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EUROPEAN ATOMIC ENERGY COMMUNITY — EURATOM

USER'S MANUAL FOR THE GAMMA TRANSPORT CODES BIGGI 3P AND BIGGI 4T

by

H. PENKUHN

1967

Joint Nuclear Research Center
Ispra Establishment — Italy

Reactor Physics Department
Reactor Theory and Analysis

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Summary

The BIGGI programs (in Fortran) calculate in plain or spherical multilayer geometry gamma angular fluxes, spectra and response functions, or buildup factors and albedos. They need a 32-K-storage, and BIGGI 4T furthermore 4 intermediate tapes. The computing time on the IBM 7090 is about 15 sec per spatial point, and an exponential transformation allows great spatial integration steps, up to 2.5 mfp. In BIGGI 3P the sources are monoenergetic and located on an outer boundary plain, in BIGGI 4T they are volumic and can be rather arbitrary in energy and spatial dependence. Furthermore BIGGI 4T contains a library with the gamma data of 30 elements. Some sample cases are described, and part of their results is compared with those of other authors.

KEYWORDS

PROGRAMMING
GAMMA RADIATION
SPECTRA
ANGULAR DISTRIBUTION
COMPUTERS

Fortran, buildup, Albedo, Biggi-Code.

User's Manual for the Gamma Transport Codes BIGGI 3P and BIGGI 4T (+)

Chapter 1

General Remarks on the BIGGI Transport Program Series(++)

The basic assumptions and equations of this method were published previously, ref. (1), (2), (9). Here we shall limit ourselves to the description of the application of the last two important versions, i.e. the input preparation and the output interpretation. A short survey of the possibilities of the programs is shown in the table. Some additional remarks: The "P" in "BIGGI 3P"(abbreviated B3P) means that in principle the pair production process can be included, the "T" in "BIGGI 4T" (abbreviated B4T), that magnetic tapes are used. The interpolation of the cross sections in wavelength is done on a 2nd degree - parabola. The 4 built-in response functions are those leading to the energy and particle fluxes, dose rate and absorbed power density (in MeV resp. quanta/cm^2/sec, rem/hr and MeV/cm^3/sec). The predecessor of B3P and B4T, BIGGI 2, differs from BIGGI 3P- apart from minor deviations - in the following points: only one-slab-geometry and no exponential transformation. The very first version, BIGGI 1, was still more restricted, especially in the wavelength integration and interpolation.

(+) Manuscript received on May 30, 1967.

(++) BIGGI = Boltzmannsche Integralgleichung für Gamma-Intensitäten

Table : The possibilities of B3P and B4T

	Program	BIGGI 3P	BIGGI 4T
physical possibilities	year	1965	1966
	geometry	plain	plain or spher.
	source location	x = 0	arbitrary
	source energies	1	9
	layers	5	9 } coupled
	spatial steps	1(in mfp)	9
	exponential transform.	applied	applied
	angular interpolation	linear	linear or expon.
	wavelength steps	5	6
	angular mesh points	8	9
	spatial mesh points	26	39
	wavelength mesh p.	71	51
cross section calculation	interpolation	yes	yes
	summation over elem.	/	yes(30 elements)
intermediate	tapes used	/	4
variables calculated and printed	angular fluxes	yes	yes
	spectra	yes	yes
	buildup factors	4	4(if source monoen.)
	albedos	2	/
	response functions	/	4 built-in, ≤4 arb.
comments in	output	short	extensive

In the following, we shall describe, rather independently, the input and output of BIGGI 3P and BIGGI 4T. (We have hesitated to publish BIGGI 3P, since it is already somewhat obsolete with its few application possibilities and not optimised in input and output. But some colleagues are already working with it, and it has compared with its follower BIGGI 4T the advantages of a) calculating the albedos, too, and b) no need of tapes. Finally, it offers the possibility to check some of the BIGGI 4T -results, so we preferred to describe it here, too).

Chapter 2

The BIGGI 3P Input+)

(Since BIGGI 3P contains no library, the input begins already with the problem data).

1st data card : FORMAT (i6, 8F6.0)

1. data = IMA = number of angular mesh points, ≤ 8;
2.-9. data = cosines of the mesh points, OM(1), OM(2),... OM(IMA), the smaller values first. The sequence -1.0; -.925; -.84; -.28; .28; .84; .925; 1.0 gave reasonable results. Sequences not symmetric to zero can be used; they give logically correct results in most cases with the exception of the energy current buildup factor $B_E^{(C)}$ for the last spatial point, and the albedo calculations are done only roughly. If neither the albedos nor $B_E^{(C)}$ are needed, the cosine mesh can be chosen asymmetric.

2nd data card : FORMAT (3F9.0)

1. data = OMO
2. " = OMU
3. " = WØM

At the last spatial point, the dose buildup factor is calculated twice: once in the usual way, once with the weight WOM between the angular (cosine!) limits OMO and OMU, and 1.0 outside. If |OMO| > 1.01, this special evaluation is skipped, and neither OMU nor WOM need be defined in this case. (This weighted summation is done only for the scattered fluxes, the unscattered fluxes are treated as usual.

+) The following 2 chapters are a revised and enlarged version of a speech held at the OECD-ENEA meeting on shielding programs at Ispra, April 26th-29th 1966

Remark: The numbers on the first two data cards remain unchanged in the whole program, they are de facto constants and no variables in a program run. But all the following data can be changed from problem to problem.

3rd data card : FORMAT (6F6.0, 6i6)

1. data = W(1) = wavelength of the source energy in Compton units C.U. (1 C.U. = $h/(m_{el}.C)$ = 0.02426Å)
2., 3.,..., 6. data = wavelength integration steps DW1, DW2,... DW5 in Compton units.
7., 8.,...,11. data = K1, K2,...K5 = indices of the last wavelength mesh points, at which the steps DW1, DW2,..., DW5 are used.
12. data = KDP : The angular fluxes in the output are printed for the wavelength indices 1 (corresponding to the source energy), 1 + KDP, 1 + 2KDP, 1 + 3KDP etc.
The values K1, K2,...K5 should obey the inequalities:
$K1 > 2$; $K2 > K1 + 1$; $K3 > K2 + 1$; $K4 > K3 + 1$; $K5 > K4 + 1$; $71 \geq K5$.
If less then 5 steps are used, e.g. only four, it is necessary that K4 = K5; in this case the condition $K5 > K4+1$ need not be fulfilled, and DW5 can be any value.
(If only two steps are used, it is analogously required that K2 = K3 = K4 = K5, and DW3, DW4 and DW5 are of no importance)

Since the right choice of the wavelength mesh presents some difficulties to a beginner in gamma transport calculations, we insert here a somewhat longer discussion. Let the source energy be E_s = 6 MeV, then we have

W (1) = 0.511/6.0 = 0.08502 CU

since λ (E) = 0.511 MeV/E, if the wavelength λ is measured in Compton units; 0.511 MeV is just the rest energy of the electron . The wavelength steps DW = DW1, DW2,..., DW5 should near a given wavelength W(K), where K is the wavelength index, obey the two conditions:

$$DW \lesssim W(K) \quad \text{and} \quad DW \ll 1.0^{+)}$$

In our example (E = 6 eV, W(1) = 0.08502 CU) we choose

$$DW1 \approx \frac{1}{4} \; W\,(1), \text{ e.g. } \; DW1 = 0.02$$

(similarly DW1 = 0.03 could be tried). After 5 such steps, i.e. at K = 1 + 5 = 6, we have a new wavelength W(6) = 0,185 $\approx$ 2 * W(1), and we can double the step, too: we put K1 = 6 and calculate for K = 7, 8, 9,... with DW2 = 0.04, until K2 = 11, where the new wavelength is about 0, 385. We double once more: DW3 = 0.08, until K3 = 16, where W(16) $\approx$ 0,785 (corresponding to about 0.65 MeV). Until W(1) + 2 (there lies the limit of the once-scattered distribution) we have still a distance of 2 - 0.7 = 1.3 CU; we put DW4 = 0.13 and K4 = K3 + 10 = 26.

(+) A simple evaluation of the Klein-Nishina scattering kernel shows that the scattering probability for $\lambda \ll 1.0$, if normalised to unity for the wavelength increase $\Delta\lambda$ = 0., behaves roughly as $(1 + 2\Delta\lambda/\lambda)^{-1}$, for the range $\Delta\lambda \ll \lambda$ and for $\Delta\lambda \gg \lambda$!

Afterwards we have only the more than once scattered distribution , which needs only a less precise mesh, e.g. DW5 = $= 2/8.5 \approx 0,2353$ (the best choice is really a value of the form $2/(n + \frac{1}{2})$ with integer n). In high -Z- media, e.g. lead, K5 must not exceed much K4, let us say K5 = K4 + 4 or K4 + 3 (the more than once scattered fluxes below $\sim$ 2 CU get rapidly absorbed). But in low -Z- media, e.g. C, H_2O or air, the greatest (cutoff-) wavelength W(K5) should be about 10 CU, or W(K5) W(1) + (K1 -1) DW1 + (K2 - K1) DW2 + (K3 - K2) DW3 + (K4 - K3) DW4 + (K5 - K4) DW5 $\sim$ 10(+).
For the above example this would mean K5 - K4 $\sim$ 34 or K5 $\sim$ 60.
In medium -Z- media, e.g. Fe, W(K5) $\sim$ 5 should be sufficient.
A test for the right or wrong choice of the cutoff wavelength W(K5) is the relative difference between the buildup factors with and without the estimated "cutoff correction" (discussed in the following chapter); if it exceeds 10-20%, the results get correspondingly unsure.
An alternative mesh for the above case (rougher but faster) would be DW1 = 0.025; DW2 = 0.05; DW3 = 0.1; DW4 = 0.2; DW5 = $\frac{2}{7.5} \approx 0.26667$; K1 = 5; K2 = 9; K3 = 12; K4 = 19; K5 material-dependent.
At K4 again the end of the once-collided flux is reached; K5 must be chosen as function of Z (the higher Z, the lower K5).

(+) For high source energies, this requirement can be somewhat relaxed, since the low-energy part of the spectrum gets less important, compared with the high-energy fluxes.

For a lower source energy Es, the problem gets simpler:

Es = 1 MeV, W(1) = 0.511/1 = 0.511 CU

DW1 = 0.1 K1 = 5 DW2 = 0.2 K2 = 13

At K2 we have the end of the once-collided flux:

$$W(K2) \approx W(1) + (K1 - 1)\,DW1 + (K2 - K1)DW2 = 2.511$$

Afterwards we proceed as above, e.g. in Fe DW3 = 2/8.5 and K3 = 24, where we put the cutoff (remember that in this condition K3 = K4 = K5 is necessary, but DW4 and DW5 are unimportant!)

Two final remarks: changes in the wavelength mesh do not influence much the results: once for a 4-MeV-source in iron all wavelength steps exept the first were doubled, but the average change of the energy buildup factors was only 2.4%, with a maximum of 4.6% (a similar confrontation will be made in the sample cases.)

If a configuration of more than one material is calculated, that with the lowest Z (or Z_{eff}) sets the limit for the cutoff wavelength W(K5). (An exception can be made if the low-Z-slab is optically thin.) But if for instance a lead-water-configuration is calculated down to 50 KeV (about 10 CU), it should be clear that in this region the gamma fluxes in lead are far from reality: our program considers neither Raleigh-scattering nor the fluorescence gammas below the lead -K- edge at 88 KeV, and near the K-discontinuity the interpolation in wavelength is no longer reliable.

4th data card : FORMAT (F6.0, 7i6)

1. data = A = parameter in the exponential transformation. If great spatial steps (up to about 2.5 mfp) are wanted, any value between 0.7 and 1.0 should be sufficient, with

the exception of high -Z- materials, if the source energy Es is above that with the minimum total cross section, E_{Min} ; then the inequality

$$\mu - A\mu_s > 0$$

(μ= total cross section, index S = source energy) should be valid for all energies below E_s. This means

$$A < \mu / \mu_s$$

Let E_s be 10 MeV, then we have in Sn ($E_{Min} \sim$ 4.5 MeV)

$$A < 0,92$$

in Pb and U ($E_{Min} \sim$ 4 MeV) $A < 0,85$

If somebody does not want to think much about this, A = 0.8 can be used as standard value for all materials from C to U and all source energies up to 10 MeV. (A = 0 means no exponential transformation at all, but then the spatial integration step must be much smaller than the above mentioned 2,5 mfp,)

2nd data = NG = number of cases with slabs of the same materials, in the same sequence,the same source wavelength W(1), and the same wavelength mesh, but with different geometries, defined on the geometry card.

3rd data = NS = number of slabs, at most 5.

4th data = MM = number of wavelength points, at which the material cross sections are given in input; in the sample cases = 24, at most 30.

5th data = MK = index of that wavelength, below which the interpolation is done quadratically and above linearly.

In our sample cases we should have MK = 16 for U, = 17 for Pb, = 18 for W, = 22 for SN, = 24 for lower -Z- elements. This index was introduced in order to get not too wrong interpolated cross section values near the K-edge discontinuities; if two points just below and above the K- or L-edge are included in the wavelength mesh on the 5. and 6. data cards, a quadratic interpolation can even lead to negative "cross sections". But this effect is usually unimportant since rarely in high -Z- media a calculation is carried down to so low energies -with the possible exception of a heterogeneous shield, as the above discussed case of lead and water layers.

6th data = MP = similar index for the pair production cross section interpolation, in the sample cases = 8 for all media. (For higher λ , i.e. lower E, this cross section is identically zero since it has a well-defined threshold near 1.022 MeV).
And as long as we neglect the pair production, i.e., we insert only zeros in the pair production library on the 13th and 14th card, we can put MP equal to an arbitrary integer.

5th and 6th data cards : FORMAT (12F6.0)

(and all the 8 following data cards, from the 7th to the 14th, have the same FORMAT, too).

Wavelength mesh table in C.U., begins in our sample cases with 0.0511 (at 10 MeV) as 1st value and ends with 34.06 (at 15 KeV) as 24 th value.

7th and 8th data cards : table of total cross section of the 1st slab in Thomson units per electron (1 Thomson unit = 1TU = 0.665 barn); its Kth value belongs to the Kth value of the wavelength mesh table in the 5th and 6th cards, K = 1 to 24 in our sample cases.

9th and 10th data cards: energy absorption cross sections of air (proportional to the conversion coefficients from energy flux to dose rate), units and reference to wavelength table as in 7th and 8th cards.

11th and 12th data cards:energy absorption cross sections of the 1st slab, units and reference to wavelength table as in 7th and 8th cards.

13th and 14th data cards:pair production cross sections of 1st slab; units and reference to wavelength table as in 7th and 8th cards.

Explanation: The program calculates from the wavelength and cross section mesh tables in the data cards 5....14 by interpolation those cross sections which belong to that wavelength mesh defined in the 3rd card, i.e. those of the given problem. Some remarks:In our sample cases we put all pair production cross sections equal to zero; so the program treats the pair production as complete absorption. Most of our cross sections are taken from (3), p.233-237.
If somebody wants to have other buildup factors than those given here, it is sufficient to insert the wanted weight function instead of the air or slab energy absorption cross sections (in a one-material shield the 9th and 10th or 11th and 12th data cards). But the nth value of this new weight function table should correspond to the nth wavelength value in the 5th and 6th data cards, n = 1, 2,....,

The program then computes instead of the dose or energy absorption buildup factors those of the newly defined weight function.
Now the program expects NS-1 sets of 8 cards analogous to the cards 7....14 which describe the following NS-1 slabs, just as the cards 7....14 describe the 1st. (NS is defined in the 4th card(+)) After these NS sets the geometry card must follow (as 15th, if NS = 1; as 23rd, if NS = 2; as 31st, if NS = 3 etc.). The geometry card is read in statement 135, all the others between the statements 20 and 40.

Geometry card, format F6.0, 7I6

1st data = DZ = spatial integration step in mfp at the source energy.

2nd data = IWV; IWV negative means an isotropic plain source at one boundary.

IWV = 0 means a perpendicularly collimated plane source at one boundary.

IWV = 1 or 2 or 3 etc. means a conic (oblique) plane source at one boundary; the angular distribution is non-zero for the 2nd or 3rd or 4th etc. cosine value on the first card and zero for all the others.

3rd data = JDP; the angular fluxes are printed out for the spatial indices 1 (source plain), 1 + JDP, 1 + 2·JDP etc.

(+) That means for NS > 1 a repeated input of the air energy absorption c.s.; this somewhat clumsy prescription and others reflect the subdeveloped stage of BIGGI 3P.

4th data = $\Im G(1)$ = spatial index of the right boundary plain of the first slab[+]; then the thickness of the 1st slab is $(\Im G(1)-1) * DZ$ mfp. If NS = 1, the data end here. If NS = 2, the program expects as

5th data = $\Im G(2)$ = spatial index of the right boundary plain of the second slab. The thickness of the 2nd slab is $(\Im G(2)-\Im G(1)) * DZ$ mfp. If NS = 2, the data end here. If NS $\geqq$ 3, the program expects as 6th... to (NS+3)th data $\Im G(3)$... to $\Im G(NS)$. The total thickness of all slabs together is $(\Im G(NS) -1) * DZ$ mfp. The upper limit of $\Im G(NS)$ is 26; the difference between two adjacent $\Im G$ should be at least 2, e.g. $\Im G(4) \geq \Im G(3)+2$.

Now a problem is defined completely, and the program begins to compute. Finished the calculations, the results are printed out, as described below. Then the program expects NG-1 new geometry cards (NG defined in the 4th card); having read one of them, the new computation is done, leaving unchanged the data defined before the geometry card.
Having finished all geometry cases the program expects new problem data, beginning with a data card as the above described 3rd card and ending with NG new geometry cards (NG defined newly).
If there are no more data cards, the program stops (in our monitor at the so-called 7/8 -card).

(+) Here and later "right" means the side opposite to the source.

Chapter 3

The BIGGI 3P Output.

The first block lists the energies of the groups in the first column, and their indices K, from 1 to K5, in the second. As an annex, one line is printed with that index (as 2nd data) at which the pair production causes the annihilation radiation (as near as possible to 0,511 MeV or, in other terms, to the wavelength 1C.U.) and the first data is the absolute difference (group wavelength - 1.0 C.U.)
The second block gives as first column the wavelengths of the groups in C.U., each of them NS times (NS = number of slabs). The next four columns give the cross sections in Thomson units per electron. The sequence is : total c.s. of the slab-energy absorption c.s. of air - energy absorption c.s. of the slab - pair production c.s. of the slab. Columns 6 lists the slab index JS going from 1 to NS repeatedly for any wavelength group, and column 7 the wavelength index K : NS times 1, NS times 2, etc. until NS times K5.
(If NG > 1 (4th data card), the first and second block are reproduced only once, at the beginning of the case described by the 1st geometry card, not at the beginning of the cases described by the following geometry cards.)
The third block contains the spectra as function of penetration depth and wavelength. It consists of JG(NS) sub-blocks, each beginning with one line containing the spatial index going from 1 (source plain, 1st sub-block) to JG(NS) (boundary plain far from the source, last sub-block) and followed by K5 pairs of numbers; the first of them is the spectrum and the second its wavelength index K; the spatial index of all of them is that at the top of the sub-block.

(The printed spectra are not the real spectra, but those multiplied with their wavelength in C.U. and divided by the unscattered spectrum).

The next block contains the buildup factors, usually in the following sequence: one line with the spatial index, one line with the sequence energy, dose, energy absorption, and particle buildup factor at that spatial point, all of them without the cutoff corrections and a 3rd line with the same sequence, but with the cutoff corrections. If the difference introduced by the correction gets too great, the cutoff wavelength was too small; in extreme cases the "corrected buildup" can get negative.

Some additional points: If JG (NS) is greater than 9, the differences between two consecutive buildup factors are printed, too, as 4th line in a sub-block. At boundary plains between two slabs, the buildup factors are calculated twice, since the energy absorption buildup factor depends on the material.

If for the last spatial point the angular integration for the dose buildup is done with different weights (2nd data card), this additional dose buildup factor appears between the last and the last but one sub-block (without low - energetic correction).

Two annexes of this block are: two lines with the energy current buildup factor for the last spatial point, without and with the low-energetic correction; and two lines with the energy albedo as first and the particle albedo as second data, first line without, second with cutoff correction. (For the albedos, too, a too small cutoff wavelength W(K5) causes too great or negative corrections, or even a negative "corrected albedo").

The next block gives angular fluxes in quadruples: first the angular flux, second the angular index (1 for the smallest cosine, usually - 1.; iMA for the greatest cosine, usually + 1., explained at the first data card), third the spatial index J (1 for the source plain, JG(NS) for the boundary plain opposite to the source), fourth the wavelength index K (1 for the source energy, or wavelength, K5 for the lowest energy = cutoff energy or highest wavelength). The angular index spacing is 1, the spatial spacing JDP (geometry card), the wavelength spacing KDP (3rd data card).
The last block (printed 3 times) gives the "principal output", i.e. a short survey of the most important input and output data.
Under the heading "Angular mesh and weights" the first two data cards are reprinted (in the same sequence, but partially with different formats; this remark applies to the reprint of the other data, too).
Under the heading "Wavelength mesh" and "Spatial and wavelength parameters" the 3rd and 4th data cards are reprinted. (If the initial NG was greater than one, NG decreases by one for each case already calculated.)
After the heading "Lambdas" there follows the wavelength mesh table, after "Sigmatotals" at first the MM (4th data card) total cross sections of the first slab, then those of the second slab etc. The other 3 less important cross section species-air and slab energy absorption and pair production - are skipped in output. In our sample cases we have MM = 24 and 8 values per line, so each slab occupies 3 lines.

The geometry card is reproduced under "Geometry".
The last sub-block gives under the heading "Place - BE - BDOSE - BEABS - BPART as first column the spatial index j and the buildup factors (with the cutoff correction) for energy, dose, energy absorption and particles, in this sequence, as in the buildup factor block explained above. The index j belongs the plain distant $(j - 1) \cdot DZ$ mfp from the source plain. At inner boundaries, the energy absorption buildup refers to the following material (e.g. if the place-index j is jG(1), the energy absorption buildup quoted in this block is that of the second slab, at jG(2) that of the 3rd slab - if these following slabs exist.)

Chapter 4

The BIGGI 3P Sample Cases.

Together with the Fortran listing of BIGGI 3P, we give in the annex a rather truncated case in order to show that even a rough energy mesh gives reasonable results.
It is the calculation of a 24 -mfp- slab of iron, with a plane perpendicularly collimated. 4 MeV source. The spatial integration step is 2 mfp, and only 14 wavelength meshpoints are used; and the first wavelength integration step is 0.06 C.U., nearly half of the initial wavelength 0.12775 C.U. (This means a very short calculation execution time, f.i. on the IBM 7090 only few sec per spatial point!)
We mark the data cards in the columns 73...80 with the following symbols:

ANGLES	for	the	1st	data	card	(angular mesh)
ANG.WGHT	"	"	2nd	"	"	(angular weight)
WL MESH	"	"	3rd	"	"	(wavelength mesh)
A NG NS	"	"	4th	"	"	(A, NG, NS, MM, MK, MP)
WL	"	"	5th	"	"	(wavelength table)
WL	"	"	6th	"	"	(" ")

FE ST for the 2 cards describing the sigmatotals of iron, SD for those 2 with the sigma-dose-values (i.e. the energy absorption cross sections of air, in T.U. per electron), FE SEA for those two with the sigmas for energy absorption of Fe.

For the other materials calculated later $-H_2O$, Al, Sn, Pb - FE is replaced by the resp. chemical symbol. The 2 empty cards describing the -here neglected- pair production cross section are not marked.
Geom or Geometry means the geometry cards. (All these marks are given only in order to explain things better to the user; they can be changed arbitrarily or skipped without effect on the program.)
At 2, 4 and 10 mfp the energy buildup factors can be compared directly with those of (3) and (4), and in spite of the extreme mesh crudeness, they are only about 3 resp. 8 resp. 18% higher than those of the moments method. Similar (and slightly higher) differences are found for the dose buildup factors: about 6 resp. 9 resp. 20%.
It might be asked whether these differences are real or at least partially due to fact that we used the cross section data of (3), which differ somewhat from those published and used in (4). A test run of the same problem+), but with the cross section data of (4, p. 12) showed that the differences in the energy buildup were smaller than 1‰ for penetrations up to 10 mfp, and even at 20 mfp they remained less than 1/2%. Such a good agreement certainly is to be expected in materials and at source energies where the Compton scattering process is dominating, as in our sample case (the Compton process is known with a very good precision since many years, so there was no considerable change in our knowledge about it in the last few years).

+)Not reproduced among the sample cases.

But where pair production and photoelectric absorption get important, our knowledge about the cross sections has increased in the last years, so the cross section and buildup factor changes should be greater.
Another question is why our calculations do not depend sensitively on the wavelength mesh, in contrast with the moments method (4, p. 38, p. 54, p. 67). This should be due to the fact that the integrands occuring in the moments method contain as factors the oscillating Legendre polynomials P_l, so they are negative in some regions, and a too rough numerical integration scheme can even produce "negative spectra" at deep penetrations (4, p. 68). Since all our integrands are not negative, we can use rougher integration steps and a rougher integration rule than the moments method (trapezoidal instead of f.i. Simpson).
A last question could be how much our results change if we use better spatial and wavelength meshes. So we recalculate the above case of a plane collimated 4-MeV- source on a 24-mfp iron slab, but with a halved spatial step (1 instead of 2 mfp) and halved wavelength steps in the important (upper) energy region. This increases the calculation execution time per spatial point by a factor $\sim$2. But in order to avoid that this report gets too thick, we give for the following cases only the "principal output" defined at the end of chapter 3.
But the energy buildup factors change by less than 1% for source distances $\leq$ 12 mfp while at 20 mfp the difference reaches 5%. This shows the surprisingly good "spatial and energetic stability" of our method for deep penetrations.

But some earlier distributed copies of B3P were not at all "energetically stable"; for special wavelength meshes, the results gat crazy (on a CDC machine; on the IBM 7090 this did not happen, it seems because the IBM made more (!) rounding errors than the CDC). If the users of the old version (the new copies have been corrected) have such difficulties, we propose either: a wavelength mesh where any wavelength mesh point distance W(K') - W(K")
is unequal to 2.0 (K', K" = all pairs from the set K = 1, 2, 3,..., K5-1, K5)
or a correction in the Fortran deck: write in the statement just before st. 280 (we quote the external formula numbers and underline the corrected numbers twice, the old and wrong values once)

IS = 2

(instead of "IS = 1")
and write in st. 290

```
290 iF (OM(IS) - OMSMA) 340, 295, 295
```

instead of..... 340, 340, 295)

Another field where our method is neither spatially nor energetically stable is the calculation of the reflection phenomena, i.e. reflected spectra and albedos; here much finer angular, wavelength, and spatial meshes are necessary, if the results shall be good, and the exponential transformation seems to lose its value here.

With the same energy mesh and material we calculate another case, changing only the geometry card: an isotropic 4-MeV-source on a 24 mfp thick iron slab, DZ = 2.0 mfp.

The average agreement with (4, p. 147) gets better than in the collimated case: at 2,4 and 10 mfp 5, -1, and 13% deviation instead of 3,8, and 18%. This confirms that our buildup factors for deeper penetrations still show not negligeable deviations from (3) and (4), but for isotropic less than for collimated sources.
Up to now the calculations have shown that the deviations are neither due to differences in the cross section library nor to our spatial and wavelength meshes. (Further calculations show that other values of A in the range 0.7 to 1.0 - instead of 0.95 - produce only small influences on the buildup factors) So the last possible reason remains the choice of the angular mesh. Really, calculations with other angular meshes show a considerable dependence of the results on the chosen angular mesh points, and the used set of 8 points (± 1.0, ± 0.925, ± 0.84, ± 0.28) was taken since it yields a reasonable compromise between the goals of precision on one and not too high computer time on the other hand. The fact that our deviations from (3) and (4) are higher in the collimated than in the isotropic source case can be explained, too, with the dependence on the angular mesh: the isotropic source is, unlike the collimated one, continuous in angle, so it presents less difficulties for a numerical angular integration.
In order to show to the user also how to handle a multislab case, we give as last sample a shielding sequence Al + H_2O + Pb + Sn + H_2O (and so, too, we give him the cross section data of some of the most interesting elements resp. materials.) Here we see also such effects as buildup factors decreasing with increasing penetration near boundaries (if

the following medium is a strong absorber as lead or in this context also void), and the energy absorption buildup can even change by one order of magnitude. (This reflects the fact that the corresponding weight function the energy absorption cross sections- can change even by two decades at a given energy, passing f.i. from water to lead!)

Chapter 5

The B4T Input.

We describe at first the library data for the 30 elements listed below.

1st and 2nd data card, format 12F6.0+):
wavelength table with 24 values, going from 0.03407 to 25.55 CU (corresponding energy range: 15 MeV to 20 KeV).

3rd and 4th data card, format 12F6.0:
24 values of the difference "total Compton cross section minus energy absorption Compton cross section", in barns per free electron, referring to the wavelength table (taken from (3, p. 148), where these quantities are listed as $\sigma_c - \sigma_{ca}$

5th data card, format 2I6:
1st data = NEG = number of elements in the library; here 30, at most 30.
2nd data = KTP = number of wavelength mesh points with pair production cross sections greater than zero (for all elements); here = 9.

6th to 95th data cards: 90 cards++), all with the format 12F6.0; the NEth triplet describes the NEth element in the library, NE = 1, 2,..., NEG.

+) In the input of floating point (decimal) numbers, we give in any case the decimal point explicitly, so-at least in input- e.g. F6.0 and F6.2 are equivalent.

++) More generally: 6th to (3*NEG+5)th data cards: 3*NEG cards.

1st card of a triplet:

1st data = atomic number Z(NE)

2nd data = atomic weight AT(NE)

3rd to (KTP+2)th data: pair production cross sections > 0 in barns per atom of element NE, referring to the wavelength table. (Here KTP + 2 = 11)

2nd and 3rd card of a triplet: total cross sections in barns per atom of element NE, referring to the wavelength table.

Remarks: The sequence of elements is here

Index NE	Z(NE)	Element	Index NE	Z(NE)	Element
1	1.	H	15	22.	TI
2	4.	BE	16	25.	MN
3	6.	C	17	26.	FE
4	7.	N	18	29.	CU
5	8.	O	19	30.	ZN
6	10.	NA	20	35.	BR
7	12.	MG	21	42.	MO
8	13.	AL	22	47.	AG
9	14.	SI	23	50.	SN
10	15.	P	24	53.	J
11	16.	S	25	56.	BA
12	18.	A	26	74.	W
13	19.	K	27	78.	PT
14	20.	CA	28	81.	TL
			29	82.	PB
			30	92.	U

The total and pair production cross sections were taken from (5), either directly or, for some elements (Ti, Mn, Zn, Br, Ag, Ba) by suitable interpolation and extrapolation in Z, using again the data of (5). The program needs the Z(NE) as floating point numbers, so they are given here in this form, too.
Our library data finish with the 3rd card of the uranium triplet. The following cards form the

Problem Data

The Response Function Option.

The first p.d. card (=problem data card) defines whether special response functions (r.f.) are needed or not. The usual r.f.s leading to the energy and particle flux, the dose rate and absorbed power are calculated in any way; but the r.f. option allows to compute f.i. (γ,f) or (γ, n) reaction rates by inserting the appropriate cross sections.

1st p.d. card (format 6I6)

1st data = NRE = number of given r.f.s, ≤ 4

2nd data = KTRG= total number of wavelength mesh points, at which the r.f.s are given as function of the gamma wavelength, ≤ 36.

3rd data =IDR(1)=identification number of the first r.f. (if NRE$\geq$1)

4th data =IDR(2)=identification number of the 2nd r.f. (if NRE$\geq$2)

5th data =IDR(3)=identification number of the 3rd r.f. (if NRE$\geq$3)

6th data =IDR(4)=identification number of the 4th r.f. (if NRE= 4)

The IDR(1), IDR(2) etc. are used as different labels for each r.f.. and later for the integrated responses; if they are skipped, the program will give to any r.f. the same identification number zero, but the results of the program will not change.

Remark: NRE$\leq$0 means that no r.f.s are wanted; in this case KTRG can be any value.

The R.F. Wavelength Mesh, Abscissae (only if NRE$\geq$ 1):1, 2, or 3 cards, format 12F6.0, (1 card, if KTRG $\leq$12; 2 cards, if 13$\leq$ KTRG$\leq$ 24; 3 cards, if 25$\leq$ KTRG$\leq$36) describing the wavelength mesh at which the r.f.s are given, the smallest wavelengths first (corresponding to the 1st and 2nd cards in the library data, but there can be more than the there mentioned 24 mesh points, and they can be at other places.

The R.F. Value Mesh, Ordinates (only if NRE$\geq$1)

The first r.f. is described by KTRG values on as many cards as are needed for the r.f. wavelength mesh, the nth ordinate belonging to the nth abscissa, n = 1, 2,... KTRG.

If NRE = 1, the r.f. data end here; for NRE = 2 follows a similar group of 1, 2, or 3 cards giving (for the same wavelength mesh) the second r.f., for NRE = 3 an analogous 3rd group and for NRE = 4 a fourth. NRE $>$ 4 is not allowed.

The Physical-Number Card, Format (I6).

1st data = NPHYS = number of physically different cases, i.e., of those cases in which all the following problem data must be newly defined; cases which differ only in the so-called "geometry input" described later, are physically analogous.

The Geometry-Number Card, Format (2I6, F6.2, I6)

1st data = NGEOM =number of different geometry cases belonging to one physical case, i.e. the number of different geometry input card sets.

2nd data = NMG = total number of materials calculated by the program, i.e. given by the input cards, $\leq$ 9.

3rd data = CP = constant describing the pair production. CP = 1.0 means a correct treatment of the pair production effect, CP = 0. its neglection (the annihilation radiation is assumed to be absorbed just in the point where the electron-positron-pair was created).

4th data = INDOUT; if > 0, the output is greatly reduced, there will be no intermediate results. INDOUT $\leq$ 0 yields a detailed output. INDOUT < 0 means, too, a direct printing of the spectra, INDOUT = 0 that all spectra are divided by that of the highest energy group. (But this denominator can vanish in some cases, e.g. collimated sources!)

The 3·NMG Partial Density Cards, Format (12F6.0)

The 1st card triplet describes the 1st material, the 2nd triplet the second material etc., finally the NMGth triplet the NMGth material. The NMth triplet (NM = 1,2,..., NMG) contains

on the 1st card as

1st data = RHO(NM, 1)	= partial H-	density	in	NMth	material
2nd data = RHO(NM, 2)	= partial Be-	"	"	"	"
12th data = RHO(NM,12)	= partial A -	"	"	"	"

on the 2nd card

1st data = RHO(NM,13)	= partial K -	"	"	"	"
12th data = RHO(NM,24)	= partial J -	"	"	"	"

on the 3rd card

1st data = RHO(NM,25)	= partial Ba-	"	"	"	"
6th data = RHO(NM,30)	= partial U -	"	"	"	"

(All densities are given in gram per cubic centimeter; which element from H to U belongs to which element index NE from 1 to 30, is given in the table at the beginning of this chapter)

Example: The water (H-density = 0,112 g/cm^3, O-density = = 0,888 g/cm^3) is defined by 0.112 in the columns 1 to 6 and 0.888 in the columns 25 to 30 of the 1st card of the triplet; all other columns in the three cards can be left blank, since the machine takes the blanks for zeros; but the zeros can also be given directly.
An further explanation referring to the atomic weights in the library and the partial densities in the problem data: The atomic weights AT(NE) are those of the natural isotopic mixtures. But the reactor technology sometimes uses materials enriched in certain isotopes (U^{235} in U, D_2O instead of H_2O etc.). Since the atomic weight can change by a factor 2 (passing from H to D), it can get necessary to correct the input data in the following way: The requirement is that the macroscopic cross sections and the electron densities have their correct values.
Both of them depend only on the ratio RHO (NM, NE)/AT(NE) of the element NE in the different layers NM, where AT(NE) is the average value $\bar{A}$ of the natural isotopic mixture. If $\bar{A}$ in the natural mixture is replaced by A_R, it is only necessary to substitute the real $\varrho = \varrho_R$ by the value

$$\varrho_{eff} = \varrho_R \cdot \bar{A}/A_R$$

for now the quotient $\varrho_{eff}/\bar{A}$ has again its true value ϱ_R/A_R. This means f.i. ϱ_{eff} (D) = 1/2 ϱ_R (D) or $\varrho_{eff}(U^{235})$ = 238/235 ϱ_R (U^{235}).
(The difference in the microscopic gamma cross sections between different isotopes can be neglected, since even the lightest nucleus, the proton, is by $\sim$ 3 1/4 decades heavier than the electron!)

The Angular Mesh Card, Format (I6, 9F6.2)

1st data = IG = number of angular mesh points, $\leq$ 9
2nd to (1 +IG)th data: OM(1), OM(2),...,OM(IG)= cosines of the IG mesh points, the smallest first.

Remarks: Which angular mesh can be used in plane geometry was already discussed in chapter 4. If regions far from small spherical sources are of interest , it might get necessary to concentrate the mesh points near the forward direction, e.g. to take IG = 9 and the sequence - 1.0; - 0.8; -0.3; 0.3; 0.8; 0.9; 0.96; 0.985; 1.0 as OM(1), OM(2),..., OM(9). Cosine values = 0.0 or $\sim$ 0.0 can lead to overestimates near optically thin slab sources, but they can be used for optically thick sources.

The Source Energies Card, Format (9 F6.0)

1st data = EV(1) = highest source energy, in MeV,
2nd " = EV(2) = " but one source energy, in MeV, until
9th " = EV(9) = lowest source energy, in MeV.

If less than 9 source energies are needed, the first superfluous EV -value must be given as value $\leq$ 0.001, f.i. as blanks or as zero.

The Wavelength Mesh Card, Format (6 (F9.4, I3))

1st, 3rd, 5th, 7th, 9th, 11th data = 1st, 2nd, 3rd,..., 6th wavelength integration step DW(1), DW(2), DW(3),..., DW(6), in CU.
2nd, 4th, 6th, 8th, 10th, 12th data= KG(1), KG(2), KG(3),.., KG(6) = indices of the last wavelength mesh points at which the steps DW(1), DW(2), DW(3),...,DW(6) are used.

Which wavelength meshes can be chosen was already discussed in chapter 2; the only differences are the names of the variables, DW1, DW2 etc. instead of DW(1), DW(2) etc., and

K1, K2 etc. instead of KG(1), KG(2) etc., and the upper limit is now

$$KG(6) \leq 51$$

The inequalities among KG(1), KG(2), KG(3),..., KG(6) correspond to those among K1, K2,..., K5. But if less than 6 steps are used, it is necessary that the first superfluous KG -value is smaller than, or equal to, the preceding KG, f.i. if the last needed value is KG(3)= 24, KG(4) must be $\leq$ 24, f.i. zero or blank, and the other steps and indices DW(4), DW(5), DW(6), KG(5), KG(6) are of no importance, f.i. they can be left blank. As in chapter 2, the order of magnitude of the cutoff correction can be used as a test for the right choice of the cutoff wavelength.

In one respect, the wavelength mesh and the source energy mesh are coupled, or at least not independent: if more than 1 source energy is used, the program assigns the highest source energy to the 1st energy group and the lower source energies to appropriate energy groups, requiring that the absolute difference between exact and approximated (group) wavelength is a minimum.

If one source energy is too near to another (or the wavelength step too great), two or more source energies can be assigned to one energy group. In this case the program continues to compute, but gives a diagnostics and neglects from the f.i. 2 source energies attached to the same energy group the second. (More about this in the following chapter about the B4T output).

The Geometry Input

The Geometry Parameters Card, Format (3I6)

1st data = KOE = index defining the geometry; if KOE $<$ 0, plain geometry and black boundaries left and right; if KOE = 0, spherical geometry and black boundaries at the innermost and outermost spherical surfaces; if KOE $>$ 0, spherical geometry, black boundary outward, the innermost sphere is assumed to consist of the same material as the inner spherical shell.

2nd data = JMDZ; if $\leq$ 0, all lengths on the later described spatial mesh card are interpreted in mfp at the highest source energy in the resp. medium; if JMDZ $>$ 0, those lengths are interpreted in cm. The combination JMDZ = 0 and JSQ $>$ 0 has a special meaning, explained in the discussion of the layer source specification card.

3rd data = I2INT = index leading to linear (if $<$ 0) or quasi - exponential interpolation and integration between two angular mesh points. (The linear case need not be explained here) "Quasi-exponential" means: between the two angular mesh points (w_1, f_1) and (w_2, f_2) we assume a third, ($\bar{w}$, $\sqrt{f_1 f_2}$) with $\bar{w} = (w_1 + w_2)/2$, i.e. an exponential behavior of f(w) in the interval in question. Using these 3 points, we do a quadratic interpolation and integration, applying the Newton and Simpson formulae. But in order to save computer time, we approximate, if I2INT = 0 (1st approximation)

$$\sqrt{f_1 f_2} \simeq \frac{f_1 + f_2}{4} + \frac{f_1 * f_2}{f_1 + f_2} = S_1$$

(we exclude in the program the case (f_1+f_2) too near to zero or negative)

or, if I2INT > 0 (2nd approximation)

$$\sqrt{f_1 f_2} \simeq \frac{1}{2} (S_1 + \frac{f_1 f_2}{S_1}) = S_2$$

S_1 is an overestimate by

$$\frac{(\sqrt{f_2} - \sqrt{f_1})^2}{4(f_1+ f_2)}$$

The relative error r_1 of S_1 is, if $|f_2 - f_1| \ll f_2 + f_1$

$$r_1 \simeq \frac{1}{8} \left(\frac{f_2 - f_1}{f_2 + f_1}\right)^4 \cdot \left\{1 + \left(\frac{f_2 - f_1}{f_2 + f_1}\right)^2\right\} ,$$

This means errors of f.i. 1,75‰, if $f_2 = 2f_1$; 2.5%, if $f_2 = 4 f_1$; 13.6%, if $f_2 = 10 f_1$; ~62%, if $f_2 = 100 f_1$.

