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**User's Guide for the
Revised SPEC-4 Neutron
Spectrum Unfolding Code**

J. O. Johnson
D. T. Ingersoll

MASTER

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DEPARTMENT OF ENERGY

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Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy: A05; Microfiche A01

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ORNL/TM-7384
Distribution Category UC-77
Gas Cooled Reactor Tech.

Contract No. W-7405-eng-26

Engineering Physics Division

USER'S GUIDE FOR THE REVISED SPEC-4 NEUTRON SPECTRUM UNFOLDING CODE

J. O. Johnson*

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Date Published - August 1980

NOTICE. This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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ABSTRACT

The SPEC-4 computer code was developed in the United Kingdom to solve the spectrum unfolding problem for spherical gas-filled proton-recoil neutron spectrometers. This report describes the ORNL version of SPEC-4 which has been applied to the analysis of data from the Tower Shielding Facility. Recent modifications are described which largely pertain to the graphical output routines. In addition, the input requirements are presented in considerable detail including suggestions and recommendations based on actual operating experience. Finally, auxiliary programs are discussed which can aid the SPEC-4 user.

I. INTRODUCTION

A. Background

The SPEC-4 computer code was developed by P. W. Benjamin, C. D. Kemshall, and A. Brickstock at the Atomic Weapons Research Establishment (AWRE), United Kingdom, to solve the spectrum unfolding problem for spherical gas-filled proton-recoil neutron spectrometers. The original report¹ and source program (consisting of the SPEC-4 master routine and subroutines SPEC2S, SNIDOW, and VSMTH) were combined with other related reports and packaged for distribution by the Radiation Shielding Information Center (RSIC)². Like all good codes, however, SPEC-4 was promptly modified for local use at ORNL - in this case, by R. M. Freestone. His motivation was to adapt the RSIC code to analyze gas proton-recoil measurements made at the Tower Shielding Facility (TSF), and to add special editing and graphical output routines. The purpose of this report is to provide formal documentation of the evolution of SPEC-4 at ORNL, and to detail input requirements. Also, helpful guidelines based on accumulated experience are presented which should aid the user in the selection of input parameters and interpretation of results.

B. Method of Solution

An effective method for measuring neutron spectra in a low-power fast reactor is the measurement of the energy distribution of recoiled protons in a gas-filled proportional counter. Combined with a detailed description of the detector response, the measured proton-recoil data can be numerically translated to yield the incident neutron energy distribution. The primary purpose of the SPEC-4 code is to determine detector responses by calculating proton-recoil energy distributions from monoenergetic neutrons, and then to unfold measured proton-recoil spectra to yield the corresponding continuous neutron energy spectra. This method has been in use for a number of years to measure neutron spectra in the energy range 1 keV to 3 Mev. The required input data includes the measured proton-recoil

spectrum, the relevant counter parameters, and an estimate of the neutron spectrum above the highest measured energy.

The basis for the analytic method used by SPEC-4 to calculate response functions is derived from the fact that monoenergetic incident neutrons produce recoiled protons with a rectangular-shaped energy distribution. The presence of the detector walls, and the geometric effects of charge collection cause the idealized rectangular distribution to be distorted; however, for spherical detectors, these distortions can be calculated almost exactly. Once the detector response has been calculated, the measured data can be unfolded using conventional differentiation techniques to yield an estimate of the incident neutron flux distribution. Because of the near-rectangular distribution of proton recoils, even neutrons with energies greater than the upper energy limit of the gas counter will induce some proton recoils within the counter and hence produce an undesirable signal. For this reason, SPEC-4 requires an estimate of the neutron flux above the upper limit of the counter in order to remove the corresponding "background" portion of the measured data. The basic steps executed by SPEC-4 are:

- (a) Calculate the proton-recoil distribution due to neutrons above the highest measured energy. The high-energy flux may be estimated, calculated, or measured (e.g., with an NE-213 spectrometer),
- (b) Calculate a matrix of proton-recoil response functions corresponding to neutron energies within the measurable limits of the detector,
- (c) Subtract the "background" data calculated in (a) from the measured data,
- (d) Unfold the net proton-recoil spectrum calculated in (c) using the response matrix calculated in (b).

Since both steps (a) and (b) must account for the response distortions due to the detector geometry, a reliable solution can be expected from SPEC-4 only for detectors having the same geometry, i.e., spherical.

C. Application to the TSF Experiments

The following discussion is a general description of the application of SPEC-4 to the TSF experiments. An internal correspondence written by R. M. Freestone (included as Appendix A) was used as a reference.

The data which SPEC-4 is designed to unfold are pulse height distributions obtained with spherical, gas-filled, proton recoil proportional counters, called Benjamin counters. At the present time, three counters are used at the TSF (SP-28, SP-26, and SP-25), each with a radius of 2.32 cm. The SP-28 counter is filled with pure hydrogen gas to a pressure of 10 atmospheres and is used to measure neutrons in an energy range from about 0.200 to 1.5 MeV. The SP-26 counter is filled with pure hydrogen gas to a pressure of 3 atmospheres and is used for neutrons in an energy range from 0.100 to 0.300 MeV. The SP-25 detector is filled with pure hydrogen gas to a pressure of one atmosphere and is used for neutrons between 40 keV and 0.200 MeV. It is possible to measure to lower energies, but electronic discrimination against gamma-rays must be employed.

Normally, a set of data from the TSF consists of a foreground and a background run for each of the three detectors. The data is acquired using a conventional 255-channel pulse-height analyzer, and then recorded in tabulated form and also punched on paper tape. The paper tape is submitted to the ORELA PDP-10 computer by TSF personnel to obtain a deck of punched data cards. These cards along with a "fact sheet" are delivered to the data analyst for subsequent unfolding. The "fact sheet" contains the normalization and calibration data needed as input for the SPEC-4 code. The analyst then has the responsibility of producing the unfolded spectrum in three formats: tabular listing, graphical plot, and punched cards.

D. Recent Modifications

For the present study, several relatively minor modifications were made to the existing ORNL version of SPEC-4. No changes were made to the

basic algorithms, rather only the output routines were revised. In terms of printed output, several edits which had been added at ORNL for diagnostic reasons were deleted. Also, the routine CILE2, which computed the final unfolded spectrum in a 51 energy-group structure frequently used at ORNL, was deleted since it gave unreliable results in the overlap region between detectors. The final output table giving the unfolded spectrum and error estimates was reformatted for convenience.

In terms of graphical output, the plotting routines which were added by R. M. Freestone were entirely replaced with updated routines. The new routines use the DISSPLA graphics software³ which provide greater flexibilities in plot construction. A second important feature of the DISSPLA software is that it allows for post-processing of the plot data, so that the SPEC-4 job becomes independent of plotting devices, and one of several DISSPOP routines⁴ are used to generate a plot on any graphics device.

It should be noted that several other modifications could have been made to SPEC-4, but insufficient time prohibited such improvements. Specifically, the input requirements could be greatly reduced by eliminating data such as the methane parameters since the methane detectors are no longer used at the TSF. Also, all fixed dimensions could be converted to flexible dimensions, and run-time allocation of memory storage space could be installed.

II. INPUT REQUIREMENTS

A. Card Descriptions

The input to the SPEC-4 program contains data used to specify the energy range values for protons in hydrogen, experimental and analytic correction factors which incorporate the physical characteristics of the hydrogen filled detectors, range-radius correction factors, and the measured pulse-height data from each experiment configuration. Original generalities in the input such as the methane energy-range data are still required, although they are not used for TSF applications.

Below is a list of the data input including card number, format, parameter name, and description.

Cards 1-31 (6F12.6)

E(J), RH(J) Hydrogen range/energy data. [See Data Note #1]

Cards 32-62 (6F12.6)

E(J), RC(J) Methane range/energy data. [See Data Note #1]

Card 63 (I2)

NSM Number of values in each of the next three arrays.
[See Data Note #2]

Cards 64-65 (10F7.0)

CFE(J) Experimental correction factors. [See Data Note #3]

Cards 66-67 (10F7.0)

CFS(J) Calculated correction factors. [See Data Note #3]

Cards 68-69 (10F7.0)

ROR(J) Range/radius correction factors corresponding to the
CFE's and CFS's. [See Data Note #3]

(Note: The preceeding input always remains fixed for TSF measurements.
The following data may change for each case.)

Card 70 (I10)

NSPE The number of points in the input neutron spectrum to follow. [See Data Note #4]

Cards 71-77 (6E12.5)

FU(J) Input spectrum values, in order of ascending energy in units of flux per unit lethargy. [See Data Note #4]

Cards 78-84 (6E12.5)

U(J) The energy midpoints in MeV corresponding to the FU(J)'s. [See Data Note #4]

Card 85 (15A4)

TPL0T1 First line of plot title. [See Data Note #5]

Card 86 (15A4)

TPL0T2 Second line of plot title. [See Data Note #5]

Card 87 (7F10.0)

CAL Analyzer energy calibration in MeV/Channel. [See Data Note #6]

BBIAS Analyzer back bias in "channels." [See Data Note #7]

EBOT Lowest energy to be analyzed. [See Data Note #8]

EMAX Maximum energy to be analyzed. [See Data Note #9]

CH Number of channels for each pulse-height spectrum. [See Data Note #10]

SMT Numerical smoothing option 1.0 - smoothing; 0.0-no smoothing. [See Data Note #11]

RTST Flag indicating that more runs follow.

RTST = 1.0 implies more to come

RTST = 0.0 implies this is last run

Card 88 (5F10.0)

RAD Counter radius in centimeters; for TSF experiments this number is always 2.32.

GPH Gas pressure of hydrogen in atmospheres at 15°C. [See Data Note #12]

GPC Gas pressure of Methane in atmospheres at 15°C. [See Data Note #12]

RES	Detector resolution in percent. Unfolded spectrum will be binned according to RES. [See Data Note #13]
RCF	Range correction factor. [See Data Note #14]
Card 89	(I2)
ITIMES	SPEC-4 offers the option of successively processing several sets of data using the information from Cards 90 and 91. ITIMES is the number of separate runs which is usually equal to 1.
Card 90	(20A4)
TLE	A title card describing the experiment configuration being analyzed. It can be obtained from TSF fact sheet.
Card 91	(4F12.5, I2, 3x, I2)
FTIME	The foreground data normalization factor. [See Data Note #15]
BTIME	The background data normalization factor. [See Data Note #15]
FGAIN	No longer used.
BGAIN	No longer used.
NOVFLO	Number of overflow cards that involve wrap-around data. [See Data Note #16]
NFLAG	A signal to indicate the existence or nonexistence of a background run. NFLAG=0 indicate background data; NFLAG > 0, sets all background to zero.
Cards 92-117	(A4,A2,6x,10F6.0)
FCTS	The foreground data. [See Data Note #17]
Cards 118-143	(A4,A2,6x,10F6.0)
BCTS	The background data. [See Data Note #17]

Cards 87-143 are entered three times with the data corresponding to each of the three counters SP-28 (10 atm), SP-26 (3 atm), and SP-25 (1 atm) in that order.

Cards 258-260 (20A4)

TITL Title printed and punched on final unfolded spectrum.
This title should be comprehensive, including all three detectors. If the user does not use all three lines for the title, blank cards must be substituted for the unused cards.

Card 261 Blank card

This concludes the input deck.

B. Data Notes

1. At present, 92 values of range-energy (R/E) data for protons in hydrogen RH(J), and protons in methane RC(J) are input. The energy E(J) is input in units of MeV, and RH(J) and RC(J) are the ranges of protons in centimeters at 1 atm pressure and 15°C. The values are input in order of increasing energy for both hydrogen and methane. These cards are always input.
2. The present value for NSM is 12 which is generally recommended. The benefits derived from increasing this value are not great enough to warrant the amount of work it would take to do so.
3. The CFE(J)'s, CFS(J)'s, and ROR(J)'s are correction factors SPEC-4 utilizes to calculate the wall effects on the proton-recoil distribution. The code uses an analytic expression, essentially exact, to calculate the wall effects. However, it was found that the analytic results did not agree with experiments using monoenergetic neutrons, and that the disagreement was found to depend, in part, on the ratio of the proton range to the radius of the gas counter. Therefore, a set of correction factors (the CFE's, CFS's, and ROR's) were obtained through a series of curves, and are used to correct the analytic results. A more detailed analysis of the correction factors along with their tabulated values are found in Section 7 of the SPEC-4 manual². These values are always input.

4. R. M. Freestone settled on a value of 15 as a convenient number for NSPE. This number is dependent upon the energy group structure of the input spectrum, which should range from about 0.9 MeV to 10 MeV. NEVER input values for this spectrum over 10 MeV, since this will cause the code to give bad results. With the group structure currently used for the NE-213 spectra, 37 points and the corresponding energy group midpoints are input to SPEC-4.

The energy midpoints are input in units of MeV, while the NE-213 spectrum (or equivalent) is input in units of flux per unit lethargy. This requires a supplementary calculation since the NE-213 spectrum is usually provided in units of flux per MeV. The conversion of the spectrum to flux per unit lethargy is performed utilizing the following equation

$$\phi(U) = \frac{\phi(E) (E_1 - E_0)}{\ln (E_1/E_0)}$$

where E_1 and E_0 are the energy boundaries corresponding to the energy midpoints at which the $\phi(E)$'s are tabulated. The high energy spectrum is input in order of ascending energy.

5. These two title cards will appear as the plot title produced at the end of the run. The titles should give adequate description of the plot and each line may be up to 60 characters long including the dollar (\$) sign which must appear as the final character in each line.
6. Each of the detectors, SP-28, SP-26, and SP-25 contains an alpha source deposited on its collector wire. The alphas deposit an equivalent proton energy which is dependent on the gas pressure. This energy deposition, divided by the channel number of the centroid of the observed alpha peak, determines the value of CAL. However, the channel containing the centroid of the alpha peak must be corrected for the zero channel. Therefore, the zero intercept value given on the TSF "fact sheet" should be subtracted from the channel containing the alpha peak. Below is a table of the proton energy due to an alpha source for the 10, 3, and 1 atm detectors.

Detector	Hydrogen Gas Pressure	Proton Energy
SP-28	10 atm	4.57 MeV
SP-26	3 atm	1.35 MeV
SP-25	1 atm	0.407 MeV

7. BBIAS is the compliment of the multichannel analyzer zero error (intercept). It is the quantity to be added to the indicated channel to give the true channel. For example, if the analyzer channel corresponding to zero energy is channel 2, then BBIAS=-2. Therefore, the negative of the zero intercept reported on the "fact sheet" should be input as BBIAS.
8. EBOT is the lowest energy (in MeV) to be analyzed. This parameter is one of the few parameters that can be legally juggled to accommodate the data. The value for EBOT can best be determined by visual examination of the raw data. A semilog plot of the raw data normally appears as a superposition of two lines: one line with a large negative gradient at low pulse-heights, and one line with a small negative gradient over the remaining pulse-heights. The low pulse-height contribution is from gamma-ray events, and EBOT should be chosen to exclude these channels. In the most recent work, an EBOT of 0.27 MeV, 0.17 MeV, and 0.05 MeV have been used for the SP-28, SP-26 and SP-25 detectors, respectively. However, these values should not be used without first visually examining the raw data.
9. EMAX is the parameter that determines the maximum energy to be unfolded. If left blank on the input card, EMAX is set internally to 1.4 MeV for the 10 atm SP-28 detector. For the subsequent counters (SP-26 and SP-25), the code uses EBOT and a fixed overlap of two resolution widths to determine EMAX values. If EMAX is entered explicitly, the input value will be used, which must be in units of MeV.

Care should be taken on how EBOT and EMAX are selected. First, they should not be too different from the counter ranges

mentioned in Section I.C. of this report. Secondly, if the automatic feature is used, EBOT for the SP-28 detector determines EMAX for the SP-26 detector, and EBOT for the SP-26 detector determines EMAX for the SP-25 detector. Therefore, the user must carefully select the values for EBOT. In any case, the resulting ranges should be compared against the raw data to assure exclusion of the gamma-ray and alpha peak contributions. Also, the overlaps in the unfolded spectrum should be visually inspected.

