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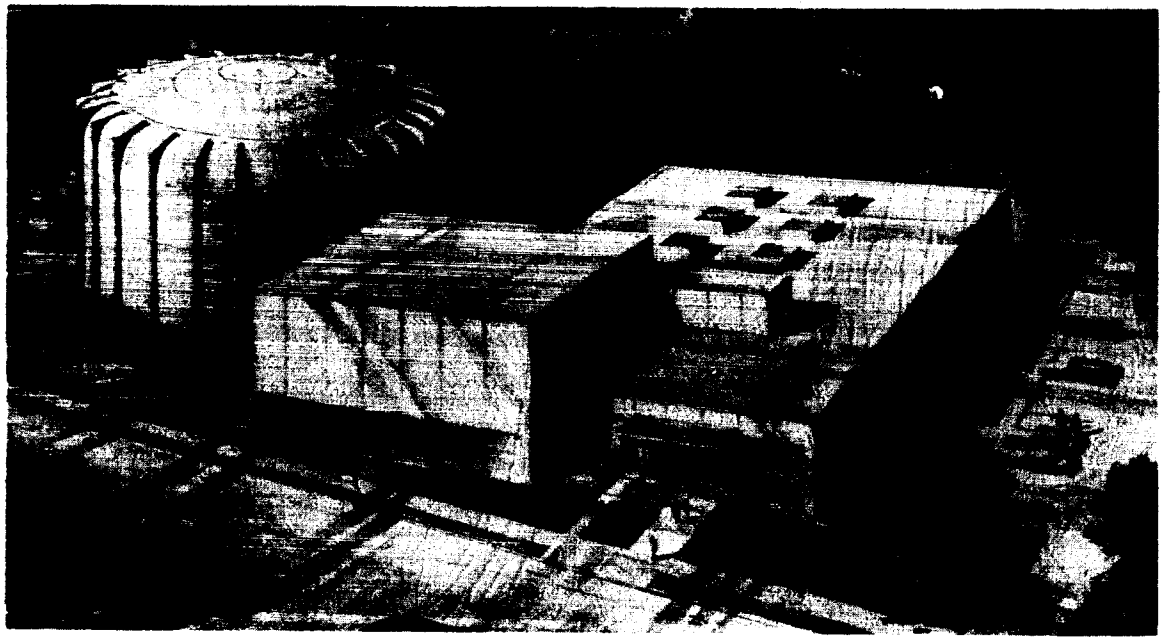

# Electron Flux and Spectrum In Thin Silicon Samples During Gamma Irradiation--A Computer Study



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March

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Atlanta, Georgia

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# ELECTRON FLUX AND SPECTRUM IN THIN SILICON SAMPLES DURING GAMMA IRRADIATION--A COMPUTER STUDY *

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## INTRODUCTION

An accurate calculational procedure for displacement production by gamma rays in silicon semiconductor material is needed for applications in basic research, in radiation damage studies, and in commercial process evaluations. Displacement by gamma rays has been shown to result primarily from the production of electrons by incident photons, then by displacement of lattice atoms by the electrons. Previous one-step calculations involving integration over electron energy of an electron-nucleus interaction, with the energy dependent photon-electron interaction included in the integration, have given results not in agreement with experimental values. The method of calculation being followed here is a two-step procedure involving first a calculation of the electron flux and spectrum, then the use of this information as input to a Monte Carlo calculational of displacement production.

This report describes the first half of the computation; the calculation of electron flux and spectrum in thin samples. A justification of the cross section equations used is give, the incorporation of these into an Algol computer program is described, and results of typical calculations are presented. Because the initial motivation for this work was its possible usefulness for analysis of spectrum effects in radiation damage studies for electronics devices, the applied relationship will also be noted throughout the report.

## BACKGROUND

### Radiation Damage in Semiconductor Devices

Disturbances in the perfect regularity of the spatial dependence of the potential function in a semiconductor crystal produce allowed energy levels in the energy band gap. Displaced atoms, vacancies, and various combinations of defect states and impurity atoms produce such disturbances. Allowed levels in the band gap constitute carrier traps, which effectively control such parameters as electron and hole lifetime. Thus any semiconductor device characteristic dependent on carrier lifetime is affected by displacement density. In transistors for example, lifetime in the base region controls current gain as shown in the equation for current transfer effeciency[1]:

$$\beta = \operatorname{sech} \frac{w}{\sqrt{D\tau}}$$

where w = base width
D = carrier diffusion constant
$\tau$ = carrier lifetime

It is this mechanism of increased trap density which produces the most important permanent damage contribution from gamma radiation exposure. Although ionization and excitation do occur, their effect is quickly minimized by the kinetics of the carriers involved.

### Displacements from Gamma Radiation

Although a photon may transfer sufficient energy to a lattice atom to cause displacement, the cross section for such direct displacements is negligibly small. Instead the major contribution arises from Compton, pair-production, or photo electrons, followed by displacement caused by the energetic electron. The electron-atom collision as described by relativistic scattering theory shows that the maximum energy transfer to the atom is given by[2]

$$E_{max} = \frac{2( Ee + 2 Me c^2 ) Ee}{M c^2}$$

where Ee = incident electron energy
Me = electron mass
M = atom mass
c = velocity of light

The best experimentally determined displacement energy for a silicon atom is about 13 eV, thus from the above relation, the minimum electron energy causing a displacement is 145 KeV. For energetic electrons,

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[1] L. B. Valdes, The Physical Theory of Transistors, McGraw-Hill, 1961, p.287

[2] D. S. Billington and J. H. Crawford, Radiation Damage in Solids, Princeton Press, 1961.

the energy transferred to the atom may result in further displacements by the primary atom. This multiplying action, plus the dependence of energy transfer on electron energy, lead to the curve shown in figure 1[3].

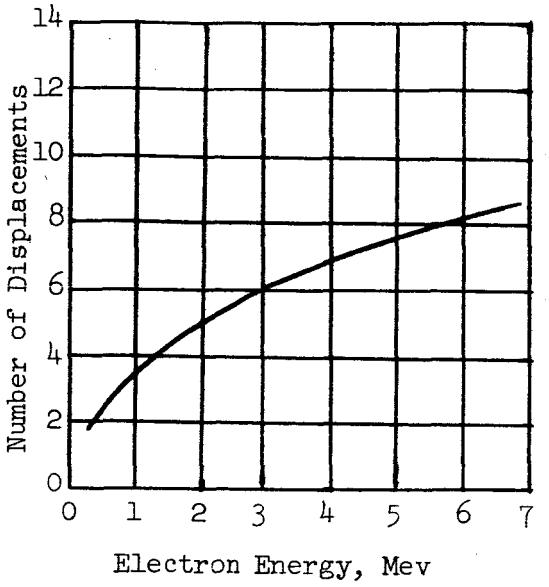


FIGURE 1. DAMAGE PRODUCTION IN THIN SILICON SAMPLES

The relation of gamma irradiation to permenent semiconductor device damage developed thus far might then be summarized as follows:

(1)- Gamma radiation produces displacements in semiconductor materials primarily through intermediate electrons. Both electrons and displacement production are energy dependent.

(2)- Displacement of lattice atoms into interstitial sites disturbs the periodicity of the potential, introducing trap levels into the forbidden energy band.

(3)- The increased trap density reduces carrier lifetime by providing recombination sites.

(4)- Reduced carrier lifetime affects engineering parameters of semiconductor devices; in transistors, the current transfer efficiency is reduced, thereby reducing transistor gain by carrier loss.

Thus calculation of the intermediate electron flux and of the resulting displacements represents the first step in analytical prediction of radiation damage to semiconductor devices from a given gamma source.

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3. J. H. Cahn, "Irradiation Damage in Germanium and Silicon due to Electrons and Gamma Rays", J. Appl. Phys, 30, 1312, (1959).

## Previous Displacement Production Calculations

Three previous calculational procedures for displacement production by gamma radiation are those of Cahn[3], Oen and Holmes[4], and Galavanov[5]. The similarities and differences of these methods with the one described in this report will be discussed after a brief review of the three approaches.

Cahn's calculations were for silicon and germanium, and included displacements by intermediate electrons from photoelectric, Compton and pair-production interactions. Photoelectron and pair production cross sections were taken from tabulated values of Davisson and Evans[6], and Grodstein[7]. The K and L shell cross sections were assumed to be 0.8 and 0.2 respectively of the total photoelectric cross section. Pair-production cross sections for equal electron and positron energy were used. The Klein-Nishina differential energy cross section was intergrated to give the Compton electron component. Cahn, as did the other investigators, assumes a sharp displacement energy threshold, and integrates an electron-nucleus collision cross section over the electron energy range from the minimum displacement energy to the available electron energy of the photoelectron interaction. The differential energy-range relation for the electron is included to account for alternate energy loss mechanisms. The electron-nucleus interaction used is that of Seitz and Koehler[8] based on the Mott-McKinley-Feshbach relativistic electron scattering cross section relations. Displacements through knock-on collisions of the primary displaced atom are included using the Kinchin and Pease model. Discussion of the computer program or of the computing machine used for the calculations is not given.

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[4] O. S. Oen and D. K. Holmes, J. Appl. Phys., 30, 1289, (1959).

[5] V. V. Galavanov, Fiz. Iverdogo Tela, 1(3), 432, (1959); translation in Soviet Physics-Solid State, p. 390.

[6] C. M. Davison and R. D. Evans, Revs. Modern Phys, 24, 79, (1952).

[7] Gladys W. Girodstein, Natl. Bur. Standards Circ. No. 583, (1957).

[8] F. Seitz and J. S. Koehler in Solid State Physics, edited by F. Seitz and D. Turnbull, Academic Press, (1956), Vol. 2, p. 305.

Oen and Holmes performed similar calculations for thick samples of several materials, although not for silicon. Their calculations for the photo-electron collision includes calculated Compton cross sections, and photoelectron cross sections calculated from the Hulme numerical method for electron energies less than 2 Mev, and the Hall high energy equations for energies greater than 2 Mev. The treatment of the electron-nucleus interaction for low Z materials was similar to that of Cahn.. Computations were performed on the now obsolete ORACLE computer. Subsequent work by these investigations has been directed toward high Z materials and based on the corresponding scattering models for nuclei of large Z[9].

The treatment of Galavanov is for germanium, and includes calculations to show that displacement by direct interactions of the photon and nucleus is negligible. Galavanov uses tabulated photoelectric cross sections, and a form of differential energy Klein-Nishina equation for the Compton cross section. The photon interaction equations are combined with a form of Mott's equation, and calculations are made for sub-intervals of electron energy rather than by direct intergration as in the previous calculations. Effects of sample geometry, knock-on interactions, and possible loss mechanisms are not mentioned.

Each of the three papers includes comments on the apparent lack of agreement between the calculated displacement production rates, and those actually observed by measuring carrier removal rate during photon irradiations. Displacement production is of the order of 10 less than the theoretically predicted value. Galavanov says that the discrepancy "is evidently due to imperfections in the experimental method of determining the number of defects". Cahn and Oen and Holmes suggest that the difficulties probably are related to the theoretical model used for the electron-nucleus interaction, and to the subsequent behavior of the displacement defect.

Based on the limited success of the displacement calculation procedures, work on the analytical approach has received less attention, while analytical and experimental studies of the mechanisms involved have expanded. Studies have been conducted to investigate the significance

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[9] O. S. Oen (private communication).

of electron energy and direction with respect to the crystal axis and to determine the displacement threshold behavior. Experimental studies have shown that a multitude of defect states associated with defect pairing with impurities dominates the carrier recombination behavior. The importance of defect annealing was established by showing that simple defects may be mobile within the lattice at temperatures as low as $4^{o}K$[10].

It is because of these recent developments, and of improved photon interaction models, that an attempt to develop a new calculational procedure for displacements in silicon devices seems desirable. The present model differs from the previous calculations promarily in that it is for irradiations of thin silicon samples by any photon spectrum extending to about 10 MeV. Calculations include photo electric, Compton, and pair-production photon-electron interactions, with cross sections being calculated for each within the computer program. Equations used for photo-electric and pair-production cross sections differ from those used by either of the previous investigators. Rather than the integration over electron energy previously used to give displacement densities directly, a discreet energy interval procedure allowing examination of the electron spectrum, and Monte-Carlo calculations for subsequent electron behavior will be employed. The value of knowledge of the electron spectrum, and of the Monte-Carlo technique will be discussed later.

Photon Interaction Models

In the three displacement calculation models discussed in the previous section, the complexity of the photon-electron calculation varied from the use of tabulated linear attenuation coefficients by Galavanov, to the calculation of cross sections by the lengthy Hulme numerical approximations by Oen and Holmes. In the present work, cross sections for photoelectric, Compton, and pair production are calculated within the computer program for given values of photon and electron energy. Comparisons of the various equations and of experimental versus theoretical results given by Davisson[11] and Evans[12] were used as a starting point for this work.

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[10] Work in the above areas is summarized in the Proceedings of the 7th International Conference on Physics of Semiconductors, Paris, 1964; Vol. 3, "Radiation Effects in Semiconductors," Academic Press (1965).

[11] C. M. Davisson in Alpha-,Beta-, and Gamma-Ray Spectroscopy, edited by Kai Siegbahn, North Holland Publishing Co., Amsterdam (1965), Vol 1, p. 37.

[12] R. D. Evans, The Atomic Nucleus, McGraw-Hill, (1955).

Theoretical models of photon interactions producing electrons are based on evaluating the quantum mechanical transition probabilities for transitions having a free electron as the final state. The matrix element for the transition is calculated from the general form

$$M = C_1 \int \Psi_B \, H_i \, \Psi_c \, d^3\gamma \qquad (1)$$

and the cross section for producing an electron of momentum $\bar{p}$ to $\bar{p} + \overline{dp}$ through this interaction by

$$d\sigma = C_2 \, |M|^2 \, d^3p \qquad (2)$$

where

$M$ = transition matrix element
$\Psi_B$ = bound state electron wave function
$\Psi_c$ = continuum state electron wave function
$H_i$ = interaction Hamiltonian
$d\sigma$ = differential cross section
$d^3p$ = volume of momentum space of interest
$C_1, C_2$ = constants

Defining the interaction Hamiltonian and the wave functions is, of course, the important and difficult part of the problem. A usual procedure involves expanding the wave functions in a series of partial waves, or expansions involving successive Born approximations. The Hamiltonian is frequently approximated by pertubation methods. To simplify the slowly converging series and higher-order pertubation models required, conditions on relativistic considerations, atomic number, and screening are usually made based on the physical considerations of a particular problem. Selection of the cross section equations to be used for a particular calculation must therefore be based on the photon and electron energy and atomic number to be considered. The scattering equations used for this problem were chosen for the photon energy range 0 - 10 MeV, for electron energies above 100 Kev, and for small Z (Z silicon = 14).

For silicon the Compton process is the major electron source for photon energies from about 0.1 to 7 Mev. The additional complications of photoelectric and pair-production calculations have been included

to assure that monoenergetic or skewed photon spectra might be accurately analyzed by this program. Calculated cross sections for silicon by the equations selected for all three interactions were shown to give good agreement with available experimental data.

Compton Scattering

Compton scattering, the scattering of photons by essentially free electrons, may be described with accuracy by the familiar Klein-Nishina equations.[13] The Klein-Nishina equations result from application of the quantum scattering theory with allowed intermediate states for which the electron may absorb a photon, in violation of normal energy conservation laws. Although the scattering cross section per unit solid angle for the scattered photon results from the Klein-Nishina formula, elementary relativistic conservation of energy and momentum between the initial and final states may be used, along with the chain rule for differentiation, to give a differential electron energy scattering cross section.

It is this differential electron energy cross section per electron which will be used for this calculation:

$$\frac{d\sigma}{d(TE)} = \frac{\pi r_o^2}{m_o c^2} \frac{1}{\alpha^2} \left\{ 2 + \left( \frac{TE}{h\nu - TE} \right)^2 \left[ \frac{1}{\alpha^2} + \frac{h\nu - TE}{h\nu} - \frac{2}{\alpha} \frac{h\nu - TE}{TE} \right] \right\} \qquad (3)$$

where

$d\sigma$ = differential cross section for Compton electron production per electron

$TE$ = electron energy

$h\nu$ = photon energy

$r_o$ = classical electron radius

$m_o c^2$ = electron rest mass energy

$\alpha = h\nu / m_o c^2$ = photon energy in electron rest mass units.

Considerations of conservation of energy and momentum give an upper electron energy limit for the Compton interaction of:

$$TE_{max} = \frac{h\nu}{1 + (1/2\alpha)}. \qquad (4)$$

Note that the differential cross section equation (3) yields positive

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[13] O. Klein and Y. Nishina, Z Physik , 52, 853, (1929).

cross sections for energies greater than TE max, and in fact has a positive singularity at TE $= h\nu$. It is therefore necessary to impose an upper electron energy limit, TEmax, on calculations with this equation.

According to Davisson, the Klein-Nishina formulation has shown agreement with experimental data for energies less than 50 Mev. Radiative corrections necessary above 50 Mev are insignificant in the 0 - 10 Mev range of interest in this calculation.

Photoelectric Scattering

Photoelectrons are produced by the interaction of photons with the orbital electrons in the presence of the nucleus. The interacting force field with the nucleus is necessary for the conservation of momentum, and consequently the probability of such interaction increases with increasing electron binding energy. Before about 1954, the most accurate theoretical results for K shell electrons were those of the Hulme[14] numerical approximation for low energies and high atomic number. The most accurate equations for low Z over rather wide energy limits now appears to be those of Pratt[15, 16]. Using approximate Coulomb wave functions, and making use of computer techniques, Pratt has carried up to 40 terms in the expansion of the wave function in cross section calculations. Although his earlier equations were developed for the high energy limit, he has extrapolated to low energies using the energy dependence relations developed by Gavrila[17] to get, for K shell photoelectric scattering:

$$\tau_K = \tau_K^0 \frac{\beta^3}{(1-\beta^2)^{3/2}} \left(\frac{mc^2}{h\nu}\right)^4 (AZ)^{2\xi} \; M(\beta) \; \exp\left[-2(AZ/\beta)\, \arccos(AZ)\right] \left\{1 + \pi AZ\left[N(\beta)/M(\beta)\right]\right\} \qquad (5)$$

$$\tau_K^0 = 4\pi r_0^2 A^4 Z^5 \left(\frac{mc^2}{h\nu}\right) = \text{high energy limit}$$

$$\xi = \left[(1-(AZ)^2)^{1/2} - 1\right] = \text{binding energy of K shell electron}$$

$$M(\beta) = \frac{4}{3} + \frac{1-3(1-\beta^2)^{1/2} + e(1-\beta^2)}{\beta^2(1-\beta^2)^{1/2}} \left[1 + \frac{(1-\beta^2)}{2\beta} \ln \frac{(1-\beta)}{(1+\beta)}\right]$$

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[14] H. R. Hulme, J. McDougill, R. A. Buckingham, and R. H. Fowler, Proc. Roy. Soc., (London), A 149, 131. (1935).

[15] R. H. Pratt, Phys. Rev., 117, 1017, (1960).

[16] R. H. Pratt, R. D. Levee, W. Aron, R.C. Pexton, H. Hall, Bul. Am. Phys. Soc., 7, 492, (1962).

[17] M. Garrila, Phys. Rev., 113, 5, (1959).

$$N(\beta) = \frac{1}{\beta^3}\left\{-\frac{4}{15}\frac{1}{(1-\beta^2)^{1/2}} + \frac{34}{15} - \frac{63}{15}(1-\beta^2)^{1/2} + \frac{25}{15}(1-\beta^2)\right.$$

$$\left. + \frac{\beta}{15}(1-\beta^2)^{3/2} + (1-\beta^2)^{1/2}\left[\frac{1-3(1-\beta^2)^{1/2}+2(1-\beta^2)}{2\beta}\right]\ln\frac{1-\beta}{1+\beta}\right\}$$

ro = classical electron radius
A = 1/137.04 =fine structure constant
$mc^2$= electron rest mass energy
$h\nu$= incident photon energy
$\beta$ = $v/c$ = velocity ratio , v = photoelectron velocity

Rather than compute an even more complicated L shell photoelectron behavior, the experimentally observed ratio, 1.09, of all photoelectrons to K shell photoelectrons for silicon[18] will be used. The energy of the photoelectron is the photon energy less the electron binding energy; only electrons of this energy appear for a given photon energy. Since displacement calculations will be concerned with electron energies in excess of 100 kev, the 1.8 kev binding energy will be neglected in these calculations.

