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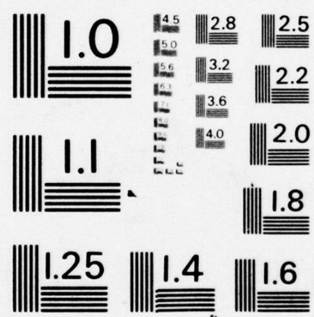

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FLAIR: A SCALING AND FOLDING CODE FOR THE GENERATION OF PHOTON TRANSPORT RESULTS IN AIR

Prepared by

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The FLAIR code was developed to easily and inexpensively generate x-ray and gamma-ray transport results in infinite air by utilizing an existing data base of x- and gamma-ray transport computed by Monte Carlo. FLAIR provides energy, angle, and time-dependent photon transport results from energy and time-dependent photon sources in infinite air. Results are possible out to ranges of fifteen mean-free-paths and are scaled with air density. FLAIR is oriented toward benchmarking radiation environments from weapon systems and calculating differential fluxes for input to radiation response codes.

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1. INTRODUCTION TO FLAIR

The FLAIR code (acronym for FoLd AIR) was developed to easily and inexpensively generate x-ray and gamma-ray transport results in infinite air by utilizing an existing data base of x- and gamma-ray air transport computed by Monte Carlo. FLAIR provides energy, angle, and time dependent photon transport results from energy and time dependent photon sources in infinite air. Results are possible out to ranges of fifteen mean-free-paths and are scaled with air density.

The Monte Carlo calculations were performed with source energy bands so that arbitrary source spectrums can be used. Time convolution is also performed for time dependent sources, although the energy and time dependence of a source must be separable. The photon transport data base is stored on two magnetic tapes, one for x-rays and one for gamma-rays. The x-ray tape has 22 energy bands from 10 keV to 300 keV and the gamma-ray tape has 25 energy bands from 10 keV to 14 MeV. Calculations below 300 keV can be performed with the gamma-ray tape, although better energy resolution would be obtained with the x-ray tape.

Problem specification is very flexible allowing the user to choose from a variety of units and input and output options. For example, a user could specify a source in photons/keV and generate forward energy current in calories/keV, or the source could be MeV/group and the results in rad(Si)/sec. This user flexibility will alleviate most of the pre-processing and post-processing of data associated with a FLAIR run.

The x-ray and gamma-ray transport data base was generated by the authors with the DART Monte Carlo code (documented in Ref. 1) which was developed specifically for this task. The DART code uses point cross sections and rigorously samples from the coherent and incoherent scattering angular distributions. Flux or current quantities computed with DART can be a joint function of up to five independent variables: two spatial, energy, time, and angle. Although DART generates a range and angle position dependence from a "gun barrel" source, FLAIR treats only isotropic sources, having integrated out the position angle dependence. A report documenting the data base and discussing our investigation of coherent and incoherent scattering effects will be published.

Since single Monte Carlo calculations were used to generate data at all ranges, energies, times and angles, our general guideline for statistical accuracy was to have less than 10% fractional standard deviations for the energy spectrum, time dependence, and angle dependence at all ranges. This was most difficult at the deep penetrations and the late times (especially at close-in radii). Importance functions and running times were set so that this 10% accuracy was met in most instances.

Several important features distinguish the FLAIR code from the ATR code;[2] these are summarized in Table 1. First ATR is more general than FLAIR including neutrons and secondary gamma rays as well as prompt x-rays and gamma-rays. FLAIR however provides much more comprehensive data for photons that includes full energy, time, angle and range dependence. FLAIR results are also more accurate: first, the the data base calculations with DART used point cross sections instead of the multigroup approximation used by ATR; and secondly, FLAIR uses the raw data without the intermediate step of curve fitting. Notice that both codes use the free-field input and a variety of output options. ATR also allows air-over-ground and high altitude

TABLE 1. COMPARISON OF THE FLAIR AND ATR CODES

Property	FLAIR	ATR
Data Base	point cross section Monte Carlo with C-I scattering, x-ray and gamma-ray only	multigroup discrete ordinates and Monte Carlo, K-N scattering, also neutron and secondary gamma-ray
Data Acquisition	directly from data base tapes	from parameterizations (effects) of data base
Data Content	complete range, energy, time, angle dependent flux	no time dependence for x-rays, range, energy, time flux or range, energy, angle fluence for gamma-rays
Convenience Features	free-field input, variety of output options	free-field input, variety of output options, air-over-ground and high altitude correction factors, integral mass scaling, built-in sources and responses
Approximate time/run	15 seconds CDC 7600	15 seconds UNIVAC 1108
Approximate cost/run	$5.00	$.50

correction factors which are not present in FLAIR. For these reasons the FLAIR code can provide a far more complete and accurate picture of photon transport in a one-dimensional atmosphere than ATR. On the other hand, with commensurate sacrifices in accuracy, ATR is faster running and provides transport data for all burst and target altitudes. ATR is oriented toward systems and "quick look" studies while FLAIR is oriented toward benchmarking radiation environments from weapon systems and calculating differential fluxes for input to radiation response codes.

2. DESCRIPTION OF FLAIR

This chapter describes in detail the workings of FLAIR. The format of the data base is presented along with equations for all operations performed by FLAIR. As each function of FLAIR is described, the corresponding input card formats are presented in detail. For user convenience these input instructions are summarized in Appendix A.

2.1 FORMAT OF THE DATA BASE

The x-ray and gamma-ray tapes contain the radiation transport data in the form of $4\pi R^2$ photon currents per group as a function of range, angle, time, energy and source energy. This data has not been parameterized, and the tapes contain one number for each five dimensional value. The format of the tapes is presented in Table 2. Notice that the order of the variables from the fastest to the slowest is energy, time, angle, range and source energy, and that the zeros for energies higher than the source energy are not written on the tape. Table 3 presents the energy bounds of the 22 x-ray and 25 gamma-ray energy groups. Because the gamma-ray tape covers the x-ray energies as well, it can also be used for x-ray calculations. However more accurate energy resolution will be obtained by using the x-ray tape for x-ray problems. These energy bands presented in Table 3 were used for both the source energy bands and the detector energy scoring bins.

The seventeen ranges for both x-rays and gamma-rays included in the data base were chosen as a number of mean-free-paths of the source energy. The data is presented as currents exactly at these ranges as calculated with a boundary crossing estimator. The first two radii are at

TABLE 2. FORMAT OF THE FLAIR DATA TAPE

Record 1 - 224 words

Hollerith header record giving references of the documents describing the work.

Record 2 - 600 words

Header record for each source energy band.

ISØR	-	source energy number
NR	-	number of radii
NE	-	number of energy bins
NT	-	number of time bins
NMU	-	number of angle bins
LENGTH	-	number of data for this source band = NR*(NE-ISØR+1)*NT*NMU
LBUFF	-	record length of each tape record for the data = 5000
NREC	-	number of records necessary to transmit LENGTH words. The last record may be a partial record.
ESØRHI	-	upper energy of source band (rest mass units)
ESØRLØ	-	lower energy of source band (rest mass units)
RBIN(18)	-	scoring radii (these are different for each source band as each DART calculation went out to 15 mean free paths)
EBIN(25)	-	energy bin boundaries (rest mass units)
TBIN(18)	-	time bin boundaries (seconds)
UBIN(6)	-	cosine bin boundaries
UNCØLD(18)	-	uncollided contribution at each radius
SIR(18)	-	fractional standard deviation of the total current at each radius

TABLE 2. (Cont'd.)

SIRE(450) - fractional standard deviations of the energy spectra total current at each radius. Energy is the fastest varying index.

Record 3 - 5000 words (or LENGTH if NREC = 1) of four dimensional differential currents. The order of variation of indices from fastest to slowest is NE, NT, NMU, NR.

Record 3 is repeated until the entire source band is completed.

Records 2 and 3 are then repeated until all source bands are completed.

TABLE 3. FLAIR X- AND GAMMA-RAY ENERGY BINS

Bin	gamma-ray upper energy bounds	x-ray upper energy bounds
1	14.0 MeV	300. keV
2	10.0	260.
3	8.0	220.
4	7.0	190.
5	6.0	160.
6	5.0	140.
7	4.0	120.
8	3.5	105.
9	3.0	90.
10	2.5	80.
11	2.0	70.
12	1.66	65.
13	1.33	60.
14	1.0	55.
15	800.0 keV	50.
16	600.0	45.
17	450.0	40.
18	300.0	35.
19	220.0	30.
20	160.0	25.
21	120.0	20.
22	90.0	15.
23	65.0	10. lower bound
24	45.0	
25	30.0	
	10.0 lower bound	

.25 and .66 mean-free-paths and the next 15 radii go from 1 to 15 mean-free-paths, respectively. Because the ranges depend on the source cross section, a calculation with a source energy spectrum will require a different range index and interpolation value for each source energy in the spectrum. Table 4 presents the 17 time bins and six angle bins used in both the x- and gamma-ray tapes.

The short initial record contains the boundaries, the uncollided contributions and fractional standard deviations of a few quantities in the data base. For angle folding and time convolution, FLAIR treats the uncollided flux as a seventh angle bin and an 18th time bin. Thus when converting current to flux, the uncollided can be given its correct response of 1.0 rather than the most forward angle bin's value of 1.2. Likewise when performing the time convolution, the uncollided is treated as a delta function contribution at time zero rather than averaged over the first time bin. At present FLAIR makes no use of the statistical information written on the first record.

2.2 GENERAL FORM OF INPUT CARDS

The input routines for FLAIR were borrowed from the ATR code[3] and as such have the same general format. Problem specifications are input in free-field format on various types of cards. An asterisk (*) indicates the start of a new card type. A character or characters following the asterisk indicate which type data will follow. For example ranges are input on *R cards, air density on a *DEN card, and the energy spectrum on a *ESOR card. Usually the units are specified after the type. For ranges, units on the *R card may be KM, KFT, MI, FT, M, CM, or GM (for grams/cm^2 of air). After the units, the values are specified on the remainder of the card or continued on further cards without an asterisk. Some card types do not contain values, but merely specify output or execution options. All input cards will be explained in the following sections which describe the FLAIR operations.

TABLE 4. FLAIR TIME AND ANGLE BINS

Bin	time bin lower bound	angle bin upper cosine
1	0.0	1.0
2	7.0(-9) sec	.666
3	1.5(-8)	.333
4	3.0(-8)	0.0
5	6.0(-8)	-.333
6	1.2(-7)	-.666
7	2.4(-7)	-1.0 lower bound
8	3.5(-7)	
9	6.0(-7)	
10	9.0(-7)	
11	1.2(-6)	
12	1.6(-6)	
13	2.0(-6)	
14	2.5(-6)	
15	3.2(-6)	
16	5.0(-6)	
17	9.0(-6)	
	1.5(-5) maximum time	

The list of values on a FLAIR (or an ATR) card is used to specify the numerical data a card may require. A number in a list may appear in a variety of forms to suit the particular user or problem. For example, some of the forms in which the number 400. may appear are as follows:

400 400. 4.E+2 4E+2 4+2 4000-1

At least one number must appear in a list of values. Two or more numbers are separated from one another by the occurrence of one or more blank characters. Therefore, the user is restricted from specifying a number in which internal blanks appear, or which is split on two or more card images. A further restriction exists upon the magnitude of such numbers: since a number is interpreted as a function of up to three integer parts (a whole part, a fractional part, and an exponent), none of the parts of a number may exceed in magnitude the greatest integer value appropriate to the host machine, nor can the number generated from these three parts exceed the host machine's allowable range of representable numbers.

2.3 RANGE INTERPOLATION AND DENSITY SCALING

Values can be calculated by a single FLAIR execution for up to 20 ranges. These ranges are input on the *R card which has the format

*R units values

where the units may be

KM - kilometers
KFT - 1000 feet
MI - miles
FT - feet

M - meters

CM - centimeter (default option used if units left blank)

GM - gram/cm^2 of air

More than one *R card may be used with different units, but the maximum number of ranges per run is 20. At least one *R card is required for each execution.

When the GM units option is used, the density known by FLAIR when the *R card is read is used to set the distance in centimeters. Therefore the density should not be changed by having a *DEN card after the *R card. If a density other than 1.29×10^{-3} gm/cm^3 (sea level) is desired, it should be set by a *DEN card before any *R GM cards are read.

Values are then obtained from the data base by semi-logarithmic interpolation on the ranges. If results are desired at RCALC, the data base is searched for the values at the radii immediately less and greater than RCALC. These values are stored respectively in two partitions of blank common (referred to as BC_{less} and $BC_{greater}$) and later interpolated into a third partition, BC_{sum}. The semi-logarithmic interpolation equations then are

$$BC_{sum} = BC_{greater}^{\alpha} \; BC_{less}^{(1-\alpha)}$$

where

$$\alpha = \frac{R_{greater} - RCALC}{R_{greater} - R_{less}} \quad .$$

If RCALC is greater than the maximum radius in the data base (15 mean-free-paths), then $BC_{sum} = 0$ is assumed. Likewise if RCALC is less than the minimum radius (.25 mean-free-paths), then $BC_{sum} = BC_{greater}$ is assumed for all values except the uncollided which is interpolated between 1.0 and the uncollided at the first radius.

FLAIR works by reading the data base tape and storing or summing the data in either a less than (BC_{less}) or a greater than ($BC_{greater}$) array in blank common when appropriate. After all the data for a single source energy have been processed, the two arrays are interpolated and summed into a third array (BC_{sum}) which contains the running sum over all source groups after interpolation. BC_{less} and $BC_{greater}$ are zeroed before reading the next source band.

FLAIR results can be scaled by air density by including a density on a *DEN card whose format is

*DEN units value

where the units may be

GM/CM3 - grams/cm^3 (default if no units are specified)
AT/BRNCM - atoms/barn-cm

If no density card is encountered, the sea level density of 1.29 x 10^{-3} gm/cm^3 is assumed. The data base calculations were performed at ρ_o = 1.00 x 10^{-3} gm/cm^3 air density. To scale the FLAIR results all input radii are multiplied by (ρ/ρ_o) to generate calculation radii (RCALC). The RCALC values are used for range interpolation while the input radii are used to divide the final results by $4\pi R^2$ if required. The time dependence is also scaled by multiplying the time bin boundaries by (ρ_o/ρ). In this manner values like photon/cm^2-sec will be divided by $(\rho/\rho_o)^3$, two factors from the radii and one from the time bins.