10. At present, a 255-channel pulse-height analyzer is used to record the data. Therefore, CH = 255.
11. If SMT = 1.0, smoothing of the raw data before processing is performed in the subroutine VSMTH using the "travelling average" method. Only if the raw data were especially good, and maximum resolution was desired, would no smoothing be considered. The penalty for smoothing is reduction in resolution, typically from 10% without smoothing to 15% with smoothing. Therefore, the value input for SMT will directly influence the value for RES (see Data Note 13). At present, there is an internal parameter, NBCH, which specifies a lower channel cut-off for smoothing. This avoids the unnecessary smoothing of the unwanted gamma-ray contribution. The value of NBCH is currently 25 which should be adequate for most cases. If unusually high or low gamma-ray fields are encountered, it may be desirable to change the value of NBCH.
12. GPH is the gas pressure for hydrogen, and depends on which detector is being considered. For the TSF experiments GPH is equal to 10 for SP-28; 3 for SP-26, and 1 for SP-25. It is input in units of atmospheres. GPC is always zero since none of the detectors used in the TSF experiments contain methane.
13. RES is the desired unfolding resolution. The counters have an inherent resolution of about 8%, but the data are seldom good enough statistically to take advantage of it. As stated in

Data Note #11, the value of SMT will determine the value for RES. If no smoothing is used, RES can be 10%. However, if smoothing is used, RES should equal 15% due to the penalty for smoothing. RES is input in units of percent.

14. The range correction factor (RCF) is used by SPEC-4 to help bring the code-calculated response function closer to reality. It is presently used only at higher values of ROR. When ROR exceeds 1.5, the ranges in the R-E tables for hydrogen and methane are multiplied by RCF, and these values are used to produce the modified response functions. RCF is detector dependent: the values are 1.10 for the 10 atm SP-28 detector, 1.03 for the 3 atm SP-26 detector, and 1.00 for the 1 atm SP-25 detector.
15. The foreground and background data normalization factors are the product of the measurement live-time and the reactor power. These numbers are reported on the "fact sheet." FTIME and BTIME should be input in units of s-kW. The normalization of the NE-213 spectrum (see Data Note 4) must also be in these units.
16. The parameter NOVFL0 is used to accommodate wrap-around data. The multichannel analyzer can only count up to 999,999 counts per channel, and, if the number of counts exceeds this value, it starts back at zero which causes erratic behavior of the data. However, wrap-around usually occurs only in the gamma-ray contamination, and therefore, it is of little importance. This data is usually not analyzed since it is cut off by EBOT. However, if the user wishes to fix the wrap-around data, an integer input equal to the number of cards of foreground counts in 10F7.0 format is placed here. There has not been any background wrap-around data to date and therefore there is no input to accommodate it.
17. The pulse-height data is input in the specified format if NOVFL0 is equal to zero. If NOVFL0 is not zero, NOVFL0 number of cards are read in A4,A2,4x,10F7.0 format. At present, there are 26 cards of raw data for each run (with 255 channels).

III. JCL REQUIREMENTS

Below is a list of the job control language (JCL) needed to run SPEC-4 utilizing a variety of post processors for graphical output.

```
// JOB CARD
//*CLASS CPU91=25S,I0=1.2,REGION=270K,CARDS=50
/*OPTIONS PAGE=62
// EXEC SPDASCR
//SYSIN DD *
    T.xxyyyyyy.anyname
//SPEC EXEC PGM=SPEC4,REGION=270K,
// PARM='SI=50,S0=51,SP=52,I0=-1,IU=-1,E0=-1,EU=-1,FD=-1'
//G0.STEPLIB DD DSN=X.DTI46103.PR0G,DISP=SHR
//G0.FT06F001 DD SYSOUT=A
//G0.C0MP0UT DD DISP=(NEW,CATLG),
// UNIT=SPDA, SPACE=(4000,(300,30),RLSE),
// DSN=T.xxyyyyyy.anyname
//G0.FT07F001 DD SYS0UT=B
//G0.FT05F001 DD *
    (Data)
    (Post-processor)
//
```

The data set names in the temporary data sets (T.xxyyyyyy.anyname) are described in the programmers guide. The letters xxx correspond to the user ID and yyyy correspond to the users charge number.

The user has several options in choosing a post-processor to produce the plot output from the SPEC-4 program. There are a few limitations, however, on the use of one of these post-processors. The three post-processors given below will likely satisfy most plotting needs.

The JCL for the Gould plotter is given below. The user cannot obtain a punched deck of the unfolded spectrum when using the Gould plotter since the plot data is transmitted as punched output. In the standard JCL for

the job, insert a "/*ROUTE PUNCH REMOTE7" after the "/*OPTIONS" card. Also, the "//GØ.FT07F001 DD SYSØUT=B" card must be changed to "//GØ.FT07F001 DD DUMMY." The post-processor JCL is as follows:

```
//GPLT EXEC GLDPLT,REGION=110K
//CØMPIN DD DSN=T.xxyyyyyy.anyname,DISP=SHR
//FT05F001 DD *
DRAW=1-END
/*
```

The CØMPIN data set must correspond to the CØMPØUT data set defined previously.

Running jobs using the Gould plotter will allow quick examination of the plot. When the user is satisfied with the results, he can submit a job to be plotted on the 763 or 925 Calcomp plotters. Using either of these two units, the user can also obtain a punched deck of the unfolded spectrum for further use. Therefore, the "/*ROUTE PUNCH REMØTE7" card should be removed, and the "//GØ.FT07F001 DD DUMMY" card should be changed back to "//GØ.FT07F001 DD SYSØUT=B." Below is the JCL for the 925 Calcomp plotter.

```
//DSKPLT EXEC PGM=PØPD92,REGION=110K,CØND=EVEN
//STEPLIB DD DSN=SYS2.DISSPØP,DISP=SHR
//FT06F001 DD SYSØUT=A
//CØMPIN DD DSN=T.xxyyyyyy.anyname,DISP=SHR
//GØ.FT49F001 DD UNIT=IN2ØU2,DISP=(NEW,KEEP),
// DCB=SYS2.DISKDCB,
// SPACE=(3208,(90),RLSE),DSN=PLØTØUT
//PLØTSUBS DD DSN=SYS2.JGSPLØTH,DISP=(SHR,PASS)
//FT05F001 DD *
DRAW=1-END
/*
```

The 925 Calcomp plotter uses a ball-point pen with a default color of black.

Below is the JCL for the 763 Calcomp plotter.

```
// EXEC PGM=PDP76,REGION=110K
//STEPLIB DD DSN=SYS2.DISSPOP,DISP=SHR
//FT06F001 DD SYSOUT=A
//C0MPIN DD DSN=T.xxyyyyyy.anyname,DISP=SHR
//G0.FT49F001 DD UNIT=IN20U2,DISP=(NEW,KEEP),
// SPACE=(TRK,(20,2),RLSE),DSN=PL0T0UT,
// DCB=SYS2.DISKDCB
//PL0TSUBS DD DSN=SYS2.JGSPL0TH,DISP=SHR
//FT05F001 DD *
DRAW=1-END
/*
```

The 763 Calcomp plotter uses a black felt-tip pen giving a high quality plot suitable for reproduction.

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IV. OUTPUT FROM SPEC-4

The output of the TSF version of SPEC-4 has been considerably expanded from the RSIC version. Much of what is printed has been added as a means of monitoring the performance of the code and the data manipulation technique.

The code first prints the Range-Energy tables for protons in hydrogen and protons in methane. Errors in inputting the gas pressure will show here. The high energy input spectrum is printed next. This is the input spectrum (NE213 for SP-28 run) along with the energy midpoints. The input spectrum is followed by a table of Response Correction Factors. These factors are calculated in the code using the input correction factors and other input parameters dependent on the particular detector. If the last entry in the right column is much greater than 2.5, then there is probably trouble with the value of EBOT. Adjusting EMAX and EBOT has a direct effect on the values for the Response Correction Factors.

The next table of output is the differential of the response matrix, followed by a number of diagnostic parameters which require a detailed study of the code to utilize. This output is generated by subroutine SNIDOW.

The output of subroutine SPEC2S is printed next, followed by the tables of the raw input foreground and background counts. A second set of smoothed foreground and background counts is printed which represents the results of the subroutine VSMTH. The "net" pulse-height spectrum, i.e., the difference of the smoothed foreground and background counts is printed next, followed by a table of the high energy pulse heights distribution. This latter table is the high energy input spectrum converted into pulse heights. A normalized difference spectrum is printed next which is equal to the smoothed net spectrum minus the high energy contributions. An edit of some input parameters is printed next followed by a binned spectrum which is presented as the calculated spectrum. This is

the final result for the particular detector being analyzed, and is the input spectrum for the next detector (at lower pressure).

The above sequence of prints is performed for each of the three detectors used in unfolding a hydrogen spectrum. After the three sets of prints, a summary edit is produced labeled "Output Spectrum Ordered by Detector." This table is headed by the final three title cards, and presents the final results for each detector starting with the 1 atm detector and proceeding to the 10 atm detector. The punched card deck which is produced from the run will contain the same information as this table, but in two formats. One format is column-oriented and corresponds exactly to the printed output, while the other format is row-oriented for convenient input into auxiliary programs.

The final table printed is titled "Output Spectrum Ordered by Energy." This table presents the same information as the previous table except that it is ordered strictly by increasing energy. This format has its advantages, but does obscure the overlap regions.

The final edit pertains to the plot output. If any problems were encountered in the plotting routines, an error message will be printed in this section. Also, a summary of the plot parameters such as axis lengths and step sizes are given.

V. OPERATING EXPERIENCE AND RECOMMENDATIONS

Several recommendations based on accumulated operating experience were included in the input data notes (Section II.B) and output descriptions (Section IV). This section is intended to expand on those comments.

The first thing a user should do is plot the raw data. Since the raw data is supplied to the analyst in the form of punched cards, it is relatively easy to feed the cards to a simple computer code for automatic plotting. A sample program to perform such a task is listed in Appendix B along with a sample plot. This plot can serve to locate EBOT, and also to identify any anomalies in the data such as bad data points or mis-punches. The user should look for the data to be a fairly straight line between the low-channel gamma-ray contamination and the high-channel alpha peak. Any significant bumps or dips that occur in this straight line region will cause poor results.

The second thing a user should do is tabularize his input data for a particular case. This step involves setting up a table of input parameters, and a table of the high energy input spectrum and corresponding energy midpoints. An example of this type of procedure is included in Appendix C. Performing this step gives the user quick reference to the input for a particular configuration and also an easy way to check his input. Finally, the user keypunches the data and runs the calculation.

As stated earlier, the only parameters the user can vary are the selections for EBOT and EMAX. Almost all other parameters are determined from data on the "fact sheet." In the input data notes (Section II.B) some past values for EBOT were discussed. These values are intended as guidelines, the actual values should be determined from visual examination of the raw channel data. Although EBOT is input in units of MeV, it can be related to channel numbers by dividing by the value of CAL. EMAX is presently set at 1.5 for SP-28, and left blank for SP-26, and SP-25. This allows the code to use the automatic overlap routine for the SP-26 and SP-25 detectors.

The energy limits on the plot produced by SPEC-4 are currently set at 0.04 MeV and 2.0 MeV. Therefore, if the user extends the analysis range outside of these limits, the code should be changed to accommodate the new limits. This requires a trivial change to subroutine SCALE.

A sample SPEC-4 case is given in Appendix C including a listing of the card input, portions of the printed output, and the resulting spectrum plot. Finally, Appendix D gives a listing of a source program which can be used to read the punched output from SPEC-4 to produce a printed edit of the unfolded spectrum identical to the final table produced by SPEC-4, and also produce a SPEC-4 type plot.

ACKNOWLEDGEMENTS

The authors wish to thank R. M. Freestone for his original work on SPEC-4 at ORNL, and for his informal user's guide which appears as App. A. Also, we would like to thank C. C. Webster and F. J. Muckenthaler for their insight and recommendations on operating the SPEC-4 code.

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Appendix A

A Brief Guide to the SPEC-4 Unfolding Code

R. M. Freestone, Jr.

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The purpose of this note is to provide a simple "cookbook" for running the TSF version of the SPEC4 code, used to unfold neutron spectra over the energy range from approximately 8 keV to 1 MeV. The organization following some general remarks, will follow the deck stacking exactly.

The data which SPEC4 is designed to unfold are pulse height distributions obtained with spherical, gas-filled, proton recoil proportional counters, called Benjamin counters, having a radius of 2.32 cm. At the present time (November 1976) two counters are used, although as many as four were used in earlier measurements. One counter, identified as SP28, is filled with pure hydrogen gas at a pressure of 10 atm, and is used in the higher energy end of the spectrum. The other counter, SP24, is filled to a total pressure of 3 atm with a mixture consisting of 85% H₂, 10% CH₄ (methane), and 5% nitrogen.

A normal set of data from the TSF will consist of one run with SP28 in so-called one-parameter mode, one run with SP24 in one-parameter mode, and two runs with SP24 in two-parameter mode, for a total of four. In one-parameter mode the data are acquired simply as counts vs pulse height, with a conventional pulse height analyzer. To describe the two-parameter acquisition, a mention of the events within the counter is necessary. Both recoil protons resulting from neutron-hydrogen collisions and electrons, usually from gamma-ray interactions in the counter walls, are created. Since the maximum energy that an electron can deposit is defined by its flight along a diameter of the counter, gamma rays can be discriminated against in one-parameter analysis by simply discarding from the analysis all data below the maximum possible electron pulse. This treatment obviously sets a lower energy limit on one-parameter analysis since low energy protons will be undistinguishable from electrons of proportionate energy.

It has been noted, however, that pulses due to electrons have a slower rate of rise than equally energetic pulses due to proton recoils. In two-parameter analysis both the magnitude of the pulse V and its rate-of-rise, dV/dt , are measured and stored using the TSF ND4420

minicomputer-based system as a 32×128 array of dV/dt vs. V . (Actually, $dV/dt/V$ is stored, but the effect is the same.) A typical $dV/dt/V$ "slice" will have a strong peak due to electrons at the left, with a slow tail which extends under a peak due to protons at the right. Before the two-parameter data can be analyzed by SPEC4 it must be preprocessed to remove the electron contribution. This is done external to SPEC4 by a short code called GSTRIP.

We now proceed to a detailed description of the input to SPEC4. TSF data is presently output on paper tapes which are submitted by TSF personnel to a DEC-10 program called "TSF" which produces a deck or decks of punched data cards. The cards are routinely delivered to Bldg 6025. More or less simultaneously (accent less!) F. J. Muckenthaler delivers to the data analyst a "fact sheet" giving all of the information required to unfold the data. In the discussion below, card numbers will be used as section headings. We begin immediately after the "//GO.FT05F001 DD *" card

Cards 1-31 (6E12.6)

Ninety-two values of range-energy values for protons in hydrogen. These cards are always input.

Cards 32-62 (6E12.6)

Ninety-two values of range-energy values for protons in methane. Always input.

Card 63 (12)

NSM: The number of values in the three arrays to follow (12 at present, and I see no reason to change).

Cards 64-65 (10F7.0)

CFE: Experimental correction factors. The code uses an analytic expression, essentially exact, to calculate wall effect corrections. It was found that for unknown reasons the analytic results did not agree with experiments using monoenergetic neutrons. The CFE's and the CFS's that follow correct the analytic result to agree with experiment.

CFS: Calculated correction factors. See above.

Cards 68-69 (10F7.0)

ROR: Range/radius correction factors. Part of corrections noted above. To this point input has been standard and unvarying. We now begin the input which varies from job-to-job.

Card 70 (I10)

NSPE: The number of points on the input spectrum to follow. I have settled on 15 as convenient.