The relative error of S_2 is

$$r_2 = \frac{1}{2} r_1^2 ,$$

if $|r_1| \ll 1$.

f.i. 0,03%, if $f_2 = 4f_1$; 1,25%, if $f_2 = 10 f_1$; ~34%, if $f_2 = 100 f_1$. In the discussion of the sample cases, we shall write something about the gain in precision with the option I2INT ≥ 0.+)

The output mesh card, format (10I6)

1st data = IOUTM; the most important ("principal") output (=energy integrals and problem input data) is printed IOUTM times at the end of the total output.

+) A price paid for this progress is a slight violation of the linearity of the Boltzmann equation: The angular integral of a sum can differ somewhat from the sum of the single integrals, if I2INT ≥ 0.

(In B3P the corresponding value was everytimes 3; the option IOUTM $\leq$ 0 is treated as if IOUTM = 1)

2nd data = IPA
3rd " = IPZ
4th " = IPD
} not needed, if INDOUT > 0; otherwise the transformed angular fluxes are printed for the angular indices IPA, IPA + IPD, IPA + 2IPD etc. which are $\lesssim$ IPZ

5th data = JPA
6th " = JPZ
7th " = JPD
} Analogous to IPA, IPZ, IPD, but referring to the spectra, too, and valid for the spatial instead of the angular indices

8th " = KPA
9th " = KPZ
10th " = KPD
} Analogous to JPA, JPZ, JPD, but valid for the wavelength instead of the spatial indices. -If INDOUT $\leq$ 0 and IPA $\leq$ 0, the spectra and angular fluxes are printed out at any mesh point in the phase space (the program then redefines: IPA = IPD = JPA = JPD = KPA = KPD = 1, IPZ = IG, JPZ = last spatial index, KPZ = last wavelength index)

The Material-to-Layer Transformation Card, Format (10I6)

1st data = MST; if $\leq$ 0, the 1st layer consists of the 1st material, the 2nd layer of the 2nd material etc., until layer NS of material NS (here NS must be smaller than or equal to NMG). MST > 0 means: 1st layer of material M(1), 2nd of material M(2), etc. until layer NS of material M(NS), where

2nd data = M(1)
3rd " = M(2)

(NS+1)th data = M(NS)

Remarks: NS is not given explicitly in input, but computed by the program itself (by the data on the layer boundary indices card).

For MST ≤ 0 the input values M(1), M(2) etc. are unimportant. - Two examples: We put NMG = 2, 1st material (1st partial density card triplet) = Fe, 2nd material (2nd corresponding triplet) = H_2O. Then NS = 2 and MST ≤ 0 means: 1st layer Fe, 2nd H_2O. NS = 3, MST > 0, M(1) = 2, M(1) =1, M(3) = 2 means: 1st layer H_2O, 2nd layer Fe, 3rd layer H_2O.

The Spatial Mesh Card, Format (10F6.0)

1st data = R = smallest radius considered in spherical geometry (= inner radius of innermost shell); in plain geometry (i.e. if KOE < 0) unimportant.

2nd data = DZ (1)= spatial integration step in layer 1
3rd " = DZ (2)= " " " " " 2
(NS+1)the data = DZ(NS)" " " " " NS

The units of R and DZ ($\mathfrak{J}$S), $\mathfrak{J}$S= 1, 2,...NS are defined by $\mathfrak{J}$MDZ on the geometry parameters card.

The Layer Boundary Indices Card, Format (9I6)

1st data = $\mathfrak{J}$G(2) = $\mathfrak{J}$ of left boundary of 2nd layer+)
2nd " = $\mathfrak{J}$G(3) = $\mathfrak{J}$ " " " " 3rd " etc.
NSth " = $\mathfrak{J}$G(NS+1)= $\mathfrak{J}$ of right boundary of the last (= NSth) layer

Remarks: The program puts $\mathfrak{J}$G(1) = 1. -We have for

$$1 \leq \mathfrak{J}S - 1 < \mathfrak{J}S \leq NS$$

$\mathfrak{J}$ of left boundary of layer $\mathfrak{J}$S = $\mathfrak{J}$ of right boundary of layer $\mathfrak{J}$S-1 (the boundaries are counted only once, which is not the case in every transport program). The thickness of the layer $\mathfrak{J}$S (slab, if KOE < 0; shell, if KOE ≥ 0) is

---

+) $\mathfrak{J}$ = symbol, here and later, for "spatial index".

$$\{ JG(JS + 1) - JG(JS) \} * DZ(JS)$$

in units defined by JMDZ (geometry parameters and spatial mesh card). The 1st layer f.i. has the thickness

$$\{ JG(2) - JG(1) \} * DZ(1) = \{ JG(2) - 1 \} * DZ(1) \text{ mfp, if}$$

JMDZ $\leq$ 0, and the same number of cm, if JMDZ $>$ 0.

Clearly we must have the inequalities

$$JG(1) < JG(2) < JG(3) < \ldots < JG(NS) < JG(NS+1)$$

(but not, as in B3P, JG(1)+1 $<$ JG(2) etc.; see ch. 2).

The first superfluous value of JG - f.i. if 3 layers are needed, we must define JG(2), JG(3), and JG(4), so JG(5) is the first superfluous - must be $\leq$ its predecessor, in our example

$$JG(5) \leq JG(4),$$

f.i. JG(5) = zero or left blank. From this violation of the natural inequalities the program determines the right value of NS, here NS = 3. (So here such a violation is necessary, except in the case NS = 9)

The Exponential Transformation Card, Format (9F6.0)

1st, 2nd, 3rd,...,NSth data = A(1), A(2), A(3),...,A(NS) = exponential transformation parameters A(JS) of the layer JS, JS = 1, 2, 3,...NS+). The exponential factor split from all the fluxes and sources is in one-layer-geometry at the point x

$$\exp \{ - A(1)\, \mu_1\, (x - x_1) \}$$

+) Some authors call these parameters A(JS) "Kahn's constants".

($x_1 = x$ of the innermost point) and in a multi-layer case

$$\exp\left\{-\int_{x_1}^{x} A(x')\,\mu_1\,(x')\,dx'\right\}$$

μ_1 is the total macroscopic cross section at the highest source energy. Let μ be the corresponding energy-dependent value; then A should obey the following conditions: $\mu(x) \pm A(x)\mu_1(x)$ should not get negative or too near to zero; the contrary would imply the possibility of negative cross sections, i.e. a reproducing instead of an absorbing medium. In a source-free layer with the sources at the left side this means that $0.7 \leq A \leq 1.0$ is a reasonable choice, if the highest source energy is not above that energy with the total cross section minimum; then we must have

$$|A| < \mathrm{Min}\left\{\mu(x)/\mu_1(x)\right\}$$

This situation was already discussed in chapter 2; but here we have also the possibility of a source-free layer with the sources at the right side, and then the sign of A must be inverted. In optically thin layers A can be put equal to zero or nearly zero. In a source-containing layer A should be chosen in such a way that the spatial source dependence is roughly proportional to the above-mentioned exponential. If an optially thick source-free layer is considered with sources at the left and at the right side, the exponential transformation should either be avoided (i.e. A = 0.0 and small DZ - values in this region), or the layer should be divided in at least two sub-layers: one in which the fluxes coming from the left prevail, where $A > 0$; one in which the fluxes coming from the right prevail, where $A < 0$; and eventually one where the flux is a flat function of x , where $A \sim 0.0$. A similar decomposition could be used in a layer with a source which has an extreme value near the layer center and changes rapidly in space at the sides.

The Angular Source Distribution Card, Format (I6, 9F6.2)

1st data = IWV = index defining the angular distribution of the sources $S(w,x,\lambda) = S_1(w) * S_2(x,\lambda)$ in quanta per (cm^3 sterad. Compton unit), w = angular, x = spatial, λ = wavelength coordinates. IWV = 0 means $S_1(w) = 1.0$ for all w, i.e. an isotropic source. IWV > 0 means a conically collimated source: $S_1(w) = 1.0$ for the value w = OM (IG+1 - IWV), defined on the angular mesh card, and $S_1(w) = 0$ for all other there given values OM (I). Between two adjacent mesh cosines OM (I) and OM (I+1) a linear or quasi-exponential interpolation is used (depending from I2INT on the geometry parameters card); so $S_1(w)$ is a continuous function of w, piecewise either linear or quadratic. Especially IWV = 1 means a perpendicular collimation.
Only values IWV ≤ IG are meaningful.
IWV < 0 means that the angular source distribution is described by the following data on this card.

2nd data = QOM(1) = S_1(OM(1))

3rd " = QOM(2) = S_1(OM(2)), until

(IG+1)th data = QOM(IG) = S_1(OM(IG))
with a similar interpolation between these points as described for the case IWV ≥ 0. If IWV ≥ 0, the values QOM(I) are superfluous in input, since they are defined by the program itself.

The Layer Source Card, Format (I6,9F6.2)

1st data = JSQ = layer source index, describes the spatial source distribution. JSQ > 0 means sources only in the JSQth layer (so only values JSQ ≤ 9 are meaningful);

JSQ =0 means for spherical geometry sources only in the central (i.e. the smallest) sphere; JSQ < 0 means that the sources are given by the input in the next cards, and the values QE(1), QE(2) etc. following here are unimportant in this case.

2nd data = QE(1) = source energy spectrum for the highest source energy EV(1) (source energies card)

3rd data = QE(2) = source energy spectrum for the 2nd source energy EV(2) etc.; there must be as many QE -values as there are source energies EV, at most 9.

If JSQ ≥ 0, the problem data end here, and we must describe finally the normalisation of the sources for this case. If JSQ = 0, at the energy EV(KV) the source strength is within the central sphere S_1(w)* QE(KV)/(4π*DW) quanta/(cm^3 sec sterad . CU) with DW = appropriate wavelength integration step from the set DW(1), DW(2),...DW(6), and S_1(w) is defined by the values on the angular source distribution card. An integration over all angles and the wavelength width of the energy group gives 0,5* $\int_{-1}^{1}$ S_1(w) dw * QE(KV) quanta/(cm^3 sec) at the energy EV(KV).
E.g. we get for an isotropic source (i.e. IWV = 0) QE(KV) quanta of energy EV(KV) per (cm^3 sec)
For JSQ =0, at all points not within the central sphere the sources vanish. If JSQ > 0 and JMDZ ≠ 0, we have in the layer JSQ at the energy EV(KV)
S_1(w)*QE(KV)/(4π DW) quanta/(cm^3 sec. sterad . CU)

Again, the sources vanish in all the other layers; the integrated results are the same as in the case JSQ = 0, apart from the source location. Especially for an isotropic source QE(KV) is the source density in γ/(cm^3 sec), at EV(KV).

If $\mathfrak{J}$SQ > 0 and $\mathfrak{J}$MDZ = 0, we multiply the above-described sources with a further factor $\Sigma^{T}_{\mathfrak{J}SQ}$ (E_{Max}) = SS(1,$\mathfrak{J}$S,1), i.e. the linear total macroscopic cross section at the highest energy in the layer $\mathfrak{J}$SQ(in cm^{-1}). This simplifies the normalisation in some cases: f.i. we simulate a plain isotropic monoenergetic source by a thin slab source. We want to define the length in mfp, so we put KOE < 0, $\mathfrak{J}$MDZ = 0, $\mathfrak{J}$SQ= 1, IWV = 0, $\mathfrak{J}$G(2)= 2, DZ(1) = $\varepsilon \ll 1.0$ (e.g. $= 10^{-2}$), and QE(1) = $1/\varepsilon$. Then the source strength of this quasi-plain source is, in quanta/(cm^2 sec):

$$QE(1) * (\text{slab thickness in cm}) * \Sigma^{T}_{\mathfrak{J}SQ}(E_1)$$

$$= \frac{1}{\varepsilon} * \left(DZ(1)/\Sigma^{T}_{1}(E_1)\right) * \Sigma^{T}_{1}(E_1) = \frac{1}{\varepsilon} * \varepsilon = 1$$

With the option $\mathfrak{J}$MDZ < 0 we should have, if the other values remain unchanged, $1/\Sigma^{T}_{1}(E_{Max})$ quanta/(cm^2 sec).

We finally have to discuss the option $\mathfrak{J}$SQ < 0. In this case the QE(1), QE(2),...etc are superfluous, and we need as next cards

The Source Fluxes Cards, Format (6E12.0)+)

Explanation: Often the source is a product of a function depending only from the spatial coordinate and another function which is material - and energy - dependent. Example: if we consider only gammas from thermal captures, the 1st function is the thermal flux and the 2nd the material-dependent capture gamma spectrum, normalised so that its energy integral gives the macroscopic radiative capture cross section of the material in question. We describe the 1st function with the source fluxes cards and the 2nd with the source spectra cards.

+) These and the following source spectra cards are the only input cards using the field specification E!

1st data (of the source fluxes cards) = FS(1) = source flux at the 1st spatial point.

2nd data = FS(2) = source flux at the 2nd spatial point.

3rd " = FS(3) = " " " " 3rd " " etc.

In this way the data continue until the data γG(NS+1), giving FS(γG(NS + 1)), in total one value per spatial point. Since only 6 values can be given on one card, we need

integer part of $\left[(\gamma MA + 5)/6\right]$

source flux cards (γMA = abbreviation for γG(NS+1)).

The Source Spectra Cards, Format (6E12.0)

Since the capture cross section and the capture gamma spectra (more generally: the 2nd of the 2 functions mentioned above in the explanation) change from material to material, they must be defined on a last set of cards. We call the number of source energies KVG. (KVG is not given explicitly in input, but computed by the program itself using the data on the source energies card) We need one card per layer if KVG is smaller than seven, otherwise two of them; but KVG cannot be greater than nine!

1st data = GS(1,1) refers to the source energy EV(1) in the 1st layer

2nd data = GS(2,2) " " " " " EV(2) " the 1st layer, until

KVGth data= GS(1,KVG) " " " " " EV(KVG) in the 1st layer

If the total layer number NS is > 1, NS - 1 analogous sets of one card (if KVG ≤ 6) or two cards (if KVG > 6) must follows; they refer to the 2nd, 3rd,...,NSth layer. (For NS=1 the problem data of one case end after GS(1, KVG)).

The gamma angular space - and energy-dependent sources are in the $\mathfrak{J}$Sth layer, at the $\mathfrak{J}$th spatial point, at the KVth source energy, and at the cosine mesh point OM(I)

GS($\mathfrak{J}$S, KV)* FS($\mathfrak{J}$)*QOM(I)/(4π*DW) quanta/(cm^3 sec sterad CU)

(see angular distribution card and layer source card).
Let FS($\mathfrak{J}$) be the thermal neutron flux at the spatial mesh point $\mathfrak{J}$, then GS($\mathfrak{J}$S, KV) is the capture gamma spectrum in the layer $\mathfrak{J}$S, in quanta of energy EV(KV) per cm. In other words, GS($\mathfrak{J}$S, KV) is the product macroscopic (f.i. thermal) neutron absorption cross section of the layer $\mathfrak{J}$S(in captures per cm) times the number of quanta per average capture with the energy EV(KV), KV = 1, 2,...,KVG. (But since the gamma sources depend only on the product GS * FS * QOM, it is possible to shift some factor, f.i. a power of 10, from one of the 3 factors GS, FS, and QOM to any other). For the most important case of isotropicity we have at the energy EV(KV) a source strength FS($\mathfrak{J}$)* GS($\mathfrak{J}$S, KV) γ/(cm^3 sec) at EV(KV), at the point $\mathfrak{J}$ in the layer $\mathfrak{J}$S.
Now a problem is defined completely, and the program executes the calculations. Afterwards the results are printed out, as described in the next chapter. If NGEOM (geometry number card) is greater than 1, (NGEOM -1) further sets of geometry cards are expected, beginning with the geometry parameters card. Their problems are executed and their results printed as above. Having done all the NGEOM cases, the program is finished, if NPHYS$\leq$1; if NPHYS$>$1, (NPHYS -1) further sets of problem data (including new geometry data) must follow, starting from the geometry number card.

Chapter 6

The B4T Output

If INDOUT$\leq$ 0 (full output, as described on the geometry number card), the program gives as 1st block the macroscopic cross sections in cm^{-1} for the materials specified on the NMG partial density card triplets; the wavelength mesh is that of the 1st and 2nd library data cards. The heading NM stands for the material index, going from 1 to NMG + 1 (NM = NMG + 1 means the air, needed for the flux-to-dose-rate conversion coefficients); K is the wavelength index, going from 1 to 24. The other headings are self-explanatory; we mention only that PAIR means pair production and EABS the energy absorption.
As an annex of the 1st block, for each material NM (from 1 to NMG+1) the total densities (RHO) and the electron densities (ELDENS) are printed, in gr/cm^3 and el/(barn cm)= = el/$Angstrom^3$. If INDOUT $>$ 0, this 1st block is skipped.
The next lines (printed in any case) show how the group wavelengths are assigned to the wavelengths of the source energies. The 1st column gives the energetic source index KV, from 2 to KVG+1 (KVG is the total number of source energies, KVG + 1 corresponds to the annihilation photon source). The 2nd column lists those energy indices from the wavelength mesh whose energies are as near as possible to the source energies, the 3rd the source wavelengths, the 4th the assigned group wavelengths and the 5th their absolute differences. (The case KV = 1, i.e. highest source energy, is skipped, since trivial.)

If the condition described in the wavelength mesh discussion is not met, the there mentioned diagnostics is printed here; then at least 2 equal indices appear in the second column.

The next block is given only if INDOUT ≤ 0; it is similar to the first and gives with the same heading the macroscopic cross sections of the NMG + 1 materials; only the sequence in NM and K and the wavelength mesh are changed (now it is that defined by the wavelength mesh card). If response functions are used (by the option NRE positive), their values are given as an annex (for the same wavelength mesh, together with their wavelength indices and their identity numbers IDR(MRE), MRE = 1, 2,..., NRE.

The following block is headed "Spectra..." (printed only if INDOUT ≤ 0). It consists of sub-blocks; each of them has its spatial index J at its top (J begins with JPA and is continued with the spacing JPD until JPZ, as given in the output mesh card), and contains at this spatial point the spectra integrated over all angles. Before each spectral value stands its wavelength index K (from KPA to KPZ with spacing KPD, output mesh card).

For INDOUT > 0 this block is suppressed; for negative INDOUT the spectra are printed directly; for INDOUT = 0 they are divided by that of the highest energy group and then printed. (But this option INDOUT = 0 can lead to difficulties, if at some spatial point the unscattered highest energy flux vanishes, f.i. for collimated sources!)

The next block (suppressed for positive INDOUT) gives, with an appropriate heading, the energy-and space-dependent angular fluxes, transformed with the exponential (described in the explanation of the exponential transformation card) and-for spherical geometry (KOE ≥ 0) with the factor $XG(J)^2$; $XG(J)$ is the distance from the center to the point with spatial index J ,in cm.

Behind each angular flux (in quanta per (cm^2.sec.sterad . Compton unit)) there is the corresponding triplet: angular index I, spatial index J, wavelength index K, in this sequence. The mesh applied in I, J, and K is described in the discussion of the output mesh card.
The next 2 lines give the "Square root error index IE" and its value. If it is zero, the square root calculations in the scattering kernel were o.K.; if it is positive, the radicandus has got negative (by machine or input errors) IE times and was substituted by an estimated value. (We guess that for an average problem - 8 angular, 20 spatial, 30 wavelength points - the program has to compute in the order of 10^5 square roots!) The next two blocks (last but one and last) are printed IOUTM (output mesh card) times, but at least once, if IOUTM is put zero or negative.
The last but one block (printed in any case) gives the total energy flux in MeV/cm^2/sec, the dose rate in rem/hr (for gammas equal to roentgen /hr), the energy absorption rate in MeV/cm^3/sec and the particle flux in photons/ cm^2/ sec, and finally for each spatial point its abscissa in cm and in mfp (= mean free path at the highest energy group) and its spatial index. At the layer boundaries the values are calculated twice (one of them, the absorbed energy rate, is material-dependent; this means a discontinuity, if the layer material changes). A spatial point is described by a sub-block of 2 or 3 lines. The 1st contains the 4 physical quantities listed in the headline without cutoff correction, and the above described 2 values and the index of the abscissa, the 2nd the 4 corresponding values with an estimated cutoff correction (and if the relative correction gets too great or even negative, a too low cutoff wavelength was chosen).

The 3rd line is printed only for monoenergetic sources and contains the 4 buildup factors of the quantities listed in the headline, cutoff correction included. (Buildup factors which would diverge are skipped; the "polyenergetic buildup factors" are not calculated because of their small interest and difficult evaluation.)
If response functions are given, their energy integrals follow as annex, each response integral in one column, preceded by the abscissa in cm and headed by their identification numbers IDR. Again, the first line of a pair is without, the second with the cutoff correction.
The last block (printed in any case) reproduces the total problem data input in the same sequence as listed in the 5th chapter about the input, with self-explanatory headlines. But the format is sometimes changed (f.i. an exponential of 10 instead of a floating point) and there are some exceptions:

1) The partial densities of the NEth element in the NMth material are given in input on a card triplet, but printed out in a column under the heading RHO(NM, NE), NM = 1, 2,..., NMG. These "material columns" are preceded by three others: the elemental index NE, its corresponding atomic number Z =Z(NE), and the partial densities used to describe normal air.
   The parantheses around the set of names "NE Z RHO(AIR, NE)" shall remind of the fact that these quantities do not figure in the problem data input.

2) If the option IPA $\leq$ 0 is used, the output mesh IPA, IPZ,.., KPZ, KPD is redefined by the program and printed in this form (then we have IPZ = IG, JPZ and KPZ = highest occuring spatial and wavelength indices, IPA, IPD, JPA, JPD, KPA, and KPD are put equal to unity).

3) If the option MST$\leq$ 0 is used, the program redefines and prints: M(1) = 1, M(2) = 2,..., M(NS) = NS (NS = total layer number).

4) The spatial mesh (R, DZ(1), DZ(2),..., DZ(NS)) is printed in cm, even if in the input the values are specified in mfp (by JMDZ $\leq$ 0).

5) If the option IWV$\geq$ 0 is used, the angular source weights QOM(I), I = 1, 2,..,IG are redefined and so printed.

6) If the option JSQ $<$ 0 is used, the values QE(KV) (KV = source energy index) are of no importance, neither in input nor in output.

7) In new physical and geometric cases, the program redefines NPHYS resp. NGEOM, subtracting 1 from the previous values.

Chapter 7

The B4T Sample Cases

We give (in the annex) a first sample similar to one of the B3P samples: a plain isotropic 4 MeV - source incident on a Fe -slab (the "plain source" simulated by a thin slab, 0.01 mfp thick). As example for a response function we take the conversion coefficients from particle flux to dose rate+), in μrem/hr per photon/cm^2/sec.
So this dose rate in microrem/hr should be 10^6 times the dose rate computed in rem/hour. (As identity number we take 415 - d= 4th, o = 15th letter in the alphabet) The comparison shows that the ratio is really 10^6 within 3‰ for all spatial points except the last where the difference is about 5‰, a satisfactory precision. Further we compare the energy buildup factors of B4T, B3P and the moments method MM (3,4):

$\mu_1 x$	B4T	B3P	MM	D(B4T) %	D(B3P) %
2	2.23	2.33	2.21	1	5
4	3.08	3.14	3.18	-3	-1
7	(4.84)	(5.17)	4.95	-2	4
10	6.96	7.80	6.90	1	12
15	(11.3)	(13.2)	10.4	8	21

(the values in parentheses are interpolated).

+) from (3, p. 17), but corrected by the factor 32.5/34 =0.956, which is not taken into account by (3) on p. 17, but mentioned there in the footnote on p. 13.

The last two columns show the relative difference of B3P and B4T compared with MM, in rounded %; the average for B4T is 3%, for B3P ~ 9%. There is more than one reason for the improved accuracy of B4T:

1) We used in B4T an angular mesh not symmetric to zero, but describing better the forward-peak in scattered and unscattered angular fluxes
2) We have improved somewhat the angular integration in B4T, using better approximations
3) We have used the option I2INT positive, which should give good results for plain isotropic sources.

Even the rougher wavelength mesh we used in B4T (17 points instead of 22 in B3P) does not deteriorate the results of B4T.

The effect of the option I2INT positive can be seen when we compare the unscattered spectra (those with K = 1) with their theoretical values. We use the values IWV = 0 (i.e. all S_1 (w)= 1, QE (1) = 12, DW (1) = 0,06; this means per cm^3 a source density (integrated over the solid angle 4π) of+)

$$\frac{1 \cdot 12}{4\pi \cdot 0{,}06} \cdot 4\pi = 200 \frac{\text{phot}}{\text{cm}^3 \text{ sec} \cdot \text{CU}}$$

(not integrated over wavelength, i.e. within the first wavelength group of width DW(1) = 0,06 CU). In order to have the source density in phot/(cm^2 sec CU) of the thin slab, we must multiply this result with the slab thickness DZ(1) in cm and, since we used the option MDZ = 0, with $\sum_1^T (E_1)$ and these 2 factors together give just the thickness in mfp, in our case 10^{-2}. So our effective plain source strength is

$$2 \text{ phot}/(\text{cm}^2 \text{ sec CU})$$

+) Here we use the prescriptions of ch.5, explanation of the layer source card and this means in a distance $\mu_1 x$ mfp from the slab source midplane an unscattered spectrum (for $\mu_1 x \gtrsim 1$)

$$2 \cdot \frac{1}{2} \cdot E_1 (\mu_1 x) \text{ phot/(cm}^2 \text{ sec CU)}$$

numerically just the exponential integral. We take its well-known values from (6) and compare them with those of B4T (we write (-n) for 10^{-n})

$\mu_1 x$	$E_1(\mu_1 x)$	B4T	Error in %
2	4,890 (-2)	4,649 (-2)	-5,2
4	3,779 (-3)	3,873 (-3)	+2,4
6	3,601 (-4)	3,644 (-4)	+1,2
8	3,767 (-5)	3,751 (-5)	-0,4
10	4,157 (-6)	4,101 (-6)	-1,4
12	4,751 (-7)	4,668 (-7)	-1,8
16	6,641 (-9)	6,515 (-9)	-1,9
20	9,836 (-11)	9,675 (-11)	-1,7
24	1,512 (-12)	1,495 (-12)	-1,1

We see at most spatial points a good precision, better than 2%; that the errors are greater at $\mu_1 x = 2$ or 4, has its reason in our angular mesh

-1,0 | -0,75 | -0,2 | 0,1 | 0,65 | 0,8 | 0,92 | 1,0

which represents well the forward peak in angle at deep penetrations, but badly the side peak ($0 \leq w \ll 1$) for small $\mu_1 x$. At an ideal plain source the angular flux even diverges as w^{-1}! At the boundary of the source slab - $\mathcal{J}=2$ - the unscattered flux should be

$$100 \left\{ 1 - E_2 \, (0{,}01) \right\} = 5{,}03$$

and B4T gets only 3,55 and for the other source boundary - J =1 - the result is still worse. But this is the case only near optically very thin sources, and the BIGGI programs aim more at the situation in deep penetrations. In "production problems" where the sources are usually thicker, these discrepancies are greatly reduced. One further remark: Near optically thin sources, the option I2INT negative (linear interpolation in angle) should give better results, but far from (thick of thin) sources the option I2INT not negative, quasi-exponential interpolation.
As next sample, we take with the same physical data a collimated 4-MeV-source incident on iron, changing on the angular mesh card IWV from 0 (isotropic) to 1 (perpendicularly collimated). Furthermore, we take I2INT = 0 (instead of 1, since here the dependence of the angular fluxes from angle will be somewhat between linear and exponential, while for isotropic plain sources it will be exponential in good approximation) and change the output mesh, so reducing the intermediate output (greater printing steps IPD, JPD, KPD). Since we discussed already in the last sample the response function and the unscattered fluxes, we limit ourselves here to the energy buildup factors BE listed in the table. (From the B3P values, we take those with the rougher spatial and wavelength mesh.)

$\mu_1 x$	B4T	B3P	MM	D(B4T) %	D(B3P) %
2	1,73	1,84	1,78	-3	3
4	2,51	2,81	2,60	-4	7
7	(3,82)	(4,49)	3,96	-4	12
10	5,31	6,44	5,47	-3	15
15	(8,21)	(10,4)	8,27	-1	20

Again we see a greater precision of B4T (average error of B4T: 3% too low, of B3P: ~ 11% too high). The reasons are the same as in the just discussed case of the isotropic source (better adapted angular mesh, improved angular integration, option I2INT = 0) A comparative run of the same problem shows that the greatest part of the gained precision is due to I2INT; for I2INT < 0 the average error in BE got 18%, ranging from 11 to 26).

As next sample, we simulate an isotropic 8-MeV- point source in tin (density 7.3 g/cm^3). We cannot define a real point source, so we specify (in cm, by JMDZ > 0) a thin shell source of inner radius r_s = 7, 1 cm (~ 1,9 mfp) and of thickness 0,37 cm (~ 0,1 mfp). The localisation of the sources in a thin shell (and not in a full sphere) has the advantage to avoid a too high self-absorption, and the rather great radius of this "point" avoids a too sharp peaking of the unscattered angular flux near the forward direction $\omega \sim 1$; even with $r_s \sim$ 2 mfp, the unscattered flux is $\neq 0$ at r = 22 mfp only in the angular interval with the half opening angle ~ 2/22, and this means a cosine interval from $\omega = 1 - \frac{1}{2} \cdot (\frac{2}{22})^2 = 0{,}9959$ to $\omega = 1$! ($r_s \sim$ 1mfp would mean a lower limit of ~0,9990 instead of 0,9959!)

Even in this more favorable condition, we must use an angular mesh with more than half of the 9 points concentrated in the small interval 0.9...1.0 (.9; .95; .98; .993; 1.0); the other 95% of the total w-range must be represented by only 4 values (-1.0; -0.4; 0.32; 0.75). We choose a reduced output (INDOUT > 0) and a rather rough wavelength mesh (only 12 points, ending already above the single-scattering cutoff- a procedure possible only in such high -Z- media as Sn).
In order to be able to compare our buildup factors with those of (3) and (4), we put the "effective point source distance" $\mu_1 r_{eff}$ equal to $\mu_1 r - \mu_1 r_s \simeq \mu_1 r - 2$ (so we assume - at least for the buildup factor comparison - a point source instead of a thin shell source at $\mu_1 r = 2$)

		B4T - results			MM results (3,4)		
$\mu_1 r$	$\mu_1 r_{eff}$	BE+)	BD	BEA	BE	BD	BEA
3	1	1.29	1.37	1.26	1.15	1.19	1.14
4	2	1.55	1.71	1.49	1.34	1.42	1.31
6	4	2.14	2.5	2.01	1.83	2.05	1.74
9	7	3.53	4.38	3.21	2.97	3.57	2.73
12	10	5.63	7.29	5.03	4.91	6.19	3.48
17	15	11.85	16.1	10.4	11.3	15.1	9.7
22	20	23.1	32.2	20.0	24.7	34.0	20.8

The comparison shows average errors of 13% in BE, 16% in BD, and 12% in BEA; the corresponding maximum errors are 19,23, and 18%, and with the exception of the last spatial point the B4T results are too high.
We can check the absolute values, too, by a plain - to - sphere transformation (7, par. 10.60.). We replace the shell

+) B= buildup factors, with E= energy, D= dose, EA= energy absorption.

source between 1.90 and 2 mfp by a spherical surface source at $\mu_1 r = 1.95$; its appropriate source density is QE (1) $\times$ DZ (1) or $(10^3 \gamma/cm^3/sec) \cdot 0,37$ cm = $370 \gamma/cm^2/sec$. With the neglection of a correction term in the order of $e^{-4} \sim 2\%$ we get an unscattered particle flux $\phi_p^{(o)}$

$$\phi_p^{(o)}(\mu_1 r) = 370 \cdot \frac{1,95}{\mu_1 r} \cdot \frac{1}{2} E_1 (\mu_1 r - 1.95) \ \gamma/cm^2/sec$$

From the program output, we extract the same quantity by dividing the total particle flux through its buildup factor. So we get the following table

$\mu_1 r$	$\mu_1 r - 1,95$	$\phi_p^{(o)}$(anal.)+)	$\phi_p^{(o)}$(B4T)+)	D %
3	1,05	24.3	26.1	+7
4	2,05	4.11	3.54	-14
6	4,05	0.214	0.179	-16
9	7,05	4.36(-3)	3.52(-3)	-19
12	10,05	1.18(-4)	0.99(-4)	-16
17	15,05	3.86(-7)	3.41(-7)	-12
22	20,05	1.54(-9)	1.52(-9)	+1

So the maximum error is 19% (too low), the average 12%, similar as the in the buildup factor results. These errors are worse than in the plane geometry case, but they are no wonder, when we think of the above -mentioned effect that at $\mu_1 r = 22$ the unscattered radiation is > 0 only in an interval from 0.9959 to 1.0, i.e. about 2‰ of the whole ω-range! Such delta-like functions make troubles in any numerical integration. As is to be expected, the results

+) anal. = analytically calculated, B4T= from program B4T, D= relative difference, referring to the analytic result.

depend sensitively from the w-mesh and still more from the option I2INT (here positive); with a worse suited w-mesh and I2INT < 0 we once got an unscattered flux by a factor ~ 4 too high at $\mu_1 r \sim 20$! (In general, I2INT < 0 seems to give overestimates for deep penetrations, f.i. at $\sim$ 20 mfp 20 - 30% in plane geometry, and one or some hundred % in spherical geometry[+)]). But as long as the errors do not exceed 20%, as in our sample, they are of no great importance in shielding calculations; he who wants higher precision in the buildup factors can calculate them in plain geometry and transform them to point sources starting from such formulae as (5-86) in (3) (by differentiating it with respect to $\mu_0 x$, f.i.). And the unscattered fluxes usually can be calculated better analytically. Certainly, if the spherical sources are greater, the errors will decrease.

Up to now we have discussed homogeneous configurations (i.e. of one material only). But one of the main aims of the BIGGI programs is just the handling of heterogeneous geometries. So we take as last but one sample a water - lead shield (plane collimated 1 MeV - source, 3 mfp H_2O +3 mfp Pb). The plain source is simulated by a water layer of thickness $2 \cdot 10^{-3}$ mfp. The material -to- layer transformation is used (MST positive), and we put M(1) = 3, M(2) = 3, M(3) = 1; this means : 1st and 2nd slab of 3rd material (water), 3rd of 1st material (lead). We describe the collimation not by the option IWV positive, but IWV negative and all the QOM(I)= 0 with the exception of the last two values which are 1.0; so we describe a sharp angular cutoff by putting closely

[+)] This behaviour might surprise; but in spherical geometry the angular flux vanishes at one angular mesh point, but is positive at its neighbour. In most cases the "angular threshold" lies between them, but I2INT < 0 assumes it at the lower mesh point, so producing in certain regions great positive instead of zero angular fluxes, unlike I2INT ≥ 0.

together the last but one and last but two values of the angular mesh, OM(I) (from -1.0 to 0.949 the angular sources are zero, from 0.951 to 1.0 they are 1.0). As in BIGGI 3P, we see at the interface a jump in the energy absorption buildup by a factor considerably different from one (here ~ 5.8).

We compare our dose buildup factors with those read from the curves of (8), fig. 1. (In the $\mu_1 x$-definition we neglect the source thickness)

μ_1 x	BD (8)	BD (B4T)	D (%)
1	1.75	1.82	4
2	2.6	2.60	0
3	3.65	3.02	21
4	2.5 (2.9)	2.47	1
5	2.45(3.2)	2.51	2
6	2.7 (3.5)	2.60	-4

For the lead ($\mu_1 x > 3$) (8) gives two values for each μ_1 x; the lower calculated by Monte Carlo, the higher by response matrices; we have quoted the higher values in parentheses. For most points our values and the Monte-Carlo-results of (8) agree within 4% or better+). Only at the interface the value of (8) is ~ 20% higher than ours. But (8) gives the same buildup factor value (=3.65) at $\mu_1 x = 3$ for the two different cases a) Pb behind $\mu_1 x = 3$ (our sample case) and b) H_2O behind $\mu_1 x = 3$, i.e. in (8) the boundary effect is neglected, while our method takes it into account.

+) (and part of these differences should be due to the fact that one cannot read exactly the third decimal place from the curve in (8))

(The assumption in (8) seem to include some sort of straight-ahead-approximation, (3, p. 166-168)). Really, a B4T run with 2 mfp water behind $\mu_1 x = 3$ mfp yields a dose buildup factor of 3.68 at $\mu_1 x = 3$, only $\sim$ 1% from the result of (8). (We made a further comparative run with an extremely rough wave-length mesh - DW(1) = 0.5, KG(1) = 5, DW(2) = 1, KG(2) = 7 -, but the other input unchanged; but the dose buildup factors differed only by 12% in the average and 20% at most from the above quoted B4T- results; in the water, most of the buildup factors were too high, in the lead too low. The changes in the energy absorption and particle buildup factors were considerably greater, at single points by factors about 3; but this is no wonder, since we reduced the number of wavelength mesh points from 35 to 7, i.e. by a factor 5!)

Up to now, we have discussed only thin (slab or shell) and monoenergetic sources; but in real shields we have sources nearly everywhere, and in most materials they are polyenergetic. So we choose as last sample a spherical shield with inner radius 100 cm, followed first by 10 cm Pb, then by 7.5 cm Fe and finally by 340 cm H_2O. The spatial step is 2.5 cm in Pb, 1.25 cm in Fe, and 20 cm in H_2O (option $\mathcal{J}$ MDZ positive). Since we have 3 shells of 3 different materials, we put MST negative, so the program puts nth shell = nth material, n = 1, 2, 3. Since the spatial steps are small in Pb and Fe, we put there A($\mathcal{J}$S)= 0 ($\mathcal{J}$S= 1;2), but A(3) = 0.9. We define a thermal neutron flux flat in Pb (= 10^{13} n/cm^2/sec), proportional to a hyperbolic cosine in the Fe, flat in the first 20 cm H_2O and then decreasing by a factor $e^2 \sim 7,4$ on each 20 cm. The capture gamma spectra are lumped together in 4 groups at 7.5; 6; 4; and 2.3 MeV. From (3,p. 251) we take the values of p. (Mat.,E)= probability that per average neutron capture in the material Mat. a quant of energy E MeV is emitted.

Neglecting the capture gammas with $E < 1$ MeV in iron we get the values in the table

KV	1	2	3	4
E	7.5 MeV	6 MeV	4 MeV	2.3 MeV
p(Pb,E)	0.93	0.07	/	/
p(Fe,E)	0.5	0.22	0.24	0.1
p(H_2O,E)	/	/	/	1.0

In order to get our needed input data GS($\mathfrak{J}$S, KV), we must multiply these p(Mat.,E) with the macroscopic capture cross section Σ_c of Mat., i.e. $5.6 \cdot 10^{-3}$/cm for Pb, 0.206/cm for Fe, and 0.022/cm for H_2O. F.i. we get for the first layer (Pb, $\mathfrak{J}$S = 1)

$GS(1,1) = \Sigma_c(Pb) * p(Pb,\ 7.5\ MeV) = 5.2 \cdot 10^{-3}\ (cm^{-1})$

$GS(1,2) = \Sigma_c(Pb) * p(Pb,\ 6\ MeV) = 4.0 \cdot 10^{-4}\ (cm^{-1})$

while GS(1,3) = GS(1,4) = 0.

Only for the iron ($\mathfrak{J}$S = 2) each GS(2, KV) is positive, for the water ($\mathfrak{J}$S = 3) only GS(3,4) = 0.022/cm does not vanish. The wavelength mesh was chosen in such a way that the first wavelength mesh points are not too far from the source energies.+) The option KOE =0 means a black-boundary condition at the inner sphere, R = 100 cm; the angular source dependence was chosen isotropic, I2INT was put equal to zero, since I2INT $<$ 0 often gave too high results. As in all the other samples, the pair production was neglected, i.e. CP = 0.

+) The cutoff lies at $\sim$ 7 CU or $E \sim 70$KeV. The cutoff corrections get a problem only for the particle fluxes (up to $\sim$80%) which therefore are considerably unsure (at least in the water); for the other energy integrals, all the corrections lie below 4%.