Unlike the ATR code, FLAIR does not have the air density table built in and as such cannot perform integral mass scaling automatically. However this can be done by hand by inputing the ranges with the GM (grams/cm^2) units option on the *R card and requesting $4\pi R^2$ results on the *EXC card (to be explained later). These results can then be divided by the real $4\pi R^2$ giving correct results for sources and detectors at different altitudes.

2.4 FOLDING AND OUTPUT OPTIONS

FLAIR allows the results to be folded with an arbitrary energy response and an arbitrary angular response. Two energy responses are built in; photons and energy (in several units). The photon response is all unity and the energy response is the average energy of the group in the desired units. Three angle responses are built in; they are current, forward current, and flux. Since the raw data is a current, the current response is all 1.0, the forward current response is three 1.0's and three zero's and the flux response is one over the average angle in an angle bin which is 1.2, 2., 6., 6., 2., and 1.2. An angle response of 1.0 is used to convert the uncollided from current to flux. These angle and energy response foldings are performed before the raw data is stored or summed in BC_{less} or $BC_{greater}$.

The user can also input his own energy or angle response with either a *ERESP or a *ARESP card. The format for the *ERESP card is

*ERESPn *title* values

n - 1 to 6 (maximum of 6 energy response cards) used to identify the response.

title - a maximum of 20 characters to be printed on output. If omitted ERESPn will be used.

values - one value needed for each energy bin from high energy to low energy.

A *ERESPn card is required if ERESPn or DERESPn appears on a *O, *T, or *P card. Similarly, the format for the *ARESPn card is

*ARESPn   *title*   values

n - 1 to 7 (maximum of 7 angle response cards) used to identify the response in the code.

title - maximum of 20 characters used to identify the response on the output. If omitted ARESPn will be assumed.

values - one value for each angle bin from forward to backward, plus one more for the uncollided. If the uncollided value is not included it will be set to the first value.

This card is required when ARESPn or DARESPn is specified on a *O, *T, or *P card.

FLAIR allows several output options which include all combinations of energy, angle, and time dependence at the desired ranges. In other words, the results may be integrated over any, all, or none of the angle, energy and time variables. Also final results may be per group, normalized per group, differential, or normalized and differential. All these options, as well as the desired response functions are specified on a *O card. The format of the *O card is as follows:

OUTPUT CARD

***O angle energy time type flag**

These parameters may occur in any order.

angle may be	or	angle dependent
FLUX		DFLUX
FCUR		DFCUR
CUR (default)		DCUR
ARESPn (7 is max. value of n)		DARESPn

energy may be	or	energy dependent
PH (default)		DPH
MEV		DMEV
KEV		DKEV
CAL		DCAL
ERESPn (6 is max. value of n)		DERESPn

time may be	or	time dependent
TIME (default)		DTIME
		DTSOR

type may be

G	for group data output
GN	for normalized group data output
D	for delta data output (default)
DN	for normalized delta data

flag may be blank or ONLY.

At least one *O card (or *P or *T card) is required for each problem execution. Notice that the angle, energy and time parameters specify both the response to be used with that variable and whether that variable is to be summed over or output with dependence. Thus FLUX causes the angle to be summed over with the flux response while DFLUX causes the angle dependence to be output as a flux. The equations then are

FLUX and DFLUX

$$O = \sum_{i=1}^{7} \text{ARESP (flux)}_i \, F_i \qquad\qquad O_i = \text{ARESP (flux)}_i \, F_i$$

where F_i is a quantity on the data tape. O and O_i then are values generated in the BC_{less} or $BC_{greater}$ arrays. Similar equations for energy and time also exist. For example if ERESP1 is a silicon flux to dose conversion (rad(Si)/(γ/cm^2)),

*O FLUX ERESP1 DTIME

generates the time dependent silicon dose. The summation performed would be

$$O_k = \sum_{i=1}^{NA} \sum_{j=1}^{NE} \text{ARESP (flux)}_i \, \text{ERESP1}_j \, F_{ijk}$$

$$k = 1, NT \quad .$$

For a second example

*O DFCUR DCAL

generates the time integrated forward current energy spectrum in units of calories with the angle dependence. Notice that the default value of TIME may be left blank. This summing operation generates a two dimensional array which looks like

$$O_{ij} = \sum_{k=1}^{NT} \text{ARESP (fcur)}_i \ \text{ERESP (cal)}_j \ F_{ijk}$$

$$i = 1, NA \qquad , \qquad j = 1, NE \quad .$$

The type parameter on the *O card may be used to modify the output units. The G option causes the results to be output as generated in FLAIR on a per group basis without dividing by any bin widths. The GN option causes any variable dependence to be normalized to 1.0 so that the sum over the entire array (it may be 1, 2, or 3 dimensional) will be 1.0. The D option (which is the default value) for delta data causes the unnormalized values to be divided by all appropriate bin widths. For angle the division is per cosine not per steradian. Thus the total integral over a D option results would equal a summation over the same G option results. The last option DN causes the data to be first normalized and then divided by all bin widths.

Normally the code also computes all lower level operations as well, so that if the user requests a three-dimensional array he will also get three two-dimensional arrays, three one-dimensional arrays, and a total value. Both printout and core storage can be minimized if ONLY is included on the *O card. In this case only the operation requested will be performed, and the lower order operations will be suppressed.

Two other cards, the *T and the *P cards, are identical to the *O card except that they also cause the results to be written to tape or punched respectively as well as printed. See the description of subroutine OUT2 in Section 3.2 for a description of the tape and punch formats.

2.5 SOURCE SPECTRUM AND YIELD NORMALIZATION

The source energy spectrum is specified on a *ESOR card which has the following format

*ESOR units values

units -		
PH	-	photons/group (default)
MEV	-	MeV/group
KEV	-	keV/group
CAL	-	calories/group
PH/MEV	-	differential photons/MeV
PH/KEV	-	differential photons/keV
E/E	-	either MeV/MeV or keV/keV
CAL/KEV	-	calories/keV differential

Values are from the highest energy group to the lowest energy group. If fewer are given than required, the lower energies will be assumed zero. One *ESOR card is required for each problem execution.

The multiplication by the energy source is performed at the same time as the range interpolation. After all data for a single source band is stored or summed in the BC_{less} and $BC_{greater}$ arrays (and the angle and energy responses are included), the data is interpolated on range, multiplied by the energy source intensity and summed into the BC_{sum} array.

The number of photons can be specified on a yield card or *Y. The format for the *Y card is as follows:

*Y units value

units -	PH	-	photons (default)
	KT	-	kilotons of photons
	MEV	-	total energy in MeV
	CAL	-	total energy in calories
	MT	-	megatons of photons
	MO	-	moles of photons

value - one value.

If the *Y card is omitted the source spectrum is determined from the normalization on the *ESOR card. If the *Y card is included, the normalization is set by the *Y card and any normalization that exists on the *ESOR card is ignored. The number of photons, the average energy of the photons and the yield of the photons in kilotons is always printed.

2.6 TIME CONVOLUTION

Time convolution of a time dependent source can be performed in FLAIR if the energy dependence and the time dependence of the source are assumed separable. Clearly time convolution is only important if the time dependence is desired. Therefore time convolution is signaled by DTSOR on the *O card (or *P or *T cards). The data for the time convolution is input on a *TSOR card which has the format

*TSOR $(t_k, w_k, k = 1, n)$

where t_k and w_k are time and weight pairs. t_k has units of seconds and w_k has units of photons. Figure 1 shows how w_k corresponds to the number of photons that can be assumed at the exact time t_k. Therefore w_k is equal to the area of the rectangle which is centered at t_k so that the time dependence is assumed to be n delta functions with corresponding weights. The code normalizes the w_k so that

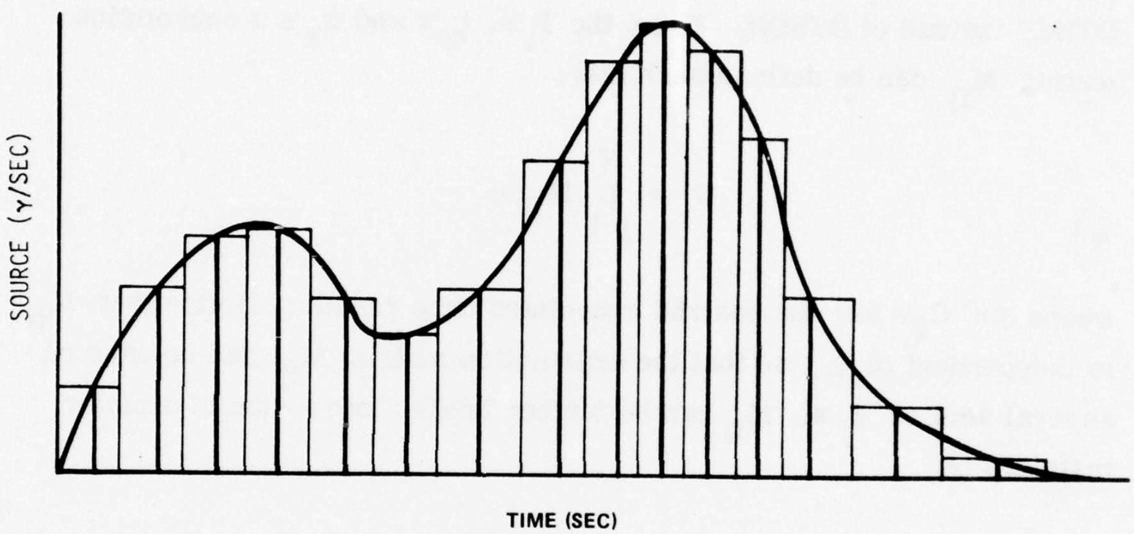

Figure 1. Representation of the Time Dependent Source for Time Convolution.

$$\sum_{k=1}^{n} w_k = 1.0 \quad .$$

The following discussion describes how the time convolution works in FLAIR. Let T_i be the present time bin boundaries which go from 0 to T_N and let φ_i be the time dependent value in the time bin between T_{i-1} and T_i. The φ_i's are calculated in FLAIR as if the *O card had been DTIME instead of DTSOR. From the T_i's, t_k's and w_k's a convolution matrix M_{ij} can be defined such that

$$C_i = \sum_{j=1}^{N} M_{ij} \varphi_j$$

where the C_i's are the desired convoluted time results. Notice that M_{ij} is independent of φ_j so that the convolution matrix M_{ij} can be used on several sets of φ_j's. M_{ij} can be further broken into a sum of simpler matrices by

$$M_{ij} = \sum_{k} w_k m_{ij}^{k} \quad .$$

where the matrices m_{ij}^{k} depend only on the T_i's and the one time t_k. Thus m_{ij}^{k} is the convolution matrix for a delta function source at a time other than zero.

For simplicity the k superscript is now dropped so that m_{ij} is defined as a function of the T_i's and the time t. Using linear interpolation, it can be seen that m_{ij} is defined by

$$m_{ij} = \begin{cases} 0 & \text{if} \quad T_{j-1} + t > T_i \\ 0 & \text{if} \quad T_j + t < T_{i-1} \\ 1 & \text{if} \quad T_{j-1} + t > T_{i-1} \\ & \quad \text{and} \quad t + T_j < T_i \\ \dfrac{T_i - T_{j-1} - t}{T_j - T_{j-1}} & \text{if} \quad t + T_{j-1} < T_i < t + T_j \\ \dfrac{T_j + t - T_{i-1}}{T_j - T_{j-1}} & \text{if} \quad T_{j-1} + t < T_{i-1} < T_j + t \end{cases}$$

where T_j are the same time bins as T_i. These equations can be seen by examining the overlap of two sets of time bins which are identical except that one is displaced by t. These expressions define the m_{ij}^k's which can be summed to define the total convolution matrix M_{ij}. The time convolution operation is performed in FLAIR after the non-convoluted time dependence has been calculated and after all source energy bands have been completed.

2.7 EXECUTION CARDS

Two additional cards need to be mentioned: the *EXC card and the ** card. The *EXC card or *EXC 4PIRSQ signals that the input is fully specified and FLAIR begins reading the data tape and calculating results. The 4PIRSQ option causes all output results (except normalized values) to be multiplied by $4\pi R^2$. If no 4PIRSQ appears on the *EXC card the results are per cm^2. After FLAIR finishes the problem, the data tape is rewound and FLAIR tries to read more input to specify another problem. The ** card terminates the job on a normal exit.

2.8 CORE STORAGE

As implied in this section but not yet stated the number of operations performed in a single calculation is limited by computer printout and blank common length. For each number printed, punched, or written to tape, three storage locations are required in blank common for BC_{less}, $BC_{greater}$, and BC_{sum}. In addition 5000 locations are used in BC to read the data tape records. Presently the entire code fits in $30,000_{10}$ locations with blank common set at $20,000_{10}$. This would allow one full three-dimensional operation with all lower operations as well. Blank common however can be reduced or increased to fit FLAIR on smaller or larger computers, with a corresponding change in number of operations which could be performed.

3. DOCUMENTATION OF FLAIR

This chapter documents the subroutines and variables used in the FLAIR code, and as such will be useful to programmers that are using or modifying FLAIR. The first section describes all variables used in the named commons and the second section documents the subroutines. Several routines used in the free-field input were borrowed from ATR and used as is by FLAIR. As such they are not documented in this report. It should be noticed that the description of subroutine CARDIN gives additional information about the input including discussion of errors in input.

3.1 DESCRIPTIONS OF FLAIR COMMON BLOCKS

Blank Common - Input and output data arrays

BUF(5000) - Contains one record of four dimensional differential flux data from FLAIRIT tape. The order of variation of indices from fastest to slowest is NEBIN, NTBIN, NUBIN, NRBIN.

BC(15000) - This array is divided into three parts, BC_{less}, $BC_{greater}$, and BC_{sum}. The length and composition of these subdivisions vary with the number and type of folding operations requested, as well as with the number of RCALC requested. The values associated with RBIN immediately less than RCALC are summed in BC_{less}. The values associated with the RBIN immediately larger than RCALC are summed in $BC_{greater}$. The interpolated results between BC_{less} and $BC_{greater}$ are accumulated in BC_{sum}. Each of these three arrays are further subdivided into NR arrays, one associated with each RCALC. Each of these is further subdivided into NIOP arrays, one for each folding operation. The storage requirements and layout for each type of fold array is described in Table 5.

