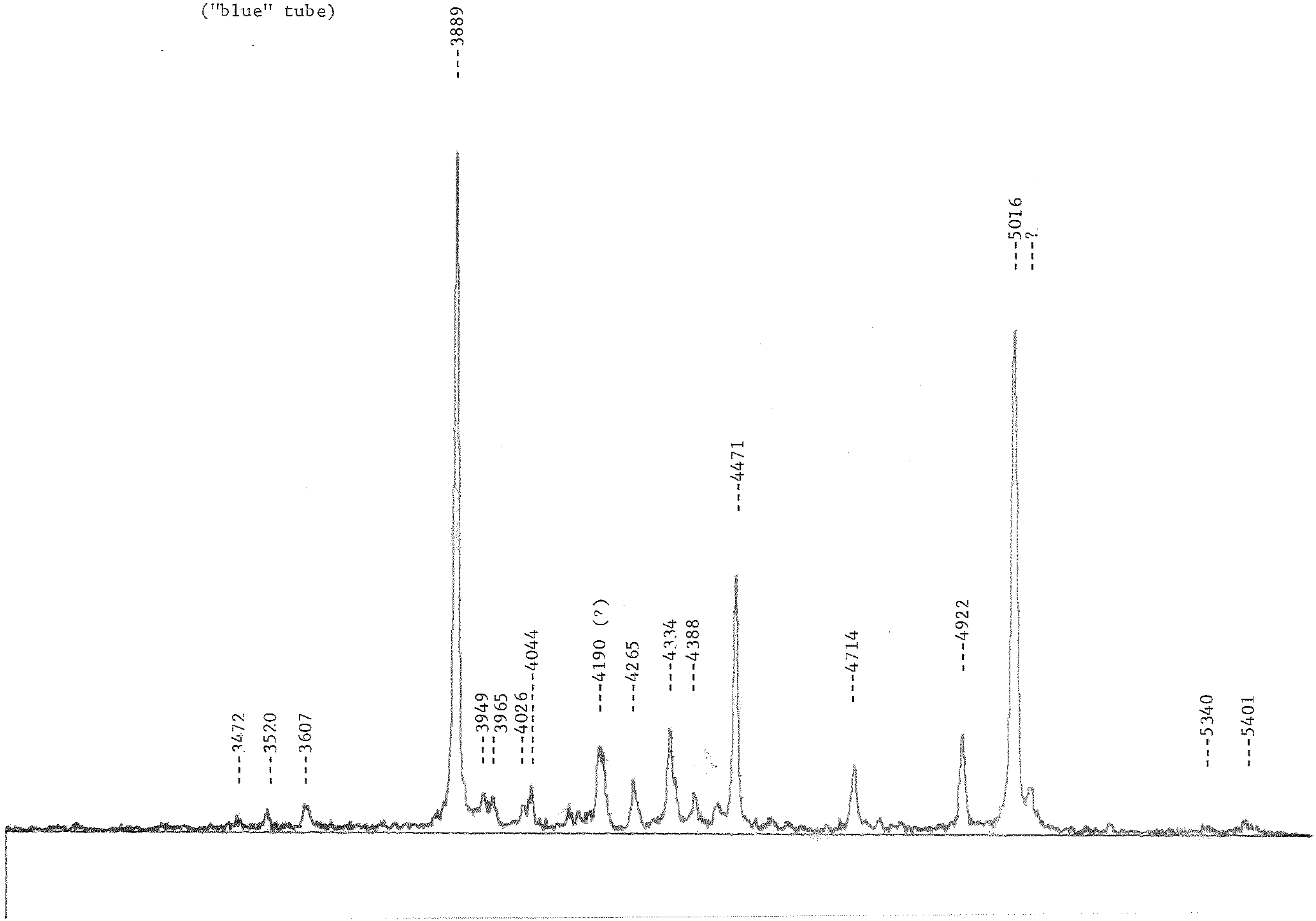
: - Weak line or bad blend; use only when necessary
* - Included in wavelength table
** - Line I D from previous list
? - I have no idea (± 10A) of wavelength
Lines above dotted line at 5401 can be found on blue scan, GS 2700

David Burstein

Neon-Argon Lamp Spectrum

("blue" tube)

GS = 2700



FURTHER CHANGES TO SDRS

In the UTILITY PROGRAMS:

(1) A new option, "PLUS C", will add any specified constant C to every channel in the buffer. C must be in the range $-8388607 < C < +8388607$.

(2) The new option is necessary because the SHIFT DATA option produces wild points when trying to shift negative numbers by a non-integral number of channels. The cure is to add a constant sufficient to make all channels positive, shift, then subtract the constant.

(3) To make data reduction in the nebular mode go slightly faster, the DIVIDE option has been modified to allow you to keep dividing by the same scan without re-reading it from the tape each time. In the DIVIDE option <u>only</u>, answering the question "SCAN:" by pressing the ALT MODE key will cause the contents of the buffer to be divided by the same scan used in the previous division. It is necessary to specify a scan number for the first use of DIVIDE, of course, and the information will probably be lost if some other program than the UTILITY PROGRAMS is used in the meantime.

Jack Baldwin
April 25, 1973

-- New Improved SCRUNCH --

The PDP-8 SDRS routines which put scanner data onto a linear wavelength scale (SCRUNCH and BATCH SCRUNCH) have been rewritten to put the most time-consuming part into machine language, with substantially the same input-output. It takes approximately one minute to set up the "Lambda Table" for a given wavelength calibration, and 5-10 seconds per scan to "scrunch" thereafter. As before, the Lambda Table is stored in a "safe" place on disk so that it need not be recalculated every time SCRUNCH is called for the same calibration. To replace old SCRUNCH on your tape you need to copy new versions of NAMES 3 and 4, and programs 10,15,and 16 from the updated SDRS tape. This does not affect the operation of any of the other SDRS programs. Further information and listings follow:

1. A word about "old" SCRUNCH - The old FOCAL version of SCRUNCH had several bugs in it which may be important for some purposes. If so, you may want to re-reduce the most sensitive data to see:

   a. The results were shifted by one unscrunched channel toward higher wavelengths. This is clearly the same error for all reductions with the same calibration, but it does produce a slight nonlinearity of approximately 0.75 Å.

   b. Reduction with fifth-order polynomial calibrations gave unpredictable errors of up to two channels.

2. Operation of new SCRUNCH - Sample teletype input-output is shown on p 3, with user responses underlined. The major departure from the old system occurs where the scans are displayed on the CRT: first the unscrunched scan is displayed in two halves on the screen, then the scrunched scan is displayed just above the old scan. The teletype responds "OK? - <Y/N>:" and if the user types "N" the result is discarded and reduction continues with another scan (if any). This halt was added to allow the user to check that the right scan was scrunched, for instance, and to keep from destroying original data by over-writing it with a bad reduction.

3. Accuracy - In wavelength, better than $\pm.02$ channels; in counting rate, about $\pm.02\Delta I$, where ΔI is the change in counting rate from one channel to the next. SCRUNCH has been tested on sample calibrations in the range 3200-9000 Å, fifth-order calibrations, on second order spectra (.625 Å/ch), and on scans containing negative numbers. If you find a bug, please let me know (during working hours).