Some final remarks: There exists another version of B4T with 15 angular, 24 spatial and 50 wavelength mesh points (the published version has 9 resp. 39 resp. 51). - Program and library are available at the ENEA Computer Programme Library, Mr. J. Rosen, C.C.R. Euratom Ispra.-

Finally, we found that it was useful to mark on the last card of the total deck (in our case the 7/8 -card behind the data) the sequence of the problem data input cards:

```
NRE, KTRG, IDR(1), IDR(2),...
  Response fu.    - mesh         }
     "       "  values, NRE *    }  if NRE > 0
NPHYS
- - - - - - - - - - - - - - - - -
NGEØM, NMG, CP, INDOUT
RHOS (1st material triplet)
 "    2nd     "       "

 "   (NMGth   "       "    )
ANGLES
EV - Mesh
WL - Mesh
- - - - - - - - - - - - - - - - - -
KOE, JMDZ, I2INT
OUT -PUT  MESH
MST
R  DZ
J BØUND
E TR
```

```
ANG DISTR
JSQ QE
FS (J)          ⎫
GS (1, KV)      ⎬ if JSQ < 0
GS (2, KV) : until
GS (NS,KV)      ⎭
```

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Annex A : The Listing and Samples of B3P

```
      DIMENSION OM(8),SOM(8),DOM(8),F(8,26,71),S(4,71,5),SP(26,71),Q(8,2
     16),W(71),WT(30),ST(4,30,5),SPR(71),STM(71),JG(5),STE(71),B(4,26)
    2 FORMAT (6F6.0,6I6)
    3 FORMAT (3F9.0)
    4 FORMAT (F6.0,7I6)
    6 FORMAT (12F6.0)
    8 FORMAT (5E16.8,2I8)
   10 FORMAT (6(E14.7,I5))
   12 FORMAT (4(E14.6,3I5))
   14 FORMAT (I6,8F6.0)
   16 FORMAT (////)
   20 FORMAT (1H1)
      READ INPUT TAPE 5,14,IMA,(OM(I),I=1,IMA)
      READ INPUT TAPE 5,3,OMO,OMU,WOM
   30 READ INPUT TAPE 5,2,W(1),DW1,DW2,DW3,DW4,DW5,K1,K2,K3,K4,K5,KDP
      READ INPUT TAPE 5,4,A,NG,NS,MM,MK,MP
      READ INPUT TAPE 5,6,(WT(M),M=1,MM)
      DO 40 JS=1,NS
      DO 40 L=1,4
   40 READ INPUT TAPE 5,6,(ST(L,M,JS),M=1,MM)
      W(2)=W(1)+.5*DW1
      DO 45 K=3,K1
   45 W(K)=W(K-1)+DW1
      IF(K5-K1)90,90,50
   50 W(K1+1)=W(K1)+.5*(DW1+DW2)
      KP=K1+2
      DO 55 K=KP,K2
   55 W(K)=W(K-1)+DW2
      IF(K5-K2)90,90,60
   60 W(K2+1)=W(K2)+.5*(DW2+DW3)
      KP=K2+2
      DO 65 K=KP,K3
   65 W(K)=W(K-1)+DW3
      IF(K5-K3)90,90,70
   70 W(K3+1)=W(K3)+.5*(DW3+DW4)
      KP=K3+2
      DO 75 K=KP,K4
   75 W(K)=W(K-1)+DW4
      IF(K5-K4)90,90,80
   80 W(K4+1)=W(K4)+.5*(DW4+DW5)
      KP=K4+2
      DO 85 K=KP,K5
   85 W(K)=W(K-1)+DW5
   90 WRITE OUTPUT TAPE 6,20
      DO 95 K=1,K5
      EN=.511/W(K)
   95 WRITE OUTPUT TAPE 6,10,EN,K
      WRITE OUTPUT TAPE 6,16
      KPA=1
      DWP=ABSF(W(1)-1.)
      DO 98 K=2,K5
      DWPN=ABSF(W(K)-1.)
      IF(DWPN-DWP)96,98,98
   96 DWP=DWPN
      KPA=K
```

```
 98   CONTINUE
      WRITE OUTPUT TAPE 6,10,DWP,KPA
      WRITE OUTPUT TAPE 6,16
      DO 120 K=1,K5
      DO 118 L=1,4
      DO 118 JS=1,NS
      DO 100 M=2,MM
      IF(W(K)-WT(M))105,100,100
100   CONTINUE
105   S(L,K,JS)=ST(L,M-1,JS)+(ST(L,M,JS)-ST(L,M-1,JS))*(W(K)-WT(M-1))/(W
     1T(M)-WT(M-1))
      IF(L-4)110,112,112
110   IF(M-MK)115,118,118
112   IF(M-MP)115,118,118
115   S(L,K,JS)=S(L,K,JS)+((ST(L,M+1,JS)-ST(L,M-1,JS))/(WT(M+1)-WT(M-1))
     1-(ST(L,M,JS)-ST(L,M-1,JS))/(WT(M)-WT(M-1)))*(W(K)-WT(M-1))*(W(K)-W
     2T(M))/(WT(M+1)-WT(M))
118   CONTINUE
120   WRITE OUTPUT TAPE 6,8,(W(K),S(1,K,JS),S(2,K,JS),S(3,K,JS),S(4,K,JS
     1),JS,K,JS=1,NS)
      WRITE OUTPUT TAPE 6,16
      DO 125 I=1,IMA
125   SOM(I)=SQRTF(1.-OM(I)*OM(I))
      IMAM1=IMA-1
      DO 130 I=1,IMAM1
130   DOM(I)=OM(I+1)-OM(I)
      DOM(IMA)=0.
135   READ INPUT TAPE 5,4,DZ,IWV,JDP,(JG(JS),JS=1,NS)
      JMA=JG(NS)
      IF(IWV)155,140,140
140   DO 145 I=1,IMA
      DO 145 J=1,JMA
145   F(I,J,1)=0.
      I=IMA-IWV
      F(I,1,1)=.3183/(DW1*(DOM(I-1)+DOM(I)))
      E=EXPF(-DZ*(1./OM(I)-A))
      DO 150 J=2,JMA
150   F(I,J,1)=F(I,J-1,1)*E
      GO TO 205
155   I=1
160   DO 165 J=1,JMA
165   F(I,J,1)=0.
170   I=I+1
      IF(I-IMA)175,175,205
175   IF(.05-ABSF(OM(I)))195,195,180
180   E=EXPF(-4.*DZ*(1.-A*OM(I))/OM(I+1))
      F(I,1,1)=.1592/(DW1*OM(I+1))
185   DO 190 J=2,JMA
190   F(I,J,1)=F(I,J-1,1)*E
      GO TO 170
195   IF(OM(I))160,160,200
200   E=EXPF(-DZ*(1./OM(I)-A))
      F(I,1,1)=.07958/(DW1*OM(I))
      GO TO 185
205   DO 215 J=1,JMA
      SUM=0.
```

```
      DO 210 I=1,IMAM1
  210 SUM=SUM+DOM(I)*(F(I,J,1)+F(I+1,J,1))
  215 SP(J,1)=3.142*SUM
  220 K=2
  225 J=1
  230 I=1
  235 KS=1
      Q(I,J)=0.
  240 CS=1.+W(KS)-W(K)
      IF(-1.-CS)245,245,260
  245 WG=SQRTF(1.-CS*CS)
      IF(ABSF(OM(I))-.99)250,250,255
  250 WK=SOM(I)
      GO TO 275
  255 WK=0.
      GO TO 275
  260 KS=KS+1
      IF(KS-K)240,265,265
  265 I=I+1
      IF(I-IMA)235,235,270
  270 J=J+1
      IF(J-JMA)230,230,400
  275 OMSMI=OM(I)*CS-WK*WG
      OMSMA=OM(I)*CS+WK*WG
      IS=2
  280 IF(OM(IS)-OMSMI)285,290,290
  285 IS=IS+1
      IF(IS-IMA)280,295,295
  290 IF(OM(IS)-OMSMA)340,295,295
  295 SUM=3.142*(F(IS-1,J,KS)+(F(IS,J,KS)-F(IS-1,J,KS))*(CS*OM(I)-OM(IS-
     11))/DOM(IS-1))
  300 PO=W(KS)/W(K)+W(K)/W(KS)-1.+CS*CS
      IF(KS-K1)305,305,310
  305 DW=DW1
      GO TO 335
  310 IF(KS-K2)315,315,320
  315 DW=DW2
      GO TO 335
  320 IF(KS-K3)325,325,330
  325 DW=DW3
      GO TO 335
  330 IF(KS-K4)332,332,334
  332 DW=DW4
      GO TO 335
  334 DW=DW5
  335 Q(I,J)=Q(I,J)+.1194*DW*PO*SUM*(W(KS)/W(K))**2
      IF(K-KPA)260,376,260
  376 IF(K-K5)377,260,260
  377 IF(J-1)378,378,379
  378 SPP=S(4,KS,1)
      GO TO 390
  379 IF(J-JMA)381,380,380
  380 SPP=S(4,KS,NS)
      GO TO 390
  381 DO 389 JS=1,NS
      JE=JG(JS)-1
```

```
      IF(JS-1)382,382,383
382   JA=2
      GO TO 384
383   JA=JG(JS-1)+1
384   IF(J-JA)386,385,386
385   SPP=S(4,KS,JS)
      GO TO 390
386   IF(J-JE)385,385,387
387   IF(J-JG(JS))388,388,389
388   SPP=.5*(S(4,KS,JS)+S(4,KS,JS+1))
      GO TO 390
389   CONTINUE
390   Q(I,J)=Q(I,J)+.1592*SPP*SP(J,KS)*DW
      GO TO 260
340   SI=(OM(I)*CS-OM(IS))/(WK*WG)
      IF(ABSF(SI)-1.+1.E-8)350,345,345
345   SUM=0.
      GO TO 355
350   SUM=(1.571-ATANF(SI/SQRTF(1.-SI*SI)))*(F(IS-1,J,KS)+(F(IS,J,KS)-F(
     1IS-1,J,KS))*(.5*OMSMI+.5*OM(IS)-OM(IS-1))/DOM(IS-1))
355   IS=IS+1
      IF(IS-IMA)360,370,370
360   IF(OM(IS)-OMSMA)365,370,370
365   OMSQ=.5*(OM(IS-1)+OM(IS))
      SUM=SUM+.5*DOM(IS-1)*(F(IS-1,J,KS)+F(IS,J,KS))/SQRTF((1.-OMSQ*OMSQ
     1)*SOM(I)*SOM(I)-(CS-OM(I)*OMSQ)**2)
      GO TO 355
370   SI=(OM(I)*CS-OM(IS-1))/(WK*WG)
      IF(ABSF(SI)-1.+1.E-8)375,375,300
375   SUM=SUM+(1.571+ATANF(SI/SQRTF(1.-SI*SI)))*(F(IS-1,J,KS)+(F(IS,J,KS
     1)-F(IS-1,J,KS))*(OMSMA-OM(IS-1))*.5/DOM(IS-1))
      GO TO 300
400   IF(K-K1-1)430,405,410
405   DW=DW2
      GO TO 430
410   IF(K-K2-1)430,415,420
415   DW=DW3
      GO TO 430
420   IF(K-K3-1)430,425,427
425   DW=DW4
      GO TO 430
427   IF(K-K4-1)430,429,430
429   DW=DW5
430   I=1
435   J=JMA
      F(I,J,K)=0.
      DO 455 JSH=1,NS
      JS=NS+1-JSH
      SIT=S(1,K,JS)-A*S(1,1,JS)*OM(I)
      ARG=DZ*(S(1,K,JS)/S(1,1,JS)-A*OM(I))/ABSF(OM(I))
      E=EXPF(-ARG)
      IF(JS-1)440,440,445
440   JGD=JG(1)-1
      GO TO 450
445   JGD=JG(JS)-JG(JS-1)
450   DO 455 JH=1,JGD
```

```
      J=JG(JS)-JH
      P1=1.-E
      P2=(1.-E*(1.+ARG))/ARG
      P3=Q(I,J)*P1+(Q(I,J+1)-Q(I,J))*P2
      P4=E+.375*DW*P2/S1T
      P5=1.-.375*DW*(P1-P2)/S1T
455   F(I,J,K)=(P3/S1T+P4*F(I,J+1,K))/P5
460   I=I+1
      IF(I-IMA)465,465,540
465   IF(OM(I)+.05)435,470,470
470   IF(OM(I)-.05)475,475,515
475   F(I,1,K)=.5*Q(I,1)/(S(1,K,1)-.375*DW)
      DO 510 JS=1,NS
      JE=JG(JS)
      IF(JS-1)480,480,485
480   JA=2
      GO TO 490
485   JA=JG(JS-1)+1
490   DO 495 J=JA,JE
495   F(I,J,K)=Q(I,J)/(S(1,K,JS)-.375*DW)
      IF(JS-NS)500,505,505
500   F(I,JE,K)=.5*F(I,JE,K)+.5*Q(I,JE)/(S(1,K,JS+1)-.375*DW)
      GO TO 510
505   F(I,JE,K)=.5*F(I,JE,K)
510   CONTINUE
      GO TO 460
515   F(I,1,K)=0.
      DO 535 JS=1,NS
      S1T=S(1,K,JS)-A*S(1,1,JS)*OM(I)
      ARG=DZ*(S(1,K,JS)/S(1,1,JS)-A*OM(I))/ABSF(OM(I))
      E=EXPF(-ARG)
      JE=JG(JS)
      IF(JS-1)520,520,525
520   JA=2
      GO TO 530
525   JA=JG(JS-1)+1
530   DO 535 J=JA,JE
      P1=1.-E
      P2=(1.-E*(1.+ARG))/ARG
      P3=Q(I,J)*P1+(Q(I,J-1)-Q(I,J))*P2
      P4=E+.375*DW*P2/S1T
      P5=1.-.375*DW*(P1-P2)/S1T
535   F(I,J,K)=(P3/S1T+P4*F(I,J-1,K))/P5
      GO TO 460
540   DO 560 J=1,JMA
      SUM=0.
      DO 555 I=1,IMAM1
555   SUM=SUM+DOM(I)*(F(I,J,K)+F(I+1,J,K))
560   SP(J,K)=3.142*SUM
      K=K+1
      IF(K-K5)225,225,565
565   DO 575 J=1,JMA
      DO 570 K=1,K5
570   SPR(K)=SP(J,K)*W(K)/SP(J,1)
      WRITE OUTPUT TAPE 6,14,J
575   WRITE OUTPUT TAPE 6,10,(SPR(K),K,K=1,K5)
```

```
      WRITE OUTPUT TAPE 6,16
      DO 620 JS=1,NS
      JE=JG(JS)
      IF(JS-1)576,576,578
  576 JA=1
      GO TO 579
  578 JA=JG(JS-1)
  579 DO 620 J=JA,JE
      SUE=0.
      SUD=0.
      SUDW=0.
      SUA=0.
      SUT=0.
      DO 615 K=2,K5
      IF(K-K1)580,580,585
  580 DW=DW1
      GO TO 610
  585 IF(K-K2)590,590,595
  590 DW=DW2
      GO TO 610
  595 IF(K-K3)600,600,605
  600 DW=DW3
      GO TO 610
  605 IF(K-K4)607,607,609
  607 DW=DW4
      GO TO 610
  609 DW=DW5
  610 SUE=SUE+SP(J,K)*DW/W(K)
      SUD=SUD+SP(J,K)*DW*S(2,K,JS)/W(K)
      IF(J-JMA)614,750,750
  750 IF(ABSF(OMO)-1.01)755,614,614
  755 DO 760 I=1,IMA
      IF(OM(I)-OMU)760,760,765
  760 CONTINUE
  765 IU=I
      DO 770 I=1,IMA
      IF(OM(I)-OMO)770,775,775
  770 CONTINUE
  775 IO=I
      DWD=DW*S(2,K,JS)/W(K)
      QFU=(F(IU,J,K)-F(IU-1,J,K))/DOM(IU-1)
      QFO=(F(IO,J,K)-F(IO-1,J,K))/DOM(IO-1)
      IF(IO-IU)780,780,785
  780 SUDW=SUDW+DWD*(SP(J,K)-6.283*(1.-WOM)*(OMO-OMU)*(F(IU-1,J,K)+QFU*(
     1.5*OMU+.5*OMO-OM(IU-1))))
      GO TO 614
  785 SUDW=SUDW+DWD*(SP(J,K)-6.283*(1.-WOM)*((OM(IU)-OMU)*(F(IU-1,J,K)+Q
     1FU*(.5*OMU+.5*OM(IU)-OM(IU-1)))+(OMO-OM(IO-1))*(F(IO-1,J,K)+QFO*(.
     25*OM(IO-1)+.5*OMO-OM(IO-1))))))
      IOM2=IO-2
      IF(IOM2-IU)614,790,790
  790 DO 795 I=IU,IOM2
  795 SUDW=SUDW-3.142*DWD*(1.-WOM)*DOM(I)*(F(I,J,K)+F(I+1,J,K))
  614 SUA=SUA+SP(J,K)*DW*S(3,K,JS)/W(K)
  615 SUT=SUT+SP(J,K)*DW
      QUE=SP(J,K5-1)*W(K5)/(SP(J,K5)*W(K5-1))
```

```
      SUEK=SUE+.75*SP(J,K5)*DW/(W(K5)*SQRTF(QUE)*LOGF(QUE))
      SUDK=SUD+(SUEK-SUE)*(1.5*S(2,K5,JS)-.5*S(2,K5-1,JS)+(S(2,K5,JS)-S(
     12,K5-1,JS))/LOGF(QUE))
      SUAK=SUA+(SUEK-SUE)*(1.5*S(3,K5,JS)-.5*S(3,K5-1,JS)+(S(3,K5,JS)-S(
     13,K5-1,JS))/LOGF(QUE))
      QUT=SP(J,K5-1)/SP(J,K5)
      SUTK=SUT+.75*SP(J,K5)*DW/(SQRTF(QUT)*LOGF(QUT))
      BE=1.+SUE/(SP(J,1)*DW1/W(1))
      BEK=1.+SUEK/(SP(J,1)*DW1/W(1))
      BD=1.+SUD/(SP(J,1)*DW1*S(2,1,JS)/W(1))
      BDK=1.+SUDK/(SP(J,1)*DW1*S(2,1,JS)/W(1))
      IF(J-JMA)800,805,805
  805 IF(ABSF(OMO)-1.01)810,800,800
  810 BDW=1.+SUDW*W(1)/(SP(J,1)*DW1*S(2,1,JS))
      WRITE OUTPUT TAPE 6,8,BDW
  800 BA=1.+SUA*W(1)/(SP(J,1)*DW1*S(3,1,JS))
      BAK=1.+SUAK/(SP(J,1)*DW1*S(3,1,JS)/W(1))
      BT=1.+SUT/(SP(J,1)*DW1)
      BTK=1.+SUTK/(SP(J,1)*DW1)
      B(1,J)=BEK
      B(2,J)=BDK
      B(3,J)=BAK
      B(4,J)=BTK
      IF(JMA-10)618,616,616
  616 DE=BEK-BEKV
      DD=BDK-BDKV
      DA=BAK-BAKV
      DT=BTK-BTKV
      WRITE OUTPUT TAPE 6,8,DE,DD,DA,DT
      BEKV=BEK
      BDKV=BDK
      BAKV=BAK
      BTKV=BTK
  618 WRITE OUTPUT TAPE 6,14,J
      WRITE OUTPUT TAPE 6,8,BE,BD,BA,BT
  620 WRITE OUTPUT TAPE 6,8,BEK,BDK,BAK,BTK
      WRITE OUTPUT TAPE 6,16
      DO 640 K=2,K5
      STM(K)=-3.142*DOM(1)*F(1,1,K)*OM(1)
      STE(K)=3.142*DOM(IMAM1)*F(IMA,JMA,K)*OM(IMA)
      I=2
  625 STM(K)=STM(K)-3.142*(DOM(I-1)+DOM(I))*F(I,1,K)*OM(I)
      IS=IMA+1-I
      STE(K)=STE(K)+3.142*(DOM(IS)+DOM(IS-1))*F(IS,JMA,K)*OM(IS)
      I=I+1
      IF(OM(I)+.05)625,630,630
  630 IF(OM(I)-.05)635,635,640
  635 STM(K)=STM(K)-.7854*DOM(I-1)*F(I,1,K)*OM(I-1)
      STE(K)=STE(K)+.7854*DOM(IS)*F(IS,JMA,K)*OM(IS+1)
  640 CONTINUE
      STP=3.142*DOM(IMAM1)*F(IMA,1,1)*OM(IMA)
      STE(1)=3.142*DOM(IMAM1)*F(IMA,JMA,1)*OM(IMA)
      I=IMAM1
  645 STP=STP+3.142*(DOM(I-1)+DOM(I))*F(I,1,1)*OM(I)
      STE(1)=STE(1)+3.142*(DOM(I-1)+DOM(I))*F(I,JMA,1)*OM(I)
      I=I-1
```

```
      IF(OM(I)-.05)650,650,645
650   IF(OM(I)+.05)660,655,655
655   STP=STP+DOM(I)*F(I,1,1)*.7854*OM(I+1)
      STE(1)=STE(1)+DOM(I)*F(I,JMA,1)*.7854*OM(I+1)
660   SUALT=0.
      SUALE=0.
      SUSTE=0.
      DO 700 K=2,K5
      IF(K-K1)665,665,670
665   DW=DW1
      GO TO 695
670   IF(K-K2)675,675,680
675   DW=DW2
      GO TO 695
680   IF(K-K3)685,685,690
685   DW=DW3
      GO TO 695
690   IF(K-K4)692,692,694
692   DW=DW4
      GO TO 695
694   DW=DW5
695   SUALT=SUALT+STM(K)*DW
      SUALE=SUALE+STM(K)*DW/W(K)
700   SUSTE=SUSTE+STE(K)*DW/W(K)
      QUALT=STM(K5-1)/STM(K5)
      SUALTK=SUALT+.75*STM(K5)*DW/(SQRTF(QUALT)*LOGF(QUALT))
      QUALE=STM(K5-1)*W(K5)    /(STM(K5)*W(K5-1))
      SUALEK=SUALE+.75*STM(K5)*DW/(W(K5)*SQRTF(QUALE)*LOGF(QUALE))
      QUSTE=STE(K5-1)*W(K5)/(STE(K5)*W(K5-1))
      SUSTEK=SUSTE+.75*STE(K5)*DW/(W(K5)*SQRTF(QUSTE)*LOGF(QUSTE))
      ALBT=SUALT/(STP*DW1)
      ALBE=SUALE/(STP*DW1/W(1))
      BST=1.+SUSTE/(STE(1)*DW1/W(1))
      ALBTK=SUALTK/(STP*DW1)
      ALBEK=SUALEK/(STP*DW1/W(1))
      BSTK=1.+SUSTEK/(STE(1)*DW1/W(1))
      WRITE OUTPUT TAPE 6,8,BST
      WRITE OUTPUT TAPE 6,8,BSTK
      WRITE OUTPUT TAPE 6,16
      WRITE OUTPUT TAPE 6,8,ALBE,ALBT
      WRITE OUTPUT TAPE 6,8,ALBEK,ALBTK
      WRITE OUTPUT TAPE 6,16
      DO 710 J=1,JMA,JDP
      DO 705 K=1,K5,KDP
705   WRITE OUTPUT TAPE 6,12,(F(I,J,K),I,J,K,I=1,IMA)
710   WRITE OUTPUT TAPE 6,16
      WRITE OUTPUT TAPE 6,20
      DO 2000 III=1,3
      WRITE OUTPUT TAPE 6,1005
1005  FORMAT (25H ANGULAR MESH AND WEIGHTS)
      WRITE OUTPUT TAPE 6,1010,IMA,(OM(I),I=1,IMA)
1010  FORMAT (I6,8E14.5)
      WRITE OUTPUT TAPE 6,1020,OMO,OMU,WOM
      WRITE OUTPUT TAPE 6,1015
1015  FORMAT (16H WAVELENGTH MESH)
      WRITE OUTPUT TAPE 6,1020,W(1),DW1,DW2,DW3,DW4,DW5,K1,K2,K3,K4,K5,K
```

```
     1DP
1020  FORMAT (6E13.6,6I6)
      WRITE OUTPUT TAPE 6,1025
1025  FORMAT (34H SPATIAL AND WAVELENGTH PARAMETERS)
      WRITE OUTPUT TAPE 6,1030,A,NG,NS,MM,MK,MP
1030  FORMAT (E15.5,7I5)
      WRITE OUTPUT TAPE 6,1035
1035  FORMAT (8H LAMBDAS)
      WRITE OUTPUT TAPE 6,1040,(WT(M),M=1,MM)
1040  FORMAT (8E15.5)
      WRITE OUTPUT TAPE 6,1045
1045  FORMAT (12H SIGMATOTALS)
      DO 1050 JS=1,NS
1050  WRITE OUTPUT TAPE 6,1040,(ST(1,M,JS),M=1,MM)
      WRITE OUTPUT TAPE 6,1055
1055  FORMAT (9H GEOMETRY)
      WRITE OUTPUT TAPE 6,1030,DZ,IWV,JDP,(JG(JS),JS=1,NS)
      WRITE OUTPUT TAPE 6,16
      WRITE OUTPUT TAPE 6,1060
1060  FORMAT (63H PLACE         BE            BDOSE          BEABS          B
     1PART     )
      DO 1065 J=1,JMA
1065  WRITE OUTPUT TAPE 6,1010,J,B(1,J),B(2,J),B(3,J),B(4,J)
      WRITE OUTPUT TAPE 6,20
2000  CONTINUE
      NG=NG-1
      IF(NG)30,30,135
      END(1,0,0,0,0,0,0,0,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
23580	56034	32561	77461

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
B	21182	51276	DOM	23563	56013	F	21078	51126	JG	23312	55420	OM	23579	56033
Q	21390	51616	SOM	23571	56023	SPR	23454	55636	SP	23236	55304	S	6310	14246
STE	23307	55413	STM	23383	55527	ST	4890	11432	W	23555	56003	WT	23484	55674

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ALBEK	4290	10302	ALBE	4289	10301	ALBTK	4288	10300	ALBT	4287	10277	ARG	4286	10276
A	4285	10275	BAK	4284	10274	BAKV	4283	10273	BA	4282	10272	BDK	4281	10271
BDKV	4280	10270	BD	4279	10267	BDW	4278	10266	BEK	4277	10265	BEKV	4276	10264
BE	4275	10263	BSTK	4274	10262	BST	4273	10261	BTK	4272	10260	BTKV	4271	10257
BT	4270	10256	CS	4269	10255	DA	4268	10254	DD	4267	10253	DE	4266	10252
DT	4265	10251	DW1	4264	10250	DW2	4263	10247	DW3	4262	10246	DW4	4261	10245
DW5	4260	10244	DWD	4259	10243	DWPN	4258	10242	DWP	4257	10241	DW	4256	10240
DZ	4255	10237	EN	4254	10236	E	4253	10235	IMAM1	4252	10234	IMA	4251	10233
IOM2	4250	10232	IO	4249	10231	I	4248	10230	IS	4247	10227	IU	4246	10226
IWV	4245	10225	JA	4244	10224	JDP	4243	10223	JE	4242	10222	JGD	4241	10221
JH	4240	10220	JMA	4239	10217	J	4238	10216	JSH	4237	10215	JS	4236	10214
K1	4235	10213	K2	4234	10212	K3	4233	10211	K4	4232	10210	K5	4231	10207
KDP	4230	10206	KPA	4229	10205	KP	4228	10204	K	4227	10203	KS	4226	10202
L	4225	10201	MK	4224	10200	MM	4223	10177	MP	4222	10176	M	4221	10175
NG	4220	10174	NS	4219	10173	OMO	4218	10172	OMSMA	4217	10171	OMSMI	4216	10170
OMSQ	4215	10167	OMU	4214	10166	PO	4213	10165	P1	4212	10164	P2	4211	10163
P3	4210	10162	P4	4209	10161	P5	4208	10160	QFO	4207	10157	QFU	4206	10156
QUALE	4205	10155	QUALT	4204	10154	QUE	4203	10153	QUSTE	4202	10152	QUT	4201	10151
SIT	4200	10150	SI	4199	10147	SPP	4198	10146	STP	4197	10145	SUAK	4196	10144
SUALEK	4195	10143	SUALE	4194	10142	SUALTK	4193	10141	SUALT	4192	10140	SUA	4191	10137
SUDK	4190	10136	SUD	4189	10135	SUDW	4188	10134	SUEK	4187	10133	SUE	4186	10132
SUM	4185	10131	SUSTEK	4184	10130	SUSTE	4183	10127	SUTK	4182	10126	SUT	4181	10125
WG	4180	10124	WK	4179	10123	WOM	4178	10122						

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)2	2	10011	8)3	3	10007	8)4	4	10005	8)6	6	10003	8)8	8	10001
8)A	10	07776	8)C	12	07773	8)E	14	07770	8)G	16	07766	8)K	20	07764
8)VD	1005	07763	8)VI	1010	07755	8)VN	1015	07753	8)VS	1020	07747	8)101	1025	07744
8)106	1030	07735	8)10B	1035	07733	8)10G	1040	07730	8)10L	1045	07726	8)10V	1055	07723
8)114	1060	07720												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	4106	10012	2)	3998	07636	3)	4011	07653	4)	32767	77777	6)	4031	07677
A)101	3749	07245	A)102	3762	07262	A)104	3775	07277	A)1G2	3788	07314	A)1G5	3803	07333
A)1G6	3822	07356	A)1G7	3831	07367	A)1G9	3846	07406	A)1GA	3865	07431	A)1GB	3874	07442
A)1GC	3887	07457	A)1GD	3896	07470	A)1GE	3915	07513	A)1GF	3934	07536	A)1GJ	3953	07561
A)1GL	3972	07604	A)1GM	3985	07621	C)G0	4119	10027	C)G2	4120	10030	C)G3	4121	10031

C)G4	4122	10032	C)G5	4123	10033	C)G6	4124	10034	C)G7	4125	10035	C)G8	4126	10036
C)G9	4127	10037	C)GA	4128	10040	C)GB	4129	10041	C)GC	4130	10042	C)GD	4131	10043
C)GE	4132	10044	C)GF	4133	10045	C)GG	4134	10046	C)100	4135	10047	C)101	4136	10050
C)102	4137	10051	C)103	4138	10052	C)104	4139	10053	C)105	4140	10054	C)106	4141	10055
C)107	4142	10056	C)1G0	4143	10057	C)1G1	4144	10060	C)1G2	4145	10061	C)1G3	4146	10062
C)1G4	4147	10063	C)1G5	4148	10064	C)1G6	4149	10065	C)1G7	4150	10066	C)1G8	4151	10067
C)1G9	4152	10070	C)1GA	4153	10071	C)1GB	4154	10072	C)1GC	4155	10073	C)1GD	4156	10074
C)1GE	4157	10075	C)1GF	4158	10076	C)1GG	4159	10077	C)1GH	4160	10100	C)1GI	4161	10101
C)1GJ	4162	10102	C)1GK	4163	10103	C)1GL	4164	10104	C)1GM	4165	10105	C)200	4166	10106
C)201	4167	10107	C)202	4168	10110	C)206	4169	10111	C)207	4170	10112	C)208	4171	10113
C)209	4172	10114	C)20A	4173	10115	C)20C	4174	10116	C)20D	4175	10117	C)20F	4176	10120
C)9G0	4177	10121	D)112	420	00644	D)114	429	00655	D)116	444	00674	D)11F	550	01046
D)12J	942	01656	D)12K	960	01700	D)14S	1764	03344	D)153	1836	03454	D)15B	2001	03721
D)15R	2253	04315	D)16N	2543	04757	D)21C	516	01004	D)21M	612	01144	D)225	793	01431
D)23Q	1278	02376	D)24F	1565	03035	D)240	1711	03257	D)253	1834	03452	D)257	1912	03570
D)271	2990	05656	D)274	3080	06010	D)314	428	00654	D)31F	549	01045	D)31M	611	01143
D)33Q	1277	02375	D)340	1710	03256	D)357	1911	03567	D)35R	2252	04314	D)36N	2542	04756
D)374	3079	06007	D)418	454	00706	D)42D	867	01543	D)420	989	01735	D)43C	1183	02237
D)43E	1192	02250	D)44C	1500	02734	D)44H	1576	03050	D)44S	1762	03342	D)450	1805	03415
D)455	1878	03526	D)45Q	2234	04272	D)47M	3452	06574	D)52D	866	01542	D)54C	1499	02733
D)54H	1575	03047	D)550	1804	03414	D)64S	1761	03341	D)714	427	00653	D)71F	548	01044
D)75R	2251	04313	D)76N	2541	04755	E)15	434	00662	E)3H	1223	02307	E)3K	1236	02324
E)3N	1257	02351	E)5T	2261	04325	E)65	2303	04377	E)68	2318	04416	E)6D	2351	04457
E)6E	2367	04477	E)6Q	2727	05247	E)6T	2840	05430	E)7E	3232	06240	E)13K	1236	02324
E)36R	2749	05275												

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ATAN	7	00007	EXP	6	00006	LOG	8	00010	SQRT	5	00005	(FIL)	4	00004
(FPT)	0	00000	(RTN)	2	00002	(STH)	3	00003	(TSH)	1	00001			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ATAN EXP LOG SQRT (FIL) (FPT) (RTN) (STH) (TSH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
30	32	00053	40	43	00234	45	50	00274	50	52	00306	55	55	00323
60	57	00335	65	60	00352	70	62	00364	75	65	00402	80	67	00414
85	70	00432	90	71	00437	95	74	00455	96	82	00525	98	84	00531
100	93	00675	105	94	00707	110	96	00732	112	97	00737	115	98	00743
118	99	01005	120	100	01033	125	107	01112	130	110	01132	135	112	01145
140	120	01205	145	122	01220	150	127	01317	155	129	01326	160	130	01361
165	131	01365	170	132	01372	175	134	01432	180	135	01441	185	137	01465
190	138	01474	195	140	01503	200	141	01507	205	144	01532	210	147	01551
215	148	01564	220	149	01572	225	150	01614	230	151	01630	235	152	01657
240	154	01701	245	156	01711	250	158	01727	255	160	01732	260	162	01736
265	164	01762	270	166	02016	275	168	02040	280	171	02064	285	172	02070
290	174	02104	295	175	02111	300	176	02126	305	178	02151	310	180	02154
315	181	02160	320	183	02163	325	184	02167	330	186	02172	332	187	02176
334	189	02201	335	190	02203	376	192	02227	377	193	02233	378	194	02240
379	196	02243	380	197	02251	381	199	02254	382	202	02311	383	204	02314
384	205	02317	385	206	02326	386	208	02340	387	209	02345	388	210	02353

389	212	02371	390	213	02377	340	215	02411	345	217	02430	350	219	02433
355	220	02475	360	222	02510	365	223	02514	370	226	02562	375	228	02600
400	230	02641	405	231	02647	410	233	02652	415	234	02660	420	236	02663
425	237	02671	427	239	02674	429	240	02702	430	241	02704	435	242	02735
440	250	03031	445	252	03036	450	253	03041	455	260	03136	460	261	03157
465	263	03212	470	264	03217	475	265	03223	480	269	03275	485	271	03300
490	272	03303	495	273	03345	500	275	03367	505	277	03410	510	278	03416
515	280	03426	520	287	03523	525	289	03527	530	290	03532	535	296	03636
540	298	03667	555	301	03727	560	302	03742	565	305	04002	570	307	04021
575	310	04043	576	319	04150	578	321	04153	579	322	04155	580	330	04322
585	332	04327	590	333	04333	595	335	04336	600	336	04342	605	338	04345
607	339	04351	609	341	04354	610	342	04356	750	345	04401	755	346	04406
760	348	04435	765	349	04437	770	352	04517	775	353	04521	780	358	04552
785	360	04614	790	363	04707	795	364	04731	614	365	04760	615	366	04766
805	378	05242	810	379	05250	800	382	05276	616	391	05363	618	401	05431
620	405	05463	625	412	05657	630	417	05756	635	418	05762	640	420	06011
645	424	06100	650	428	06162	655	429	06167	660	431	06207	665	436	06226
670	438	06231	675	439	06235	680	441	06241	685	442	06245	690	444	06250
692	445	06254	694	447	06257	695	448	06261	700	450	06272	705	475	06575
710	480	06634	1050	506	07102	1065	521	07200	2000	524	07234			

ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
(FPT) (TSHM) (RTN) (STHM) (FIL) SQRT EXP ATAN LOG

EXECUTION

0.4000000E 01	1
0.3239303E 01	2
0.2346728E 01	3
0.1660439E 01	4
0.1194623E 01	5
0.8408063E 00	6
0.6027721E 00	7
0.4571684E-00	8
0.3604303E-00	9
0.2974822E-00	10
0.2532524E-00	11
0.2204724E-00	12
0.1952058E-00	13
0.1751349E-00	14

0.1177500E-00 8

0.12774999E-00	0.17701838E-00	0.97011539E-01	0.11999922E-00	0.	1	1
0.15775000E-00	0.18821711E-00	0.10352176E-00	0.11986145E-00	0.	1	2
0.21775000E-00	0.21205410E-00	0.11373252E-00	0.12197992E-00	0.	1	3
0.30774999E-00	0.24754047E-00	0.12476322E-00	0.12772387E-00	-0.	1	4
0.42774999E-00	0.29155034E-00	0.13508892E-00	0.13605347E-00	-0.	1	5
0.60774998E 00	0.34743246E-00	0.14314074E-00	0.14566982E-00	-0.	1	6
0.84774998E 00	0.40712889E-00	0.14796711E-00	0.15390548E-00	-0.	1	7
0.11177500E 01	0.46275951E-00	0.14831536E-00	0.15991797E-00	-0.	1	8
0.14177499E 01	0.51696871E 00	0.14594386E-00	0.16803861E-00	-0.	1	9
0.17177499E 01	0.57038800E 00	0.14180141E-00	0.18063482E-00	-0.	1	10
0.20177499E 01	0.62346656E 00	0.13795707E-00	0.19954701E-00	-0.	1	11
0.23177499E 01	0.68514013E 00	0.13448389E-00	0.22989772E-00	-0.	1	12
0.26177499E 01	0.75349387E 00	0.13141549E-00	0.27010865E-00	-0.	1	13
0.29177499E 01	0.82741580E 00	0.12877140E-00	0.31926321E-00	-0.	1	14

```
       1
0.1277500E-00        1 0.                  2 0.                  3 0.1224889E-05      4 0.2185049E-04      5 0.1220336E-03       6
0.3229589E-03        7 0.2382609E-02       8 0.7055136E-02       9 0.3389644E-02     10 0.8985431E-02     11 0.4103968E-02      12
0.3217909E-02       13 0.2700140E-02      14
       2
0.1277500E-00        1 0.6669167E-01       2 0.6177753E-01       3 0.5292320E-01      4 0.3623650E-01      5 0.3297685E-01       6
0.3842811E-01        7 0.3792903E-01       8 0.4297372E-01       9 0.4277785E-01     10 0.5354730E-01     11 0.4477559E-01      12
0.4041177E-01       13 0.3769130E-01      14
       3
0.1277500E-00        1 0.1348785E-00       2 0.1299846E-00       3 0.1174251E-00      4 0.9006638E-01      5 0.8172977E-01       6
0.8578700E-01        7 0.8599240E-01       8 0.9351804E-01       9 0.9630959E-01     10 0.1129035E-00     11 0.9994365E-01      12
0.8942561E-01       13 0.8339460E-01      14
       4
0.1277500E-00        1 0.2057126E-00       2 0.2048425E-00       3 0.1921487E-00      4 0.1559248E-00      5 0.1435275E-00       6
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0.276398E-01	1	7	9	0.423884E-01	2	7	9	0.606757E-01	3	7	9	0.209609E-00	4	7	9
0.248786E-00	5	7	9	0.295270E-00	6	7	9	0.325647E-00	7	7	9	0.339001E-00	8	7	9
0.862125E-01	1	7	10	0.954361E-01	2	7	10	0.113251E-00	3	7	10	0.182395E-00	4	7	10
0.194629E-00	5	7	10	0.216857E-00	6	7	10	0.232257E-00	7	7	10	0.240828E-00	8	7	10
0.182962E-00	1	7	11	0.211737E-00	2	7	11	0.204552E-00	3	7	11	0.155987E-00	4	7	11
0.153655E-00	5	7	11	0.169055E-00	6	7	11	0.172944E-00	7	7	11	0.179630E-00	8	7	11
0.174792E-00	1	7	12	0.169786E-00	2	7	12	0.159429E-00	3	7	12	0.131326E-00	4	7	12
0.125790E-00	5	7	12	0.133863E-00	6	7	12	0.136650E-00	7	7	12	0.142081E-00	8	7	12
0.116644E-00	1	7	13	0.114792E-00	2	7	13	0.113290E-00	3	7	13	0.106036E-00	4	7	13
0.105230E-00	5	7	13	0.108676E-00	6	7	13	0.112012E-00	7	7	13	0.116326E-00	8	7	13
0.906228E-01	1	7	14	0.901140E-01	2	7	14	0.900948E-01	3	7	14	0.903178E-01	4	7	14
0.898403E-01	5	7	14	0.910106E-01	6	7	14	0.931011E-01	7	7	14	0.952264E-01	8	7	14

0.	1	9	1	0.	2	9	1	0.	3	9	1	0.	4	9	1
0.	5	9	1	0.	6	9	1	0.	7	9	1	0.317825E 02	8	9	1
0.	1	9	2	0.	2	9	2	0.	3	9	2	0.	4	9	2
0.	5	9	2	0.122934E 01	6	9	2	0.143265E 02	7	9	2	0.878475E 02	8	9	2
0.	1	9	3	0.	2	9	3	0.	3	9	3	0.	4	9	3
0.274350E-01	5	9	3	0.607761E 01	6	9	3	0.137746E 02	7	9	3	0.201854E 02	8	9	3
0.	1	9	4	0.	2	9	4	0.	3	9	4	0.471753E-03	4	9	4
0.158645E-00	5	9	4	0.575890E 01	6	9	4	0.740218E 01	7	9	4	0.684891E 01	8	9	4
0.	1	9	5	0.512259E-05	2	9	5	0.106131E-04	3	9	5	0.105434E-01	4	9	5
0.345606E-00	5	9	5	0.346763E 01	6	9	5	0.369714E 01	7	9	5	0.413848E 01	8	9	5
0.428052E-04	1	9	6	0.180126E-03	2	9	6	0.464291E-03	3	9	6	0.553987E-01	4	9	6
0.522916E 00	5	9	6	0.177585E 01	6	9	6	0.217290E 01	7	9	6	0.267090E 01	8	9	6
0.157325E-02	1	9	7	C.291197E-02	2	9	7	0.544813E-02	3	9	7	0.124741E-00	4	9	7
0.551664E 00	5	9	7	0.993797E 00	6	9	7	0.106743E 01	7	9	7	0.125624E 01	8	9	7
0.845822E-02	1	9	8	0.140415E-01	2	9	8	0.252328E-01	3	9	8	0.199682E-00	4	9	8
0.430844E-00	5	9	8	0.589821E 00	6	9	8	0.638838E 00	7	9	8	0.662835E 00	8	9	8
0.326209E-01	1	9	9	0.501290E-01	2	9	9	0.723971E-01	3	9	9	0.256565E-00	4	9	9
0.313103E-00	5	9	9	0.377774E-00	6	9	9	0.417429E-00	7	9	9	0.434612E-00	8	9	9
0.102258E-00	1	9	10	0.114453E-00	2	9	10	0.136252E-00	3	9	10	0.226937E-00	4	9	10
0.244834E-00	5	9	10	0.275910E-00	6	9	10	0.296185E-00	7	9	10	0.307719E-00	8	9	10
0.220023E-00	1	9	11	0.253300E-00	2	9	11	0.247818E-00	3	9	11	0.194450E-00	4	9	11
0.193396E-00	5	9	11	0.214160E-00	6	9	11	0.219809E-00	7	9	11	0.228804E-00	8	9	11
0.217800E-00	1	9	12	0.211467E-00	2	9	12	0.198617E-00	3	9	12	0.164158E-00	4	9	12
0.157751E-00	5	9	12	0.169117E-00	6	9	12	0.172883E-00	7	9	12	0.179889E-00	8	9	12
0.145972E-00	1	9	13	0.143608E-00	2	9	13	0.141696E-00	3	9	13	0.132394E-00	4	9	13
0.131772E-00	5	9	13	0.136859E-00	6	9	13	0.141114E-00	7	9	13	0.146667E-00	8	9	13
0.113752E-00	1	9	14	0.113101E-00	2	9	14	0.113018E-00	3	9	14	0.112805E-00	4	9	14
0.112296E-00	5	9	14	0.114229E-00	6	9	14	0.116978E-00	7	9	14	0.119804E-00	8	9	14