TABLE 5. BC STORAGE FOR EACH TYPE OF FLAIR FOLDING OPERATION

Type of Operation	Storage Required	Location of Uncollided	Order of Variation of Indices[a]
No folding (total)	2	2	
Angle dependent	NUBIN	1	
Time dependent	NTBIN	1	
Time dependent, time convoluted	NTBIN+1	NTBIN+1	
Energy dependent	NEBIN	ISOR	
Angle, time dependent	NUBIN*NTBIN	1	NUBIN, NTBIN
Angle, time dependent, time convoluted	NUBIN*NTBIN+1	NUBIN*NTBIN+1	NUBIN, NTBIN
Angle, energy dependent	NUBIN*NEBIN	(ISOR-1)*NUBIN+1	NUBIN, NEBIN
Time, energy dependent	NTBIN*NEBIN	(ISOR-1)*NTBIN+1	NTBIN, NEBIN
Time, energy dependent, time convoluted	NTBIN*NEBIN+NEBIN	NEBIN+NTBIN+ISOR	NTBIN, NEBIN
Angle, time, energy dependent	NUBIN*NTBIN*NEBIN	(ISOR-1)*NUBIN*NTBIN+1	NUBIN, NTBIN, NEBIN
Angle, time, energy dependent, time convoluted	NUBIN*NTBIN*NEBIN+NEBIN	NHBIN*NTBIN*NEBIN+ISOR	NUBIN, NTBIN, NEBIN

[a] From fastest to slowest.

/ACCSRY/ - Hollerith constants for input processing subroutines.

IDP - decimal point.

IEX - letter E.

MIN - minus sign.

IPL - plus sign.

LPAR - left parenthesis.

IBLK - blank.

IRPAR - right parenthesis.

ISTR - asterisk.

/BIGGER/ - Maximum storage limit for BC.

LIMIT - maximum storage size for BC. By changing this value and changing the blank common card the program can be changed to use more or less storage.

/BINS/ - Bin structure information.

RBIN(20) - scoring radii in (centimeters), NRBIN values.

EBIN(30) - energy bin boundaries (rest mass units), NEBIN+1 values.

UBIN(10) - cosine bin boundaries, NUBIN values.

TBIN(20) - time bin boundaries.

UNCOLD(20) - uncollided number flux contribution at each scoring radii.

DELE(30) - 1/absolute value of the energy bin width.

DELT(20) - 1/absolute value of the time bin width.

DELU(10) - 1/absolute value of the angle bin width.

/CDATA/ - Input variables.

RCALC(20) - input radii converted to centimeters.

NIOP - number of folding operations requested.

NR - number of RCALC values.

RINPUT(20) - input radii converted to centimeters.

PIRSQ - = 0 if values are not multiplied by $4\pi R^2$
= 1 if values are multiplied by $4\pi R^2$.

ARHOL(7, 20) - Hollerith identifier associated with user supplied angular response functions ARESP1 to ARESP7.

ERHOL(7, 20) - Hollerith identifier associated with user supplied energy response functions ERESP1 to ERESP6.

Y - source yield, default value 1.0 photons.

ITSOR(25) - = 1 if time convolution desired
= 0 if not.

TSORT(50) - user supplied time values for time convolution.

TSORW(50) - user supplied weight associated with TSORT for time convolution.

NTSOR - number of TSORT, TSORW pairs.

/CESOR/ - Information about the source energy spectrum.

ESOR - source energy normalization.

ESBAR - average energy of the source spectrum.

SORN(27) - normalized source energy spectrum.

ESORKT - ESOR, converted to KT of photons.

YKT - Y, converted to KT of photons.

IXORG - = 1 for x-ray input tape
= 2 for gamma ray input tape.

/DIGIT/ - Hollerith constants for input handling subroutines.

IDG(10) - Hollerith representation of integers 0-9.

/FOLDER/ - Information needed to fold and output parameters requested.

IFOLD(25) - index defining each type of fold operation requested.

1 = no folding requested
2 = fold on angle parameter
3 = fold on time parameter
4 = fold on energy parameter
5 = fold on angle and time
6 = fold on angle and energy
7 = fold on energy and time
8 = fold on angle, time and energy.

IFOLDS(25) - the number of storage locations in BC required by each fold operation.

LFOLD(25) - location of first value of each operation in BC relative to the starting location of each output radii requested.

IFLAG(25) - index indicating the type of output requested for each operation.

1 = print delta data
2 = print group data
3 = print normalized delta data
4 = punch delta data
5 = punch group data
6 = punch normalized delta data
7 = write delta data tape
8 = write group data tape
9 = write normalized delta data on tape.

IR - index of source radii associated with a particular flux differential.

IE - index of energy bin associated with a particular flux differential.

IT - index of time bin associated with a particular flux differential.

IMU - index of cosine bin associated with a particular flux differential.

IANG(25) - index of angle response function requested for each operation; 1 -3 refer to built in response functions, 5-10 refer to input supplied functions.

NTNMU - NTBIN*NUBIN (number of time bins * number of cosine bins).

NTNE - NTBIN*NEBIN.

NTNUNE - NUBIN*NEBIN.

/NGXI/

ICC - used by ATR subroutines.

NGX - used by ATR subroutines.

ITCH - pointer to which character in ICH is currently being processed.

ICH(80) - 80 column input card image.

/OUTP/ - Input and output unit numbers.

NONPG - specifies maximum number of output values on a print line. Set at 8 by the program, can be set smaller to produce a narrower output page.

NOUT - output unit, set equal 6.

NIN - input unit, set equal 5.

/POINT/ - Storage information for FOLD.

LPOINT(19) - the nth value points to location in KPOINT associated with the nth RBIN.

KPOINT(40) - locations in BC_{less} and $BC_{greater}$ to be used by FOLD.

LS(18) - the number of locations in KPOINT associated with each RBIN.

PL(20) - used to interpolate final sum to the requested RCALC.

PG(20) - used to interpolate final sum to the requested RCALC.

Further explanation of LPOINT, KPOINT, and LS is required since they direct the storage of data in the blank common array BC. Whenever data from a new radius (IR) is read, LS(IR) is examined to determine how many RCALC's will need this data for interpolation. If LS(IR) is zero, the data at this radius is skipped. LPOINT(IR) then points to a location in KPOINT where locations in BC are stored. LS(IR) locations in BC are stored in KPOINT beginning at LPOINT(IR). Thus the data will be stored in BC LS(IR) times, and the locations of these stores are stored in the KPOINT array beginning at LPOINT(IR).

/RESP/ - Response functions.

SOR(1, 27) - input on *ESOR card.

RANG(10, 7) - ten angular response functions of NUBIN+1 values each. Functions 1 through 3 are built into the code, 4-10 may be input.

RENG(10, 27) - ten energy response functions with NEBIN values each. Functions 1 through 4 are preset, 5-10 may be input.

/TDATA/ - Contains data read from input tape.

ISOR	-	source energy number.
NRBIN	-	number of radii for source energy band.
NEBIN	-	number of energy bins.
NTBIN	-	number of time bins.
NUBIN	-	number of angle bins.
LENGTH	-	number of data for this source band = NRBIN*(NEBIN-ISOR+1)*NTBIN*NUBIN.
IBUF	-	length of FLAIRIT input record = 5000.
NREC	-	number of records necessary to transmit LENGTH words. The last record may be a partial record.
ESORHI	-	upper energy of source band (rest mass units).
ESORLO	-	lower energy of source band (rest mass units).

3.2 FLAIR SUBROUTINE DESCRIPTION

Subroutine CARDIN

This subroutine initializes and selects default values for required program variables. A test is made to determine the type of card being read, then a branch executed to the appropriate code for processing.

The *R card is checked for units. If none have been specified, centimeters are assumed. The values are read and converted to centimeters if necessary. More than one *R card may be used to input a maximum of 20 radii.

The *O card is searched for various parameters which may be in any order. Default values are set for any that are missing. A blank *O card will be interpreted as *O PH CUR TIME D. Any duplicate parameters on the card will be ignored. The *T and *P cards are processed in the same manner as a *O card, except tape or punch output is flagged.

The *ARESPn card is searched for a title (maximum 20 characters) flagged with a * before and after. If none is found ARESPn will be used. NUBIN or NUBIN+1 values are required. The NUBIN+1 value is applied to the uncollided component. If it is omitted it will be set equal to the first value. If less than NUBIN values are read, the card will be flagged as illegal. A maximum of 7 *ARESP cards may be used.

The *ERESPn card is also searched for a title (maximum 20 characters). If no title has been punched, ERESPn will be used. The program expects NEBIN values. If too few values are found, the card will be considered illegal. A maximum of 6 *ERESP cards may be used.

The *ESOR card is checked for units. If no units are specified photons/group are assumed. The values are read and converted to program units if necessary. If less than NEBIN values are input, the array will be zero filled. These values are summed to obtain the source normalization, and then used to compute average energy of the source spectrum. Only one *ESOR card is used per *EXC card. Duplicate *ESOR cards will be ignored.

The *DEN card is checked for units. If the units have been left blank, GM/CM^3 are assumed. The value read from the card is converted to program units if necessary. If no value is found, the card will be ignored. If the *DEN card is not encountered the code uses the default value of 1.29×10^{-3} GM/CM^3. If more than one *DEN is found it will be ignored.

The *TSOR card is read and checked for an even number of values. The program expects time-weight pairs, i.e.,

*TSOR Time 1 Weight 1 Time 2 Weight 2 ...

Any additional *TSOR cards are ignored.

The *Y card is checked for unit specification. If it has been omitted, units of photons are assumed. One value is expected by the code. If one is not found, the card will be considered illegal and be ignored. The value that is found, is converted to program units and is used instead of the source normalization computed from the *ESOR card. The *Y card is optional and only one should occur before each *EXC card. Additional ones will be ignored.

The *EXC signals end of all cards needed to process one batch job. If 4PIRSQ appears on the card, $4\pi R^2$ values will be output.

The ** card signals end of job. The size of BC limits the number of operations that can be processed at one pass as a function of number of radii and type of operation. Multiple batches can be processed on one run. If the ** card does not follow the *EXC card the code attempts to process another batch.

After the *EXC has been read, CARDIN checks to see if enough information has been input to proceed. If required information is missing and no default can be supplied, the program stops with an error message.

A synopsis of the folding operations requested is printed to tell the user how the code has interpreted the input cards. If all criteria to proceed have been satisfied control returns to the main program.

Subroutines GETVAL, RDWRTC, FREFNO, INTERR, INGET, NNBCHR were borrowed from ATR to be used by CARDIN. These routines convert Hollerith data to floating point or integer values.

Called from: FLAIR.

Subroutines called: GETVAL, RDWRTC, NNBCHR, NCHR.

Commons required: Blank, ACCSRY, BIGGER, BINS, CDATA, CESOR, DIGIT, FOLDER, IRDINK, NGXI, OUTP, RESP.

Variables required: See input instructions in Appendix A and throughout the text of Section 2.

Main Program **FLAIR**

FLAIR sets the storage limit for BC and initializes it to zero. The first record of the data tape (tape 3) is read to determine if it is an x-ray tape or gamma-ray tape.

The first record or header record associated with ISOR=1 is read to determine bin structure. The header record for succeeding source groups will be ignored except for values which change, i.e., ISOR, LENGTH, NREC, ESORHI, ESORLO, RBIN and UNCOLD).

Subroutine CARDIN is called to read and process all input cards up to and including a *EXC card. An error in input will cause a program stop in CARDIN.

If source energy group ISOR has been requested by the *ESOR card, RTEST is called to determine which source energy radii are needed to compute values of BC_{less} and $BC_{greater}$. The data corresponding to each flagged RBIN is processed, other data is ignored. A call to UNPR gives values of IE, IT, IMU, IR for each data value. FOLD adds the value to appropriate location in BC_{less} or $BC_{greater}$. When all records associated with source group ISOR have been read, the uncollided component is added through a call to entry UNCOLL.

All values in the BC_{less} and $BC_{greater}$ arrays are modified by the source normalization or by the value input on the *Y card. SUM is called to interpolate between BC_{less} and $BC_{greater}$ and add to the accumulative totals in BC_{sum}. Each required source group is handled in the same manner until all required groups are processed.

If $4\pi R^2$ values have not been requested, BC_{sum} is divided by $4\pi R^2$. If time convolution is requested TIMCON is called. If x-ray data is being input EBIN is converted to keV for output. After a call to OUTPUT, the input tape is rewound and control returns to the beginning to work on the next batch if one has been requested.

Subroutines called: CARDIN, RTEST, UNPR, FOLD, SUM, TIMCON, OUTPUT.

Commons required: Blank, BINS, FOLDER, RESP, TDATA, CDATA, POINT, OUTP, BIGGER, CESOR.

Units required: INPUT, OUTPUT, TAPE5=INPUT, TAPE6= OUTPUT, TAPE3.

Optional units: TAPE7, TAPE8.

Subroutine FOLD (IOP, IWAY, DATA)

Subroutine FOLD processes one value of differential flux (DATA) on each call. Knowing the corresponding angle bin (IMU) and energy bin (IE), DATA is multiplied by the proper angle and energy response function. Using the pointers determined by RTEST and knowing the type of folding operation requested, the proper storage locations in BC_{less} or $BC_{greater}$ can be determined. DATA is then added to the computed locations.

The entry UNCOLL is used to add the uncollided component to the proper location, after being modified by the angle and energy response functions. See the layout of BC_{less} and $BC_{greater}$ in the blank common description.

Called from: FLAIR.

Subroutines called: none.

Entry points: UNCOLL.

Commons required: Blank, FOLDER, POINT, RESP, TDATA.

Variables required:

IOP - index of current folding operation.

IWAY - index for a computed GO TO

1 = total operation (no folding)
2 = angle dependent operation
3 = time dependent operation
4 = energy dependent operation

5 = angle and time dependent operation
6 = angle and energy dependent operation
7 = time and energy dependent operation
8 = angle, time and energy dependent operation
9 = total operation uncollided
10 = angle and time dependent, time convoluted, uncollided
11 = time dependent, time convoluted, uncollided
12 = time and energy dependent, time convoluted, uncollided
13 = angle, time and energy dependent, time convoluted, uncollided

DATA - the current four-dimensional differential flux value.