Programmers' Notes

1. Detailed workings of SCRUNCH - A listing of the three relevant programs is shown on pp 4-6. Programs 10-2 and 16-2,3 are used only in the calculation and storage of a new "Lambda Table". Program 16-4,5 is used only in SCRUNCH or the first scan of BATCH SCRUNCH, to create a "bin" table from the table stored on disk.
   a. Program 10 retrieves the calibration coefficients C(J) from tape (where $100x\lambda(\text{Å}) = \sum_J C(J)x(100xCH\#)^J$) and stores it on disk, along with the coefficients of the derivative of the calibration polynomial.

   b. Program 16-2,3 creates a 2-record table giving the wavelength of the edge of every second channel in the scrunched data. This is then turned into a table of channel numbers by solving the calibration polynomial λ = poly(ch) for channel (using Taylor's method - subroutine 16-3). This channel number table then gives the position in the unscrunched data (times 100 to maintain an accuracy of .01 channels) of the edge of every other channel of the scrunched data. Shifting this table left one position and subtracting then gives the "bin table" - the number of unscrunched channels that are to go into successive pairs of scrunched channels. This is stored on disk record 17 in single precision.

   c. Program 16-4,5 gets the bin table in record 17, "fills it out" to give the bin size of every scrunched channel, and stores it in records 9-12. To accomplish the filling out (subroutine 16-5) we use the overlay PAIR, which merely takes successive high and low order words from the buffer and pairs them (high,low,high,low...) in the other buffer.

   d. Program 15. 15-11 gets the scan, displays it, puts it into paired format on the disk, scrunches it (overlay SCRN) into the bin table, and displays the result. Notice that it is necessary to divide the scrunched data through by the bin sizes at the end: this is because SCRUNCH is always used on ratios of counting rates, and so one wishes merely to correct the abscissa of each channel without changing the ordinate. If one wanted to scrunch a scan of absolute fluxes, this division would not be performed. Program 15-15 stores the wavelength of the beginning and end of the scan and saves the scan on tape.

2. The overlays X PAIR, X SCRN - Brief descriptions of these new overlays in NAME(4) are given on p 7. The "paired" format for double precision (like that used in FORTRAN) is much more efficient for routines like SCRN which call one double precision word at a time from disk because it is not necessary to read the single precision words from two different blocks. SCRN will be useful in any situation where data is to be put on a different non-linear abscissa scale (like log λ); the detailed write-up of the present SCRUNCH can be used as a model. See Lloyd Robinson for listings of PAIR and SCRN and a flowchart for SCRN.