Pair-Production

Pair-production is the absorption of a photon of energy greater than $2mc^2$, followed by the emission of a positron-electron pair with total energy, including rest mass energy, equal to that of the photon. The same quantum scattering approach described earlier is applied to this case, the only difference being that the electron is initially in a negative energy state. Bethe and Heitler[19] first obtained a solution for pair-production using plane waves for both the positron and electron, using the Born approximation, neglecting screening effects, and including the electron-nucleus interaction as a perturbation term in the interaction relation. Since electron velocity distribution is of interest in the present calculation, the use of the Born approximation leads to difficulty, as the Born approximation requires that $\frac{Z}{137\beta} \ll 1$ . The atomic number of silicon is sufficiently low, but if small electron velocities are to be included in the calculations, the corresponding small value of $\beta$ invalidates the above condition.

[18] Ibid, Davisson, Appendix I.

[19] H. A. Bethe and W. Heitler, Proc. Roy. Soc. (London), A146, 83, (1934).

Hough[20] has noted the difficulty at low electron energies, and has developed an equation with correction terms to the Bethe-Heitler equation.

At low photon energies ($4.2 > \alpha > 2$), Hough's equation leads to the Bethe-Heitler value for equal division of energy by the positron and electron, times a factor which symmetrically reduces the cross section to zero as the kinetic energy either particle approaches the total available kinetic energy. Hough's equation is:

$$\Phi_x = C\,\Phi_0\,p[1+0.135(\Phi_0-0.52)\,p(1-p^2)] \qquad (6)$$

where $\Phi_0$ = Bethe-Heitler equation for equal energy to positron and electron

$$= (1-\gamma)\left[\tfrac{1}{3}(4-\gamma^2)(L-1) - \gamma^2(a-1) - \gamma^4(L-a)\right]$$

$$\gamma = 2/\alpha$$

$$L = [2/(1-\gamma^2)]\,\ln(\alpha/2)$$

$$a = [1/(1-\gamma^2)^{1/2}]\,\ln\left[\left(\frac{\alpha}{2}\right) + \left(\left(\frac{\alpha}{2}\right)^2 - 1\right)^{1/2}\right]$$

$$p = 2[X(1-X)]^{1/2}$$

$X = \dfrac{(TE-1)}{(\alpha-2)}$ = fraction of kinetic energy to electron

$$C = \frac{Z^2 r_0^2}{m_0 c^2}$$

The second term in brackets of equation (6) is the correction term, which is omitted when it is less than zero ($4.2 > \alpha$). Hough gives data showing the good agreement of his equation with the Bethe-Heitler equation for higher energies, and the desired departure from the Bethe-Heitler values for $\alpha < 10$.

Neither the Bethe-Heitler nor Hough treatment account for the slight difference in energy for the positron and electron due to nuclear attraction and repulsion. Evans shows that the positron will receive a maximum of

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[20] P.V.C. Hough, Phys. Rev., 73, 226, (1948).

0.0075 Z Mev more energy than the electron, and this at very low energies. For the present calculations, displacements by positrons will be calculated using the same equations as for electrons, and therefore no attempt to account for the assymetry will be included.

# DISCUSSION OF SCATTERSHOT III COMPUTER CALCULATIONS

## Calculational Procedure

The SCATTERSHOT III computer program is a computational procedure for calculating the electron flux and spectrum in silicon, given an incident photon flux and spectrum. A program remaining to be written will take the data and output of SCATTERSHOT III as input for performing Monte-Carlo calculations of displacement production within small silicon samples. A Monte-Carlo calculation will be used to allow more flexible consideration of several interaction models, of losses due to sample geometry and of competing loss process. The relative significance of the various electron processes and of their effect on correlation with experimental results should be more readily displayed with Monte-Carlo calculations.

In this program the electron flux and spectrum are calculated for a given photon energy, photon flux, and photon spectrum weighting factor. The energy range for possible electron energies is divided into equal increments, and the number of electrons produced in each energy increment is calculated. The calculation is repeated for any number of sets of values for photon energy, flux, and spectrum weight, and a running total of electrons in each energy increment is carried throughout the calculation. Thus for an isotope source having a single energy of photon emission, the calculations are performed for this photon energy value only, and the spectrum weight is unity. For an isotope having several values of photon emission energy, the calculations versus electron energy are repeated for each photon energy, the appropriate weighting factor for each photon energy is used, and a running total of electron flux in each increment is stored in an array. If computations are to be made for an incident photon spectrum, the photon spectrum is divided into any number of energy intervals, a representative energy and fraction of photons in each interval is chosen, and the running total electron flux for each photon energy interval is computed. In each case the final running total electron flux is the desired total electron flux.

Because the photo electron flux is assumed in this program to be mononenergetic for a given incident photon energy, the photoelectron flux is calculated and recorded separately, and is not added into an electron energy increment.

A detailed step-by-step explanation of the calculational procedure along with computer flow charts is given in Appendix I. A copy of the program is also given, and representative data is given in Appendix II.

Program Checkout

After the computer program was debugged of simple errors, a check of calcuated versus published values for each of the three interaction mechanisms was made. For a checkout of the photoelectric scattering equations, values of calculated cross section were compared to those of Davisson.[21] For photon energies of 0.04, 0.10, 0.662 Mev, the differences between Davisson's values and the calculated values are 2.5%. 0.9%, and 5% respectively. In the present calculations, only photon energies greater than about 0.1 Mev are of interest, and the cross section is down by a factor of $10^3$ at 1 Mev, thus the region of significant contribution is also the region of very close agreement by the calculated values.

For calculations at the three values of photon energy of the graphs given by Davisson for Compton interaction[22], the calculated values do not depart by a detectable amount from the curves of Davisson.

Calculated pair production cross sections for photon energies of $4\ m_0c^2$ and $15\ m_0c^2$ were compared to the values taken from Evans[23]. Agreement was observed to within the accuracy of the graphical technique.

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[21] Davisson, Ibid., Appendix 1, p. 833

[22] Davisson, Ibid, p. 57

[23] Evans, Ibid, p. 704.

## Calculations for Several Photon Sources

Using the SCATTERSHOT III program, calculations were made of the electron flux and spectrum in silicon for 250 Kev photons, $Cs^{137}$, $Co^{60}$, $Na^{24}$, and fission gammas. The calculations were normalized to one Roentgen: based on the flux producing one Roentgen (Tables 1 and 2), the corresponding values of photon flux and spectrum weight are given for the various photon components.

An electron energy increment of 0.01 Mev was used, and the number of electrons in each increment was calculated using cross sections calculated for the mid point energy. These computer results are given in Appendix II. The results are presented in terms of differential electron flux versus energy in Figures 2 - 6.

Note that, as mentioned earlier, the Compton effect dominates the electron production. The smooth Compton curves peaking at the maximum electron energy corresponding to each photon component are disturbed noticeably by pair production only for the $Na^{24}$ curve. For each source, the one photoelectron peak occurs at an electron energy greater than the allowed Compton maximum, thus is possibly important in experiments such as displacement threshold determination. For silicon, photoelectric and pair production electrons would be dominant only for very soft or very hard incident photon spectra. The "saw-tooth" electron spectrum shown in Figure 6 for incident photons having a $U^{235}$ fission spectrum should instead be a smooth curve. Because a single representative energy was used for each of the thirteen energy intervals of the incident fission photon flux, a non-existent Compton peak corresponding to each is calculated. This irregularity could be minimized by decreasing the photon energy interval size, i.e., by increasing the number of components in the energy breakdown of the incident photon spectrum. The dashed line in Figure 6 is an estimate of the actual electron spectrum.

## Review of Results

Although the final objective for this study is the calculation of displacement densities, the results of this first phase of the study are informative. Results of the computer tabulations (Appendix II) for

Table 1 - Energy Analysis of Monoenergic Sources
(Calculated from data in Rockwell, Reactor Shielding Design Manual, page 20)

| Source | Photon Energy (Mev) | Normalized Spectrum Weight | Photons per Roentgen $cm^2$ |
|---|---|---|---|
| Idealized X-ray Machine | 0.250 | 1.0 | $7.20 \times 10^9$ |
| $Cs^{137}$ | 0.662 | 1.0 | $2.56 \times 10^9$ |
| $Co^{60}$ | 1.173<br>1.332 | 0.5<br>0.5 | $1.59 \times 10^9$ |
| $Na^{24}$ | 1.380<br>2.758 | 0.5 | $1.10 \times 10^9$ |

Table 2 - Energy Analysis of Prompt Fission Gamma Spectrum
(Calculated from data in Rockwell, Reactor Shielding Design Manual, page 34

| Photon Energy, $h\nu$ (Mev) | Photons per fission in $\frac{1}{2}$ Mev interval about $h\nu$ | Normalized Spectrum Weight |
|---|---|---|
| 0.5 | 3.1 | 0.443 |
| 1.0 | 1.9 | 0.272 |
| 1.5 | 0.84 | 0.120 |
| 2.0 | 0.55 | 0.0789 |
| 2.5 | 0.29 | 0.0415 |
| 3.0 | 0.15 | 0.0214 |
| 3.5 | 0.062 | 0.0089 |
| 4.0 | 0.065 | 0.0093 |
| 4.5 | 0.024 | 0.0034 |
| 5.0 | 0.019 | 0.0027 |
| 5.5 | 0.017 | 0.0024 |
| 6.0 | 0.007 | 0.0010 |
| 6.5 | 0.004 | 0.0006 |

Photon flux for one Roentgen = $1.73 \times 10^9 \frac{\text{photons}}{cm^2}$

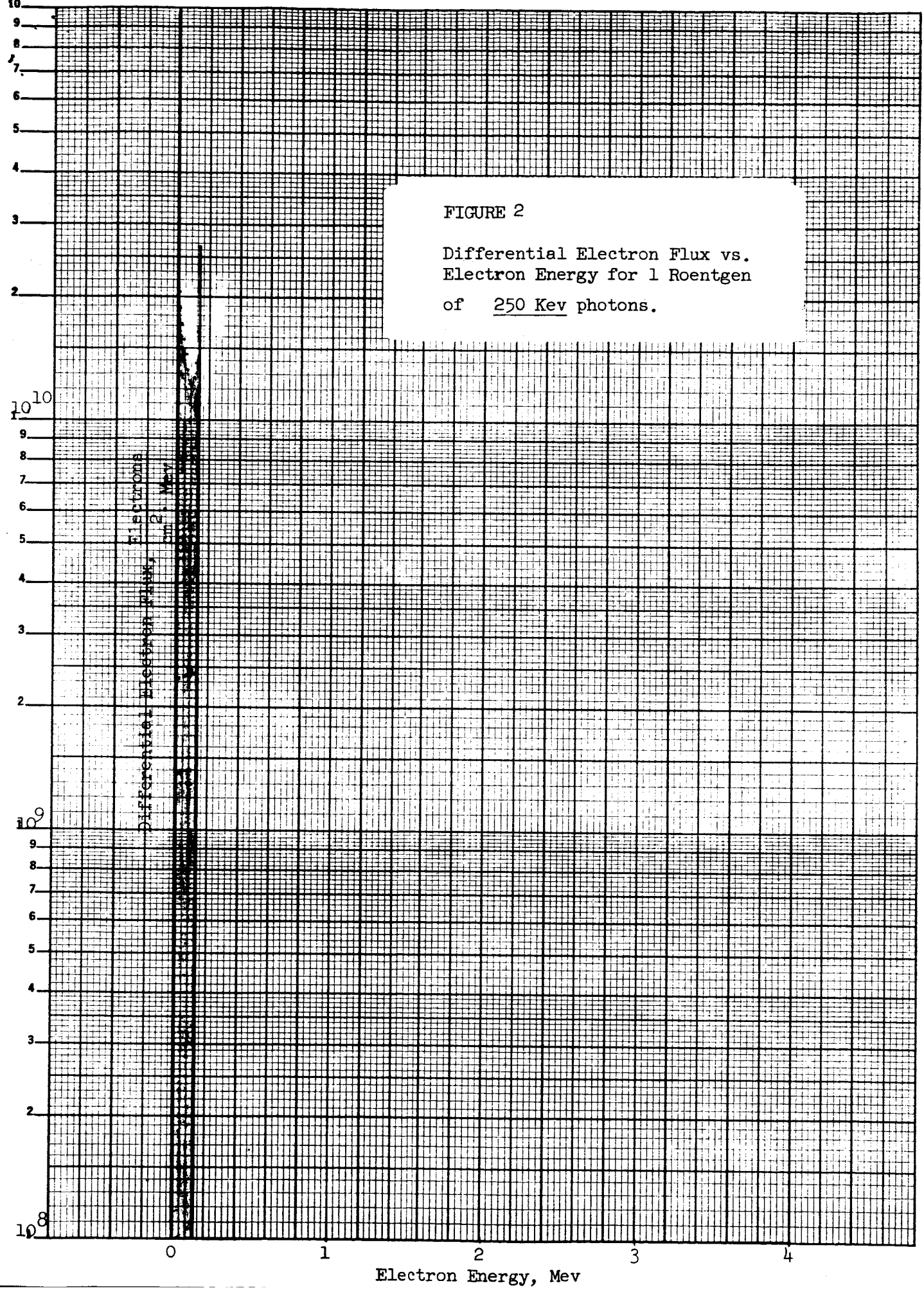



FIGURE 2

Differential Electron Flux vs. Electron Energy for 1 Roentgen of 250 Kev photons.

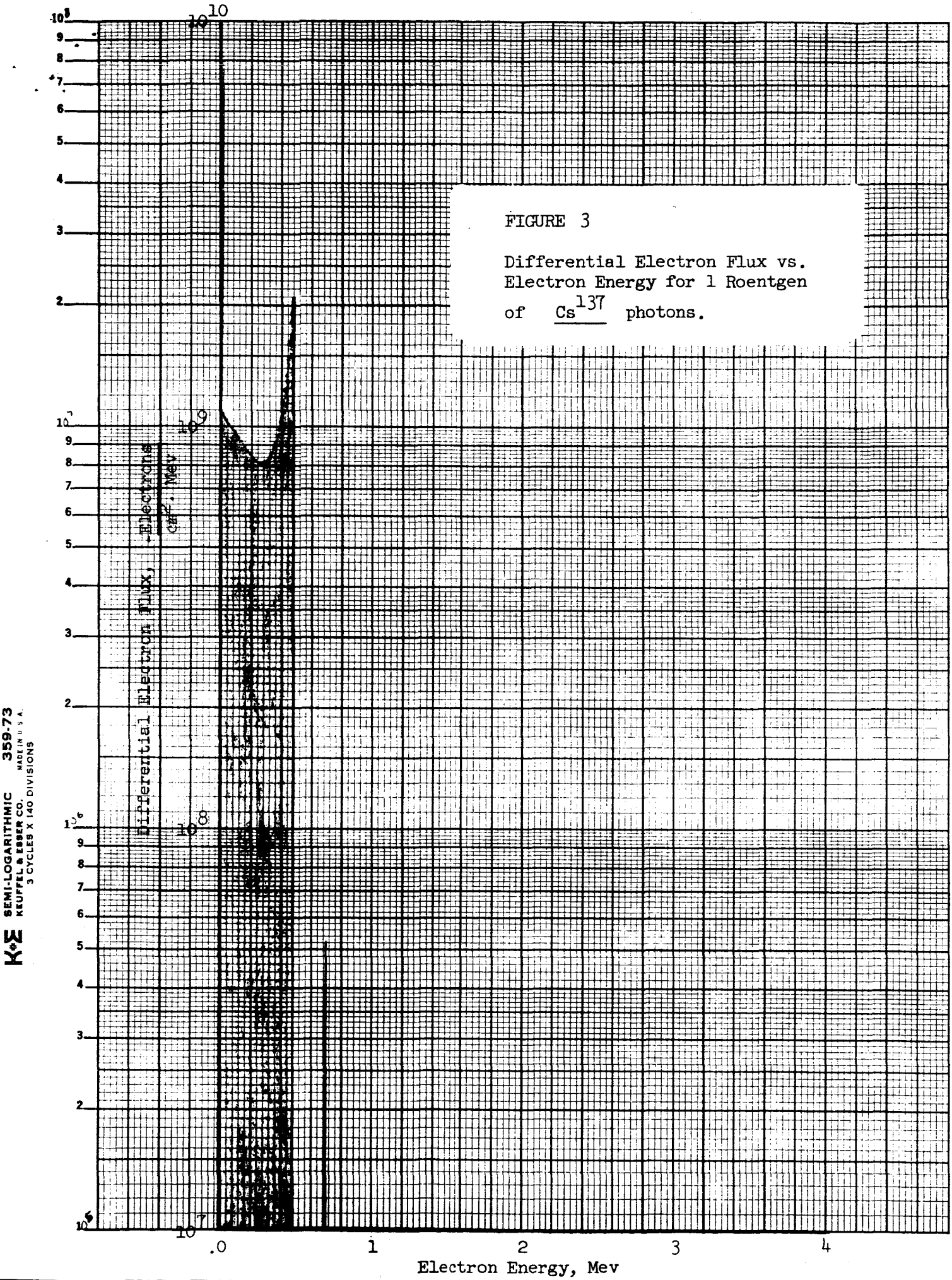



FIGURE 3

Differential Electron Flux vs. Electron Energy for 1 Roentgen of $\underline{Cs^{137}}$ photons.

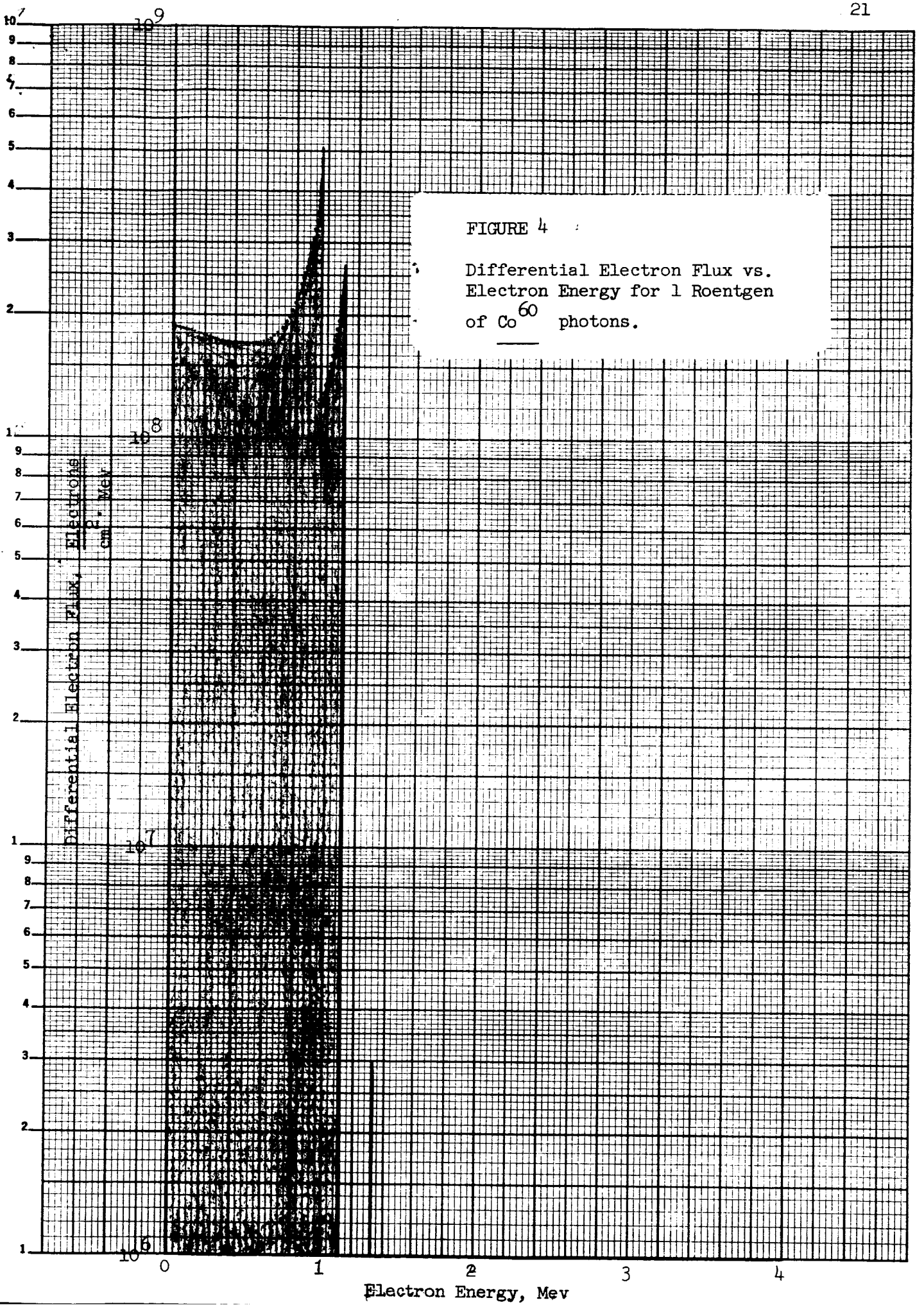



FIGURE 4

Differential Electron Flux vs. Electron Energy for 1 Roentgen of $Co^{60}$ photons.