Cards 71-73 (6E12.5)

FU: SPEC4 computes the contribution to the pulse height spectrum from neutrons having energies greater than the upper limit of analysis and subtracts it out. It therefore requires an estimate of the higher energy spectrum. Ideally, this should be an NE213 spectrum measured under the same conditions as the proton recoil spectrum. In practice this is not always available, so a "nearly alike" spectrum or a calculated spectrum must be used. A SPEC4 result is not usually very sensitive to this input. FU must be in units of flux/lethargy units. I use:

$$\phi(u) = \frac{\phi(E)\Delta E}{1u(E_1/E_0)}$$

Cards 74-76 (6E12.5)

U: The midpoints in MeV of E_1 , E_0 , above.

$$(E_0 + \Delta E = E_1)$$

Card 77 (10A8)

TPLLOT: A title for the log plot produced as part of the output. (DISKPLLOT).(10A8)

Card 78 (7F10.0)

CAL, BBIAS, EBOT, DUMY, CH, SMT, RTST. CAL is the detector calibration in MeV/channel. SP28 contains an alpha source deposited on its collector wire. The alphas deposit an equivalent proton

energy of 4.57 MeV. This number, divided by the channel number of the centroid of the observed alpha peak, gives CAL.

SP24 contains 5% N₂. The $^{14}\text{N}(n,p)^{14}\text{C}$ reaction with thermal neutron deposits 611 keV of energy in this peak. Obviously, 0.611/channel number will give CAL in MeV/channel. This is the method used for one-parameter data. For two-parameter data the previously mentioned fact sheet gives the energy in keV corresponding to channel 128.

In current practice this is usually ~220 keV for the low gain segment, ~55 keV for the high gain run. BBIAS is the complement of the multichannel analyzer zero error. It is the quantity to be added to the indicated data channel to give the true channel. For example, if the analyzer channel corresponding to zero energy turns out to be channel 2, BBIAS = -2.

EBOT is the lowest energy to be analyzed in the run being treated. This is sometimes a delicate choice. Although theoretically the counters have a definite gamma-electron energy upper limit, intense gamma fields tend to smear the gamma peak to higher pulse heights. A suitable EBOT can usually be chosen by plotting the raw data and noting the point at which the high and steep gamma peak joins the relatively slowly diminishing proton curve. However, any unfolded result showing a peak at its low energy end should be carefully examined for possible gamma contamination. In my most recent work I have used an EBOT of ~270 keV for SP28.

DUMY is presently an unused constant. In the original version of the code it was EMAX, the maximum energy to be unfolded. In the present version EMAX is set to 1.4 MeV for the SP28, 10 atm data by the code, and automatically for later runs. CH is the number of channels of data - 255 for SP28 data.

SMT is the smoothing option. SPEC4 offers via subroutine VSMTH the option of smoothing the raw data before processing. Traveling average smoothing is used. I have found smoothing to be nearly

For SP26 use 1.35 MeV/channel number; for SP25 use 0.407 MeV/channel number. (From RMF notes of 4/9/74 - Runs 1389C, 1389B, 1390D, and 1390C)

always desirable. Only in a situation where the raw data were super-good and maximum resolution was desired would I consider not smoothing. $SMT \leq 0.$, do not smooth. RTST is the flag indicating that more runs follow. RTST = 1., more to come; RTST = 0., this is last run (of a set of four).

Card 79 (7F10.0)

RAD, GPH, GPC, RES, RCF. RAD is the counter radius--2.32 cm. GPH is the hydrogen gas pressure in atm.: 10 atm for SP28. GPC is the methane gas pressure, 0. for SP28.

RES is the desired unfolding resolution. The counters have an inherent resolution of about 8%, but the data are seldom good enough statistically to take advantage of it. I have used 10%, but 15% gives the most believable results. RCF is a range correction factor used by SPEC4 to help to bring the code-calculated response functions closer to reality. For SP28 it is 1.10; as will be seen later, it varies according to the particular detector.

Card 80 (12)

ITIMES: SPEC4 offers the option of successively processing several sets of data using the information from Cards 80 and 81. ITIMES is the number of runs, but since the TSF never replicates runs, ITIMES is always 1.

Card 81 (10A8)

TLE: A title card describing the particular data set being analyzed. Obtained from F.J.M's fact sheet.

Card 82

FTIME, BTIME, FGAIN, BGAIN, NFLAG. (4F12,5,5x,I2).

FTIME is the foreground normalization factor, the product of live time and reactor power. Units are min*W.

BTIME is the background normalization factor, as above.

FGAIN, BGAIN: Historical remnants; not used.

NFLAG: A signal to indicate the existence or nonexistence of a background run. If NFLAG is nonzero, background is set to zero in column 55.

Cards 83 to 108 (12x, 10F6.0)

255 channels of data

If a background run was made, the cards comprising its 255 channels follow immediately--no blanks or signals. At one time I included an option for correcting for gain differences between foreground and background but found that with usually only fractional channel differences between the two, and using smoothing, this option was more trouble than it was worth.

This completes the processing of one run. The program (RTST = 1.) will go back to the format of card 80 and should, or will, read in the data for a one-parameter run with SP24. The same cautions with regard to EBOT exist. RCF is 1.07 for SP24. There will be 255 channels of data for this run.

The code is so written that an automatic overlap of two resolution widths is made in going from one run to the next. This overlap region should be examined with care in the output. Often troubles with gamma contamination may be discovered in this region. A second problem, particularly with data having poor statistics, is that sometimes the tail of the N_2 calibration peak may contaminate the high-energy end of the SP24 one-parameter distribution. In such cases the only remedy is to go back to the raw data and by observation juggle the EBOT's to get into "clean" areas.

After processing the SP24 one-parameter data the code will again return to the format of card 80 to find the parameters for the next run. Since this run is the output of GSTRIP operating on the 32 x 128 array, the number of channels, CH, will be 128.

A final return to the format of card 80, this time with RTST=0., completes the processing of a four-run Benjamin counter spectrum.

The last three cards in the input deck should be a title for the tabular output of results. If three cards are not needed, pad with blanks.

The output of the TSF version of SPEC4 has been considerably expanded from that available with the original version available from RSIC. Much of what is printed has been added as a means of monitoring the performance of both the code and the data acquisition techniques.

The code first prints the range-energy table. Errors in inputting the gas pressures will show here.

The high-energy input spectrum is printed, followed by the response correction factors. If the last entry in the right column is much greater than 2.5, there is probably trouble with EBOT's.

Next is printed the differential of the response matrix, followed by a number of values which really require a detailed study of the code to utilize. They probably could be scratched.

The output of the subroutine SPEC2S, the high energy contribution to be subtracted, is printed. It is again printed in a normalized, more easily used form below as "High Energy Pulse Heights to be Subtracted."

The raw foreground and background counts, followed by the smoothed net counts, are printed.

The normalized difference spectrum is printed. This is the input spectrum minus the high energy contribution.

Finally, a binned grouped spectrum is printed, followed by the real result, the unfolded spectrum "Calculated Neutron Spectrum."

The above are printed for each of the four runs. At the finish a neat, ordered table of results is printed followed by some binning information and finally by the spectrum in the commonly used 51-group structure.

A log Calcomp plot is also produced.

The final output is a punched card replica of the result table to be used to produce reproduction quality output when needed (my program "EDIT").

Appendix B
Listing of the RAWDAT Program

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A source listing of a sample graphics program for plotting "raw" pulse-height data is shown in Fig. 1. This program uses DISSPLA graphics software and the associated post processors. Although the purpose of most of the input parameters is obvious from the parameter name, IPTS requires additional explanation. IPTS specifies the number of data points which are to be read in a F7.0 format rather than the usual F6.0 format. Normally, $IPTS = 10 * NOVFO$ where NOVFO is the overflow parameter input to SPEC-4.

Usually, RAWDAT will produce 6 plots: a foreground and a background plot for each of the 3 counters. Sample plots are shown in Figs. 2 and 3 which display the foreground and background data for a 3 atm detector. Visual examination of the plots shows the relatively straight line between the low-channel gamma-ray contamination and the high-channel alpha peak. Hence appropriate values of EBOT and EMAX can be obtained from the plots.

```

DIMENSION X(255),Y(255),XLABEL(4),YLABEL(5),TITLE1(15),TITLE2(15)
DATA NPTS,IMARKR,INAME,IHT1,IHT2,NMARK,HITE/255,8,100,-3,2,-1,.18/
DATA XLABEL/4HCHAN,4HNEL,4HNUMB,4HERS /
DATA YLABEL/4HCOUN,4HTS P,4HER C,4HHANN,4HEL$ /
CALL COMPRS
5 READ(5,100,END=99) IPLT, IPTS, NLINE, WDATA, PAGEX, PAGEY
  READ(5,200) XPHYOR, YPHYOR, XAXIS, YAXIS, XORIGN, XSTEP, YORIGN, YMX
  READ(5,300) TITLE1, TITLE2
100 FORMAT(4(2X,I4),2(2X,F6.0))
200 FORMAT(6(2X,F6.0),2(2X,F8.0))
300 FORMAT(15A4)
DO 10 I=1,NPTS
10 X(I)=I
  IF(NDATA.EQ.1) GO TO 40
  IF(IPTS.EQ.0) GO TO 83
  READ(5,400) (Y(I),I=1,IPTS)
400 FORMAT(10X,10F7.0)
83 IPTS=IPTS+1
  READ(5,500) (Y(I),I=IPTS1,NPTS)
500 FORMAT(12X,10F6.0)
  DO 70 J=1,NPTS
  IF(Y(J).EQ.0.0) Y(J)=1.0
70 CONTINUE
  WRITE(6,50)
50 FORMAT(5X,'THE RAW DATA FROM THE MCA TO BE PLOTTED')
  WRITE(6,30) Y
30 FORMAT(10(2X,F8.0))
40 CALL DGNPL(IPLT)
  CALL PAGE(PAGEX,PAGEY)
  CALL PHYSOR(XPHYOR,YPHYOR)
  CALL MARKER(IMARKR)
  CALL GRACE(0.0)
  CALL HEIGHT(HITE)
  CALL TITLF(1H,1,XLABEL,INAME,YLABEL,INAME,XAXIS,YAXIS)
  CALL HEADIN(TITLE1,INAME,IHT1,NLINE)
  CALL HEADIN(TITLE2,INAME,IHT2,NLINE)
  IF(YORIGN+YMX.EQ.0.0) GO TO 91
  YMIN=YORIGN
  YMAX=YMX
  GO TO 92
91 YMIN=Y(1)
  YMAX=Y(1)
  DO 20 J=2,NPTS
  IF(Y(J).LT.YMIN) YMIN=Y(J)
  IF(Y(J).GT.YMAX) YMAX=Y(J)
20 CONTINUE
92 WRITE(6,60) YMIN,YMAX
60 FORMAT(2X,'YMIN='F8.0,5X,'YMAX='F8.0)
  CALL ALGPLT(YMIN,YMAX,YAXIS,YORIGN,YCYCL)
  CALL YLOG(XORIGN,XSTEP,YORIGN,YCYCL)
  CALL DTIFRM(XAXIS,YAXIS)
  CALL CURVE(X,Y,NPTS,NMARK)
  CALL ENDDL(IPLT)
  GO TO 5
99 CALL DONEPL
  STOP
  END

SUBROUTINE DTIFRM(XA,YA)
  TSIZE=0.10
  CALL FRAME
  CALL BLNK1(0.0,YA-TSIZE,0.0,YA,0)
  CALL GRID(0,1)
  CALL RESET('BLNK1')
  CALL BLNK2(0.0,XA,0.0,YA-TSIZE,0)
  CALL GRID(1,0)
  CALL RESET('BLNK2')
  RETURN
  END

```

Fig. 1. Source Listing of the RAWDAT Program for Plotting Pulse-Height Data from the Hydrogen Counters.

SPECTRUM MODIFIER SHIELD CONFIGURATION

RUN NO. 1460A; 3 ATM DETECTOR (SP26); FOREGROUND DATA

Fig. 2. Sample RAWDAT Plot.

SPECTRUM MODIFIER SHIELD CONFIGURATION

RUN NC. 1460B; 3 ATM DETECTOR (SP26); BACKGROUND DATA

Fig. 3. Sample RAWDAT Plot.

Appendix C
A Sample Problem for SPEC-4

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As described in Sections I and II, SPEC-4 requires as input an estimate of the neutron flux above the highest measurable energy of the gas detectors. For most TSF applications, this spectrum is provided by an NE-213 measurement made under the same conditions as the hydrogen counter measurements. The unfolded NE-213 spectrum is normally expressed in units of $n/(cm^2 \cdot s \cdot kW \cdot MeV)$, i.e., flux per unit energy. In order to convert the energy flux to a lethargy flux as required by SPEC-4, a simple calculation is required. Table 1 shows the results of a flux conversion for a sample NE-213 spectrum.

When performing a SPEC-4 calculation, it is generally good practice to tabularize the required input parameters for easy reference. Table 2 shows a sample table including the usual source which provides the input values.

A listing of the input for a typical SPEC-4 calculation is given in Fig. 4. The corresponding output from SPEC-4 is listed in Fig. 5. Only the output from the 10 atm detector is given, for brevity, and also the final edit of the full spectrum from the three detectors. Figure 6 shows the plot which is produced by SPEC-4 including the estimated errors. If poor overlap between the detectors is observed, EBOT may have been improperly chosen, or the data may be in error. Small discrepancies in the overlap can always be expected.

Table 1. Conversion of NE-213 Spectrum from Energy to Lethargy

NE-213 Case: 7773B,C Spectrum Modifier only

E_{LB} (MeV) ^a	E_{Mid} (MeV)	$\frac{E_{UB}-E_{LB}}{\ln(E_{UB}/E_{LB})}$	$\phi(E)^b$	$\phi(U)$
1	0.859	0.907	4.511+1 ^c	4.092+1
2	0.957	1.007	4.452+1	4.478+1
3	1.057	1.107	3.897+1	4.308+1
4	1.157	1.205	3.413+1	4.116+1
5	1.257	1.310	2.988+1	3.910+1
6	1.361	1.412	2.662+1	3.755+1
7	1.461	1.511	2.440+1	3.684+1
8	1.560	1.610	2.278+1	3.666+1
9	1.660	1.710	2.117+1	3.620+1
10	1.760	1.813	1.942+1	3.528+1
11	1.872	1.932	1.751+1	3.402+1
12	2.016	2.100	1.567+1	3.174+1
13	2.198	2.296	1.251+1	2.872+1
14	2.397	2.497	1.028+1	2.568+1
15	2.601	2.703	8.527	2.302+1
16	2.801	2.898	7.403	2.146+1
17	2.998	3.098	6.481	2.007+1
18	3.197	3.297	5.639	1.859+1
19	3.399	3.501	4.907	1.718+1
20	3.604	3.707	4.333	1.605+1
21	3.807	3.906	3.984	1.560+1
22	4.029	4.153	3.536	1.473+1
23	4.303	4.454	3.445	1.534+1
24	4.603	4.752	3.070	1.458+1
25	4.897	5.042	2.685	1.354+1
26	5.194	5.346	2.329	1.244+1
27	5.496	5.645	2.027	1.144+1
28	5.792	5.938	1.713	1.018+1
29	6.096	6.254	1.398	8.736
30	6.405	6.556	1.176	7.703
31	6.697	6.839	1.032	7.087
32	7.037	7.236	8.714-1	6.326
33	7.486	7.767	6.940-1	5.367
34	7.986	8.237	5.552-1	4.574
35	8.497	8.758	4.194-1	3.670
36	9.010	9.261	3.236-1	2.994
37	9.501	9.741	2.526-1	2.462
38	10.000			

^aLower boundary of energy bin.^bUnfolded NE-213 neutron spectrum, normally in units of $n/(cm^2 \cdot s \cdot kW \cdot MeV)$.^cRead as 4.511×10^1 .