K. Nordsieck

SAMPLE TELETYPE OUTPUT

```
SCRUNCH

SCAN NO.:21  UNIT:7
NEW LAMBDA TABLE? <Y/N>:Y

LAMBDA SCALE (ANG/CHAN):1.25                    / Set up new Lambda Table
SLIT? <L,R,B>:B
CALIB. NO.:7
LAM(Ø) = 4867.33Ø  ANG/CH =     1.25Ø

SCAN 21  OK? <Y/N>:Y                            / CRT display of scrunched
SAVE AS SCAN:29  UNIT:7                           and unscrunched scans.

SCRUNCH

SCAN NO.:22  UNIT:7
NEW LAMBDA TABLE? <Y/N>:N                       / Use old Lambda Table
LAM(Ø) = 4867.33Ø  ANG/CH =     1.25Ø

SCAN 22  OK? <Y/N>:Y
SAVE AS SCAN:3Ø  UNIT:7



SCRUNCH                                         / BATCH SCRUNCH


SCAN # (UNIT 7)
(-1 TO END)
:12
:14
:15
:-1
NEW LAMBDA TABLE? <Y/N>:Y

LAMBDA SCALE (ANG/CHAN):1.25
SLIT? <L,R,B>:B
CALIB. NO.:5
LAM(Ø) = 4763.8Ø7  ANG/CH =     1.25Ø

SCAN 12  OK? <Y/N>:Y                            / CRT display for each scan
                                                        .
SCAN 14  OK? <Y/N>:Y                                    .
                                                        .
SCAN 15  OK? <Y/N>:Y                                    .
```

```
X FILE(1Ø)

B=11766*W
C:LICK FOCAL SCN73-C  06G*

Ø1.Ø1 X CALL(1,1)

Ø2.Ø5 D 7
Ø2.1Ø D 4;I (-OO)2.9;F J=Ø,5;S C(J)=-C(J)/1ØØ↑J
Ø2.2Ø X STOR(143,121;5Ø*C(1)-C(Ø));X STOR(143,125;Z2*2)
Ø2.4Ø S S=-C(5);F J=1,4;S S=S*2Ø48ØØ-C(5-J)
Ø2.5Ø X STOR(42,Ø;C(Ø)/S);X STOR(42,4;1/S)
Ø2.6Ø X NAME(3);F J=Ø,5;X STOR(4Ø,4*J;C(J));X STOR(41,4*J;-1Ø24*J*C(J))
Ø2.7Ø X END(Ø)
Ø2.9Ø D 5.2;X CALL(15,175)

Ø3.1Ø D 7;D 4;I (-OO)3.9
Ø3.15 X CLER(Ø);X SAV(6);X PUTN(48,512,2ØØØ,512)
Ø3.2Ø S C(Ø)=C(Ø)-2.5E5
Ø3.25 D 2.6;F K=1,4;D 6
Ø3.8Ø X END(Ø)
Ø3.9Ø I (1-OO)3.95;D 5.3;T !"EXTINC = Ø"
Ø3.91 X END(Ø)
Ø3.95 D 5.2;X CALL(11,15Ø)

Ø4.1Ø X STAT(-1);A !"CALIB. NO."CN;I (CN)4.9,4.8;I (85-CN)4.9
Ø4.2Ø X MGET(S1);X MGET(S2,1);S SF(Ø)=1Ø;S SF(1)=2.E4;S SF(2)=8.E7
Ø4.3Ø S SF(3)=1.E11;S SF(4)=1.E14;S SF(5)=1.E17
Ø4.4Ø F J=Ø,5;S CH=6*CN-5+J;S C(J)=(FCHAN(CH)+FCHAN(CH,1))/(2*SF(J))
Ø4.5Ø X CLER(Ø);F J=1,4;X SAV(J);X PUTN(8*J,Ø,512*(J-1),512,1)
Ø4.7Ø S OO=Ø;R
Ø4.8Ø S OO=1;R
Ø4.9Ø S OO=2;R

Ø5.2Ø T "IMPOSSIBLE!"
Ø5.3Ø X CLER(Ø);F J=18,25;X SAV(J)
Ø5.4Ø X OUT(6);X DIVD(Ø,Ø,1,3);X SAV(J)

Ø6.1Ø X PULL(K);X POLY(4Ø,Ø,5);S D=FITR(FPEAK(Ø,Ø,511)/4ØØØ+1)
Ø6.15 X DIVD(Ø,Ø,1,D);X SAV(K);X PULL(6);X DIVD(K);S C(Ø)=138.74829
Ø6.2Ø S C(1)=Ø;S C(2)=1.Ø5842/D↑2;S C(3)=-.Ø133932/D↑3
Ø6.25 S C(4)=.596811E-4/D↑4;F J=Ø,4;X STOR(41,4*J;C(J))
Ø6.3Ø X POLY(41,Ø,4);X SAV(K+17);X SAV(K+21)

Ø7.1Ø S S1=Ø;S S2=1
*
```

```
 X CALL(15)
*X FILE(15)

B=11753*
*J
C:LICK FOCAL SCN73-C  O+E;

01.01 X CALL(1,2)
01.05 E
01.20 X STAT(-1);T !!"SCRUNCH"!
01.30 A !"SCAN NO."O;I (O)1.01;A " UNIT"U
01.45 A !"NEW LAMBDA TABLE? <Y/N>"LC;I (LC-25)1.9
01.47 A !!"LAMBDA SCALE (ANG/CHAN)"Z2;S Z2=100*Z2
01.48 A !"SLIT? <L,R,B>"SL;I (0B-SL)1.5;X CALL(10,2)
01.49 G 1.8
01.50 I (0L-SL)1.6;S S1=1;S S2=1;G 1.7
01.60 S S1=0;S S2=0
01.70 X CALL(10,266)
01.80 X CALL(16,2,1)
01.90 X CALL(16,4,1)
01.95 X NAME(0);I (BP-0Y)11.1,6.2,11.1

03.10 S SC=FPEAK(0,100,2047)/200+1;X SWIT(-1);F K=0,0;D 3.15
03.15 F J=0,2,2;D 3.2;D 3.3
03.20 X CLER(1);X CRT(1,0,0,1,2,(J+K)*256)
03.30 X PULL(J+1,1);X PULL(J+2);X CRT(SC,1024,0,1,4,(J+K)*256)

06.10 D 1.2;T !!"SCAN # (UNIT 7)"!"(-1 TO END)";S VV=0;S U=7
06.12 S BP=25
06.15 A !R(VV);I (R(VV))1.45;S VV=VV+1;G 6.15
06.20 S VV=-1
06.30 S VV=VV+1;S O=R(VV);I (O)1.01

11.10 X MTAK(8,32*O,32,U);D 3.1;X NAME(4)
11.20 F J=0,3;X PULL(J+1);X PAIR(0);X SAV(J+5,1)
11.40 F J=9,12;X PULL(J);X SCRN(5,T(J-9));X DIVD(J,0,100);X SAV(J-8)

15.20 X EDIT(2046,100,W);X EDIT(2047,100,W1)
15.22 S D=FTAK(15,121);I (D-2048)15.23;S D=D-4096
15.23 X EDIT(2045,100,D);D 3.15;X NAME(0)
15.25 T %2.0 !!"SCAN"O;A "  OK? <Y/N>"OK;I (OK-0Y)15.4
15.27 I (BP-0Y)15.28,15.3
15.28 A !"SAVE AS SCAN"O;I (O)1.01;A " UNIT"U
15.30 X MPUT(8,32*O,32,U)
15.40 I (BP-0Y)15.5,6.3
15.50 X CALL(1,2)
*
```

```
*

 X FILE(16)

B=11772*W
C:LICK FOCAL SCN73-C  O:H.

01.01 X CALL(1,1)

02.10 F J=1,2;X PULL(J);X POLY(143,121,1);X SAV(J)
02.20 S NC=FITR(204800*S/Z2);I (NC-2037)2.4;S NC=2036
02.40 F J=1,2;X PULL(J);X POLY(42,0,1);X SAV(10);D 3
02.50 X NAME(2);X SHOV(3,1024,-1,17)
02.70 F J=0,1;X PULL(4-J,J);X OUT(2-J,J)
02.80 X FORM(0);X SAV(17,1);X PUT(143,120,NC)
02.90 X END(0)

03.10 F IT=1,3;D 3.3;D 3.4
03.20 X SAV(J);X SAV(J+2);R
03.30 X POLY(41,4,4);X SAV(11);X PULL(10);X POLY(40,0,5)
03.40 X IN(J);X DIVD(11,0,1024);X IN(10);X SAV(10)

04.10 X NAME(4);S W1=FASK(143,121);S Z2=FASK(143,125)/2
04.20 S NC=FTAK(143,120);S W=W1+Z2*NC
04.25 T %7.03 !"LAM(0) ="W1/100,"  ANG/CH ="Z2/100
04.30 X PULL(17);X FORM(0);X SAV(9,1);X SAV(11)
04.40 F J=9,2,11;D 5
04.50 X ERAS(NC,900,2048-NC);F J=1,3;S T(J)=FTOTL(0,900,512*J)
04.60 X END(0)

05.10 X PULL(J);X DIVD(0,0,1,2);X SAV(J+1);X PUTN(8*J+8,0,0,512)
05.20 X PULL(J,1);X OUT(J+1,1);X FORM(0);X PAIR(0)
05.30 X CLER(0);X FORM(0);X SAV(J,1);X SAV(J+1)

10.10 S R1=FASK(79,121);S R2=4095*NO*FASK(47,121);I (R1*R2)10.12,10.7
10.12 S R1=R1/R2
10.15 S R2=FITR(.4342945*FLOG(R1));I (R2)10.2;S R1=R1/10↑R2;G 10.3
10.20 S R1=R1*10↑(-R2)
10.30 F J=1,4;X PULL(J);X DIVD(J+8,0,4095*R1);X SAV(J)
10.40 X STOR(47,121;0);X PUT(47,121,R2);D 10.5;X END(0)
10.50 F K=0,1;F J=0,2;S D=FTAK(79+8*K,126-5*K+J);X PUT(71,121+3*K+J,D)
10.70 S R1=1;S R2=0;G 10.3
*
```

OVERLAYS X PAIR AND X SCRN

Overlay no. 4

```
/X PAIR(N,B)
/TAKES N LOW ORDER WORDS AND N HIGH ORDER WORDS FROM
/BUFFER B, STARTING WITH CHANNEL Ø, AND PAIRS THEM
/IN THE ORDER   HIGH(Ø),LOW(Ø),HIGH(1),LOW(1) .... .
/RESULT IS IN THE OTHER BUFFER, WITH BUFFER B
/UNAFFECTED. DEFAULT: IF N <Ø, =Ø, OR >512, SETS
/N = 512.
/
```

```
PAUSE/X SCRN(R,W,B)
/SCRUNCHES SCANNER DATA IN DISK RECORDS R,R+1... INTO A
/512 WORD TABLE OF BIN SIZES IN BUFFER B. DISK RECORDS
/MUST BE IN DOUBLE PRECISION PAIRED FORMAT: HIGH(Ø),
/LOW(Ø),HIGH(1),LOW(1),....,HIGH(511),LOW(511). W SPECIFIES
/THE POSITION IN THE UNSCRUNCHED DATA OF THE LEFT EDGE OF
/BIN Ø, TIMES 1ØØ: FOR INSTANCE THE MIDDLE OF CHANNEL 1
/HAS W=15Ø. THE BIN SIZE TABLE CONTAINS THE NUMBER OF UN-
/SCRUNCHED CHANNELS, TIMES 1ØØ, IN EACH SCRUNCHED CHANNEL
/(SINGLE PRECISION ONLY, AND >Ø OR =Ø).
/
```

STANDARD STAR SYSTEM

I. General Notes

There are two different flux calibration systems, reached by setting switch 1,1 and pressing the green "start" button.