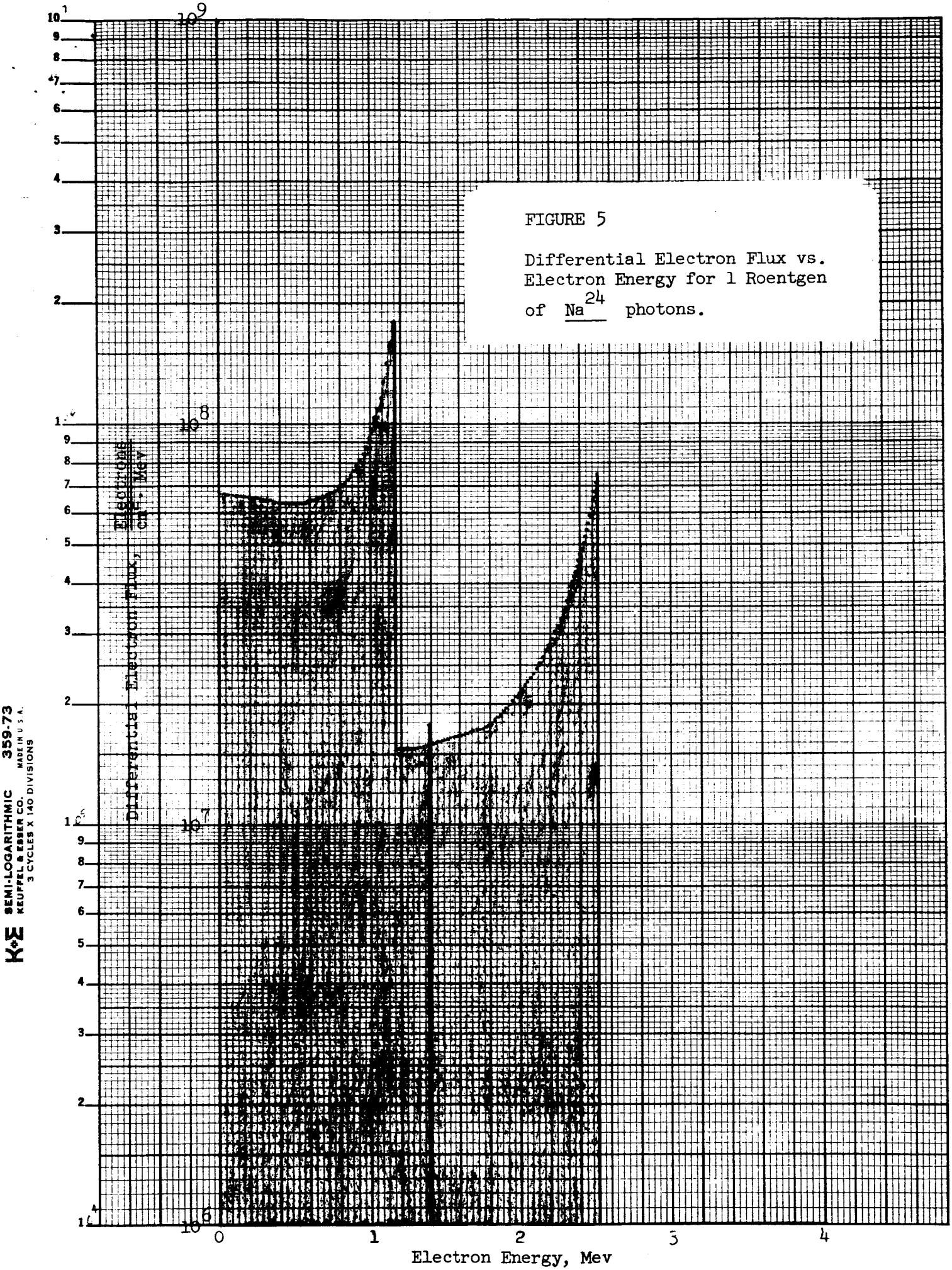



FIGURE 5

Differential Electron Flux vs. Electron Energy for 1 Roentgen of $Na^{24}$ photons.

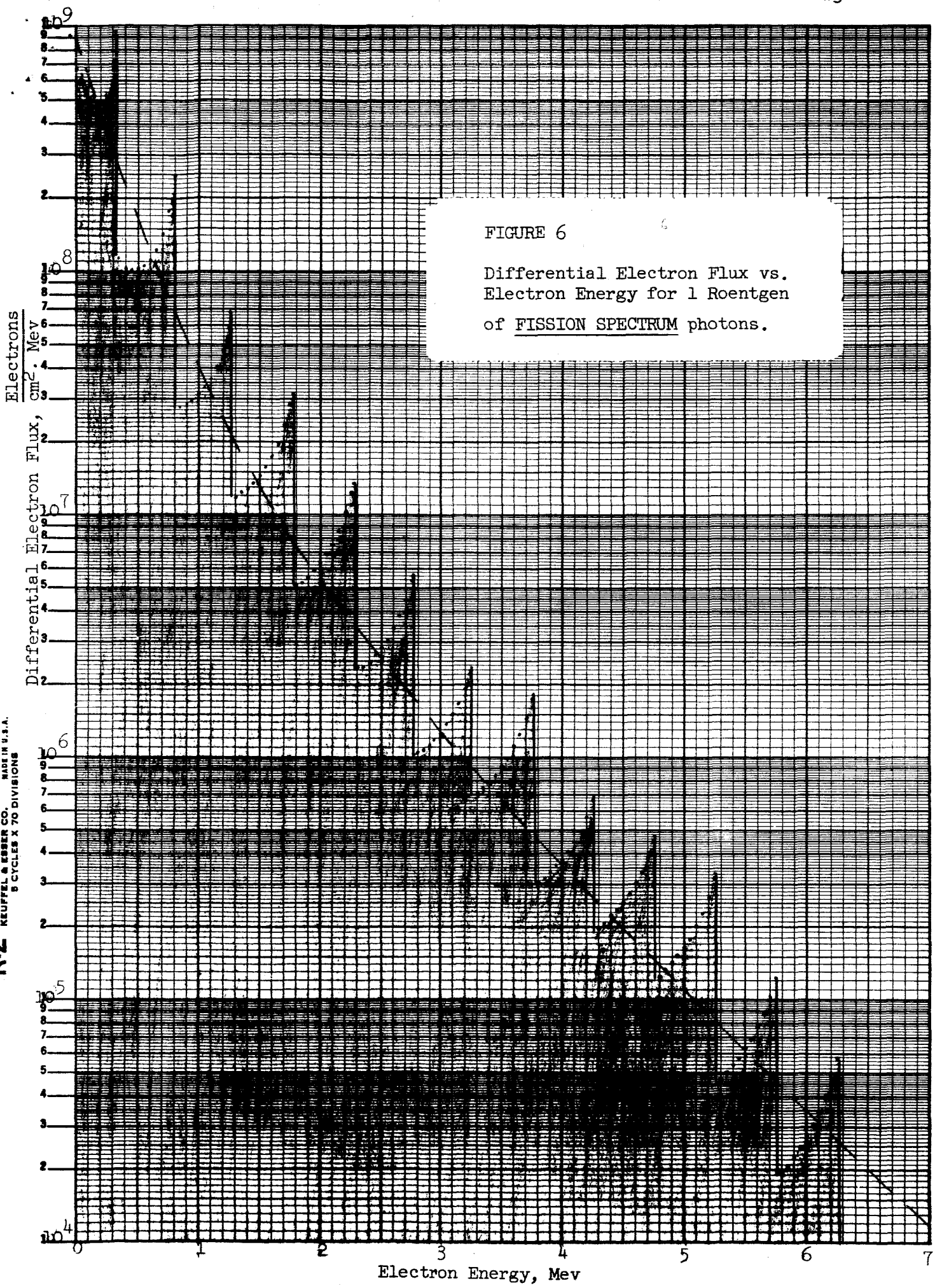
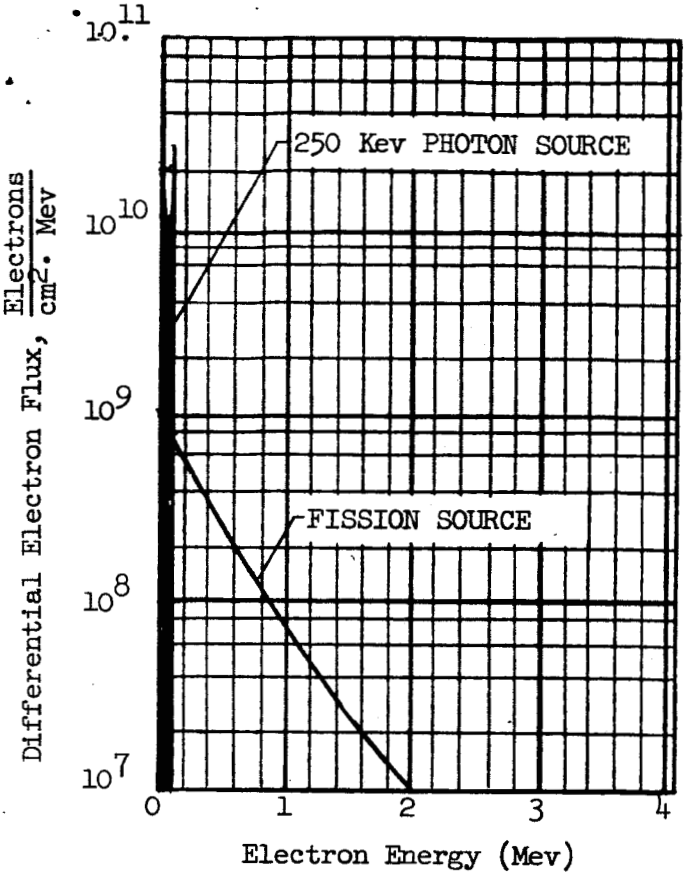
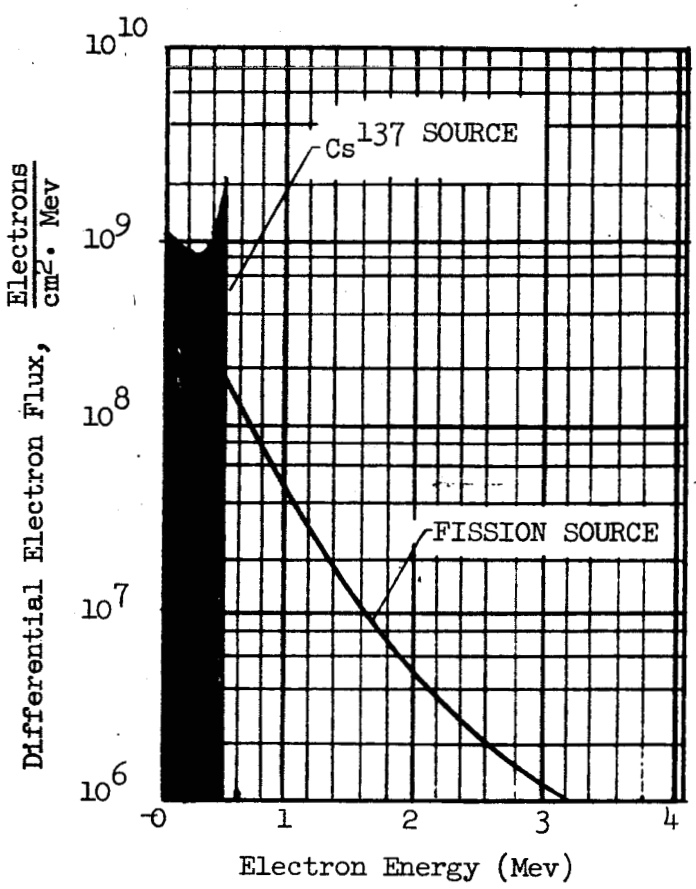
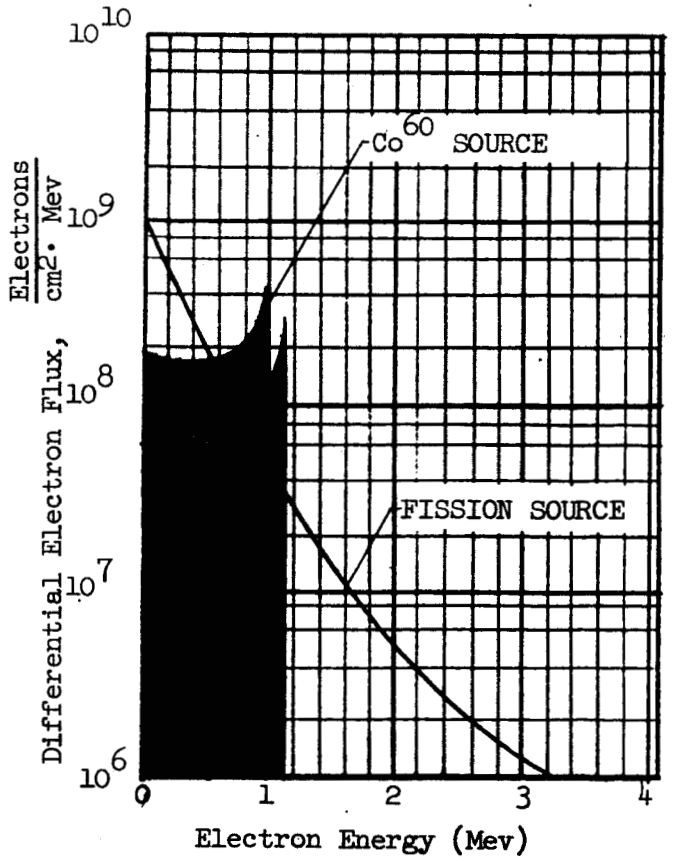



FIGURE 6

Differential Electron Flux vs. Electron Energy for 1 Roentgen of FISSION SPECTRUM photons.



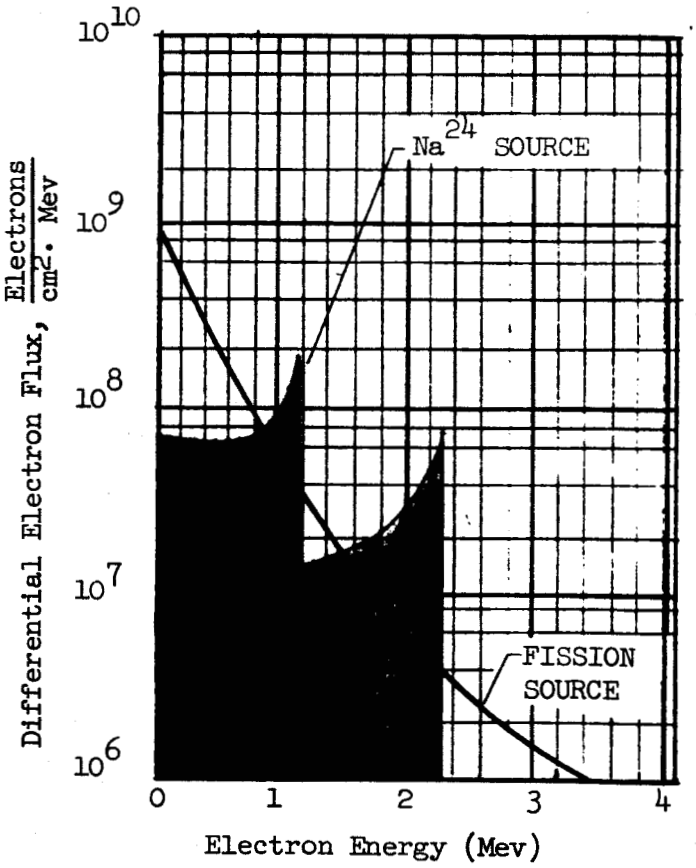




FIGURE 1 - Electron Flux and Spectrum from one Roentgen in Common Sources Compared to Fission Source

electron flux and spectrum are summarized in Figure 7. The electron flux curve from the fission gamma spectrum (Figure 6) is super-imposed on each curve to facilitate visual comparisons. Values at points of interest are given in Table 3.

TABLE 3 Summary of SCATTERSHOT III Results

| Photon Source | Photon Energy (Mev) | Compton Edge Energy (Mev) | Photoelectron Flux of Energy Photon Energy (elec./$cm^2 \cdot R$) | Compton, Pair Electron Flux with Energy > 0.145 Mev, (elec /$cm^2 \cdot R$) |
|---|---|---|---|---|
| 250 Kev Photons | 0.250 | 0.124 | $2.3 \times 10^7$ | 0 |
| $Cs^{137}$ | 0.662 | 0.478 | $5.3 \times 10^5$ | $3.4 \times 10^6$ |
| $Co^{60}$ | 1.173<br>1.332 | 0.963<br>1.118 | $3.9 \times 10^4$<br>$2.8 \times 10^4$ | $1.9 \times 10^6$ |
| $Na^{24}$ | 1.380<br>2.758 | 1.164<br>2.524 | $1.8 \times 10^4$<br>$3.4 \times 10^3$ | $1.14 \times 10^6$ |

In the first section of this report, a minimum displacement threshold by electrons of 0.145 Mev was reported. From Table 6, it is seen that the Compton flux from 250 Kev photons has a maximum energy of 0.124 Mev, and cannot produce displacements. The only electron component from 250 Kev photons of sufficient energy to cause displacements is the $2.3 \times 10^7$ electrons/$cm^2 \cdot R$ photo electron flux of energy (0.250 Mev - electron binding energy). Note, however, that the photoelectron component alone is greater than six time the total electron component of any other source. The significance of the knock-on collisions as displayed in Figure 1 now becomes apparent, since the data in Table 6 would **infer** that Roentgen-per-Roentgen, the lower energy photons are more efficient for displacement production. That this is not the case is indicated by reported experimental results.[24]

An alternate explanation for the greater effectiveness for damage

[24] J. W. Cleland, R. F. Bass, and J. H. Crawford, Proceedings of the 7th International Conference on Physics of Semiconductors, Vol. 3, Academic Press (1965), p. 402.

production by higher energy photons discussed by Cleland, et. al., is that the nature of the defect formed might depend on electron energy. The lower energy electrons might be producing large numbers of defects, but of unstable types which might anneal at low temperature. Although the measurements cited were made at $77^{\circ}K$, the irradiations were conducted at $40^{\circ}C$.

Very large discrepancies ( $\sim 2000$) between predicted and observed displacement rates are reported by Cleland, et. al., for low energy sources as $Cs^{137}$. Additional experiments using the large photopeak electron fluxes from various low energy isotope photon sources might be used to explore displacement producton in the low energy range.

With regard to the applied practice of simulating gamma radiation effects damage from fission spectra by using isotope sources, the possible uncertainty is apparent. Certainly the Roentgen-per-Roentgen comparison commonly used could result in underestimates of radiation damage in silicon by factors of 1000 or greater if low energy isotope or x-ray sources are used for the irradiation testing. An analytical method for correlating data between sources will require additional clarification of existing concepts of the electron-produced displacement process. The next phase of this program will be an investigation of this process.