Variables changed: each call to FOLD changes all locations in BC_{less} and $BC_{greater}$ requiring DATA.

Subroutine OUTPUT (IOP, LE, L)

Subroutine OUTPUT offers four printed output options; group data, normalized group data, delta data and normalized delta data. If an option has not been specified on the *O card read by CARDIN, delta data will be selected.

If group data is desired the BC_{sum} array is output as is. If normalized group data is flagged, each value in BC_{sum} for this fold operation will be divided by the sum of these values, and then output. If delta data is requested, each value in BC_{sum} associated with the fold operation is divided by the appropriate delta values. If normalized delta values are requested, the appropriate BC_{sum} array is divided by the array sum and by the required delta values.

Appropriate titles are selected to define the output to the user. One fold operation is output with each call to OUTPUT. The maximum number of columns output per page is set by NONPG. The code sets NONPG=8, this can be reduced to produce a narrower page if desired. If an entire line of output is all zeros, it will not be printed.

Card or tape output are available through a call to OUT2. Printed output will also be produced.

Called from: **FLAIR.**

Subroutines called: OUT2.

Commons required: Blank, BINS, CDATA, CESOR, DIGIT, FOLDER, OUTP, TDATA.

Variables required:

IOP - index indicating the fold operation being output.

LE - starting location in BC_{sum} for operation IOP at the first radius.

L - the number of locations associated with one radius.

Variables changed: If other than group data is requested, the storage locations in BC_{sum} associated with operation IOP are changed as requested.

Subroutine OUT2 (ITAPE, IOP, LE, L, IFOLDS)

If punched output is requested, the first card contains IOP, RCALC(I), IFOLDS. Format is I5, 5X, E10.4, I10. Then IFOLDS values from BC_{sum} are punched with format 8E10.4. This pattern is repeated for each RCALC.

If a tape is desired, 2 records of unformatted data are written for each RCALC. The first record contains IOP, RCALC(I), IFOLDS. The second record contains IFOLDS values from BC_{sum} associated with IOP and RCALC(I).

Called from: OUTPUT.

Subroutines called: none.

Commons required: CDATA.

Variables required:

ITAPE	-	file to be punched or written.
IOP	-	index of current fold operation.
LE	-	starting location of BC_{sum}.
L	-	number of locations associated with each RCALC.
IFOLDS	-	number of storage locations to output.

Subroutine RTEST

Subroutine RTEST is called once for each source energy band to be processed. The code determines which source energy band radii (RBIN(J)) will be needed for storing values in BC_{less} and $BC_{greater}$. It further decides how many times RBIN(J) associated values will be stored and the starting locations for each store.

Values for PG(I) and PL(I) are computed for each requested input radius (RCALC(I)) to be used later by SUM to interpolate the results between BC_{less} and $BC_{greater}$.

If RCALC(I) is less than RBIN(1), nothing will be stored in BC_{less}. Later the $BC_{greater}$ value will be added to BC_{sum}. If RCALC(I) is greater than RBIN(NEBIN), nothing is stored in BC_{less} or $BC_{greater}$. Later a value of zero will be added to BC_{sum}.

Called from: FLAIR.

Subroutines called: none.

Commons required: BINS, CDATA, FOLDER, POINT, TDATA.

Variables required: none.

Variables changed:

LPOINT(19)-	LPOINT(J)+1 points to the first location in KPOINT to find the first BC storage location for data associated with RBIN(J).

KPOINT(40) - starting locations in BC_{less} and $BC_{greater}$ to be used by FOLD.

LS(18) - LS(J) gives the number of locations in KPOINT associated with RBIN(J).

PL(20) - power applied to BC_{less} during interpolation process. One value for each RCALC.

PG(20) - power applied to $BC_{greater}$ during interpolation process. One value for each RCALC.

Subroutine SUM

After all required data has been read for one source energy group, SUM is called to interpolate between BC_{less} and $BC_{greater}$. If PL equals zero, no interpolation is required, and the $BC_{greater}$ value is added to BC_{sum}. If PL is non zero, a semilog interpolation is used to determine the value added to BC_{sum}.

Called from: FLAIR.

Subroutines called: none.

Commons required: Blank, CDATA, FOLDER, POINT.

Variables required: none.

Variables changed: all values of BC_{sum}; BC_{less} and $BC_{greater}$ are set to zero upon return to FLAIR.

Subroutine TIMCON

Subroutine TIMCON is called if time convolution has been requested. The values of TSORT and TSORW are processed to create a matrix M. The type of fold operation is determined in order to properly set the DO index and incrementing parameters needed to access correct values in BC_{sum}. One fold operation is handled at a time. All collided components are multiplied by matrix M and summed in vector C. The BC_{sum} values are then replaced by C. The uncollided component is added to the proper location in BC_{sum}.

Called from: FLAIR.

Subroutines called: none.

Commons required: Blank, BINS, CDATA, FOLDER, TDATA.

Variables required:

J1	-	J1+1 is location of first word of BC_{sum}.
L	-	number of locations associated with one RCALC.

Variables changed: locations in BC_{sum} which should be time convoluted.

Subroutine UNPR(I)

Subroutine UNPR computes or "unpacks" the indices IR, IE, IT, and IMU for the Ith differential flux. I was computed in DART using the following equation

I = IE + NEBIN (IT-1+NTBIN*(IMU-1+NUBIN*(IR-1)))

where IE runs from ISOR to NEBIN.

The subroutine checks if the correct value of I is one greater than the last one processed. If it is, a short cut is used to determine IR, IE, IT and IMU.

Called from: FLAIR.

Subroutines called: none.

Commons required: FOLDER, TDATA.

Variables required:

I	-	index to be unpacked, varies from 1 to LENGTH.

Variables changed:

IR	-	index of associated radii.
IE	-	index of associated energy bin.
IT	-	index of associated time bin
IMU	-	index of associated cosine bin.

REFERENCES

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APPENDIX A

SUMMARY OF FLAIR INPUT INSTRUCTIONS

The following card types are available in FLAIR:

*R
*O
*T
*P
*DEN
*ESOR
*Y
*TSOR
*ARESPn
*ERESPn
*EXC
**

The * is punched in column 1, the identifier follows immediately with no blanks allowed.

Each run requires at least one *R card, at least one *O card (or *T or *P), an *ESOR card, and an *EXC card.

The parameters on each card are separated by one or more blanks. Parameters may be continued on a second card, except for the *O, *T, *P cards.

Range Card - Sets the ranges where results will be calculated.

*R units values

units may be KM, KFT, MI, FT, M, CM (default), GM

More than one *R card may be used. Maximum number of radii per run is 20.

Density Card - Sets the air density.

*DEN units values

units may be GM/CM^3 (default), AT/BRNCM

If *DEN card is omitted a value of 1.29×10^{-3} gm/cm^3 will be used.

Source Spectrum Card - Defines the energy dependence of the source.

*ESOR units values

units may be PH (default), MEV, KEV, CAL, PH/MEV, PH/KEV, E/E, CAL/KEV

One *ESOR card is required for each execution. Any normalization that exists on the *ESOR card is over-ridden by a yield card.

Yield Card - Sets the source normalization.

*Y units values

units may be PH (default), KT, MEV, CAL, MT, MO

If used, a yield card over-rides the source normalization used on the *ESOR card.

Output Card - Specifies the output including responses, dimensionality of results and form of output.

*O angle energy time type flag

These parameters may occur in any order.

angle may be	or	angle dependent
FLUX		DFLUX
FCUR		DFCUR
CUR (default)		DCUR
ARESPn (7 is max. value of n)		DARESPn

energy may be	or	energy dependent
PH (default)		DPH
MEV		DMEV
KEV		DKEV
CAL		DCAL
ERESPn (6 is max. value of n)		DERESPn

time may be	or	time dependent
TIME (default)		DTIME
		DTSOR

type may be

G	for group data output
GN	for normalized group data output
D	for delta data output (default)
DN	for normalized delta data

flag may be blank or ONLY.

If ONLY is specified, only the operation requested will be output. If left blank,all lower level operations will be output as well. For example, if a time and angle dependent operation is requested, the time dependent output, the angle dependent output, and the total data will be output.

Tape Card - Specifies output to tape.

*T angle energy time type flag

This is the same as an *O card, but data will be written on tape unit 7.

Punch Card - Specifies output to punch.

*P angle energy time type flag

This is the same as an *O card, but data will be written on unit 8 for punching.

Angle Response Card - Sets user input angle response.

*ARESPn *title* values

n = 1, 7 (maximum of 7 angle response cards)

title - is a maximum of 20 characters enclosed by asterisks, if omitted ARESPn will be used.

values - one value needed for each angle bin, plus one more for uncollided data. If last value not input it will be set equal to the first value.

This card required when ARESPn or DARESPn is specified on *O, *T or *P cards.

Energy Response Card - Sets user input energy response.

*ERESPn *title* values

n = 1, 6 (maximum of 6 energy response cards)

title - is a maximum of 20 characters enclosed by asterisks, if omitted ERESPn will be used.

values - one value needed for each energy bin.

This card required when ERESPn or DERESPn is specified on *O, *T or *P cards.

Execution Cards - Indicates completion of input.

*EXC or *EXC 4PIRSQ

The *EXC card signals the end of input batch. If 4PIRSQ is specified all values are multiplied by $4\pi R^2$ where R is the radius in centimeters.

End of Job Card - Indicates end of job.

**

The ** card signals end of job, allowing multiple batches each ending with the *EXC card. If ** card is missing job will terminate trying to read the next batch after finishing the previous batch.

APPENDIX B

THREE SAMPLE FLAIR CALCULATIONS

This Appendix presents three sample FLAIR calculations that were selected to demonstrate both the use and utility of the FLAIR code. The first two are x-ray calculations with a 15 kT blackbody spectrum and the third is a gamma-ray calculation. To execute FLAIR either the x-ray or the gamma-ray data tape which ever is appropriate must be mounted on unit three. The input cards used for the sample problems are listed as part of the problem output. Each of the three problems executes in less than 14 seconds on a CDC 7600 computer for a cost of less than five dollars each.

The first calculation computes forward current calories from a 15 kT blackbody source at thirteen ranges, giving both total calories and energy spectra. The second sample calculation demonstrates time convolution as well as other options. Again the x-ray source is a 15 kT blackbody this time at a 1000 ft range. Time dependence is calculated with all the source at time zero and with the source spread over two shakes (2×10^{-8} seconds). Energy spectra and angle dependence are also calculated. The third calculation is a gamma-ray calculation that demonstrates the use of the user input energy and angle response functions. The assumed response functions represent dose in rads(Si) in a missile vulnerability calculation, although the response function themselves are ficticious and do not relate to any existing missile. The gamma-ray source spectrum also is ficticious and is to be used only as a sample problem. Fluences and sample missile responses are calculated at three ranges.

SAMPLE PROBLEM 1

FLAIR XRAY DATA TAPE

BY
SCIENCE APPLICATIONS, INC, LA JOLLA, CALIF
JANUARY 1974

CONTRACT DAAD05-73-C-0154

BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

REFERENCES

1. W. A. WOOLSON, D. L. HUFFMAN, W. H. SCOTT,JR., AND W. A. COLEMAN, DART- A MONTE CARLO CODE FOR ATMOSPHERIC TRANSPORT OF X-RAYS AND GAMMA RAYS, SCIENCE APPLICATIONS, INC., LA JOLLA, CALIF, SAI-74-515-LJ, (MARCH 1974)

2. W. H. SCOTT,JR, AND H. L. COLBORN, FLAIR- A SCALING AND FOLDING CODE FOR THE GENERATION OF PHOTON TRANSPORT RESULTS IN AIR, SCIENCE APPLICATIONS, INC., LA JOLLA, CALIF., SAI-74-516-LJ, (MARCH 1974)

3. W. H. SCOTT,JR., W. A. WOOLSON, AND D. L. HUFFMAN, PHOTON TRANSPORT IN AIR INCLUDING COHERENT AND INCOHERENT SCATTERING WITH DART, SCIENCE APPLICATIONS, INC., LA JOLLA, CALIF, SAI-74-517-LJ, (MARCH 1974)

LIST OF INPUT

```
*ESOR PH/KEV 2,3340-09 2,443-08 1,667-07 8,909-7 3,252-6 9,230-6 2,175-5
  4,433-5 7,790-5 1,150-4 1,572-4 1,875-4 2,223-4 2,587-4 3,044-4 3,442-4
   3,813-4 4,152-4 4,370-4 4,412-4 4,198-4 3,634-4
*R KFT 1 2 3 4 5 6 7 8 9 10 11 12 13
*O DCAL FCUR D
*Y  KT 1
*DEN     ,0001
*EXC
```

SOURCE ENERGY SPECTRUM

	UPPER ENERGY (KEV)	INPUT (PHOTONS/ KEV)	PHOTONS/GROUP	NORMALIZED PHOTONS/GROUP
1	,3000E+03	,2334E-08	,9336E-07	,4083E-05
2	,2600E+03	,2443E-07	,9772E-06	,4274E-04
3	,2200E+03	,1667E-06	,5001E-05	,2187E-03
4	,1900E+03	,8909E-06	,2673E-04	,1169E-02
5	,1600E+03	,3252E-05	,6504E-04	,2845E-02
6	,1400E+03	,9230E-05	,1846E-03	,8074E-02
7	,1200E+03	,2175E-04	,3262E-03	,1427E-01
8	,1050E+03	,4433E-04	,6649E-03	,2908E-01
9	,9000E+02	,7790E-04	,7790E-03	,3407E-01
10	,8000E+02	,1150E-03	,1150E-02	,5030E-01
11	,7000E+02	,1572E-03	,7860E-03	,3438E-01
12	,6500E+02	,1875E-03	,9375E-03	,4100E-01
13	,6000E+02	,2223E-03	,1111E-02	,4861E-01
14	,5500E+02	,2587E-03	,1293E-02	,5657E-01
15	,5000E+02	,3044E-03	,1522E-02	,6657E-01
16	,4500E+02	,3442E-03	,1721E-02	,7527E-01
17	,4000E+02	,3813E-03	,1906E-02	,8339E-01
18	,3500E+02	,4152E-03	,2076E-02	,9080E-01
19	,3000E+02	,4370E-03	,2185E-02	,9557E-01
20	,2500E+02	,4412E-03	,2206E-02	,9649E-01
21	,2000E+02	,4198E-03	,2099E-02	,9181E-01
22	,1500E+02	,3634E-03	,1817E-02	,7947E-01