The following SDRS programs may also be called from the usual settings of switch 1,1 and switch 1,4:

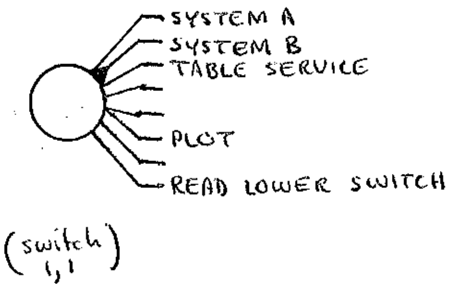
PLOT.

NOISE FILTER.

UTILITY PROGRAMS. (except DIVIDE)

BATCH PLOT.

REDUCED DATA LOG LIST/EDIT.



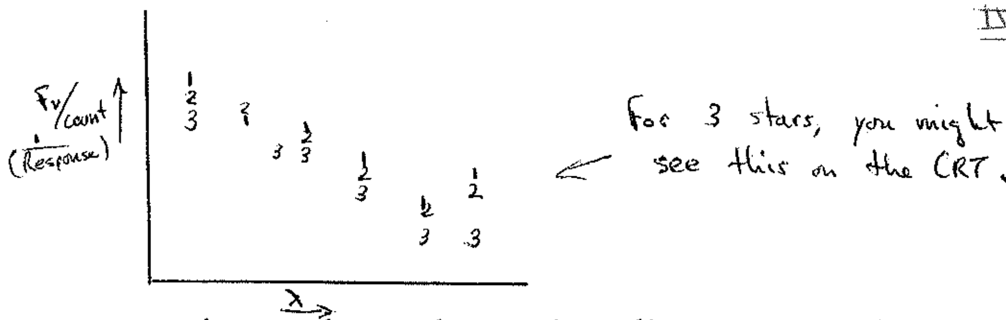
II. System A

For converting scans containing $\frac{\text{PROGRAM STAR}}{\text{STANDARD STAR}}$ to an absolute F_ν scale. Tables of the standard star F_ν values are stored on tape, already interpolated to contain 1 point per 1.25Å. This system is debugged and fully operational.

III. System B

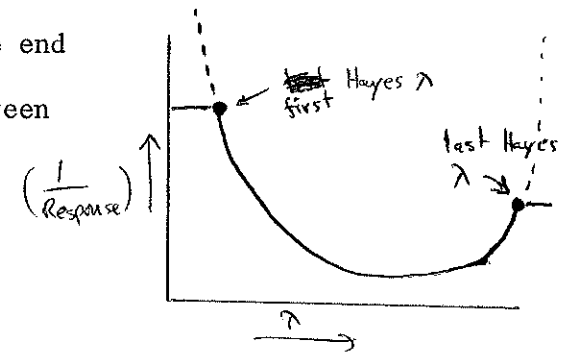
Also called the "Miller System." This is for reducing scans containing $\frac{\text{PROGRAM STAR}}{\text{QUARTZ}}$. Tables of the standard star calibrations are stored on the tape. These may be updated using the TABLE SERVICE program, or they may be temporarily altered while using SYSTEM B. The tables contain the following information for each Hayes wavelength for each standard star: F_ν, central λ (Å), bandpass (Å).

System B first asks you to generate a response curve (for converting counts $\rightarrow F_\nu$) using scans of $\frac{\text{STANDARD STAR}}{\text{QUARTZ}}$ for any number of standard stars. Just type in standard star scan numbers and identify the star names when asked. The curves will be displayed on the CRT; the points are plotted as numbers corresponding to which standard star they were derived from.



You will then have an opportunity to change the vertical display scale, delete bad points, delete whole curves, and grey shift the curves to get them to lie on top of each other. The curves are then averaged together.

If the tube response is zero at one end of the scan, the response curve will go to ∞ and do bad things to the scaling necessary in the integer arithmetic, so you are given the opportunity of chopping off one end or the other. Finally, a curve is interpolated between points, using quadratic interpolation. There is a choice of linear or quadratic interpolation for the λs outside of the Hayes wavelengths.



The final response curve may be stored on tape to be recalled later, or used directly.

The next stage of the program allows you to multiply $\frac{\text{PROGRAM STAR}}{\text{QUARTZ}}$ scans by the response curve.

System B is not thoroughly debugged. All known bugs are out, but the program has been used only 15 or 20 times, so be careful!

Jack Baldwin

Oct. 73
JAB

Loading Program for System A.

This program allows you to generate and store the smooth standard star spectra which are used by System A. A combination of cubic least-squares fitting and quadratic interpolation may be used. The basic options available in the program are to list the directory of standard stars already loaded on the tape, to delete existing standard star entries, to alter an existing entry, or to generate a new entry.

The routines for altering or generating entries are basically the same; you are first asked to enter a table of wavelengths and fluxes, then there are unlimited opportunities to interpolate between points in the table, to store the results on tape, and to quit. The program will first ask for a common exponent for the fluxes; the fluxes may then be entered in units of any convenient power of ten. All of the wavelength and flux points should be entered at this time. The points should be entered in order of increasing wavelength. A negative wavelength is used to terminate the entry sequence. If an error is made, there are two ways to correct it. If an error in the wavelength is noticed while the corresponding flux is being entered, enter a negative number for the flux and the point will be ignored. If, however, the error is not noticed until after you have moved on to the next point, don't panic. After the whole table has been entered, the next phase of the program allows you to correct entries. If a negative wavelength or flux is entered at this next stage, the point will be ignored in the fitting procedure. Enter a negative point number to terminate the correction routine. The flux entries will then be automatically scaled so that the largest entry will be in the range 10^5 - 10^6. If an existing standard star spectrum is being altered, it is necessary to enter the point having the highest flux in the whole spectrum, so that this automatic scaling will yield the same results as when the original data was entered.

The program is now ready to start interpolating between points, loading the results into a "buffer" stored on disk. If an existing standard star entry is being ~~offered~~ altered, the appropriate spectrum will have been read into this buffer. Otherwise, the buffer will be ~~empty~~ empty. The program will go in a loop with four options: cubic fit, quadratic interpolation, save the buffer on tape, and exit the whole program --- then back to cubic fit again.

If you elect to make a cubic fit, you will be asked for the range of data points to be used, the fit will be displayed, you will be asked if you wish to load the fit into the buffer, and, if so, over what range of wavelengths. When loading the fit, you will also be asked "MATCH LEFT?", "MATCH RIGHT" meaning should the fit be adjusted to match the existing values in the buffer at either or both of the boundaries of its wavelength range.