An alternate approach to the applied problem not requiring an extension into areas poorly defined at present, would be to use combinations of isotope sources to stimulate the electron spectrum produced by the fission (or other) photon source. It is the secondary electron flux and spectrum, not the incident gamma flux and spectrum which must be simulated in radiation damage experiments. The required intensity from several isotopes could be calculated using SCATTERSHOT III, to match the electron flux and spectrum calculated for the photon spectrum of a mission source. Thus the radiation damage inside a semiconductor device in the isotope-combination source would accurately approximate that from a mission gamma flux and spectrum, regardless of the complexities of the electron-nucleus interaction or of subsequent defect motion.

# APPENDIX I

## The SCATTERSHOT III Program

Figure 8 shows a flow diagram of the computer calculation procedure. Although the immediate interest is in silicon, atomic number was left as a parameter which may be varied within the limitations to low Z for the photon cross section models used.

Referring to the numbers on the flow chart of Figure 8, the steps in the program are:

1) Read in the values of atomic number and atomic density from the first data card.

2) Read in one set of values of photon energy, photon flux, and spectrum weight. When no more sets of values (i.e., data cards) are available, transfer control to lable STOP which terminates calculations.

3) Write headings to show the set of values from step 2 for which calculations are being made.

4) Calculate and write out photoelectron flux in the sample for the given input parameters. The calculation is based on the cross section equation of Platt, equation 5, and is shown in the flow chart of Figure 9. The first five calculations are relativity constants used later in the calculation, and AZ is the fine structure constant. Photo-electron flux (PEFLX) is calculated using the cross section (TAU). Although not shown in the flow chart, the ratio 1.09 of all photoelectrons to K shell photoelectrons for silicon is included as discussed earlier.

5) Calculate and write out the maximum energy (TCMAX) of Compton electrons for the given input data set. The differential Compton electron flux at TCMAX is also calculated and written.

6) Test to see whether the photon energy is less than the required 1.02 Mev required for pair production. If YES, proceed with calcula- of Compton electron flux only; if no, begin the calculation of Compton and pair production flux. Both processes give a spectrum of electron energies, thus the number of electrons in equal inter -

vals of electron energy are calculated and written versus the mid point energy.

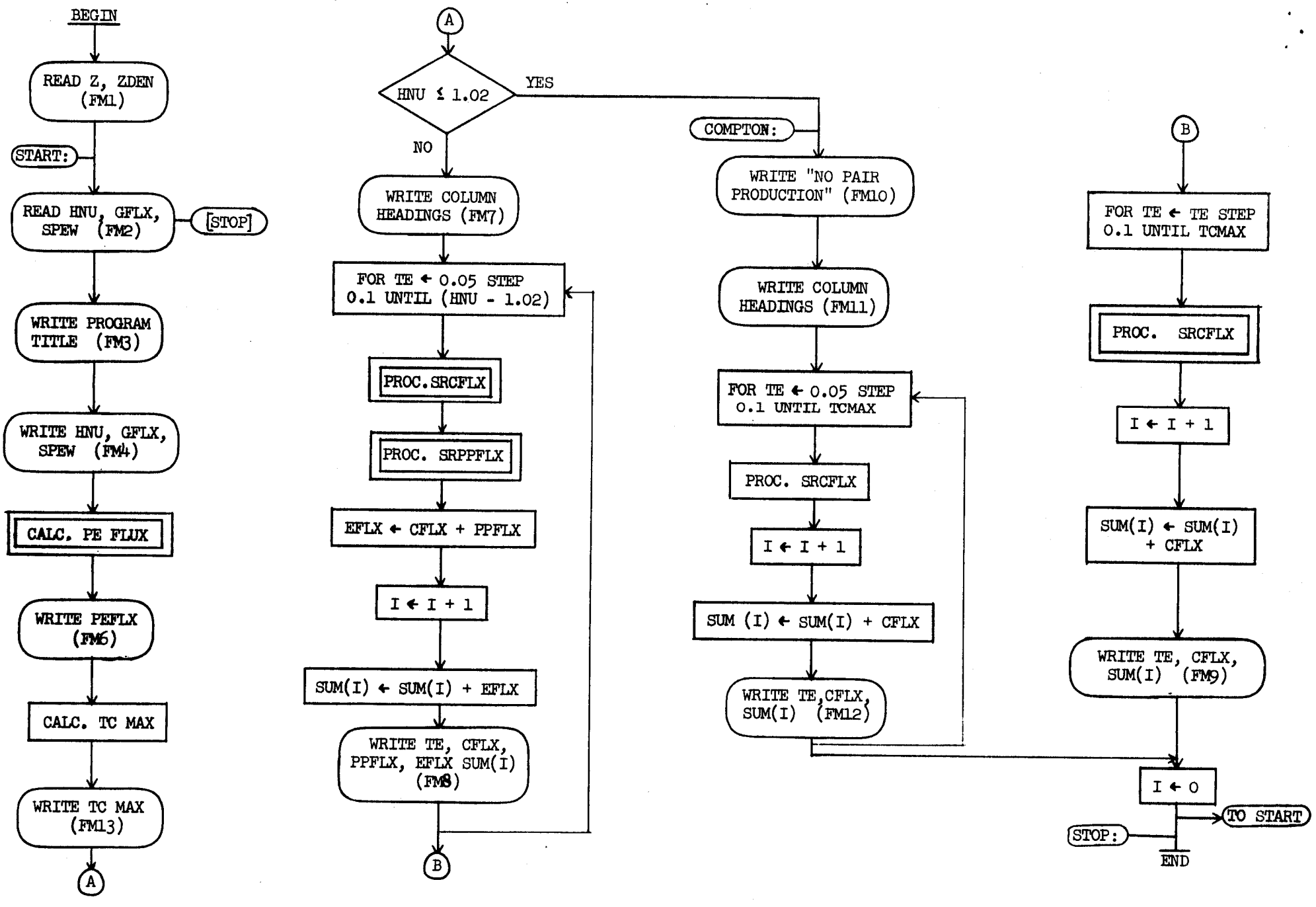
7a) These steps represent the calculation of Compton and pair production electron flux for electron energies from zero to the maximum for pair production. The calculation is repeated for each electron energy increment, and the accumulated flux for that increment is stored in the array, SUM [I] . The procedures for Compton flux (CFLX) and pair production flux (PPFLX) given in Figures 10 and 11 are straightforward application of the cross section equations (3) and (5) developed in the section on photon interaction models.

7b) Calculation of Compton electron flux is continued from 7a for electron energies greater than the maximum possible from pair production. For all values of incident photon energy, the difference between the photon energy and the Compton edge is less than 1.02, thus TCMAX $(h\nu - 1.02)$.

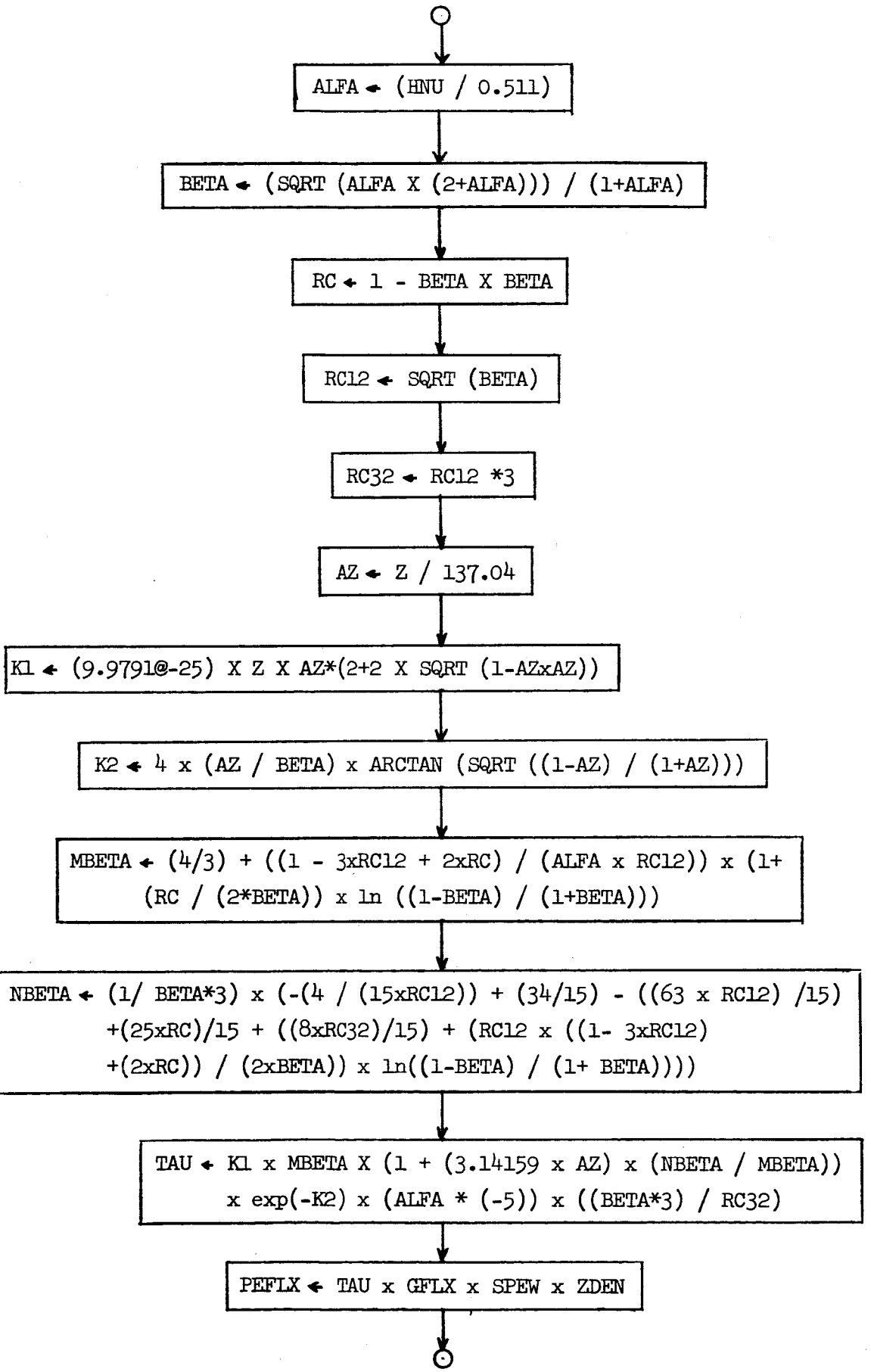
8) The alternate path to 7a and 7b is the calculation of Compton flux only for photon energies less than 1.02 Mev, the pair production threshold.

9) The index of the array is reset to zero before returning to START (Step 2) to go through the complete calculation for the next photon energy component.

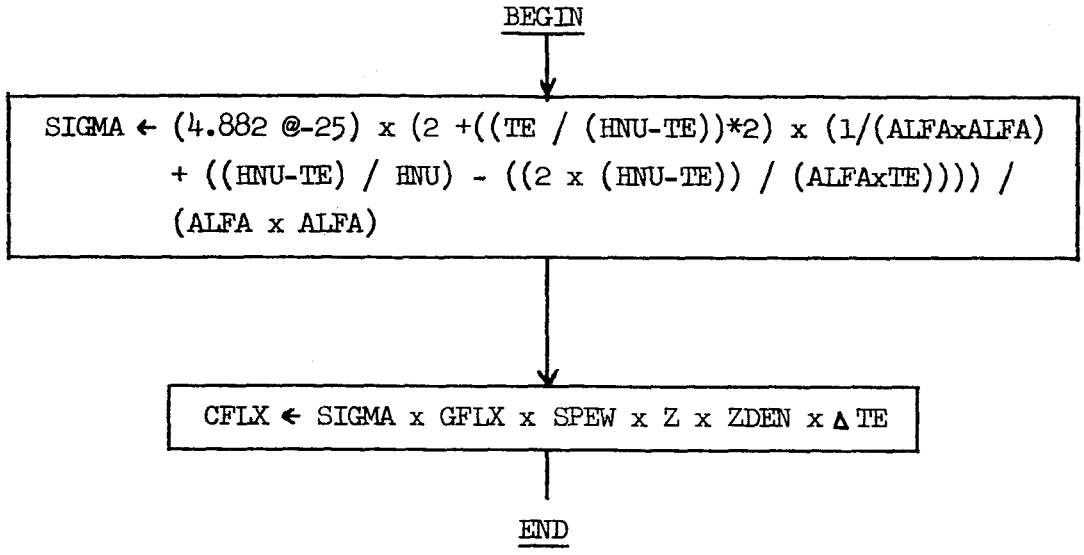
10) If no more values of photon energy are available, control is transferred to STOP to terminate the program. The electron flux values for the last printout of the array sum [I], labeled Running Total Electron Flux, is the total electron flux in the sample.

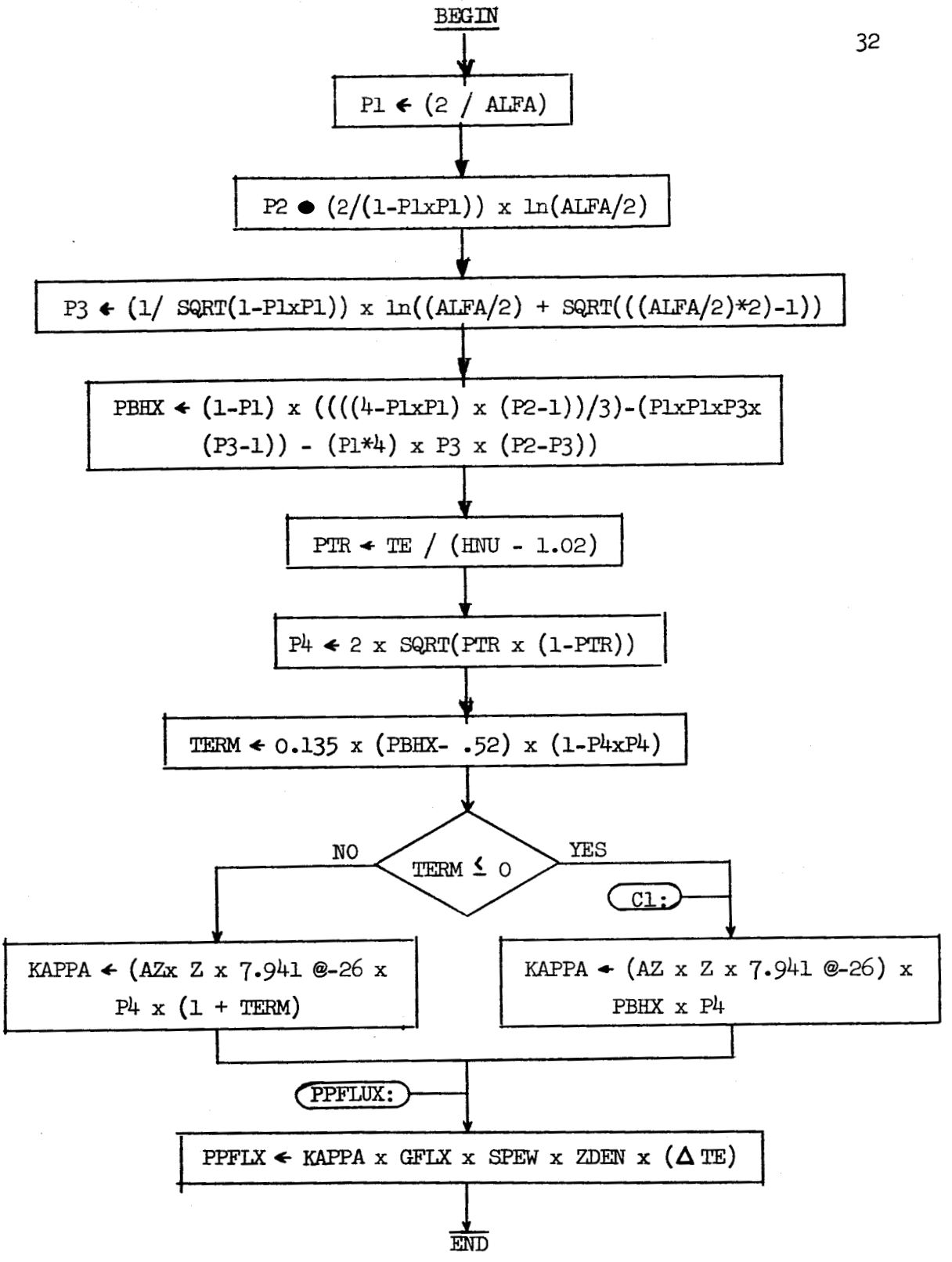

BEGIN
READ Z, ZDEN (FM1)
START:
READ HNU, GFLX, SPEW (FM2)
[STOP]
WRITE PROGRAM TITLE (FM3)
WRITE HNU, GFLX, SPEW (FM4)
CALC. PE FLUX
WRITE PEFLX (FM6)
CALC. TC MAX
WRITE TC MAX (FM13)
A
A
HNU ≤ 1.02
YES
NO
WRITE COLUMN HEADINGS (FM7)
FOR TE ← 0.05 STEP 0.1 UNTIL (HNU - 1.02)
PROC. SRCFLX
PROC. SRPPFLX
EFLX ← CFLX + PPFLX
I ← I + 1
SUM(I) ← SUM(I) + EFLX
WRITE TE, CFLX, PPFLX, EFLX SUM(I) (FM8)
B
COMPTON:
WRITE "NO PAIR PRODUCTION" (FM10)
WRITE COLUMN HEADINGS (FM11)
FOR TE ← 0.05 STEP 0.1 UNTIL TCMAX
PROC. SRCFLX
I ← I + 1
SUM (I) ← SUM(I) + CFLX
WRITE TE, CFLX, SUM(I) (FM12)
B
FOR TE ← TE STEP 0.1 UNTIL TCMAX
PROC. SRCFLX
I ← I + 1
SUM(I) ← SUM(I) + CFLX
WRITE TE, CFLX, SUM(I) (FM9)
I ← 0
TO START
STOP:
END