AVERAGE ENERGY OF SOURCE SPECTRUM IS ,4333E+02 KEV

SOURCE NORMALIZATION IS ,2286E-01 PHOTONS

WHICH IS EQUIVALENT TO ,3794E-28 KT OF PHOTONS

YIELD CARD ENCOUNTERED

SOURCE NORMALIZATION CHANGED TO ,6027E+27 PHOTONS

WHICH IS EQUIVALENT TO ,1000E+01 KT OF PHOTONS

SAMPLE PROBLEM 1

FLAIR XRAY DATA TAPE

BY
SCIENCE APPLICATIONS, INC, LA JOLLA, CALIF
JANUARY 1974

CONTRACT DAAD05-73-C-0154

BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

REFERENCES

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2. W. H. SCOTT,JR. AND H. L. COLBORN, FLAIR- A SCALING AND FOLDING CODE FOR THE GENERATION OF PHOTON TRANSPORT RESULTS IN AIR, SCIENCE APPLICATIONS, INC., LA JOLLA, CALIF., SAI-74-516-LJ, (MARCH 1974)

3. W. H. SCOTT,JR., W. A. WOOLSON, AND D. L. HUFFMAN, PHOTON TRANSPORT IN AIR INCLUDING COHERENT AND INCOHERENT SCATTERING WITH DART, SCIENCE APPLICATIONS, INC., LA JOLLA, CALIF, SAI-74-517-LJ, (MARCH 1974)

```
RADII IN CENTIMETERS
  1  3,04801E+04
  2  6,09601E+04
  3  9,14402E+04
  4  1,21920E+05
  5  1,52400E+05
  6  1,82880E+05
  7  2,13360E+05
  8  2,43840E+05
  9  2,74321E+05
 10  3,04801E+05
 11  3,35281E+05
 12  3,65761E+05
 13  3,96241E+05

RESULTS ARE NOT 4PIR**2

DENSITY= ,1000E-03

OPERATION    DEPENDENCE    ANGLE RESP   ENERGY RESP   GROUP   NORMALIZED   DELTA   CARDS   TAPE   TSUR

   1               ENERGY    FCUR          CAL                                *

   2                         FCUR          CAL                                *

OPERATION   1  ABSOLUTE      ENERGY DEPENDENT

ENERGY RESPONSE IS CALORIES

ANGLE  RESPONSE IS FORWARD CURRENT

RESULTS ARE PER KEV
```

	UPPER ENERGY	RADII (CM) 3.048E+04	6.096E+04	9.144E+04	1.219E+05	1.524E+05	1.829E+05	2.134E+05	2.438E+05
1	3.000E+02	4.269E-05	8.061E-06	2.699E-06	1.142E-06	5.500E-07	2.873E-07	1.584E-07	9.099E-08
2	2.600E+02	3.850E-04	7.303E-05	2.457E-05	1.040E-05	5.016E-06	2.627E-06	1.447E-06	8.315E-07
3	2.200E+02	2.225E-03	4.191E-04	1.396E-04	5.854E-05	2.802E-05	1.454E-05	7.938E-06	4.525E-06
4	1.900E+02	1.021E-02	1.933E-03	6.457E-04	2.714E-04	1.304E-04	6.746E-05	3.682E-05	2.096E-05
5	1.600E+02	3.182E-02	6.021E-03	2.000E-03	8.360E-04	4.012E-04	2.059E-04	1.119E-04	6.322E-05
6	1.400E+02	7.947E-02	1.525E-02	5.101E-03	2.151E-03	1.038E-03	5.329E-04	2.905E-04	1.635E-04
7	1.200E+02	1.645E-01	3.198E-02	1.073E-02	4.553E-03	2.199E-03	1.131E-03	6.171E-04	3.454E-04
8	1.050E+02	3.008E-01	5.995E-02	2.031E-02	8.727E-03	4.219E-03	2.178E-03	1.185E-03	6.654E-04
9	9.000E+01	4.726E-01	9.604E-02	3.269E-02	1.421E-02	6.873E-03	3.567E-03	1.940E-03	1.069E-03
10	8.000E+01	6.456E-01	1.357E-01	4.679E-02	2.071E-02	1.004E-02	5.244E-03	2.854E-03	1.608E-03

11	7.000E+01	8.063E-01	1.726E-01	5.969E-02	2.668E-02	1.298E-02	6.816E-03	3.715E-03	2.094E-03
12	6.500E+01	9.187E-01	1.997E-01	6.977E-02	3.142E-02	1.534E-02	8.067E-03	4.409E-03	2.490E-03
13	6.000E+01	1.025E+00	2.254E-01	7.952E-02	3.604E-02	1.766E-02	9.301E-03	5.089E-03	2.872E-03
14	5.500E+01	1.115E+00	2.465E-01	8.779E-02	4.002E-02	1.969E-02	1.038E-02	5.668E-03	3.193E-03
15	5.000E+01	1.191E+00	2.608E-01	9.321E-02	4.224E-02	2.073E-02	1.089E-02	5.931E-03	3.332E-03
16	4.500E+01	1.197E+00	2.548E-01	9.062E-02	4.033E-02	1.960E-02	1.020E-02	5.511E-03	3.077E-03
17	4.000E+01	1.111E+00	2.209E-01	7.596E-02	3.249E-02	1.534E-02	7.806E-03	4.151E-03	2.285E-03
18	3.500E+01	9.097E-01	1.573E-01	4.868E-02	1.898E-02	8.406E-03	4.067E-03	2.087E-03	1.121E-03
19	3.000E+01	5.987E-01	7.778E-02	1.862E-02	5.943E-03	2.288E-03	1.009E-03	4.883E-04	2.532E-04
20	2.500E+01	2.624E-01	1.899E-02	2.673E-03	5.576E-04	1.600E-04	5.933E-05	2.635E-05	1.315E-05
21	2.000E+01	4.745E-02	1.067E-03	5.201E-05	4.201E-06	5.348E-07	1.636E-07	6.815E-08	3.452E-08
22	1.500E+01	8.808E-04	2.333E-07	1.797E-09	2.174E-11	4.755E-13	2.013E-14	1.340E-15	3.028E-16
23	1.000E+01								

RADII (CM)

	UPPER ENERGY	2.743E+05	3.048E+05	3.353E+05	3.658E+05	3.962E+05
1	3.000E+02	5.394E-08	3.268E-08	2.021E-08	1.270E-08	8.071E-09
2	2.600E+02	4.929E-07	2.985E-07	1.845E-07	1.158E-07	7.355E-08
3	2.200E+02	2.651E-06	1.568E-06	9.723E-07	6.045E-07	3.808E-07
4	1.900E+02	1.223E-05	7.316E-06	4.454E-06	2.748E-06	1.719E-06
5	1.600E+02	3.663E-05	2.180E-05	1.317E-05	8.079E-06	5.021E-06
6	1.400E+02	9.467E-05	5.612E-05	3.376E-05	2.065E-05	1.276E-05
7	1.200E+02	1.999E-04	1.177E-04	7.053E-05	4.283E-05	2.630E-05
8	1.050E+02	3.850E-04	2.263E-04	1.356E-04	8.209E-05	5.026E-05
9	9.000E+01	6.290E-04	3.696E-04	2.207E-04	1.331E-04	8.119E-05
10	8.000E+01	9.265E-04	5.449E-04	3.250E-04	1.962E-04	1.194E-04
11	7.000E+01	1.205E-03	7.057E-04	4.197E-04	2.528E-04	1.539E-04
12	6.500E+01	1.436E-03	8.415E-04	5.009E-04	3.016E-04	1.837E-04
13	6.000E+01	1.657E-03	9.706E-04	5.772E-04	3.467E-04	2.106E-04
14	5.500E+01	1.841E-03	1.080E-03	6.419E-04	3.849E-04	2.333E-04
15	5.000E+01	1.911E-03	1.117E-03	6.627E-04	3.981E-04	2.415E-04
16	4.500E+01	1.756E-03	1.020E-03	6.019E-04	3.593E-04	2.170E-04
17	4.000E+01	1.290E-03	7.439E-04	4.353E-04	2.584E-04	1.554E-04
18	3.500E+01	6.224E-04	3.546E-04	2.061E-04	1.219E-04	7.320E-05
19	3.000E+01	1.374E-04	7.710E-05	4.457E-05	2.624E-05	1.561E-05
20	2.500E+01	6.964E-06	3.876E-06	2.216E-06	1.297E-06	7.723E-07
21	2.000E+01	1.869E-08	1.020E-08	5.580E-09	3.428E-09	2.217E-09
22	1.500E+01	3.544E-21	0.	0.	0.	0.
23	1.000E+01					

OPERATION 2 TOTALS (NOT 4PIR**2)

ENERGY RESPONSE IS CALORIES

ANGLE RESPONSE IS FORWARD CURRENT

SOURCE NORMALIZATION IS .6027E+27 PHOTONS WHICH IS EQUIVALENT TO .1000E+01 KT OF PHOTONS

RADIUS (CM)	UNCOLLIDED	SCATTERED	TOTAL
3.048E+04	4.111E+01	2.529E+01	6.640E+01
6.096E+04	5.538E+00	7.792E+00	1.333E+01
9.144E+04	1.373E+00	3.176E+00	4.549E+00
1.219E+05	4.400E-01	1.551E+00	1.991E+00
1.524E+05	1.627E-01	7.971E-01	9.598E-01
1.829E+05	6.606E-02	4.319E-01	4.980E-01
2.134E+05	2.863E-02	2.412E-01	2.698E-01
2.438E+05	1.303E-02	1.381E-01	1.511E-01
2.743E+05	6.163E-03	8.058E-02	8.674E-02
3.048E+05	3.006E-03	4.772E-02	5.073E-02
3.353E+05	1.504E-03	2.862E-02	3.012E-02
3.658E+05	7.686E-04	1.734E-02	1.811E-02
3.962E+05	4.001E-04	1.060E-02	1.100E-02

SAMPLE PROBLEM 2

FLAIR XRAY DATA TAPE

BY
SCIENCE APPLICATIONS, INC, LA JOLLA, CALIF
JANUARY 1974

CONTRACT DAAD05-73-C-0154.

BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

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  4.433-5 7.790-5 1.150-4 1.572-4 1.875-4 2.223-4 2.587-4 3.044-4 3.442-4
   3.813-4 4.152-4 4.370-4 4.412-4 4.198-4 3.634-4
*O DKEV DFLUX ONLY
*O KEV DTIME FLUX DN ONLY
*O DKEV DISUR FLUX DN
*O CAL FCUR
*O CAL FLUX
*R  KFT  1
*Y  KT  1
*TSUR .1-8 .1 .3-8 .3 .5-8 .5 .7-8 .8 .9-8 1.0  1.1-8 1.0 1.3-8 .8
     1.5-8 .5 1.7-8 .3  1.9-8 .1
*EXC 4PIRSQ
```

SOURCE ENERGY SPECTRUM

	UPPER ENERGY (KEV)	INPUT (PHOTONS/ KEV)	PHOTONS/GROUP	NORMALIZED PHOTONS/GROUP
1	.3000E+03	.2334E-08	.9336E-07	.4083E-05
2	.2600E+03	.2443E-07	.9772E-06	.4274E-04
3	.2200E+03	.1667E-06	.5001E-05	.2187E-03
4	.1900E+03	.8909E-06	.2673E-04	.1169E-02
5	.1600E+03	.3252E-05	.6504E-04	.2845E-02
6	.1400E+03	.9230E-05	.1846E-03	.8074E-02
7	.1200E+03	.2175E-04	.3262E-03	.1427E-01
8	.1050E+03	.4433E-04	.6649E-03	.2908E-01
9	.9000E+02	.7790E-04	.7790E-03	.3407E-01
10	.8000E+02	.1150E-03	.1150E-02	.5030E-01
11	.7000E+02	.1572E-03	.7860E-03	.3438E-01
12	.6500E+02	.1875E-03	.9375E-03	.4100E-01
13	.6000E+02	.2223E-03	.1111E-02	.4861E-01
14	.5500E+02	.2587E-03	.1293E-02	.5657E-01
15	.5000E+02	.3044E-03	.1522E-02	.6657E-01
16	.4500E+02	.3442E-03	.1721E-02	.7527E-01
17	.4000E+02	.3813E-03	.1906E-02	.8339E-01
18	.3500E+02	.4152E-03	.2076E-02	.9080E-01
19	.3000E+02	.4370E-03	.2185E-02	.9557E-01
20	.2500E+02	.4412E-03	.2206E-02	.9649E-01
21	.2000E+02	.4198E-03	.2099E-02	.9181E-01
22	.1500E+02	.3634E-03	.1817E-02	.7947E-01

AVERAGE ENERGY OF SOURCE SPECTRUM IS .4333E+02 KEV

SOURCE NORMALIZATION IS .2286E-01 PHOTONS

WHICH IS EQUIVALENT TO .3794E-28 KT OF PHOTONS

YIELD CARD ENCOUNTERED

SOURCE NORMALIZATION CHANGED TO .6027E+27 PHOTONS WHICH IS EQUIVALENT TO .1000E+01 KT OF PHOTONS