The quadratic interpolation routine will only work between points entered in the data table; no extrapolation is possible. Loading into the buffer is automatic. The "MATCH LEFT", "MATCH RIGHT" options are offered here also.

LOG SHEET

TAPE: ______

4096 SCAN #	2048 SCAN #	OBJECT	FROM TAPE	DATE OBSERVED	DIVIDED BY	λ(0)	SCRUNCH	LINE ZAP	FLUX CAL.	λ CAL. #	NOTES
0	0										
	1										SDRS PROGRAMS
1	2										AND TABLES
	3										
2	4										
	5										
3	6										
	7										
4	8										
	9										
5	10										
	11										
6	12										
	13										
7	14										
	15										
8	16										
	17										
9	18										
	19										
10	20										
	21										
11	22										
	23										
12	24										
	25										
13	26										
	27										
14	28										
	29										
15	30										
	31										
16	32										
	33										
17	34										
	35										

REVISIONS TO

SCANNER DATA REDUCTION SYSTEM

January 28, 1974

JACK BALDWIN

DAVID BURSTEIN

REVISIONS OF SDRS

1. LOG LIST REDUCED DATA: Format improved for faster listing
2. UTILITY PROGRAMS: SHIFT DATA routine will now compute the shift necessary to align two scans. Enter X=0 for the number of channels to be shifted. You will be asked for L2 = starting wavelength of scan to be added to the buffer after the shift, and for DL = wavelength scale (Angstroms/Channel). If X≠0 is entered, the program will work as before.
3. COMBINE CHANNELS: This program is now called DIVIDE/COMBINE CHANNELS. Data being reduced in the nebular mode can now be divided by the quartz lamp or standard star spectrum using this program, without adding the two slits together. This is accomplished by setting toggle switch (3, 4) in the "up" position at the time you are asked for the program star scan number. After the division, the data for each slit will be displayed separately and stored in separate 2048 channel scans. The provision to always divide by the same scan, formerly called for by typing "SAME" for the standard star scan number, is now reached by typing "ALT MODE" for the standard star scan number. The provision to not divide by anything, formerly called for by typing "NONE" for the standard star scan number, is now reached by typing "-1".
4. Increased precision: The DIVIDE/COMBINE CHANNELS program and the STANDARD STAR SYSTEM have been improved to reduce the importance of truncation errors. During the process of dividing by the standard star spectrum, some extra scaling is done so that the highest point in the normalized spectrum will have a value of at least 20,000 and typically 100,000. All other points in the spectrum will have been divided accurately to the nearest rounded integer value. It is possible

that there will occassionally be overflows in the division (the output will jump from a very large positive number to a very large negative number), in which case the scans should be divided using option D in the UTILITY PROGRAMS.

The STANDARD STAR SYSTEM will now multiply the response function or standard star spectrum by the SDRS output spectrum using triple precision integer arithmetic and then scale the data back down to double precision. The final answers will be normalized so that the highest peak will have a value between 10^5 and 10^6.

Jack Baldwin
January 23, 1974

NEW WAVELENGTH CALIBRATION SYSTEM

FOR SDRS

The Wavelength Calibration System has been rewritten to make it more flexible and, hopefully, more coherent. It utilized the same storage space on the SDRS tape as the old Wavelength Calibration System.

A step by step explanation of how to use the new system is given below. Some points however, should first be emphasized. In general, the Wavelength Calibration System matches wavelengths with the positions of the centers of emission lines (from scans of the comparison lamps) to delineate the pin cushion distortion effect of the image tube.

First, the line centers are found by finding the first moments of the line profiles. Wavelengths are matched to each usable line, and a least squares fit is done to the center 800 channels (channel numbers 600-1400), lambda (to nearest .01 Å) vs. channel number. The channel number of a line is the channel the center of that line falls in (to the nearest .01 of a channel). Residuals are calculated (in the sense calculated wavelength-real) for all lines in the operation. A plot of these residuals vs. channel number resemble a cubic curve and a third order least squares fit is put through them. The coefficients from the linear and the third order fit are then added together. If the data are accurate enough, a fifth order fit can be made to the residuals of the third order fit. (However, if the data are "ill-conditioned" - i.e., if they don't define a fifth order fit well enough - the fifth order fit will go berserk and <u>must</u> be rejected.)

This whole procedure is done for both the right slit (which is done first) and the left slit. A fifth order fit in the right slit must be followed by a fifth order fit in the left slit. The total output of the Wavelength Calibration System is either 4 coefficients (third order) or 6 coefficients (fifth order).

The centroids of the peaks can either be found by hand (individually picking out the line and marking the continuum), or the computer can do it. A wavelength table, which can be modified for individual needs (see below), is stored on the SDRS tape. Wavelengths can be matched to lines either by individually entering each wavelength at the appropriate time, or by identifying 3 lines with channel numbers 600-1400, one line with channel number less than 600 and one line with channel number greater than 1400.

The identification of these five lines allows the computer (in the later options) to roughly define the cubic calibration curve, and to identify all the other usable lines in the spectrum that are in its wavelength table. As long as the "(I)D OVER" option in (5d) is not used, once a wavelength is entered for a line, that wavelength is kept. Therefore, each time a wavelength is entered by hand, it should be the complete wavelength, to the nearest .01 Å. If the "(I) D OVER" option is used, only wavelengths entered in the manual peak finding operation will be retained.

The Wavelength Calibration System, as set up here, does not have a specific "Bail-out" routine. Instead, all lines for a given calibration are first found, and the channel numbers of these centers put in a table. Then, either automatically or by hand, wavelengths are assigned to these lines. The scans used for comparison can be made with the comparison lamps, sky, star, or whatever. Misidentified lines may be deleted, or the entire wavelength identification process may be repeated at a late stage in the calibration, without a major loss of time.

In order to have as accurate a calibration as possible, one should have comparison scans with reasonably "well-defined" lines. By reasonably "well-defined" it is meant that the line is strong enough that its centroid is not appreciably affected by counting statistics (ideally, there should be at least 800 cts/channel for the center 10 channels of the line), and that it is not a blend of two or more lines whose centroid changes with time or excitation voltage. The effect of the outgassing of helium in the Ne-He-Ar tube is a good example of the latter effect. The wavelengths given for the He-Ne or He-Ar blends in 1972 probably aren't correct in 1974.

It is hoped that a combination of individual lamps of He, Hg-Ar, and Ne will provide adequate coverage of the spectrum from the red to the blue. As a final caution, if the set of lines used for a given calibration does not have enough lines at either end of the 2048 channel spectrum, the cubic fit will not be well-determined. Accuracy,in both the wavelength determination of unknown object lines and equivalent width determinations of lines in certain parts of the spectrum, will be affected accordingly.

My thanks go to Jack Baldwin, who aided in the conception of several key programs, and whose ability to foul-up even the simplest of programs made debugging the system much easier. If anyone has trouble with any part of the Wavelength Calibration System, I can be reached at 429-2267 (office) or 426-0221 (home) between 9:00 AM - 8:00 PM.