"PROCEDURE" PEFLUX



PROCEDURE SRCFLX






PROCEDURE PPFLX

```
0)  ALGOL  COMPILER-GEORGIA  INSTITUTE  OF  TECH
                                        JANUARY  3, 1966
BEGIN

      FILE IN CARD (2,10);
      FILE OUT PRINT 6(2,15);
      INTEGER I;
      REAL    ALFA, BETA, RC, RC12, RC32, AZ, K1, K2, MBETA, NBETA, TAU,
              PEFLX;
      REAL    Z, ZOEN, HNU, GFLX, SPEW;
      REAL    TCMAX, TE, SIGMA, CFLX, P1, P2, P3, P4, PTR, PHHX, TERM,
              KAPPA,EFLX,PPFLX;
 COMMENT; FIRST DATA CARD CONTAINS ATOMIC NUMBER OF TARGET,DENSITY OF
          ATOMS PER CC OF TARGET  (FORMAT FM1),
          FOLLOWING DATA CARDS EACH CONTAIN PHOTON ENERGY IN MEV, GAMMA
          FLUX IN PHOTONS PER CC, SPECTRUM WEIGHT AS NORMALIZED RATIO,
          (FORMAT  FM2),  ANY NUMBER OF CARDS IN F42 MAY BE USED;
    FORMAT   FM1(I5,X15,E10.3), FM2(F10.5,X10,E10.3,X10,E10.3),

    FM3("SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC
,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM" ///),
    FM4(X5,"CALCULATION FOR:   GAMMA FLUX=",E10.3," PHOTONS /(SQ.CM.)(S
EC.)" ,/,X25,"GAMMA ENERGY=",F10.3," MEV"/,X25,"SPECTRUM WEIGHT=",E10.3
,///),
    FM6(X10,    "THE PHOTOELECTRON FLUX IS",E10.3," ELECTRONS/SQ.CM."/),
    FM7("ELECTRON ENERGY",X5,"COMPTON FLUX",X8,"PAIR PRODUCTION FLUX",
      X10,"PARTIAL SUM",X13,"RUNNING TOTAL"/,X4,"(MEV)",X60,
      "ELECTRON FLUX",X12,"ELECTRON FLUX",/),
    FM8(X3,F6.3,X11,E10.3,X15,E10.3,X15,E10.3,X15,E10.3),
    FM9(X3,F4.3,X11,E10.3,X45,E10.3),
    FM10(X5,"INCIDENT PHOTON ENERGY IS LESS THAN THE PAIR PRODUCTION THRE
SHOLD" //),
    FM11("ELECTRON ENERGY",X5,"COMPTON (TOTAL) FLUX" ,  X54,
      "RUNNING TOTAL",/,X4,"(MEV)",X45, "ELECTRON FLUX"),
    FM12(X3,F6.3,X16,E10.3,X60,E10.3);

     FORMAT  FM13 ( X10, " THE VALUE OF TCMAX IS  " , F6.3,  "  MEV",/

X10, "THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS ",E10.3,
       " ELECTRONS/SQ CM "//);

  ARRAY  SUM[0:1900];
     LABEL    COMPTON,FINISH,START,STOP;
     PROCEDURE SRCFLX;
  COMMENT ; THIS PROCEDURE CALCULATES COMPTON ELECTRON FLUX;
  BEGIN
     SIGMA+(4.882    E-25)* (2+((TE/(HNU-TE))*2)* (1/(ALFA*ALFA)+((HNU-TE)
          /HNU)-((2*(HNU-TE))/ (ALFA*TE))))/ (ALFA*ALFA));
     CFLX + GFLX * SPEW * SIGMA *Z  * ZOEN   *.01   ;
  END;
     PROCEDURE SRPPFLX;
  COMMENT ; THIS PROCEDURE CALCULATES   PAIR  ELECTRON FLUX;
  BEGIN
     LABEL   C1, C2,   PPFLUX;

     P1 + 2/ALFA;
     P2 + (2/(1-(P1*P1)))* LN(ALFA/2);
     P3 + (1/SQRT(1- P1*P1)) * LN((ALFA/2) + SQRT(((ALFA/2)*2)-1));
     PHHX + (1-P1)* ((((4-P1*P1)* (P2-1) ) /3)- (P1*P1*P3*(P3-1)) -(P1+4)
          * P3 * (P2-P3)));
     PTR + TE / (HNU - 1.022);
     P4 + 2*SQRT(PTR* (1-PTR));
     TERM + 0.135 * (PHHX - 0.52) * P4 * (1-P4*P4)   ;
       IF TERM ≤ 0 THEN GO TO C1;
     KAPPA +(AZ*Z*7.941E-26) *PHHX * P4* (1+ TERM)/(HNU - 1.022));
       GO TO PPFLUX;
     C1: KAPPA+(AZ*Z*7.941    E-26)* PHHX * P4/(HNU - 1.022));
     PPFLUX: PPFLX + GFLX * SPEW * KAPPA * ZOEN *.01
  END;

START;
     COMMENT; BEGINNING OF CALCULATION;
     (1) READ (CARD, FM1, I,ZOEN);
     START:
     (2) READ (CARD, FM2, HNU,GFLX,SPEW) [STOP];
     (3) WRITE (PRINT,FM3);
     WRITE (PRINT,FM4, GFLX, HNU, SPEW);
     COMMENT; BEGINNING OF CALCULATION OF PHOTOELECTRON FLUX;
       ALFA + HNU/0.511;
       BETA + (SQRT(ALFA * (2+ ALFA ))) / ( 1 + ALFA );
       RC + 1- BETA * BETA ;
       RC12 + SQRT(RC);
       RC32 + RC12*3;
       AZ + Z/137.04;
START (4) K1 +(9.9791E-25)*Z*AZ*(2+2*SQRT(1-AZ*AZ));
       K2 + 4*(AZ/BETA)*ARCTAN(SQRT((1-AZ)/(1+AZ)));
       MBETA + (4/3)+((1-3*RC12 + 2*RC) /(ALFA*RC12))*(1+(RC/(2*BETA))*
             LN((1-BETA) / (1+BETA)));
       NBETA +(1/BETA*3)*(-(4/(15*RC12))+(34/15)-((63*RC12)/15)+(25*RC)/15
            +((8*RC32) /15) + (RC12 * ((1-(3*RC12) + (2*RC)) / (2*BETA)) *
              LN((1-BETA)/(1+BETA))));
       TAU + K1*MBETA*(1+(3.14159*AZ)* (NBETA/MBETA))* EXP(-K2)
                 *(ALFA*(-5))  * (( BETA * (3)) / RC32));
       PEFLX + GFLX * SPEW * TAU * ZOEN        ;
     WRITE(PRINT,FM6, PEFLX);
     COMMENT; BEGINNING OF CALCULATION OF COMPTON AND PAIR ELECTRON FLUX;
       TCMAX + HNU/(1+(1/(2*ALFA)));
       TE+ TCMAX;
       SRCFLX;
     (5) WRITE (PRINT,FM13,TCMAX,CFLX);
       I+ 0;
     (6) IF HNU ≤1.022  THEN GO TO COMPTON;
3    WRITE (PRINT,FM7);
     (7a) FOR TE+0.005 STEP .01 UNTIL (HNU - 1.022)  DO
START BEGIN
       SRCFLX;
       SRPPFLX;
4      EFLX + CFLX + PPFLX;
       I+ I+1;
       SUM[I]  + SUM[I] + EFLX ;
     WRITE (PRINT, FM8, TE,CFLX,PPFLX,EFLX, SUM[I]);
     END;
     (7b) FOR TE + TE       STEP  .01 UNTIL(TCMAX)DO
     BEGIN
       SRCFLX ;
       I+ I+1;
       SUM[I]  + SUM[I] + CFLX ;
     WRITE (PRINT, FM9, TE,CFLX ,SUM[I]);
     END;
       GO TO FINISH ;
     COMPTON;
START (8) WRITE(PRINT,FM10);
     WRITE(PRINT,FM11);
       FOR TE + 0.005    STEP .01 UNTIL TCMax DO
     BEGIN



       SRCFLX;
       I+ I+1;
       SUM[I]  + SUM[I] + CFLX ;
     WRITE (PRINT,FM12, TE,CFLX,SUM[I]) ;
     END;
     FINISH;
     (9)    WRITE (PRINT (PAGE));
       GO TO START;
     (10) STOP;
     END.
```

APPENDIX II: Data from SCATTERSHOT III Calculations

FOR: -250 Kev Source
-$Cs^{137}$ Gamma Source
-$Co^{60}$ Gamma Source
-$Na^{24}$ Gamma Source
- Fission Gamma Source

SCATTERSHOT III - A H-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 7.200E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 0.250 MEV
SPECTRUM WEIGHT= 1.000E+00

THE PHOTOELECTRON FLUX IS 2.303E+07 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 0.124 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 2.650E+08 ELECTRONS/SQ CM

INCIDENT PHOTON ENERGY IS LESS THAN THE PAIR PRODUCTION THRESHOLD

| ELECTRON ENERGY (MEV) | COMPTON (TOTAL) FLUX | RUNNING TOTAL ELECTRON FLUX |
|---|---|---|
| 0.005 | 2.047E+08 | 2.047E+08 |
| 0.015 | 1.878E+08 | 1.878E+08 |
| 0.025 | 1.716E+08 | 1.716E+08 |
| 0.035 | 1.566E+08 | 1.566E+08 |
| 0.045 | 1.434E+08 | 1.434E+08 |
| 0.055 | 1.325E+08 | 1.325E+08 |
| 0.065 | 1.249E+08 | 1.249E+08 |
| 0.075 | 1.221E+08 | 1.221E+08 |
| 0.085 | 1.257E+08 | 1.257E+08 |
| 0.095 | 1.384E+08 | 1.384E+08 |
| 0.105 | 1.638E+08 | 1.638E+08 |
| 0.115 | 2.071E+08 | 2.071E+08 |

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC, COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 2.560E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 0.662 MEV
SPECTRUM WEIGHT= 1.000E+00

THE PHOTOELECTRON FLUX IS 5.311E+05 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 0.478 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 2.094E+07 ELECTRONS/SQ CM

INCIDENT PHOTON ENERGY IS LESS THAN THE PAIR PRODUCTION THRESHOLD

| ELECTRON ENERGY (MEV) | COMPTON (TOTAL) FLUX | RUNNING TOTAL ELECTRON FLUX |
|---|---|---|
| 0.005 | 1.076E+07 | 1.076E+07 |
| 0.015 | 1.063E+07 | 1.063E+07 |
| 0.025 | 1.051E+07 | 1.051E+07 |
| 0.035 | 1.038E+07 | 1.038E+07 |
| 0.045 | 1.026E+07 | 1.026E+07 |
| 0.055 | 1.013E+07 | 1.013E+07 |
| 0.065 | 1.001E+07 | 1.001E+07 |
| 0.075 | 9.885E+06 | 9.885E+06 |
| 0.085 | 9.763E+06 | 9.763E+06 |
| 0.095 | 9.643E+06 | 9.643E+06 |
| 0.105 | 9.523E+06 | 9.523E+06 |
| 0.115 | 9.405E+06 | 9.405E+06 |
| 0.125 | 9.290E+06 | 9.290E+06 |
| 0.135 | 9.176E+06 | 9.176E+06 |
| 0.145 | 9.065E+06 | 9.065E+06 |
| 0.155 | 8.956E+06 | 8.956E+06 |
| 0.165 | 8.851E+06 | 8.851E+06 |
| 0.175 | 8.750E+06 | 8.750E+06 |
| 0.185 | 8.653E+06 | 8.653E+06 |
| 0.195 | 8.561E+06 | 8.561E+06 |
| 0.205 | 8.475E+06 | 8.475E+06 |
| 0.215 | 8.395E+06 | 8.395E+06 |
| 0.225 | 8.322E+06 | 8.322E+06 |
| 0.235 | 8.258E+06 | 8.258E+06 |
| 0.245 | 8.203E+06 | 8.203E+06 |
| 0.255 | 8.159E+06 | 8.159E+06 |
| 0.265 | 8.128E+06 | 8.128E+06 |
| 0.275 | 8.111E+06 | 8.111E+06 |
| 0.285 | 8.110E+06 | 8.110E+06 |
| 0.295 | 8.128E+06 | 8.128E+06 |
| 0.305 | 8.168E+06 | 8.168E+06 |
| 0.315 | 8.233E+06 | 8.233E+06 |
| 0.325 | 8.326E+06 | 8.326E+06 |
| 0.335 | 8.453E+06 | 8.453E+06 |
| 0.345 | 8.618E+06 | 8.618E+06 |
| 0.355 | 8.828E+06 | 8.828E+06 |
| 0.365 | 9.091E+06 | 9.091E+06 |
| 0.375 | 9.416E+06 | 9.416E+06 |
| 0.385 | 9.813E+06 | 9.813E+06 |
| 0.395 | 1.030E+07 | 1.030E+07 |
| 0.405 | 1.088E+07 | 1.088E+07 |
| 0.415 | 1.159E+07 | 1.159E+07 |

| | | |
|---|---|---|
| 0.425 | 1.244E+07 | 1.244E+07 |
| 0.435 | 1.347E+07 | 1.347E+07 |
| 0.445 | 1.471E+07 | 1.471E+07 |
| 0.455 | 1.621E+07 | 1.621E+07 |
| 0.465 | 1.804E+07 | 1.804E+07 |
| 0.475 | 2.027E+07 | 2.027E+07 |

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC, COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.590@+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 1.173 MEV
SPECTRUM WEIGHT= 5.000@-01

THE PHOTOELECTRON FLUX IS 3.876@+04 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 0.963 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 3.088@+06 ELECTRONS/SQ CM

| ELECTRON ENERGY (MEV) | COMPTON FLUX | PAIR PRODUCTION FLUX | PARTIAL SUM ELECTRON FLUX | RUNNING TOTAL ELECTRON FLUX |
|---|---|---|---|---|
| 0.005 | 1.068@+06 | 6.566@+02 | 1.069@+06 | 1.069@+06 |
| 0.015 | 1.064@+06 | 1.098@+03 | 1.066@+06 | 1.066@+06 |
| 0.025 | 1.061@+06 | 1.364@+03 | 1.062@+06 | 1.062@+06 |
| 0.035 | 1.057@+06 | 1.548@+03 | 1.058@+06 | 1.058@+06 |
| 0.045 | 1.053@+06 | 1.678@+03 | 1.054@+06 | 1.054@+06 |
| 0.055 | 1.049@+06 | 1.766@+03 | 1.051@+06 | 1.051@+06 |
| 0.065 | 1.045@+06 | 1.817@+03 | 1.047@+06 | 1.047@+06 |
| 0.075 | 1.041@+06 | 1.835@+03 | 1.043@+06 | 1.043@+06 |
| 0.085 | 1.038@+06 | 1.820@+03 | 1.039@+06 | 1.039@+06 |
| 0.095 | 1.034@+06 | 1.772@+03 | 1.036@+06 | 1.036@+06 |
| 0.105 | 1.030@+06 | 1.689@+03 | 1.032@+06 | 1.032@+06 |
| 0.115 | 1.027@+06 | 1.564@+03 | 1.028@+06 | 1.028@+06 |
| 0.125 | 1.023@+06 | 1.385@+03 | 1.024@+06 | 1.024@+06 |
| 0.135 | 1.019@+06 | 1.129@+03 | 1.021@+06 | 1.021@+06 |
| 0.145 | 1.016@+06 | 7.168@+02 | 1.017@+06 | 1.017@+06 |
| 0.155 | 1.013@+06 | | | 1.013@+06 |
| 0.165 | 1.009@+06 | | | 1.009@+06 |
| 0.175 | 1.006@+06 | | | 1.006@+06 |
| 0.185 | 1.002@+06 | | | 1.002@+06 |
| 0.195 | 9.992@+05 | | | 9.992@+05 |
| 0.205 | 9.960@+05 | | | 9.960@+05 |
| 0.215 | 9.929@+05 | | | 9.929@+05 |
| 0.225 | 9.898@+05 | | | 9.898@+05 |
| 0.235 | 9.868@+05 | | | 9.868@+05 |
| 0.245 | 9.839@+05 | | | 9.839@+05 |
| 0.255 | 9.810@+05 | | | 9.810@+05 |
| 0.265 | 9.782@+05 | | | 9.782@+05 |
| 0.275 | 9.755@+05 | | | 9.755@+05 |
| 0.285 | 9.729@+05 | | | 9.729@+05 |
| 0.295 | 9.704@+05 | | | 9.704@+05 |
| 0.305 | 9.680@+05 | | | 9.680@+05 |
| 0.315 | 9.656@+05 | | | 9.656@+05 |
| 0.325 | 9.634@+05 | | | 9.634@+05 |
| 0.335 | 9.613@+05 | | | 9.613@+05 |
| 0.345 | 9.593@+05 | | | 9.593@+05 |
| 0.355 | 9.574@+05 | | | 9.574@+05 |
| 0.365 | 9.557@+05 | | | 9.557@+05 |
| 0.375 | 9.541@+05 | | | 9.541@+05 |
| 0.385 | 9.526@+05 | | | 9.526@+05 |
| 0.395 | 9.513@+05 | | | 9.513@+05 |
| 0.405 | 9.502@+05 | | | 9.502@+05 |
| 0.415 | 9.492@+05 | | | 9.492@+05 |
| 0.425 | 9.484@+05 | | | 9.484@+05 |
| 0.435 | 9.478@+05 | | | 9.478@+05 |

| | | |
|---|---|---|
| 0.445 | 9.474E+05 | 9.474E+05 |
| 0.455 | 9.472E+05 | 9.472E+05 |
| 0.465 | 9.473E+05 | 9.473E+05 |
| 0.475 | 9.476E+05 | 9.476E+05 |
| 0.485 | 9.481E+05 | 9.481E+05 |
| 0.495 | 9.490E+05 | 9.490E+05 |
| 0.505 | 9.501E+05 | 9.501E+05 |
| 0.515 | 9.515E+05 | 9.515E+05 |
| 0.525 | 9.533E+05 | 9.533E+05 |
| 0.535 | 9.555E+05 | 9.555E+05 |
| 0.545 | 9.580E+05 | 9.580E+05 |
| 0.555 | 9.609E+05 | 9.609E+05 |
| 0.565 | 9.643E+05 | 9.643E+05 |
| 0.575 | 9.682E+05 | 9.682E+05 |
| 0.585 | 9.725E+05 | 9.725E+05 |
| 0.595 | 9.775E+05 | 9.775E+05 |
| 0.605 | 9.830E+05 | 9.830E+05 |
| 0.615 | 9.891E+05 | 9.891E+05 |
| 0.625 | 9.959E+05 | 9.959E+05 |
| 0.635 | 1.003E+06 | 1.003E+06 |
| 0.645 | 1.012E+06 | 1.012E+06 |
| 0.655 | 1.021E+06 | 1.021E+06 |
| 0.665 | 1.031E+06 | 1.031E+06 |
| 0.675 | 1.042E+06 | 1.042E+06 |
| 0.685 | 1.055E+06 | 1.055E+06 |
| 0.695 | 1.068E+06 | 1.068E+06 |
| 0.705 | 1.083E+06 | 1.083E+06 |
| 0.715 | 1.099E+06 | 1.099E+06 |
| 0.725 | 1.117E+06 | 1.117E+06 |
| 0.735 | 1.137E+06 | 1.137E+06 |
| 0.745 | 1.158E+06 | 1.158E+06 |
| 0.755 | 1.182E+06 | 1.182E+06 |
| 0.765 | 1.208E+06 | 1.208E+06 |
| 0.775 | 1.236E+06 | 1.236E+06 |
| 0.785 | 1.267E+06 | 1.267E+06 |
| 0.795 | 1.302E+06 | 1.302E+06 |
| 0.805 | 1.340E+06 | 1.340E+06 |
| 0.815 | 1.382E+06 | 1.382E+06 |
| 0.825 | 1.428E+06 | 1.428E+06 |
| 0.835 | 1.479E+06 | 1.479E+06 |
| 0.845 | 1.536E+06 | 1.536E+06 |
| 0.855 | 1.600E+06 | 1.600E+06 |
| 0.865 | 1.670E+06 | 1.670E+06 |
| 0.875 | 1.749E+06 | 1.749E+06 |
| 0.885 | 1.837E+06 | 1.837E+06 |
| 0.895 | 1.937E+06 | 1.937E+06 |
| 0.905 | 2.048E+06 | 2.048E+06 |
| 0.915 | 2.175E+06 | 2.175E+06 |
| 0.925 | 2.318E+06 | 2.318E+06 |
| 0.935 | 2.482E+06 | 2.482E+06 |
| 0.945 | 2.670E+06 | 2.670E+06 |
| 0.955 | 2.886E+06 | 2.886E+06 |

"SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC, COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.590@+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 1.332 MEV
SPECTRUM WEIGHT= 5.000@-01