```
RADII IN CENTIMETERS
 1  3.04801E+04

RESULTS ARE      4PIR**2

DENSITY= .1290E-02
```

OPERATION	DEPENDENCE	ANGLE RESP	ENERGY RESP	GROUP	NORMALIZED	DELTA	CARDS	TAPE	TSOR
1	ANGLE ENERGY	FLUX	KEV			*			
2	TIME	FLUX	KEV		*	*			
3	TIME ENERGY	FLUX	KEV		*	*			*
4	TIME	FLUX	KEV		*	*			*
5	ENERGY	FLUX	KEV		*	*			
6		FLUX	KEV		*	*			
7		FCUR	CAL			*			
8		FLUX	CAL			*			

TSOR

TIME	WEIGHT
.1000E-08	.1852E-01
.3000E-08	.5556E-01
.5000E-08	.9259E-01
.7000E-08	.1481E+00
.9000E-08	.1852E+00
.1100E-07	.1852E+00
.1300E-07	.1481E+00
.1500E-07	.9259E-01
.1700E-07	.5556E-01
.1900E-07	.1852E-01

OPERATION 1 4PIR**2 ENERGY AND ANGLE DEPENDENCE

ENERGY RESPONSE IS KEV

ANGLE RESPONSE IS FLUX

RESULTS ARE PER KEV PER COSINE

RADIUS 1 3.0480E+04 (CM)

	UPPER ENERGY KEV	COSINE 1.000E+00 1	6.660E-01 2	3.330E-01 3	0. 4	-3.330E-01 5	-6.660E-01 6
1	3.000E+02	1.399E+21	1.737E+17	0.	0.	0.	0.
2	2.600E+02	1.298E+22	9.796E+19	2.928E+18	0.	0.	0.
3	2.200E+02	6.712E+22	1.807E+21	1.935E+20	4.057E+18	1.387E+17	0.
4	1.900E+02	3.031E+23	1.530E+22	3.140E+21	2.922E+20	4.423E+19	2.275E+18
5	1.600E+02	8.720E+23	7.632E+22	2.300E+22	3.936E+21	1.027E+21	1.363E+20
6	1.400E+02	2.188E+24	2.652E+23	1.004E+23	2.783E+22	1.137E+22	3.386E+21
7	1.200E+02	4.418E+24	7.264E+23	3.221E+23	1.174E+23	6.670E+22	3.306E+22
8	1.050E+02	8.265E+24	1.722E+24	8.681E+23	4.191E+23	2.740E+23	1.773E+23
9	9.000E+01	1.301E+25	3.312E+24	1.882E+24	1.007E+24	7.369E+23	5.588E+23
10	8.000E+01	1.868E+25	5.601E+24	3.323E+24	2.004E+24	1.606E+24	1.324E+24
11	7.000E+01	2.349E+25	8.007E+24	5.167E+24	3.214E+24	2.660E+24	2.269E+24
12	6.500E+01	2.756E+25	1.025E+25	6.730E+24	4.491E+24	3.680E+24	3.167E+24
13	6.000E+01	3.096E+25	1.263E+25	8.528E+24	5.829E+24	4.943E+24	4.328E+24
14	5.500E+01	3.351E+25	1.508E+25	1.042E+25	7.516E+24	6.329E+24	5.618E+24
15	5.000E+01	3.371E+25	1.673E+25	1.249E+25	8.927E+24	7.878E+24	6.984E+24
16	4.500E+01	2.934E+25	1.629E+25	1.245E+25	9.448E+24	8.317E+24	7.573E+24
17	4.000E+01	2.020E+25	1.271E+25	9.924E+24	7.930E+24	7.156E+24	6.638E+24
18	3.500E+01	9.058E+24	6.518E+24	5.402E+24	4.456E+24	4.057E+24	3.825E+24
19	3.000E+01	1.848E+24	1.483E+24	1.302E+24	1.124E+24	1.045E+24	9.826E+23
20	2.500E+01	8.801E+22	7.656E+22	7.197E+22	6.348E+22	5.986E+22	5.776E+22
21	2.000E+01	2.379E+20	2.233E+20	2.159E+20	1.154E+20	1.773E+20	1.289E+20
23	1.000E+01						

OPERATION 2 NORMALIZED TIME DEPENDENT

ENERGY RESPONSE IS KEV

ANGLE RESPONSE IS FLUX

RESULTS ARE PER SECOND

	TIME (SEC)	RADII (CM) 3.048E+04
1	0.	5.571E+06
2	5.426E-09	1.522E+06
3	1.163E-08	1.447E+06
4	2.326E-08	1.423E+06
5	4.651E-08	1.430E+06
6	9.302E-08	1.391E+06
7	1.860E-07	1.299E+06
8	2.713E-07	1.106E+06
9	4.651E-07	7.607E+05
10	6.977E-07	4.460E+05
11	9.302E-07	2.178E+05
12	1.240E-06	8.504E+04
13	1.550E-06	2.785E+04
14	1.938E-06	5.914E+03
15	2.481E-06	3.657E+02
16	3.876E-06	6.929E-01
17	6.977E-06	4.313E-08
18	1.500E-05	

OPERATION 3 NORMALIZED ENERGY AND TIME DEPENDENCE

ENERGY RESPONSE IS KEV

ANGLE RESPONSE IS FLUX

TSOR INCLUDED

RESULTS ARE PER KEV PER SECOND

RADIUS 1 3.0480E+04 (CM)

	UPPER ENERGY KEV	TIME (SEC) 0. 1	5.426E-09 2	1.163E-08 3	2.326E-08 4	4.651E-08 5	9.302E-08 6	1.860E-07 7	2.713E-07 8
1	3.000E+02	6.583E+00	2.038E+01	1.209E+01	2.823E+00	4.852E-01	1.937E-02	1.644E-04	9.423E-07
2	2.600E+02	4.662E+01	1.469E+02	9.545E+01	3.210E+01	1.074E+01	1.448E+00	1.245E-01	4.997E-03
3	2.200E+02	2.111E+02	6.708E+02	4.502E+02	1.666E+02	6.947E+01	1.568E+01	2.814E+00	2.588E-01
4	1.900E+02	7.501E+02	2.417E+03	1.725E+03	7.752E+02	4.047E+02	1.190E+02	2.928E+01	4.693E+00
5	1.600E+02	1.817E+03	5.906E+03	4.354E+03	2.092E+03	1.256E+03	5.080E+02	1.697E+02	3.672E+01
6	1.400E+02	3.528E+03	1.164E+04	9.121E+03	5.040E+03	3.440E+03	1.625E+03	6.585E+02	1.889E+02
7	1.200E+02	5.594E+03	1.866E+04	1.514E+04	9.091E+03	6.949E+03	4.068E+03	2.028E+03	7.096E+02
8	1.050E+02	7.627E+03	2.597E+04	2.233E+04	1.461E+04	1.278E+04	8.848E+03	5.164E+03	2.196E+03
9	9.000E+01	8.882E+03	3.066E+04	2.705E+04	1.888E+04	1.805E+04	1.489E+04	1.043E+04	5.279E+03
10	8.000E+01	8.734E+03	3.072E+04	2.871E+04	2.194E+04	2.267E+04	2.121E+04	1.709E+04	1.037E+04
11	7.000E+01	8.102E+03	2.877E+04	2.758E+04	2.167E+04	2.394E+04	2.575E+04	2.297E+04	1.610E+04
12	6.500E+01	7.127E+03	2.577E+04	2.583E+04	2.075E+04	2.456E+04	2.794E+04	2.718E+04	2.119E+04
13	6.000E+01	5.814E+03	2.133E+04	2.196E+04	1.849E+04	2.272E+04	2.842E+04	3.036E+04	2.605E+04
14	5.500E+01	4.217E+03	1.578E+04	1.691E+04	1.504E+04	1.926E+04	2.605E+04	3.099E+04	3.052E+04
15	5.000E+01	2.675E+03	1.020E+04	1.132E+04	1.033E+04	1.456E+04	2.184E+04	2.871E+04	3.182E+04
16	4.500E+01	1.296E+03	5.058E+03	5.864E+03	5.897E+03	8.532E+03	1.456E+04	2.140E+04	2.713E+04
17	4.000E+01	4.150E+02	1.670E+03	2.076E+03	2.242E+03	3.529E+03	6.867E+03	1.128E+04	1.755E+04
18	3.500E+01	6.603E+01	2.772E+02	3.704E+02	4.336E+02	8.104E+02	1.861E+03	3.651E+03	6.651E+03
19	3.000E+01	6.642E-02	9.035E-01	6.061E+00	1.853E+01	5.336E+01	1.782E+02	4.537E+02	1.059E+03
20	2.500E+01	0.	0.	1.116E-04	6.282E-02	3.051E-01	2.605E+00	9.360E+00	3.293E+01
21	2.000E+01	0.	0.	0.	0.	6.028E-07	6.801E-04	6.872E-03	4.014E-02
23	1.000E+01								

TIME (SEC)

	UPPER ENERGY KEV	4.651E-07 9	6.977E-07 10	9.302E-07 11	1.240E-06 12	1.550E-06 13	1.938E-06 14	2.481E-06 15	3.876E-06 16
1	3.000E+02	3.813E-08	0.	0.	0.	0.	0.	0.	0.
2	2.600E+02	1.443E-04	6.921E-07	0.	0.	0.	0.	0.	0.
3	2.200E+02	1.405E-02	6.983E-04	2.740E-05	7.266E-07	7.462E-09	1.158E-09	8.455E-12	0.
4	1.900E+02	5.071E-01	5.735E-02	7.105E-03	8.306E-04	8.714E-05	5.345E-06	9.359E-08	2.087E-10
5	1.600E+02	5.488E+00	7.930E-01	1.273E-01	1.933E-02	2.561E-03	2.176E-04	9.696E-06	2.735E-08
6	1.400E+02	3.715E+01	7.169E+00	1.350E+00	2.734E-01	4.325E-02	5.088E-03	1.220E-04	3.572E-07
7	1.200E+02	1.700E+02	3.951E+01	8.605E+00	1.927E+00	3.117E-01	3.726E-02	2.245E-03	7.198E-06
8	1.050E+02	6.594E+02	1.827E+02	4.607E+01	1.058E+01	2.013E+00	2.728E-01	1.444E-02	5.892E-05
9	9.000E+01	1.875E+03	5.932E+02	1.630E+02	4.067E+01	8.399E+00	1.231E+00	4.396E-02	1.373E-04
10	8.000E+01	4.364E+03	1.572E+03	4.768E+02	1.214E+02	2.840E+01	4.481E+00	2.096E-01	7.705E-04
11	7.000E+01	7.776E+03	3.139E+03	1.025E+03	2.844E+02	6.796E+01	1.076E+01	5.036E-01	1.931E-03
12	6.500E+01	1.140E+04	4.960E+03	1.778E+03	5.026E+02	1.320E+02	1.914E+01	9.913E-01	4.865E-03
13	6.000E+01	1.584E+04	7.615E+03	2.873E+03	8.827E+02	2.311E+02	4.148E+01	1.941E+00	9.761E-03
14	5.500E+01	2.086E+04	1.108E+04	4.628E+03	1.528E+03	4.193E+02	7.616E+01	4.241E+00	1.578E-02
15	5.000E+01	2.513E+04	1.507E+04	6.899E+03	2.484E+03	7.482E+02	1.392E+02	7.649E+00	3.414E-02
16	4.500E+01	2.543E+04	1.735E+04	8.933E+03	3.537E+03	1.136E+03	2.321E+02	1.525E+01	7.103E-02
17	4.000E+01	1.957E+04	1.542E+04	9.026E+03	4.003E+03	1.390E+03	3.151E+02	2.017E+01	9.082E-02
18	3.500E+01	9.254E+03	8.770E+03	5.890E+03	2.954E+03	1.129E+03	2.754E+02	1.908E+01	8.647E-02
19	3.000E+01	1.828E+03	2.072E+03	1.632E+03	9.379E+02	3.939E+02	1.093E+02	8.332E+00	4.074E-02
20	2.500E+01	7.616E+01	1.046E+02	9.714E+01	6.455E+01	3.064E+01	9.151E+00	7.531E-01	4.188E-03
21	2.000E+01	1.184E-01	2.666E-01	2.542E-01	2.190E-01	1.098E-01	3.286E-02	1.069E-03	3.869E-06
23	1.000E+01								

TIME (SEC)

	UPPER ENERGY KEV	6.977E-06 17
5	1.600E+02	7.291E-14
6	1.400E+02	8.135E-11
7	1.200E+02	8.355E-10
8	1.050E+02	2.214E-08
9	9.000E+01	2.544E-08
10	8.000E+01	2.307E-07
11	7.000E+01	6.540E-07
12	6.500E+01	2.557E-06
13	6.000E+01	5.433E-06
14	5.500E+01	4.546E-06
15	5.000E+01	1.536E-05
16	4.500E+01	3.317E-05
17	4.000E+01	4.027E-05
18	3.500E+01	3.820E-05
19	3.000E+01	2.014E-05
20	2.500E+01	2.433E-06
21	2.000E+01	1.412E-09
23	1.000E+01	

OPERATION 4 NORMALIZED TIME DEPENDENT

ENERGY RESPONSE IS KEV

ANGLE RESPONSE IS FLUX

TSOR INCLUDED

RESULTS ARE PER SECOND

	TIME (SEC)	RADII (CM) 3.048E+04
1	0.	6.730E+05
2	5.426E-09	2.320E+06
3	1.163E-08	2.056E+06
4	2.326E-08	1.437E+06
5	4.651E-08	1.428E+06
6	9.302E-08	1.395E+06
7	1.860E-07	1.310E+06
8	2.713E-07	1.116E+06
9	4.651E-07	7.755E+05
10	6.977E-07	4.614E+05
11	9.302E-07	2.252E+05
12	1.240E-06	8.932E+04
13	1.550E-06	2.933E+04
14	1.938E-06	6.319E+03
15	2.481E-06	4.055E+02
16	3.876E-06	1.870E+00
17	6.977E-06	8.636E-04
18	1.500E-05	

OPERATION 5 NORMALIZED ENERGY DEPENDENT

ENERGY RESPONSE IS KEV

ANGLE RESPONSE IS FLUX

RESULTS ARE PER KEV

RADII (CM)

	UPPER ENERGY	3.048E+04
1	3.000E+02	4.015E-07
2	2.600E+02	3.755E-06
3	2.200E+02	1.984E-05
4	1.900E+02	9.237E-05
5	1.600E+02	2.802E-04
6	1.400E+02	7.450E-04
7	1.200E+02	1.631E-03
8	1.050E+02	3.363E-03
9	9.000E+01	5.881E-03
10	8.000E+01	9.330E-03
11	7.000E+01	1.285E-02
12	6.500E+01	1.602E-02
13	6.000E+01	1.927E-02
14	5.500E+01	2.249E-02
15	5.000E+01	2.485E-02
16	4.500E+01	2.390E-02
17	4.000E+01	1.850E-02
18	3.500E+01	9.546E-03
19	3.000E+01	2.231E-03
20	2.500E+01	1.197E-04
21	2.000E+01	3.349E-07
22	1.500E+01	0.
23	1.000E+01	

OPERATION 6 4PIR**2 TOTALS

ENERGY RESPONSE IS KEV

ANGLE RESPONSE IS FLUX

SOURCE NORMALIZATION IS .6027E+27 PHOTONS WHICH IS EQUIVALENT TO .1000E+01 KT OF PHOTONS

RADIUS (CM)	UNCOLLIDED	SCATTERED	TOTAL
3.048E+04	2.165E+25	1.142E+27	1.164E+27

OPERATION 7 4PIR**2 TOTALS

ENERGY RESPONSE IS CALORIES

ANGLE RESPONSE IS FORWARD CURRENT

SOURCE NORMALIZATION IS .6027E+27 PHOTONS WHICH IS EQUIVALENT TO .1000E+01 KT OF PHOTONS

RADIUS (CM)	UNCOLLIDED	SCATTERED	TOTAL
3.048E+04	8.291E+08	2.163E+10	2.246E+10

OPERATION 8 4PIR**2 TOTALS

ENERGY RESPONSE IS CALORIES

ANGLE RESPONSE IS FLUX

SOURCE NORMALIZATION IS .6027E+27 PHOTONS WHICH IS EQUIVALENT TO .1000E+01 KT OF PHOTONS

RADIUS (CM)	UNCOLLIDED	SCATTERED	TOTAL
3.048E+04	8.291E+08	4.373E+10	4.456E+10

SAMPLE PROBLEM 3

FLAIR GAMMA RAY DATA TAPE

BY
SCIENCE APPLICATIONS, INC, LA JOLLA, CALIF
MARCH 1974

CONTRACT DAAD05-73-C-0154

BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

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LIST OF INPUT

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*ESOR 0 0 .1 .15 .4 .8 .5 .6 .7 .6 .8 .6 .6 .4 .3 .2 .1
*Y  KT 1
*R  KFT  1 2 3
*ARESP1 *SAMPLE MISSLE* 1.2 1.5 3 2 .7 .4 1.0
*ERESP1 *SAMP MISSLE RAD(ST)*  3.0-9 2.5-9 1.8-9 1.7-9 1.5-9 1.3-9 1.1-9
    1.0-9  9.0-10 7.4-10 6.12-10 5.10-10 4.05-10 3.10-10 2.20-10 1.37-10
  6.5-11 1.2-11 9.5-12 7.5-12 3.0-12 0  0  0  0
*O FLUX  DMEV  GN
*O  ARESP1  DERESP1  DTIME  GN
*EXC
```