DAVID BURSTEIN

LAMBDA TABLE MAKER - Or, how to make your own wavelength table with a little fuss and a lot of computer typing.

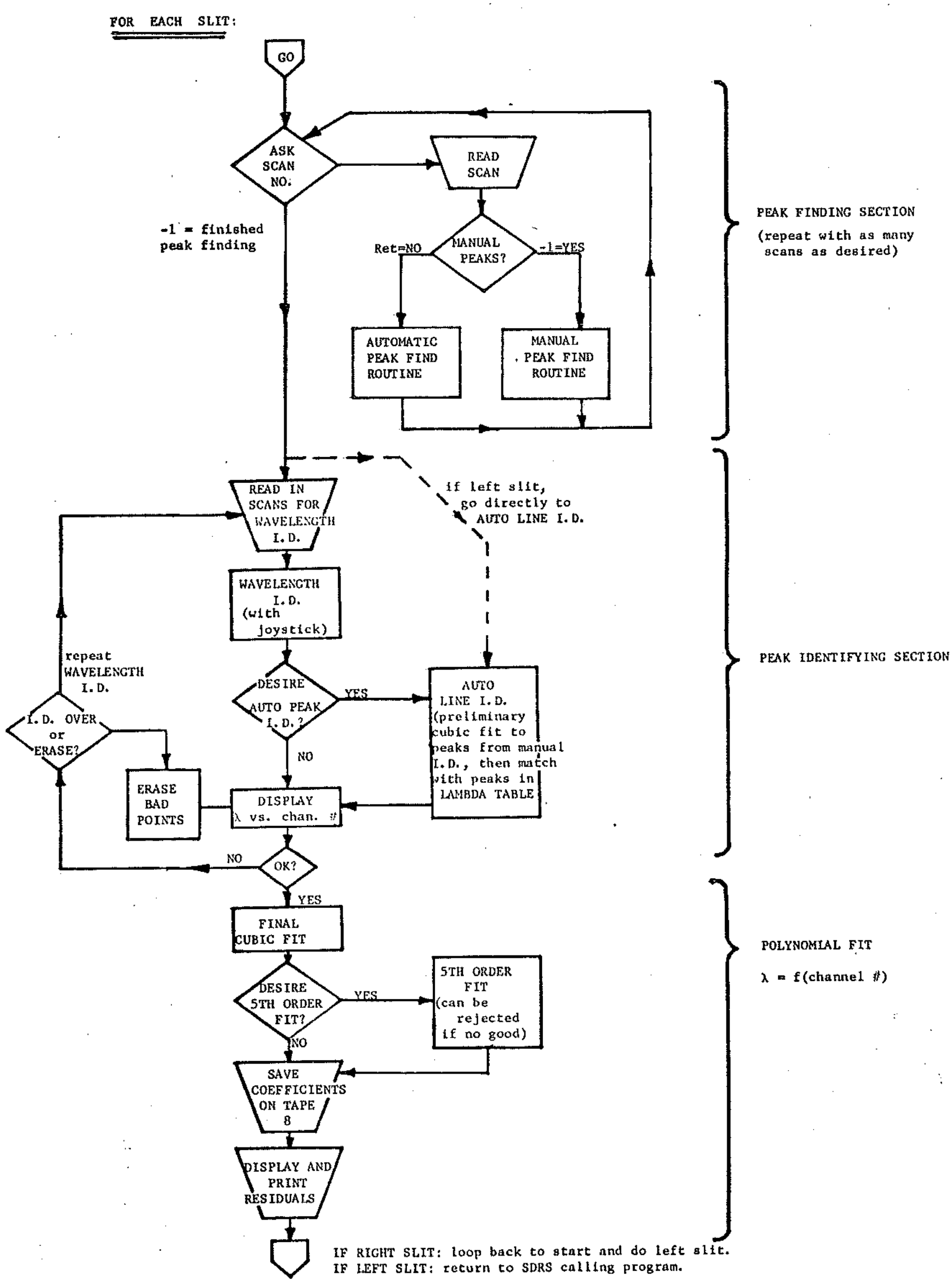
To revise the wavelength table on your own copy of the SDRS tape, for individual use, type X CALL (25, 2). Computer will type "LAMBDA TABLE MAKER", then "PRESENT TABLE", and it will print out the current wavelength table on the tape, in the form:

LINE NUMBER	WAVELENGTH
0	3888.65

for all lines in the table. When done, the computer types "ADD LINES E.G. 4358.30 (-1 = END):". When teletype asks "ADD LA:" type in new wavelength to nearest .01 Å. Up to 400 wavelengths can be stored in the table. Computer will continue to ask "ADD LA:" until -1 is entered. Then computer types "DELETE LINES - GIVE#(-1 TO END)". When asked "LINE#:" type in line number (0-400) of line to be deleted. This command will be repeated until -1 is entered. Computer will then reorder the new table and will print it out as "PRESENT TABLE". Then computer asks "OK?(Y/N):". If :N is typed, program goes back to beginning; if :Y is typed, "SAVE ON TAPE 8" is typed - save new wavelength table on SDRS tape. When table is saved, "DONE!" is typed and SDRS is restarted.

NOTE: Wavelength 19100.00 is not a mistake. It is necessary for the Wavelength Calibration System to work properly - never erase it. Make sure you only enter wavelengths that are routinely used, and that all wavelengths are correct. Wavelength 19100.00 should always be the last wavelength entered in the table.

FLOW CHART: NEW λ CALIBRATION PROGRAM



A STEP BY STEP EXPLANATION OF NEW WAVELENGTH CALIBRATION SYSTEM

TO ENTER: Type G; enter as in old system. Go to (1)

(1) INITIAL INPUT - Takes comparison scan numbers for finding comparison line centroids. Teletype types "WAVELENGTH CALIBRATION"

a) CRT asks "WAVELENGTH CALIBRATION"
"SCAN # (+100 IF SKY)"

Enter scan number, adding 100 to the number if the number of lines to be found is less than 10. Right slit is done first. When right slit calibration coefficients are stored on tape, left slit is done. When all lines needed for a particular slit are found, type -1 here to exit to (4) for <R> slit; exit to (7) for <L> slit. Note: Any number of scans can be used any number of times to obtain the required number of lines for the calibration.

(2) AUTOMATIC PEAK FINDING - Computer routine for identifying prominent lines in a spectrum (and sometimes also noise). When a line (or noise) is identified, the first moment center of the line is found and stored. Any line not found by this routine can be found by the MANUAL PKS routine (3).

a) CRT displays scan
CRT asks "TYPE -1 FOR MANUAL PKS:"
:-1: Go to MANUAL PKS subroutine (3)
: Hit RETURN: CRT displays scan again, does some thinking, then types out

"<R> SLIT SCAN # = " scan #
(or <L>)

"SCALE=" scale of CRT plot

CRT puts an arrow at the bottom of the center of each place where it thinks there is a line. Any noise or unusable lines should be erased in (2b).

b) At the end of peak finding,
CRT asks "ERASE POINTS? (Y/N)"
: N : Return to (1a)

:Y : Joystick marker (JM) displayed.
Place vertical part of JM over arrow pointing to line to be erased. Press SS 3, 11 to erase. Erase all extraneous lines and noise. Repeat as often as desired. Press 3, 11 without moving JM to exit to (1a).