THE PHOTOELECTRON FLUX IS 2.839@+04 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 1.118 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 2.646@+06 ELECTRONS/SQ CM

| ELECTRON ENERGY (MEV) | COMPTON FLUX | PAIR PRODUCTION FLUX | PARTIAL SUM ELECTRON FLUX | RUNNING TOTAL ELECTRON FLUX |
|---|---|---|---|---|
| 0.005 | 8.289@+05 | 1.382@+03 | 8.303@+05 | 1.899@+06 |
| 0.015 | 8.265@+05 | 2.355@+03 | 8.289@+05 | 1.894@+06 |
| 0.025 | 8.242@+05 | 2.988@+03 | 8.272@+05 | 1.889@+06 |
| 0.035 | 8.218@+05 | 3.473@+03 | 8.253@+05 | 1.883@+06 |
| 0.045 | 8.195@+05 | 3.866@+03 | 8.234@+05 | 1.878@+06 |
| 0.055 | 8.172@+05 | 4.193@+03 | 8.214@+05 | 1.872@+06 |
| 0.065 | 8.149@+05 | 4.468@+03 | 8.194@+05 | 1.866@+06 |
| 0.075 | 8.127@+05 | 4.700@+03 | 8.174@+05 | 1.861@+06 |
| 0.085 | 8.105@+05 | 4.896@+03 | 8.154@+05 | 1.855@+06 |
| 0.095 | 8.083@+05 | 5.060@+03 | 8.133@+05 | 1.849@+06 |
| 0.105 | 8.061@+05 | 5.194@+03 | 8.113@+05 | 1.843@+06 |
| 0.115 | 8.039@+05 | 5.301@+03 | 8.092@+05 | 1.837@+06 |
| 0.125 | 8.018@+05 | 5.384@+03 | 8.072@+05 | 1.832@+06 |
| 0.135 | 7.997@+05 | 5.441@+03 | 8.051@+05 | 1.826@+06 |
| 0.145 | 7.976@+05 | 5.476@+03 | 8.031@+05 | 1.820@+06 |
| 0.155 | 7.956@+05 | 5.487@+03 | 8.011@+05 | 1.814@+06 |
| 0.165 | 7.936@+05 | 5.476@+03 | 7.990@+05 | 1.808@+06 |
| 0.175 | 7.916@+05 | 5.441@+03 | 7.970@+05 | 1.803@+06 |
| 0.185 | 7.896@+05 | 5.384@+03 | 7.950@+05 | 1.797@+06 |
| 0.195 | 7.877@+05 | 5.301@+03 | 7.930@+05 | 1.792@+06 |
| 0.205 | 7.858@+05 | 5.194@+03 | 7.910@+05 | 1.787@+06 |
| 0.215 | 7.839@+05 | 5.060@+03 | 7.890@+05 | 1.782@+06 |
| 0.225 | 7.821@+05 | 4.896@+03 | 7.870@+05 | 1.777@+06 |
| 0.235 | 7.804@+05 | 4.700@+03 | 7.851@+05 | 1.772@+06 |
| 0.245 | 7.786@+05 | 4.468@+03 | 7.831@+05 | 1.767@+06 |
| 0.255 | 7.769@+05 | 4.193@+03 | 7.811@+05 | 1.762@+06 |
| 0.265 | 7.753@+05 | 3.866@+03 | 7.791@+05 | 1.757@+06 |
| 0.275 | 7.737@+05 | 3.473@+03 | 7.771@+05 | 1.753@+06 |
| 0.285 | 7.721@+05 | 2.988@+03 | 7.751@+05 | 1.748@+06 |
| 0.295 | 7.706@+05 | 2.355@+03 | 7.729@+05 | 1.743@+06 |
| 0.305 | 7.691@+05 | 1.382@+03 | 7.705@+05 | 1.738@+06 |
| 0.315 | 7.677@+05 | | | 1.733@+06 |
| 0.325 | 7.664@+05 | | | 1.730@+06 |
| 0.335 | 7.651@+05 | | | 1.726@+06 |
| 0.345 | 7.638@+05 | | | 1.723@+06 |
| 0.355 | 7.626@+05 | | | 1.720@+06 |
| 0.365 | 7.615@+05 | | | 1.717@+06 |
| 0.375 | 7.605@+05 | | | 1.715@+06 |
| 0.385 | 7.595@+05 | | | 1.712@+06 |
| 0.395 | 7.586@+05 | | | 1.710@+06 |
| 0.405 | 7.578@+05 | | | 1.708@+06 |
| 0.415 | 7.570@+05 | | | 1.706@+06 |
| 0.425 | 7.563@+05 | | | 1.705@+06 |
| 0.435 | 7.558@+05 | | | 1.704@+06 |

| | | |
|---|---|---|
| 0.445 | 7.553E+05 | 1.703E+06 |
| 0.455 | 7.549E+05 | 1.702E+06 |
| 0.465 | 7.546E+05 | 1.702E+06 |
| 0.475 | 7.544E+05 | 1.702E+06 |
| 0.485 | 7.543E+05 | 1.702E+06 |
| 0.495 | 7.543E+05 | 1.703E+06 |
| 0.505 | 7.545E+05 | 1.705E+06 |
| 0.515 | 7.548E+05 | 1.706E+06 |
| 0.525 | 7.552E+05 | 1.709E+06 |
| 0.535 | 7.557E+05 | 1.711E+06 |
| 0.545 | 7.565E+05 | 1.714E+06 |
| 0.555 | 7.573E+05 | 1.718E+06 |
| 0.565 | 7.583E+05 | 1.723E+06 |
| 0.575 | 7.595E+05 | 1.728E+06 |
| 0.585 | 7.609E+05 | 1.733E+06 |
| 0.595 | 7.625E+05 | 1.740E+06 |
| 0.605 | 7.643E+05 | 1.747E+06 |
| 0.615 | 7.662E+05 | 1.755E+06 |
| 0.625 | 7.685E+05 | 1.764E+06 |
| 0.635 | 7.709E+05 | 1.774E+06 |
| 0.645 | 7.736E+05 | 1.785E+06 |
| 0.655 | 7.766E+05 | 1.798E+06 |
| 0.665 | 7.799E+05 | 1.811E+06 |
| 0.675 | 7.835E+05 | 1.826E+06 |
| 0.685 | 7.874E+05 | 1.842E+06 |
| 0.695 | 7.916E+05 | 1.860E+06 |
| 0.705 | 7.963E+05 | 1.879E+06 |
| 0.715 | 8.013E+05 | 1.901E+06 |
| 0.725 | 8.067E+05 | 1.924E+06 |
| 0.735 | 8.126E+05 | 1.949E+06 |
| 0.745 | 8.189E+05 | 1.977E+06 |
| 0.755 | 8.258E+05 | 2.008E+06 |
| 0.765 | 8.332E+05 | 2.041E+06 |
| 0.775 | 8.413E+05 | 2.077E+06 |
| 0.785 | 8.499E+05 | 2.117E+06 |
| 0.795 | 8.593E+05 | 2.161E+06 |
| 0.805 | 8.693E+05 | 2.209E+06 |
| 0.815 | 8.802E+05 | 2.262E+06 |
| 0.825 | 8.919E+05 | 2.320E+06 |
| 0.835 | 9.046E+05 | 2.384E+06 |
| 0.845 | 9.183E+05 | 2.455E+06 |
| 0.855 | 9.331E+05 | 2.533E+06 |
| 0.865 | 9.490E+05 | 2.619E+06 |
| 0.875 | 9.663E+05 | 2.715E+06 |
| 0.885 | 9.850E+05 | 2.822E+06 |
| 0.895 | 1.005E+06 | 2.942E+06 |
| 0.905 | 1.027E+06 | 3.076E+06 |
| 0.915 | 1.051E+06 | 3.226E+06 |
| 0.925 | 1.077E+06 | 3.395E+06 |
| 0.935 | 1.105E+06 | 3.587E+06 |
| 0.945 | 1.136E+06 | 3.805E+06 |
| 0.955 | 1.169E+06 | 4.055E+06 |
| 0.965 | 1.206E+06 | 1.206E+06 |
| 0.975 | 1.246E+06 | 1.246E+06 |
| 0.985 | 1.290E+06 | 1.290E+06 |
| 0.995 | 1.338E+06 | 1.338E+06 |
| 1.005 | 1.391E+06 | 1.391E+06 |
| 1.015 | 1.449E+06 | 1.449E+06 |
| 1.025 | 1.514E+06 | 1.514E+06 |
| 1.035 | 1.586E+06 | 1.586E+06 |
| 1.045 | 1.666E+06 | 1.666E+06 |
| 1.055 | 1.755E+06 | 1.755E+06 |

| | | |
|---|---|---|
| 1.065 | 1.855@+06 | 1.855@+06 |
| 1.075 | 1.968@+06 | 1.968@+06 |
| 1.085 | 2.095@+06 | 2.095@+06 |
| 1.095 | 2.239@+06 | 2.239@+06 |
| 1.105 | 2.403@+06 | 2.403@+06 |
| 1.115 | 2.592@+06 | 2.592@+06 |

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC, COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.100E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 1.380 MEV
SPECTRUM WEIGHT= 5.000E-01

THE PHOTOELECTRON FLUX IS 1.801E+04 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 1.164 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 1.754E+06 ELECTRONS/SQ CM

| ELECTRON ENERGY (MeV) | COMPTON FLUX | PAIR PRODUCTION FLUX | PARTIAL SUM ELECTRON FLUX | RUNNING TOTAL ELECTRON FLUX |
|---|---|---|---|---|
| 0.005 | 5.343E+05 | 1.080E+03 | 5.354E+05 | 5.354E+05 |
| 0.015 | 5.329E+05 | 1.845E+03 | 5.347E+05 | 5.347E+05 |
| 0.025 | 5.315E+05 | 2.347E+03 | 5.338E+05 | 5.338E+05 |
| 0.035 | 5.301E+05 | 2.735E+03 | 5.328E+05 | 5.328E+05 |
| 0.045 | 5.287E+05 | 3.052E+03 | 5.317E+05 | 5.317E+05 |
| 0.055 | 5.273E+05 | 3.320E+03 | 5.306E+05 | 5.306E+05 |
| 0.065 | 5.259E+05 | 3.549E+03 | 5.295E+05 | 5.295E+05 |
| 0.075 | 5.246E+05 | 3.747E+03 | 5.283E+05 | 5.283E+05 |
| 0.085 | 5.233E+05 | 3.918E+03 | 5.272E+05 | 5.272E+05 |
| 0.095 | 5.219E+05 | 4.065E+03 | 5.260E+05 | 5.260E+05 |
| 0.105 | 5.206E+05 | 4.192E+03 | 5.248E+05 | 5.248E+05 |
| 0.115 | 5.193E+05 | 4.299E+03 | 5.236E+05 | 5.236E+05 |
| 0.125 | 5.181E+05 | 4.389E+03 | 5.225E+05 | 5.225E+05 |
| 0.135 | 5.168E+05 | 4.462E+03 | 5.213E+05 | 5.213E+05 |
| 0.145 | 5.156E+05 | 4.520E+03 | 5.201E+05 | 5.201E+05 |
| 0.155 | 5.143E+05 | 4.562E+03 | 5.189E+05 | 5.189E+05 |
| 0.165 | 5.131E+05 | 4.589E+03 | 5.177E+05 | 5.177E+05 |
| 0.175 | 5.119E+05 | 4.602E+03 | 5.166E+05 | 5.166E+05 |
| 0.185 | 5.108E+05 | 4.601E+03 | 5.154E+05 | 5.154E+05 |
| 0.195 | 5.096E+05 | 4.585E+03 | 5.142E+05 | 5.142E+05 |
| 0.205 | 5.085E+05 | 4.555E+03 | 5.131E+05 | 5.131E+05 |
| 0.215 | 5.074E+05 | 4.510E+03 | 5.119E+05 | 5.119E+05 |
| 0.225 | 5.063E+05 | 4.449E+03 | 5.108E+05 | 5.108E+05 |
| 0.235 | 5.053E+05 | 4.373E+03 | 5.096E+05 | 5.096E+05 |
| 0.245 | 5.042E+05 | 4.279E+03 | 5.085E+05 | 5.085E+05 |
| 0.255 | 5.032E+05 | 4.168E+03 | 5.074E+05 | 5.074E+05 |
| 0.265 | 5.022E+05 | 4.037E+03 | 5.063E+05 | 5.063E+05 |
| 0.275 | 5.013E+05 | 3.886E+03 | 5.051E+05 | 5.051E+05 |
| 0.285 | 5.003E+05 | 3.710E+03 | 5.040E+05 | 5.040E+05 |
| 0.295 | 4.994E+05 | 3.504E+03 | 5.029E+05 | 5.029E+05 |
| 0.305 | 4.985E+05 | 3.270E+03 | 5.018E+05 | 5.018E+05 |
| 0.315 | 4.977E+05 | 2.993E+03 | 5.007E+05 | 5.007E+05 |
| 0.325 | 4.969E+05 | 2.663E+03 | 4.995E+05 | 4.995E+05 |
| 0.335 | 4.961E+05 | 2.254E+03 | 4.984E+05 | 4.984E+05 |
| 0.345 | 4.953E+05 | 1.722E+03 | 4.971E+05 | 4.971E+05 |
| 0.355 | 4.946E+05 | 8.393E+02 | 4.955E+05 | 4.955E+05 |
| 0.365 | 4.940E+05 | | | 4.940E+05 |
| 0.375 | 4.933E+05 | | | 4.933E+05 |
| 0.385 | 4.927E+05 | | | 4.927E+05 |
| 0.395 | 4.922E+05 | | | 4.922E+05 |
| 0.405 | 4.917E+05 | | | 4.917E+05 |
| 0.415 | 4.912E+05 | | | 4.912E+05 |
| 0.425 | 4.908E+05 | | | 4.908E+05 |
| 0.435 | 4.904E+05 | | | 4.904E+05 |

| | | |
|---|---|---|
| 0.445 | 4.901E+05 | 4.901E+05 |
| 0.455 | 4.898E+05 | 4.898E+05 |
| 0.465 | 4.896E+05 | 4.896E+05 |
| 0.475 | 4.895E+05 | 4.895E+05 |
| 0.485 | 4.894E+05 | 4.894E+05 |
| 0.495 | 4.894E+05 | 4.894E+05 |
| 0.505 | 4.894E+05 | 4.894E+05 |
| 0.515 | 4.895E+05 | 4.895E+05 |
| 0.525 | 4.897E+05 | 4.897E+05 |
| 0.535 | 4.900E+05 | 4.900E+05 |
| 0.545 | 4.903E+05 | 4.903E+05 |
| 0.555 | 4.907E+05 | 4.907E+05 |
| 0.565 | 4.912E+05 | 4.912E+05 |
| 0.575 | 4.918E+05 | 4.918E+05 |
| 0.585 | 4.925E+05 | 4.925E+05 |
| 0.595 | 4.934E+05 | 4.934E+05 |
| 0.605 | 4.943E+05 | 4.943E+05 |
| 0.615 | 4.953E+05 | 4.953E+05 |
| 0.625 | 4.964E+05 | 4.964E+05 |
| 0.635 | 4.977E+05 | 4.977E+05 |
| 0.645 | 4.991E+05 | 4.991E+05 |
| 0.655 | 5.007E+05 | 5.007E+05 |
| 0.665 | 5.024E+05 | 5.024E+05 |
| 0.675 | 5.042E+05 | 5.042E+05 |
| 0.685 | 5.063E+05 | 5.063E+05 |
| 0.695 | 5.085E+05 | 5.085E+05 |
| 0.705 | 5.109E+05 | 5.109E+05 |
| 0.715 | 5.134E+05 | 5.134E+05 |
| 0.725 | 5.162E+05 | 5.162E+05 |
| 0.735 | 5.193E+05 | 5.193E+05 |
| 0.745 | 5.225E+05 | 5.225E+05 |
| 0.755 | 5.260E+05 | 5.260E+05 |
| 0.765 | 5.298E+05 | 5.298E+05 |
| 0.775 | 5.339E+05 | 5.339E+05 |
| 0.785 | 5.383E+05 | 5.383E+05 |
| 0.795 | 5.430E+05 | 5.430E+05 |
| 0.805 | 5.480E+05 | 5.480E+05 |
| 0.815 | 5.535E+05 | 5.535E+05 |
| 0.825 | 5.593E+05 | 5.593E+05 |
| 0.835 | 5.656E+05 | 5.656E+05 |
| 0.845 | 5.723E+05 | 5.723E+05 |
| 0.855 | 5.796E+05 | 5.796E+05 |
| 0.865 | 5.874E+05 | 5.874E+05 |
| 0.875 | 5.958E+05 | 5.958E+05 |
| 0.885 | 6.048E+05 | 6.048E+05 |
| 0.895 | 6.145E+05 | 6.145E+05 |
| 0.905 | 6.250E+05 | 6.250E+05 |
| 0.915 | 6.362E+05 | 6.362E+05 |
| 0.925 | 6.484E+05 | 6.484E+05 |
| 0.935 | 6.615E+05 | 6.615E+05 |
| 0.945 | 6.757E+05 | 6.757E+05 |
| 0.955 | 6.910E+05 | 6.910E+05 |
| 0.965 | 7.077E+05 | 7.077E+05 |
| 0.975 | 7.257E+05 | 7.257E+05 |
| 0.985 | 7.452E+05 | 7.452E+05 |
| 0.995 | 7.665E+05 | 7.665E+05 |
| 1.005 | 7.896E+05 | 7.896E+05 |
| 1.015 | 8.149E+05 | 8.149E+05 |
| 1.025 | 8.425E+05 | 8.425E+05 |
| 1.035 | 8.727E+05 | 8.727E+05 |
| 1.045 | 9.058E+05 | 9.058E+05 |
| 1.055 | 9.423E+05 | 9.423E+05 |

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| | | |
|---|---|---|
| 1.065 | 9.825@+05 | 9.825@+05 |
| 1.075 | 1.027@+06 | 1.027@+06 |
| 1.085 | 1.076@+06 | 1.076@+06 |
| 1.095 | 1.131@+06 | 1.131@+06 |
| 1.105 | 1.192@+06 | 1.192@+06 |
| 1.115 | 1.260@+06 | 1.260@+06 |
| 1.125 | 1.337@+06 | 1.337@+06 |
| 1.135 | 1.424@+06 | 1.424@+06 |
| 1.145 | 1.522@+06 | 1.522@+06 |
| 1.155 | 1.634@+06 | 1.634@+06 |

SCATTERSHOT III - A H-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC, COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.100E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 2.758 MEV
SPECTRUM WEIGHT= 5.000E-01

THE PHOTOELECTRON FLUX IS 3.404E+03 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 2.524 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 7.956E+05 ELECTRONS/SQ CM

| ELECTRON ENERGY (MEV) | COMPTON FLUX | PAIR PRODUCTION FLUX | PARTIAL SUM ELECTRON FLUX | RUNNING TOTAL ELECTRON FLUX |
|---|---|---|---|---|
| 0.005 | 1.339E+05 | 1.861E+03 | 1.358E+05 | 6.711E+05 |
| 0.015 | 1.338E+05 | 3.227E+03 | 1.370E+05 | 6.718E+05 |
| 0.025 | 1.337E+05 | 4.165E+03 | 1.379E+05 | 6.717E+05 |
| 0.035 | 1.336E+05 | 4.922E+03 | 1.386E+05 | 6.714E+05 |
| 0.045 | 1.336E+05 | 5.573E+03 | 1.391E+05 | 6.709E+05 |
| 0.055 | 1.335E+05 | 6.150E+03 | 1.396E+05 | 6.702E+05 |
| 0.065 | 1.334E+05 | 6.672E+03 | 1.401E+05 | 6.696E+05 |
| 0.075 | 1.333E+05 | 7.151E+03 | 1.405E+05 | 6.688E+05 |
| 0.085 | 1.332E+05 | 7.595E+03 | 1.408E+05 | 6.680E+05 |
| 0.095 | 1.331E+05 | 8.009E+03 | 1.412E+05 | 6.672E+05 |
| 0.105 | 1.331E+05 | 8.398E+03 | 1.415E+05 | 6.663E+05 |
| 0.115 | 1.330E+05 | 8.765E+03 | 1.418E+05 | 6.654E+05 |
| 0.125 | 1.329E+05 | 9.112E+03 | 1.420E+05 | 6.645E+05 |
| 0.135 | 1.328E+05 | 9.441E+03 | 1.423E+05 | 6.636E+05 |
| 0.145 | 1.328E+05 | 9.755E+03 | 1.425E+05 | 6.626E+05 |
| 0.155 | 1.327E+05 | 1.005E+04 | 1.428E+05 | 6.617E+05 |
| 0.165 | 1.326E+05 | 1.034E+04 | 1.430E+05 | 6.607E+05 |
| 0.175 | 1.326E+05 | 1.062E+04 | 1.432E+05 | 6.597E+05 |
| 0.185 | 1.325E+05 | 1.088E+04 | 1.434E+05 | 6.588E+05 |
| 0.195 | 1.324E+05 | 1.113E+04 | 1.436E+05 | 6.578E+05 |
| 0.205 | 1.324E+05 | 1.137E+04 | 1.437E+05 | 6.568E+05 |
| 0.215 | 1.323E+05 | 1.161E+04 | 1.439E+05 | 6.558E+05 |
| 0.225 | 1.322E+05 | 1.183E+04 | 1.441E+05 | 6.548E+05 |
| 0.235 | 1.322E+05 | 1.205E+04 | 1.442E+05 | 6.539E+05 |
| 0.245 | 1.321E+05 | 1.226E+04 | 1.444E+05 | 6.529E+05 |
| 0.255 | 1.321E+05 | 1.246E+04 | 1.445E+05 | 6.519E+05 |
| 0.265 | 1.320E+05 | 1.266E+04 | 1.447E+05 | 6.509E+05 |
| 0.275 | 1.320E+05 | 1.284E+04 | 1.448E+05 | 6.500E+05 |
| 0.285 | 1.319E+05 | 1.303E+04 | 1.449E+05 | 6.490E+05 |
| 0.295 | 1.319E+05 | 1.320E+04 | 1.451E+05 | 6.480E+05 |
| 0.305 | 1.318E+05 | 1.337E+04 | 1.452E+05 | 6.470E+05 |
| 0.315 | 1.318E+05 | 1.354E+04 | 1.453E+05 | 6.460E+05 |
| 0.325 | 1.317E+05 | 1.370E+04 | 1.454E+05 | 6.450E+05 |
| 0.335 | 1.317E+05 | 1.385E+04 | 1.455E+05 | 6.439E+05 |
| 0.345 | 1.316E+05 | 1.400E+04 | 1.456E+05 | 6.427E+05 |
| 0.355 | 1.316E+05 | 1.414E+04 | 1.457E+05 | 6.412E+05 |
| 0.365 | 1.316E+05 | 1.428E+04 | 1.459E+05 | 6.398E+05 |
| 0.375 | 1.315E+05 | 1.442E+04 | 1.460E+05 | 6.393E+05 |
| 0.385 | 1.315E+05 | 1.455E+04 | 1.460E+05 | 6.388E+05 |
| 0.395 | 1.315E+05 | 1.467E+04 | 1.461E+05 | 6.383E+05 |
| 0.405 | 1.314E+05 | 1.480E+04 | 1.462E+05 | 6.379E+05 |
| 0.415 | 1.314E+05 | 1.492E+04 | 1.463E+05 | 6.375E+05 |
| 0.425 | 1.314E+05 | 1.503E+04 | 1.464E+05 | 6.372E+05 |
| 0.435 | 1.314E+05 | 1.514E+04 | 1.465E+05 | 6.369E+05 |