0.	1	11	1	0.	2	11	1	0.	3	11	1	0.	4	11	1
0.	5	11	1	0.	6	11	1	0.	7	11	1	0.260213E 02	8	11	1
0.	1	11	2	0.	2	11	2	0.	3	11	2	0.	4	11	2
0.	5	11	2	0.107818E 01	6	11	2	0.143297E 02	7	11	2	0.104625E 03	8	11	2
0.	1	11	3	0.	2	11	3	0.	3	11	3	0.	4	11	3
0.241553E-01	5	11	3	0.660573E 01	6	11	3	0.158091E 02	7	11	3	0.254486E 02	8	11	3
0.	1	11	4	0.	2	11	4	0.	3	11	4	0.414640E-03	4	11	4
0.168192E-00	5	11	4	0.660949E 01	6	11	4	0.875831E 01	7	11	4	0.833068E 01	8	11	4
0.	1	11	5	0.445875E-05	2	11	5	0.924560E-05	3	11	5	0.109622E-01	4	11	5
0.386840E-00	5	11	5	0.405884E 01	6	11	5	0.436237E 01	7	11	5	0.490356E 01	8	11	5
0.427925E-04	1	11	6	0.183651E-03	2	11	6	0.475281E-03	3	11	6	0.613226E-01	4	11	6
0.590939E 00	5	11	6	0.209711E 01	6	11	6	0.257444E 01	7	11	6	0.316316E 01	8	11	6
0.169881E-02	1	11	7	0.315178E-02	2	11	7	0.593231E-02	3	11	7	0.141006E-00	4	11	7
0.635445E 00	5	11	7	0.117345E 01	6	11	7	0.126608E 01	7	11	7	0.149680E 01	8	11	7
0.927068E-02	1	11	8	0.155067E-01	2	11	8	0.279716E-01	3	11	8	0.226810E-00	4	11	8
0.500843E 00	5	11	8	0.695212E 00	6	11	8	0.755569E 00	7	11	8	0.787587E 00	8	11	8
0.362633E-01	1	11	9	0.559535E-01	2	11	9	0.814518E-01	3	11	9	0.294908E-00	4	11	9
0.365023E-00	5	11	9	0.444588E-00	6	11	9	0.491783E-00	7	11	9	0.512064E 00	8	11	9
0.114481E-00	1	11	10	0.129202E-00	2	11	10	0.154138E-00	3	11	10	0.262760E-00	4	11	10
0.285411E-00	5	11	10	0.323682E-00	6	11	10	0.347976E-00	7	11	10	0.361978E-00	8	11	10
0.248735E-00	1	11	11	0.286485E-00	2	11	11	0.282656E-00	3	11	11	0.225341E-00	4	11	11
0.225490E-00	5	11	11	0.250650E-00	6	11	11	0.257722E-00	7	11	11	0.268574E-00	8	11	11
0.252025E-00	1	11	12	0.244687E-00	2	11	12	0.229875E-00	3	11	12	0.190535E-00	4	11	12
0.183529E-00	5	11	12	0.197616E-00	6	11	12	0.202160E-00	7	11	12	0.210431E-00	8	11	12
0.169158E-00	1	11	13	0.166428E-00	2	11	13	0.164253E-00	3	11	13	0.153532E-00	4	11	13
0.153186E-00	5	11	13	0.159604E-00	6	11	13	0.164620E-00	7	11	13	0.171192E-00	8	11	13
0.132032E-00	1	11	14	0.131292E-00	2	11	14	0.131200E-00	3	11	14	0.130816E-00	4	11	14
0.130375E-00	5	11	14	0.132947E-00	6	11	14	0.136240E-00	7	11	14	0.139634E-00	8	11	14

0.	1	13	1	0.	2	13	1	0.	3	13	1	0.	4	13	1
0.	5	13	1	0.	6	13	1	0.	7	13	1	0.213045E 02	8	13	1
0.	1	13	2	0.	2	13	2	0.	3	13	2	0.	4	13	2
0.	5	13	2	0.920067E 00	6	13	2	0.137620E 02	7	13	2	0.120224E 03	8	13	2
0.	1	13	3	0.	2	13	3	0.	3	13	3	0.	4	13	3
0.206585E-01	5	13	3	0.700406E 01	6	13	3	0.175174E 02	7	13	3	0.299435E 02	8	13	3
0.	1	13	4	0.	2	13	4	0.	3	13	4	0.	4	13	4
0.174492E-00	5	13	4	0.732228E 01	6	13	4	0.988656E 01	7	13	4	0.952810E 01	8	13	4
0.	1	13	5	0.	2	13	5	0.	3	13	5	0	4	13	5
0.419910E-00	5	13	5	0.454838E 01	6	13	5	0.489942E 01	7	13	5	0.552632E 01	8	13	5
0.	1	13	6	0.	2	13	6	0.	3	13	6	0.	4	13	6
0.645591E 00	5	13	6	0.235770E 01	6	13	6	0.290257E 01	7	13	6	0.356609E 01	8	13	6
0.	1	13	7	0.	2	13	7	0.	3	13	7	0.	4	13	7
0.698715E 00	5	13	7	0.131938E 01	6	13	7	0.142753E 01	7	13	7	0.169247E 01	8	13	7
0.	1	13	8	0.	2	13	8	0.	3	13	8	0.	4	13	8
0.541284E 00	5	13	8	0.778770E 00	6	13	8	0.849344E 00	7	13	8	0.888281E 00	8	13	8
0.	1	13	9	0.	2	13	9	0.	3	13	9	0.	4	13	9
0.373990E-00	5	13	9	0.489578E-00	6	13	9	0.546504E 00	7	13	9	0.571565E 00	8	13	9
0.	1	13	10	0.	2	13	10	0.	3	13	10	0.	4	13	10
0.268126E-00	5	13	10	0.340173E-00	6	13	10	0.372682E-00	7	13	10	0.392506E-00	8	13	10
0.	1	13	11	0.	2	13	11	0.	3	13	11	0.	4	13	11
0.192497E-00	5	13	11	0.240603E-00	6	13	11	0.253856E-00	7	13	11	0.267995E-00	8	13	11
0.	1	13	12	0.	2	13	12	0.	3	13	12	0.	4	13	12
0.139258E-00	5	13	12	0.165578E-00	6	13	12	0.172158E-00	7	13	12	0.179869E-00	8	13	12
0.	1	13	13	0.	2	13	13	0.	3	13	13	0.	4	13	13
0.997728E-01	5	13	13	0.111918E-00	6	13	13	0.115650E-00	7	13	13	0.120798E-00	8	13	13
0.	1	13	14	0.	2	13	14	0.	3	13	14	0.	4	13	14
0.704730E-01	5	13	14	0.755227E-01	6	13	14	0.776257E-01	7	13	14	0.807463E-01	8	13	14

```
 ..ULAR MESH AND WEIGHTS
   8  -0.10000E 01  -0.92500E 00  -0.84000E 00  -0.28000E-00   0.28000E-00   0.84000E 00   0.92500E 00   0.10000E 01
0.100000E 01-0.100000E 01 0.500000E 00
WAVELENGTH MESH
0.127750E-00 0.600000E-01 0.120000E-00 0.240000E-00 0.300000E-00-0.          3     5     7    14    14     1
SPATIAL AND WAVELENGTH PARAMETERS
   0.95000E 00     4     1    24    24     8
LAMBDAS
   0.51100E-01     0.63900E-01     0.85200E-01     0.10220E-00     0.12770E-00     0.17030E-00     0.25550E-00     0 34060E-00
   0.51100E 00     0.63870E 00     0.85160E 00     0.10220E 01     0.12770E 01     0.17030E 01     0.25550E 01     0 34060E 01
   0.51100E 01     0.63870E 01     0.85160E 01     0.10220E 02     0.12770E 02     0.17030E 02     0.25550E 02     0.34060E 02
SIGMATOTALS
   0.15800E-00     0.15800E-00     0.16300E-00     0.16800E-00     0.17700E-00     0.19300E-00     0.22700E-00     0 26000E-00
   0.31900E-00     0.35600E-00     0.40800E-00     0.44400E-00     0.49300E-00     0.56800E 00     0.74000E 00     0.98100E 00
   0.18400E 01     0.29800E 01     0.60600E 01     0.98100E 01     0.18700E 02     0.43100E 02     0.13800E 03     0.31200E 03
GEOMETRY
   0.20000E 01     0    2   13
```

PLACE	BE	BDOSE	BEABS	BPART
1	0.10073E 01	0.10107E 01	0.10121E 01	0.11003E 01
2	0.18442E 01	0.20233E 01	0.19375E 01	0.36837E 01
3	0.28121E 01	0.32128E 01	0.30230E 01	0.69326E 01
4	0.39032E 01	0.45662E 01	0.42583E 01	0.10798E 02
5	0.51126E 01	0.60742E 01	0.56350E 01	0.15210E 02
6	0.64436E 01	0.77386E 01	0.71546E 01	0.20140E 02
7	0.79049E 01	0.95690E 01	0.88255E 01	0.25597E 02
8	0.95095E 01	0.11581E 02	0.10662E 02	0.31613E 02
9	0.11274E 02	0.13793E 02	0.12681E 02	0.38238E 02
10	0.13217E 02	0.16231E 02	0.14906E 02	0.45537E 02
11	0.15363E 02	0.18921E 02	0.17360E 02	0.53571E 02
12	0.17710E 02	0.21861E 02	0.20011E 02	0.61868E 02
13	0.19362E 02	0.23774E 02	0.21003E 02	0.54519E 02

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ANGULAR MESH AND WEIGHTS
     8  -0.10000E 01  -0.92500E 00  -0.84000E 00  -0.28000E-00   0.28000E-00   0.84000E 00   0.92500E 00   0.10000E 01
0.100000E 01-0.100000E 01 0.500000E 00
WAVELENGTH MESH
0.127750E-00 0.300000E-01 0.600000E-01 0.120000E-00 0.260000E-00-0.                    5      9     14     22     22      3
SPATIAL AND WAVELENGTH PARAMETERS
   0.95000E 00      2      1     24     24      8
LAMBDAS
   0.51100E-01     0.63900E-01     0.85200E-01     0.10220E-00     0.12770E-00     0.17030E-00     0.25550E-00     0.34060E-00
   0.51100E 00     0.63870E 00     0.85160E 00     0.10220E 01     0.12770E 01     0.17030E 01     0.25550E 01     0.34060E 01
   0.51100E 01     0.63870E 01     0.85160E 01     0.10220E 02     0.12770E 02     0.17030E 02     0.25550E 02     0.34060E 02
SIGMATOTALS
   0.15800E-00     0.15800E-00     0.16300E-00     0.16800E-00     0.17700E-00     0.19300E-00     0.22700E-00     0.26000E-00
   0.31900E-00     0.35600E-00     0.40800E-00     0.44400E-00     0.49300E-00     0.56800E 00     0.74000E 00     0.98100E 00
   0.18400E 01     0.29800E 01     0.60600E 01     0.98100E 01     0.18700E 02     0.43100E 02     0.13800E 03     0.31200E 03
GEOMETRY
   0.10000E 01      0      2     25
```

PLACE	BE	BDOSE	BEABS	BPART
1	0.10071E 01	0.10104E 01	0.10117E 01	0.10957E 01
2	0.14151E 01	0.14980E 01	0.14572E 01	0.22528E 01
3	0.18559E 01	0.20293E 01	0.19413E 01	0.35517E 01
4	0.23314E 01	0.26078E 01	0.24680E 01	0.50302E 01
5	0.28384E 01	0.32284E 01	0.30330E 01	0.66682E 01
6	0.33743E 01	0.38874E 01	0.36329E 01	0.84455E 01
7	0.39375E 01	0.45822E 01	0.42654E 01	0.10348E 02
8	0.45272E 01	0.53114E 01	0.49292E 01	0.12365E 02
9	0.51429E 01	0.60743E 01	0.56234E 01	0.14493E 02
10	0.57845E 01	0.68705E 01	0.63478E 01	0.16726E 02
11	0.64520E 01	0.76999E 01	0.71022E 01	0.19064E 02
12	0.71457E 01	0.85628E 01	0.78869E 01	0.21504E 02
13	0.78658E 01	0.94595E 01	0.87021E 01	0.24049E 02
14	0.86128E 01	0.10390E 02	0.95482E 01	0.26697E 02
15	0.93872E 01	0.11356E 02	0.10426E 02	0.29451E 02
16	0.10189E 02	0.12357E 02	0.11335E 02	0.32311E 02
17	0.11020E 02	0.13394E 02	0.12277E 02	0.35279E 02
18	0.11879E 02	0.14468E 02	0.13253E 02	0.38356E 02
19	0.12769E 02	0.15579E 02	0.14262E 02	0.41546E 02
20	0.13689E 02	0.16729E 02	0.15306E 02	0.44850E 02
21	0.14639E 02	0.17918E 02	0.16386E 02	0.48270E 02
22	0.15622E 02	0.19147E 02	0.17502E 02	0.51806E 02
23	0.16635E 02	0.20415E 02	0.18649E 02	0.55409E 02
24	0.17638E 02	0.21663E 02	0.19734E 02	0.58292E 02
25	0.17888E 02	0.21830E 02	0.19349E 02	0.49073E 02

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ANGULAR MESH AND WEIGHTS
     8  -0.10000E 01  -0.92500E 00  -0.84000E 00  -0.28000E-00   0.28000E-00   0.84000E 00   0.92500E 00   0.10000E 01
0.100000E 01-0.100000E 01 0.500000E 00
WAVELENGTH MESH
0.127750E-00 0.300000E-01 0.600000E-01 0.120000E-00 0.260000E-00-0.          5     9    14    22    22     3
SPATIAL AND WAVELENGTH PARAMETERS
    0.95000E 00     1     1    24    24     8
LAMBDAS
    0.51100E-01     0.63900E-01     0.85200E-01     0.10220E-00     0.12770E-00     0.17030E-00     0.25550E-00     0.34060E-00
    0.51100E 00     0.63870E 00     0.85160E 00     0.10220E 01     0.12770E 01     0.17030E 01     0.25550E 01     0.34060E 01
    0.51100E 01     0.63870E 01     0.85160E 01     0.10220E 02     0.12770E 02     0.17030E 02     0.25550E 02     0.34060E 02
SIGMATOTALS
    0.15800E-00     0.15800E-00     0.16300E-00     0.16800E-00     0.17700E-00     0.19300E-00     0.22700E-00     0.26000E-00
    0.31900E-00     0.35600E-00     0.40800E-00     0.44400E-00     0.49300E-00     0.56800E 00     0.74000E 00     0.98100E 00
    0.18400E 01     0.29800E 01     0.60600E 01     0.98100E 01     0.18700E 02     0.43100E 02     0.13800E 03     0.31200E 03
GEOMETRY
    0.20000E 01   -10     3    13
```

PLACE	BE	BDOSE	BEABS	BPART
1	0.10387E 01	0.10502E 01	0.10448E 01	0.11660E 01
2	0.23347E 01	0.26234E 01	0.24893E 01	0.53359E 01
3	0.31415E 01	0.36366E 01	0.34145E 01	0.83793E 01
4	0.44098E 01	0.52086E 01	0.48461E 01	0.12784E 02
5	0.59778E 01	0.71677E 01	0.66282E 01	0.18442E 02
6	0.78039E 01	0.94612E 01	0.87132E 01	0.25199E 02
7	0.98480E 01	0.12036E 02	0.11053E 02	0.32862E 02
8	0.12063E 02	0.14831E 02	0.13590E 02	0.41211E 02
9	0.14403E 02	0.17785E 02	0.16271E 02	0.50031E 02
10	0.16831E 02	0.20849E 02	0.19050E 02	0.59147E 02
11	0.19320E 02	0.23988E 02	0.21896E 02	0.68428E 02
12	0.21834E 02	0.27149E 02	0.24728E 02	0.77253E 02
13	0.23206E 02	0.28672E 02	0.25276E 02	0.67152E 02

ANGULAR MESH AND WEIGHTS
8 -0.10000E 01 -0.92500E 00 -0.84000E 00 -0.28000E-00 0.28000E-00 0.84000E 00 0.92500E 00 0.10000E 01
0.100000E 01-0.100000E 01 0.500000E 00
WAVELENGTH MESH
0.511000E 00 0.625000E-01 0.307700E-00-0. -0. -0. 33 68 68 68 68 1
SPATIAL AND WAVELENGTH PARAMETERS
0.90000E 00 1 5 24 17 8
LAMBDAS

0.51100E-01	0.63900E-01	0.85200E-01	0.10220E-00	0.12770E-00	0.17030E-00	0.25550E-00	0.34060E-00
0.51100E 00	0.63870E 00	0.85160E 00	0.10220E 01	0.12770E 01	0.17030E 01	0.25550E 01	0.34060E 01
0.51100E 01	0.63870E 01	0.85160E 01	0.10220E 02	0.12770E 02	0.17030E 02	0.25550E 02	0.34060E 02

SIGMATOTALS

0.11900E-00	0.12500E-00	0.13700E-00	0.14600E-00	0.16100E-00	0.18300E-00	0.22400E-00	0.25900E-00
0.31700E-00	0.35300E-00	0.40200E-00	0.43500E-00	0.47800E-00	0.53300E 00	0.62100E 00	0.68900E 00
0.83400E 00	0.96300E 00	0.12900E 01	0.16800E 01	0.26300E 01	0.53900E 01	0.17200E 02	0.40600E 02
0.98500E-01	0.10800E-00	0.12400E-00	0.13500E-00	0.15200E-00	0.17800E-00	0.22200E-00	0.25900E-00
0.31800E-00	0.35400E-00	0.40200E-00	0.43500E-00	0.47700E-00	0.53100E 00	0.61200E 00	0.67000E 00
0.75100E 00	0.80100E 00	0.88200E 00	0.95400E 00	0.11000E 01	0.15100E 01	0.32400E 01	0.68800E 01
0.30900E-00	0.29000E-00	0.27400E-00	0.26900E-00	0.26400E-00	0.26600E-00	0.28800E-00	0.32300E-00
0.43200E-00	0.52700E 00	0.71900E 00	0.91500E 00	0.13100E 01	0.22500E 01	0.56500E 01	0.11600E 02
0.33400E 02	0.89000E 01	0.19900E 02	0.32700E 02	0.61600E 02	0.14100E 03	0.44100E 03	0.83300E 03
0.22700E-00	0.21800E-00	0.21200E-00	0.21000E-00	0.21000E-00	0.21800E-00	0.24100E-00	0.27200E-00
0.33700E-00	0.38400E-00	0.45900E-00	0.52500E 00	0.64600E 00	0.90700E 00	0.18000E 01	0.33400E 01
0.93700E 01	0.17000E 02	0.37200E 02	0.60500E 02	0.11200E 03	0.24600E 03	0.98000E 02	0.22400E 03
0.98500E-01	0.10800E-00	0.12400E-00	0.13500E-00	0.15200E-00	0.17800E-00	0.22200E-00	0.25900E-00
0.31800E-00	0.35400E-00	0.40200E-00	0.43500E-00	0.47700E-00	0.53100E 00	0.61200E 00	0.67000E 00
0.75100E 00	0.80100E 00	0.88200E 00	0.95400E 00	0.11000E 01	0.15100E 01	0.32400E 01	0.68800E 01

GEOMETRY
0.50000E 00 0 1 5 11 13 16 24

PLACE	BE	BDOSE	BEABS	BPART
1	0.10650E 01	0.10626E 01	0.10723E 01	0.13234E 01
2	0.14775E 01	0.14796E 01	0.15247E 01	0.24311E 01
3	0.18885E 01	0.18939E 01	0.19796E 01	0.35669E 01
4	0.23338E 01	0.23427E 01	0.24844E 01	0.48791E 01
5	0.28503E 01	0.28697E 01	0.28706E 01	0.68468E 01
6	0.34475E 01	0.34944E 01	0.34892E 01	0.96509E 01
7	0.40729E 01	0.41469E 01	0.41364E 01	0.12448E 02
8	0.47269E 01	0.48254E 01	0.48104E 01	0.15245E 02
9	0.53776E 01	0.54940E 01	0.54768E 01	0.17672E 02
10	0.59080E 01	0.60294E 01	0.60164E 01	0.18542E 02
11	0.58184E 01	0.59317E 01	0.50349E 02	0.13965E 02
12	0.43083E 01	0.44140E 01	0.69848E 01	0.58959E 01
13	0.42280E 01	0.43237E 01	0.53767E 01	0.58270E 01
14	0.48427E 01	0.49593E 01	0.66475E 01	0.71054E 01
15	0.53022E 01	0.54335E 01	0.75240E 01	0.79826E 01
16	0.61763E 01	0.63025E 01	0.63189E 01	0.11784E 02
17	0.77530E 01	0.79047E 01	0.79090E 01	0.20049E 02
18	0.91394E 01	0.93348E 01	0.93234E 01	0.27763E 02
19	0.10505E 02	0.10756E 02	0.10727E 02	0.35519E 02
20	0.11878E 02	0.12189E 02	0.12143E 02	0.43265E 02
21	0.13234E 02	0.13600E 02	0.13538E 02	0.50563E 02
22	0.14469E 02	0.14868E 02	0.14799E 02	0.56135E 02
23	0.15225E 02	0.15611E 02	0.15556E 02	0.56261E 02
24	0.13950E 02	0.14269E 02	0.14274E 02	0.38774E 02

Annex B : The Listing and Samples of B4T

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$ID    60.5418.2728 PENKUHN       250 11 0103 015 004     34
$IBJOB          NOSOURCE                                      03/31/67
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SIGMAS IN CM**-1 WAVELENGTHS IN COMPTON UNITS

NM	K	SIGMATOTAL	SIGMAPAIR	SIGMAEABS	WAVELENGTH
1	1	6.2768E-01	5.1923E-01	5.9831E-01	3.4070E-02
1	2	5.5210E-01	4.0586E-01	5.0871E-01	5.1100E-02
1	3	5.1923E-01	3.4605E-01	4.6534E-01	6.3900E-02
1	4	4.9294E-01	2.7901E-01	4.2261E-01	8.5200E-02
1	5	4.7980E-01	2.3858E-01	3.9653E-01	1.0220E-01
1	6	4.7322E-01	1.8929E-01	3.7136E-01	1.2770E-01
1	7	4.7651E-01	1.2915E-01	3.4528E-01	1.7030E-01
1	8	5.1595E-01	5.6524E-02	3.3082E-01	2.5550E-01
1	9	5.7839E-01	1.8075E-02	3.4475E-01	3.4070E-01
1	10	7.7228E-01	-0.	4.5430E-01	5.1100E-01
1	11	9.4645E-01	-0.	5.7188E-01	6.3900E-01
1	12	1.2882E 00	-0.	8.3281E-01	8.5200E-01
1	13	1.6366E 00	-0.	1.1219E 00	1.0220E 00
1	14	2.3563E 00	-0.	1.7688E 00	1.2770E 00
1	15	4.0093E 00	-0.	3.3140E 00	1.7030E 00
1	16	1.0122E 01	-0.	9.2648E 00	2.5550E 00
1	17	2.0769E 01	-0.	1.9794E 01	3.4070E 00
1	18	5.9810E 01	-0.	5.8668E 01	5.1100E 00
1	19	2.3990E 01	-0.	2.2761E 01	6.3900E 00
1	20	5.3238E 01	-0.	5.1904E 01	8.5200E 00
1	21	9.0044E 01	-0.	8.8654E 01	1.0220E 01
1	22	1.6201E 02	-0.	1.6056E 02	1.2770E 01
1	23	3.4506E 02	-0.	3.4356E 02	1.7030E 01
1	24	1.0187E 03	-0.	1.0171E 03	2.5550E 01
2	1	2.3861E-01	1.5569E-01	2.1463E-01	3.4070E-02
2	2	2.3117E-01	1.1931E-01	1.9575E-01	5.1100E-02
2	3	2.3167E-01	9.9845E-02	1.8767E-01	6.3900E-02
2	4	2.3861E-01	7.7845E-02	1.8119E-01	8.5200E-02
2	5	2.4538E-01	6.3461E-02	1.7740E-01	1.0220E-01
2	6	2.5892E-01	4.7384E-02	1.7576E-01	1.2770E-01
2	7	2.8261E-01	2.9615E-02	1.7547E-01	1.7030E-01
2	8	3.3253E-01	1.0154E-02	1.8140E-01	2.5550E-01
2	9	3.7992E-01	2.5384E-03	1.8918E-01	3.4070E-01
2	10	4.6707E-01	-0.	2.0747E-01	5.1100E-01
2	11	5.2122E-01	-0.	2.1543E-01	6.3900E-01
2	12	5.9738E-01	-0.	2.2558E-01	8.5200E-01
2	13	6.4984E-01	-0.	2.2964E-01	1.0220E 00
2	14	7.2091E-01	-0.	2.4132E-01	1.2770E 00
2	15	8.1060E-01	-0.	2.4301E-01	1.7030E 00
2	16	1.0831E 00	-0.	3.8347E-01	2.5550E 00
2	17	1.4300E 00	-0.	6.3359E-01	3.4070E 00
2	18	2.6992E 00	-0.	1.7664E 00	5.1100E 00
2	19	4.3153E 00	-0.	3.3121E 00	6.3900E 00
2	20	8.8845E 00	-0.	7.7955E 00	8.5200E 00
2	21	1.4384E 01	-0.	1.3249E 01	1.0220E 01
2	22	2.7330E 01	-0.	2.6142E 01	1.2770E 01
2	23	6.3038E 01	-0.	6.1814E 01	1.7030E 01
2	24	2.0307E 02	-0.	2.0176E 02	2.5550E 01
3	1	5.8033E-02	2.8535E-02	4.9502E-02	3.4070E-02
3	2	6.1645E-02	2.1732E-02	4.9045E-02	5.1100E-02
3	3	6.4896E-02	1.8060E-02	4.9244E-02	6.3900E-02
3	4	7.1096E-02	1.3786E-02	5.0670E-02	8.5200E-02
3	5	7.6093E-02	1.0716E-02	5.1910E-02	1.0220E-01
3	6	8.3558E-02	8.4882E-03	5.3975E-02	1.2770E-01
3	7	9.5236E-02	5.1772E-03	5.7124E-02	1.7030E-01
3	8	1.1637E-01	1.8060E-03	6.2602E-02	2.5550E-01
3	9	1.3485E-01	4.8160E-04	6.6997E-02	3.4070E-01
3	10	1.6555E-01	-0.	7.3203E-02	5.1100E-01
3	11	1.8421E-01	-0.	7.5431E-02	6.3900E-01
3	12	2.0950E-01	-0.	7.7237E-02	8.5200E-01
3	13	2.2635E-01	-0.	7.6875E-02	1.0220E 00
3	14	2.4863E-01	-0.	7.8019E-02	1.2770E 00

3	15	2.7812E-01	-0.	7.6213E-02	1.7030E 00
3	16	3.2327E-01	-0.	7.4407E-02	2.5550E 00
3	17	3.6000E-01	-0.	7.6695E-02	3.4070E 00
3	18	4.3284E-01	-0.	1.0102E-01	5.1100E 00
3	19	5.0147E-01	-0.	1.4460E-01	6.3900E 00
3	20	6.6822E-01	-0.	2.8083E-01	8.5200E 00
3	21	8.7892E-01	-0.	4.7510E-01	1.0220E 01
3	22	1.3665E 00	-0.	9.4394E-01	1.2770E 01
3	23	2.8174E 00	-0.	2.3822E 00	1.7030E 01
3	24	8.9698E 00	-0.	8.5034E 00	2.5550E 01
4	1	1.9015E-02	6.4080E-03	1.5374E-02	3.4070E-02
4	2	2.1861E-02	4.8244E-03	1.6483E-02	5.1100E-02
4	3	2.3992E-02	3.9891E-03	1.7311E-02	6.3900E-02
4	4	2.6604E-02	3.0403E-03	1.7885E-02	8.5200E-02
4	5	3.0131E-02	2.4523E-03	1.9809E-02	1.0220E-01
4	6	3.3899E-02	1.8309E-03	2.1272E-02	1.2770E-01
4	7	3.9558E-02	1.1025E-03	2.3290E-02	1.7030E-01
4	8	4.9278E-02	3.8087E-04	2.6329E-02	2.5550E-01
4	9	5.7429E-02	1.0290E-04	2.8467E-02	3.4070E-01
4	10	7.0550E-02	-0.	3.1133E-02	5.1100E-01
4	11	7.8500E-02	-0.	3.2068E-02	6.3900E-01
4	12	8.9390E-02	-0.	3.2937E-02	8.5200E-01
4	13	9.6472E-02	-0.	3.2670E-02	1.0220E 00
4	14	1.0569E-01	-0.	3.2870E-02	1.2770E 00
4	15	1.1818E-01	-0.	3.2001E-02	1.7030E 00
4	16	1.3609E-01	-0.	2.9864E-02	2.5550E 00
4	17	1.4892E-01	-0.	2.7993E-02	3.4070E 00
4	18	1.6689E-01	-0.	2.5254E-02	5.1100E 00
4	19	1.7785E-01	-0.	2.5522E-02	6.3900E 00
4	20	1.9582E-01	-0.	3.0467E-02	8.5200E 00
4	21	2.1186E-01	-0.	3.9489E-02	1.0220E 01
4	22	2.4473E-01	-0.	6.4347E-02	1.2770E 01
4	23	3.3621E-01	-0.	1.5048E-01	1.7030E 01
4	24	7.1950E-01	-0.	5.2041E-01	2.5550E 01
5	1	2.2927E-05	8.2646E-06	1.8691E-05	3.4070E-02
5	2	2.6058E-05	6.2340E-06	1.9800E-05	5.1100E-02
5	3	2.8446E-05	5.1794E-06	2.0673E-05	6.3900E-02
5	4	3.2054E-05	3.9180E-06	2.1909E-05	8.5200E-02
5	5	3.5410E-05	3.2020E-06	2.3399E-05	1.0220E-01
5	6	3.9661E-05	2.3462E-06	2.4969E-05	1.2770E-01
5	7	4.6207E-05	1.4540E-06	2.7278E-05	1.7030E-01
5	8	5.7429E-05	5.1726E-07	3.0726E-05	2.5550E-01
5	9	6.6814E-05	1.2293E-07	3.3115E-05	3.4070E-01
5	10	8.2079E-05	0.	3.6213E-05	5.1100E-01
5	11	9.1343E-05	0.	3.7315E-05	6.3900E-01
5	12	1.0396E-04	0.	3.8272E-05	8.5200E-01
5	13	1.1219E-04	0.	3.7953E-05	1.0220E 00
5	14	1.2320E-04	0.	3.8466E-05	1.2770E 00
5	15	1.3727E-04	0.	3.6984E-05	1.7030E 00
5	16	1.5839E-04	0.	3.4784E-05	2.5550E 00
5	17	1.7353E-04	0.	3.2828E-05	3.4070E 00
5	18	1.9494E-04	0.	3.0132E-05	5.1100E 00
5	19	2.0794E-04	0.	3.0693E-05	6.3900E 00
5	20	2.3010E-04	0.	3.7700E-05	8.5200E 00
5	21	2.5050E-04	0.	4.9933E-05	1.0220E 01
5	22	2.8527E-04	0.	7.5371E-05	1.2770E 01
5	23	4.1066E-04	0.	1.9455E-04	1.7030E 01
5	24	9.0045E-04	0.	6.6879E-04	2.5550E 01

NM	RHO	EL-DENSITY (IN GR/CUBCM RESP. ELECTRONS/(BARN*CM))
1	1.130E 01	2.695E 00
2	7.850E 00	2.200E 00
3	2.700E 00	7.826E-01

4	10.000E-01	3.340E-01
5	1.293E-03	3.887F-04

VOLUME SOURCES INDEX KV,ASSIGNED WAVELENGTH INDEX K=KQ(KV),WAVELENGTH,ASSIGNED WAVELENGTH,ABSOLUTE DIFFERENCE

2	8	1.0000E 00	1.0877E 00	8.7750E-02

SIGMAS IN CM**-1 WAVELENGTHS IN COMPTON UNITS

NM	K	SIGMATOTAL	SIGMAPAIR	SIGMALABS	WAVELENGTH
1	1	4.7322E-01	1.8921E-01	3.7132F-01	1.2775E-01
2	1	2.5895E-01	4.7360E-02	1.7576E-01	1.2775E-01
3	1	8.3572F-02	8.4837E-03	5.3979E-02	1.2775F-01
4	1	3.3906E-02	1.8299F-03	2.1275E-02	1.2775E-01
5	1	3.9669E-05	2.3450E-06	2.4972E-05	1.2775E-01
1	2	4.7440E-01	1.4522E-01	3.5166E-01	1.5775E-01
2	2	2.7554E-01	3.4293E-02	1.7533E-01	1.5775E-01
3	2	9.1873E-02	6.0400E-03	5.6225E-02	1.5775E-01
4	2	3.7946E-02	1.2916E-03	2.2730E-02	1.5775E-01
5	2	4.4343E-05	1.6875E-06	2.6638E-05	1.5775E-01
1	3	4.9563E-01	8.4486E-02	3.3372E-01	2.1775E-01
2	3	3.1073E-01	1.7315E-02	1.7854E-01	2.1775E-01
3	3	1.0733E-01	3.0472E-03	6.0308E-02	2.1775E-01
4	3	4.5165E-02	6.4588E-04	2.5094E-02	2.1775F-01
5	3	5.2684E-05	8.6539E-07	2.9329F-05	2.1775E-01
1	4	5.5150E-01	3.2944E-02	3.3613E-01	3.0775E-01
2	4	3.6189E-01	5.4835E-03	1.8606F-01	3.0775E-01
3	4	1.2795E-01	9.9379E-04	6.5399E-02	3.0775E-01
4	4	5.4402E-02	2.1040E-04	2.7704E-02	3.0775E-01
5	4	6.3323E-05	2.7543E-07	3.2257E-05	3.0775E-01
1	5	6.7210E-01	8.8356F-03	3.9406E-01	4.2775E-01
2	5	4.2662E-01	1.2409E-03	1.9963F-01	4.2775E-01
3	5	1.5138E-01	2.3543E-04	7.0632E-02	4.2775F-01
4	5	6.4499E-02	5.0304F-05	3.0033F-02	4.2775E-01
5	5	7.5036E-05	6.0093F-08	3.4932E-05	4.2775E-01
1	6	9.0176E-01	-0.	5.4045E-01	6.0775E-01
2	6	5.0858E-01	-0.	2.1361E-01	6.0775E-01
3	6	1.7990E-01	-0.	7.4966E-02	6.0775E-01
4	6	7.6657F-02	-0.	3.1869F-02	6.0775E-01
5	6	8.9198E-05	0.	3.7082E-05	6.0775E-01
1	7	1.2804E 00	-0.	8.2650E-01	8.4775E-01
2	7	5.9597E-01	-0.	2.2543F-01	8.4775E-01
3	7	2.0904E-01	-0.	7.7225E-02	8.4775E-01
4	7	8.9195E-02	-0.	3.2933E-02	8.4775E-01
5	7	1.0373E-04	0.	3.8267E-05	8.4775E-01
1	8	1.8028F 00	-0.	1.2688F 00	1.0877E 00
2	8	6.6941E-01	-0.	2.3342E-01	1.0877E 00
3	8	2.3243E-01	-0.	7.7330E-02	1.0877E 00
4	8	9.8974E-02	-0.	3.2773E-02	1.0877E 00
5	8	1.1522F-04	0.	3.8186E-05	1.0877E 00
1	9	2.5041E 00	-0.	1.9029E 00	1.3277E 00
2	9	7.2997E-01	-0.	2.3912E-01	1.3277E 00
3	9	2.5238E-01	-0.	7.7772E-02	1.3277E 00
4	9	1.0730E-01	-0.	3.2773E-02	1.3277E 00
5	9	1.2500E-04	0.	3.8276E-05	1.3277E 00
1	10	3.3831E 00	-0.	2.7201E 00	1.5677E 00
2	10	7.7877E-01	-0.	2.3752E-01	1.5677E 00
3	10	2.6926E-01	-0.	7.6721E-02	1.5677E 00
4	10	1.1447E-01	-0.	3.2292F-02	1.5677E 00
5	10	1.3305E-04	0.	3.7427E-05	1.5677E 00

1	11	4.5163E 00	-0.	3.7988E 00	1.8077E 00
2	11	8.4009E-01	-0.	2.5437E-01	1.8077E 00
3	11	2.8413E-01	-0.	7.5770E-02	1.8077E 00
4	11	1.2066E-01	-0.	3.1724E-02	1.8077E 00
5	11	1.4019E-04	0.	3.6700E-05	1.8077E 00
1	12	5.9363E 00	-0.	5.1705E 00	2.0477E 00
2	12	9.1188E-01	-0.	2.8664E-01	2.0477E 00
3	12	2.9741E-01	-0.	7.4989E-02	2.0477E 00
4	12	1.2604E-01	-0.	3.1104E-02	2.0477E 00
5	12	1.4653E-04	0.	3.6065E-05	2.0477E 00
1	13	7.7163E 00	-0.	6.9054E 00	2.2877E 00
2	13	9.8958E-01	-0.	3.2761E-01	2.2877E 00
3	13	3.1002E-01	-0.	7.4533E-02	2.2877E 00
4	13	1.3102E-01	-0.	3.0505E-02	2.2877E 00
5	13	1.5241E-04	0.	3.5448E-05	2.2877E 00
1	14	9.8560E 00	-0.	9.0036E 00	2.5277E 00
2	14	1.0732E 00	-0.	3.7728E-01	2.5277E 00
3	14	3.2196E-01	-0.	7.4402E-02	2.5277E 00
4	14	1.3560E-01	-0.	2.9928E-02	2.5277E 00
5	14	1.5781E-04	0.	3.4851E-05	2.5277E 00
1	15	1.2225E 01	-0.	1.1337E 01	2.7677E 00
2	15	1.1517E 00	-0.	4.2615E-01	2.7677E 00
3	15	3.3246E-01	-0.	7.4361E-02	2.7677E 00
4	15	1.3953E-01	-0.	2.9365E-02	2.7677E 00
5	15	1.6245E-04	0.	3.4258E-05	2.7677E 00
1	16	1.5042E 01	-0.	1.4119E 01	3.0077E 00
2	16	1.2435E 00	-0.	4.9009E-01	3.0077E 00
3	16	3.4281E-01	-0.	7.4802E-02	3.0077E 00
4	16	1.4322E-01	-0.	2.8828E-02	3.0077E 00
5	16	1.6681E-04	0.	3.3694E-05	3.0077E 00
1	17	1.8329E 01	-0.	1.7374E 01	3.2477E 00
2	17	1.3505E 00	-0.	5.7079E-01	3.2477E 00
3	17	3.5315E-01	-0.	7.5767E-02	3.2477E 00
4	17	1.4671E-01	-0.	2.8317E-02	3.2477E 00
5	17	1.7093E-04	0.	3.3163E-05	3.2477E 00

IDR(MRE)	K	INTERPOLATED RESPONSES
415	1	5.0788E 00
415	2	4.4114E 00
415	3	3.5273E 00
415	4	2.7457E 00
415	5	2.1430E 00
415	6	1.5900E 00
415	7	1.1753E 00
415	8	9.1976E-01
415	9	7.5141E-01
415	10	6.2931E-01
415	11	5.3698E-01
415	12	4.6815E-01
415	13	4.0884E-01
415	14	3.5905E-01
415	15	3.2728E-01
415	16	2.9931E-01
415	17	2.7366E-01

SPECTRA IN PAIRS,WAVELENGTH INDEX K,SPECTRUM SP(J,K) IN PHOTONS/(SQCM*SEC*COMPTON UNIT),OR SP(J,K)/SP(J,1),IF INDOUT=0
SPATIAL INDEX J AT THE TOP OF EACH SUB-BLOCK