(3) MANUAL PEAK FINDING - This routine finds line centroids individually using JM. CRT asks "MANUAL PKS - HIT RETURN TO START:"
:Hit return when ready

CRT displays spectrum at a scale of 2.

a) CRT writes "SC=" current scale; then
CRT asks "SC=:" type in new scale or -1 if scale is OK.

If -1 is typed, JM is displayed. CRT writes "MARK PK"

Mark the center of the line (either emission or absorption) to be found with vertical part of JM. Press 3, 11 to go on. (to end program, press 3, 11 without moving JM - return to (1a)).

b) Once peak is marked the line is displayed on an expanded scale.

CRT writes "MARK CONTINUUM - SET SS 3, 6 FOR ABSORPTION"

(If line is an emission line, <u>do</u> <u>not</u> set 3, 6; if line is in absorption set 3, 6 to up position.) Mark continuum of line with horizontal part of JM, making sure JM is <u>not</u> below (<u>above</u> for absorption line) line bottom (<u>top</u>). Press 3, 11. A first moment fit is done to the line, an arrow is placed at the approximate position of the line centroid.

Teletype writes "PK=" the channel number of the center of the line (to nearest .01 Å).

Teletype asks "LA=:" Enter complete wavelength of line to nearest .01 in Angstroms, or type -1 to reject the line. Program goes back to (3a).

<u>NOTE</u>: Once a line has a wavelength centered here, there is no need to reenter wavelength for that slit. For the <L> slit, identify here all lines not used in the <R> slit calibration. If, for any reason (such as SS 3, 6 set for an emission line!) centroid is not found, program return to (3a) without printing "PK=" etc.

(4) WAVELENGTH IDENTIFICATION - Wavelengths are matched to lines found in subroutines (1) - (3); either five lines can be identified to enable computer identification of the rest (via wavelength table); or all lines to be used can be identified; or any combination of these two main options. Although this program is initially only used in <R> slit calibration, it can be also reached by using the <I> option of (5d) for either the <R> or <L> slit. In section (4a), all scans to be used in the manual wavelength I.D. are read from tape to disk. Then, in (4b) and (4c), these scans are displayed on the CRT (one or two at a time) and lines are identified by hand.

a) CRT writes "WAVELENGTH ID"
"GIVE SCAN #S(-1 TO GO ON)"

CRT asks "SCAN#=:" Give scan number of the lines to be matched with wavelengths. (Up to 6 scans can be stored on disk). Type -1 to continue.

b) CRT writes "ID ALL NON-TABLE LINES"
"3 IN CENTER, 2 ON SIDES"

CRT asks "1ST SCAN#:" Enter scan number to be displayed
"2ND SCAN#(OR -1):" 2nd scan to be displayed. Type -1 if only first scan to be displayed.(CRT can display one or two scans at once).

NOTE: To assure a proper match-up of wavelength with peak by the automatic routine; at least 3 lines with channel numbers 600-1400, one with channel number less than 600, and one with channel number greater than 1400; must be identified with a wavelength (A channel number is the position of the line center). This is done to pin down the preliminary cubic fit curve. If the automatic identification routine is not to be used, identify all desired lines here. In addition, all lines not in your current wavelength table must be identified in this program.

c) JM is displayed; mark the line to be given a wavelength with vertical part of JM to identify line. When line center's channel number is found by the computer, an asterisk is put where the line is. (If no asterisk is put down, that particular line was not in disk storage, and is therefore unusable.)

Teletype writes " " (the channel number of line center)

Teletype asks "LA=:" Give the wavelength of the line to nearest .01 Å.

Repeat this process until you are done with scan(s). Then press 3, 11 twice in a row without moving JM to exit.

CRT asks "MORE?(Y/N):" Y Go to (4b)
N Go to (5)

(5) RESIDUALS FROM LINEAR FIT: A linear least squares fit is done to lines in the center 800 channels.

a) CRT asks (on the bottom of displayed scan)

"AUTO LINE I D ?(Y/N):"

: Y After fit is done to lines already identified, then routine (7) will match up as many lines as it can with wavelengths from wavelength table (WT). (For the <R> slit, WT is pulled from SDRS tape; for the <L> slit, WT is comprised of lines used in <R> slit calibration)

: N Only those lines previously identified will be used in linear and cubic fits.

b) The computer does a linear fit of LA (wavelength) vs. PK (line center) for all lines in channels 600-1400. CRT displays residuals from linear fit for all lines identified; residuals should appear as a cubic curve. If the points don't form a cubic, type N in (5c).

c) CRT asks "OK? <Y/N>:" Here one can "Bail Out" into (5d). This option appears each time linear fit is done.

: Y Go to (6)
: N CRT gives two options

d) CRT asks "<I> D OVER OR <E>RASE PTS?:"

: E:JM is displayed. Place the vertical part of the JM over the point of the curve to be erased. Repeat as often as desired. When done press 3, 11 twice without moving JM. Go to (5b)

: I:Go to (4) and start over. Only those wavelengths entered in manual peak finding program will still be retained.

(6) CUBIC FIT TO RESIDUALS FROM LINEAR FIT

a) If : Y is typed in (5a), residual points are displayed, no cubic curve is shown. Go to (7)

b) If : N is typed in (5a) and everything is OK, the residuals from the linear fit are displayed, the cubic curve is shown. Go to (8a)

(7) AUTOMATIC LINE IDENTIFICATION: All the line centers stored are ordered from lowest to highest. Then, for

a) <R> IGHT SLIT - The wavelength table on user's SDRS tape is used. As many peaks are matched with wavelengths as possible

b) <L>EFT SLIT - The wavelengths used in the right slit calibration form the wavelength table for the left slit.

When program is done, it returns to (5b).

(8) FIFTH ORDER FIT, STORAGE OF COEFFICIENTS

a) CRT asks "5TH ORDER FIT? <Y/N>:"
: N Go to (8b)
: Y Computer does fifth order fit to the residuals from the cubic fit; displays residual points, then the attempted fifth order curve. If the data is not sufficient, curve will go haywire and must be rejected below.

CRT asks "OK?<Y/N>:"

: Y Fifth order coefficients are retained. Go to (8b)

: N Fifth order coefficients are rejected. Only previously found third order coefficients are kept. Go to (8b).

NOTE: If fifth order fit is used in right slit, it must also be used in left slit to avoid disasters in the SUM RAW DATA program.

b) Teletype writes "SAVE ON TAPE"
"<R> CALIB#" next calibration number
(or <L>)
"COEFF ARE:" Coefficients are typed out. Four are typed if third order fit; six are typed if fifth order fit.

If the calibration number is greater than 84, the teletype writes "FULL!" and reinitializes the calibration number to 1. Caution - old calibrations will be written over. Go to (9).