Table 2. Fact Sheet for Hydrogen Counter

Configuration: Spec Mod only

Detector: SP-28; 10 atm

Card #	Columns	Parameter	Value	Source ^a
1	1-2	NSM	12	1
2	1-10	NSPE	37	1
3	1-10	CAL	0.0090513	2
	11-20	BBIAS	-1.8	2
	21-30	EBOT	0.270	3
	31-40	DUMMY	0.0	1
	41-50	CH	255.0	1
	51-60	SMT	1.0	3
	61-70	RTST	1.0	3
4	1-10	RAD	2.32	1
	11-20	GPH	10.0	3
	21-30	GPC	0.0	1
	31-40	RES	0.15	3
	41-50	RCF	1.10	3
5	1-2	ITIMES	1	1
6	1-12	FTIME	503.0 (kW·s)	2
	13-24	BTIME	195.2 (kW·s)	2
	25-36	FGAIN	X	1
	37-48	BGAIN	X	1
	49-50	NOVFLO	0	3
	54-55	NFLAF	0	3

^aSource of input value: 1 = normally fixed

2 = supplied by TSF experimenter

3 = determined by detector and/
or condition of data.

1.0	0.0147	1.5	0.0195	2.0	0.0235	CARD	01			
2.5	0.0272	3.0	0.0310	4.0	0.0375	CARD	02			
5.0	0.0435	6.0	0.0490	7.0	0.0545	CARD	03			
8.0	0.0595	9.0	0.0645	10.0	0.0690	CARD	04			
12.5	0.0800	15.0	0.0910	17.5	0.1010	CARD	05			
20.0	0.110	25.0	0.128	30.0	0.144	CARD	06			
35.0	0.160	40.0	0.174	45.0	0.190	CARD	07			
50.0	0.205	55.0	0.220	60.0	0.236	CARD	08			
65.0	0.251	70.0	0.266	75.0	0.282	CARD	09			
80.0	0.297	95.0	0.313	90.0	0.329	CARD	10			
95.0	0.346	100.0	0.362	110.0	0.400	CARD	11			
120.0	0.439	125.0	0.455	130.0	0.475	CARD	12			
140.0	0.514	150.0	0.551	160.0	0.598	CARD	13			
170.0	0.640	175.0	0.662	180.0	0.682	CARD	14			
190.0	0.730	200.0	0.780	225.0	0.920	CARD	15			
250.0	1.050	275.0	1.220	300.0	1.370	CARD	16			
350.0	1.73	400.0	2.13	450.0	2.57	CARD	17			
500.0	3.05	550.0	3.57	600.0	4.12	CARD	18			
650.0	4.72	700.0	5.35	750.0	6.02	CARD	19			
800.0	6.72	850.0	7.46	900.0	8.24	CARD	20			
950.	9.16	1000.0	9.91	1100.	11.7	CARD	2			
1200.	13.6	1250.	14.6	1300.	15.6	CARD	22			
1400.	17.6	1500.	20.2	1600.	22.5	CARD	23			
1700.	25.0	1750.	26.4	1800.	27.8	CARD	24			
1900.	31.0	2000.	33.8	2250.	41.3	CARD	25			
2500.	50.6	2750.	59.0	3000.	70.3	CARD	26			
3500.	92.8	4000.	118.	4500.	146.	CARD	27			
5000.	177.	5500.	210.	6000.	246.	CARD	28			
6500.	285.	7000.	326.	7500.	370.	CARD	29			
8000.	417.	8500.	466.	9000.	518.	CARD	30			
9500.	628.	10000.	752.			CARD	31			
1.0	.0050	1.5	.0070	2.0	.0082	CARD	32			
2.5	.0097	3.0	.0101	4.0	.0130	CARD	33			
5.0	.0155	6.0	.0170	7.0	.0190	CARD	34			
8.0	.0295	9.0	.0220	10.0	.0235	CARD	35			
12.5	.0275	15.0	.0307	17.5	.0340	CARD	36			
20.0	.0367	25.0	.0420	30.0	.0470	CARD	37			
35.0	.0513	40.0	.0565	45.0	.0610	CARD	38			
50.	.0660	55.	.0710	60.	.0760	CARD	39			
65.	.0805	70.	.0850	75.	.0905	CARD	40			
80.	.0950	85.	.100	90.	.105	CARD	41			
95.	.110	100.	.115	110.	.125	CARD	42			
120.	.135	125.	.140	130.	.145	CARD	43			
140.	.155	150.	.165	160.	.175	CARD	44			
170.	.185	175.	.190	180.	.195	CARD	45			
190.	.205	200.	.210	225.	.255	CARD	46			
250.	.290	275.	.330	300.	.375	CARD	47			
350.	.470	400.	.575	450.	.690	CARD	48			
500.	.810	550.	.940	600.	1.07	CARD	49			
650.	1.22	700.	1.39	750.	1.55	CARD	50			
800.	1.72	850.	1.92	900.	2.12	CARD	51			
950.	2.32	1000.	2.50	1100.	3.00	CARD	52			
1200.	3.45	1250.	3.70	1300.	3.95	CARD	53			
1400.	4.45	1500.	5.02	1600.	5.60	CARD	54			
1700.	6.15	1750.	6.45	1800.	6.85	CARD	55			
1900.	7.50	2000.	8.24	2250.	10.0	CARD	56			
2500.	12.2	2750.	14.4	3000.	16.7	CARD	57			
3500.	22.0	4000.	27.9	4500.	34.5	CARD	58			
5000.	41.6	5500.	49.4	6000.	57.8	CARD	59			
6500.	66.7	7000.	76.3	7500.	86.5	CARD	60			
8000.	97.2	8500.	108.	9000.	120.	CARD	61			
9500.	132.2	10000.	143.			CARD	62			
12						CARD	63			
1.22	1.32	1.51	1.75	2.06	2.52	3.448	5.155	7.692	13.89	CPE
40.0	999.9									CPE
1.0	1.122	1.285	1.50	1.785	2.16	2.762	3.84	5.405	8.13	CPS
17.24	62.50									CPS
0.0	0.15	0.30	0.45	0.60	0.75	0.90	1.1	1.25	1.4	ROR
1.6	1.8									ROR

Fig. 4. Input Listing for SPEC-4 Sample Problem.

37 POINTS FROM NE213 RUN 7773B AND 7773C ON 2/28/79 FOR JOJHCA01

40.9182	44.7958	43.0781	41.1573	39.1011	37.5541
36.8478	36.6579	36.1980	35.2312	34.0220	31.7437
28.7165	25.6790	23.0186	21.4550	20.0680	18.5910
17.1750	16.0500	15.6050	14.7250	15.3370	14.5790
13.5430	12.4420	11.4380	10.1770	8.7358	7.7032
7.0869	6.3256	5.3670	4.5744	3.6699	2.9944
2.4624					
.90694	1.0066	1.1069	1.2047	1.3096	1.4121
1.5107	1.6100	1.7095	1.8125	1.9323	2.1000
2.2961	2.4988	2.7026	2.8994	3.0975	3.2965
3.5009	3.7074	3.9061	4.1528	4.4540	4.7521
5.0422	5.3459	5.6453	5.9380	6.2542	6.5557
6.9390	7.2352	7.7365	8.2364	8.7578	9.2613
9.7411					

SPECTRUM MODIFIER SHIELD CONFIGURATIONS

RUNS 1459A, 1458A, 1460A, 1460B, 1461NB, 1461NA/ #JOJHCA01\$

.009051297	-1.8	0.34	1.5	255.0	1.0	1.0
2.32	10.0	0.0	15.0	1.10		

1

RUN 1459A W BKGD 1458A SP-28(10 ATN) ZERO CH=1.8; ALPHA CALIB=506.7

503.0	176.9	474.4	127.67	476.23	445.808	854.610	713.035	558.905	517.645	510.21071
1459A	13489071141026	949893	793766	669342	568488	485341	421146	380305	351262	
1459A	021328907307250290163271719258042245514233097220428209152196135									03
1459A	031183032171214159366152089145527139151132309125578119431113057									04
1459A	041107130102234097069092429088965084930081942078412076093073688									05
1459A	051071901069549067063064899063159060790058599056479055071052677									06
1459A	061051175049467048014045917004538042856041861039940038726036917									07
1459A	071035689034075033308032256031124030035029133028385027215026365									08
1459A	081025466024881024015023060022404021960021404020792020222019605									09
1459A	091019268019081018217017608017448016803016245015703015272014821									10
1459A	101014391014037013431013331012947012576012173011734011251010873									11
1459A	111010618010403010038009679009471009208008980008744008362008140									12
1459A	121007949007718007552007299006964007089006693006457006328006098									13
1459A	131005999005687095631005455005243005113005013004796004720004651									14
1459A	1410045010043060041550041100040220038003671003482003525003321									15
1459A	151003329003251003113002989002905002814002698002599002494002415									16
1459A	161002428002382002253002151002038002032001958001845001820001747									17
1459A	171001763001682001616001448001434001397001359001374001284001239									18
1459A	181001226001139001104001120001079000911000973000911000850000842									19
1459A	191000792000784000732000668000679000627000599000583000547000513									20
1459A	201000517000451000439000473000428000392000358000375000345000325									21
1459A	211000319000305000253000281000241000230000194000179000195000179									22
1459A	221000183000147000141000132000111000120000102000091000072000069									23
1459A	23100007400004900006000005300005300004000045000029000041000036									24
1459A	241000035000023000027000031000036000033000029000029000021000032									25
1459A	00002000003200002000026000018010000									26
1458A	001000069000242001060035064081521038344049796170418143012104854									01
1458A	011079100061367047642037835031050025591020350019485017856016237									02
1458A	021014731013525012261011380010687009717009127008370007772007233									03
1458A	031006617006237005858005454005144004314004364004162003914003617									04
1458A	041003512003194003113002917002796002697002599002427002484002301									05
1458A	051002260002209002078001996002004001930001811001718001646001587									06
1458A	061001477001453001525001320001265001241001217001170001171001057									07
1458A	07100109700110900102100036000962000885000861000860000787000812									08
1458A	081000748000696000693000660000629000613000591000581000538000565									09
1458A	091000512000518000463000431000437000394000383000378000349000326									10
1458A	101000329000323000307000295000252000254000288000224000243000261									11
1458A	111000225000235000260000212000200000210000185000174000204000202									12
1458A	121000180000193000174000188000165000159000137000158000150000138									13
1458A	131000122000110000117000125000115000105000134000121000092000111									14
1458A	14100010000096000097000073000063000067000073000098000074000058									15
1458A	151000067000066000066000053000058000061000052000053000055000054									16
1458A	16100049000039000045000037000051000043000042000038000045000035									17
1458A	171000033000024000034000031000027000030000035000019000022000025									18

Fig. 4. Cont'd

1453A	181000025000023000026000016000022000014000021000016000018000012	19				
1458A	191000015000016000011000014000013000010000011000014000014000008	20				
1458A	20100001600000900000900001900001100000900000090000010000009000010	21				
1458A	211000006000007000008000008000009000003000006000004000003000003	22				
1458A	221000004000005000004000002000008000006000004000004000006000004	23				
1458A	231000003000005000005000006000001000004000004000005000004000006	24				
1458A	241000003000002000005000005000004000001000003000003000005000000	25				
1458A	00000600000500000300000700000400000400000	26				
.004527163	-1.8	0.17	0.0	255.0	1.0	1.0
2.32	3.0	0.0	15.0	1.03		
1						
RUN	1460A W BKGD 1460B	SP-26 (2 ATM) ZERO CH=1.8; ALPHA CALIB=300.0				
	1398.0	493.6	2	0		
1460A	5547	22296	131936	984237	971103	602571 326483 195540 208576 643819
1460A	12305251093860	912520	765271	651930	563169	494530 434130 384266 343113
1460A	021313506294770279984270447261124251682241589231389220247209784					03
1460A	03119991918913817686916969162509158177155346153113147779143372					04
1460A	041139888134819131308126401123557119149116259112790109545107184					05
1460A	051104649102788100252097241094933092691088893086652083647080771					06
1460A	061078429075138072185069185066534064391062243060986059351058056					07
1460A	071056936055234054219052944050774049660049038047212046526044883					08
1460A	081043450042405040804039615038975037994036855035771034861033738					09
1460A	091033215032319031478030816030058029095028773028124027774027011					10
1460A	101026559026014025464024548024145023925023204022873022264021607					11
1460A	1102120302098602027401985019820018898018510017888017537017219					12
1460A	121016769016305016204015582015195014734014365014235013583013360					13
1460A	131012974012726012211012068011516011159010979010504010393010085					14
1460A	141009840009479009161008841008782008559008173007947007994007518					15
1460A	151007409007271006937006724006710006284006165006113005929005814					16
1460A	161005491005539005305005081004924004762004718004551004311004266					17
1460A	171004162003951003936003779003737003622003461003402003339003147					18
1460A	181003140003045002868002784002783002627002577002517002429002326					19
1460A	191002217002181002112002082001961001897001847001716001690001776					20
1460A	201001565001487001513001510001437001355001250001233001146001201					21
1460A	211001140001085001026001009000979000933000901000870000815000795					22
1460A	221000759000769000734000677000659000576000646000648000531000533					23
1460A	231000554000477000499000376000443000421000402000357000325000351					24
1460A	241000310000299000261000256000260000209000209000213000217					25
1460A	000205000199000202000198000174010000					26
31460B	001000330001781053379073512030824019958050784167786135647104424					01
31460B	011080439061915046886036745029574024065020755018087016405014880					02
31460B	02101361201262101205701165010776010032009567008853008482008148					03
31460B	031007669007125006951095768006494006078005931005627005608005266					04
31460B	041005089005052004875004593004399004187004203004014003797003642					05
31460B	051003449003242003297003205002940002895002716002734002526002535					06
31460B	061002422002305002158002125002074002090001888001916001812001698					07
31460B	071001660001665001548001488001502001394001311001341001314001251					08
31460B	081001190001218001185001129001109001026001039000963000964000937					09
31460B	091000994000895000836000833000849000775000770000763000742000725					10
31460B	10100071900072100064700066000622000593000631000638000629000602					11
31460B	111000550000538000513000520000559000494000473000494000452000476					12
31460B	12100042100042600040900043000399000400000338000385000371000319					13
31460B	131000325000284000327000310000294000289000276000254000271000259					14
31460B	1410002400025000022000024500020800019000192000211000174000197					15
31460B	151000209000187000164000184000147000164000149000177000141000133					16
31460B	161000153000132000129000139000124000147000118000116000113000125					17
31460B	171000107000122000095000099000077000086000072000072000093000068					18
31460B	181000067000064000062000057000068000052000056000057000060000050					19
31460B	191000043000034000049000038000044000037000032000041000033000049					20
31460B	201000036000040000029000049000028000039000034000036000037000032					21
31460B	211000036000039000033000035000043000044000031000039000049000042					22
31460B	221000037000035000033000037000039000051000029000041000053000041					23

Fig. 4. Cont'd

81460B	231000030000034000038000041000030000026000032000028000034000036	24
81460B	241000034000029000026000032000025000030000019000026000025000028	25
81460B	000029000016000027000027000024002000	26
.001904878	-1.8 0.06 0.0 255.0 1.0 0.0	
2.32	1.0 0.0 15.0 1.00	