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|---|---|---|---|---|
| 0.445 | 1.313E+05 | 1.525E+04 | 1.466E+05 | 6.367E+05 |
| 0.455 | 1.313E+05 | 1.535E+04 | 1.467E+05 | 6.365E+05 |
| 0.465 | 1.313E+05 | 1.545E+04 | 1.468E+05 | 6.364E+05 |
| 0.475 | 1.313E+05 | 1.555E+04 | 1.468E+05 | 6.363E+05 |
| 0.485 | 1.313E+05 | 1.564E+04 | 1.469E+05 | 6.363E+05 |
| 0.495 | 1.313E+05 | 1.573E+04 | 1.470E+05 | 6.363E+05 |
| 0.505 | 1.313E+05 | 1.582E+04 | 1.471E+05 | 6.365E+05 |
| 0.515 | 1.312E+05 | 1.590E+04 | 1.471E+05 | 6.367E+05 |
| 0.525 | 1.312E+05 | 1.599E+04 | 1.472E+05 | 6.369E+05 |
| 0.535 | 1.312E+05 | 1.606E+04 | 1.473E+05 | 6.373E+05 |
| 0.545 | 1.312E+05 | 1.614E+04 | 1.474E+05 | 6.377E+05 |
| 0.555 | 1.312E+05 | 1.621E+04 | 1.474E+05 | 6.382E+05 |
| 0.565 | 1.312E+05 | 1.628E+04 | 1.475E+05 | 6.388E+05 |
| 0.575 | 1.312E+05 | 1.635E+04 | 1.476E+05 | 6.394E+05 |
| 0.585 | 1.313E+05 | 1.641E+04 | 1.477E+05 | 6.402E+05 |
| 0.595 | 1.313E+05 | 1.647E+04 | 1.477E+05 | 6.411E+05 |
| 0.605 | 1.313E+05 | 1.653E+04 | 1.478E+05 | 6.421E+05 |
| 0.615 | 1.313E+05 | 1.659E+04 | 1.479E+05 | 6.432E+05 |
| 0.625 | 1.313E+05 | 1.664E+04 | 1.480E+05 | 6.444E+05 |
| 0.635 | 1.313E+05 | 1.670E+04 | 1.480E+05 | 6.458E+05 |
| 0.645 | 1.314E+05 | 1.675E+04 | 1.481E+05 | 6.472E+05 |
| 0.655 | 1.314E+05 | 1.679E+04 | 1.482E+05 | 6.489E+05 |
| 0.665 | 1.314E+05 | 1.684E+04 | 1.483E+05 | 6.506E+05 |
| 0.675 | 1.315E+05 | 1.688E+04 | 1.483E+05 | 6.526E+05 |
| 0.685 | 1.315E+05 | 1.692E+04 | 1.484E+05 | 6.547E+05 |
| 0.695 | 1.315E+05 | 1.696E+04 | 1.485E+05 | 6.570E+05 |
| 0.705 | 1.316E+05 | 1.699E+04 | 1.486E+05 | 6.594E+05 |
| 0.715 | 1.316E+05 | 1.703E+04 | 1.486E+05 | 6.621E+05 |
| 0.725 | 1.317E+05 | 1.706E+04 | 1.487E+05 | 6.650E+05 |
| 0.735 | 1.317E+05 | 1.708E+04 | 1.488E+05 | 6.681E+05 |
| 0.745 | 1.318E+05 | 1.711E+04 | 1.489E+05 | 6.714E+05 |
| 0.755 | 1.318E+05 | 1.714E+04 | 1.490E+05 | 6.750E+05 |
| 0.765 | 1.319E+05 | 1.716E+04 | 1.491E+05 | 6.789E+05 |
| 0.775 | 1.320E+05 | 1.718E+04 | 1.491E+05 | 6.830E+05 |
| 0.785 | 1.320E+05 | 1.720E+04 | 1.492E+05 | 6.875E+05 |
| 0.795 | 1.321E+05 | 1.721E+04 | 1.493E+05 | 6.923E+05 |
| 0.805 | 1.322E+05 | 1.723E+04 | 1.494E+05 | 6.974E+05 |
| 0.815 | 1.322E+05 | 1.724E+04 | 1.495E+05 | 7.029E+05 |
| 0.825 | 1.323E+05 | 1.725E+04 | 1.496E+05 | 7.089E+05 |
| 0.835 | 1.324E+05 | 1.726E+04 | 1.497E+05 | 7.152E+05 |
| 0.845 | 1.325E+05 | 1.726E+04 | 1.498E+05 | 7.221E+05 |
| 0.855 | 1.326E+05 | 1.727E+04 | 1.499E+05 | 7.294E+05 |
| 0.865 | 1.327E+05 | 1.727E+04 | 1.500E+05 | 7.373E+05 |
| 0.875 | 1.328E+05 | 1.727E+04 | 1.501E+05 | 7.458E+05 |
| 0.885 | 1.329E+05 | 1.726E+04 | 1.502E+05 | 7.549E+05 |
| 0.895 | 1.330E+05 | 1.726E+04 | 1.503E+05 | 7.648E+05 |
| 0.905 | 1.331E+05 | 1.725E+04 | 1.504E+05 | 7.753E+05 |
| 0.915 | 1.332E+05 | 1.724E+04 | 1.505E+05 | 7.867E+05 |
| 0.925 | 1.333E+05 | 1.723E+04 | 1.506E+05 | 7.990E+05 |
| 0.935 | 1.335E+05 | 1.722E+04 | 1.507E+05 | 8.122E+05 |
| 0.945 | 1.336E+05 | 1.721E+04 | 1.508E+05 | 8.265E+05 |
| 0.955 | 1.337E+05 | 1.719E+04 | 1.509E+05 | 8.420E+05 |
| 0.965 | 1.339E+05 | 1.717E+04 | 1.510E+05 | 8.587E+05 |
| 0.975 | 1.340E+05 | 1.715E+04 | 1.512E+05 | 8.768E+05 |
| 0.985 | 1.342E+05 | 1.713E+04 | 1.513E+05 | 8.965E+05 |
| 0.995 | 1.343E+05 | 1.710E+04 | 1.514E+05 | 9.179E+05 |
| 1.005 | 1.345E+05 | 1.707E+04 | 1.515E+05 | 9.412E+05 |
| 1.015 | 1.346E+05 | 1.704E+04 | 1.517E+05 | 9.666E+05 |
| 1.025 | 1.348E+05 | 1.701E+04 | 1.518E+05 | 9.943E+05 |
| 1.035 | 1.350E+05 | 1.698E+04 | 1.519E+05 | 1.025E+06 |
| 1.045 | 1.351E+05 | 1.694E+04 | 1.521E+05 | 1.058E+06 |
| 1.055 | 1.353E+05 | 1.690E+04 | 1.522E+05 | 1.095E+06 |

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|---|---|---|---|---|
| 1.065 | 1.355E+05 | 1.686E+04 | 1.524E+05 | 1.135E+06 |
| 1.075 | 1.357E+05 | 1.682E+04 | 1.525E+05 | 1.179E+06 |
| 1.085 | 1.359E+05 | 1.677E+04 | 1.527E+05 | 1.229E+06 |
| 1.095 | 1.361E+05 | 1.673E+04 | 1.528E+05 | 1.284E+06 |
| 1.105 | 1.363E+05 | 1.668E+04 | 1.530E+05 | 1.345E+06 |
| 1.115 | 1.365E+05 | 1.662E+04 | 1.532E+05 | 1.413E+06 |
| 1.125 | 1.368E+05 | 1.657E+04 | 1.533E+05 | 1.490E+06 |
| 1.135 | 1.370E+05 | 1.651E+04 | 1.535E+05 | 1.577E+06 |
| 1.145 | 1.372E+05 | 1.645E+04 | 1.537E+05 | 1.676E+06 |
| 1.155 | 1.375E+05 | 1.639E+04 | 1.539E+05 | 1.788E+06 |
| 1.165 | 1.377E+05 | 1.632E+04 | 1.540E+05 | 1.540E+05 |
| 1.175 | 1.380E+05 | 1.625E+04 | 1.542E+05 | 1.542E+05 |
| 1.185 | 1.382E+05 | 1.618E+04 | 1.544E+05 | 1.544E+05 |
| 1.195 | 1.385E+05 | 1.611E+04 | 1.546E+05 | 1.546E+05 |
| 1.205 | 1.388E+05 | 1.603E+04 | 1.548E+05 | 1.548E+05 |
| 1.215 | 1.391E+05 | 1.595E+04 | 1.550E+05 | 1.550E+05 |
| 1.225 | 1.394E+05 | 1.587E+04 | 1.552E+05 | 1.552E+05 |
| 1.235 | 1.397E+05 | 1.579E+04 | 1.554E+05 | 1.554E+05 |
| 1.245 | 1.400E+05 | 1.570E+04 | 1.557E+05 | 1.557E+05 |
| 1.255 | 1.403E+05 | 1.561E+04 | 1.559E+05 | 1.559E+05 |
| 1.265 | 1.406E+05 | 1.551E+04 | 1.561E+05 | 1.561E+05 |
| 1.275 | 1.409E+05 | 1.541E+04 | 1.563E+05 | 1.563E+05 |
| 1.285 | 1.413E+05 | 1.531E+04 | 1.566E+05 | 1.566E+05 |
| 1.295 | 1.416E+05 | 1.521E+04 | 1.568E+05 | 1.568E+05 |
| 1.305 | 1.420E+05 | 1.510E+04 | 1.571E+05 | 1.571E+05 |
| 1.315 | 1.423E+05 | 1.499E+04 | 1.573E+05 | 1.573E+05 |
| 1.325 | 1.427E+05 | 1.487E+04 | 1.576E+05 | 1.576E+05 |
| 1.335 | 1.431E+05 | 1.475E+04 | 1.579E+05 | 1.579E+05 |
| 1.345 | 1.435E+05 | 1.462E+04 | 1.581E+05 | 1.581E+05 |
| 1.355 | 1.439E+05 | 1.450E+04 | 1.584E+05 | 1.584E+05 |
| 1.365 | 1.443E+05 | 1.436E+04 | 1.587E+05 | 1.587E+05 |
| 1.375 | 1.447E+05 | 1.423E+04 | 1.590E+05 | 1.590E+05 |
| 1.385 | 1.452E+05 | 1.409E+04 | 1.593E+05 | 1.593E+05 |
| 1.395 | 1.456E+05 | 1.394E+04 | 1.596E+05 | 1.596E+05 |
| 1.405 | 1.461E+05 | 1.379E+04 | 1.599E+05 | 1.599E+05 |
| 1.415 | 1.466E+05 | 1.363E+04 | 1.602E+05 | 1.602E+05 |
| 1.425 | 1.470E+05 | 1.347E+04 | 1.605E+05 | 1.605E+05 |
| 1.435 | 1.475E+05 | 1.330E+04 | 1.608E+05 | 1.608E+05 |
| 1.445 | 1.480E+05 | 1.313E+04 | 1.612E+05 | 1.612E+05 |
| 1.455 | 1.486E+05 | 1.295E+04 | 1.615E+05 | 1.615E+05 |
| 1.465 | 1.491E+05 | 1.277E+04 | 1.619E+05 | 1.619E+05 |
| 1.475 | 1.496E+05 | 1.258E+04 | 1.622E+05 | 1.622E+05 |
| 1.485 | 1.502E+05 | 1.238E+04 | 1.626E+05 | 1.626E+05 |
| 1.495 | 1.508E+05 | 1.218E+04 | 1.629E+05 | 1.629E+05 |
| 1.505 | 1.514E+05 | 1.196E+04 | 1.633E+05 | 1.633E+05 |
| 1.515 | 1.520E+05 | 1.174E+04 | 1.637E+05 | 1.637E+05 |
| 1.525 | 1.526E+05 | 1.152E+04 | 1.641E+05 | 1.641E+05 |
| 1.535 | 1.532E+05 | 1.128E+04 | 1.645E+05 | 1.645E+05 |
| 1.545 | 1.539E+05 | 1.103E+04 | 1.649E+05 | 1.649E+05 |
| 1.555 | 1.545E+05 | 1.077E+04 | 1.653E+05 | 1.653E+05 |
| 1.565 | 1.552E+05 | 1.051E+04 | 1.657E+05 | 1.657E+05 |
| 1.575 | 1.559E+05 | 1.023E+04 | 1.661E+05 | 1.661E+05 |
| 1.585 | 1.566E+05 | 9.936E+03 | 1.666E+05 | 1.666E+05 |
| 1.595 | 1.574E+05 | 9.631E+03 | 1.670E+05 | 1.670E+05 |
| 1.605 | 1.581E+05 | 9.311E+03 | 1.674E+05 | 1.674E+05 |
| 1.615 | 1.589E+05 | 8.975E+03 | 1.679E+05 | 1.679E+05 |
| 1.625 | 1.597E+05 | 8.620E+03 | 1.683E+05 | 1.683E+05 |
| 1.635 | 1.605E+05 | 8.245E+03 | 1.687E+05 | 1.687E+05 |
| 1.645 | 1.613E+05 | 7.847E+03 | 1.692E+05 | 1.692E+05 |
| 1.655 | 1.622E+05 | 7.421E+03 | 1.696E+05 | 1.696E+05 |
| 1.665 | 1.631E+05 | 6.964E+03 | 1.700E+05 | 1.700E+05 |
| 1.675 | 1.640E+05 | 6.469E+03 | 1.704E+05 | 1.704E+05 |

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|---|---|---|---|---|
| 1.685 | 1.649E+05 | 5.927E+03 | 1.708E+05 | 1.708E+05 |
| 1.695 | 1.659E+05 | 5.323E+03 | 1.712E+05 | 1.712E+05 |
| 1.705 | 1.668E+05 | 4.635E+03 | 1.715E+05 | 1.715E+05 |
| 1.715 | 1.678E+05 | 3.81AE+03 | 1.717E+05 | 1.717E+05 |
| 1.725 | 1.689E+05 | 2.763E+03 | 1.716E+05 | 1.716E+05 |
| 1.735 | 1.699E+05 | 8.30AE+02 | 1.708E+05 | 1.708E+05 |
| 1.745 | 1.710E+05 | | | 1.710E+05 |
| 1.755 | 1.721E+05 | | | 1.721E+05 |
| 1.765 | 1.733E+05 | | | 1.733E+05 |
| 1.775 | 1.745E+05 | | | 1.745E+05 |
| 1.785 | 1.757E+05 | | | 1.757E+05 |
| 1.795 | 1.769E+05 | | | 1.769E+05 |
| 1.805 | 1.782E+05 | | | 1.782E+05 |
| 1.815 | 1.795E+05 | | | 1.795E+05 |
| 1.825 | 1.809E+05 | | | 1.809E+05 |
| 1.835 | 1.823E+05 | | | 1.823E+05 |
| 1.845 | 1.837E+05 | | | 1.837E+05 |
| 1.855 | 1.852E+05 | | | 1.852E+05 |
| 1.865 | 1.867E+05 | | | 1.867E+05 |
| 1.875 | 1.883E+05 | | | 1.883E+05 |
| 1.885 | 1.899E+05 | | | 1.899E+05 |
| 1.895 | 1.916E+05 | | | 1.916E+05 |
| 1.905 | 1.933E+05 | | | 1.933E+05 |
| 1.915 | 1.951E+05 | | | 1.951E+05 |
| 1.925 | 1.969E+05 | | | 1.969E+05 |
| 1.935 | 1.988E+05 | | | 1.988E+05 |
| 1.945 | 2.007E+05 | | | 2.007E+05 |
| 1.955 | 2.027E+05 | | | 2.027E+05 |
| 1.965 | 2.048E+05 | | | 2.048E+05 |
| 1.975 | 2.069E+05 | | | 2.069E+05 |
| 1.985 | 2.092E+05 | | | 2.092E+05 |
| 1.995 | 2.114E+05 | | | 2.114E+05 |
| 2.005 | 2.138E+05 | | | 2.138E+05 |
| 2.015 | 2.163E+05 | | | 2.163E+05 |
| 2.025 | 2.188E+05 | | | 2.188E+05 |
| 2.035 | 2.214E+05 | | | 2.214E+05 |
| 2.045 | 2.241E+05 | | | 2.241E+05 |
| 2.055 | 2.269E+05 | | | 2.269E+05 |
| 2.065 | 2.298E+05 | | | 2.298E+05 |
| 2.075 | 2.329E+05 | | | 2.329E+05 |
| 2.085 | 2.360E+05 | | | 2.360E+05 |
| 2.095 | 2.392E+05 | | | 2.392E+05 |
| 2.105 | 2.426E+05 | | | 2.426E+05 |
| 2.115 | 2.461E+05 | | | 2.461E+05 |
| 2.125 | 2.498E+05 | | | 2.498E+05 |
| 2.135 | 2.536E+05 | | | 2.536E+05 |
| 2.145 | 2.575E+05 | | | 2.575E+05 |
| 2.155 | 2.616E+05 | | | 2.616E+05 |
| 2.165 | 2.659E+05 | | | 2.659E+05 |
| 2.175 | 2.704E+05 | | | 2.704E+05 |
| 2.185 | 2.751E+05 | | | 2.751E+05 |
| 2.195 | 2.800E+05 | | | 2.800E+05 |
| 2.205 | 2.850E+05 | | | 2.850E+05 |
| 2.215 | 2.904E+05 | | | 2.904E+05 |
| 2.225 | 2.960E+05 | | | 2.960E+05 |
| 2.235 | 3.018E+05 | | | 3.018E+05 |
| 2.245 | 3.079E+05 | | | 3.079E+05 |
| 2.255 | 3.144E+05 | | | 3.144E+05 |
| 2.265 | 3.212E+05 | | | 3.212E+05 |
| 2.275 | 3.283E+05 | | | 3.283E+05 |
| 2.285 | 3.358E+05 | | | 3.358E+05 |
| 2.295 | 3.437E+05 | | | 3.437E+05 |

| | | |
|---|---|---|
| 2.305 | 3.520E+05 | 3.520E+05 |
| 2.315 | 3.608E+05 | 3.608E+05 |
| 2.325 | 3.701E+05 | 3.701E+05 |
| 2.335 | 3.800E+05 | 3.800E+05 |
| 2.345 | 3.905E+05 | 3.905E+05 |
| 2.355 | 4.016E+05 | 4.016E+05 |
| 2.365 | 4.135E+05 | 4.135E+05 |
| 2.375 | 4.261E+05 | 4.261E+05 |
| 2.385 | 4.396E+05 | 4.396E+05 |
| 2.395 | 4.540E+05 | 4.540E+05 |
| 2.405 | 4.695E+05 | 4.695E+05 |
| 2.415 | 4.861E+05 | 4.861E+05 |
| 2.425 | 5.040E+05 | 5.040E+05 |
| 2.435 | 5.233E+05 | 5.233E+05 |
| 2.445 | 5.442E+05 | 5.442E+05 |
| 2.455 | 5.668E+05 | 5.668E+05 |
| 2.465 | 5.915E+05 | 5.915E+05 |
| 2.475 | 6.184E+05 | 6.184E+05 |
| 2.485 | 6.478E+05 | 6.478E+05 |
| 2.495 | 6.802E+05 | 6.802E+05 |
| 2.505 | 7.159E+05 | 7.159E+05 |
| 2.515 | 7.555E+05 | 7.555E+05 |