SOURCE ENERGY SPECTRUM

	UPPER ENERGY (MEV)	INPUT (PHOTONS/GROUP)	PHOTONS/GROUP	NORMALIZED PHOTONS/GROUP
1	.1400E+02	0.	0.	0.
2	.1000E+02	0.	0.	0.
3	.8000E+01	.1000E+00	.1000E+00	.1460E-01
4	.7000E+01	.1500E+00	.1500E+00	.2190E-01
5	.6000E+01	.4000E+00	.4000E+00	.5839E-01
6	.5000E+01	.8000E+00	.8000E+00	.1168E+00
7	.4000E+01	.5000E+00	.5000E+00	.7299E-01
8	.3500E+01	.6000E+00	.6000E+00	.8759E-01
9	.3000E+01	.7000E+00	.7000E+00	.1022E+00
10	.2500E+01	.6000E+00	.6000E+00	.8759E-01
11	.2000E+01	.8000E+00	.8000E+00	.1168E+00
12	.1660E+01	.6000E+00	.6000E+00	.8759E-01
13	.1330E+01	.6000E+00	.6000E+00	.8759E-01
14	.1000E+01	.4000E+00	.4000E+00	.5839E-01
15	.8000E+00	.3000E+00	.3000E+00	.4380E-01
16	.6000E+00	.2000E+00	.2000E+00	.2920E-01
17	.4500E+00	.1000E+00	.1000E+00	.1460E-01
18	.3000E+00	0.	0.	0.
19	.2200E+00	0.	0.	0.
20	.1600E+00	0.	0.	0.
21	.1200E+00	0.	0.	0.
22	.9000E-01	0.	0.	0.
23	.6500E-01	0.	0.	0.
24	.4500E-01	0.	0.	0.
25	.3000E-01	0.	0.	0.

AVERAGE ENERGY OF SOURCE SPECTRUM IS .2686E+04 KEV

SOURCE NORMALIZATION IS .6850E+01 PHOTONS

WHICH IS EQUIVALENT TO .7045E-24 KT OF PHOTONS

YIELD CARD ENCOUNTERED

SOURCE NORMALIZATION CHANGED TO .9724E+25 PHOTONS WHICH IS EQUIVALENT TO .1000E+01 KT OF PHOTONS

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RADII IN CENTIMETERS
 1  3.04801E+04
 2  6.09601E+04
 3  9.14402E+04

RESULTS ARE NOT 4PIR**2

DENSITY= .1290E-02

OPERATION     DEPENDENCE     ANGLE RESP    ENERGY RESP    GROUP    NORMALIZED    DELTA    CARDS    TAPE    TSOR

    1                ENERGY    FLUX           MEV            *          *
    2                          FLUX           MEV            *          *
    3           TIME ENERGY    ARESP1         ERESP1         *          *
    4           TIME           ARESP1         ERESP1         *          *
    5                ENERGY    ARESP1         ERESP1         *          *
    6                          ARESP1         ERESP1         *          *