2

	1	3.5547E 00	4	2.2197E-02	7	1.1133E-02	10	8.5654E-03	13	3.2311E-03	16	1.4278E-03
3	1	4.6493E-02	4	1.0896E-02	7	3.7449E-03	10	2.3834E-03	13	1.7052E-03	16	1.0933E-03
4	1	3.8732E-03	4	1.5717E-03	7	5.5588E-04	10	3.4912E-04	13	2.5737E-04	16	1.6431E-04
5	1	3.6444E-04	4	2.3801E-04	7	7.9695E-05	10	4.9688E-05	13	3.6976E-05	16	2.3434E-05
6	1	3.7505E-05	4	3.5678E-05	7	1.1410E-05	10	7.0781E-06	13	5.3016E-06	16	3.3431E-06
7	1	4.1007E-06	4	5.2848E-06	7	1.6357E-06	10	1.0117E-06	13	7.6130E-07	16	4.7851E-07
8	1	4.6676E-07	4	7.7643E-07	7	2.3476E-07	10	1.4495E-07	13	1.0946F-07	16	6.8656E-08
9	1	5.4605E-08	4	1.1347E-07	7	3.3731E-08	10	2.0807E-08	13	1.5752E-08	16	9.8669E-09
10	1	6.5154E-09	4	1.6530E-08	7	4.8516E-09	10	2.9911E-09	13	2.2688E-09	16	1.4198E-09
11	1	7.8921E-10	4	2.4034E-09	7	6.9855E-10	10	4.3052E-10	13	3.2702E-10	16	2.0453E-10
12	1	9.6751E-11	4	3.4910E-10	7	1.0068E-10	10	6.2020E-11	13	4.7147E-11	16	2.9464E-11
13	1	1.1978E-11	4	5.0688E-11	7	1.4515E-11	10	8.8621E-12	13	6.6659E-12	16	4.1284E-12
14	1	1.4953E-12	4	7.3603E-12	7	1.9452E-12	10	7.4046E-13	13	3.1142E-13	16	1.3004E-13

ANGULAR FLUXES F(I,J,K) (TRANSFORMED),FOLLOWED BY THEIR INDEX TRIPLES I(ANGULAR),J(SPATIAL),K(WAVELENGTH)

0.	2	2	1	1.5141E 00	4	2	1	1.9765E-01	6	2	1	1.5832E-01	8	2	1
2.0926E-04	2	2	4	1.2753E-03	4	2	4	1.2622E-04	6	2	4	5.2765E-05	8	2	4
1.9277E-03	2	2	7	3.2702E-04	4	2	7	5.1997E-05	6	2	7	7.3062E-05	8	2	7
1.4696E-03	2	2	10	2.3047E-04	4	2	10	3.5785E-05	6	2	10	2.9881E-05	8	2	10
4.8969E-04	2	2	13	1.3358E-04	4	2	13	1.0810E-05	6	2	13	1.0132E-05	8	2	13
1.9530E-04	2	2	16	7.7063E-05	4	2	16	1.5153E-05	6	2	16	1.1780E-05	8	2	16
0.	2	3	1	2.1831E-08	4	3	1	1.0863E-01	6	3	1	1.4329E-01	8	3	1
2.7438E-07	2	3	4	2.3814E-03	4	3	4	2.1175E-02	6	3	4	1.9916E-02	8	3	4
1.4701E-04	2	3	7	1.9628E-03	4	3	7	4.4900E-03	6	3	7	7.3691E-03	8	3	7
8.0614E-04	2	3	10	1.4528E-03	4	3	10	1.6778E-03	6	3	10	1.5004E-03	8	3	10
1.0454E-03	2	3	13	8.4195E-04	4	3	13	8.1341E-04	6	3	13	8.3593E-04	8	3	13
5.8658E-04	2	3	16	5.8183E-04	4	3	16	5.5846E-04	6	3	16	5.6058E-04	8	3	16
0.	2	4	1	3.0085E-16	4	4	1	5.9620E-02	6	4	1	1.2965E-01	8	4	1
4.1691E-10	2	4	4	8.2909E-04	4	4	4	2.2831E-02	6	4	4	3.5963E-02	8	4	4
5.0023E-05	2	4	7	1.8561E-03	4	4	7	4.8905E-03	6	4	7	6.1840E-03	8	4	7
6.9430E-04	2	4	10	1.4125E-03	4	4	10	1.7076E-03	6	4	10	1.8591E-03	8	4	10
1.0266E-03	2	4	13	8.2055E-04	4	4	13	8.9285E-04	6	4	13	9.5584E-04	8	4	13
5.8682E-04	2	4	16	5.7938E-04	4	4	16	5.7113E-04	6	4	16	5.8315E-04	8	4	16
0.	2	5	1	4.1459E-24	4	5	1	3.2720E-02	6	5	1	1.1731E-01	8	5	1

3.2317E-12	2	5	4	4.4138E-04	4	5	4	2.2977E-02	6	5	4	4.6922E-02	8	5	4
2.8047E-05	2	5	7	1.8108E-03	4	5	7	4.7193E-03	6	5	7	5.7646E-03	8	5	7
6.3762E-04	2	5	10	1.3424E-03	4	5	10	1.6416E-03	6	5	10	1.8018E-03	8	5	10
9.8830E-04	2	5	13	7.7680E-04	4	5	13	8.5617E-04	6	5	13	9.2930E-04	8	5	13
5.6133E-04	2	5	16	5.5262E-04	4	5	16	5.4210E-04	6	5	16	5.5346E-04	8	5	16
0.	2	6	1	5.7134E-32	4	6	1	1.7957E-02	6	6	1	1.0615E-01	8	6	1
2.5050E-14	2	6	4	2.5255E-04	4	6	4	2.2801E-02	6	6	4	5.3401E-02	8	6	4
1.7361E-05	2	6	7	1.7689E-03	4	6	7	4.4827E-03	6	6	7	5.6146E-03	8	6	7
5.9430E-04	2	6	10	1.2782E-03	4	6	10	1.5682E-03	6	6	10	1.7114E-03	8	6	10
9.5038E-04	2	6	13	7.3777E-04	4	6	13	8.1488E-04	6	6	13	8.8862E-04	8	6	13
5.3712E-04	2	6	16	5.2743E-04	4	6	16	5.1445E-04	6	6	16	5.2412E-04	8	6	16
0.	2	7	1	0.	4	7	1	9.8551E-03	6	7	1	9.6048E-02	8	7	1
1.9418E-16	2	7	4	1.5139E-04	4	7	4	2.2536E-02	6	7	4	5.6486E-02	8	7	4
1.2062E-05	2	7	7	1.7229E-03	4	7	7	4.2612E-03	6	7	7	5.5063E-03	8	7	7
5.5824E-04	2	7	10	1.2208E-03	4	7	10	1.5015E-03	6	7	10	1.6315E-03	8	7	10
9.1396E-04	2	7	13	7.0392E-04	4	7	13	7.7838E-04	6	7	13	8.5059E-04	8	7	13
5.1525E-04	2	7	16	5.0492E-04	4	7	16	4.9057E-04	6	7	16	4.9872E-04	8	7	16
0.	2	8	1	0.	4	8	1	5.4086E-03	6	8	1	8.6907E-02	8	8	1
1.5052E-18	2	8	4	9.5474E-05	4	8	4	2.2247E-02	6	8	4	5.7229E-02	8	8	4
9.3610E-06	2	8	7	1.6743E-03	4	8	7	4.0646E-03	6	8	7	5.3835E-03	8	8	7
5.2732E-04	2	8	10	1.1688E-03	4	8	10	1.4408E-03	6	8	10	1.5614E-03	8	8	10
8.7936E-04	2	8	13	6.7380E-04	4	8	13	7.4587E-04	6	8	13	8.1597E-04	8	8	13
4.9510E-04	2	8	16	4.8444E-04	4	8	16	4.6952E-04	6	8	16	4.7641E-04	8	8	16
0.	2	9	1	0.	4	9	1	2.9683E-03	6	9	1	7.8637E-02	8	9	1
1.1667E-20	2	9	4	6.3265E-05	4	9	4	2.1950E-02	6	9	4	5.6483E-02	8	9	4
7.7536E-06	2	9	7	1.6248E-03	4	9	7	3.8897E-03	6	9	7	5.2430E-03	8	9	7
5.0029E-04	2	9	10	1.1213E-03	4	9	10	1.3848E-03	6	9	10	1.4982E-03	8	9	10
8.4664E-04	2	9	13	6.4643E-04	4	9	13	7.1625E-04	6	9	13	7.8403E-04	8	9	13
4.7628E-04	2	9	16	4.6551E-04	4	9	16	4.5049E-04	6	9	16	4.5637E-04	8	9	16
0.	2	10	1	0.	4	10	1	1.6290E-03	6	10	1	7.1154E-02	8	10	1
9.0440E-23	2	10	4	4.3765E-05	4	10	4	2.1648E-02	6	10	4	5.4879E-02	8	10	4
6.6951E-06	2	10	7	1.5755E-03	4	10	7	3.7318E-03	6	10	7	5.0921E-03	8	10	7
4.7631E-04	2	10	10	1.0776E-03	4	10	10	1.3325E-03	6	10	10	1.4402E-03	8	10	10
8.1576E-04	2	10	13	6.2120E-04	4	10	13	6.8886E-04	6	10	13	7.5428E-04	8	10	13
4.5861E-04	2	10	16	4.4786E-04	4	10	16	4.3300E-04	6	10	16	4.3806E-04	8	10	16
0.	2	11	1	0.	4	11	1	8.9403E-04	6	11	1	6.4383E-02	8	11	1
7.0105E-25	2	11	4	3.1337E-05	4	11	4	2.1340E-02	6	11	4	5.2859E-02	8	11	4
5.9377E-06	2	11	7	1.5272E-03	4	11	7	3.5874E-03	6	11	7	4.9375E-03	8	11	7
4.5480E-04	2	11	10	1.0371E-03	4	11	10	1.2835E-03	6	11	10	1.3865E-03	8	11	10
7.8660E-04	2	11	13	5.9779E-04	4	11	13	6.6335E-04	6	11	13	7.2642E-04	8	11	13
4.4196E-04	2	11	16	4.3134E-04	4	11	16	4.1678E-04	6	11	16	4.2117E-04	8	11	16
0.	2	12	1	0.	4	12	1	4.9066E-04	6	12	1	5.8256E-02	8	12	1
5.4342E-27	2	12	4	2.3047E-05	4	12	4	2.1027E-02	6	12	4	5.0714E-02	8	12	4
5.3426E-06	2	12	7	1.4803E-03	4	12	7	3.4538E-03	6	12	7	4.7836E-03	8	12	7
4.3483E-04	2	12	10	9.9941E-04	4	12	10	1.2376E-03	6	12	10	1.3363E-03	8	12	10
7.5800E-04	2	12	13	5.7583E-04	4	12	13	6.3945E-04	6	12	13	7.0025E-04	8	12	13
4.2545E-04	2	12	16	4.1562E-04	4	12	16	4.0153E-04	6	12	16	4.0539E-04	8	12	16
0.	2	13	1	0.	4	13	1	2.6928E-04	6	13	1	5.2712E-02	8	13	1
4.2043E-29	2	13	4	1.7311E-05	4	13	4	2.0711E-02	6	13	4	4.8624E-02	8	13	4
4.2630E-06	2	13	7	1.4350E-03	4	13	7	3.3296E-03	6	13	7	4.6328E-03	8	13	7
3.9882E-04	2	13	10	9.6228E-04	4	13	10	1.1939E-03	6	13	10	1.2892E-03	8	13	10
6.9984E-04	2	13	13	5.5105E-04	4	13	13	6.1486E-04	6	13	13	6.7407E-04	8	13	13
3.8785E-04	2	13	16	3.9420E-04	4	13	16	3.8267E-04	6	13	16	3.8666E-04	8	13	16
0.	2	14	1	0.	4	14	1	1.4778E-04	6	14	1	4.7696E-02	8	14	1
0.	2	14	4	1.3234E-05	4	14	4	2.0393E-02	6	14	4	4.6693E-02	8	14	4
0.	2	14	7	1.3849E-03	4	14	7	3.2134E-03	6	14	7	4.4870E-03	8	14	7

0.	2 14 10	8.2214E-04	4 14 10	1.0807E-03	6 14 10	1.2234E-03	8 14 10
0.	2 14 13	3.4724E-04	4 14 13	4.3958E-04	6 14 13	4.9672E-04	8 14 13
0.	2 14 16	1.6542E-04	4 14 16	1.6940E-04	6 14 16	1.8279E-04	8 14 16

IE=SQARE ROOT ERROR INDEX
0

FIRST LINE OF EACH SUB-BLOCK VALUES WITHOUT,SECOND LINE WITH LOW-ENERGETIC CORRECTION
THIRD LINE OF EACH SUB-BLOCK CORRESPONDING BUILDUP FACTORS,LOW-ENERGETIC CORRECTION INCLUDED

ENERGY FLUX MEV/SQCM/SEC	DOSE RATE REM/HOUR	EN.-ABS.-RATE MEV/CUBCM/SEC	PARTICLE FLUX PHOT/SQCM/SEC	X IN CM	X IN MFP(EMAX)	X-INDEX J
5.4141E-01	6.9687E-07	9.5714E-02	1.5337E-01	0	0.	1
5.4146E-01	6.9695E-07	9.5757E-02	1.5380E-01			
1.0476E 00	1.0605E 00	1.0541E 00	1.1902E 00			
8.8407E-01	1.1343E-06	1.5604E-01	2.4226E-01	3.8618E-02	10.0000E-03	2
8.8415E-01	1.1344E-06	1.5611E-01	2.4295E-01			
1.0364E 00	1.0458E 00	1.0411E 00	1.1391E 00			
8.8407E-01	1.1343E-06	1.5604E-01	2.4226E-01	3.8618E-02	10.0000E-03	2
8.8415E-01	1.1344E-06	1.5611E-01	2.4295E-01			
1.0364E 00	1.0458E 00	1.0411E 00	1.1391E 00			
2.4825E-02	3.5726E-08	4.6259E-03	1.4269E-02	7.7429E 00	2.0050E 00	3
2.4927E-02	3.5885E-08	4.7233E-03	1.5272E-02			
2.2340E 00	2.5294E 00	2.4084E 00	5.4746E 00			
2.4825E-02	3.5726E-08	4.6259E-03	1.4269E-02	7.7429E 00	2.0050E 00	3
2.4927E-02	3.5885E-08	4.7233E-03	1.5272E-02			
2.2340E 00	2.5294E 00	2.4084E 00	5.4746E 00			
2.8464E-03	4.2150E-09	5.3880E-04	1.8864E-03	1.5467E 01	4.0050E 00	4
2.8617E-03	4.2388E-09	5.5344E-04	2.0371E-03			
3.0785E 00	3.5864E 00	3.3875E 00	8.7659E 00			
3.6628E-04	5.5269E-10	6.9936E-05	2.6116E-04	2.3190E 01	6.0050E 00	5
3.6846E-04	5.5608E-10	7.2021E-05	2.8262E-04			
4.2126E 00	5.0003E 00	4.6849E 00	1.2925E 01			
4.9290E-05	7.5325E-11	9.4656E-06	3.6791E-05	3.0914E 01	8.0050E 00	6
4.9600E-05	7.5808E-11	9.7624E-06	3.9845E-05			
5.5104E 00	6.6239E 00	6.1708E 00	1.7707E 01			
6.8011E-06	1.0484E-11	1.3112E-06	5.2304E-06	3.8637E 01	1.0005E 01	7
6.8453E-06	1.0553E-11	1.3536E-06	5.6667E-06			
6.9554E 00	8.4332E 00	7.8252E 00	2.3031E 01			
9.5258E-07	1.4773E-12	1.8414E-07	7.4751E-07	4.6361E 01	1.2005E 01	8
9.5892E-07	1.4872E-12	1.9021E-07	8.1000E-07			
8.5601E 00	1.0441E 01	9.6609E 00	2.8923E 01			
1.3469E-07	2.0979E-13	2.6085E-08	1.0719E-07	5.4085E 01	1.4005E 01	9
1.3560E-07	2.1121E-13	2.6957E-08	1.1615E-07			
1.0347E 01	1.2676E 01	1.1703E 01	3.5452E 01			
1.9166E-08	2.9948E-14	3.7168E-09	1.5405E-08	6.1808E 01	1.6005E 01	10
1.9297E-08	3.0152E-14	3.8421E-09	1.6693E-08			
1.2341E 01	1.5166E 01	1.3980E 01	4.2702E 01			
2.7398E-09	4.2912E-15	5.3181E-10	2.2179E-09	6.9532E 01	1.8005E 01	11
2.7586E-09	4.3206E-15	5.4984E-10	2.4032E-09			
1.4564E 01	1.7940E 01	1.6516E 01	5.0752E 01			
3.9301E-10	6.1664E-16	7.6335E-11	3.1974E-10	7.7255E 01	2.0005E 01	12
3.9572E-10	6.2087E-16	7.8928E-11	3.4640E-10			
1.7042E 01	2.1029E 01	1.9339E 01	5.9672E 01			

5.6472E-11 5.6847E-11 1.9774E 01	8.8709E-17 8.9295E-17 2.4429E 01	1.0965E-11 1.1323E-11 2.2411E 01	4.5904E-11 4.9584E-11 6.8991E 01	8.4979E 01	2.2005E 01	13
7.7906E-12 7.7960E-12 2.1723E 01	1.2151E-17 1.2160E-17 2.6649E 01	1.4743E-12 1.4788E-12 2.3444E 01	5.3339E-12 5.3786E-12 5.9948E 01	9.2703E 01	2.4005E 01	14

X IN CM	RESPONSE INTEGRALS UNDER THEIR ID. NUMBERS IDR(MRE),1ST LINE WITHOUT,2ND WITH CUTOFF CORRECTION
	415
0. 0.	6.9618E-01 6.9626E-01
3.8618E-02 3.8618E-02	1.1331E 00 1.1332E 00
7.7429E 00 7.7429E 00	3.5830E-02 3.5926E-02
1.5467E 01 1.5467E 01	4.2308E-03 4.2453E-03
2.3190E 01 2.3190E 01	5.5509E-04 5.5715E-04
3.0914E 01 3.0914E 01	7.5680E-05 7.5974E-05
3.8637E 01 3.8637E 01	1.0536E-05 1.0578E-05
4.6361E 01 4.6361E 01	1.4849E-06 1.4909E-06
5.4085E 01 5.4085E 01	2.1089E-07 2.1176E-07
6.1808E 01 6.1808E 01	3.0108E-08 3.0234E-08
6.9532E 01 6.9532E 01	4.3145E-09 4.3326E-09
7.7255E 01 7.7255E 01	6.2003E-10 6.2263E-10
8.4979E 01 8.4979E 01	8.9199E-11 8.9566E-11
9.2703E 01 9.2703E 01	1.2214E-11 1.2223E-11

PROBLEM DATA REPRODUCTION

RESPONSE FUNCTION NUMBER NRE (IF NOT POSITIVE,NO RESPONSE FUNCTIONS),KTRG=NUMBER OF THEIR WAVELENGTH MESH POINTS,
RESPONSE FUNCTION IDENTIFICATION NUMBERS IDR(MRE),FROM MRE=1 TO MRE=NRE

1 24 415

RESPUNSE FUNCTICN WAVELENGTH MESH AND VALUES

5.1100E-02	6.3870E-02	8.5160E-02	1.0220E-01	1.2770E-01	1.7030E-01	2.5550E-01	3.4060E-01
5.1100E-01	6.3870E-01	8.5160E-01	1.0220E 00	1.2770E 00	1.7030E 00	2.5550E 00	3.4060E 00
5.1100E 00	6.3870E 00	8.5160E 00	1.0220E 01	1.2770E 01	1.7030E 01	2.5550E 01	3.4060E 01
1.0200E 01	8.4800E 00	6.8400E 00	6.0000E 00	5.0800E 00	4.1700E 00	3.1200E 00	2.5400E 00
1.8400E 00	1.5200E 00	1.1700E 00	9.7500E-01	7.8000E-01	5.7000E-01	3.5400E-01	2.5800E-01
1.5300E-01	1.2400E-01	1.1350E-01	1.2400E-01	1.6200E-01	2.7400E-01	6.3200E-01	1.1700E 00

NPHYS=NUMBER OF PHYSICALLY DIFFERENT CASES
4

PHYSICAL INPUT REPRODUCTION

NGEOM=NUMBER OF DIFFERENT GEOMETRIES,NMG=NUMBER OF MATERIALS,CP=PAIR PRODUCTION CONSTANT (=0. ANNIHILATION PHOTONS NEGLECTED,=1.INCLUDED),INDOUT=OUTPUT INDEX (POSITIVE=REDUCED, 0 OR NEGATIVE=FULL OUTPUT)

2 4 0. -1

PARTIAL DENSITIES RHO(NM,NE) OF ELEMENT NE IN MATERIAL NM.NE,Z(NE),RHO(AIR,NE) NOT GIVEN IN PROBLEM DATA INPUT,BUT PRINTED HERE FOR BETTER EXPLANATION.

(NE	Z	RHO(AIR,NE))	RHO(1,NE)	RHO(2,NE)	RHO(3,NE)	RHO(4,NE)	RHO(5,NE)	RHO(6,NE)	RHO(7,NE)	RHO(8,NE)	RHO(9,NE)
1	1.	0.	-0.	-0.	-0.	1.120E-01					
2	4.	0.	-0.	-0.	-0.	-0.					
3	6.	0.	-0.	-0.	-0.	-0.					
4	7.	9.760E-04	-0.	-0.	-0.	-0.					
5	8.	3.000E-04	-0.	-0.	-0.	8.880E-01					
6	11.	0.	-0.	-0.	-0.	-0.					
7	12.	0.	-0.	-0.	-0.	-0.					
8	13.	0.	-0.	-0.	2.700E 00	-0.					
9	14.	0.	-0.	-0.	-0.	-0.					
10	15.	0.	-0.	-0.	-0.	-0.					
11	16.	0.	-0.	-0.	-0.	-0.					
12	18.	1.700E-05	-0.	-0.	-0.	-0.					
13	19.	0.	-0.	-0.	-0.	-0.					
14	20.	0.	-0.	-0.	-0.	-0.					
15	22.	0.	-0.	-0.	-0.	-0.					
16	25.	0.	-0.	-0.	-0.	-0.					
17	26.	0.	-0.	7.850E 00	-0.	-0.					
18	29.	0.	-0.	-0.	-0.	-0.					
19	30.	0.	-0.	-0.	-0.	-0.					
20	35.	0.	-0.	-0.	-0.	-0.					
21	42.	0.	-0.	-0.	-0.	-0.					
22	47.	0.	-0.	-0.	-0.	-0.					
23	50.	0.	-0.	-0.	-0.	-0.					
24	53.	0.	-0.	-0.	-0.	-0.					
25	56.	0.	-0.	-0.	-0.	-0.					
26	74.	0.	-0.	-0.	-0.	-0.					
27	78.	0.	-0.	-0.	-0.	-0.					
28	81.	0.	-0.	-0.	-0.	-0.					
29	82.	0.	1.130E 01	-0.	-0.	-0.					
30	92.	0.	-0.	-0.	-0.	-0.					

ANGULAR MESH,IG=NUMBER OF ANGULAR POINTS AND OM(I)=COSINE MESH VALUES,SMALLEST FIRST
8 -1.0000 -0.7500 -0.2000 0.1000 0.6500 0.8000 0.9200 1.0000

SOURCE ENERGIES EV(KV) IN MEV,HIGHEST FIRST
4.0000E 00

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COUPLES OF WAVELENGTH STEPS DW(NDL) IN COMPTON UNITS AND LAST MESH INDICES KG(NDL),AT WHICH DW(NDL) IS USED
   0.0600   3    0.1200   5    0.2400 17

    GEOMETRY INPUT REPRODUCTION

KOE=PLAIN (NEG.) OR SPHERICAL (POS. OR 0) GEOMETRY,JMDZ=UNIT LENGTH OPTION (POS.=R AND DZ(JS) ARE INTERPRETED IN CM, 0
OR NEG. IN MFP(MAX.EN.)),I2INT=LINEAR (IF NEG.) OR QUASI-EXPONENTIAL INTERPOLATION AND INTEGRATION (1ST ORDER APPROXI-
MATION OF THE SQUARE ROOTS,IF I2INT=0 - 2ND ORDER,IF I2INT POS.)
    -1        0       1

IOUTM=NUMBER OF MAIN OUTPUT REPRODUCTIONS,IPA,IPZ,IPD,JPA,JPZ,JPD,KPA,KPZ,KPD=OUTPUT MESHES IN ANGLE,SPACE AND WAVE-
LENGTH FOR SPECTRA AND ANGULAR FLUXES - IF IPA AND INDOUT NOT-POSITIVE,FULLEST POSSIBLE OUTPUT
     1       2       8       2       2      14       1       1      17       3

MST,M(1),M(2),...M(NS).MST=0 OR NEGATIVE=1ST LAYER OF 1ST MATERIAL,2ND LAYER OF 2ND MATERIAL ETC-MST POSITIVE=1ST LAYER
OF MATERIAL M(1),2ND LAYER OF MATERIAL M(2) ETC..IF MST NOT POSITIVE,M(1),M(2),.. NOT NEEDED IN INPUT,BUT REDEFINED BY
THE PROGRAM
     1       2       2       2

INITIAL RADIUS R AND SPATIAL INTEGRATION STEPS DZ(JS) IN EACH LAYER JS,OUTPUT IN CM
   -0.              3.8618E-02     7.7043E 00     7.7236E 00

SPATIAL INDICES JG(JS) OF THE LEFT BOUNDARIES OF THE LAYERS JS,JS=2,3,4 ETC..THE LAST JG BELONGS TO THE RIGHT BOUNDARY
OF THE LAST LAYER.THE PROGRAM PUTS JG(1)=1.THICKNESS OF LAYER JS=(JG(JS+1)-JG(JS))*DZ(JS) IN UNITS GIVEN BY JMDZ.
     2       3      14

EXPONENTIAL TRANSFORMATION PARAMETERS A(JS)
   -0.              9.5000E-01     9.5000E-01

IWV=ANGULAR SOURCE INDEX (IF 0,ISOTROPIC - IF POSITIVE,COLLIMATED IN DIRECTION OM(IG+1-IWV) -IF NEGATIVE,THE SOURCE
STRENGTH IS QOM(I) IN THE DIRECTION OM(I)),ANGULAR SOURCE STRENGTHS QOM(I),I=1,2,.. ,IG.(IF IWV IS NOT-NEGATIVE,THE
QOM(I) ARE NOT NEEDED IN INPUT,BUT REDEFINED BY THE PROGRAM)
     0     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000

LAYER SOURCE INDEX JSQ (POSITIVE=SOURCES IN JSQTH LAYER,0=SOURCES IN CENTRAL SPHERE,NEGATIVE=SOURCES EVERYWHERE DES-
CRIBED BY LAST INPUT CARDS),LAYER SOURCE SPECTRUM QE(KV),IF JSQ NOT-NEGATIVE.(JSQ POSITIVE AND JMDZ=0 MEAN MULTIPLICA-
TION OF THE QE(KV) WITH SIGMATOTAL OF MAXIMUM SOURCE ENERGY.)
     1    12.0000
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SPECTRA IN PAIRS,WAVELENGTH INDEX K,SPECTRUM SP(J,K) IN PHOTONS/(SQCM*SEC*COMPTON UNIT),OR SP(J,K)/SP(J,1),IF INDOUT=0
SPATIAL INDEX J AT THE TOP OF EACH SUB-BLOCK

J	K	SP	K	SP	K	SP	K	SP	K	SP
1	1	0.	5	2.4113E-07	9	1.0881E-04	13	3.4468E-05	17	1.2778E-05
4	1	4.8827E-04	5	9.7704E-05	9	2.9718E-05	13	1.9765E-05	17	1.0703E-05
7	1	1.2103E-06	5	7.0626E-07	9	2.1913E-07	13	1.4801E-07	17	7.9611E-08
10	1	3.0000E-09	5	3.3021E-09	9	1.0223E-09	13	6.9212E-10	17	3.7128E-10
13	1	7.4363E-12	5	1.3135E-11	9	4.0238E-12	13	2.6800E-12	17	1.4191E-12

ANGULAR FLUXES F(I,J,K) (TRANSFORMED),FOLLOWED BY THEIR INDEX TRIPLES I(ANGULAR),J(SPATIAL),K(WAVELENGTH)

F	I	J	K	F	I	J	K	F	I	J	K
0.	1	1	1	0.	4	1	1	0.	7	1	1
0.	1	1	5	0.	4	1	5	0.	7	1	5
6.7855E-07	1	1	9	0.	4	1	9	0.	7	1	9
1.1172E-05	1	1	13	0.	4	1	13	0.	7	1	13
2.3979E-06	1	1	17	0.	4	1	17	0.	7	1	17
0.	1	4	1	0.	4	4	1	0.	7	4	1
0.	1	4	5	4.1646E-05	4	4	5	9.9972E-04	7	4	5
4.9294E-06	1	4	9	1.2809E-04	4	4	9	1.4438E-04	7	4	9
1.0791E-04	1	4	13	6.1629E-05	4	4	13	6.4400E-05	7	4	13
3.4699E-05	1	4	17	3.9510E-05	4	4	17	3.7410E-05	7	4	17
0.	1	7	1	0.	4	7	1	0.	7	7	1
0.	1	7	5	7.5477E-05	4	7	5	3.1582E-03	7	7	5
8.4925E-06	1	7	9	2.8984E-04	4	7	9	3.6578E-04	7	7	9
2.4362E-04	1	7	13	1.3762E-04	4	7	13	1.5299E-04	7	7	13
7.8055E-05	1	7	17	8.6855E-05	4	7	17	8.4194E-05	7	7	17
0.	1	10	1	0.	4	10	1	0.	7	10	1
0.	1	10	5	9.1353E-05	4	10	5	4.8176E-03	7	10	5
1.0538E-05	1	10	9	4.0602E-04	4	10	9	5.2826E-04	7	10	9
3.4544E-04	1	10	13	1.9206E-04	4	10	13	2.1728E-04	7	10	13
1.0926E-04	1	10	17	1.2068E-04	4	10	17	1.1760E-04	7	10	17
0.	1	13	1	0.	4	13	1	0.	7	13	1
0.	1	13	5	9.7600E-05	4	13	5	5.8982E-03	7	13	5
9.4517E-06	1	13	9	4.8036E-04	4	13	9	6.3520E-04	7	13	9
3.9127E-04	1	13	13	2.2533E-04	4	13	13	2.5842E-04	7	13	13
1.2049E-04	1	13	17	1.3937E-04	4	13	17	1.3684E-04	7	13	17

IE=SQARE ROOT ERROR INDEX
0

FIRST LINE OF EACH SUB-BLOCK VALUES WITHOUT,SECOND LINE WITH LOW-ENERGETIC CORRECTION
THIRD LINE OF EACH SUB-BLOCK CORRESPONDING BUILDUP FACTORS,LOW-ENERGETIC CORRECTION INCLUDED

ENERGY FLUX MEV/SQCM/SEC	DOSE RATE REM/HOUR	EN.-ABS.-RATE MEV/CUBCM/SEC	PARTICLE FLUX PHOT/SQCM/SEC	X IN CM	X IN MFP(EMAX)	X-INDEX J
3.5606E-05	6.7299E-11	9.5662E-06	1.1479E-04	0.	0.	1
3.6436E-05	6.8627E-11	1.0258E-05	1.2174E-04			
6.4180E-03	8.1889E-09	1.1319E-03	1.7277E-03	3.8618E-02	10.0000E-03	2
6.4193E-03	8.1909E-09	1.1330E-03	1.7387E-03			
1.0084E 00	1.0119E 00	1.0126E 00	1.0925E 00			
6.4180E-03	8.1889E-09	1.1319E-03	1.7277E-03	3.8618E-02	10.0000E-03	2
6.4193E-03	8.1909E-09	1.1330E-03	1.7387E-03			
1.0084E 00	1.0119E 00	1.0126E 00	1.0925E 00			
1.4921E-03	2.0778E-09	2.7301E-04	7.0797E-04	7.7429E 00	2.0050E 00	3
1.4961E-03	2.0841E-09	2.7688E-04	7.4780E-04			
1.7279E 00	1.8930E 00	1.8194E 00	3.4545E 00			
1.4921E-03	2.0778E-09	2.7301E-04	7.0797E-04	7.7429E 00	2.0050E 00	3
1.4961E-03	2.0841E-09	2.7688E-04	7.4780E-04			
1.7279E 00	1.8930E 00	1.8194E 00	3.4545E 00			
2.9285E-04	4.2326E-10	5.4510E-05	1.6760E-04	1.5467E 01	4.0050E 00	4
2.9401E-04	4.2506E-10	5.5614E-05	1.7895E-04			
2.5089E 00	2.8528E 00	2.7002E 00	6.1085E 00			
5.3104E-05	7.8434E-11	9.9897E-06	3.3604E-05	2.3190E 01	6.0050E 00	5
5.3353E-05	7.8823E-11	1.0228E-05	3.6055E-05			
3.3642E 00	3.9090E 00	3.6694E 00	9.0939E 00			
9.1738E-06	1.3747E-11	1.7385E-06	6.1882E-06	3.0914E 01	8.0050E 00	6
9.2216E-06	1.3821E-11	1.7842E-06	6.6585E-06			
4.2965E 00	5.0648E 00	4.7297E 00	1.2409E 01			
1.5333E-06	2.3216E-12	2.9214E-07	1.0814E-06	3.8637E 01	1.0005E 01	7
1.5419E-06	2.3350E-12	3.0034E-07	1.1657E-06			
5.3082E 00	6.3223E 00	5.8830E 00	1.6053E 01			
2.5022E-07	3.8183E-13	4.7874E-08	1.8237E-07	4.6361E 01	1.2005E 01	8
2.5169E-07	3.8413E-13	4.9282E-08	1.9684E-07			
6.4027E 00	7.6852E 00	7.1327E 00	2.0029E 01			
4.0106E-08	6.1573E-14	7.6986E-09	2.9974E-08	5.4085E 01	1.4005E 01	9
4.0352E-08	6.1956E-14	7.9331E-09	3.2385E-08			
7.5847E 00	9.1591E 00	8.4840E 00	2.4349E 01			
6.3399E-09	9.7804E-15	1.2202E-09	4.8328E-09	6.1808E 01	1.6005E 01	10
6.3799E-09	9.8427E-15	1.2584E-09	5.2253E-09			
8.8609E 00	1.0752E 01	9.9440E 00	2.9029E 01			
9.9137E-10	1.5353E-15	1.9121E-10	7.6775E-10	6.9532E 01	1.8005E 01	11
9.9777E-10	1.5453E-15	1.9732E-10	8.3056E-10			
1.0240E 01	1.2473E 01	1.1522E 01	3.4095E 01			
1.5369E-10	2.3878E-16	2.9694E-11	1.2054E-10	7.7255E 01	2.0005E 01	12
1.5469E-10	2.4035E-16	3.0658E-11	1.3044E-10			
1.1731E 01	1.4334E 01	1.3227E 01	3.9565E 01			

2.3635E-11	3.6810E-17	4.5695E-12	1.8641E-11	8.4979E 01	2.2005E 01	13
2.3786E-11	3.7046E-17	4.7134E-12	2.0118E-11			
1.3328E 01	1.6326E 01	1.5026E 01	4.5089E 01			
3.4654E-12	5.3639E-18	6.5406E-13	2.3189E-12	9.2703E 01	2.4005E 01	14
3.4680E-12	5.3680E-18	6.5613E-13	2.3397E-12			
1.4358E 01	1.7479E 01	1.5456E 01	3.8747E 01			

X IN CM RESPONSE INTEGRALS UNDER THEIR ID. NUMBERS IDR(MRE),1ST LINE WITHOUT,2ND WITH CUTOFF CORRECTION

X IN CM	415
0.	6.7975E-05
0.	6.9166E-05
3.8618E-02	8.1784E-03
3.8618E-02	8.1801E-03
7.7429E 00	2.0819E-03
7.7429E 00	2.0858E-03
1.5467E 01	4.2463E-04
1.5467E 01	4.2573E-04
2.3190E 01	7.8741E-05
2.3190E 01	7.8980E-05
3.0914E 01	1.3807E-05
3.0914E 01	1.3852E-05
3.8637E 01	2.3323E-06
3.8637E 01	2.3406E-06
4.6361E 01	3.8368E-07
4.6361E 01	3.8509E-07
5.4085E 01	6.1881E-08
5.4085E 01	6.2116E-08
6.1808E 01	9.8305E-09
6.1808E 01	9.8689E-09
6.9532E 01	1.5433E-09
6.9532E 01	1.5495E-09
7.7255E 01	2.4004E-10
7.7255E 01	2.4101E-10
8.4979E 01	3.7007E-11
8.4979E 01	3.7155E-11
9.2703E 01	5.3910E-12
9.2703E 01	5.3948E-12

PROBLEM DATA REPRODUCTION

RESPONSE FUNCTION NUMBER NRE (IF NOT POSITIVE,NO RESPONSE FUNCTIONS),KTRG=NUMBER OF THEIR WAVELENGTH MESH POINTS,
RESPONSE FUNCTION IDENTIFICATION NUMBERS IDR(MRE),FROM MRE=1 TO MRE=NRE
1 24 415

RESPONSE FUNCTION WAVELENGTH MESH AND VALUES

5.1100E-02	6.3870E-02	8.5160E-02	1.0220E-01	1.2770E-01	1.7030E-01	2.5550E-01	3.4060E-01
5.1100E-01	6.3870E-01	8.5160E-01	1.0220E 00	1.2770E 00	1.7030E 00	2.5550E 00	3.4060E 00
5.1100E 00	6.3870E 00	8.5160E 00	1.0220E 01	1.2770E 01	1.7030E 01	2.5550E 01	3.4060E 01

1.0200E 01	8.4800E 00	6.8400E 00	6.0000E 00	5.0800E 00	4.1700E 00	3.1200E 00	2.5400E 00
1.8400E 00	1.5200E 00	1.1700E 00	9.7500E-01	7.8000E-01	5.7000E-01	3.5400E-01	2.5800E-01
1.5300E-01	1.2400E-01	1.1350E-01	1.2400E-01	1.6200E-01	2.7400E-01	6.3200E-01	1.1700E 00

NPHYS=NUMBER OF PHYSICALLY DIFFERENT CASES
4

PHYSICAL INPUT REPRODUCTION

NGEOM=NUMBER OF DIFFERENT GEOMETRIES,NMG=NUMBER OF MATERIALS,CP=PAIR PRODUCTION CONSTANT (=0. ANNIHILATION PHOTONS NEGLECTED,=1.INCLUDED),INDOUT=OUTPUT INDEX (POSITIVE=REDUCED, 0 OR NEGATIVE=FULL OUTPUT)

1 4 0. -1

PARTIAL DENSITIES RHO(NM,NE) OF ELEMENT NE IN MATERIAL NM.NE,Z(NE),RHO(AIR,NE) NOT GIVEN IN PROBLEM DATA INPUT,BUT PRINTED HERE FOR BETTER EXPLANATION.

(NE	Z	RHO(AIR,NE))	RHO(1,NE)	RHO(2,NE)	RHO(3,NE)	RHO(4,NE)	RHO(5,NE)	RHO(6,NE)	RHO(7,NE)	RHO(8,NE)	RHO(9,NE)
1	1.	0.	-0.	-0.	-0.	1.120E-01					
2	4.	0.	-0.	-0.	-0.	-0.					
3	6.	0.	-0.	-0.	-0.	-0.					
4	7.	9.760E-04	-0.	-0.	-0.	-0.					
5	8.	3.000E-04	-0.	-0.	-0.	8.880E-01					
6	11.	0.	-0.	-0.	-0.	-0.					
7	12.	0.	-0.	-0.	-0.	-0.					
8	13.	0.	-0.	-0.	2.700E 00	-0.					
9	14.	0.	-0.	-0.	-0.	-0.					
10	15.	0.	-0.	-0.	-0.	-0.					
11	16.	0.	-0.	-0.	-0.	-0.					
12	18.	1.700E-05	-0.	-0.	-0.	-0.					
13	19.	0.	-0.	-0.	-0.	-0.					
14	20.	0.	-0.	-0.	-0.	-0.					
15	22.	0.	-0.	-0.	-0.	-0.					
16	25.	0.	-0.	-0.	-0.	-0.					
17	26.	0.	-0.	7.850E 00	-0.	-0.					
18	29.	0.	-0.	-0.	-0.	-0.					
19	30.	0.	-0.	-0.	-0.	-0.					
20	35.	0.	-0.	-0.	-0.	-0.					
21	42.	0.	-0.	-0.	-0.	-0.					
22	47.	0.	-0.	-0.	-0.	-0.					
23	50.	0.	-0.	-0.	-0.	-0.					
24	53.	0.	-0.	-0.	-0.	-0.					
25	56.	0.	-0.	-0.	-0.	-0.					
26	74.	0.	-0.	-0.	-0.	-0.					
27	78.	0.	-0.	-0.	-0.	-0.					
28	81.	0.	-0.	-0.	-0.	-0.					
29	82.	0.	1.130E 01	-0.	-0.	-0.					
30	92.	0.	-0.	-0.	-0.	-0.					