1

RUN 1461NB W BKGD 1461NA SP-25(1 ATM) ZERO CH=1.8;ALPHA CALIB=228.3

1727.0	873.4	2	0
1461NB	3860 14665 116402 762561 740779 524927 352818 196518 525754 1169766		
1461NB	1050256 874493 725003 596873 489825 399180 323104 263315 221227 192019		
1461NB	21171670156751147370140304135308130238125395120537117388114167	3	
1461NB	31109910107105103871100935 97911 93751 89263 86054 81412 78558	4	
1461NB	41 75704 72237 68376 65750 63110 61303 59175 57226 55620 54611	5	
1461NB	51 53634 52811 51971 50789 50353 50197 49271 48333 47865 46884	6	
1461NB	61 46064 45142 44227 43520 42696 41450 40627 39569 39153 38218	7	
1461NB	71 37413 36583 35650 34911 34172 32983 32553 30898 30326 29696	8	
1461NB	81 29022 28564 28352 27677 27709 27244 27035 26514 26393 25914	9	
1461NB	91 25420 24991 24866 24612 24276 23947 23460 23276 22916 22684	10	
1461NB	101 21995 21814 21687 21246 20858 20817 20228 19966 19588 19370	11	
1461NB	111 18877 18543 18278 17860 17959 17806 16996 17326 16709 16628	12	
1461NB	121 16222 16135 15824 15687 15547 15409 14905 14668 14593 14412	13	
1461NB	131 14105 13648 13700 13613 13279 12995 12739 12519 12223 12183	14	
1461NB	141 11716 11641 11482 10937 10793 10599 10338 10343 10030 9871	15	
1461NB	151 9789 9341 9201 9077 8684 8707 8278 8273 8019 8176	16	
1461NB	161 7690 7707 7458 7514 7469 7333 7083 6909 7002 6812	17	
1461NB	171 6767 6642 6552 6243 6243 6047 5931 5958 5765 5645	18	
1461NB	181 5436 5474 5314 5430 5135 5301 5063 5042 4859 4821	19	
1461NB	191 4719 4663 4400 4352 4249 4181 4139 4034 3809 3834	20	
1461NB	201 3753 3673 3600 3657 3479 3399 3290 3419 3277 3082	21	
1461NB	211 3084 2969 2925 2958 2881 2846 2806 2587 2431 2547	22	
1461NB	221 2578 2551 2251 2136 2305 2149 2194 2192 2041 2144	23	
1461NB	231 2088 1991 1909 1963 2028 1785 1704 1685 1664 1603	24	
1461NB	241 1594 1572 1562 1574 1499 1419 1461 1421 1324 1250	25	
1461NB	251 1378 1238 1161 1307 1187	26	
1461NA	1 322 1385 30084 75516 44531 32055 405131 70532157475126607	1	
1461NA	11102499 83523 66602 53146 41933 33183 26361 21356 17733 14788	2	
1461NA	21 13214 11809 10720 10116 9328 9027 8286 7987 7753 7301	3	
1461NA	31 6848 6537 6331 6016 5758 5304 5245 4943 4804 4622	4	
1461NA	41 4194 4394 4148 3956 3919 3710 3795 3502 3585 3444	5	
1461NA	51 3225 3269 3184 3105 2959 2990 3062 2780 2744 2610	6	
1461NA	61 2645 2553 2503 2406 2346 2323 2261 2198 2225 2108	7	
1461NA	71 2164 2053 2048 2091 1877 1864 1819 1779 1730 1730	8	
1461NA	81 1732 1693 1564 1631 1542 1548 1557 1553 1456 1484	9	
1461NA	91 1470 1334 1296 1387 1373 1278 1256 1253 1296 1223	10	
1461NA	101 1210 1190 1109 1117 1170 1133 1064 1113 1004 962	11	
1461NA	111 1024 1007 980 976 933 902 942 914 821 865	12	
1461NA	121 844 777 797 797 802 780 768 720 648 709	13	
1461NA	131 660 613 674 630 626 627 600 617 597 543	14	
1461NA	141 601 557 519 525 459 539 487 435 452 478	15	
1461NA	151 444 440 423 389 443 457 405 408 380 376	16	
1461NA	161 381 362 359 361 364 360 339 298 326 314	17	
1461NA	171 317 286 304 291 301 271 282 271 260 231	18	
1461NA	181 236 258 220 229 224 234 259 206 180 213	19	
1461NA	191 202 195 199 182 199 164 167 183 156 171	20	
1461NA	201 162 158 158 165 158 150 142 139 138 151	21	
1461NA	211 146 80 101 125 125 154 123 116 95 84	22	
1461NA	221 132 130 46 57 103 87 65 92 107 87	23	
1461NA	231 69 109 60 83 120 52 68 73 61 56	24	
1461NA	241 50 58 69 55 89 67 67 78 27 57	25	
1461NA	251 42 50 56 54 53	26	

RUNS 1459A(BKGD 1458A),SP-28(10 ATM); 1460A(BKGD 1460B),SP-26(3 ATM);
 1461NB(BKGD 1461NA),SP-25(1 ATM) A-CALIB(1461C-1461D(1 ATM)); DET 460CM
 ON CL 3EHIND SPEC MOD NE213 INPUT SPECTRU1=7773B,C ON 2/28/79 :HCA01

Fig. 4. Cont'd

RANGE ENERGY DATA			
E	TH	PCW4	RANGE
0.0010	0.0147	0.0050	0.0015
0.0015	0.0195	0.0070	0.0020
0.0020	0.0235	0.0092	0.0024
0.0025	0.0277	0.0097	0.0027
0.0030	0.0310	0.0101	0.0031
0.0040	0.0375	0.0130	0.0033
0.0050	0.0435	0.0155	0.0043
0.0060	0.0490	0.0170	0.0049
0.0070	0.0545	0.0190	0.0054
0.0090	0.0575	0.0205	0.0059
0.0090	0.0645	0.0220	0.0064
0.0100	0.0690	0.0235	0.0069
0.0125	0.0900	0.0275	0.0080
0.0150	0.0910	0.0377	0.0091
0.0175	0.1010	0.0340	0.0101
0.0200	0.1100	0.0367	0.0110
0.0250	0.1280	0.0420	0.0128
0.0300	0.1440	0.0470	0.0144
0.0350	0.1600	0.0515	0.0160
0.0400	0.1740	0.0565	0.0174
0.0450	0.1900	0.0610	0.0190
0.0500	0.2050	0.0660	0.0205
0.0550	0.2200	0.0710	0.0220
0.0600	0.2360	0.0760	0.0236
0.0650	0.2510	0.0805	0.0251
0.0700	0.2660	0.0850	0.0266
0.0750	0.2820	0.0905	0.0282
0.0900	0.2770	0.0950	0.0297
0.0850	0.3130	0.1000	0.0313
0.0900	0.3290	0.1050	0.0329
0.0950	0.3460	0.1100	0.0346
0.1000	0.3620	0.1150	0.0362
0.1100	0.4000	0.1250	0.0400
0.1200	0.4380	0.1350	0.0438
0.1250	0.4550	0.1400	0.0455
0.1300	0.4750	0.1450	0.0475
0.1400	0.5140	0.1550	0.0514
0.1500	0.5510	0.1650	0.0551
0.1600	0.5980	0.1750	0.0598
0.1700	0.6400	0.1850	0.0640
0.1750	0.6620	0.1900	0.0662
0.1800	0.6820	0.1950	0.0682
0.1900	0.7300	0.2050	0.0730
0.2000	0.7800	0.2130	0.0780
0.2250	0.9200	0.2550	0.0920
0.2500	1.0500	0.2900	0.1050
0.2750	1.2200	0.3300	0.1220
0.3000	1.3700	0.3750	0.1370
0.3500	1.7100	0.4700	0.1730
0.4000	2.1300	0.5750	0.2130
0.4500	2.5700	0.6900	0.2570
0.5000	3.0500	0.8100	0.3050
0.5500	3.5700	0.9400	0.3570
0.6000	4.1200	1.0700	0.4120
0.6500	4.7200	1.2200	0.4720
0.7000	5.3500	1.3900	0.5350
0.7500	6.0200	1.5500	0.6020
0.8000	6.7200	1.7200	0.6720
0.8500	7.4600	1.9200	0.7460
0.9000	8.2400	2.1200	0.8240
0.9500	9.1600	2.3200	0.9160
1.0000	9.9100	2.5000	0.9910
1.1000	11.7000	3.0000	1.1700
1.2000	13.6000	3.4500	1.3600
1.2500	14.6000	3.7000	1.4600
1.3000	15.6000	3.9500	1.5600
1.4000	17.6000	4.4500	1.7600
1.5000	20.2000	5.0200	2.0200
1.6000	22.5000	5.6000	2.2500
1.7000	25.0000	6.1500	2.5000
1.7500	26.4000	6.4500	2.6400
1.8000	27.9000	6.8500	2.7800
1.9000	31.0000	7.5000	3.1000
2.0000	33.6000	8.2400	3.3600
2.2500	41.3000	10.0000	4.1300
2.5000	50.6000	12.2000	5.0600
2.7500	59.0000	14.4000	5.9000
3.0000	70.3000	16.7000	7.0300
3.5000	92.8000	22.0000	9.2800
4.0000	118.0000	27.9000	11.8000
4.5000	146.0000	34.5000	14.6000
5.0000	177.0000	41.6000	17.7000
5.5000	210.0000	49.4000	21.0000
6.0000	246.0000	57.9000	24.6000
6.5000	285.0000	66.7000	28.5000
7.0000	326.0000	76.3000	32.6000
7.5000	370.0000	86.5000	37.0000
8.0000	417.0000	97.2000	41.7000
8.5000	466.0000	108.0000	46.6000
9.0000	519.0000	120.0000	51.9000
9.5000	628.0000	132.2000	62.8000
10.0000	752.0000	143.0000	75.2000

Fig. 5. Listing of Output
from SPEC-4 Sample Problem.

INPUT SPECTRUM

4.0918E 01	4.4786E 01	4.3078E 01	4.1157E 01	3.9101E 01	3.7554E 01	3.6848E 01	3.6658E 01	3.6193E 01	3.5291E 01
3.4022E 01	3.1744E 01	2.9716E 01	2.5679E 01	2.3019E 01	2.1455E 01	2.0068E 01	1.8591E 01	1.7175E 01	1.6050E 01
1.5605E 01	1.4725E 01	1.5337E 01	1.4579E 01	1.3543E 01	1.2442E 01	1.1438E 01	1.0177E 01	8.7358E 00	7.7032E 00
7.0969E 00	6.3256E 00	5.3670E 00	4.5744E 00	3.6699E 00	2.7944E 00	2.4624E 00			
9.0694E-01	1.0066E 00	1.1069E 00	1.2047E 00	1.3096E 00	1.4121E 00	1.5107E 00	1.6100E 00	1.7095E 00	1.9125E 00
1.9323E 00	2.1000E 00	2.2961E 00	2.4988E 00	2.7026E 00	2.8984E 00	3.0975E 00	3.2965E 00	3.5009E 00	3.7074E 00
3.9061E 00	4.1528E 00	4.4540E 00	4.7521E 00	5.0422E 00	5.3459E 00	5.6453E 00	5.9380E 00	6.2542E 00	6.5557E 00
6.8190E 00	7.2352E 00	7.7365E 00	8.2364E 00	8.7578E 00	9.2613E 00	9.7411E 00			

RESPONSE CORRECTION FACTORS

EMID	SNIDOW	EXPT
0.3236	1.0540	1.2642
0.3779	1.0685	1.2761
0.4414	1.0874	1.2917
0.5230	1.1153	1.3145
0.6181	1.1622	1.3668
0.7224	1.2236	1.4385
0.8492	1.3152	1.5437
1.0033	1.4709	1.7175
1.1801	1.7279	1.9977
1.3840	2.1470	2.5041

MATRIX OF MONOENERGETIC NEUTRON DIFFERENTIAL RECOIL PROTON DISTRIBUTIONS

5.0880E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0402E-02	3.9909E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1235E-02	2.1854E-02	3.1273E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.5291E-02	1.5115E-02	2.0589E-02	2.3811E-01	0.0	0.0	0.0	0.0	0.0	0.0
1.1026E-02	1.1141E-02	1.4706E-02	1.8346E-02	1.7882E-01	0.0	0.0	0.0	0.0	0.0
9.5169E-03	8.5567E-03	1.1477E-02	1.3960E-02	1.5298E-02	1.3497E-01	0.0	0.0	0.0	0.0
6.5226E-03	6.6389E-03	8.8460E-03	1.0955E-02	1.2017E-02	1.2747E-02	9.9931E-02	0.0	0.0	0.0
5.1489E-03	5.2100E-03	6.8861E-03	7.8944E-03	9.6701E-03	1.0635E-02	1.3373E-02	7.0966E-02	0.0	0.0
4.1229E-03	3.8167E-03	4.5425E-03	7.1777E-03	7.6437E-03	7.8964E-03	1.1624E-02	1.1613E-02	4.9352E-02	0.0
1.5220E-03	4.9316E-03	4.5181E-03	5.4777E-03	7.1282E-03	7.0418E-03	9.4649E-03	9.8405E-03	1.0863E-02	3.1893E-02

RANGE/RADIUS= 0.910 TOP VALUE= 0.23690

MODIFIED SNIDOW VALUES

0.1141E 01	0.1089E 01	0.1037E 01	0.9908E 00	0.9395E 00	0.8986E 00	0.8515E 00	0.7895E 00	0.7401E 00	0.6905E 00
0.6351E 00	0.5853E 00	0.5305E 00	0.4832E 00	0.4349E 00	0.3874E 00	0.3406E 00	0.2973E 00	0.2555E 00	0.2095E 00

ES (J) VALUES

0.0	0.7895E-01	0.1579E 00	0.2369E 00	0.3158E 00	0.3947E 00	0.4737E 00	0.5526E 00	0.6316E 00	0.7105E 00
0.7895E 00	0.9684E 00	0.9474E 00	0.1026E 01	0.1105E 01	0.1184E 01	0.1263E 01	0.1342E 01	0.1421E 01	0.1500E 01
0.1579E 00	0.1659E 01	0.1737E 01	0.1816E 01	0.1895E 01	0.1974E 01	0.2053E 01	0.2132E 01	0.2211E 01	0.2289E 01
0.2369E 01	0.2447E 01	0.2526E 01	0.2605E 01	0.2684E 01	0.2763E 01	0.2842E 01	0.2921E 01	0.3000E 01	0.3079E 01
0.3158E 01	0.3237E 01	0.3316E 01	0.3395E 01	0.3474E 01	0.3553E 01	0.3632E 01	0.3711E 01	0.3789E 01	0.3868E 01
0.3947E 01	0.4026E 01	0.4105E 01	0.4184E 01	0.4263E 01	0.4342E 01	0.4421E 01	0.4500E 01	0.4579E 01	0.4658E 01
0.4737E 01	0.4816E 01	0.4895E 01	0.4974E 01	0.5053E 01	0.5132E 01	0.5211E 01	0.5289E 01	0.5368E 01	0.5447E 01
0.5526E 01	0.5605E 01	0.5684E 01	0.5763E 01	0.5842E 01	0.5921E 01	0.6000E 01	0.6079E 01	0.6158E 01	0.6237E 01

FM (I) VALUES

0.1539E 01	0.1618E 01	0.1697E 01	0.1776E 01	0.1855E 01	0.1934E 01	0.2013E 01	0.2092E 01	0.2171E 01	0.2250E 01
0.2250E 01	0.2329E 01	0.2408E 01	0.2487E 01	0.2566E 01	0.2645E 01	0.2724E 01	0.2803E 01	0.2882E 01	0.2961E 01
0.2961E 01	0.3040E 01	0.3119E 01	0.3198E 01	0.3277E 01	0.3356E 01	0.3435E 01	0.3514E 01	0.3593E 01	0.3672E 01
0.3672E 01	0.3751E 01	0.3830E 01	0.3909E 01	0.3988E 01	0.4067E 01	0.4146E 01	0.4225E 01	0.4304E 01	0.4383E 01

FS (J) VALUES

0.2401E-01	0.23100E-01	0.22175E-01	0.21074E-01	0.19846E-01	0.18520E-01	0.17110E-01	0.15784E-01	0.14352E-01	0.13066E-01
0.1134E-01	0.10651E-01	0.95405E-02	0.85565E-02	0.75782E-02	0.66775E-02	0.58223E-02	0.50579E-02	0.43206E-02	0.35755E-02
0.26883E-02	0.19651E-02	0.13961E-02	0.92284E-03	0.55860E-03	0.31362E-03	0.17457E-03	0.65247E-04	0.12633E-04	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ZS (J) VALUES

0.24440E 01	0.22850E 01	0.19549E 01	0.16396E 01	0.13757E 01	0.10174E 01	0.70883E 00	0.50896E 00	0.40344E 00	0.29933E 00
0.24221E 00	0.20410E 00	0.16321E 00	0.13941E 00	0.12131E 00	0.10299E 00	0.85769E-01	0.72963E-01	0.60773E-01	0.50285E-01
0.40950E-01	0.32835E-01	0.25253E-01	0.19073E-01	0.12520E-01	0.80752E-02	0.44974E-02	0.19370E-02	0.43276E-03	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Fig. 5. Cont'd