(9) RESIDUAL PRINTOUT: When it is done storing the calibration coefficients,

a) Teletype asks "RESID? <Y/N>:"
: N If right slit was completed, go to (1) to do the left slit. If left slit was done, restarts SDRS.

: Y CRT displays residuals in numerical form in the sense of (calc-real)x 100 in Å. Teletype types out the total sigma.

b) Teletype asks "RESID? <Y/N>:" again
If :Y is given this time, Teletype will write what CRT displayed in (9a).

BATCH FLUX

Use Batch Flux for two or more scans with the same standard star, or same response curve, and the same $\lambda(\emptyset)$.

Mostly this bypasses having to shift the fluxing curves to $\lambda(\emptyset)$ for each scan. It does it once at the beginning, and then it is done.

Furthermore it relieves one of having to continuously give instructions for the next scan number, where to save it, etc. It is similar in operation to "Batch Scrunch".

A table is typed out as it fluxes, giving the scan number, and the "flux scale", ie, the power of 10.

Two CRT plots occur for each scan fluxed: an original plot, and a fluxed result. To further save time, one or both of these plots may be bypassed. It saves time of going to the plot program and back again.

SW 3,7 Bypass verification and store results on tape.

3,6 Bypass 1st plot: original

3,5 Bypass 2nd plot: fluxed scan.

3,4 Bypass table of System A standards.

1975 July 2
Alan T. Koski

SCAN:-1

BATCH FLUX

(1)

SYS. B FLUX CAL.

System B.

Find response curve as usual.

```
RESPONSE CURVE KNOWN?:N
ANG/CH:1.25
DIRECTORY?:N
SCAN:5  3443 5868
MODIFY FLUXES?:Y
ADD OR CHANGE (-1 TO END)
DIR# WAVE FLUX(FLT PT) BNDWDTH
:2 :3450 :1.952E-24 :10
:2 :5840 :1.504E-24 :52
:10 :3450 :1.611E-24 :10
:10 :5840 :2.338E-24 :52
:-1
DELETE (-1 TO END)
DIR# WAVE
:-1

  (-1 TO END)
    DATA(7)
CVE  SCN#    NAME          FIRST LAST DIR#  OK?
 1  :5   BD+33 2642   3443 5868  :2    :Y
 2  :7   40 4032      3443 5868  :10   :Y
 3  :-1
SCALE TIMES:1:
SCALE TIMES:10
SCALE TIMES:10
SCALE TIMES:5
SCALE TIMES:.2
SCALE TIMES:-1
DELETE PTS?:Y
-1 TO END
CVE PNT
:1 :1
:2 :1
:-1
SCALE TIMES:.1
SCALE TIMES:-1
DELETE PTS?:N
DELETE CURVES?:N
GREY SHIFT?:N
LIN OR PARAB EXTRAP <L/P>:L
SCALE TIMES:-1
FLATTEN LEFT?:Y
FLATTEN RIGHT?:N
SCALE TIMES:-1
RANGE
  POINTS 3500 5840
  DATA   3443 5868
  EXTRAP 3375 5935
SAVE RESPONSE CURVE?:Y
DRIVE 7 SCAN:1
LABEL(12)...RSCV S5/7

READY TO REDUCE DATA
SCAN:-1
```

← give -1, then dial up Batch flux; or give it a scan number to continue as in old manner.

```
BATCH FLUX,SAME STD,SAME L(0),SYS <A/B>:B
```

← tell it which system

```
SCAN #S
:1
```

```
OPTION:S SCAN #:0  UNIT:7
OPTION:C

OPTION:A SCAN #:1  UNIT:7 M,D:1 :1
OPTION:F
OPTION:S SCAN #:1  UNIT:7
OPTION:Q


PLOT

ZERO CALCOMP
UNIT:7
PTS/CH:1 DOTS?:N
SCAN:6 SCALE:-900 =  345 OFFSET:100 CALCOMP?:N
SCAN:-1
```

BATCH FLUX (2)

System B ...

```
BATCH FLUX,SAME STD,SAME L(0),SYS <A/B>:B
```
← tell it which system.

```
SCAN #S
:4
:8
:10
:12
:14
:16
:18
:-1
RESPONSE CURVE
```
← asks for Response curve.

```
SCAN:0
ID CK
LABEL  RSCV S4/6
RANGE    3441   5865
EXTRAP   3373   5933
ANG/CH 1.25
OK?:Y
READY TO REDUCE DATA
  4 SC=- 29 OK?:Y
  8 SC=- 30 OK?:Y
 10 SC=- 30 OK?:Y
 12 SC=- 31 OK?:Y
 14 SC=- 30
 16 SC=- 31
 18 SC=- 29
```

← have to verify result.

← or flip switch 3,7 up to bypass verification and store result (as in Batch scrunch).

```
UTILITY PROGRAMS
OPTION:A SCAN #:12  UNIT:7 M,D:0 :0

OPTION:Q


PLOT

ZERO CALCOMP
UNIT:7
PTS/CH:1 DOTS?:N
SCAN:12 SCALE:-900 = 9325 OFFSET:0 CALCOMP?:N
SCAN:16 SCALE:= 9325 OFFSET:CALCOMP?:
SCAN:18 SCALE:=  180 OFFSET:0 CALCOMP?:N
SCAN:SCALE:10 OFFSET:CALCOMP?:N
SCAN:-1

UTILITY PROGRAMS
```

BATCH FLUX (3)

System A.

```
BATCH FLUX,SAME STD,SAME L(0),SYS <A/B>:A   <- tell it which system
ANG/CH:1.25

SCAN #S
:10
:14
:18
:22
:-1
  1    BD+33 2642     <- prints out system A table. (SW 3,4 flat [not up])
  2    BD+28 4211
  3    BD+25 3941
  4    FEIGE 25
  5    FEIGE 15
  6    FEIGE 56
  7    HILTNER 102
  8    BD+40 4032
STD + # 1-8:1     <- ask for standard star number from table
 10 SC=- 30       <- bypass verification SW 3,7 up.
 14 SC=- 30
 18 SC=- 30
 22 SC=- 31

BATCH FLUX,SAME STD,SAME L(0),SYS <A/B>:A
ANG/CH:1.25

SCAN #S
 11
 15
 18    <- Dumb mistake.
 23
 -1    <- no table print out: SW 3,4 up. The table is up here
STD + # 1-8:1
 11 SC=- 30
 15 SC=- 30
 18 SC=- 54 OK?:N    <- SW 3,7 flat.
 23 SC=- 31

ATCH FLUX,SAME STD,SAME L(0),SYS <A/B>:A
NG/CH:1.25

CAN #S
18    <- repeat dumb mistake.
-1
TD + # 1-8:1
19 SC=- 54 OK?:N

ATCH FLUX,SAME STD,SAME L(0),SYS <A/B>:A
NG/CH:1.25

AN #S
9
1
D + # 1-8:1
9 SC=- 30

TCH FLUX,SAME STD,SAME L(0),SYS <A/B>:A
G/CH:1.25

AN #S
2
6
0
1
```