ANGULAR MESH,IG=NUMBER OF ANGULAR POINTS AND CM(I)=COSINE MESH VALUES,SMALLEST FIRST
8 -1.0000 -0.7500 -0.2000 0.1000 0.6500 0.8000 0.9200 1.0000

SOURCE ENERGIES EV(KV) IN MEV,HIGHEST FIRST
4.0000E 00

COUPLES OF WAVELENGTH STEPS DW(NDL) IN COMPTON UNITS AND LAST MESH INDICES KG(NDL),AT WHICH DW(NDL) IS USED

```
C.C600  3    C.1200  5    C.2400 17

GEOMETRY INPUT REPRODUCTION

KOE=PLAIN (NEG.) OR SPHERICAL (POS. OR O) GEOMETRY,JMDZ=UNIT LENGTH OPTION (POS.=R AND DZ(JS) ARE INTERPRETED IN CM, O
OR NEG. IN MFP(MAX.EN.)),I2INT=LINEAR (IF NEG.) OR QUASI-EXPONENTIAL INTERPOLATION AND INTEGRATION (1ST ORDER APPROXI-
MATION OF THE SQUARE ROOTS,IF I2INT=0 - 2ND ORDER,IF I2INT POS.)
   -1      0     -0

IOUTM=NUMBER OF MAIN OUTPUT REPRODUCTIONS,IPA,IPZ,IPD,JPA,JPZ,JPD,KPA,KPZ,KPD=OUTPUT MESHES IN ANGLE,SPACE AND WAVE-
LENGTH FOR SPECTRA AND ANGULAR FLUXES - IF IPA AND INDOUT NOT-POSITIVE,FULLEST POSSIBLE OUTPUT
    1      1      8      3      1     13      3      1     17      4

MST,M(1),M(2),...M(NS).MST=0 OR NEGATIVE=1ST LAYER OF 1ST MATERIAL,2ND LAYER OF 2ND MATERIAL ETC-MST POSITIVE=1ST LAYER
OF MATERIAL M(1),2ND LAYER OF MATERIAL M(2) ETC..IF MST NOT POSITIVE,M(1),M(2),.. NOT NEEDED IN INPUT,BUT REDEFINED BY
THE PROGRAM
    1      2      2      2

INITIAL RADIUS R AND SPATIAL INTEGRATION STEPS DZ(JS) IN EACH LAYER JS,OUTPUT IN CM
  -0.            3.8618E-02     7.7043E 00     7.7236E 00

SPATIAL INDICES JG(JS) OF THE LEFT BOUNDARIES OF THE LAYERS JS,JS=2,3,4 ETC..THE LAST JG BELONGS TO THE RIGHT BOUNDARY
OF THE LAST LAYER.THE PROGRAM PUTS JG(1)=1.THICKNESS OF LAYER JS=(JG(JS+1)-JG(JS))*DZ(JS) IN UNITS GIVEN BY JMDZ.
    2      3     14

EXPONENTIAL TRANSFORMATION PARAMETERS A(JS)
  -0.            9.5000E-01     9.5000E-01

IWV=ANGULAR SOURCE INDEX (IF 0,ISOTROPIC - IF POSITIVE,COLLIMATED IN DIRECTION OM(IG+1-IWV) -IF NEGATIVE,THE SOURCE
STRENGTH IS QOM(I) IN THE DIRECTION OM(I)),ANGULAR SOURCE STRENGTHS QOM(I),I=1,2,.. ,IG.(IF IWV IS NOT-NEGATIVE,THE
QOM(I) ARE NOT NEEDED IN INPUT,BUT REDEFINED BY THE PROGRAM)
    1     0.         0.         0.         0.         0.         0.         0.         1.0000

LAYER SOURCE INDEX JSQ (POSITIVE=SOURCES IN JSQTH LAYER,0=SOURCES IN CENTRAL SPHERE,NEGATIVE=SOURCES EVERYWHERE DES-
CRIBED BY LAST INPUT CARDS),LAYER SOURCE SPECTRUM QE(KV),IF JSQ NOT-NEGATIVE.(JSQ POSITIVE AND JMDZ=0 MEAN MULTIPLICA-
TION OF THE QE(KV) WITH SIGMATOTAL OF MAXIMUM SOURCE ENERGY.)
    1    12.0000


VOLUME SOURCES  INDEX KV,ASSIGNED WAVELENGTH INDEX K=KQ(KV),WAVELENGTH,ASSIGNED WAVELENGTH,ABSOLUTE DIFFERENCE
    2     10  1.0000E 00  9.4887E-01  5.1125E-02
```

IE=SQARE ROOT ERROR INDEX
0

FIRST LINE OF EACH SUB-BLOCK VALUES WITHOUT,SECOND LINE WITH LOW-ENERGETIC CORRECTION
THIRD LINE OF EACH SUB-BLOCK CORRESPONDING BUILDUP FACTORS,LOW-ENERGETIC CORRECTION INCLUDED

ENERGY FLUX MEV/SQCM/SEC	DOSE RATE REM/HOUR	EN.-ABS.-MATL MEV/CUBCM/SEC	PARTICLE FLUX PHOT/SQCM/SEC	X IN CM	X IN MFP(EMAX)	X-INDEX J
2.7726E 03	2.9659E-03	6.3637E 02	3.9967E 02	7.1000E 00	1.9011E 00	1
2.7746E 03	2.9696E-03	6.3842E 02	4.1268E 02			
1.0642E 00	1.0822E 00	1.0608E 00	1.2663E 00			
3.3778E 03	3.5989E-03	7.7652E 02	4.7130E 02	7.4700E 00	2.0001E 00	2
3.3797E 03	3.6022E-03	7.7836E 02	4.8288E 02			
1.0448E 00	1.0581E 00	1.0424E 00	1.1943E 00			
3.3778E 03	3.5989E-03	7.7652E 02	4.7130E 02	7.4700E 00	2.0001E 00	2
3.3797E 03	3.6022E-03	7.7836E 02	4.8288E 02			
1.0448E 00	1.0581E 00	1.0424E 00	1.1943E 00			
2.7026E 02	3.0130E-04	6.0786E 01	5.0790E 01	1.1205E 01	3.0002E 00	3
2.7053E 02	3.0179E-04	6.1026E 01	5.2177E 01			
1.2934E 00	1.3709E 00	1.2640E 00	1.9958E 00			
4.3716E 01	5.0802E-05	9.6514E 00	1.0290E 01	1.4940E 01	4.0003E 00	4
4.3779E 01	5.0916E-05	9.7066E 00	1.0605E 01			
1.5480E 00	1.7105E 00	1.4868E 00	2.9999E 00			
1.0926E 01	1.3044E-05	2.3800E 00	2.9124E 00	1.8675E 01	5.0003E 00	5
1.0947E 01	1.3080E-05	2.3977E 00	3.0136E 00			
1.8071E 00	2.0516E 00	1.7147E 00	3.9800E 00			
3.0660E 00	3.7588E-06	6.5860E-01	9.1266E-01	2.2410E 01	6.0004E 00	6
3.0730E 00	3.7714E-06	6.6480E-01	9.4845E-01			
2.1434E 00	2.4994E 00	2.0087E 00	5.2923E 00			
3.0660E 00	3.7588E-06	6.5860E-01	9.1266E-01	2.2410E 01	6.0004E 00	6
3.0730E 00	3.7714E-06	6.6480E-01	9.4845E-01			
2.1434E 00	2.4994E 00	2.0087E 00	5.2923E 00			
5.1837E-01	6.5799E-07	1.0939E-01	1.7652E-01	2.8010E 01	7.4998E 00	7
5.1990E-01	6.6074E-07	1.1076E-01	1.8450E-01			
2.7607E 00	3.3335E 00	2.5478E 00	7.8374E 00			
9.9109E-02	1.2938E-07	2.0599E-02	3.7211E-02	3.3610E 01	8.9992E 00	8
9.9456E-02	1.3001E-07	2.0913E-02	3.9046E-02			
3.5281E 00	4.3818E 00	3.2137E 00	1.1081E 01			
2.0442E-02	2.7305E-08	4.1956E-03	8.2724E-03	3.9210E 01	1.0499E 01	9
2.0523E-02	2.7450E-08	4.2689E-03	8.7039E-03			
4.4708E 00	5.6815E 00	4.0286E 00	1.5169E 01			
4.4321E-03	6.0337E-09	9.0018E-04	1.9043E-03	4.4810E 01	1.1998E 01	10
4.4514E-03	6.0682E-09	9.1775E-04	2.0079E-03			
5.6281E 00	7.2897E 00	5.0267E 00	2.0309E 01			
4.4321E-03	6.0337E-09	9.0018E-04	1.9043E-03	4.4810E 01	1.1998E 01	10
4.4514E-03	6.0682E-09	9.1775E-04	2.0079E-03			
5.6281E 00	7.2897E 00	5.0267E 00	2.0309E 01			
3.6463E-04	5.1005E-10	7.3081E-05	1.7074E-04	5.4150E 01	1.4499E 01	11
3.6644E-04	5.1329E-10	7.4734E-05	1.8051E-04			
8.2518E 00	1.0982E 01	7.2905E 00	3.2519E 01			

3.2077E-05 3.2251E-05 1.1850E 01	4.5773E-11 4.6084E-11 1.6088E 01	6.3634E-06 6.5223E-06 1.0382E 01	1.5932E-05 1.6872E-05 4.9594E 01	6.3490E 01	1.7000E 01	12
2.9465E-06 2.9635E-06 1.6682E 01	4.2683E-12 4.2987E-12 2.2992E 01	5.8000E-07 5.9555E-07 1.4523E 01	1.5278E-06 1.6199E-06 7.2951E 01	7.2830E 01	1.9501E 01	13
2.7861E-07 2.8028E-07 2.3073E 01	4.0834E-13 4.1132E-13 3.2172E 01	5.4513E-08 5.6041E-08 1.9985E 01	1.4924E-07 1.5828E-07 1.0424E 02	8.2170E 01	2.2001E 01	14
2.6611E-08 2.6645E-08 3.0963E 01	3.9238E-14 3.9300E-14 4.3392E 01	5.1228E-09 5.1498E-09 2.5925E 01	1.4084E-08 1.4231E-08 1.3230E 02	9.1510E 01	2.4502E 01	15

X IN CM	RESPONSE INTEGRALS UNDER THEIR ID. NUMBERS IDR(MRE),1ST LINE WITHOUT,2ND WITH CUTOFF CORRECTION
	415
7.1000E 00 7.1000E 00	2.9878E 03 2.9919E 03
7.4700E 00 7.4700E 00	3.6251E 03 3.6287E 03
1.1205E 01 1.1205E 01	3.0376E 02 3.0420E 02
1.4940E 01 1.4940E 01	5.1223E 01 5.1289E 01
1.8675E 01 1.8675E 01	1.3154E 01 1.3174E 01
2.2410E 01 2.2410E 01	3.7909E 00 3.8021E 00
2.8010E 01 2.8010E 01	6.6359E-01 6.6609E-01
3.3610E 01 3.3610E 01	1.3047E-01 1.3105E-01
3.9210E 01 3.9210E 01	2.7531E-02 2.7666E-02
4.4810E 01 4.4810E 01	6.0825E-03 6.1151E-03
5.4150E 01 5.4150E 01	5.1402E-04 5.1709E-04
6.3490E 01 6.3490E 01	4.6117E-05 4.6413E-05
7.2830E 01 7.2830E 01	4.2994E-06 4.3283E-06
8.2170E 01 8.2170E 01	4.1123E-07 4.1407E-07
9.1510E 01	3.9510E-08

9.1510E 01   3.9561E-08

PROBLEM DATA REPRODUCTION

RESPONSE FUNCTION NUMBER NRE (IF NOT POSITIVE,NO RESPONSE FUNCTIONS),KTRG=NUMBER OF THEIR WAVELENGTH MESH POINTS,
RESPONSE FUNCTION IDENTIFICATION NUMBERS IDR(MRE),FROM MRE=1 TO MRE=NRE
1   24   415

RESPONSE FUNCTION WAVELENGTH MESH AND VALUES

5.1100E-02	6.3870E-02	8.5160E-02	1.0220E-01	1.2770E-01	1.7030E-01	2.5550E-01	3.4060E-01
5.1100E-01	6.3870E-01	8.5160E-01	1.0220E 00	1.2770E 00	1.7030E 00	2.5550E 00	3.4060E 00
5.1100E 00	6.3870E 00	8.5160E 00	1.0220E 01	1.2770E 01	1.7030E 01	2.5550E 01	3.4060E 01
1.0200E 01	8.4800E 00	6.8400E 00	6.0000E 00	5.0800E 00	4.1700E 00	3.1200E 00	2.5400E 00
1.8400E 00	1.5200E 00	1.1700E 00	9.7500E-01	7.8000E-01	5.7000E-01	3.5400E-01	2.5800E-01
1.5300E-01	1.2400E-01	1.1350E-01	1.2400E-01	1.6200E-01	2.7400E-01	6.3200E-01	1.1700E 00

NPHYS=NUMBER OF PHYSICALLY DIFFERENT CASES
3

PHYSICAL INPUT REPRODUCTION

NGEOM=NUMBER OF DIFFERENT GEOMETRIES,NMG=NUMBER OF MATERIALS,CP=PAIR PRODUCTION CONSTANT (=0. ANNIHILATION PHOTONS NEG-
LECTED,=1.INCLUDED),INDOUT=OUTPUT INDEX (POSITIVE=REDUCED, 0 OR NEGATIVE=FULL OUTPUT)

1   1   0.   1

PARTIAL DENSITIES RHO(NM,NE) OF ELEMENT NE IN MATERIAL NM.NE,Z(NE),RHO(AIR,NE) NOT GIVEN IN PROBLEM DATA INPUT,BUT
PRINTED HERE FOR BETTER EXPLANATION.

(NE	Z	RHO(AIR,NE))	RHO(1,NE)	RHO(2,NE)	RHO(3,NE)	RHO(4,NE)	RHO(5,NE)	RHO(6,NE)	RHO(7,NE)	RHO(8,NE)	RHO(9,NE)
1	1.	0.	-0.								
2	4.	0.	-0.								
3	6.	0.	-0.								
4	7.	9.760E-04	-0.								
5	8.	3.000E-04	-0.								
6	11.	0.	-0.								
7	12.	0.	-0.								
8	13.	0.	-0.								
9	14.	0.	-0.								
10	15.	0.	-0.								
11	16.	0.	-0.								
12	18.	1.700E-05	-0.								
13	19.	0.	-0.								
14	20.	0.	-0.								
15	22.	0.	-0.								
16	25.	0.	-0.								
17	26.	0.	-0.								
18	29.	0.	-0.								
19	30.	0.	-0.								
20	35.	0.	-0.								
21	42.	0.	-0.								
22	47.	0.	-0.								
23	50.	0.	7.300E 00								
24	53.	0.	-0.								
25	56.	0.	-0.								

```
26   74.  0.          -0.
27   78.  0.          -0.
28   81.  0.          -0.
29   82.  0.          -0.
30   92.  0.          -0.

ANGULAR MESH,IG=NUMBER OF ANGULAR POINTS AND OM(I)=COSINE MESH VALUES,SMALLEST FIRST
     9   -1.0000    -0.4000     0.3200     0.7500     0.9000     0.9500     0.9800     0.9930     1.0000

SOURCE ENERGIES EV(KV) IN MEV,HIGHEST FIRST
   8.0000E 00

COUPLES OF WAVELENGTH STEPS DW(NDL) IN COMPTON UNITS AND LAST MESH INDICES KG(NDL),AT WHICH DW(NDL) IS USED
  0.0200  4   0.0600  6   0.1200  8   0.3100 12

   GEOMETRY INPUT REPRODUCTION

KOE=PLAIN (NEG.) OR SPHERICAL (POS. OR 0) GEOMETRY,JMDZ=UNIT LENGTH OPTION (POS.=R AND DZ(JS) ARE INTERPRETED IN CM, 0
OR NEG. IN MFP(MAX.EN.)),I2INT=LINEAR (IF NEG.) OR QUASI-EXPONENTIAL INTERPOLATION AND INTEGRATION (1ST ORDER APPROXI-
MATION OF THE SQUARE ROOTS,IF I2INT=0 - 2ND ORDER,IF I2INT POS.)
    1     1     1

IOUTM=NUMBER OF MAIN OUTPUT REPRODUCTIONS,IPA,IPZ,IPD,JPA,JPZ,JPD,KPA,KPZ,KPD=OUTPUT MESHES IN ANGLE,SPACE AND WAVE-
LENGTH FOR SPECTRA AND ANGULAR FLUXES - IF IPA AND INDOUT NOT-POSITIVE,FULLEST POSSIBLE OUTPUT
    1     1     9     1     1    15     1     1    12     1

MST,M(1),M(2),...M(NS).MST=0 OR NEGATIVE=1ST LAYER OF 1ST MATERIAL,2ND LAYER OF 2ND MATERIAL ETC-MST POSITIVE=1ST LAYER
OF MATERIAL M(1),2ND LAYER OF MATERIAL M(2) ETC..IF MST NOT POSITIVE,M(1),M(2),.. NOT NEEDED IN INPUT,BUT REDEFINED BY
THE PROGRAM
    1     1     1     1     1

INITIAL RADIUS R AND SPATIAL INTEGRATION STEPS DZ(JS) IN EACH LAYER JS,OUTPUT IN CM
   7.1000E 00    3.7000E-01    3.7350E 00    5.6000E 00    9.3400E 00

SPATIAL INDICES JG(JS) OF THE LEFT BOUNDARIES OF THE LAYERS JS,JS=2,3,4 ETC..THE LAST JG BELONGS TO THE RIGHT BOUNDARY
OF THE LAST LAYER.THE PROGRAM PUTS JG(1)=1.THICKNESS OF LAYER JS=(JG(JS+1)-JG(JS))*DZ(JS) IN UNITS GIVEN BY JMDZ.
    2     6    10    15

EXPONENTIAL TRANSFORMATION PARAMETERS A(JS)
  -0.            8.0000E-01    8.0000E-01    8.0000E-01

IWV=ANGULAR SOURCE INDEX (IF 0,ISOTROPIC - IF POSITIVE,COLLIMATED IN DIRECTION OM(IG+1-IWV) -IF NEGATIVE,THE SOURCE
STRENGTH IS QOM(I) IN THE DIRECTION OM(I)),ANGULAR SOURCE STRENGTHS QOM(I),I=1,2,.. ,IG.(IF IWV IS NOT-NEGATIVE,THE
QOM(I) ARE NOT NEEDED IN INPUT,BUT REDEFINED BY THE PROGRAM)
    0     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000

LAYER SOURCE INDEX JSQ (POSITIVE=SOURCES IN JSQTH LAYER,0=SOURCES IN CENTRAL SPHERE,NEGATIVE=SOURCES EVERYWHERE DES-
CRIBED BY LAST INPUT CARDS),LAYER SOURCE SPECTRUM QE(KV),IF JSQ NOT-NEGATIVE.(JSQ POSITIVE AND JMDZ=0 MEAN MULTIPLICA-
TION OF THE QE(KV) WITH SIGMATOTAL OF MAXIMUM SOURCE ENERGY.)
    1 1000.0000


VOLUME SOURCES  INDEX KV,ASSIGNED WAVELENGTH INDEX K=KQ(KV),WAVELENGTH,ASSIGNED WAVELENGTH,ABSOLUTE DIFFERENCE
    2     5  1.0000E 00  1.0360E 00  3.6000E-02
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IE=SQARE ROOT ERROR INDEX
0

FIRST LINE OF EACH SUB-BLOCK VALUES WITHOUT,SECOND LINE WITH LOW-ENERGETIC CORRECTION
THIRD LINE OF EACH SUB-BLOCK CORRESPONDING BUILDUP FACTORS,LOW-ENERGETIC CORRECTION INCLUDED

ENERGY FLUX MEV/SQCM/SEC	DOSE RATE REM/HOUR	EN.-ABS.-RATE MEV/CUBCM/SEC	PARTICLE FLUX PHOT/SQCM/SEC	X IN CM	X IN MFP(EMAX)	X-INDEX J
2.5028E-02	4.3795E-08	7.3545E-04	1.4992E-01	0.	0.	1
2.5905E-02	4.6194E-08	7.7239E-04	1.7291E-01			
7.7798E-01	1.4332E-06	2.4195E-02	9.8628E-01	2.8349E-02	2.0000E-03	2
7.7908E-01	1.4362E-06	2.4241E-02	1.0149E 00			
1.0802E 00	1.0800E 00	1.0795E 00	1.4072E 00			
7.7798E-01	1.4332E-06	2.4195E-02	9.8628E-01	2.8349E-02	2.0000E-03	2
7.7908E-01	1.4362E-06	2.4241E-02	1.0149E 00			
1.0802E 00	1.0800E 00	1.0795E 00	1.4072E 00			
4.6111E-01	8.5302E-07	1.4386E-02	8.9457E-01	1.4203E 01	1.0020E 00	3
4.6539E-01	8.6514E-07	1.4572E-02	1.0150E 00			
1.8006E 00	1.8153E 00	1.6109E 00	3.9271E 00			
2.3511E-01	4.3572E-07	7.3456E-03	5.3018E-01	2.8377E 01	2.0020E 00	4
2.3786E-01	4.4342E-07	7.4640E-03	6.0570E-01			
2.5674E 00	2.5957E 00	2.5878E 00	6.5378E 00			
9.8332E-02	1.8413E-07	3.1071E-03	1.8069E-01	4.2551E 01	3.0020E 00	5
9.8605E-02	1.8484E-07	3.1181E-03	1.8729E-01			
2.9686E 00	3.0181E 00	3.0153E 00	5.6386E 00			
9.8332E-02	1.8413E-07	2.3643E-01	1.8069E-01	4.2551E 01	3.0020E 00	5
9.8605E-02	1.8484E-07	2.6318E-01	1.8729E-01			
2.9686E 00	3.0181E 00	1.7441E 01	5.6386E 00			
2.8859E-02	5.4206E-08	1.8674E-02	3.6351E-02	4.3846E 01	4.0020E 00	6
2.8859E-02	5.4206E-08	1.8675E-02	3.6351E-02			
2.4228E 00	2.4681E 00	3.4511E 00	3.0518E 00			
1.0539E-02	1.9788E-08	6.6259E-03	1.3087E-02	4.5141E 01	5.0020E 00	7
1.0539E-02	1.9788E-08	6.6259E-03	1.3087E-02			
2.4668E 00	2.5118E 00	3.4137E 00	3.0631E 00			
3.9075E-03	7.3375E-09	2.4471E-03	4.8451E-03	4.6436E 01	6.0020E 00	8
3.9075E-03	7.3375E-09	2.4471E-03	4.8451E-03			
2.5492E 00	2.5961E 00	3.5141E 00	3.1609E 00			
1.4303E-03	2.6861E-09	8.3945E-04	1.7373E-03	4.7731E 01	7.0020E 00	9
1.4303E-03	2.6861E-09	8.3945E-04	1.7373E-03			
2.6002E 00	2.6483E 00	3.3592E 00	3.1583E 00			

X IN CM	RESPONSE INTEGRALS UNDER THEIR ID. NUMBERS IDR(MRE),1ST LINE WITHOUT,2ND WITH CUTOFF CORRECTION
	415
0.	4.4552E-02
0.	4.7209E-02
2.8349E-02	1.4319E 00
2.8349E-02	1.4352E 00
1.4203E 01	8.5472E-01

1.4203E 01	8.6869E-01
2.8377E 01	4.3722E-01
2.8377E 01	4.4596E-01
4.2551E 01	1.8469E-01
4.2551E 01	1.8545E-01
4.3846E 01	5.4267E-02
4.3846E 01	5.4267E-02
4.5141E 01	1.9809E-02
4.5141E 01	1.9809E-02
4.6436E 01	7.3456E-03
4.6436E 01	7.3456E-03
4.7731E 01	2.6888E-03
4.7731E 01	2.6888E-03

PROBLEM DATA REPRODUCTION

RESPONSE FUNCTION NUMBER NRE (IF NOT POSITIVE,NO RESPONSE FUNCTIONS),KTRG=NUMBER OF THEIR WAVELENGTH MESH POINTS,
RESPONSE FUNCTION IDENTIFICATION NUMBERS IDR(MRE),FROM MRE=1 TO MRE=NRE
1 24 415

RESPONSE FUNCTION WAVELENGTH MESH AND VALUES

5.1100E-02	6.3870E-02	8.5160E-02	1.0220E-01	1.2770E-01	1.7030E-01	2.5550E-01	3.4060E-01
5.1100E-01	6.3870E-01	8.5160E-01	1.0220E 00	1.2770E 00	1.7030E 00	2.5550E 00	3.4060E 00
5.1100E 00	6.3870E 00	8.5160F 00	1.0220E 01	1.2770E 01	1.7030E 01	2.5550E 01	3.4060E 01
1.0200E 01	8.4800E 00	6.8400E 00	6.0000E 00	5.0800E 00	4.1700E 00	3.1200E 00	2.5400E 00
1.8400E 00	1.5200E 00	1.1700E 00	9.7500E-01	7.8000E-01	5.7000E-01	3.5400E-01	2.5800E-01
1.5300E-01	1.2400E-01	1.1350E-01	1.2400E-01	1.6200E-01	2.7400E-01	6.3200E-01	1.1700E 00

NPHYS=NUMBER OF PHYSICALLY DIFFERENT CASES
2

PHYSICAL INPUT REPRODUCTION

NGEOM=NUMBER OF DIFFERENT GEOMETRIES,NMG=NUMBER OF MATERIALS,CP=PAIR PRODUCTION CONSTANT (=0. ANNIHILATION PHOTONS NEG-
LECTED,=1.INCLUDED),INDOUT=OUTPUT INDEX (POSITIVE=REDUCED, 0 OR NEGATIVE=FULL OUTPUT)

1 3 0. 1

PARTIAL DENSITIES RHO(NM,NE) OF ELEMENT NE IN MATERIAL NM.NE,Z(NE),RHO(AIR,NE) NOT GIVEN IN PROBLEM DATA INPUT,BUT
PRINTED HERE FOR BETTER EXPLANATION.

(NE	Z	RHO(AIR,NE))	RHO(1,NE)	RHO(2,NE)	RHO(3,NE)	RHO(4,NE)	RHO(5,NE)	RHO(6,NE)	RHO(7,NE)	RHO(8,NE)	RHO(9,NE)
1	1.	0.	-0.	-0.	1.120E-01						
2	4.	0.	-0.	-0.	-0.						
3	6.	0.	-0.	-0.	-0.						
4	7.	9.760E-04	-0.	-0.	-0.						
5	8.	3.000E-04	-0.	-0.	8.880E-01						
6	11.	0.	-0.	-0.	-0.						
7	12.	0.	-0.	-0.	-0.						

8	13.	0.	-0.	-0.	-0.
9	14.	0.	-0.	-0.	-0.
10	15.	0.	-0.	-0.	-0.
11	16.	0.	-0.	-0.	-0.
12	18.	1.700E-05	-0.	-0.	-0.
13	19.	0.	-0.	-0.	-0.
14	20.	0.	-0.	-0.	-0.
15	22.	0.	-0.	-0.	-0.
16	25.	0.	-0.	-0.	-0.
17	26.	0.	-0.	7.850E 00	-0.
18	29.	0.	-0.	-0.	-0.
19	30.	0.	-0.	-0.	-0.
20	35.	0.	-0.	-0.	-0.
21	42.	0.	-0.	-0.	-0.
22	47.	0.	-0.	-0.	-0.
23	50.	0.	-0.	-0.	-0.
24	53.	0.	-0.	-0.	-0.
25	56.	0.	-0.	-0.	-0.
26	74.	0.	-0.	-0.	-0.
27	78.	0.	-0.	-0.	-0.
28	81.	0.	-0.	-0.	-0.
29	82.	0.	1.130E 01	-0.	-0.
30	92.	0.	-0.	-0.	-0.

ANGULAR MESH,IG=NUMBER OF ANGULAR POINTS AND OM(I)=COSINE MESH VALUES,SMALLEST FIRST
8 -1.0000 -0.6500 -0. 0.5000 0.8000 0.9490 0.9510 1.0000

SOURCE ENERGIES EV(KV) IN MEV,HIGHEST FIRST
1.0000E 00

COUPLES OF WAVELENGTH STEPS DW(NDL) IN COMPTON UNITS AND LAST MESH INDICES KG(NDL),AT WHICH DW(NDL) IS USED
0.1500 5 0.2000 12 0.2667 35

GEOMETRY INPUT REPRODUCTION

KOE=PLAIN (NEG.) OR SPHERICAL (POS. OR 0) GEOMETRY,JMDZ=UNIT LENGTH OPTION (POS.=R AND DZ(JS) ARE INTERPRETED IN CM, 0 OR NEG. IN MFP(MAX.EN.)),I2INT=LINEAR (IF NEG.) OR QUASI-EXPONENTIAL INTERPOLATION AND INTEGRATION (1ST ORDER APPROXI-MATION OF THE SQUARE ROOTS,IF I2INT=0 - 2ND ORDER,IF I2INT POS.)
-4 -4 -0

IOUTM=NUMBER OF MAIN OUTPUT REPRODUCTIONS,IPA,IPZ,IPD,JPA,JPZ,JPD,KPA,KPZ,KPD=OUTPUT MESHES IN ANGLE,SPACE AND WAVE-LENGTH FOR SPECTRA AND ANGULAR FLUXES - IF IPA AND INDOUT NOT-POSITIVE,FULLEST POSSIBLE OUTPUT
1 1 8 1 1 9 1 1 35 1

MST,M(1),M(2),...M(NS).MST=0 OR NEGATIVE=1ST LAYER OF 1ST MATERIAL,2ND LAYER OF 2ND MATERIAL ETC-MST POSITIVE=1ST LAYER OF MATERIAL M(1),2ND LAYER OF MATERIAL M(2) ETC..IF MST NOT POSITIVE,M(1),M(2),.. NOT NEEDED IN INPUT,BUT REDEFINED BY THE PROGRAM
1 3 3 1

INITIAL RADIUS R AND SPATIAL INTEGRATION STEPS DZ(JS) IN EACH LAYER JS,OUTPUT IN CM
-0. 2.8349E-02 1.4174E 01 1.2949E 00

SPATIAL INDICES JG(JS) OF THE LEFT BOUNDARIES OF THE LAYERS JS,JS=2,3,4 ETC..THE LAST JG BELONGS TO THE RIGHT BOUNDARY OF THE LAST LAYER.THE PROGRAM PUTS JG(1)=1.THICKNESS OF LAYER JS=(JG(JS+1)-JG(JS))*DZ(JS) IN UNITS GIVEN BY JMDZ.
2 5 9

EXPONENTIAL TRANSFORMATION PARAMETERS A(JS)
-0. 9.0000E-01 9.0000E-01

IWV=ANGULAR SOURCE INDEX (IF 0,ISOTROPIC - IF POSITIVE,COLLIMATED IN DIRECTION OM(IG+1-IWV) -IF NEGATIVE,THE SOURCE STRENGTH IS QOM(I) IN THE DIRECTION OM(I)),ANGULAR SOURCE STRENGTHS QOM(I),I=1,2,.. ,IG.(IF IWV IS NOT-NEGATIVE,THE QOM(I) ARE NOT NEEDED IN INPUT,BUT REDEFINED BY THE PROGRAM)
-1 -0. -0. -0. -0. -0. -0. 1.0000 1.0000

LAYER SOURCE INDEX JSQ (POSITIVE=SOURCES IN JSQTH LAYER,0=SOURCES IN CENTRAL SPHERE,NEGATIVE=SOURCES EVERYWHERE DES-

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CRIBED BY LAST INPUT CARDS),LAYER SOURCE SPECTRUM QE(KV),IF JSQ NOT-NEGATIVE.(JSQ POSITIVE AND JMDZ=0 MEAN MULTIPLICA-
TION OF THE QE(KV) WITH SIGMATOTAL OF MAXIMUM SOURCE ENERGY.)
    1 1000.0000



VOLUME SOURCES  INDEX KV,ASSIGNED WAVELENGTH INDEX K=KQ(KV),WAVELENGTH,ASSIGNED WAVELENGTH,ABSOLUTE DIFFERENCE
     2       2  8.5167E-02  8.7133E-02  1.9667E-03
     3       3  1.2775E-01  1.2513E-01  2.6167E-03
     4       5  2.2217E-01  2.1913E-01  3.0406E-03
     5      10  1.0000E 00  9.9413E-01  5.8667E-03
```

IE=SQARE ROOT ERROR INDEX
0

FIRST LINE OF EACH SUB-BLOCK VALUES WITHOUT,SECOND LINE WITH LOW-ENERGETIC CORRECTION

ENERGY FLUX MEV/SQCM/SEC	DOSE RATE REM/HOUR	EN.-ABS.-RATE MEV/CUBCM/SEC	PARTICLE FLUX PHOT/SQCM/SEC	X IN CM	X IN MFP(EMAX)	X-INDEX J
4.5613E 11	5.0750E 05	2.0310E 11	7.9994E 10	1.0000E 02	5.1314E 01	1
4.5613E 11	5.0750E 05	2.0310E 11	7.9994E 10			
9.7641E 11	1.0970E 06	4.3640E 11	1.8366E 11	1.0250E 02	5.2597E 01	2
9.7641E 11	1.0970E 06	4.3640E 11	1.8366E 11			
1.3298E 12	1.5443E 06	5.8716E 11	2.9460E 11	1.0500E 02	5.3879E 01	3
1.3298E 12	1.5443E 06	5.8716E 11	2.9460E 11			
2.6468E 12	3.1895E 06	1.1511E 12	6.8689E 11	1.0750E 02	5.5162E 01	4
2.6468E 12	3.1895E 06	1.1511E 12	6.8689E 11			
1.4590E 13	1.7162E 07	6.9267E 12	3.6286E 12	1.1000E 02	5.6445E 01	5
1.4590E 13	1.7162E 07	6.9269E 12	3.6287E 12			
1.4590E 13	1.7162E 07	2.6961E 12	3.6286E 12	1.1000E 02	5.6445E 01	5
1.4590E 13	1.7162E 07	2.6961E 12	3.6287E 12			
1.8114E 13	2.1394E 07	3.3718E 12	4.9601E 12	1.1125E 02	5.6736E 01	6
1.8114E 13	2.1394E 07	3.3721E 12	4.9611E 12			
1.4474E 13	1.7487E 07	2.7173E 12	4.6959E 12	1.1250E 02	5.7027E 01	7
1.4474E 13	1.7488E 07	2.7178E 12	4.6972E 12			
1.3437E 13	1.6537E 07	2.5384E 12	4.8819E 12	1.1375E 02	5.7319E 01	8
1.3437E 13	1.6537E 07	2.5390E 12	4.8836E 12			
1.5626E 13	1.9348E 07	2.9547E 12	5.8065E 12	1.1500E 02	5.7610E 01	9
1.5627E 13	1.9348E 07	2.9555E 12	5.8085E 12			
2.0642E 13	2.5602E 07	3.6990E 12	7.5601E 12	1.1625E 02	5.7901E 01	10
2.0642E 13	2.5602E 07	3.9006E 12	7.5644E 12			
2.1411E 13	2.7834E 07	4.1833E 12	9.9217E 12	1.1750E 02	5.8192E 01	11
2.1427E 13	2.7864E 07	4.3132E 12	1.0239E 13			
2.1411E 13	2.7834E 07	4.6105E 11	9.9217E 12	1.1750E 02	5.8192E 01	11
2.1427E 13	2.7864E 07	4.6152E 11	1.0239E 13			
1.5505E 13	2.2742E 07	3.8055E 11	1.1598E 13	1.3750E 02	5.8679E 01	12
1.5599E 13	2.2931E 07	3.8350E 11	1.4315E 13			
6.3833E 12	9.5760E 06	1.6038E 11	6.0625E 12	1.5750E 02	5.9166E 01	13
6.4614E 12	9.7356E 06	1.6286E 11	8.6573E 12			
3.7298E 12	5.6800E 06	9.5244E 10	3.5817E 12	1.7750E 02	5.9653E 01	14
3.7764E 12	5.7759E 06	9.6737E 10	5.1988E 12			
1.4161E 12	2.1612E 06	3.6218E 10	1.5326E 12	1.9750E 02	6.0140E 01	15
1.4400E 12	2.2108E 06	3.6989E 10	2.4160E 12			
5.3912E 11	8.1810E 05	1.3695E 10	6.2167E 11	2.1750E 02	6.0627E 01	16
5.5016E 11	8.4120E 05	1.4053E 10	1.0581E 12			
2.1800E 11	3.2618E 05	5.4517E 09	2.5179E 11	2.3750E 02	6.1114E 01	17
2.2277E 11	3.3621E 05	5.6072E 09	4.4938E 11			

9.4076E 10 9.6076E 10	1.3789E 05 1.4211E 05	2.3003E 09 2.3657E 09	1.0371E 11 1.8845E 11	2.5750E 02	6.1601E 01	18
4.3073E 10 4.3911E 10	6.1614E 04 6.3380E 04	1.0258E 09 1.0532E 09	4.3841E 10 7.9442E 10	2.7750E 02	6.2088E 01	19
2.0775E 10 2.1130E 10	2.8974E 04 2.9723E 04	4.8137E 08 4.9298E 08	1.9133E 10 3.4143E 10	2.9750E 02	6.2575E 01	20
1.0477E 10 1.0631E 10	1.4267E 04 1.4592E 04	2.3655E 08 2.4159E 08	8.6577E 09 1.5106E 10	3.1750E 02	6.3062E 01	21
5.4841E 09 5.5534E 09	7.3130E 03 7.4586E 03	1.2103E 08 1.2329E 08	4.0725E 09 6.9221E 09	3.3750E 02	6.3549E 01	22
2.9589E 09 2.9911E 09	3.8779E 03 3.9454E 03	6.4084E 07 6.5131E 07	1.9921E 09 3.2953E 09	3.5750E 02	6.4036E 01	23
1.6354E 09 1.6509E 09	2.1141E 03 2.1466E 03	3.4893E 07 3.5397E 07	1.0113E 09 1.6287E 09	3.7750E 02	6.4523E 01	24
9.2098E 08 9.2866E 08	1.1782E 03 1.1942E 03	1.9428E 07 1.9676E 07	5.3049E 08 8.2907E 08	3.9750E 02	6.5010E 01	25
5.2609E 08 5.2982E 08	6.6773E 02 6.7548E 02	1.1002E 07 1.1122E 07	2.8443E 08 4.2199E 08	4.1750E 02	6.5497E 01	26
3.0302E 08 3.0450E 08	3.8198E 02 3.8501E 02	6.2899E 06 6.3370E 06	1.4934E 08 1.9733E 08	4.3750E 02	6.5984E 01	27
1.7204E 08 1.7214E 08	2.1359E 02 2.1380E 02	3.5130E 06 3.5162E 06	5.8005E 07 6.0578E 07	4.5750E 02	6.6471E 01	28

X IN CM RESPONSE INTEGRALS UNDER THEIR ID. NUMBERS IDR(MRE),1ST LINE WITHOUT,2ND WITH CUTOFF CORRECTION

X IN CM	415
1.0000E 02 1.0000E 02	5.1522E 11 5.1522E 11
1.0250E 02 1.0250E 02	1.1133E 12 1.1133E 12
1.0500E 02 1.0500E 02	1.5653E 12 1.5653E 12
1.0750E 02 1.0750E 02	3.2282E 12 3.2282E 12
1.1000E 02 1.1000E 02	1.7381E 13 1.7381E 13
1.1125E 02 1.1125E 02	2.1668E 13 2.1668E 13
1.1250E 02 1.1250E 02	1.7702E 13 1.7703E 13
1.1375E 02 1.1375E 02	1.6733E 13 1.6734E 13
1.1500E 02 1.1500E 02	1.9575E 13 1.9576E 13

1.1625E 02	2.5901E 13
1.1625E 02	2.5902E 13
1.1750E 02	2.8129E 13
1.1750E 02	2.8158E 13
1.3750E 02	2.2926E 13
1.3750E 02	2.3079E 13
1.5750E 02	9.6534E 12
1.5750E 02	9.7508E 12
1.7750E 02	5.7239E 12
1.7750E 02	5.8196E 12
1.9750E 02	2.1786E 12
1.9750E 02	2.2309E 12
2.1750E 02	8.2502E 11
2.1750E 02	8.5085E 11
2.3750E 02	3.2908E 11
2.3750E 02	3.4077E 11
2.5750E 02	1.3918E 11
2.5750E 02	1.4419E 11
2.7750E 02	6.2220E 10
2.7750E 02	6.4326E 10
2.9750E 02	2.9273E 10
2.9750E 02	3.0161E 10
3.1750E 02	1.4420E 10
3.1750E 02	1.4802E 10
3.3750E 02	7.3945E 09
3.3750E 02	7.5631E 09
3.5750E 02	3.9224E 09
3.5750E 02	3.9995E 09
3.7750E 02	2.1389E 09
3.7750E 02	2.1755E 09
3.9750E 02	1.1923E 09
3.9750E 02	1.2100E 09
4.1750E 02	6.7582E 08
4.1750E 02	6.8396E 08
4.3750E 02	3.8665E 08
4.3750E 02	3.8864E 08
4.5750E 02	2.1622E 08
4.5750E 02	2.1640E 08

PROBLEM DATA REPRODUCTION

RESPONSE FUNCTION NUMBER NRE (IF NOT POSITIVE,NO RESPONSE FUNCTIONS),KTRG=NUMBER OF THEIR WAVELENGTH MESH POINTS,
RESPONSE FUNCTION IDENTIFICATION NUMBERS IDR(MRE),FROM MRE=1 TO MRE=NRE

1 24 415

RESPONSE FUNCTION WAVELENGTH MESH AND VALUES

5.1100E-02	6.3870E-02	8.5160E-02	1.0220E-01	1.2770E-01	1.7030E-01	2.5550E-01	3.4060E-01
5.1100E-01	6.3870E-01	8.5160E-01	1.0220E 00	1.2770E 00	1.7030E 00	2.5550E 00	3.4060E 00
5.1100E 00	6.3870E 00	8.5160E 00	1.0220E 01	1.2770E 01	1.7030E 01	2.5550E 01	3.4060E 01
1.0200E 01	8.4800E 00	6.8400E 00	6.0000E 00	5.0800E 00	4.1700E 00	3.1200E 00	2.5400E 00
1.8400E 00	1.5200E 00	1.1700E 00	9.7500E-01	7.8000E-01	5.7000E-01	3.5400E-01	2.5800E-01
1.5300E-01	1.2400E-01	1.1350E-01	1.2400E-01	1.6200E-01	2.7400E-01	6.3200E-01	1.1700E 00

NPHYS=NUMBER OF PHYSICALLY DIFFERENT CASES
1

PHYSICAL INPUT REPRODUCTION

NGEOM=NUMBER OF DIFFERENT GEOMETRIES,NMG=NUMBER OF MATERIALS,CP=PAIR PRODUCTION CONSTANT (=0. ANNIHILATION PHOTONS NEGLECTED,=1.INCLUDED),INDOUT=OUTPUT INDEX (POSITIVE=REDUCED, 0 OR NEGATIVE=FULL OUTPUT)

1 3 0. 20

PARTIAL DENSITIES RHO(NM,NE) OF ELEMENT NE IN MATERIAL NM.NE,Z(NE),RHO(AIR,NE) NOT GIVEN IN PROBLEM DATA INPUT,BUT
PRINTED HERE FOR BETTER EXPLANATION.