OUTPUT OF SPCC 25

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-3.9172E-04-1.7410E-04 2.3990E-02 2.3886E-02 2.3781E-02 2.3677E-02 2.3572E-02 2.3467E-02 2.3363E-02 2.3258E-02
2.3154E-02 2.3048E-02 2.2942E-02 2.2836E-02 2.2729E-02 2.2623E-02 2.2517E-02 2.2411E-02 2.2305E-02 2.2198E-02
2.2076E-02 2.1950E-02 2.1823E-02 2.1697E-02 2.1571E-02 2.1444E-02 2.1318E-02 2.1191E-02 2.1064E-02 2.0923E-02
2.0742E-02 2.0614E-02 2.0500E-02 2.0359E-02 2.0219E-02 2.0079E-02 1.9937E-02 1.9792E-02 1.9640E-02 1.9487E-02
1.9335E-02 1.9183E-02 1.9030E-02 1.8879E-02 1.8726E-02 1.8574E-02 1.8415E-02 1.8253E-02 1.8091E-02 1.7930E-02
1.7769E-02 1.7606E-02 1.7444E-02 1.7282E-02 1.7120E-02 1.6969E-02 1.6815E-02 1.6663E-02 1.6511E-02 1.6358E-02
1.6206E-02 1.6054E-02 1.5902E-02 1.5747E-02 1.5592E-02 1.5418E-02 1.5254E-02 1.5089E-02 1.4925E-02 1.4761E-02
1.4596E-02 1.4432E-02 1.4276E-02 1.4129E-02 1.3981E-02 1.3833E-02 1.3685E-02 1.3538E-02 1.3390E-02 1.3242E-02
1.3094E-02 1.2952E-02 1.2812E-02 1.2671E-02 1.2531E-02 1.2390E-02 1.2250E-02 1.2109E-02 1.1968E-02 1.1828E-02
1.1692E-02 1.1555E-02 1.1418E-02 1.1282E-02 1.1145E-02 1.1009E-02 1.0872E-02 1.0736E-02 1.0602E-02 1.0475E-02
1.0347E-02 1.0220E-02 1.0092E-02 9.9647E-03 9.8372E-03 9.7096E-03 9.5821E-03 9.4644E-03 9.3514E-03 9.2385E-03
9.1255E-03 9.0125E-03 8.8996E-03 8.7866E-03 8.6736E-03 8.5607E-03 8.4483E-03 8.3360E-03 8.2217E-03 8.1114E-03
7.9991E-03 7.8868E-03 7.7745E-03 7.6621E-03 7.5521E-03 7.4487E-03 7.3453E-03 7.2419E-03 7.1385E-03 7.0351E-03
6.9317E-03 6.8283E-03 6.7249E-03 6.6243E-03 6.5261E-03 6.4279E-03 6.3297E-03 6.2316E-03 6.1334E-03 6.0352E-03
5.9370E-03 5.8399E-03 5.7493E-03 5.6616E-03 5.5738E-03 5.4860E-03 5.3983E-03 5.3105E-03 5.2228E-03 5.1350E-03
5.0476E-03 4.9630E-03 4.8783E-03 4.7937E-03 4.7091E-03 4.6244E-03 4.5398E-03 4.4552E-03 4.3705E-03 4.2855E-03
4.2000E-03 4.1144E-03 4.0289E-03 3.9434E-03 3.8578E-03 3.7723E-03 3.6867E-03 3.6012E-03 3.5042E-03 3.4024E-03
3.3005E-03 3.1986E-03 3.0969E-03 2.9949E-03 2.8931E-03 2.7912E-03 2.6894E-03 2.6061E-03 2.5231E-03 2.4401E-03
2.3571E-03 2.2741E-03 2.1911E-03 2.1080E-03 2.0250E-03 1.9466E-03 1.8801E-03 1.8136E-03 1.7472E-03 1.6807E-03
1.6142E-03 1.5477E-03 1.4813E-03 1.4149E-03 1.3559E-03 1.3027E-03 1.2495E-03 1.1963E-03 1.1431E-03 1.0900E-03
1.0368E-03 9.8359E-04 9.3040E-04 8.8698E-04 8.4516E-04 8.0334E-04 7.6153E-04 7.1971E-04 6.7789E-04 6.3607E-04
5.9426E-04 5.5244E-04 5.1062E-04 4.6881E-04 4.2699E-04 3.8517E-04 3.4336E-04 3.0154E-04 2.5972E-04 2.1791E-04
1.7609E-04 1.3427E-04 9.2457E-05 5.0643E-05 8.8250E-06 3.2993E-05 7.4911E-05 1.1662E-04 1.5844E-04 2.0026E-04
-2.4207E-04-2.8389E-04-3.2571E-04-3.6753E-04-4.0938E-04-4.5116E-04-4.9298E-04-5.3479E-04-5.7661E-04-6.1843E-04
-6.6024E-04-7.0206E-04-7.4388E-04-7.8569E-04-8.2751E-04-8.6933E-04-9.1114E-04-9.5296E-04-9.9477E-04-1.0366E-03
-1.0794E-03-1.1202E-03-1.1620E-03-1.2039E-03-1.2457E-03

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FOREGROUND TIME= 503.00 BACKGROUND TIME= 195.20

