



# OAK RIDGE NATIONAL LABORATORY

operated by

UNION CARBIDE CORPORATION

for the

U.S. ATOMIC ENERGY COMMISSION



ORNL - TM - 234 *44*

COPY NO. - *50*

DATE - May 16, 1962

A System for Generating Gamma Ray Cross Section Data for  
Use with the IBM-7090 Computer

S. K. Penny

M. B. Emmett

D. K. Trubey

## ABSTRACT

A system for generating detailed tables of gamma ray cross section data has been devised for use on the IBM-7090 computer. This system obviates the preparation of large amounts of cross section data. It also provides a scheme for rapid access to these tabulated values.

## NOTICE

This document contains information of a preliminary nature and was prepared primarily for internal use at the Oak Ridge National Laboratory. It is subject to revision or correction and therefore does not represent a final report. The information is not to be abstracted, reprinted or otherwise given public dissemination without the approval of the ORNL patent branch, Legal and Information Control Department.

A System for Generating Gamma Ray Cross Section Data for Use  
with the IBM-7090 Computer

S. K. Penny, M. B. Emmett, and D. K. Trubey

A system for generating detailed tables of gamma-ray cross-section data for any mixture of elements, as well as providing a means of rapid access to this data, has been devised for use on the IBM-7090. The system was primarily designed for use in various Monte Carlo codes but can be easily used with other codes.

The system consists of a master magnetic tape which contains a limited amount of cross section data, a code to update and edit the master tape, and a package of subroutines to generate detailed tables using the data on the master tape.

The detailed table that is constructed may contain several media (several mixtures). Within each medium table there are subtables corresponding to total cross sections, the ratios of the scattering cross section to the total cross section, and, optionally, the ratios of the pair production cross section to the total cross section. Each subtable is constructed on the basis of the gamma ray energy being in electron rest mass units. The subtables contain energy groups which are bounded by energies which are exactly powers of two. Within each of these groups the energy is evenly spaced and the number of intervals is also exactly a power of two. This construction of the tables is to provide for the more rapid variation of the cross sections at lower energies as well as providing a means of rapid access to any number in the table given a gamma ray energy.

The master tape contains photoelectric and pair production cross sections which are listed in standard compilations.<sup>(1)-(3)</sup> It also contains the atomic number and the atomic density (atoms/gm x  $10^{-24}$ ) for each element. The photoelectric absorption edges are handled by listing two energies which are quite closely spaced.

The detailed table is constructed by using the absorption data from the master tape and a subroutine which computes the Compton scattering cross section. For each element a table of the total cross section corresponding to energies on the master tape is formed. For each energy in the detailed table, a total cross section and/or a pair production cross section is obtained by log-log interpolation (or extrapolation only when necessary) in the data tables from the master tape. These cross sections, as well as scattering cross sections, are then accumulated element by element in the detailed table.

The use of this system will be described now. If one wishes to generate cross sections for the first time he must use the following call statement.

```
CALL GTSIGW (2, IPP)
```

where

IPP = 0; pair production cross sections are not included in the table,

IPP = 1; pair production cross sections are included in the table.

The master tape must be logical number 29. The table will be generated in memory and also written on logical tape number 30. The following input must be supplied.

FORTRAN FORMAT

(4I4)	NMED, NINT, ILØW, IHIGH	
⋮		
I4	NELE	} ith medium
⋮		
I4, E9.3	LEMNØ, DENSITY kth element of ith medium	

NMED = number of media  
 $2^{NINT}$  = number of intervals in energy groups  
 $2^{ILØW}$  = lower energy bound of table (electron rest mass units)  
 $2^{IHIGH}$  = upper energy bound of table (electron rest mass units)  
 NELE = number of elements in a given medium  
 LEMNØ = atomic number of the element in a given medium  
 DENSITY = density (gm/cc) of the element in a given medium

This input must be from logical tape number 32.

Once the cross section table has been generated and written on tape, one may, at another time, read this table into memory without re-generation and consequently without the previous input data by using the following:

CALL GTSIGW (1,IPP)

The logical tape number is still 30 and of course the master tape is not needed.

If the cross sections are in memory by either of the previous schemes, one may obtain a cross section value for a given energy by the following:

Place the energy (electron rest mass units) in the location ~~COMMON~~ (7) and use:

CALL GTSIGW (0, IPP, MED).

MED = medium number (0, 1, 2, 3, ...) in the order that it was generated.

The total cross section will appear in ~~COMMON~~ (9), the ratio of scattering to total will appear in ~~COMMON~~ (10), and, dependent on the value of IPP, the ratio of pair production to total will appear in ~~COMMON~~ (11).

If it is desired to have flexibility in the storage allocation for energy and the cross sections and to rid oneself of the bulk of the generation package, one may use the previously generated logical tape number 30 in the following way:

```
CALL GTSIGP (1, IPP)
```

This has precisely the same function as:

```
CALL GTSIGW (1, IPP).
```

The table look-up is effected by:

```
CALL GTSIGP (0, IPP, MED, ENERGY, TOTAL, SCAT, PAIR)
```

where the last four parameters' meanings are obvious.

Both subroutines GTSIGW and GTSIGP communicate with the cross section table as if the table were a subroutine. This was done to provide flexibility in locating the table in memory and in the table size. Therefore, one must write the following FAP pseudo-subroutine:

```

      COUNT 4
      " Entry" ENERGY XSECT
      BSS      N-1
      XSECT   BSS      1
      END

```

where  $N \geq \text{NMED}(2 + \text{IPP}) [2^{\text{NINT}(\text{IHIGH-IL}/W)} + 1]$

This same storage may be used for different detailed tables as long as the above inequality is satisfied.

Anyone who is interested in the system may obtain copies of the subroutines as well as further information concerning their use from the authors.

#### References

- (1) G. W. Grodstein, "X-Ray Attenuation Coefficients from 10 kev to 100 kev," N.B.S. Circular 583.
- (2) R. I. McGinnies, "X-Ray Attenuation Coefficients from 10 kev to 100 kev," Supplement to NBS Circular 583.
- (3) Ellery Storm et al, "Gamma Ray Absorption Coefficients for Elements 1 through 100 Derived from the Theoretical Values of the National Bureau of Standards," LA-2237.

Distribution

1. E. P. Blizard
2. H. S. Moran
3. C. D. Zerby
4. H. E. Stern
5. F. B. K. Kam
6. R. E. Maerker
- 7-9. S. K. Penny
10. W. E. Kinney
11. J. G. Sullivan
12. H. P. Carter
13. V. E. Anderson
- 14.-19. D. K. Trubey
20. M. T. Harkrider
21. M. B. Emmett
- 22.-46. Laboratory Records (LRD)
- 47.-48. Central Research Library (CRL)
49. Document Reference (DRS)
50. Laboratory Records - Record Copy  
(LRD-RC)
- 51.-65. Division of Technical Information  
Extension (DTIE)
66. Research and Development Division  
(ORO)