(NE	Z	RHO(AIR,NE))	RHO(1,NE)	RHO(2,NE)	RHO(3,NE)	RHO(4,NE)	RHO(5,NE)	RHO(6,NE)	RHO(7,NE)	RHO(8,NE)	RHO(9,NE)
1	1.	0.	-0.	-0.	1.120E-01						
2	4.	0.	-0.	-0.	-0.						
3	6.	0.	-0.	-0.	-0.						
4	7.	9.760E-04	-0.	-0.	-0.						
5	8.	3.000E-04	-0.	-0.	8.880E-01						
6	11.	0.	-0.	-0.	-0.						
7	12.	0.	-0.	-0.	-0.						
8	13.	0.	-0.	-0.	-0.						
9	14.	0.	-0.	-0.	-0.						
10	15.	0.	-0.	-0.	-0.						
11	16.	0.	-0.	-0.	-0.						
12	18.	1.700E-05	-0.	-0.	-0.						
13	19.	0.	-0.	-0.	-0.						
14	20.	0.	-0.	-0.	-0.						
15	22.	0.	-0.	-0.	-0.						
16	25.	0.	-0.	-0.	-0.						
17	26.	0.	-0.	7.850E 00	-0.						
18	29.	0.	-0.	-0.	-0.						
19	30.	0.	-0.	-0.	-0.						
20	35.	0.	-0.	-0.	-0.						
21	42.	0.	-0.	-0.	-0.						
22	47.	0.	-0.	-0.	-0.						
23	50.	0.	-0.	-0.	-0.						
24	53.	0.	-0.	-0.	-0.						
25	56.	0.	-0.	-0.	-0.						
26	74.	0.	-0.	-0.	-0.						
27	78.	0.	-0.	-0.	-0.						
28	81.	0.	-0.	-0.	-0.						
29	82.	0.	1.130E 01	-0.	-0.						
30	92.	0.	-0.	-0.	-0.						

ANGULAR MESH,IG=NUMBER OF ANGULAR POINTS AND OM(I)=COSINE MESH VALUES,SMALLEST FIRST
9 -1.0000 -0.7000 -0.2000 0.2000 0.6000 0.8000 0.9300 0.9800 1.0000

SOURCE ENERGIES EV(KV) IN MEV,HIGHEST FIRST

```
   7.5000E 00     6.0000E 00     4.0000E 00     2.3000E 00

COUPLES OF WAVELENGTH STEPS DW(NDL) IN COMPTON UNITS AND LAST MESH INDICES KG(NDL),AT WHICH DW(NDL) IS USED
  0.0380  3   0.0500  5   0.1000  7   0.2000  9   0.3000 30

   GEOMETRY INPUT REPRODUCTION

KOE=PLAIN (NEG.) OR SPHERICAL (POS. OR 0) GEOMETRY,JMDZ=UNIT LENGTH OPTION (POS.=R AND DZ(JS) ARE INTERPRETED IN CM, 0
OR NEG. IN MFP(MAX.EN.)),I2INT=LINEAR (IF NEG.) OR QUASI-EXPONENTIAL INTERPOLATION AND INTEGRATION (1ST ORDER APPROXI-
MATION OF THE SQUARE ROOTS,IF I2INT=0 - 2ND ORDER,IF I2INT POS.)
    0     1    -0

IOUTM=NUMBER OF MAIN OUTPUT REPRODUCTIONS,IPA,IPZ,IPD,JPA,JPZ,JPD,KPA,KPZ,KPD=OUTPUT MESHES IN ANGLE,SPACE AND WAVE-
LENGTH FOR SPECTRA AND ANGULAR FLUXES - IF IPA AND INDOUT NOT-POSITIVE,FULLEST POSSIBLE OUTPUT
    1     1     9     1     1    28     1     1    30     1

MST,M(1),M(2),...M(NS).MST=0 OR NEGATIVE=1ST LAYER OF 1ST MATERIAL,2ND LAYER OF 2ND MATERIAL ETC-MST POSITIVE=1ST LAYER
OF MATERIAL M(1),2ND LAYER OF MATERIAL M(2) ETC..IF MST NOT POSITIVE,M(1),M(2),.. NOT NEEDED IN INPUT,BUT REDEFINED BY
THE PROGRAM
   -1     1     2     3

INITIAL RADIUS R AND SPATIAL INTEGRATION STEPS DZ(JS) IN EACH LAYER JS,OUTPUT IN CM
   1.0000E 02     2.5000E 00     1.2500E 00     2.0000E 01

SPATIAL INDICES JG(JS) OF THE LEFT BOUNDARIES OF THE LAYERS JS,JS=2,3,4 ETC..THE LAST JG BELONGS TO THE RIGHT BOUNDARY
OF THE LAST LAYER.THE PROGRAM PUTS JG(1)=1.THICKNESS OF LAYER JS=(JG(JS+1)-JG(JS))*DZ(JS) IN UNITS GIVEN BY JMDZ.
    5    11    28

EXPONENTIAL TRANSFORMATION PARAMETERS A(JS)
   0.             0.             9.0000E-01

IWV=ANGULAR SOURCE INDEX (IF 0,ISOTROPIC - IF POSITIVE,COLLIMATED IN DIRECTION OM(IG+1-IWV) -IF NEGATIVE,THE SOURCE
STRENGTH IS QOM(I) IN THE DIRECTION OM(I)),ANGULAR SOURCE STRENGTHS QOM(I),I=1,2,.. ,IG.(IF IWV IS NOT-NEGATIVE,THE
QOM(I) ARE NOT NEEDED IN INPUT,BUT REDEFINED BY THE PROGRAM)
    0     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000

LAYER SOURCE INDEX JSQ (POSITIVE=SOURCES IN JSQTH LAYER,0=SOURCES IN CENTRAL SPHERE,NEGATIVE=SOURCES EVERYWHERE DES-
CRIBED BY LAST INPUT CARDS),LAYER SOURCE SPECTRUM QE(KV),IF JSQ NOT-NEGATIVE.(JSQ POSITIVE AND JMDZ=0 MEAN MULTIPLICA-
TION OF THE QE(KV) WITH SIGMATOTAL OF MAXIMUM SOURCE ENERGY.)
   -1    -0.        -0.        -0.        -0.

SOURCE-DEFINING FLUXES FS(J),ONE VALUE FOR EACH SPATIAL POINT J,F.I.IN NEUTRONS/SQARECM/SEC

   1.0000E 13     1.0000E 13     1.0000E 13     1.0000E 13     1.0000E 13     3.8000E 12     1.5000E 12    10.0000E 11
   1.5000E 12     3.8000E 12     1.0000E 13     1.0000E 13     1.3500E 12     1.8300E 12     2.4700E 11     3.3400E 10
   4.5100E 09     6.1000E 08     8.1700E 07     1.1100E 07     1.5000E 06     2.0300E 05     2.7400E 04     3.7100E 03
   5.0000E 02     6.8000E 01     9.2000E 00     1.2500E 00

SOURCE SPECTRA GS(JS,KV)=QUANTA OF ENERGY EV(KV) PER CM IN THE JSTH LAYER,EACH UNIT GIVES THE KVG SOURCES IN ONE LAYER

   5.2000E-03     4.0000E-04    -0.            -0.

   1.0300E-01     4.5000E-02     5.0000E-02     2.1000E-02

  -0.            -0.            -0.             2.2000E-02

1640 LINES OUTPUT THIS JOB.

                                                             02/22/67                              PAGE  1

$IBSYS
 RETURNING TO IBSYS.
***(END OF FILE)***
```

```
C       BIGGI4T
        DIMENSION ST(2,30,24),RHO(10,30),Z(30),AT(30),SZ(3,10,24),DSCT(24)
       1,D(10),ED(10),WT(24),OM(9),W(51),WV(10),KQ(10),SM(3,10,51),SOM(9),
       2DOM(9),M(10),SS(3,10,51),JG(10),DZ(9),SP(39,51),FS(39),F(9,13,51),
       3FT1(5967),FT2(5967),FT3(5967),GS(9,9),DW(6),KG(6),EV(10),Q(9,39,2)
       4,A(9),QOM(9),TE(39),SPR(51),XP(39),XG(39),EDZ(10),QE(9),DWV(10),DW
       5VN(10),WTR(36),RE(4,36),SRE(4,51),FK(9,39),SU(8),SUR(8,39),STT(144
       60),IDR(4)
        EQUIVALENCE(F,FT1,FT2,FT3),(FK,SUR),(ST,STT,SM),(SS,SZ),(Q,SPR,DWV
       1),(I0,I0)
      2 FORMAT (2I6,1P4E12.4)
      3 FORMAT (6(F9.4,I3))
      4 FORMAT (12F6.0)
      5 FORMAT (6E12.0)
      6 FORMAT (///)
      8 FORMAT (I6,1P2E12.3)
     10 FORMAT (I6,11F6.2)
     12 FORMAT (4(1PE17.4,3I3))
     14 FORMAT (11I6)
     15 FORMAT (I3)
     16 FORMAT (7(I6,1PE11.4))
     18 FORMAT (1P5E13.4)
     20 FORMAT (1P6E15.4,I10)
     21 FORMAT (2I6,F6.0,2I6)
     22 FORMAT (/)
     24 FORMAT (1H1)
     25 FORMAT (2I6,2F6.2)
     26 FORMAT (1P8E14.4)
C       LIBRARY DATA INPUT
        READ (5,4) (WT(KT),KT=1,24)                                  ,1   ,2   ,3   ,4   ,5
        READ (5,4) (DSCT(KT),KT=1,24)                                ,6   ,7   ,8   ,9   ,10
        READ (5,2) NEG,KTP                                           ,11  ,12  ,13  ,14
        DO 30 NE=1,NEG                                               ,15
        READ (5,4) Z(NE),AT(NE),(ST(2,NE,KT),KT=1,KTP)               ,16  ,17  ,18  ,19  ,20  ,21

     30 READ (5,4) (ST(1,NE,KT),KT=1,24)                             ,22  ,23  ,24  ,25  ,26  ,27

        KTPP1=KTP+1                                                  ,28
        DO 31 KT=KTPP1,24                                            ,29
        DO 31 NE=1,NEG                                               ,30
     31 ST(2,NE,KT)=0.
C       RESPONSE FUNCTION INPUT                                      ,31  ,32  ,33
        READ (5,14) NRE,KTRG,(IDR(MRE),MRE=1,NRE)                    ,34  ,35  ,36  ,37  ,38  ,39

        IF(NRE)34,34,32                                              ,40
     32 READ (5,4) (WTR(KTR),KTR=1,KTRG)                             ,41
        READ (5,4) ((RE(MRE,KTR),KTR=1,KTRG),MRE=1,NRE)              ,42  ,43  ,44  ,45  ,46
C       PROBLEM DATA INPUT AND CALCULATION OF MIXTURE CROSS SECTIONS ,47  ,48  ,49  ,50  ,51  ,52
                                                                     ,53  ,54
     34 READ (5,25) NPHYS                                            ,55  ,56  ,57
     35 READ (5,21) NGEOM,NMG,CP,INDOUT                              ,58  ,59  ,60  ,61  ,62
        NMGP1=NMG+1                                                  ,63
        DO 36 NM=1,NMG                                               ,64
     36 READ (5,4) (RHO(NM,NE),NE=1,NEG)                             ,65  ,66  ,67  ,68  ,69  ,70
```

```
      DO 37 NE=1,NEG                                                  ,71
   37 RHO(NMG+1,NE)=0.                                                ,72   ,73
      RHO(NMG+1,4)=.000976                                            ,74
      RHO(NMG+1,5)=.0003                                              ,75
      RHO(NMG+1,12)=.000017                                           ,76
      DO 40 NM=1,NMGP1                                                ,77
      EDZ(NM)=0.                                                      ,78
      D(NM)=0.                                                        ,79
      DO 38 NE=1,NEG                                                  ,80
      EDZ(NM)=EDZ(NM)+.602*RHO(NM,NE)*Z(NE)/AT(NE)                    ,81
   38 D(NM)=D(NM)+RHO(NM,NE)                                          ,82   ,83
      DO 40 KT=1,24                                                   ,84
      DO 39 L=1,2                                                     ,85
      SZ(L,NM,KT)=0.                                                  ,86
      DO 39 NE=1,NEG                                                  ,87
   39 SZ(L,NM,KT)=SZ(L,NM,KT)+.602*RHO(NM,NE)*ST(L,NE,KT)/AT(NE)      ,88   ,89   ,90
   40 SZ(3,NM,KT)=SZ(1,NM,KT)-EDZ(NM)*DSCT(KT)-SZ(2,NM,KT)*2.*WT(KT)*CP
C     TAPE OPERATIONS                                                 ,91   ,92   ,93
      REWIND 8                                                        ,94
      WRITE (8) STT                                                   ,95   ,96   ,97
      REWIND 8                                                        ,98
      WRITE (6,24)                                                    ,99   ,100
      IF(INDOUT)41,41,46                                              ,101
   41 WRITE (6,42)                                                    ,102  ,103
   42 FORMAT (110H    NM     K  SIGMATOTAL   SIGMAPAIR   SIGMAEABS  WAVE
     1LENGTH   SIGMAS IN CM**-1   WAVELENGTHS IN COMPTON UNITS)
      WRITE (6,22)                                                    ,104  ,105
      DO 43 NM=1,NMGP1                                                ,106
      DO 43 KT=1,24                                                   ,107
   43 WRITE (6,2) NM,KT,(SZ(L,NM,KT),L=1,3),WT(KT)                    ,108  ,109  ,110  ,111  ,112  ,113
                                                                      ,114  ,115  ,116
      WRITE (6,6)                                                     ,117  ,118
      WRITE (6,44)                                                    ,119  ,120
   44 FORMAT (71H    NM      RHO     EL-DENSITY  (IN GR/CUBCM RESP. ELEC
     1TRONS/(BARN*CM)))
      WRITE (6,8) (NM,D(NM),EDZ(NM),NM=1,NMGP1)                       ,121  ,122  ,123  ,124  ,125
      WRITE (6,6)
C     ENERGIES AND ANGLES                                             ,126  ,127
   46 READ (5,10) IG,(OM(I),I=1,IG)                                   ,128  ,129  ,130  ,131  ,132  ,133

      READ (5,4) (EV(KV),KV=1,9)                                      ,134  ,135  ,136  ,137  ,138
      DO 47 KV=2,9                                                    ,139
      IF(EV(KV)-.001)49,49,47                                         ,140
   47 CONTINUE                                                        ,141  ,142
      KV=10                                                           ,143
   49 KVG=KV-1                                                        ,144
      READ (5,3) (DW(NDL),KG(NDL),NDL=1,6)                            ,145  ,146  ,147  ,148  ,149
      DO 51 NDL=2,6                                                   ,150
      IF(KG(NDL)-KG(NDL-1))53,53,51                                   ,151
   51 CONTINUE                                                        ,152  ,153
      NDL=7                                                           ,154
   53 NDLG=NDL-1                                                      ,155
      W(1)=.511/EV(1)                                                 ,156
      KGG=KG(NDLG)                                                    ,157
      DO 60 NDL=1,NDLG                                                ,158
      IF(NDL-1)48,48,50                                               ,159
```

EXTERNAL FORMULA NUMBER - SOURCE STATEMENT - INTERNAL FORMULA NUMBER(S)

```
48 W(2)=W(1)+.5*DW(1)                                                    ,160
   KP=3                                                                  ,161
   GO TO 55                                                              ,162
50 KGM=KG(NDL-1)                                                         ,163
   W(KGM+1)=W(KGM)+.5*(DW(NDL-1)+DW(NDL))                                ,164
   KP=KG(NDL-1)+2                                                        ,165
55 KGO=KG(NDL)                                                           ,166
   DO 60 K=KP,KGO                                                        ,167
60 W(K)=W(K-1)+DW(NDL)                                                   ,168   ,169   ,170
   KVGP=KVG+1                                                            ,171
   EV(KVGP)=.511                                                         ,172
   WRITE (6,65)                                                          ,173   ,174
65 FORMAT (111H VOLUME SOURCES  INDEX KV,ASSIGNED WAVELENGTH INDEX K=
  1KQ(KV),WAVELENGTH,ASSIGNED WAVELENGTH,ABSOLUTE DIFFERENCE)
   DO 80 KV=2,KVGP                                                       ,175
   WV(KV)=.511/EV(KV)                                                    ,176
   KQ(KV)=1                                                              ,177
   DWV(KV)=ABS(W(1)-WV(KV))                                              ,178
   DO 75 K=2,KGG                                                         ,179
   DWVN(KV)=ABS(W(K)-WV(KV))                                             ,180
   IF(DWVN(KV)-DWV(KV))70,70,75                                          ,181
70 DWV(KV)=DWVN(KV)                                                      ,182
   KQ(KV)=K                                                              ,183
75 CONTINUE                                                              ,184   ,185
   KQKV=KQ(KV)                                                           ,186
80 WRITE (6,2) KV,KQKV,WV(KV),W(KQKV),DWV(KV)                            ,187   ,188   ,189   ,190
   WV(1)=W(1)                                                            ,191
   KQ(1)=1                                                               ,192
   WRITE (6,6)                                                           ,193   ,194
   IF(KVG-1)88,88,74                                                     ,195
74 DO 76 KV=2,KVG                                                        ,196
   IF(KQ(KV)-KQ(KV-1))79,77,79                                           ,197
79 IF(KQ(KV)-KQ(KVGP))76,77,76                                           ,198
76 CONTINUE                                                              ,199   ,200
   GO TO 88                                                              ,201
77 WRITE (6,78)                                                          ,202   ,203
78 FORMAT (117H0 TWO OR MORE SOURCE ENERGIES ARE ASSIGNED TO ONE ENER
  1GY GROUP. ONLY THE FIRST OF THEM (LOWEST KV) WILL BE CONSIDERED/15
  2H BY THE PROGRAM)
88 WRITE (6,6)
C  CROSS SECTION AND RESPONSE FUNCTION INTERPOLATION IN WAVELENGTH,
C 1QUADRATIC                                                             ,204   ,205
   IF(INDOUT)81,81,82                                                    ,206
81 WRITE (6,42)                                                          ,207   ,208
   WRITE (6,22)                                                          ,209   ,210
82 DO 100 K=1,KGG                                                        ,211
   DO 98 L=1,3                                                           ,212
   DO 98 NM=1,NMGP1                                                      ,213
   DO 83 KT=1,23                                                         ,214
   IF(W(K)-WT(KT))86,86,83                                               ,215
83 CONTINUE                                                              ,216   ,217
   SM(L,NM,K)=SZ(L,NM,24)                                                ,218
   GO TO 98                                                              ,219
86 DQ1=(SZ(L,NM,KT)-SZ(L,NM,KT-1))/(WT(KT)-WT(KT-1))                     ,220
   SM(L,NM,K)=SZ(L,NM,KT-1)+DQ1*(W(K)-WT(KT-1))                          ,221
   GO TO(95,90,95),L                                                     ,222
```

```
  EXTERNAL FORMULA NUMBER   -   SOURCE STATEMENT   -   INTERNAL FORMULA NUMBER(S)
   90 IF(KT-KTP)95,98,98                                                    ,223
   95 DQ2=(SZ(L,NM,KT+1)-SZ(L,NM,KT-1))/(WT(KT+1)-WT(KT-1))                ,224
      SM(L,NM,K)=SM(L,NM,K)+(DQ2-DQ1)*(W(K)-WT(KT-1))*(W(K)-WT(KT))/(WT(
     1KT+1)-WT(KT))                                                         ,225
   98 CONTINUE                                                              ,226  ,227  ,228
      IF(INDOUT)99,99,100                                                   ,229
   99 WRITE (6,2) (NM,K,(SM(L,NM,K),L=1,3),W(K),NM=1,NMGP1)                ,230  ,231  ,232  ,233  ,234  ,235
                                                                            ,236  ,237  ,238
  100 CONTINUE                                                              ,239  ,240
      WRITE (6,6)                                                           ,241  ,242
      IF(NRE)112,112,102                                                    ,243
  102 DO 106 K=1,KGG                                                        ,244
      DO 106 MRE=1,NRE                                                      ,245
      KTRGM=KTRG-1                                                          ,246
      DO 103 KTR=1,KTRGM                                                    ,247
      IF(W(K)-WTR(KTR))104,104,103                                          ,248
  103 CONTINUE                                                              ,249  ,250
      SRE(MRE,K)=RE(MRE,KTRG)                                               ,251
      GO TO 106                                                             ,252
  104 DQ1=(RE(MRE,KTR)-RE(MRE,KTR-1))/(WTR(KTR)-WTR(KTR-1))                ,253
      DQ2=(RE(MRE,KTR+1)-RE(MRE,KTR-1))/(WTR(KTR+1)-WTR(KTR-1))            ,254
      SRE(MRE,K)=RE(MRE,KTR-1)+DQ1*(W(K)-WTR(KTR-1))+(DQ2-DQ1)*(W(K)-WTR
     1(KTR-1))*(W(K)-WTR(KTR))/(WTR(KTR+1)-WTR(KTR))                        ,255
  106 CONTINUE                                                              ,256  ,257  ,258
      IF(INDOUT)107,107,112                                                 ,259
  107 WRITE (6,109)                                                         ,260  ,261
  109 FORMAT (36H IDR(MRE)   K   INTERPOLATED RESPONSES)
      WRITE (6,22)                                                          ,262  ,263
      DO 111 MRE=1,NRE                                                      ,264
      DO 110 K=1,KGG                                                        ,265
  110 WRITE (6,2) (IDR(MRE),K,SRE(MRE,K))                                   ,266  ,267  ,268  ,269
  111 WRITE (6,22)                                                          ,270  ,271  ,272
      WRITE (6,6)
C     GEOMETRY INPUT                                                        ,273  ,274
  112 READ (5,14) KOE,JMDZ,I2INT                                            ,275  ,276  ,277  ,278  ,279
      READ (5,14) IOUTM,IPA,IPZ,IPD,JPA,JPZ,JPD,KPA,KPZ,KPD                 ,280  ,281  ,282  ,283  ,284  ,285
                                                                            ,286  ,287  ,288  ,289  ,290  ,291

      IPAS=1                                                                ,292
      IF(IPA)114,114,117                                                    ,293
  114 IPAS=0                                                                ,294
      IPA=1                                                                 ,295
      IPZ=IG                                                                ,296
      IPD=1                                                                 ,297
      JPA=1                                                                 ,298
      JPD=1                                                                 ,299
      KPA=1                                                                 ,300
      KPZ=KGG                                                               ,301
      KPD=1                                                                 ,302
  117 IGM=IG-1                                                              ,303
      IF(KOE)113,118,118                                                    ,304
  113 DO 115 I=1,IG                                                         ,305
      IF(ABS(OM(I))-.02)116,115,115                                         ,306
  115 CONTINUE                                                              ,307  ,308
      GO TO 118                                                             ,309
  116 IO=I                                                                  ,310
```

```
      IN=I-1                                          ,311
      IP=I+1                                          ,312
      GO TO 123                                       ,313
118   IO=-1                                           ,314
      DO 119 I=1,IG                                   ,315
      IF(OM(I))119,119,121                            ,316
119   CONTINUE                                        ,317  ,318
121   IP=I                                            ,319
      IN=I-1                                          ,320
123   DO 125 I=1,IG                                   ,321
      SOM(I)=SQRT(1.-OM(I)**2)                        ,322
125   DOM(I)=OM(I+1)-OM(I)                            ,323  ,324
      DOM(IG)=0.                                      ,325
      READ (5,14) MST,(M(JS),JS=1,9)                  ,326  ,327  ,328  ,329  ,330  ,331
      READ (5,4) R,(DZ(JS),JS=1,9)                    ,332  ,333  ,334  ,335  ,336  ,337
      READ (5,14) (JG(JS),JS=2,10)                    ,338  ,339  ,340  ,341  ,342
      JG(1)=1                                         ,343
      DO 132 JS=3,10                                  ,344
      IF(JG(JS)-JG(JS-1))133,133,132                  ,345
132   CONTINUE                                        ,346  ,347
      JS=11                                           ,348
133   NS=JS-2                                         ,349
      NB=NS+1                                         ,350
      IF(IPAS)127,127,128                             ,351
127   JPZ=JG(NB)                                      ,352
128   READ (5,4) (A(JS),JS=1,NS)                      ,353  ,354  ,355  ,356  ,357
      IF(MST)130,130,150                              ,358
130   DO 135 JS=1,NS                                  ,359
135   M(JS)=JS                                        ,360  ,361
150   DO 155 JS=1,NS                                  ,362
      MJS=M(JS)                                       ,363
      ED(JS)=EDZ(MJS)                                 ,364
      DO 155 L=1,3                                    ,365
      DO 155 K=1,KGG                                  ,366
155   SS(L,JS,K)=SM(L,MJS,K)                          ,367  ,368  ,369  ,370
      JMA=JG(NB)                                      ,371
      TE(1)=1.                                        ,372
      IF(JMDZ)160,160,170                             ,373
160   DO 165 JS=1,NS                                  ,374
165   DZ(JS)=DZ(JS)/SS(1,JS,1)                        ,375  ,376
      R=R/SS(1,1,1)                                   ,377
170   IF(KOE)173,171,171                              ,378
171   XG(1)=R                                         ,379
      XP(1)=R*SS(1,1,1)                               ,380
      GO TO 174                                       ,381
173   XG(1)=.0                                        ,382
      XP(1)=.0                                        ,383
174   DO 175 JS=1,NS                                  ,384
      E=EXP(-A(JS)*SS(1,JS,1)*DZ(JS))                 ,385
      JA=JG(JS)+1                                     ,386
      JE=JG(JS+1)                                     ,387
      DO 175 J=JA,JE                                  ,388
      TE(J)=TE(J-1)*E                                 ,389
      XG(J)=XG(J-1)+DZ(JS)                            ,390
```

```
      EXTERNAL FORMULA NUMBER   -   SOURCE STATEMENT   -   INTERNAL FORMULA NUMBER(S)
  175 XP(J)=XP(J-1)+SS(1,JS,1)*DZ(JS)
C     HIGHEST ENERGY AND OTHER SOURCE ENERGIES                   ,391  ,392  ,393
      DO 178 I=1,IG                                              ,394
      DO 178 J=1,JMA                                             ,395
      DO 178 LR=1,2                                              ,396
  178 Q(I,J,LR)=0.                                               ,397  ,398  ,399  ,400
  185 READ (5,10) IWV,(QOM(I),I=1,IG)                            ,401  ,402  ,403  ,404  ,405  ,406

      IF(IWV)207,190,200                                         ,407
  190 DO 195 I=1,IG                                              ,408
  195 QOM(I)=1.                                                  ,409  ,410
      GO TO 207                                                  ,411
  200 DO 205 I=1,IG                                              ,412
  205 QOM(I)=0.                                                  ,413  ,414
      I=IG+1-IWV                                                 ,415
      QOM(I)=1.                                                  ,416
  207 READ (5,10) JSQ,(QE(KV),KV=1,KVG)                          ,417  ,418  ,419  ,420  ,421  ,422

      KV=1                                                       ,423
      NDL=1                                                      ,424
      IF(JSQ)209,217,221                                         ,425
  209 READ (5,5) (FS(J),J=1,JMA)                                 ,426  ,427  ,428  ,429  ,430
      DO 210 JS=1,NS                                             ,431
  210 READ (5,5) (GS(JS,KV),KV=1,KVG)                            ,432  ,433  ,434  ,435  ,436  ,437

      KV=1                                                       ,438
  213 DO 215 JS=1,NS                                             ,439
      JE=JG(JS+1)-1                                              ,440
      JA=JG(JS)                                                  ,441
      DO 215 J=JA,JE                                             ,442
      DO 215 I=1,IG                                              ,443
      QH=GS(JS,KV)*QOM(I)/(12.57*DW(NDL))                        ,444
      Q(I,J,2)=QH*FS(J)/TE(J)                                    ,445
  215 Q(I,J+1,1)=QH*FS(J+1)/TE(J+1)                              ,446  ,447  ,448  ,449
      GO TO 230                                                  ,450
  217 DO 219 I=1,IG                                              ,451
  219 Q(I,1,1)=QOM(I)*QE(KV)/(12.57*DW(NDL))                     ,452  ,453
      GO TO 230                                                  ,454
  221 JE=JG(JSQ+1)-1                                             ,455
      JA=JG(JSQ)                                                 ,456
      DO 225 I=1,IG                                              ,457
      DO 225 J=JA,JE                                             ,458
      Q(I,J,2)=QOM(I)*QE(KV)/(12.57*DW(NDL)*TE(J))               ,459
      Q(I,J+1,1)=Q(I,J,2)*TE(J)/TE(J+1)                          ,460
      IF(JMDZ)225,223,225                                        ,461
  223 Q(I,J,2)=Q(I,J,2)*SS(1,JSQ,1)                              ,462
      Q(I,J+1,1)=Q(I,J+1,1)*SS(1,JSQ,1)                          ,463
  225 CONTINUE                                                   ,464  ,465  ,466
  230 IF(KOE)240,233,233                                         ,467
  233 DO 236 J=1,JMA                                             ,468
      DO 236 I=1,IG                                              ,469
      DO 236 LR=1,2                                              ,470
  236 Q(I,J,LR)=Q(I,J,LR)*XG(J)**2                               ,471  ,472  ,473  ,474
  240 IF(KV-1)245,245,430
C     SPATIAL INTEGRATION                                        ,475
  245 K=1                                                        ,476
```

```
      IE=0
C     TAPE REWINDS                                                  ,477
      REWIND 2                                                      ,478
      REWIND 4                                                      ,479
      REWIND 3                                                      ,480
      GO TO 265                                                     ,481
 250  DO 255 NDL=1,NDLG                                             ,482
      IF(K-KG(NDL))265,265,255                                      ,483
 255  CONTINUE                                                      ,484   ,485
 265  I=1                                                           ,486
 267  FK(I,JMA)=.0                                                  ,487
      JS=NS                                                         ,488
 269  S1T=SS(1,JS,K)-A(JS)*SS(1,JS,1)*OM(I)                         ,489
      DWL=DW(NDL)*.25*ED(JS)/S1T                                    ,490
      IF(K-1)266,266,268                                            ,491
 266  DWL=0.                                                        ,492
 268  IF(KOE)270,280,280                                            ,493
 270  ARG=S1T*DZ(JS)/ABS(OM(I))                                     ,494
      E=EXP(-ARG)                                                   ,495
      P1=1.-E                                                       ,496
      P2=(1.-E*(1.+ARG))/ARG                                        ,497
      JGD=JG(JS+1)-JG(JS)                                           ,498
      DO 275 JH=1,JGD                                               ,499
      J=JG(JS+1)-JH                                                 ,500
      P3=Q(I,J,2)*P1+(Q(I,J+1,1)-Q(I,J,2))*P2                       ,501
      P4=E+DWL*P2                                                   ,502
      P5=1.-DWL*(P1-P2)                                             ,503
 275  FK(I,J)=(P3/S1T+P4*FK(I,J+1))/P5                              ,504   ,505
      GO TO 310                                                     ,506
 280  JGD=JG(JS+1)-JG(JS)                                           ,507
      JH=1                                                          ,508
 282  J=JG(JS+1)-JH                                                 ,509
      ARG1=SQRT(XG(J+1)**2-(SOM(I)*XG(J))**2)                       ,510
      ARG2=ARG1+OM(I)*XG(J)                                         ,511
      ARG=ARG2*S1T                                                  ,512
      E=EXP(-ARG)                                                   ,513
      P1=1.-E                                                       ,514
      P2=(1.-E*(1.+ARG))/ARG                                        ,515
      GF=(XG(J)/XG(J+1))**2                                         ,516
      IF(I-1)285,285,290                                            ,517
 285  QN=Q(I,J+1,1)*GF                                              ,518
      FKN=FK(I,J+1)*GF                                              ,519
      GO TO 305                                                     ,520
 290  OMN=-ARG1/XG(J+1)                                             ,521
      DO 295 IS=2,IG                                                ,522
      IF(OM(IS)-OMN)295,300,300                                     ,523
 295  CONTINUE                                                      ,524   ,525
      IS=IG                                                         ,526
 300  DO1=(OMN-OM(IS-1))/DOM(IS-1)                                  ,527
      QN=Q(IS-1,J+1,1)+(Q(IS,J+1,1)-Q(IS-1,J+1,1))*DO1              ,528
      FKN=FK(IS-1,J+1)+(FK(IS,J+1)-FK(IS-1,J+1))*DO1                ,529
      QN=QN*GF*EXP(-A(JS)*SS(1,JS,1)*(DZ(JS)+OM(I)*ARG2))           ,530
      FKN=FKN*GF                                                    ,531
 305  P3=Q(I,J,2)*P1+(QN-Q(I,J,2))*P2                               ,532
      P4=E+DWL*P2                                                   ,533
      P5=1.-DWL*(P1-P2)                                             ,534
```

```
      FK(I,J)=(P3/S1T+P4*FKN)/P5                                   ,535
      JH=JH+1                                                      ,536
      IF(JH-JGD)282,282,310                                        ,537
310   JS=JS-1                                                      ,538
      IF(JS)311,311,269                                            ,539
311   I=I+1                                                        ,540
      IF(I-IN)267,267,312                                          ,541
312   IF(IO)330,330,315                                            ,542
315   S1T=SS(1,01,K)-DW(NDL)*ED(1)*.25                             ,543
      IF(K-1)316,316,317                                           ,544
316   S1T=SS(1,1,K)                                                ,545
317   FK(IO,1)=.5*(Q(IO,1,1)+Q(IO,1,2))/S1T                        ,546
      DO 325 JS=1,NS                                               ,547
      JA=JG(JS)+1                                                  ,548
      JE=JG(JS+1)                                                  ,549
      S1T=SS(1,JS,K)                                               ,550
      IF(K-1)319,319,318                                           ,551
318   S1T=S1T-DW(NDL)*ED(JS)*.25                                   ,552
319   DO 320 J=JA,JE                                               ,553
320   FK(IO,J)=Q(IO,J,1)/S1T                                       ,554  ,555
      IF(JS-NS)321,324,324                                         ,556
321   S1T=SS(1,JS+1,K)                                             ,557
      IF(K-1)323,323,322                                           ,558
322   S1T=S1T-DW(NDL)*ED(JS+1)*.25                                 ,559
323   FK(IO,JE)=.5*(FK(IO,JE)+Q(IO,JE,2)/S1T)                      ,560
      GO TO 325                                                    ,561
324   FK(IO,JE)=.5*FK(IO,JE)                                       ,562
325   CONTINUE                                                     ,563  ,564
330   I=IP                                                         ,565
332   IF(KOE)335,345,350                                           ,566
335   FK(I,1)=0.                                                   ,567
      DO 340 JS=1,NS                                               ,568
      S1T=SS(1,JS,K)-A(JS)*SS(1,JS,1)*OM(I)                        ,569
      DWL=DW(NDL)*.25*ED(JS)/S1T                                   ,570
      IF(K-1)336,336,338                                           ,571
336   DWL=0.                                                       ,572
338   ARG=S1T*DZ(JS)/ABS(OM(I))                                    ,573
      E=EXP(-ARG)                                                  ,574
      P1=1.-E                                                      ,575
      P2=(1.-E*(1.+ARG))/ARG                                       ,576
      JA=JG(JS)+1                                                  ,577
      JE=JG(JS+1)                                                  ,578
      DO 340 J=JA,JE                                               ,579
      P3=Q(I,J,1)*P1+(Q(I,J-1,2)-Q(I,J,1))*P2                      ,580
      P4=E+DWL*P2                                                  ,581
      P5=1.-DWL*(P1-P2)                                            ,582
340   FK(I,J)=(P3/S1T+P4*FK(I,J-1))/P5                             ,583  ,584  ,585
      GO TO 407                                                    ,586
345   FK(I,1)=0.                                                   ,587
      GO TO 365                                                    ,588
350   S1T=SS(1,1,K)                                                ,589
      DWL=DW(NDL)*ED(1)*.25/S1T                                    ,590
      IF(K-1)352,352,354                                           ,591
352   DWL=0.                                                       ,592
354   ARG2=2.*R*OM(I)                                              ,593
      ARG=ARG2*SS(1,1,K)                                           ,594
```

```
EXTERNAL FORMULA NUMBER   -   SOURCE STATEMENT           INTERNAL FORMULA NUMBER(S)
     E=EXP(-ARG)                                                ,595
     P1=1.-E                                                    ,596
     P2=(1.-E*(1.+ARG))/ARG                                     ,597
     OMN=-OM(I)                                                 ,598
     DO 355 IS=2,IG                                             ,599
     IF(OM(IS)-OMN)355,360,360                                  ,600
355  CONTINUE                                                   ,601   ,602
     IS=IG                                                      ,603
360  DO1=(OMN-OM(IS-1))/DOM(IS-1)                               ,604
     QN=Q(IS-1,1,1)+(Q(IS,1,1)-Q(IS-1,1,1))*DO1                 ,605
     FKN=FK(IS-1,1)+(FK(IS,1)-FK(IS-1,1))*DO1                   ,606
     P3=Q(I,1,1)*P1+(QN-Q(I,1,1))*P2                            ,607
     P4=E+DWL*P2                                                ,608
     P5=1.-DWL*(P1-P2)                                          ,609
     FK(I,1)=(P3/S1T+P4*FKN)/P5                                 ,610
365  JS=1                                                       ,611
367  S1T=SS(1,JS,K)-A(JS)*SS(1,JS,1)*OM(I)                      ,612
     DWL=DW(NDL)*.25*ED(JS)/S1T                                 ,613
     IF(K-1)366,366,368                                         ,614
366  DWL=0.                                                     ,615
368  J=JG(JS)+1                                                 ,616
369  DISKR=XG(J-1)**2-(SOM(I)*XG(J))**2                         ,617
     IF(DISKR)370,375,375                                       ,618
370  OMN=-OM(I)                                                 ,619
     LR=1                                                       ,620
     JN=J                                                       ,621
     GF=1.                                                      ,622
     ARG2=2.*XG(J)*OM(I)                                        ,623
     ARG=ARG2*S1T                                               ,624
     EX=EXP(-A(JS)*ARG2*SS(1,JS,1)*OM(I))                       ,625
     GO TO 377                                                  ,626
375  ARG1=SQRT(DISKR)                                           ,627
     ARG2=-ARG1+OM(I)*XG(J)                                     ,628
     ARG=ARG2*S1T                                               ,629
     LR=2                                                       ,630
     JN=J-1                                                     ,631
     EX=EXP(-A(JS)*SS(1,JS,1)*(DZ(JS)-ARG2*OM(I)))              ,632
     GF=(XG(J)/XG(J-1))**2                                      ,633
     OMN=ARG1/XG(J-1)                                           ,634
377  E=EXP(-ARG)                                                ,635
     P1=1.-E                                                    ,636
     P2=(1.-E*(1.+ARG))/ARG                                     ,637
     IF(I-IG)385,380,380                                        ,638
380  QN=Q(I,J-1,2)*GF                                           ,639
     FKN=FK(I,J-1)*GF                                           ,640
     GO TO 400                                                  ,641
385  DO 390 IS=2,IG                                             ,642
     IF(OM(IS)-OMN)390,395,395                                  ,643
390  CONTINUE                                                   ,644   ,645
     IS=IG                                                      ,646
395  Q0=Q(IS-1,JN,LR)                                           ,647
     Q1=Q(IS,JN,LR)                                             ,648
     FK0=FK(IS-1,JN)                                            ,649
     FK1=FK(IS,JN)                                              ,650
     GO TO 613                                                  ,651
397  QN=QN*GF*EX                                                ,652
```

```
       EXTERNAL FORMULA NUMBER   -   SOURCE STATEMENT   -   INTERNAL FORMULA NUMBER(S)
       FKN=FKN*CF                                                        ,653
   400 P3=Q(I,J,1)*P1+(QN-Q(I,J,1))*P2                                   ,654
       P4=E+DWL*P2                                                       ,655
       P5=1.-DWL*(P1-P2)                                                 ,656
       FK(I,J)=(P3/S1T+P4*FKN)/P5                                        ,657
       J=J+1                                                             ,658
       IF(J-JG(JS+1))369,369,405                                         ,659
   405 JS=JS+1                                                           ,660
       IF(JS-NS)367,367,407                                              ,661
   407 I=I+1                                                             ,662
       IF(I-IG)332,332,381
C  SPECTRUM EVALUATION BY LINEAR OR QUASI-EXPONENTIAL ANGULAR INTEGRATION ,663
   381 DO 389 J=1,JMA                                                    ,664
       SUM=0.                                                            ,665
       DO 388 I=1,IGM                                                    ,666
       F2=FK(I,J)+FK(I+1,J)                                              ,667
       IF(I2INT)382,383,383                                              ,668
   382 DINT=.5*DOM(I)*F2                                                 ,669
       GO TO 388                                                         ,670
   383 IF(F2-1.E-32)382,384,384                                          ,671
   384 FP=FK(I,J)*FK(I+1,J)                                              ,672
       SQF=.25*F2+FP/F2                                                  ,673
       IF(I2INT)387,387,386                                              ,674
   386 SQF=.5*(SQF+FP/SQF)                                               ,675
   387 DINT=.66667*DOM(I)*(.25*F2+SQF)                                   ,676
   388 SUM=SUM+DINT                                                      ,677    ,678
   389 SP(J,K)=6.283*SUM                                                 ,679    ,680
       IF(JMA-13)410,410,412                                             ,681
   410 DO 411 I=1,IG                                                     ,682
       DO 411 J=1,JMA                                                    ,683
   411 F(I,J,K)=FK(I,J)                                                  ,684    ,685    ,686
       GO TO 420
C      TAPE OPERATIONS                                                   ,687
   412 IF(K-1)406,406,402                                                ,688
   402 READ (2) FT1                                                      ,689    ,690    ,691
       REWIND 2                                                          ,692
   406 DO 413 I=1,IG                                                     ,693
       DO 413 J=1,13                                                     ,694
   413 F(I,J,K)=FK(I,J)                                                  ,695    ,696    ,697
       WRITE (2) FT1                                                     ,698    ,699    ,700
       REWIND 2                                                          ,701
       IF(JMA-26)414,414,416                                             ,702
   414 IF(K-1)404,404,403                                                ,703
   403 READ (4) FT2                                                      ,704    ,705    ,706
       REWIND 4                                                          ,707
   404 DO 415 I=1,IG                                                     ,708
       DO 415 J=14,JMA                                                   ,709
   415 F(I,J-13,K)=FK(I,J)                                               ,710    ,711    ,712
       WRITE (4) FT2                                                     ,713    ,714    ,715
       REWIND 4                                                          ,716
       GO TO 420                                                         ,717
   416 IF(K-1)401,401,399                                                ,718
   399 READ (4) FT2                                                      ,719    ,720    ,721
       REWIND 4                                                          ,722
   401 DO 417 I=1,IG                                                     ,723
       DO 417 J=14,26                                                    ,724
```

```
  417 F(I,J-13,K)=FK(I,J)                                          ,725   ,726   ,727
      WRITE (4) FT2                                                ,728   ,729   ,730
      REWIND 4                                                     ,731
      IF(K-1)398,398,419                                           ,732
  419 READ (3) FT3                                                 ,733   ,734   ,735
      REWIND 3                                                     ,736
  398 DO 418 I=1,IG                                                ,737
      DO 418 J=27,JMA                                              ,738
  418 F(I,J-26,K)=FK(I,J)                                          ,739   ,740   ,741
      WRITE (3) FT3                                                ,742   ,743   ,744
      REWIND 3
C     STEP TO NEXT WAVELENGTH                                      ,745
  420 K=K+1                                                        ,746
      DO 424 I=1,IG                                                ,747
      DO 424 J=1,JMA                                               ,748
      DO 424 LR=1,2                                                ,749
  424 Q(I,J,LR)=0.                                                 ,750   ,751   ,752   ,753
      IF(K-KG(NDLG))421,421,650                                    ,754
  421 DO 422 KV=2,KVGP                                             ,755
      IF(K-KQ(KV))422,425,422                                      ,756
  422 CONTINUE                                                     ,757   ,758
      GO TO 430                                                    ,759
  425 DO 426 NDL=1,NDLG                                            ,760
      IF(KQ(KV)-KG(NDL))427,427,426                                ,761
  426 CONTINUE                                                     ,762   ,763
  427 IF(KV-KVGP)428,430,430                                       ,764
  428 IF(JSQ)213,217,221
C SCATTERING TERM EVALUATION BY INTEGRATION OVER ANGLES AND WAVELENGTHS   ,765
  430 IF(JMA-13)434,434,432
C     TAPE OPERATIONS                                              ,766
  432 READ (2) FT1                                                 ,767   ,768   ,769
      REWIND 2                                                     ,770
  434 J=1                                                          ,771
  435 IF(J-14)436,438,440                                          ,772
  436 JT=J                                                         ,773
      GO TO 450                                                    ,774
  438 JT=1                                                         ,775
      READ (4) FT2                                                 ,776   ,777   ,778
      REWIND 4                                                     ,779
      GO TO 450                                                    ,780
  440 IF(J-27)442,444,446                                          ,781
  442 JT=J-13                                                      ,782
      GO TO 450                                                    ,783
  444 JT=1                                                         ,784
      READ (3) FT3                                                 ,785   ,786   ,787
      REWIND 3                                                     ,788
      GO TO 450                                                    ,789
  446 JT=J-26                                                      ,790
  450 I=1                                                          ,791
  452 KS=1                                                         ,792
  460 CS=1.+W(KS)-W(K)                                             ,793
      DISKR=W(K)-W(KS)-2.                                          ,794
      DO 461 NDL=1,NDLG                                            ,795
      IF(KS-KG(NDL))462,462,461                                    ,796
  461 CONTINUE                                                     ,797   ,798
  462 IF(ABS(DISKR)-.5*DW(NDL))463,463,464                         ,799
```

```
   EXTERNAL FORMULA NUMBER  -  SOURCE STATEMENT  -  INTERNAL FORMULA NUMBER(S)
463 GW=(W(KS)+.5*DW(NDL)-W(K)+2.)/DW(NDL)                     ,800
    GO TO 466                                                 ,801
464 IF(DISKR)465,480,480                                      ,802
465 GW=1.                                                     ,803
466 IF(-1.-CS)468,467,467                                     ,804
467 WG=0.                                                     ,805
    CS=-1.                                                    ,806
    GO TO 469                                                 ,807
468 WG=SQRT(1.-CS**2)                                         ,808
469 IF(ABS(OM(I))-.9999)470,470,475                           ,809
470 WK=SOM(I)                                                 ,810
    GO TO 485                                                 ,811
475 WK=0.                                                     ,812
    GO TO 485                                                 ,813
480 KS=KS+1                                                   ,814
    IF(KS-K)460,595,595                                       ,815
485 OMSMI=OM(I)*CS-WK*WG                                      ,816
    OMSMA=OM(I)*CS+WK*WG                                      ,817
    DO 490 IS=2,IG                                            ,818
    IF(OM(IS)-OMSMI)490,490,495                               ,819
490 CONTINUE                                                  ,820    ,821
    IS=IG                                                     ,822
495 IF(OM(IS)-OMSMA)555,500,500                               ,823
500 OMN=CS*OM(I)                                              ,824
    INTF=1                                                    ,825
    GO TO 630                                                 ,826
502 SUM=FN*3.1416                                             ,827
505 VWL=W(KS)/W(K)                                            ,828
    PO=(VWL+1./VWL-1.+CS**2)*VWL**2                           ,829
    DO 507 JS=1,NS                                            ,830
    IF(J-JG(JS+1))509,511,507                                 ,831
507 CONTINUE                                                  ,832    ,833
509 VED=1.                                                    ,834
    GO TO 513                                                 ,835
511 VED=ED(JS+1)/ED(JS)                                       ,836
513 DQ1=ED(JS)*.0794*DW(NDL)*GW*PO*SUM                        ,837
    DQ2=DQ1*VED                                               ,838
    Q(I,J,1)=Q(I,J,1)+DQ1                                     ,839
    Q(I,J,2)=Q(I,J,2)+DQ2                                     ,840
    IF(K-KQ(KVGP))480,525,480                                 ,841
525 IF(KG(NDLG)-K-1)480,480,530                               ,842
530 DO 535 JS=1,NS                                            ,843
    IF(J-JG(JS+1))540,550,535                                 ,844
535 CONTINUE                                                  ,845    ,846
540 SPP=SS(2,JS,KS)*CP                                        ,847
    DQ=.1592*SPP*SP(J,KS)*DW(NDL)                             ,848
    DO 545 LR=1,2                                             ,849
545 Q(I,J,LR)=Q(I,J,LR)+DQ                                    ,850    ,851
    GO TO 480                                                 ,852
550 SPP=SS(2,JS,KS)*CP                                        ,853
    Q(I,J,1)=Q(I,J,1)+.1592*SPP*SP(J,KS)*DW(NDL)              ,854
    SPP=SS(2,JS+1,KS)*CP                                      ,855
    Q(I,J,2)=Q(I,J,2)+.1592*SPP*SP(J,KS)*DW(NDL)              ,856
    GO TO 480                                                 ,857
555 SI=(OM(I)*CS-OM(IS))/(WK*WG)                              ,858
    IF(ABS(SI)-1.+1.E-8)565,565,560                           ,859
```

```
  560 SUM=0.                                                            ,860
      GO TO 570                                                         ,861
  565 OMN=.75*OMSMI+.25*OM(IS)                                          ,862
      INTF=2                                                            ,863
      GO TO 630                                                         ,864
  567 SUM=(1.5708-ARSIN(SI))*FN                                         ,865
  570 IS=IS+1                                                           ,866
      IF(IS-IG)575,585,585                                              ,867
  575 IF(OM(IS)-OMSMA)580,585,585                                       ,868
  580 OMN=.5*(OM(IS-1)+OM(IS))                                          ,869
      DEN2=(1.-OMN**2)*SOM(I)**2-(CS-OM(I)*OMN)**2                      ,870
      IF(DEN2)581,581,582                                               ,871
  581 IE=IE+1                                                           ,872
      DEN2=.25                                                          ,873
  582 INTF=4                                                            ,874
      GO TO 630                                                         ,875
  584 SUM=SUM+(FN*DOM(IS-1)/SQRT(DEN2))*(1.+(DEN2+3.*(OMN -OM(I)*CS)**2)
     1*DOM(IS-1)**2/(24.*DEN2**2))                                      ,876
      GO TO 570                                                         ,877
  585 SI=(OM(I)*CS-OM(IS-1))/(WK*WG)                                    ,878
      IF(ABS(SI)-1.+1.E-8)590,590,505                                   ,879
  590 OMN=.75*OMSMA+.25*OM(IS-1)                                        ,880
      INTF=3                                                            ,881
      GO TO 630                                                         ,882
  592 SUM=SUM+(1.5708+ARSIN(SI))*FN                                     ,883
      GO TO 505                                                         ,884
  595 I=I+1                                                             ,885
      IF(I-IG)452,452,596                                               ,886
  596 J=J+1                                                             ,887
      IF(J-JMA)435,435,598                                              ,888
  598 DO 600 I=1,IG                                                     ,889
  600 Q(I,JMA,2)=0.                                                     ,890    ,891
      IF(KOE)605,605,250                                                ,892
  605 DO 610 I=1,IG                                                     ,893
  610 Q(I,1,1)=0.                                                       ,894    ,895
      GO TO 250
C LINEAR OR QUASI-EXPONENTIAL INTERPOLATION IN ANGLE                    ,896
  613 DO1=(OMN-OM(IS-1))/DOM(IS-1)                                      ,897
      QN=Q0+(Q1-Q0)*DO1                                                 ,898
      FKN=FK0+(FK1-FK0)*DO1                                             ,899
      IF(I2INT)626,615,615                                              ,900
  615 DO2=DO1*(OM(IS)-OMN)/DOM(IS-1)                                    ,901
      QS=Q0+Q1                                                          ,902
      IF(QS-1.E-32)619,616,616                                          ,903
  616 QP=Q0*Q1                                                          ,904
      SQQ=.25*QS+QP/QS                                                  ,905
      IF(I2INT)618,618,617                                              ,906
  617 SQQ=.5*(SQQ+QP/SQQ)                                               ,907
  618 QN=QN-2.*DO2*(QS-2.*SQQ)                                          ,908
  619 FKS=FK0+FK1                                                       ,909
      IF(FKS-1.E-32)628,620,620                                         ,910
  620 FKP=FK0*FK1                                                       ,911
      SQFK=.25*FKS+FKP/FKS                                              ,912
      IF(I2INT)622,622,621                                              ,913
  621 SQFK=.5*(SQFK+FKP/SQFK)                                           ,914
  622 FKN=FKN-2.*DO2*(FKS-2.*SQFK)                                      ,915
```