FOREGROUND COUNTS EXPERIMENT NUMBER 1459A

```

1769. 4744. 12767. 47623. 445808. 854610. 713035. 559905. 517645. 1021071.
1348907. 1141026. 949893. 793766. 669342. 568488. 495341. 421146. 380305. 351262.
328907. 307250. 290163. 271719. 258042. 245514. 233097. 220428. 209152. 196135.
183032. 171214. 158866. 152089. 145527. 139151. 132309. 125578. 119431. 113057.
107130. 102234. 97063. 92429. 88965. 84930. 81942. 78412. 76093. 73688.
71901. 69549. 67063. 64899. 63159. 60790. 58599. 56478. 55071. 52677.
51175. 49467. 48014. 45917. 44538. 42856. 41861. 39940. 38726. 36917.
35689. 34075. 33309. 32256. 31124. 30035. 29133. 28385. 27215. 26365.
25466. 24891. 24015. 23060. 22404. 21860. 21404. 20792. 20222. 19605.
19268. 19081. 18217. 17608. 17448. 16803. 16245. 15703. 15272. 14821.
14391. 14037. 13431. 13331. 12947. 12576. 12173. 11734. 11251. 10873.
10618. 10403. 10038. 9679. 9471. 9208. 8980. 8744. 8362. 8140.
7949. 7714. 7557. 7299. 6964. 7089. 6691. 6457. 6378. 6098.
5999. 5687. 5631. 5455. 5243. 5113. 5013. 4796. 4720. 4651.
4501. 4306. 4155. 4110. 4022. 3838. 3671. 3482. 3525. 3321.
3329. 3251. 3113. 2989. 2905. 2814. 2688. 2599. 2494. 2415.
2428. 2382. 2253. 2151. 2038. 2032. 1958. 1845. 1820. 1747.
1763. 1682. 1616. 1488. 1434. 1397. 1359. 1374. 1284. 1239.
1220. 1138. 1104. 1120. 1078. 911. 913. 911. 850. 844.
792. 784. 732. 668. 679. 627. 599. 583. 547. 513.
517. 451. 439. 473. 428. 392. 358. 375. 345. 325.
319. 305. 253. 281. 241. 230. 198. 179. 195. 179.
183. 147. 141. 132. 111. 120. 102. 91. 77. 69.
74. 49. 60. 53. 53. 40. 45. 29. 41. 36.
35. 23. 27. 31. 36. 33. 29. 29. 21. 32.
20. 32. 20. 26. 18.

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BACKGROUND COUNTS EXPERIMENT NUMBER 1459A

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69. 242. 1060. 35064. 61521. 39344. 49796. 170418. 143012. 104854.
79100. 61367. 47642. 37835. 31050. 25591. 20350. 19485. 17856. 16237.
14731. 13525. 12261. 11280. 10687. 9717. 9127. 8370. 7772. 7233.
6617. 6237. 5050. 5454. 5144. 4814. 4364. 4162. 3914. 3617.
3512. 3194. 3113. 2917. 2796. 2697. 2599. 2427. 2484. 2301.
2260. 2209. 2078. 1996. 2004. 1930. 1811. 1718. 1646. 1587.
1477. 1453. 1525. 1320. 1265. 1241. 1217. 1170. 1171. 1057.
1097. 1109. 1021. 936. 962. 885. 861. 860. 787. 812.
749. 696. 693. 660. 629. 613. 591. 581. 538. 565.
512. 514. 483. 431. 437. 394. 383. 374. 349. 326.
329. 323. 307. 295. 257. 254. 288. 224. 243. 261.
225. 235. 260. 212. 200. 210. 185. 174. 204. 202.
180. 193. 174. 188. 165. 159. 137. 159. 150. 138.
122. 110. 117. 125. 115. 105. 134. 121. 92. 111.
100. 96. 97. 73. 63. 67. 73. 89. 74. 58.
67. 66. 66. 53. 58. 61. 52. 53. 55. 54.
49. 39. 45. 37. 51. 43. 42. 38. 45. 35.
31. 24. 34. 31. 27. 30. 35. 19. 22. 25.
25. 23. 26. 16. 22. 14. 21. 16. 19. 12.
15. 16. 11. 14. 13. 10. 11. 14. 14. 8.
16. 9. 9. 19. 11. 9. 9. 10. 9. 10.
6. 7. 8. 8. 9. 3. 6. 4. 3. 3.
4. 5. 4. 2. 8. 6. 4. 4. 6. 4.
3. 5. 5. 6. 1. 4. 5. 5. 4. 6.
3. 2. 5. 5. 4. 1. 3. 3. 5. 0.
6. 5. 3. 7. 4.

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Fig. 5. Cont'd

RESULTS FROM SUBROUTINE VSMTB											
1769.	4744.	12767.	47623.	445909.	854610.	713035.	558905.	517645.	1021071.		
1348907.	1141026.	949893.	793766.	669342.	564488.	510626.	456947.	410371.	371929.		
340986.	315994.	295284.	277516.	261765.	247403.	233971.	221129.	208675.	196577.		
184965.	174060.	164064.	155063.	146990.	139676.	132950.	126721.	121011.	115278.		
110033.	104943.	100159.	95688.	91540.	87707.	84175.	80920.	77911.	75117.		
72503.	70038.	67644.	65450.	63288.	61199.	59175.	57216.	55321.	53496.		
51728.	50063.	48393.	46770.	45193.	43652.	42156.	40705.	39300.	37943.		
36634.	35374.	34163.	33002.	31891.	30828.	29812.	28845.	27923.	27045.		
26215.	25425.	24670.	23989.	23294.	22626.	21984.	21364.	20761.	20178.		
19613.	19065.	18532.	18013.	17510.	17019.	16541.	16076.	15622.	15191.		
14751.	14334.	13928.	13533.	13149.	12791.	12426.	12071.	11726.	11390.		
11063.	10743.	10432.	10131.	9837.	9553.	9276.	9008.	8749.	8497.		
8253.	8017.	7789.	7568.	7354.	7147.	6945.	6761.	6571.	6386.		
6206.	6031.	5861.	5695.	5533.	5375.	5222.	5072.	4926.	4785.		
4647.	4512.	4381.	4255.	4131.	4011.	3894.	3780.	3670.	3568.		
3463.	3360.	3260.	3162.	3067.	2975.	2885.	2796.	2710.	2626.		
2544.	2465.	2387.	2312.	2238.	2167.	2098.	2031.	1965.	1901.		
1839.	1779.	1725.	1668.	1612.	1558.	1505.	1454.	1405.	1356.		
1309.	1263.	1218.	1175.	1132.	1091.	1051.	1013.	975.	938.		
903.	869.	835.	803.	774.	744.	714.	685.	657.	630.		
604.	579.	555.	531.	508.	486.	464.	443.	423.	404.		
386.	368.	350.	334.	318.	302.	289.	275.	261.	248.		
236.	223.	212.	201.	190.	180.	170.	160.	151.	142.		
134.	126.	119.	112.	104.	97.	90.	84.	79.	73.		
68.	63.	59.	54.	36.	33.	29.	29.	21.	32.		
20.	32.	20.	26.	18.							

69.	242.	1060.	35064.	61521.	38344.	49796.	170418.	143012.	104854.		
79100.	61367.	47642.	37835.	31050.	25591.	23024.	20633.	18527.	16729.		
15199.	13881.	12726.	11703.	10790.	9969.	9222.	8539.	7913.	7342.		
6924.	6351.	5926.	5533.	5170.	4835.	4529.	4258.	4027.	3801.		
3594.	3402.	3226.	3066.	2920.	2789.	2669.	2560.	2461.	2368.		
2291.	2194.	2119.	2041.	1966.	1893.	1821.	1751.	1684.	1621.		
1560.	1505.	1450.	1398.	1349.	1301.	1256.	1212.	1171.	1131.		
1092.	1055.	1019.	984.	950.	917.	885.	854.	823.	794.		
765.	737.	711.	686.	661.	636.	613.	589.	567.	545.		
524.	503.	483.	464.	445.	428.	410.	394.	378.	364.		
350.	336.	324.	313.	302.	292.	283.	274.	265.	257.		
249.	242.	234.	228.	221.	215.	209.	203.	197.	192.		
187.	182.	176.	172.	167.	162.	157.	153.	148.	144.		
140.	135.	131.	127.	123.	119.	115.	112.	108.	104.		
101.	98.	94.	91.	88.	85.	83.	80.	77.	75.		
72.	70.	68.	66.	63.	61.	59.	57.	56.	54.		
52.	50.	49.	47.	45.	44.	42.	41.	40.	38.		
37.	36.	35.	34.	32.	31.	30.	29.	28.	27.		
26.	25.	24.	23.	23.	22.	21.	20.	20.	19.		
18.	18.	17.	16.	16.	15.	15.	14.	14.	13.		
13.	12.	12.	12.	11.	11.	10.	10.	10.	9.		
9.	9.	9.	8.	8.	8.	8.	7.	7.	7.		
7.	6.	6.	6.	6.	6.	6.	5.	5.	5.		
5.	5.	5.	5.	5.	4.	4.	4.	4.	4.		
4.	4.	4.	4.	4.	1.	3.	3.	5.	0.		
6.	5.	3.	7.	8.							

SMOOTHED FOREGROUND MINUS BACKGROUND

1591.	4120.	10036.	0.	287278.	755804.	584719.	119764.	149125.	750879.		
1145078.	982893.	827127.	696271.	599331.	502544.	451296.	403780.	362631.	324822.		
301920.	280236.	263493.	247359.	233960.	221715.	210207.	199125.	188284.	177657.		
167381.	157688.	148795.	140806.	133667.	127217.	121279.	115748.	110633.	105584.		
100772.	96179.	91846.	87788.	84014.	80521.	77297.	74322.	71571.	69015.		
66626.	64374.	62235.	60189.	58222.	56322.	54483.	52704.	50981.	49320.		
47709.	46184.	44656.	43167.	41717.	40299.	38921.	37581.	36283.	35029.		
33819.	32654.	31537.	30466.	29442.	28464.	27532.	26645.	25801.	25000.		
24244.	23524.	22839.	22222.	21591.	20987.	20405.	19845.	19300.	18773.		
18263.	17768.	17286.	16818.	16362.	15917.	15483.	15060.	14647.	14244.		
13850.	13467.	13093.	12729.	12371.	12038.	11698.	11367.	11043.	10729.		
10421.	10121.	9828.	9544.	9267.	8999.	8738.	8485.	8240.	8002.		
7772.	7549.	7334.	7126.	6925.	6729.	6540.	6367.	6189.	6015.		
5846.	5682.	5523.	5369.	5216.	5068.	4925.	4785.	4648.	4516.		
4386.	4261.	4139.	4020.	3904.	3791.	3682.	3575.	3471.	3375.		
3276.	3180.	3085.	2994.	2904.	2817.	2732.	2648.	2567.	2488.		
2411.	2335.	2262.	2191.	2121.	2054.	1988.	1925.	1863.	1803.		
1744.	1687.	1635.	1581.	1529.	1478.	1428.	1379.	1332.	1286.		
1242.	1198.	1155.	1114.	1070.	1035.	997.	960.	924.	890.		
856.	823.	791.	761.	733.	704.	676.	648.	622.	596.		
571.	547.	524.	501.	479.	458.	437.	417.	398.	380.		
362.	345.	328.	312.	297.	282.	270.	256.	243.	230.		
218.	207.	196.	185.	175.	165.	155.	146.	138.	129.		
121.	114.	106.	100.	92.	86.	79.	73.	69.	63.		
58.	53.	49.	44.	26.	30.	21.	21.	9.	32.		
5.	19.	12.	8.	8.							

Fig. 5. Cont'd

HIGH ENERGY PULSE HEIGHTS TO BE SUBTRACTED

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-2.0746E 02-9.2205E 01 1.2706E 04 1.2650E 04 1.2595E 04 1.2539E 04 1.2484E 04 1.2429E 04 1.2373E 04 1.2318E 04
1.2262E 04 1.2207E 04 1.2150E 04 1.2094E 04 1.2038E 04 1.1982E 04 1.1925E 04 1.1869E 04 1.1813E 04 1.1757E 04
1.1692E 04 1.1625E 04 1.1558E 04 1.1491E 04 1.1424E 04 1.1357E 04 1.1290E 04 1.1223E 04 1.1156E 04 1.1088E 04
1.1007E 04 1.0932E 04 1.0857E 04 1.0781E 04 1.0708E 04 1.0633E 04 1.0559E 04 1.0482E 04 1.0401E 04 1.0321E 04
1.0240E 04 1.0159E 04 1.0079E 04 9.9991E 03 9.9175E 03 9.8369E 03 9.7529E 03 9.6672E 03 9.5815E 03 9.4958E 03
9.4101E 03 9.3244E 03 9.2387E 03 9.1530E 03 9.0673E 03 8.9863E 03 8.9056E 03 8.8250E 03 8.7443E 03 8.6637E 03
8.5830E 03 8.5024E 03 8.4217E 03 8.3396E 03 8.2526E 03 8.1666E 03 8.0785E 03 7.9915E 03 7.9045E 03 7.8175E 03
7.7305E 03 7.6434E 03 7.5609E 03 7.4827E 03 7.4045E 03 7.3262E 03 7.2480E 03 7.1697E 03 7.0915E 03 7.0132E 03
6.9350E 03 6.8598E 03 6.7854E 03 6.7109E 03 6.6365E 03 6.5620E 03 6.4876E 03 6.4131E 03 6.3387E 03 6.2644E 03
6.1921E 03 6.1197E 03 6.0474E 03 5.9751E 03 5.9027E 03 5.8304E 03 5.7580E 03 5.6857E 03 5.6152E 03 5.5477E 03
5.4801E 03 5.4126E 03 5.3450E 03 5.2775E 03 5.2099E 03 5.1424E 03 5.0748E 03 5.0125E 03 4.9527E 03 4.8928E 03
4.8330E 03 4.7732E 03 4.7133E 03 4.6535E 03 4.5937E 03 4.5339E 03 4.4744E 03 4.4149E 03 4.3554E 03 4.2959E 03
4.2364E 03 4.1770E 03 4.1175E 03 4.0580E 03 3.9997E 03 3.9409E 03 3.8902E 03 3.8354E 03 3.7806E 03 3.7259E 03
3.6711E 03 3.6164E 03 3.5616E 03 3.5083E 03 3.4563E 03 3.4043E 03 3.3523E 03 3.3003E 03 3.2483E 03 3.1963E 03
3.1443E 03 3.0923E 03 3.0404E 03 2.9985E 03 2.9520E 03 2.9055E 03 2.8590E 03 2.8125E 03 2.7661E 03 2.7196E 03
2.6733E 03 2.6285E 03 2.5836E 03 2.5388E 03 2.4940E 03 2.4492E 03 2.4044E 03 2.3595E 03 2.3147E 03 2.2697E 03
2.2244E 03 2.1791E 03 2.1334E 03 2.0885E 03 2.0432E 03 1.9979E 03 1.9525E 03 1.9072E 03 1.8559E 03 1.8019E 03
1.7480E 03 1.6941E 03 1.6401E 03 1.5862E 03 1.5322E 03 1.4783E 03 1.4243E 03 1.3803E 03 1.3363E 03 1.2923E 03
1.2483E 03 1.2044E 03 1.1604E 03 1.1164E 03 1.0725E 03 1.0309E 03 9.9573E 02 9.6053E 02 9.2532E 02 8.9012E 02
8.5491E 02 8.1971E 02 7.8450E 02 7.4930E 02 7.1810E 02 6.8993E 02 6.6176E 02 6.3359E 02 6.0543E 02 5.7726E 02
5.4909E 02 5.2092E 02 4.9276E 02 4.6976E 02 4.4761E 02 4.2546E 02 4.0332E 02 3.8117E 02 3.5902E 02 3.3687E 02
3.1473E 02 2.9258E 02 2.7043E 02 2.4829E 02 2.2614E 02 2.0399E 02 1.8185E 02 1.5970E 02 1.3755E 02 1.1541E 02
9.3261E 01 7.1114E 01 4.8966E 01 2.6821E 01 4.6738E 00-1.7473E 01-3.9621E 01-6.1766E 01-8.3914E 01-1.0606E 02
-1.2821E 02-1.5035E 02-1.7250E 02-1.9465E 02-2.1679E 02-2.3894E 02-2.6109E 02-2.8323E 02-3.0538E 02-3.2753E 02
-3.4967E 02-3.7182E 02-3.9397E 02-4.1612E 02-4.3826E 02-4.6041E 02-4.8256E 02-5.0470E 02-5.2685E 02-5.4900E 02
-5.7114E 02-5.9329E 02-6.1544E 02-6.3758E 02-6.5973E 02

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NORMALIZING FACTOR = 5.2762E 05

304.5	924.0	-585.7	-2774.8	60251.9	163035.4	125519.9	23544.1	29996.6	162003.7
248043.6	212920.6	178765.6	150074.6	126629.6	107605.1	96376.3	85965.9	76952.1	69548.5
63639.6	59917.6	55042.4	51737.7	48813.3	46142.2	43632.5	41216.4	38853.1	36538.5
34300.9	32191.0	30256.7	28520.6	26971.2	25572.8	24286.5	23090.2	21985.8	20896.0
19858.2	18688.2	17915.7	17063.3	16253.2	15504.6	14815.7	14182.0	13597.4	13055.6
12550.3	12075.1	11624.8	11194.9	10782.0	10383.0	9997.4	9624.8	9264.6	8918.0
8582.2	8265.5	7948.0	7639.5	7340.5	7048.6	6765.2	6490.6	6224.9	5968.8
5722.4	5486.1	5259.1	5041.3	4833.9	4636.5	4449.3	4271.9	4104.0	3945.4
3796.7	3655.3	3521.3	3402.3	3280.4	3164.0	3052.9	2946.4	2843.2	2743.9
2647.8	2555.0	2465.2	2378.3	2294.2	2212.5	2133.2	2056.3	1991.1	1907.5
1835.9	1766.7	1699.5	1634.2	1570.4	1512.5	1452.8	1393.8	1336.0	1280.0
1225.7	1173.0	1122.0	1072.7	1025.2	979.4	935.2	892.8	852.0	813.0
775.5	739.7	705.6	673.0	641.6	610.8	581.3	555.4	528.2	502.1
477.1	453.2	430.2	407.9	386.0	365.0	344.9	325.6	307.1	289.4
272.5	256.3	239.8	224.0	208.8	194.3	180.4	167.2	154.6	143.8
132.3	120.9	110.1	99.8	90.0	80.6	71.8	63.3	55.3	47.8
40.8	34.3	28.1	22.4	17.1	12.3	7.9	3.8	1.5	0.1
-0.9	-1.6	-1.0	-1.1	-0.8	-0.2	0.7	-0.2	-0.9	-1.3
-1.5	-1.4	-1.1	-0.5	0.3	0.9	0.3	-0.1	-0.2	-0.1
0.2	0.8	1.5	2.5	3.3	3.1	3.1	3.3	3.6	4.1
4.9	5.7	6.8	6.9	6.9	7.1	7.4	7.9	8.6	9.4
10.4	11.5	12.7	14.0	15.5	17.2	19.3	21.2	23.1	25.2
27.4	29.7	32.2	34.7	37.3	40.0	42.8	45.6	48.6	51.6
54.7	57.9	61.2	64.6	67.9	71.3	74.7	79.2	83.1	85.6
92.4	93.2	97.1	101.0	101.0	107.7	110.5	115.4	117.3	127.4
126.3	134.3	147.7	141.6						

RUN 1459A W BKGD 1459A SP-2P(10 ATM) ZERO CH=1.8;ALPHA CALIB=506.7

BIAS=-2.90 CHANNELS: 255. SMOOTH= 1. BOTTOM ENERGY = 0.3400 MEV
 HYDROGEN PRESSURE=10.00 CARBON PRESSURE= 0.0 RESOLUTION= 15.

GROUPED SPECTRUM OF SLOPES PER MONITOR COUNT

MONITOR COUNT = 503.
 CALIBRATION = 0.00906344

INDICATED CHANNEL	ENERGY BOUNDARY	MID ENERGY	SIGMA	GROUPED SPECTRUM	INTERNAL	ERROR**2 EXTERNAL		
36	41	0.2964	0.3508	0.3236	7.71	6897.820	0.4721E 04	0.2533E 05
42	47	0.3508	0.4051	0.3773	7.12	4864.188	0.3594E 04	0.2179E 05
48	55	0.4051	0.4776	0.4414	6.58	3901.771	0.2480E 04	0.1075E 05
56	65	0.4776	0.5683	0.5230	6.02	3380.144	0.1650E 04	0.2791E 04
66	76	0.5683	0.6680	0.6181	5.51	2653.002	0.1100E 04	0.2772E 04
77	88	0.6680	0.7767	0.7224	5.07	1636.105	0.7200E 03	0.1980E 04
89	104	0.7767	0.9218	0.8492	4.65	1286.914	0.4060E 03	0.4838E 03
105	122	0.9218	1.0849	1.0033	4.25	882.818	0.2324E 03	0.3100E 03
123	143	1.0849	1.2752	1.1801	3.89	486.627	0.1193E 03	0.1361E 03
144	167	1.2752	1.4927	1.3840	3.57	224.640	0.5627E 02	0.5794E 02

Fig. 5. Cont'd

CALCULATED NEUTRON SPECTRUM

04-04-80

ENERGY BOUNDARY		FLUX / GROUP	FLUX / MEV	FLUX / LETHARGY	O/O ERROR	
					INTERNAL	EXTERNAL
0.2964	0.3508	1.1440E 04	2.1036E 05	6.7905E 04	1.19	0.59
0.3508	0.4051	1.0195E 04	1.8747E 05	7.0731E 04	1.48	0.74
0.4051	0.4776	1.0064E 04	1.3980E 05	6.1129E 04	1.59	0.80
0.4776	0.5683	1.1489E 04	1.2676E 05	6.6124E 04	1.50	0.75
0.5683	0.6680	1.2173E 04	1.2210E 05	7.5310E 04	1.54	0.77
0.6680	0.7767	9.5383E 03	8.7699E 04	6.3230E 04	2.11	1.06
0.7767	0.9218	9.8922E 03	6.8215E 04	5.7790E 04	2.09	1.04
0.9218	1.0849	1.0103E 04	6.1931E 04	6.2000E 04	2.18	1.09
1.0849	1.2752	9.3099E 03	4.3660E 04	5.1410E 04	2.74	1.37
1.2752	1.4927	7.0436E 03	3.2381E 04	4.4723E 04	3.34	1.67
SUMMED FLUX=		0.1002E 06				

SUM OF RAW COUNTS OVER INDICATED CHANNELS = 0.3776601E 07

OUTPUT SPECTRUM READY FOR NEXT SPEC 4 RUN AT LOWER PRESSURE

NSPE = 42

U	PU
3.2356E-01	6.7905E 04
3.7795E-01	7.0731E 04
4.4139E-01	6.1129E 04
5.2296E-01	6.6124E 04
6.1813E-01	7.5310E 04
7.2236E-01	6.3230E 04
8.4924E-01	5.7790E 04
1.0033E 00	6.2000E 04
1.1801E 00	5.1410E 04
1.3840E 00	4.4723E 04
1.4121E 00	4.4223E 04
1.5107E 00	4.3391E 04
1.6100E 00	4.3168E 04
1.7095E 00	4.2626E 04
1.8125E 00	4.1546E 04
1.9323E 00	4.0064E 04
2.1000E 00	3.7381E 04
2.2961E 00	3.3816E 04
2.4988E 00	3.0239E 04
2.7026E 00	2.7106E 04
2.8984E 00	2.5265E 04
3.0975E 00	2.3632E 04
3.2965E 00	2.1892E 04
3.5009E 00	2.0225E 04
3.7074E 00	1.8900E 04
3.9061E 00	1.8376E 04
4.1528E 00	1.7340E 04
4.4540E 00	1.8061E 04
4.7521E 00	1.7168E 04
5.0422E 00	1.5948E 04
5.3459E 00	1.4651E 04
5.6453E 00	1.3469E 04
5.9480E 00	1.1944E 04
6.2542E 00	1.0297E 04
6.5557E 00	9.0711E 03
6.8390E 00	8.3454E 03
7.2352E 00	7.4489E 03
7.7365E 00	6.3201E 03
8.2364E 00	5.3867E 03
8.7578E 00	4.2216E 03
9.2613E 00	3.5261E 03
9.7411E 00	2.8997E 03

***NOTE: The preceding output is repeated for the 3 atm
and 1 atm detectors

OUTPUT SPECTRUM ORDERED BY DETECTOR

04-04-90

RUNS 1459A(BKGD 1459A), SP-22(10 ATM); 1460A(BKGD 1460B), SP-26(3 ATM);
 1461NB(BKGD 1461NA), SP-25(1 ATM) A-CALIB(1461C-1461D(1 ATM)); DET 460CM
 ON CL BEHIND SPEC MOD NE213 INPUT SPECTRUM=7773B,C ON 2/28/79 :HCA01

N	ENERGY BOUNDARY (MEV)	FLUX (N/(CM2*S*MEV*KW))	ERROR (PERCENT)
1	0.0570 0.0678	8.8338E 05	1.76
1	0.0678 0.0786	8.8067E 05	1.94
1	0.0786 0.0930	4.5768E 05	2.96
1	0.0930 0.1092	2.7269E 05	4.97
1	0.1092 0.1290	4.4959E 05	2.71
1	0.1290 0.1524	3.7236E 05	3.01
1	0.1524 0.1794	2.1996E 05	4.90
1	0.1794 0.2100	2.3905E 05	4.45
2	0.1525 0.1797	2.1724E 05	2.24
2	0.1797 0.2114	2.2800E 05	2.08
2	0.2114 0.2476	2.3612E 05	1.98
2	0.2476 0.2929	2.9024E 05	1.39
2	0.2929 0.3427	2.2640E 05	1.78
2	0.3427 0.4015	1.9239E 05	1.90
3	0.2964 0.3508	2.1036E 05	1.19
3	0.3508 0.4051	1.8747E 05	1.48
3	0.4051 0.4776	1.3880E 05	1.59
3	0.4776 0.5683	1.2676E 05	1.50
3	0.5683 0.6680	1.2210E 05	1.54
3	0.6680 0.7767	8.7699E 04	2.11
3	0.7767 0.9218	6.8215E 04	2.09
3	0.9218 1.0849	6.1931E 04	2.18
3	1.0849 1.2752	4.3660E 04	2.74
3	1.2752 1.4927	3.2381E 04	3.34

OUTPUT SPECTRUM ORDERED BY ENERGY

04-04-90

RUNS 1459A(BKGD 1459A), SP-22(10 ATM); 1460A(BKGD 1460B), SP-26(3 ATM);
 1461NB(BKGD 1461NA), SP-25(1 ATM) A-CALIB(1461C-1461D(1 ATM)); DET 460CM
 ON CL BEHIND SPEC MOD NE213 INPUT SPECTRUM=7773B,C ON 2/28/79 :HCA01

N	ENERGY BOUNDARY (MEV)	FLUX (N/(CM2*S*MEV*KW))	ERROR (PERCENT)
1	0.0570 0.0678	8.8338E 05	1.76
2	0.0678 0.0786	8.8067E 05	1.94
3	0.0786 0.0930	4.5768E 05	2.96
4	0.0930 0.1092	2.7269E 05	4.97
5	0.1092 0.1290	4.4959E 05	2.71
6	0.1290 0.1524	3.7236E 05	3.01
7	0.1524 0.1794	2.1996E 05	4.90
8	0.1525 0.1797	2.1724E 05	2.24
9	0.1794 0.2100	2.3905E 05	4.45
10	0.1797 0.2114	2.2800E 05	2.08
11	0.2114 0.2476	2.3612E 05	1.98
12	0.2476 0.2929	2.9024E 05	1.39
13	0.2929 0.3427	2.2640E 05	1.78
14	0.2964 0.3508	2.1036E 05	1.19
15	0.3427 0.4015	1.9239E 05	1.90
16	0.3508 0.4051	1.8747E 05	1.48
17	0.4051 0.4776	1.3880E 05	1.59
18	0.4776 0.5683	1.2676E 05	1.50
19	0.5683 0.6680	1.2210E 05	1.54
20	0.6680 0.7767	8.7699E 04	2.11
21	0.7767 0.9218	6.8215E 04	2.09
22	0.9218 1.0849	6.1931E 04	2.18
23	1.0849 1.2752	4.3660E 04	2.74
24	1.2752 1.4927	3.2381E 04	3.34

Fig. 5. Cont'd

PLOTING COMMENCING

..... DISSPLA VERSION 7.5
 NC. OF FIRST PLOT100

PLCT NO. 100 WITH THE TITLE
 SPECTRUM MODIFIER SHIELD CONFIGURATIONS
 HAS BEEN COMPLETED.

PLCT ID. READS
 PLOT 100 12.54.01 FRI 4 APR, 1980 JOB=JOJPLT1 . ORNL DISSPLA VER 7.5

DATA FOR PLOT

NC. OF CURVES DRAWN 3

HORIZ. AXIS LENGTH 8.5 INS.
 VERT. AXIS LENGTH 6.0 INS.

HORIZ. ORIGIN 0.4000E-01 VERT. ORIGIN 0.2000E 05

HORIZ. AXIS LOG
 CYCLE LENGTH 5.00 INS./CYCLE

VERT. AXIS LOG
 CYCLE LENGTH 3.53 INS./CYCLE

.....
 . LOCATION OF CURRENT PHYSICAL ORIGIN .
 . X= 1.50 Y= 1.00 INCHPS .
 . FROM LOWER LEFT CORNER OF PAGE .

END DISSPLA -- 1835 VECTORS GENERATED IN 1 PLOT FRAMES.

SPECTRUM MODIFIER SHIELD CONFIGURATION

RUNS 1459A,1458A,1460A,1460B,1461NB,1461NA/ #JOJHCA01

Fig. 6. Final Spectrum Plot from the SPEC-4 Sample Problem.

Appendix D
Listing of the BENJPLT Program

D-2

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A source listing of a sample follow-up program for plotting SPEC-4 results is given in Fig. 7. A listing of a sample input is given in Fig. 8, which consists of cards which are punched by SPEC-4, excluding the final two title cards. These titles can be the same ones used as input to the SPEC-4 case. As with RAWDAT (App. B), BENJPLT uses the DISSPLA graphics software and post-processing of the plot data. Besides producing a plot identical to SPEC-4, BENJPLT also prints an edit of the unfolded spectrum in a format identical to the final output of SPEC-4. Therefore, BENJPLT is especially useful for providing publication-quality listings and plots independent of the original SPEC-4 case.