ARESP1  SAMPLE MISSLE
 .1200E+01  .1500E+01  .3000E+01  .2000E+01  .7000E+00  .4000E+00  .1000E+01

ERESP1  SAMP MISSLE RAD(SI)
 .3000E-08  .2500E-08  .1800E-08  .1700E-08  .1500E-08  .1300E-08  .1100E-08  .1000E-08  .9000E-09  .7400E-09
 .6120E-09  .5100E-09  .4050E-09  .3100E-09  .2200E-09  .1370E-09  .6500E-10  .1200E-10  .9500E-11  .7500E-11
 .3000E-11 0.         0.         0.         0.
```

OPERATION 1 NORMALIZED ENERGY DEPENDENT

ENERGY RESPONSE IS MEV

ANGLE RESPONSE IS FLUX

RESULTS ARE PER GROUP

	UPPER ENERGY	RADII (CM) 3.048E+04	6.096E+04	9.144E+04
1	1.400E+01	0.	0.	0.
2	1.000E+01	0.	0.	0.
3	8.000E+00	3.647E-02	3.961E-02	4.475E-02
4	7.000E+00	4.708E-02	5.066E-02	5.694E-02
5	6.000E+00	1.004E-01	1.024E-01	1.092E-01
6	5.000E+00	1.574E-01	1.537E-01	1.568E-01
7	4.000E+00	8.120E-02	7.863E-02	7.929E-02
8	3.500E+00	8.371E-02	8.037E-02	7.997E-02
9	3.000E+00	8.288E-02	7.940E-02	7.833E-02
10	2.500E+00	6.798E-02	7.025E-02	7.142E-02
11	2.000E+00	5.730E-02	5.185E-02	4.899E-02
12	1.650E+00	4.698E-02	4.661E-02	4.496E-02
13	1.330E+00	4.453E-02	4.515E-02	4.348E-02
14	1.000E+00	2.668E-02	2.768E-02	2.637E-02
15	8.000E-01	2.696E-02	2.875E-02	2.752E-02
16	6.000E-01	2.745E-02	2.803E-02	2.629E-02
17	4.500E-01	2.770E-02	2.839E-02	2.624E-02
18	3.000E-01	1.881E-02	1.897E-02	1.750E-02
19	2.200E-01	1.673E-02	1.694E-02	1.532E-02
20	1.600E-01	1.350E-02	1.383E-02	1.240E-02
21	1.200E-01	1.213E-02	1.263E-02	1.131E-02
22	9.000E-02	1.174E-02	1.252E-02	1.102E-02
23	6.500E-02	9.093E-03	1.013E-02	8.840E-03
24	4.500E-02	3.002E-03	3.447E-03	3.005E-03
25	3.000E-02	7.563E-05	8.907E-05	7.924E-05
26	1.000E-02			

OPERATION 2 TOTALS (NOT 4PIR**2)

ENERGY RESPONSE IS MEV

ANGLE RESPONSE IS FLUX

SOURCE NORMALIZATION IS .9724E+25 PHOTONS WHICH IS EQUIVALENT TO .1000E+01 KT OF PHOTONS

RADIUS (CM)	UNCOLLIDED	SCATTERED	TOTAL
3.048E+04	5.877E+14	4.657E+14	1.053E+15
6.096E+04	4.325E+13	5.913E+13	1.024E+14
9.144E+04	6.045E+12	1.093E+13	1.698E+13

OPERATION 3 NORMALIZED ENERGY AND TIME DEPENDENCE

ENERGY RESPONSE IS SAMP MISSLE RAD(SI)

ANGLE RESPONSE IS SAMPLE MISSILE

RESULTS ARE PER GROUP

RADIUS 1 3.0480E+04 (CM)

		TIME (SEC)							
		0.	5.426E-09	1.163E-08	2.326E-08	4.651E-08	9.302E-08	1.860E-07	2.713E-07
UPPER ENERGY MEV		1	2	3	4	5	6	7	8
3	8.000E+00	3.313E-02	0.	0.	0.	0.	0.	0.	0.
4	7.000E+00	4.600E-02	2.159E-06	0.	0.	0.	0.	0.	0.
5	6.000E+00	1.029E-01	5.259E-04	4.570E-07	0.	0.	0.	0.	0.
6	5.000E+00	1.609E-01	4.215E-03	2.675E-04	9.844E-07	0.	0.	0.	0.
7	4.000E+00	8.294E-02	5.229E-03	1.233E-03	1.163E-05	2.050E-08	0.	0.	0.
8	3.500E+00	8.401E-02	7.811E-03	3.923E-03	1.426E-04	4.670E-07	0.	0.	0.
9	3.000E+00	8.007E-02	9.778E-03	8.135E-03	1.393E-03	1.129E-05	3.440E-08	0.	0.
10	2.500E+00	5.160E-02	1.068E-02	1.159E-02	5.929E-03	2.049E-04	1.872E-06	0.	0.
11	2.000E+00	4.375E-02	6.635E-03	8.788E-03	7.834E-03	1.170E-03	1.301E-05	6.486E-08	0.
12	1.660E+00	2.485E-02	6.865E-03	9.452E-03	1.033E-02	4.538E-03	1.411E-04	1.558E-06	6.385E-08
13	1.330E+00	1.535E-02	4.859E-03	8.544E-03	1.326E-02	1.046E-02	1.607E-03	2.556E-05	1.991E-06
14	1.000E+00	5.799E-03	1.947E-03	3.634E-03	6.992E-03	9.345E-03	3.962E-03	1.877E-04	1.764E-05
15	8.000E-01	2.444E-03	1.084E-03	2.194E-03	4.759E-03	8.394E-03	7.890E-03	1.297E-03	2.557E-04
16	6.000E-01	8.952E-04	5.127E-04	1.016E-03	2.246E-03	4.744E-03	6.947E-03	3.042E-03	1.888E-03
17	4.500E-01	1.245E-04	8.764E-05	2.147E-04	6.238E-04	1.766E-03	3.798E-03	2.534E-03	2.856E-03
18	3.000E-01	2.592E-06	4.273E-06	1.195E-05	3.804E-05	1.281E-04	3.919E-04	3.604E-04	5.747E-04
19	2.200E-01	3.140E-07	7.875E-07	2.738E-06	1.119E-05	4.889E-05	2.009E-04	2.510E-04	5.370E-04
20	1.600E-01	5.364E-08	2.007E-07	8.551E-07	3.750E-06	1.798E-05	8.765E-05	1.360E-04	3.899E-04
21	1.200E-01	4.296E-09	7.620E-09	4.068E-08	2.974E-07	2.127E-06	1.561E-05	3.152E-05	1.261E-04
26	1.000E-02								

		TIME (SEC)							
		4.651E-07	6.977E-07	9.302E-07	1.240E-06	1.550E-06	1.938E-06	2.481E-06	3.876E-06
UPPER ENERGY MEV		9	10	11	12	13	14	15	16
13	1.330E+00	2.686E-08	0.	0.	0.	0.	0.	0.	0.
14	1.000E+00	3.502E-07	1.533E-08	9.248E-09	0.	0.	0.	0.	0.
15	8.000E-01	8.473E-06	3.558E-07	2.514E-08	2.789E-09	3.763E-10	0.	5.642E-13	0.
16	6.000E-01	4.330E-04	1.335E-04	6.819E-05	2.482E-05	1.160E-05	4.480E-06	1.793E-06	5.835E-08
17	4.500E-01	1.015E-03	2.839E-04	1.172E-04	3.879E-05	1.806E-05	6.832E-06	2.192E-06	1.266E-07
18	3.000E-01	3.249E-04	1.436E-04	7.752E-05	2.815E-05	1.294E-05	4.950E-06	1.676E-06	1.019E-07
19	2.200E-01	4.128E-04	2.215E-04	1.430E-04	6.406E-05	3.210E-05	1.453E-05	5.245E-06	1.468E-07
20	1.600E-01	4.062E-04	2.727E-04	2.040E-04	1.018E-04	5.563E-05	2.808E-05	1.053E-05	4.332E-07
21	1.200E-01	1.804E-04	1.542E-04	1.385E-04	7.903E-05	4.974E-05	2.703E-05	1.120E-05	5.284E-07
26	1.000E-02								

TIME (SEC)

UPPER ENERGY MEV		6.977E-06 17
16	6.000E-01	2.806E-11
17	4.500E-01	2.723E-11
18	3.000E-01	3.150E-12
19	2.200E-01	5.634E-12
20	1.600E-01	1.859E-11
21	1.200E-01	2.190E-11
26	1.000E-02	

RADIUS 2 6.0960E+04 (CM)

TIME (SEC)

UPPER ENERGY MEV		0. 1	5.426E-09 2	1.163E-08 3	2.326E-08 4	4.651E-08 5	9.302E-08 6	1.860E-07 7	2.713E-07 8
3	8.000E+00	3.602E-02	0.	0.	0.	0.	0.	0.	0.
4	7.000E+00	4.927E-02	4.818E-04	2.724E-06	0.	0.	0.	0.	0.
5	6.000E+00	1.002E-01	3.936E-03	5.189E-04	4.917E-06	0.	0.	0.	0.
6	5.000E+00	1.466E-01	1.257E-02	6.740E-03	5.193E-04	4.387E-06	0.	0.	0.
7	4.000E+00	6.521E-02	9.790E-03	8.730E-03	2.037E-03	3.256E-05	1.943E-07	0.	0.
8	3.500E+00	6.023E-02	1.097E-02	1.282E-02	7.167E-03	3.241E-04	1.611E-06	0.	0.
9	3.000E+00	5.084E-02	1.148E-02	1.579E-02	1.476E-02	2.701E-03	3.543E-05	1.973E-09	0.
10	2.500E+00	2.802E-02	9.130E-03	1.548E-02	2.078E-02	1.093E-02	5.142E-04	2.045E-06	6.770E-09
11	2.000E+00	1.951E-02	4.830E-03	8.197E-03	1.435E-02	1.441E-02	2.441E-03	3.304E-05	6.794E-07
12	1.660E+00	9.172E-03	3.652E-03	7.017E-03	1.269E-02	1.732E-02	8.241E-03	3.560E-04	2.734E-05
13	1.330E+00	4.457E-03	2.023E-03	4.228E-03	9.523E-03	1.752E-02	1.661E-02	2.664E-03	4.784E-04
14	1.000E+00	1.273E-03	6.361E-04	1.433E-03	3.648E-03	8.402E-03	1.205E-02	4.567E-03	1.699E-03
15	8.000E-01	4.272E-04	2.929E-04	6.770E-04	1.919E-03	5.297E-03	1.039E-02	5.830E-03	4.729E-03
16	6.000E-01	2.363E-04	2.028E-04	3.979E-04	9.306E-04	2.441E-03	5.647E-03	4.220E-03	5.020E-03
17	4.500E-01	1.537E-05	2.194E-05	5.937E-05	2.051E-04	7.229E-04	2.295E-03	2.337E-03	3.847E-03
18	3.000E-01	7.588E-07	1.488E-06	4.024E-06	1.318E-05	5.167E-05	1.988E-04	2.555E-04	5.811E-04
19	2.200E-01	6.349E-08	2.546E-07	8.867E-07	4.247E-06	1.942E-05	9.603E-05	1.513E-04	4.451E-04
20	1.600E-01	1.947E-08	8.200E-08	3.414E-07	1.672E-06	7.842E-06	4.317E-05	7.865E-05	2.864E-04
21	1.200E-01	1.847E-11	1.101E-09	9.583E-09	7.229E-08	7.230E-07	6.303E-06	1.593E-05	8.085E-05
26	1.000E-02								

TIME (SEC)

UPPER ENERGY MEV		4.651E-07 9	6.977E-07 10	9.302E-07 11	1.240E-06 12	1.550E-06 13	1.938E-06 14	2.481E-06 15	3.876E-06 16
12	1.660E+00	4.783E-08	0.	0.	0.	0.	0.	0.	0.
13	1.330E+00	1.132E-05	1.180E-07	1.556E-10	0.	0.	0.	0.	0.
14	1.000E+00	9.861E-05	4.689E-06	3.598E-07	3.675E-09	7.076E-11	0.	0.	0.
15	8.000E-01	7.374E-04	8.028E-05	9.166E-06	9.087E-07	1.242E-07	8.599E-09	2.296E-10	2.192E-13
16	6.000E-01	1.914E-03	4.789E-04	1.730E-04	4.872E-05	1.825E-05	7.859E-06	2.595E-06	7.454E-08
17	4.500E-01	2.132E-03	8.645E-04	4.168E-04	1.338E-04	5.695E-05	1.924E-05	5.649E-06	1.887E-07
18	3.000E-01	4.446E-04	2.289E-04	1.400E-04	5.706E-05	2.659E-05	1.096E-05	3.907E-06	1.261E-07
19	2.200E-01	4.646E-04	3.028E-04	2.178E-04	1.026E-04	5.414E-05	2.496E-05	9.228E-06	2.920E-07
20	1.600E-01	3.965E-04	3.172E-04	2.761E-04	1.513E-04	9.058E-05	4.690E-05	1.809E-05	8.150E-07
21	1.200E-01	1.524E-04	1.609E-04	1.700E-04	1.090E-04	7.542E-05	4.237E-05	1.903E-05	1.003E-06
26	1.000E-02								

TIME (SEC)

UPPER ENERGY MEV		6.977E-06 17
16	6.000E-01	1.766E-11
17	4.500E-01	3.591E-11
18	3.000E-01	8.538E-12
19	2.200E-01	8.166E-11
20	1.600E-01	9.741E-11
21	1.200E-01	1.081E-10
26	1.000E-02	

RADIUS 3 9.1440E+04 (CM)

TIME (SEC)

UPPER ENERGY MEV		0. 1	5.426E-09 2	1.163E-08 3	2.326E-08 4	4.651E-08 5	9.302E-08 6	1.860E-07 7	2.713E-07 8
3	8.000E+00	4.012E-02	1.954E-05	0.	0.	0.	0.	0.	0.
4	7.000E+00	5.239E-02	2.723E-03	1.801E-04	4.549E-07	0.	0.	0.	0.
5	6.000E+00	9.831E-02	7.868E-03	4.326E-03	2.480E-04	5.085E-07	0.	0.	0.
6	5.000E+00	1.294E-01	1.716E-02	1.553E-02	5.855E-03	1.730E-04	3.462E-07	0.	0.
7	4.000E+00	5.164E-02	1.034E-02	1.339E-02	9.424E-03	9.705E-04	9.181E-06	0.	0.
8	3.500E+00	4.353E-02	1.037E-02	1.521E-02	1.657E-02	4.940E-03	9.576E-05	1.100E-08	0.
9	3.000E+00	3.255E-02	9.283E-03	1.541E-02	2.178E-02	1.440E-02	1.047E-03	2.882E-06	0.
10	2.500E+00	1.546E-02	6.202E-03	1.203E-02	2.168E-02	2.443E-02	6.526E-03	1.412E-04	4.849E-06
11	2.000E+00	8.854E-03	2.923E-03	5.563E-03	1.150E-02	1.883E-02	1.195E-02	8.350E-04	6.892E-05
12	1.660E+00	3.529E-03	1.856E-03	3.878E-03	8.739E-03	1.661E-02	1.791E-02	3.401E-03	6.651E-04
13	1.330E+00	1.410E-03	8.738E-04	1.992E-03	5.340E-03	1.305E-02	1.989E-02	8.361E-03	3.797E-03
14	1.000E+00	3.169E-04	2.462E-04	6.179E-04	1.783E-03	5.119E-03	1.072E-02	6.300E-03	5.454E-03
15	8.000E-01	1.038E-04	1.180E-04	2.818E-04	8.868E-04	2.896E-03	7.714E-03	5.898E-03	7.062E-03
16	6.000E-01	1.380E-04	1.424E-04	2.736E-04	5.906E-04	1.425E-03	3.779E-03	3.485E-03	5.274E-03
17	4.500E-01	7.331E-06	1.167E-05	3.573E-05	1.136E-04	3.900E-04	1.406E-03	1.690E-03	3.441E-03
18	3.000E-01	4.923E-07	6.814E-07	2.235E-06	9.148E-06	3.287E-05	1.261E-04	1.792E-04	4.607E-04
19	2.200E-01	3.034E-08	1.475E-07	5.521E-07	2.597E-06	1.212E-05	6.060E-05	9.837E-05	3.318E-04
20	1.600E-01	7.369E-09	2.851E-08	2.236E-07	1.024E-06	4.943E-06	2.904E-05	5.371E-05	1.981E-04
21	1.200E-01	2.307E-10	0.	4.168E-10	4.406E-08	4.785E-07	3.869E-06	1.010E-05	5.441E-05
26	1.000E-02								

TIME (SEC)

UPPER ENERGY MEV		4.651E-07 9	6.977E-07 10	9.302E-07 11	1.240E-06 12	1.550E-06 13	1.938E-06 14	2.481E-06 15	3.876E-06 16
11	2.000E+00	7.809E-08	0.	0.	0.	0.	0.	0.	0.
12	1.660E+00	8.775E-06	2.548E-07	2.560E-08	0.	0.	0.	0.	0.
13	1.330E+00	2.950E-04	1.336E-05	2.946E-07	1.353E-09	2.117E-10	0.	0.	0.
14	1.000E+00	9.130E-04	9.630E-05	1.212E-05	6.876E-07	2.106E-08	1.210E-09	0.	0.
15	8.000E-01	2.428E-03	5.154E-04	1.290E-04	1.954E-05	2.538E-06	4.305E-07	2.570E-08	5.531E-11
16	6.000E-01	2.732E-03	9.694E-04	3.908E-04	1.023E-04	3.377E-05	9.850E-06	3.457E-06	1.036E-07
17	4.500E-01	2.343E-03	1.072E-03	5.920E-04	2.171E-04	8.927E-05	3.408E-05	8.910E-06	4.056E-07
18	3.000E-01	4.263E-04	2.444E-04	1.636E-04	7.098E-05	3.516E-05	1.603E-05	5.728E-06	2.204E-07
19	2.200E-01	3.945E-04	2.943E-04	2.257E-04	1.159E-04	6.597E-05	3.048E-05	1.262E-05	5.358E-07
20	1.600E-01	3.117E-04	2.888E-04	2.684E-04	1.584E-04	1.017E-04	5.447E-05	2.269E-05	9.813E-07
21	1.200E-01	1.146E-04	1.332E-04	1.530E-04	1.057E-04	7.843E-05	4.762E-05	2.305E-05	1.325E-06
26	1.000E-02								

TIME (SEC)

UPPER ENERGY MEV		6.977E-06 17
16	6.000E-01	3.606E-11
17	4.500E-01	1.159E-10
18	3.000E-01	4.723E-11
19	2.200E-01	5.687E-11
20	1.600E-01	2.403E-10
21	1.200E-01	3.897E-10
26	1.000E-02	

OPERATION 4 NORMALIZED TIME DEPENDENT

ENERGY RESPONSE IS SAMP MISSLE RAD(SI)

ANGLE RESPONSE IS SAMPLE MISSILE

RESULTS ARE PER GROUP

	TIME (SEC)	RADII (CM) 3.048E+04	6.096E+04	9.144E+04
1	0.	7.242E-01	5.625E-01	4.735E-01
2	5.426E-09	6.206E-02	7.050E-02	7.008E-02
3	1.163E-08	6.291E-02	8.376E-02	8.933E-02
4	2.326E-08	5.831E-02	9.109E-02	1.057E-01
5	4.651E-08	4.463E-02	8.252E-02	1.046E-01
6	9.302E-08	2.719E-02	5.984E-02	8.208E-02
7	1.860E-07	8.461E-03	2.095E-02	3.072E-02
8	2.713E-07	6.910E-03	1.747E-02	2.693E-02
9	4.651E-07	2.790E-03	6.420E-03	1.000E-02
10	6.977E-07	1.200E-03	2.446E-03	3.639E-03
11	9.302E-07	7.381E-04	1.397E-03	1.936E-03
12	1.240E-06	3.303E-04	5.970E-04	7.882E-04
13	1.550E-06	1.765E-04	3.177E-04	4.045E-04
14	1.938E-06	8.402E-05	1.504E-04	1.921E-04
15	2.481E-06	3.196E-05	5.796E-05	7.594E-05
16	3.876E-06	1.399E-06	2.508E-06	3.594E-06
17	6.977E-06	1.567E-10	4.966E-10	1.430E-09
18	1.500E-05			

OPERATION 5 NORMALIZED ENERGY DEPENDENT

ENERGY RESPONSE IS SAMP MISSLE RAD(SI)

ANGLE RESPONSE IS SAMPLE MISSILE

RESULTS ARE PER GROUP

	UPPER ENERGY	RADII (CM) 3.048E+04	6.096E+04	9.144E+04
1	1.400E+01	0.	0.	0.
2	1.000E+01	0.	0.	0.
3	8.000E+00	3.218E-02	3.535E-02	3.978E-02
4	7.000E+00	4.527E-02	4.927E-02	5.516E-02
5	6.000E+00	1.007E-01	1.038E-01	1.103E-01
6	5.000E+00	1.672E-01	1.651E-01	1.677E-01
7	4.000E+00	8.758E-02	8.577E-02	8.615E-02
8	3.500E+00	9.471E-02	9.195E-02	9.113E-02
9	3.000E+00	9.972E-02	9.663E-02	9.495E-02
10	2.500E+00	8.220E-02	8.591E-02	8.699E-02
11	2.000E+00	7.045E-02	6.447E-02	6.067E-02
12	1.660E+00	5.891E-02	5.907E-02	5.670E-02
13	1.330E+00	5.669E-02	5.778E-02	5.496E-02
14	1.000E+00	3.328E-02	3.358E-02	3.147E-02
15	8.000E-01	2.926E-02	3.026E-02	2.789E-02
16	6.000E-01	2.206E-02	2.147E-02	1.919E-02
17	4.500E-01	1.336E-02	1.293E-02	1.135E-02
18	3.000E-01	2.065E-03	1.966E-03	1.757E-03
19	2.200E-01	1.903E-03	1.862E-03	1.636E-03
20	1.600E-01	1.675E-03	1.666E-03	1.480E-03
21	1.200E-01	7.963E-04	8.195E-04	7.186E-04
22	9.000E-02	0.	0.	0.
23	6.500E-02	0.	0.	0.
24	4.500E-02	0.	0.	0.
25	3.000E-02	0.	0.	0.
26	1.000E-02			

OPERATION 6 TOTALS (NOT 4PIR**2)

ENERGY RESPONSE IS SAMP MISSLE RAD(SI)

ANGLE RESPONSE IS SAMPLE MISSILE

SOURCE NORMALIZATION IS .9724E+25 PHOTONS WHICH IS EQUIVALENT TO .1000E+01 KT OF PHOTONS

RADIUS (CM)	UNCOLLIDED	SCATTERED	TOTAL
3.048E+04	1.727E+05	1.137E+05	2.864E+05
6.096E+04	1.242E+04	1.511E+04	2.753E+04
9.144E+04	1.705E+03	2.879E+03	4.583E+03

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