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```
628 IF(QN)623,623,624                                              ,916
623 QN=0.                                                          ,917
624 IF(FKN)625,625,626                                             ,918
625 FKN=0.                                                         ,919
626 GO TO 397                                                      ,920
630 DO1=(OMN-OM(IS-1))/DOM(IS-1)                                   ,921
    F0=F(IS-1,JT,KS)                                               ,922
    F1=F(IS,JT,KS)                                                 ,923
    FN=F0+(F1-F0)*DO1                                              ,924
    IF(I2INT)636,631,631                                           ,925
631 F2=F0+F1                                                       ,926
    IF(F2-1.E-32)636,632,632                                       ,927
632 FP=F0*F1                                                       ,928
    DO2=DO1*(OM(IS)-OMN)/DOM(IS-1)                                 ,929
    SQF=.25*F2+FP/F2                                               ,930
    IF(I2INT)634,634,633                                           ,931
633 SQF=.5*(SQF+FP/SQF)                                            ,932
634 FN=FN-2.*DO2*(F2-2.*SQF)                                       ,933
    IF(FN)635,635,636                                              ,934
635 FN=0.                                                          ,935
636 GO TO (502,567,592,584),INTF                                   ,936
C   FINAL OUTPUT
650 IF(INDOUT)655,655,700                                          ,937
655 WRITE (6,658)                                                  ,938  ,939
658 FORMAT (119H SPECTRA IN PAIRS,WAVELENGTH INDEX K,SPECTRUM SP(J,K)
   1IN PHOTONS/(SQCM*SEC*COMPTON UNIT),OR SP(J,K)/SP(J,1),IF INDOUT=0)
    WRITE (6,660)                                                  ,940  ,941
660 FORMAT (45H SPATIAL INDEX J AT THE TOP OF EACH SUB-BLOCK)
    DO 672 J=JPA,JPZ,JPD                                           ,942
    WRITE (6,22)                                                   ,943  ,944
    WRITE (6,15) J                                                 ,945  ,946  ,947
    DO 670 K=KPA,KPZ,KPD                                           ,948
    IF(INDOUT)662,668,700                                          ,949
662 SPR(K)=SP(J,K)*TE(J)                                           ,950
    IF(KOE)670,665,665                                             ,951
665 SPR(K)=SPR(K)/XG(J)**2                                         ,952
    GO TO 670                                                      ,953
668 SPR(K)=SP(J,K)/SP(J,1)                                         ,954
670 CONTINUE                                                       ,955  ,956
672 WRITE (6,16) (K,SPR(K),K=KPA,KPZ,KPD)                          ,957  ,958  ,959  ,960  ,961  ,962

    WRITE (6,6)                                                    ,963  ,964
    WRITE (6,675)                                                  ,965  ,966
675 FORMAT (106H ANGULAR FLUXES F(I,J,K) (TRANSFORMED),FOLLOWED BY THE
   1IR INDEX TRIPLES I(ANGULAR),J(SPATIAL),K(WAVELENGTH))
    WRITE (6,22)                                                   ,967  ,968
C   TAPE OPERATIONS
    IF(JMA-13)681,681,678                                          ,969
678 IF(JPZ-13)680,680,683                                          ,970
680 READ (2) FT1                                                   ,971  ,972  ,973
    REWIND 2                                                       ,974
681 DO 682 J=JPA,JPZ,JPD                                           ,975
    WRITE (6,22)                                                   ,976  ,977
    DO 682 K=KPA,KPZ,KPD                                           ,978
682 WRITE (6,12) (F(I,J,K),I,J,K,I=IPA,IPZ,IPD)                    ,979  ,980  ,981  ,982  ,983  ,984
                                                                   ,985
```

```
     GO TO 700                                          ,986
683  IF(JPA-13)684,684,695                              ,987
684  DO 685 J=JPA,JPZ,JPD                               ,988
     IF(J-13)685,685,686                                ,989
685  CONTINUE                                           ,990  ,991
686  J2=J                                               ,992
     J1=J-JPD                                           ,993
     READ (2) FT1                                       ,994  ,995  ,996
     REWIND 2                                           ,997
     DO 687 J=JPA,J1,JPD                                ,998
     WRITE (6,22)                                       ,999  ,1000
     DO 687 K=KPA,KPZ,KPD                               ,1001
687  WRITE (6,12) (F(I,J,K),I,J,K,I=IPA,IPZ,IPD)        ,1002 ,1003 ,1004 ,1005 ,1006 ,1007
                                                        ,1008
     READ (4) FT2                                       ,1009 ,1010 ,1011
     REWIND 4                                           ,1012
     IF(JPZ-26)688,688,690                              ,1013
688  DO 689 J=J2,JPZ,JPD                                ,1014
     JT=J-13                                            ,1015
     WRITE (6,22)                                       ,1016 ,1017
     DO 689 K=KPA,KPZ,KPD                               ,1018
689  WRITE (6,12) (F(I,JT,K),I,J,K,I=IPA,IPZ,IPD)       ,1019 ,1020 ,1021 ,1022 ,1023 ,1024
                                                        ,1025
     GO TO 700                                          ,1026
690  DO 691 J=J2,JPZ,JPD                                ,1027
     IF(J-26)691,691,692                                ,1028
691  CONTINUE                                           ,1029 ,1030
692  J4=J                                               ,1031
     J3=J-JPD                                           ,1032
     READ (4) FT2                                       ,1033 ,1034 ,1035
     REWIND 4                                           ,1036
     DO 693 J=J2,J3,JPD                                 ,1037
     WRITE (6,22)                                       ,1038 ,1039
     JT=J-13                                            ,1040
     DO 693 K=KPA,KPZ,KPD                               ,1041
693  WRITE (6,12) (F(I,JT,K),I,J,K,I=IPA,IPZ,IPD)       ,1042 ,1043 ,1044 ,1045 ,1046 ,1047
                                                        ,1048
     READ (3) FT3                                       ,1049 ,1050 ,1051
     REWIND 3                                           ,1052
     DO 694 J=J4,JPZ,JPD                                ,1053
     JT=J-26                                            ,1054
     WRITE (6,22)                                       ,1055 ,1056
     DO 694 K=KPA,KPZ,KPD                               ,1057
694  WRITE (6,12) (F(I,JT,K),I,J,K,I=IPA,IPZ,IPD)       ,1058 ,1059 ,1060 ,1061 ,1062 ,1063
                                                        ,1064
     GO TO 700                                          ,1065
695  IF(JPA-26)698,698,696                              ,1066
696  READ (3) FT3                                       ,1067 ,1068 ,1069
     REWIND 3                                           ,1070
     DO 697 J=JPA,JPZ,JPD                               ,1071
     JT=J-26                                            ,1072
     WRITE (6,22)                                       ,1073 ,1074
     DO 697 K=KPA,KPZ,KPD                               ,1075
697  WRITE (6,12) (F(I,JT,K),I,J,K,I=IPA,IPZ,IPD)       ,1076 ,1077 ,1078 ,1079 ,1080 ,1081
                                                        ,1082
     GO TO 700                                          ,1083
```

```
698 IF(JPZ-26)699,699,702                                                          ,1084
699 READ (4) FT2                                                                   ,1085 ,1086 ,1087
    REWIND 4                                                                       ,1088
    DO 701 J=JPA,JPZ,JPD                                                           ,1089
    WRITE (6,22)                                                                   ,1090 ,1091
    JT=J-13                                                                        ,1092
    DO 701 K=KPA,KPZ,KPD                                                           ,1093
701 WRITE (6,12) (F(I,JT,K),I=IPA,IPZ,IPD)                                         ,1094 ,1095 ,1096 ,1097 ,1098 ,1099
                                                                                   ,1100
    GO TO 700                                                                      ,1101
702 DO 703 J=JPA,JPZ,JPD                                                           ,1102
    IF(J-26)703,703,704                                                            ,1103
703 CONTINUE                                                                       ,1104 ,1105
704 J2=J                                                                           ,1106
    J1=J-JPD                                                                       ,1107
    READ (4) FT2                                                                   ,1108 ,1109 ,1110
    REWIND 4                                                                       ,1111
    DO 705 J=JPA,J1,JPD                                                            ,1112
    WRITE (6,22)                                                                   ,1113 ,1114
    JT=J-13                                                                        ,1115
    DO 705 K=KPA,KPZ,KPD                                                           ,1116
705 WRITE (6,12) (F(I,JT,K),I,J,K,I=IPA,IPZ,IPD)                                   ,1117 ,1118 ,1119 ,1120 ,1121 ,1122
                                                                                   ,1123
    READ (3) FT3                                                                   ,1124 ,1125 ,1126
    REWIND 3                                                                       ,1127
    DO 707 J=J2,JPZ,JPD                                                            ,1128
    JT=J-26                                                                        ,1129
    WRITE (6,22)                                                                   ,1130 ,1131
    DO 707 K=KPA,KPZ,KPD                                                           ,1132
707 WRITE (6,12) (F(I,JT,K),I,J,K,I=IPA,IPZ,IPD)                                   ,1133 ,1134 ,1135 ,1136 ,1137 ,1138
                                                                                   ,1139
700 WRITE (6,24)                                                                   ,1140 ,1141
    WRITE (6,709)                                                                  ,1142 ,1143
709 FORMAT (26H IE=SQARE ROOT ERROR INDEX)
    WRITE (6,2) IE                                                                 ,1144 ,1145 ,1146
    DO 885 IOUT=1,IOUTM                                                            ,1147
    WRITE (6,710)                                                                  ,1148 ,1149
710 FORMAT (86HCFIRST LINE OF EACH SUB-BLOCK VALUES WITHOUT,SECOND LIN
   1E WITH LOW-ENERGETIC CORRECTION)
    IF(KVG-1)712,712,716                                                           ,1150
712 WRITE (6,714)                                                                  ,1151 ,1152
714 FORMAT (93H THIRD LINE OF EACH SUB-BLOCK CORRESPONDING BUILDUP FAC
   1TORS,LOW-ENERGETIC CORRECTION INCLUDED)
716 WRITE (6,22)                                                                   ,1153 ,1154
    WRITE (6,706)                                                                  ,1155 ,1156
706 FORMAT (104H    ENERGY FLUX     DOSE RATE   EN.-ABS.-RATE  PARTICL
   1E FLUX       X IN CM      X IN MFP(EMAX)   X-INDEX J)
    WRITE (6,708)                                                                  ,1157 ,1158
708 FORMAT (60H    MEV/SQCM/SEC    REM/HOUR    MEV/CUBCM/SEC  PHOT/SQC
   1M/SEC)
    WRITE (6,22)                                                                   ,1159 ,1160
    DO 750 JS=1,NS                                                                 ,1161
    JA=JG(JS)                                                                      ,1162
    JE=JG(JS+1)                                                                    ,1163
    DO 750 J=JA,JE                                                                 ,1164
    DO 718 L=1,4                                                                   ,1165
```

```
      SU(L)=0.                                                   ,1166
  718 SUR(L,J)=0.                                                ,1167 ,1168
      DO 728 K=1,KGG                                             ,1169
      DO 720 NDL=1,NDLG                                          ,1170
      IF(K-KG(NDL))722,722,720                                   ,1171
  720 CONTINUE                                                   ,1172 ,1173
  722 POS=.511*SP(J,K)*DW(NDL)/W(K)                              ,1174
      SU(1)=SU(1)+POS                                            ,1175
      SU(2)=SU(2)+POS*SM(3,NMGP1,K)/19.64                        ,1176
      SU(3)=SU(3)+POS*SS(3,JS,K)                                 ,1177
      SU(4)=SU(4)+SP(J,K)*DW(NDL)                                ,1178
      IF(NRE)728,728,724                                         ,1179
  724 DO 726 L=1,NRE                                             ,1180
  726 SUR(L,J)=SUR(L,J)+SP(J,K)*SRE(L,K)*DW(NDL)                 ,1181 ,1182
  728 CONTINUE                                                   ,1183 ,1184
      K=KGG                                                      ,1185
      NM=NMGP1                                                   ,1186
      POS=.511*SP(J,K)*DW(NDLG)/W(K)                             ,1187
      QW=SP(J,K-1)*W(K)/(SP(J,K)*W(K-1))                         ,1188
      SU(5)=SU(1)+.75*POS/(SQRT(QW)*ALOG(QW))                    ,1189
      SU(6)=SU(2)+(SU(5)-SU(1))*(1.5*SM(3,NM,K)-.5*SM(3,NM,K-1)+(SM(3,NM
     1,K)-SM(3,NM,K-1))/ALOG(QW))/19.64                          ,1190
      SU(7)=SU(3)+(SU(5)-SU(1))*(1.5*SS(3,JS,K)-.5*SS(3,JS,K-1)+(SS(3,JS
     1,K)-SS(3,JS,K-1))/ALOG(QW))                                ,1191
      QP=SP(J,K-1)/SP(J,K)                                       ,1192
      SU(8)=SU(4)+.75*SP(J,K)*DW(NDLG)/(SQRT(QP)*ALOG(QP))       ,1193
      IF(NRE)734,734,730                                         ,1194
  730 DO 732 L=1,NRE                                             ,1195
      FSRE=1.5*SRE(L,K)-.5*SRE(L,K-1)+(SRE(L,K)-SRE(L,K-1))/ALOG(QP)   ,1196
      IF(FSRE-.3*SRE(L,K))731,732,732                            ,1197
  731 FSRE=SRE(L,K)*.5                                           ,1198
  732 SUR(L+4,J)=SUR(L,J)+(SU(8)-SU(4))*FSRE                     ,1199 ,1200
  734 DO 738 L=1,8                                               ,1201
      SU(L)=SU(L)*TE(J)                                          ,1202
      SUR(L,J)=SUR(L,J)*TE(J)                                    ,1203
      IF(KOE)738,736,736                                         ,1204
  736 SU(L)=SU(L)/XG(J)**2                                       ,1205
      SUR(L,J)=SUR(L,J)/XG(J)**2                                 ,1206
  738 CONTINUE                                                   ,1207 ,1208
      IF(KVG-1)740,740,746                                       ,1209
  740 DEN=SP(J,1)*DW(1)*.511*TE(J)/W(1)                          ,1210
      IF(KOE)743,742,742                                         ,1211
  742 DEN=DEN/XG(J)**2                                           ,1212
  743 IF(DEN)746,746,744                                         ,1213
  744 BE=SU(5)/DEN                                               ,1214
      BD=SU(6)/(DEN*SM(3,NMGP1,1)/19.64)                         ,1215
      BA=SU(7)/(DEN*SS(3,JS,1))                                  ,1216
      BP=SU(8)/(DEN*W(1)/.511)                                   ,1217
  746 WRITE (6,20) SU(1),SU(2),SU(3),SU(4),XG(J),XP(J),J         ,1218 ,1219 ,1220
      WRITE (6,20) SU(5),SU(6),SU(7),SU(8)                       ,1221 ,1222 ,1223
      IF(KVG-1)748,748,750                                       ,1224
  748 IF(DEN)750,750,749                                         ,1225
  749 WRITE (6,20) BE,BD,BA,BP                                   ,1226 ,1227 ,1228
  750 WRITE (6,22)                                               ,1229 ,1230 ,1231 ,1232
      IF(NRE)760,760,752                                         ,1233
  752 WRITE (6,754)                                              ,1234 ,1235
```

```
754  FORMAT (114H0      X IN CM      RESPONSE INTEGRALS UNDER THEIR ID.
    1NUMBERS IDR(MRE),1ST LINE WITHOUT,2ND WITH CUTOFF CORRECTION)
     WRITE (6,22)                                                    ,1236 ,1237
     WRITE (6,756) (IDR(MRE),MRE=1,NRE)                              ,1238 ,1239 ,1240 ,1241 ,1242
756  FORMAT (I23,3I15)
     WRITE (6,22)                                                    ,1243 ,1244
     LM=4+NRE                                                        ,1245
     DO 758 J=1,JMA                                                  ,1246
     WRITE (6,20) XG(J),(SUR(L,J),L=1,NRE)                           ,1247 ,1248 ,1249 ,1250 ,1251 ,1252

     WRITE (6,20) XG(J),(SUR(L,J),L=5,LM)                            ,1253 ,1254 ,1255 ,1256 ,1257 ,1258

758  WRITE (6,22)                                                    ,1259 ,1260 ,1261
760  WRITE (6,6)                                                     ,1262 ,1263
     WRITE (6,765)                                                   ,1264 ,1265
765  FORMAT (26H PROBLEM DATA REPRODUCTION)
     WRITE (6,6)                                                     ,1266 ,1267
     WRITE (6,770)                                                   ,1268 ,1269
770  FORMAT (114H RESPONSE FUNCTION NUMBER NRE (IF NOT POSITIVE,NO RESP
    1ONSE FUNCTIONS),KTRG=NUMBER OF THEIR WAVELENGTH MESH POINTS,)
     WRITE (6,771)                                                   ,1270 ,1271
771  FORMAT (72H RESPONSE FUNCTION IDENTIFICATION NUMBERS IDR(MRE),FROM
    1 MRE=1 TO MRE=NRE)
     WRITE (6,14) NRE,KTRG,(IDR(MRE),MRE=1,NRE)                      ,1272 ,1273 ,1274 ,1275 ,1276 ,1277

     WRITE (6,22)                                                    ,1278 ,1279
     IF(NRE)778,778,772                                              ,1280
772  WRITE (6,774)                                                   ,1281 ,1282
774  FORMAT (45H RESPONSE FUNCTION WAVELENGTH MESH AND VALUES)
     WRITE (6,22)                                                    ,1283 ,1284
     WRITE (6,26) (WTR(KTR),KTR=1,KTRG)                              ,1285 ,1286 ,1287 ,1288 ,1289
     WRITE (6,22)                                                    ,1290 ,1291
     DO 776 MRE=1,NRE                                                ,1292
     WRITE (6,26) (RE(MRE,KTR),KTR=1,KTRG)                           ,1293 ,1294 ,1295 ,1296 ,1297
776  WRITE (6,22)                                                    ,1298 ,1299 ,1300
778  WRITE (6,6)                                                     ,1301 ,1302
     WRITE (6,780)                                                   ,1303 ,1304
780  FORMAT (43H NPHYS=NUMBER OF PHYSICALLY DIFFERENT CASES)
     WRITE (6,25) NPHYS                                              ,1305 ,1306 ,1307
     WRITE (6,783)                                                   ,1308 ,1309
783  FORMAT (31H0    PHYSICAL INPUT REPRODUCTION)
     WRITE (6,790)                                                   ,1310 ,1311
790  FORMAT (120H0NGEOM=NUMBER OF DIFFERENT GEOMETRIES,NMG=NUMBER OF MA
    1TERIALS,CP=PAIR PRODUCTION CONSTANT (=0. ANNIHILATION PHOTONS NEG-
    2/86H LECTED,=1.INCLUDED),INDOUT=OUTPUT INDEX (POSITIVE=REDUCED, 0
    3OR NEGATIVE=FULL OUTPUT))
     WRITE (6,22)                                                    ,1312 ,1313
     WRITE (6,21) NGEOM,NMG,CP,INDOUT                                ,1314 ,1315 ,1316
     WRITE (6,795)                                                   ,1317 ,1318
795  FORMAT (115H0PARTIAL DENSITIES RHO(NM,NE) OF ELEMENT NE IN MATERIA
    1L NM.NE,Z(NE),RHO(AIR,NE) NOT GIVEN IN PROBLEM DATA INPUT,BUT/37H
    2PRINTED HERE FOR BETTER EXPLANATION.)
     WRITE (6,800)                                                   ,1319 ,1320
800  FORMAT (118H (NE   Z RHO(AIR,NE)) RHO(1,NE)  RHO(2,NE)  RHO(3,NE)
    1RHO(4,NE)  RHO(5,NE)  RHO(6,NE)  RHO(7,NE)  RHO(8,NE)  RHO(9,NE))
     WRITE (6,22)                                                    ,1321 ,1322
```

```
    DO 805 NE=1,NEG                                                        ,1323
805 WRITE (6,810) NE,Z(NE),RHO(NMGP1,NE),(RHO(NM,NE),NM=1,NMG)             ,1324 ,1325 ,1326 ,1327 ,1328 ,1329
                                                                           ,1330
810 FORMAT (I3,F5.0,1P10E11.3)
    WRITE (6,22)                                                           ,1331 ,1332
    WRITE (6,815)                                                          ,1333 ,1334
815 FORMAT (85H ANGULAR MESH,IG=NUMBER OF ANGULAR POINTS AND OM(I)=COS
   1INE MESH VALUES,SMALLEST FIRST)
    WRITE (6,820) IG,(OM(I),I=1,IG)                                        ,1335 ,1336 ,1337 ,1338 ,1339 ,1340
820 FORMAT (I6,11F10.4)
    WRITE (6,825)                                                          ,1341 ,1342
825 FORMAT (44H0SOURCE ENERGIES EV(KV) IN MEV,HIGHEST FIRST)
    WRITE (6,26) (EV(KV),KV=1,KVG)                                         ,1343 ,1344 ,1345 ,1346 ,1347
    WRITE (6,830)                                                          ,1348 ,1349
830 FORMAT (108H0COUPLES OF WAVELENGTH STEPS DW(NDL) IN COMPTON UNITS
   1AND LAST MESH INDICES KG(NDL),AT WHICH DW(NDL) IS USED)
    WRITE (6,3) (DW(NDL),KG(NDL),NDL=1,NDLG)                               ,1350 ,1351 ,1352 ,1353 ,1354
    WRITE (6,832)                                                          ,1355 ,1356
832 FORMAT (31H0     GEOMETRY INPUT REPRODUCTION)
    WRITE (6,835)                                                          ,1357 ,1358
835 FORMAT (119H0KOE=PLAIN (NEG.) OR SPHERICAL (POS. OR 0) GEOMETRY,JM
   1DZ=UNIT LENGTH OPTION (POS.=R AND DZ(JS) ARE INTERPRETED IN CM, 0/
   2120H OR NEG. IN MFP(MAX.EN.)),I2INT=LINEAR (IF NEG.) OR QUASI-EXPO
   3NENTIAL INTERPOLATION AND INTEGRATION (1ST ORDER APPROXI- /65H MAT
   4ION OF THE SQUARE ROOTS,IF I2INT=0 - 2ND ORDER,IF I2INT POS.))
    WRITE (6,14) KOE,JMDZ,I2INT                                            ,1359 ,1360 ,1361
    WRITE (6,823)                                                          ,1362 ,1363
823 FORMAT (117H0IOUTM=NUMBER OF MAIN OUTPUT REPRODUCTIONS,IPA,IPZ,IPD
   1,JPA,JPZ,JPD,KPA,KPZ,KPD=OUTPUT MESHES IN ANGLE,SPACE AND WAVE-/95
   2H LENGTH FOR SPECTRA AND ANGULAR FLUXES - IF IPA AND INDOUT NOT-PO
   3SITIVE,FULLEST POSSIBLE OUTPUT)
    WRITE (6,14) IOUTM,IPA,IPZ,IPD,JPA,JPZ,JPD,KPA,KPZ,KPD                 ,1364 ,1365 ,1366
    WRITE (6,840)                                                          ,1367 ,1368
840 FORMAT (120H0MST,M(1),M(2),...M(NS).MST=0 OR NEGATIVE=1ST LAYER OF
   1 1ST MATERIAL,2ND LAYER OF 2ND MATERIAL ETC-MST POSITIVE=1ST LAYER
   2)
    WRITE (6,842)                                                          ,1369 ,1370
842 FORMAT (119H OF MATERIAL M(1),2ND LAYER OF MATERIAL M(2) ETC..IF M
   1ST NOT POSITIVE,M(1),M(2),.. NOT NEEDED IN INPUT,BUT REDEFINED BY/
   212H THE PROGRAM)
    WRITE (6,14) MST,(M(JS),JS=1,NS)                                       ,1371 ,1372 ,1373 ,1374 ,1375 ,1376
    WRITE (6,860)                                                          ,1377 ,1378
860 FORMAT (84H0INITIAL RADIUS R AND SPATIAL INTEGRATION STEPS DZ(JS)
   1IN EACH LAYER JS,OUTPUT IN CM)
    WRITE (6,26) R,(DZ(JS),JS=1,NS)                                        ,1379 ,1380 ,1381 ,1382 ,1383 ,1384
    WRITE (6,845)                                                          ,1385 ,1386
845 FORMAT (119H0SPATIAL INDICES JG(JS) OF THE LEFT BOUNDARIES OF THE
   1LAYERS JS,JS=2,3,4 ETC..THE LAST JG BELONGS TO THE RIGHT BOUNDARY/
   2114H OF THE LAST LAYER.THE PROGRAM PUTS JG(1)=1.THICKNESS OF LAYER
   3 JS=(JG(JS+1)-JG(JS))*DZ(JS) IN UNITS GIVEN BY JMDZ.)
    WRITE (6,14) (JG(JS),JS=2,NB)                                          ,1387 ,1388 ,1389 ,1390 ,1391
    WRITE (6,850)                                                          ,1392 ,1393
850 FORMAT (44H0EXPONENTIAL TRANSFORMATION PARAMETERS A(JS))
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      WRITE (6,26) (A(JS),JS=1,NS)                                          ,1394 ,1395 ,1396 ,1397 ,1398
      WRITE (6,865)                                                         ,1399 ,1400
  865 FORMAT (116HOIWV=ANGULAR SOURCE INDEX (IF 0,ISOTROPIC - IF POSITIV
     1E,COLLIMATED IN DIRECTION OM(IG+1-IWV) -IF NEGATIVE,THE SOURCE/116
     2H STRENGTH IS QOM(I) IN THE DIRECTION OM(I)),ANGULAR SOURCE STRENG
     3THS QOM(I),I=1,2,.. ,IG.(IF IWV IS NOT-NEGATIVE,THE/61H QOM(I) ARE
     4 NOT NEEDED IN INPUT,BUT REDEFINED BY THE PROGRAM))
      WRITE (6,820) IWV,(QOM(I),I=1,IG)                                     ,1401 ,1402 ,1403 ,1404 ,1405 ,1406

      WRITE (6,870)                                                         ,1407 ,1408
  870 FORMAT (119HOLAYER SOURCE INDEX JSQ (POSITIVE=SOURCES IN JSQTH LAY
     1ER,0=SOURCES IN CENTRAL SPHERE,NEGATIVE=SOURCES EVERYWHERE DES- /
     2119H CRIBED BY LAST INPUT CARDS),LAYER SOURCE SPECTRUM QE(KV),IF J
     3SQ NOT-NEGATIVE.(JSQ POSITIVE AND JMDZ=0 MEAN MULTIPLICA-/
     462H TION OF THE QE(KV) WITH SIGMATOTAL OF MAXIMUM SOURCE ENERGY.))
      WRITE (6,820) JSQ,(QE(KV),KV=1,KVG)                                   ,1409 ,1410 ,1411 ,1412 ,1413 ,1414

      IF(JSQ)875,882,882                                                    ,1415
  875 WRITE (6,877)                                                         ,1416 ,1417
  877 FORMAT (48HOSOURCE FLUXES FS(J),ONE VALUE PER SPATIAL POINT)
      WRITE (6,26) (FS(J),J=1,JMA)                                          ,1418 ,1419 ,1420 ,1421 ,1422
      WRITE (6,878)                                                         ,1423 ,1424
  878 FORMAT (119HOSOURCE SPECTRA GS(JS,KV)=QUANTA OF ENERGY EV(KV) PER
     1CM IN THE JSTH LAYER,EACH UNIT GIVES THE KVG SOURCES IN ONE LAYER)
      WRITE (6,22)                                                          ,1425 ,1426
      DO 880 JS=1,NS                                                        ,1427
      WRITE (6,26) (GS(JS,KV),KV=1,KVG)                                     ,1428 ,1429 ,1430 ,1431 ,1432
  880 WRITE (6,22)                                                          ,1433 ,1434 ,1435
  882 WRITE (6,24)                                                          ,1436 ,1437
  885 CONTINUE                                                              ,1438 ,1439
      NGEOM=NGEOM-1                                                         ,1440
      IF(NGEOM)890,890,112                                                  ,1441
  890 NPHYS=NPHYS-1                                                         ,1442
      IF(NPHYS)895,895,892
C     TAPE OPERATIONS                                                       ,1443
  892 READ (8) STT                                                          ,1444 ,1445 ,1446
      REWIND 8                                                              ,1447
      GO TO 35                                                              ,1448
  895 STOP                                                                  ,1449
      END                                                                   ,1450
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EUR 3555 e

C O R R I G E N D U M

USER'S MANUAL FOR THE GAMMA TRANSPORT CODES BIGGI 3P AND BIGGI 4T

by

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When this report was in print, we had to remove an error from BIGGI 4T, in the spatial integration part for the spherical case. A series of statements in and near the range between the external formula numbers 330 and 407 was changed. Further more the program was a bit simplified by shifting the statements 613...626 before 397. Finally we found that no presently available Fortran IV compiler of the IBM 360/65 computer (neither level G nor H) could compile BIGGI 4T; only the Fortran IV compiler of the IBM 7090 succeeded. In order to have a generally compilable version we split a subroutine called ENINT from the main program. (ENINT includes most of the statements in the range of the external formula numbers 708...760)

Neither the input nor the output is affected by these three changes; but some of the comments explaining the output were enlarged.

Some final remarks about our last experiences with BIGGI 4T: For angular mesh points ØM(I) near zero the IBM 360/65 can give sometimes the diagnostics "exponent underflow" (results near or below 10^{-80}), where the IBM 7090 gave no diagnostics, by simply zeros. If no tapes or disks are needed, i.e. if the number of spatial points JMA is at most 13, the calculation is much faster than in the case JMA greater than 13; a similar limit is 26 (step from two to three tapes). For low-energetic sources and light materials it can get necessary to choose on the first 1 or 2 mfp small spatial steps, f.i. 0.5 mfp; afterwards the step can be greater, f.i. 2 or 3 mfp. The last version of BIGGI 4T for the IBM 360/65 uses a spatial mesh point limit 30 instead of 13, so speeding up considerably the cases with $14 \leq$ JMA ≤ 30.

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Alfred Nobel

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