```

C
C B E N J P L T -PLOTS BENJAMIN COUNTER SPECTRA OUT OF SPEC4 CODE
C
COMMON/PASS/PAGEX,PAGEY,XPHYOR,YPHYOR,HITE,INAME,XAXIS,YAXIS,
1 NLINE,IHT1,IHT2,NCNT,NPMX,NTITL,NLABL,NPT2
DIMENSION IDENT(19)
NCASE=190
CALL COMPRS
998 READ(5,501,END=999) IDENT,NCNT
CALL CONTRL(NCASE)
NCASE=NCASE+1
GO TO 998
999 CALL DONEPL
501 FORMAT(19A4,I4)
STOP
END
SUBROUTINE CONTRL(NCASE)

C
C CONTRL PERFORMS ALL THE CALLS TO AND FROM THE SUBROUTINES
C
COMMON/PASS/PAGEX,PAGEY,XPHYOR,YPHYOR,HITE,INAME,XAXIS,YAXIS,
1 NLINE,IHT1,IHT2,NCNT,NPMX,NTITL,NLABL,NPT2
DIMENSION EBD(60,3),FLX(60,3),ERFLX(60,3),NPT(3),TITLE1(15)
DIMENSION TITLE2(15),XLABEL(7),YLABEL(7),XVEC(120),YVEC(120)

C
C SET DEFAULT AND READ CONTRL PARAMETERS
C
PAGEX=11.0
PAGEY=8.5
XPHYOR=1.5
YPHYOR=1.0
HITE=0.18
INAME=100
XAXIS=8.5
YAXIS=6.0
NLINE=2
IHT1=-3
IHT2=2
IF(NCNT.EQ.0) NCNT=3
NPMX=60
NTITL=15
NLABL=7
NPT2=120
1 CALL DATRD(EBD,FLX,ERFLX,NPT)
CALL SCALE(EBD,FLX,ERFLX,NPT)
CALL PLTSET(EBD,FLX,ERFLX,NPT,NCASE,TITLE1,TITLE2,XVEC,YVEC)
RETURN
END

SUBROUTINE SCALE(EBD,FLX,ERFLX,NPT)

C
C SCALE CALCULATES THE MINIMUM AND MAXIMUM VALUES OF THE INPUT DATA
C
COMMON/PASS/PAGEX,PAGEY,XPHYOR,YPHYOR,HITE,INAME,XAXIS,YAXIS,
1 NLINE,IHT1,IHT2,NCNT,NPMX,NTITL,NLABL,NPT2
COMMON/LIMIT/XMIN,XMAX,YMIN,YMAX
DIMENSION EBD(NPMX,NCNT),FLX(NPMX,NCNT),ERFLX(NPMX,NCNT)
DIMENSION NPT(NCNT)
XMIN = 0.04
XMAX = 2.00
YMIN=FLX(1,1)*(1.0-ERFLX(1,1)/100.0)
YMAX=FLX(1,1)*(1.0+ERFLX(1,1)/100.0)
DO 20 K=1,NCNT
II=NPT(K)
DO 30 J=1,II
FRIGH=FLX(J,K)*(1.0+ERFLX(J,K)/100.0)
FLOW=FLX(J,K)*(1.0-ERFLX(J,K)/100.0)

```

Fig. 7. Source Listing of the BENJPLT Program.

```

      IF (PHIGH.GT.YMAX) YMAX=PHIGH
      IF (FLOW.LT.YMIN) YMIN=FLOW
30  CONTINUE
20  CONTINUE
      YMAX=YMAX*1.10
      YMIN=YMIN*0.90
      RETURN
      END

      SUBROUTINE DATRD (EBD,FLX,ERFLX,NPT)
C
C  DATRD IS USED TO READ THE HYDROGEN SPECTRA DATA FROM CARDS
C
      COMMON/PASS/PAGEX,PAGEY,XPHYOR,YPHYOR,HITE,INAME,XAXIS,YAXIS,
1  NLINE,IHT1,IHT2,NCNT,NPMX,NTITL,NLABL,NPT2
      DIMENSION EBD(NPMX,NCNT),FLX(NPMX,NCNT),ERFLX(NPMX,NCNT)
      DIMENSION ID(20),NPT(NCNT)
      WRITE(6,600)
      DO 10 I=1,3
      READ(5,501) ID
10  WRITE(6,601) ID
      WRITE(6,602)

C
      DO 100 K=1,NCNT
      READ(5,502) NPT(K)
      NPQ=NPT(K)
      NPT1=NPT(K)+1
      READ(5,503) (EBD(I,K),I=1,NPT1)
      READ(5,504) (FLX(I,K),I=1,NPQ)
      READ(5,503) (ERFLX(I,K),I=1,NPQ)
100 CONTINUE

C
      DO 200 K=1,NCNT
      WRITE(6,603)
      KN = NCNT - K + 1
      KK = NPT(KN)
      DO 200 J=1,KN
200 WRITE(6,604) J,EBD(J,KN),EBD(J+1,KN),FLX(J,KN),ERFLX(J,KN)

C
501 FORMAT(20A4)
502 FORMAT(I3)
503 FORMAT(10F8.4)
504 FORMAT(3X,6E12.5)
600 FORMAT(1H1)
601 FORMAT(1H,20A4)
602 FORMAT(1H0,7X,2H N,5X,15HENERGY BOUNDARY,13X,4HFLUX,16X,5HERROR,/
1 20X,5H(MEV),12X,18H(N/(CM2*S*MEV*KW)),6X,9H(PERCENT))
603 FORMAT(1H )
604 FORMAT(1H ,7X,I2,6X,F6.4,3X,F6.4,10X,1E10.4,10X,0PF7.2)
      RETURN
      END

      SUBROUTINE PLTSET (EBD,FLX,ERFLX,NPT,NCASE,TITLE1,TITLE2,XVEC,YVEC)
C
C  PLTSET PERFORMS PLOT SETUP AND EXECUTION
C
      COMMON/PASS/PAGEX,PAGEY,XPHYOR,YPHYOR,HITE,INAME,XAXIS,YAXIS,
1  NLINE,IHT1,IHT2,NCNT,NPMX,NTITL,NLABL,NPT2
      COMMON/LIMIT/XMIN,XMAX,YMIN,YMAX
      DIMENSION TITLE1(NTITL),TITLE2(NTITL),XLABEL(7),YLABEL(11)
      DIMENSION EBD(NPMX,NCNT),FLX(NPMX,NCNT),ERFLX(NPMX,NCNT)
      DIMENSION NPT(NCNT),XVEC(NPT2),YVEC(NPT2)
      DATA XLABEL/4HNEUT,4HRON ,4HENER,4HGY (,4H()M(,4HE)V),4H$ /
      DATA YLABEL/4HFLUX,4H (N,4H/(CM,4H!2H0,4H.5(2,4H!EXH,4HX(*S,
1 4H*)M(,4HE)V(,4H*K)W,4H))$ /

```

Fig. 7. Cont'd

```

READ(5,501) TITLE1,TITLE2
CALL BGNPL(NCASE)
WRITE(6,601)
WRITE(6,602) XMIN,XMAX,YMIN,YMAX
601 FORMAT(1H0,11X,'XMIN',15X,'XMAX',15X,'YMIN',15X,'YMAX',/)
602 FORMAT(1H ,1P4(7X,F12.5))
CALL PAGE(PAGEX,PAGEY)
CALL PHYSOR(XPHYOR,YPHYCR)
CALL GRACE(0.0,0.0)
CALL HEIGHT(HITE)
CALL YAXANG(0.0)
CALL SIMPLX
CALL MIXALF('L/CSTD')
CALL MX3ALF('INSTRUCTION',1H!)
CALL TITLE(1H ,1,XLABEL,INAME,YLABEL,INAME,XAXIS,YAXIS)
CALL HEADIN(TITLE1,INAME,IHT1,NLINE)
CALL HEADIN(TITLE2,INAME,IHT2,NLINE)
CALL ALGPLT(XMIN,XMAX,XAXIS,XOR,XC)
CALL ALGPLT(YMIN,YMAX,YAXIS,YOR,YC)
CALL LCGLOG(XCR,XC,YOR,YC)
CALL DTIPRM(XAXIS,YAXIS)
CALL HISTP(EBD,FLX,ERFLX,NPT,XVEC,YVEC)
CALL ENDPL(NCASE)
C
501 FORMAT(15A4)
RETURN
END
SUBROUTINE DTIPRM(XA,YA)
C
C DTIPRM WILL FRAME THE PLOT AND ADD TICK MARKS INSIDE THE BOX
C
TSIZE=0.10
CALL FRAME
CALL BLNK1(0.0,XA-TSIZE,0.0,YA,0)
CALL GRID(0,1)
CALL RESET('BLNK1')
CALL BLNK2(0.0,XA,0.0,YA-TSIZE,0)
CALL GRID(1,0)
CALL RESET('BLNK2')
RETURN
END
SUBROUTINE HISTP(EBD,FLX,ERFLX,NPT,XVEC,YVEC)
C
C HISTP SETS THE INPUT DATA IN A FORMAT FOR HISTOGRAM PLOTTING
C
COMMON/PASS/PAGEX,PAGEY,XPHYOR,YPHYOR,HITE,INAME,XAXIS,YAXIS,
1 NLINE,IHT1,IHT2,NCNT,NPMX,NTITL,NLABL,NPT2
DIMENSION EBD(NPMX,NCNT),FLX(NPMX,NCNT),NPT(NCNT),XVEC(NPT2)
DIMENSION YVEC(NPT2),ERFLX(NPMX,NCNT)
DO 40 K=1,NCNT
LL=NPT(K)
DO 50 J=1,LL
XVEC(2*J-1)=EBD(J,K)
XVEC(2*J)=EBD(J+1,K)
YVEC(2*J-1)=FLX(J,K)
YVEC(2*J)=FLX(J,K)
50 CONTINUE
CALL CURVE(XVEC,YVEC,2*LL,0)
40 CONTINUE
DO 60 K=1,NCNT
MM=NPT(K)
DO 60 J=1,MM
EM=(EBD(J,K)+EBD(J+1,K))/2.0
PHI=FLX(J,K)*(1.0+ERFLX(J,K)/100.0)
FLO=FLX(J,K)*(1.0-ERFLX(J,K)/100.0)
CALL RLVEC(EM,PHI,EM,FLC,0)
60 CONTINUE
RETURN
END

```

Fig. 7. Cont'd

```

RUNS 1459A,58A,60A,60B,61NB,61NA; SPEC MOD ONLY/#JOJHCA01
RUNS 1459A(BKGD 1458A),SP-28(10 ATH); 1460A(BKGD 1460B),SP-26(3 ATH);
1461NB(BKGD 1461NA),SP-25(1 ATH) A-CALIB(1461C-1461D(1 ATH)); DET 460CM
ON CL BEHIND SPEC MOD RE213 INPUT SPECTRUM=7773B,C ON 2/28/79 :HCA01
10 DATA PCINTS THIS RUN
0.2964 0.3508 0.4051 0.4776 0.5683 0.6680 0.7767 0.9218 1.0849 1.2752
1.4927
2.10360E 05 1.87468E 05 1.38804E 05 1.26759E 05 1.22100E 05 8.76993E 04
6.82149E 04 6.19307E 04 4.36602E 04 3.23809E 04
1.19 1.48 1.59 1.50 1.54 2.11 2.09 2.18 2.74 3.34
6 DATA PCINTS THIS RUN
0.1525 0.1797 0.2114 0.2476 0.2929 0.3427 0.4015
2.17243E 05 2.28003E 05 2.36117E 05 2.90238E 05 2.26400E 05 1.92394E 05
2.24 2.08 1.98 1.39 1.78 1.90
8 DATA PCINTS THIS RUN
0.0570 0.0678 0.0786 0.0930 0.1092 0.1290 0.1524 0.1794 0.2100
8.83383E 05 8.80671E 05 4.57682E 05 2.72687E 05 4.49591E 05 3.72362E 05
2.19957E 05 2.38049E 05
1.76 1.94 2.96 4.97 2.71 3.01 4.90 4.45
SPECTRUM MODIFIER SHIELD CONFIGURATIONS
RUNS 1459A,1458A,1460A,1460B,1461NB,1461NA/ #JOJHCA01$

```

Fig. 8. Listing of Input Needed for BENJPLT.

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