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730@+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 0.500 MEV
SPECTRUM WEIGHT= 4.430@-01

THE PHOTOELECTRON FLUX IS 3.362@+05 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 0.331 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 9.357@+06 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730@+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 1.000 MEV
SPECTRUM WEIGHT= 2.720@-01

THE PHOTOELECTRON FLUX IS 3.407@+04 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 0.796 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 2.230@+06 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730@+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 1.500 MEV
SPECTRUM WEIGHT= 1.200@-01

THE PHOTOELECTRON FLUX IS 5.553@+03 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 1.282 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 5.996@+05 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730@+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 2.000 MEV
SPECTRUM WEIGHT= 7.890@-02

THE PHOTOELECTRON FLUX IS 1.826@+03 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 1.773 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 2.826@+05 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 2.500 MEV
SPECTRUM WEIGHT= 4.150E-02

THE PHOTOELECTRON FLUX IS 5.424E+02 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 2.268 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 1.157E+05 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 3.000 MEV
SPECTRUM WEIGHT= 2.140E-02

THE PHOTOELECTRON FLUX IS 1.871E+02 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 2.765 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 4.885E+04 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 3.500 MEV
SPECTRUM WEIGHT= 8.900E-03

THE PHOTOELECTRON FLUX IS 5.358E+01 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 3.262 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 1.719E+04 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 4.000 MEV
SPECTRUM WEIGHT= 9.300E-03

THE PHOTOELECTRON FLUX IS 4.038E+01 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 3.760 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 1.557E+04 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 4.500 MEV
SPECTRUM WEIGHT= 3.400E-03

THE PHOTOELECTRON FLUX IS 1.102E+01 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 4.258 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 5.022E+03 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 5.000 MEV
SPECTRUM WEIGHT= 2.700E-03

THE PHOTOELECTRON FLUX IS 6.706E+00 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 4.757 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 3.568E+03 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 5.500 MEV
SPECTRUM WEIGHT= 2.400E-03

THE PHOTOELECTRON FLUX IS 4.664E+00 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 5.256 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 2.870E+03 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 6.000 MEV
SPECTRUM WEIGHT= 1.000E-03

THE PHOTOELECTRON FLUX IS 1.546E+00 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 5.755 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 1.092E+03 ELECTRONS/SQ CM

SCATTERSHOT III - A B-5500 PROGRAM FOR CALCULATING PHOTOELECTRIC,COMPTON, AND PAIR ELECTRON FLUX AND SPECTRUM

CALCULATION FOR: GAMMA FLUX= 1.730E+09 PHOTONS /(SQ.CM.)(SEC.)
GAMMA ENERGY= 6.500 MEV

SPECTRUM WEIGHT= 6.000@-04

THE PHOTOELECTRON FLUX IS 7.479@-01 ELECTRONS/SQ.CM.

THE VALUE OF TCMAX IS 6.254 MEV
THE DIFFERENTIAL ENERGY FLUX AT TCMAX IS 6.025@+02 ELECTRONS/SQ C

| ELECTRON ENERGY (MEV) | RUNNING TOTAL ELECTRON FLUX |
|---|---|
| 0.015 | 6.760@+06 |
| 0.025 | 6.640@+06 |
| 0.035 | 6.520@+06 |
| 0.045 | 6.401@+06 |
| 0.055 | 6.282@+06 |
| 0.065 | 6.164@+06 |
| 0.075 | 6.047@+06 |
| 0.085 | 5.932@+06 |
| 0.095 | 5.819@+06 |
| 0.105 | 5.708@+06 |
| 0.115 | 5.601@+06 |
| 0.125 | 5.497@+06 |
| 0.135 | 5.398@+06 |
| 0.145 | 5.305@+06 |
| 0.155 | 5.219@+06 |
| 0.165 | 5.141@+06 |
| 0.175 | 5.072@+06 |
| 0.185 | 5.016@+06 |
| 0.195 | 4.973@+06 |
| 0.205 | 4.948@+06 |
| 0.215 | 4.942@+06 |
| 0.225 | 4.961@+06 |
| 0.235 | 5.009@+06 |
| 0.245 | 5.092@+06 |
| 0.255 | 5.218@+06 |
| 0.265 | 5.395@+06 |
| 0.275 | 5.636@+06 |
| 0.285 | 5.955@+06 |
| 0.295 | 6.370@+06 |
| 0.305 | 6.904@+06 |
| 0.315 | 7.588@+06 |
| 0.325 | 8.460@+06 |
| 0.335 | 9.574@+06 |
| 0.345 | 1.014@+06 |
| 0.355 | 1.012@+06 |
| 0.365 | 1.010@+06 |
| 0.375 | 1.009@+06 |
| 0.385 | 1.007@+06 |
| 0.395 | 1.006@+06 |
| 0.405 | 1.005@+06 |
| 0.415 | 1.004@+06 |
| 0.425 | 1.004@+06 |
| 0.435 | 1.004@+06 |
| 0.445 | 1.004@+06 |
| 0.455 | 1.005@+06 |
| 0.465 | 1.006@+06 |
| 0.475 | 1.008@+06 |
| 0.485 | 1.010@+06 |
| 0.495 | 1.013@+06 |
| 0.505 | 1.016@+06 |
| 0.515 | 1.021@+06 |

39773

| | |
|---|---|
| 0.525 | 1.024e+06 |
| 0.535 | 1.032e+06 |
| 0.545 | 1.039e+06 |
| 0.555 | 1.047e+06 |
| 0.565 | 1.056e+06 |
| 0.575 | 1.066e+06 |
| 0.585 | 1.077e+06 |
| 0.595 | 1.091e+06 |
| 0.605 | 1.105e+06 |
| 0.615 | 1.122e+06 |
| 0.625 | 1.140e+06 |
| 0.635 | 1.161e+06 |
| 0.645 | 1.185e+06 |
| 0.655 | 1.211e+06 |
| 0.665 | 1.241e+06 |
| 0.675 | 1.275e+06 |
| 0.685 | 1.312e+06 |
| 0.695 | 1.355e+06 |
| 0.705 | 1.403e+06 |
| 0.715 | 1.457e+06 |
| 0.725 | 1.518e+06 |
| 0.735 | 1.588e+06 |
| 0.745 | 1.667e+06 |
| 0.755 | 1.758e+06 |
| 0.765 | 1.862e+06 |
| 0.775 | 1.982e+06 |
| 0.785 | 2.121e+06 |
| 0.795 | 2.283e+06 |
| 0.805 | 2.472e+06 |
| 0.815 | 2.729e+05 |
| 0.825 | 2.740e+05 |
| 0.835 | 2.752e+05 |
| 0.845 | 2.764e+05 |
| 0.855 | 2.777e+05 |
| 0.865 | 2.791e+05 |
| 0.875 | 2.806e+05 |
| 0.885 | 2.822e+05 |
| 0.895 | 2.838e+05 |
| 0.905 | 2.856e+05 |
| 0.915 | 2.875e+05 |
| 0.925 | 2.895e+05 |
| 0.935 | 2.916e+05 |
| 0.945 | 2.939e+05 |
| 0.955 | 2.963e+05 |
| 0.965 | 2.988e+05 |
| 0.975 | 3.014e+05 |
| 0.985 | 3.041e+05 |
| 0.995 | 3.070e+05 |
| 1.005 | 3.105e+05 |
| 1.015 | 3.142e+05 |
| 1.025 | 3.182e+05 |
| 1.035 | 3.224e+05 |
| 1.045 | 3.270e+05 |
| 1.055 | 3.318e+05 |
| 1.065 | 3.370e+05 |
| 1.075 | 3.426e+05 |
| 1.085 | 3.486e+05 |
| 1.095 | 3.550e+05 |
| 1.105 | 3.620e+05 |
| 1.115 | 3.695e+05 |
| 1.125 | 3.776e+05 |
| 1.135 | 3.863e+05 |

| | |
|---|---|
| 1.145 | 3.958@+05 |
| 1.155 | 4.061@+05 |
| 1.165 | 4.174@+05 |
| 1.175 | 4.296@+05 |
| 1.185 | 4.431@+05 |
| 1.195 | 4.577@+05 |
| 1.205 | 4.738@+05 |
| 1.215 | 4.916@+05 |
| 1.225 | 5.112@+05 |
| 1.235 | 5.330@+05 |
| 1.245 | 5.573@+05 |
| 1.255 | 5.845@+05 |
| 1.265 | 6.150@+05 |
| 1.275 | 6.494@+05 |
| 1.285 | 6.884@+05 |
| 1.295 | 1.181@+05 |
| 1.305 | 1.189@+05 |
| 1.315 | 1.197@+05 |
| 1.325 | 1.206@+05 |
| 1.335 | 1.216@+05 |
| 1.345 | 1.225@+05 |
| 1.355 | 1.235@+05 |
| 1.365 | 1.245@+05 |
| 1.375 | 1.257@+05 |
| 1.385 | 1.268@+05 |
| 1.395 | 1.280@+05 |
| 1.405 | 1.293@+05 |
| 1.415 | 1.306@+05 |
| 1.425 | 1.320@+05 |
| 1.435 | 1.334@+05 |
| 1.445 | 1.349@+05 |
| 1.455 | 1.364@+05 |
| 1.465 | 1.381@+05 |
| 1.475 | 1.398@+05 |
| 1.485 | 1.415@+05 |
| 1.495 | 1.433@+05 |

39775

| | |
|---|---|
| 1.765 | 3.007E+05 |
| 1.775 | 3.168E+05 |
| 1.785 | 4.937E+04 |
| 1.795 | 4.978E+04 |
| 1.805 | 5.019E+04 |
| 1.815 | 5.063E+04 |
| 1.825 | 5.108E+04 |
| 1.835 | 5.154E+04 |
| 1.845 | 5.202E+04 |
| 1.855 | 5.253E+04 |
| 1.865 | 5.305E+04 |
| 1.875 | 5.359E+04 |
| 1.885 | 5.415E+04 |
| 1.895 | 5.473E+04 |
| 1.905 | 5.533E+04 |
| 1.915 | 5.596E+04 |
| 1.925 | 5.662E+04 |
| 1.935 | 5.730E+04 |
| 1.945 | 5.801E+04 |
| 1.955 | 5.875E+04 |
| 1.965 | 5.951E+04 |
| 1.975 | 6.030E+04 |
| 1.985 | 6.109E+04 |
| 1.995 | 6.193E+04 |
| 2.005 | 6.292E+04 |
| 2.015 | 6.395E+04 |
| 2.025 | 6.503E+04 |
| 2.035 | 6.617E+04 |
| 2.045 | 6.737E+04 |
| 2.055 | 6.864E+04 |
| 2.065 | 6.997E+04 |
| 2.075 | 7.138E+04 |
| 2.085 | 7.287E+04 |
| 2.095 | 7.445E+04 |
| 2.105 | 7.613E+04 |
| 2.115 | 7.792E+04 |
| 2.125 | 7.982E+04 |
| 2.135 | 8.184E+04 |
| 2.145 | 8.401E+04 |
| 2.155 | 8.633E+04 |
| 2.165 | 8.881E+04 |
| 2.175 | 9.149E+04 |
| 2.185 | 9.437E+04 |
| 2.195 | 9.749E+04 |
| 2.205 | 1.009E+05 |
| 2.215 | 1.045E+05 |
| 2.225 | 1.085E+05 |
| 2.235 | 1.129E+05 |
| 2.245 | 1.177E+05 |
| 2.255 | 1.230E+05 |
| 2.265 | 1.288E+05 |
| 2.275 | 1.354E+05 |
| 2.285 | 2.197E+04 |
| 2.295 | 2.216E+04 |
| 2.305 | 2.236E+04 |
| 2.315 | 2.257E+04 |
| 2.325 | 2.278E+04 |
| 2.335 | 2.300E+04 |
| 2.345 | 2.322E+04 |
| 2.355 | 2.346E+04 |
| 2.365 | 2.370E+04 |
| 2.375 | 2.395E+04 |

| | |
|---|---|
| 2.385 | 2.421E+04 |
| 2.395 | 2.448E+04 |
| 2.405 | 2.476E+04 |
| 2.415 | 2.505E+04 |
| 2.425 | 2.536E+04 |
| 2.435 | 2.567E+04 |
| 2.445 | 2.599E+04 |
| 2.455 | 2.633E+04 |
| 2.465 | 2.668E+04 |
| 2.475 | 2.704E+04 |
| 2.485 | 2.740E+04 |
| 2.495 | 2.779E+04 |
| 2.505 | 2.823E+04 |
| 2.515 | 2.869E+04 |
| 2.525 | 2.917E+04 |
| 2.535 | 2.968E+04 |
| 2.545 | 3.021E+04 |
| 2.555 | 3.077E+04 |
| 2.565 | 3.136E+04 |
| 2.575 | 3.199E+04 |
| 2.585 | 3.264E+04 |
| 2.595 | 3.334E+04 |
| 2.605 | 3.407E+04 |
| 2.615 | 3.485E+04 |
| 2.625 | 3.567E+04 |
| 2.635 | 3.655E+04 |
| 2.645 | 3.749E+04 |
| 2.655 | 3.849E+04 |
| 2.665 | 3.956E+04 |
| 2.675 | 4.070E+04 |
| 2.685 | 4.194E+04 |
| 2.695 | 4.326E+04 |
| 2.705 | 4.470E+04 |
| 2.715 | 4.625E+04 |
| 2.725 | 4.794E+04 |
| 2.735 | 4.977E+04 |
| 2.745 | 5.179E+04 |
| 2.755 | 5.399E+04 |
| 2.765 | 5.643E+04 |
| 2.775 | 1.016E+04 |
| 2.785 | 1.023E+04 |
| 2.795 | 1.031E+04 |
| 2.805 | 1.040E+04 |
| 2.815 | 1.048E+04 |
| 2.825 | 1.057E+04 |
| 2.835 | 1.066E+04 |
| 2.845 | 1.075E+04 |
| 2.855 | 1.084E+04 |
| 2.865 | 1.094E+04 |
| 2.875 | 1.104E+04 |
| 2.885 | 1.115E+04 |
| 2.895 | 1.126E+04 |
| 2.905 | 1.137E+04 |
| 2.915 | 1.148E+04 |
| 2.925 | 1.160E+04 |
| 2.935 | 1.173E+04 |
| 2.945 | 1.185E+04 |
| 2.955 | 1.199E+04 |
| 2.965 | 1.212E+04 |
| 2.975 | 1.225E+04 |
| 2.985 | 1.237E+04 |
| 2.995 | 1.251E+04 |

| | |
|---|---|
| 3.005 | 1.269E+04 |
| 3.015 | 1.288E+04 |
| 3.025 | 1.307E+04 |
| 3.035 | 1.328E+04 |
| 3.045 | 1.349E+04 |
| 3.055 | 1.372E+04 |
| 3.065 | 1.395E+04 |
| 3.075 | 1.420E+04 |
| 3.085 | 1.446E+04 |
| 3.095 | 1.473E+04 |
| 3.105 | 1.502E+04 |
| 3.115 | 1.532E+04 |
| 3.125 | 1.564E+04 |
| 3.135 | 1.598E+04 |
| 3.145 | 1.634E+04 |
| 3.155 | 1.672E+04 |
| 3.165 | 1.713E+04 |
| 3.175 | 1.756E+04 |
| 3.185 | 1.803E+04 |
| 3.195 | 1.853E+04 |
| 3.205 | 1.906E+04 |
| 3.215 | 1.964E+04 |
| 3.225 | 2.027E+04 |
| 3.235 | 2.094E+04 |
| 3.245 | 2.168E+04 |
| 3.255 | 2.248E+04 |
| 3.265 | 2.337E+04 |
| 3.275 | 6.854E+03 |
| 3.285 | 6.920E+03 |
| 3.295 | 6.988E+03 |
| 3.305 | 7.059E+03 |
| 3.315 | 7.130E+03 |
| 3.325 | 7.205E+03 |
| 3.335 | 7.282E+03 |
| 3.345 | 7.361E+03 |
| 3.355 | 7.443E+03 |
| 3.365 | 7.528E+03 |
| 3.375 | 7.616E+03 |
| 3.385 | 7.706E+03 |
| 3.395 | 7.800E+03 |
| 3.405 | 7.897E+03 |
| 3.415 | 7.997E+03 |
| 3.425 | 8.101E+03 |
| 3.435 | 8.209E+03 |
| 3.445 | 8.321E+03 |
| 3.455 | 8.436E+03 |
| 3.465 | 8.556E+03 |
| 3.475 | 8.678E+03 |
| 3.485 | 8.802E+03 |
| 3.495 | 8.933E+03 |
| 3.505 | 9.082E+03 |
| 3.515 | 9.237E+03 |
| 3.525 | 9.400E+03 |
| 3.535 | 9.570E+03 |
| 3.545 | 9.749E+03 |
| 3.555 | 9.936E+03 |
| 3.565 | 1.013E+04 |
| 3.575 | 1.034E+04 |
| 3.585 | 1.056E+04 |
| 3.595 | 1.079E+04 |
| 3.605 | 1.103E+04 |
| 3.615 | 1.128E+04 |

| | |
|---|---|
| 3.625 | 1.155E+04 |
| 3.635 | 1.184E+04 |
| 3.645 | 1.214E+04 |
| 3.655 | 1.247E+04 |
| 3.665 | 1.281E+04 |
| 3.675 | 1.318E+04 |
| 3.685 | 1.358E+04 |
| 3.695 | 1.400E+04 |
| 3.705 | 1.446E+04 |
| 3.715 | 1.495E+04 |
| 3.725 | 1.549E+04 |
| 3.735 | 1.607E+04 |
| 3.745 | 1.670E+04 |
| 3.755 | 1.739E+04 |
| 3.765 | 1.814E+04 |
| 3.775 | 2.979E+03 |
| 3.785 | 3.003E+03 |
| 3.795 | 3.028E+03 |
| 3.805 | 3.054E+03 |
| 3.815 | 3.081E+03 |
| 3.825 | 3.108E+03 |
| 3.835 | 3.136E+03 |
| 3.845 | 3.164E+03 |
| 3.855 | 3.194E+03 |
| 3.865 | 3.225E+03 |
| 3.875 | 3.256E+03 |
| 3.885 | 3.289E+03 |
| 3.895 | 3.322E+03 |
| 3.905 | 3.357E+03 |
| 3.915 | 3.392E+03 |
| 3.925 | 3.429E+03 |
| 3.935 | 3.467E+03 |
| 3.945 | 3.506E+03 |
| 3.955 | 3.546E+03 |
| 3.965 | 3.587E+03 |
| 3.975 | 3.628E+03 |
| 3.985 | 3.668E+03 |
| 3.995 | 3.711E+03 |
| 4.005 | 3.765E+03 |
| 4.015 | 3.821E+03 |
| 4.025 | 3.880E+03 |
| 4.035 | 3.941E+03 |
| 4.045 | 4.005E+03 |
| 4.055 | 4.071E+03 |
| 4.065 | 4.141E+03 |
| 4.075 | 4.214E+03 |
| 4.085 | 4.291E+03 |
| 4.095 | 4.372E+03 |
| 4.105 | 4.457E+03 |
| 4.115 | 4.546E+03 |
| 4.125 | 4.640E+03 |
| 4.135 | 4.740E+03 |
| 4.145 | 4.845E+03 |
| 4.155 | 4.957E+03 |
| 4.165 | 5.076E+03 |
| 4.175 | 5.203E+03 |
| 4.185 | 5.338E+03 |
| 4.195 | 5.483E+03 |
| 4.205 | 5.637E+03 |
| 4.215 | 5.804E+03 |
| 4.225 | 5.983E+03 |
| 4.235 | 6.178E+03 |

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|---|---|
| 4.245 | 6.388E+03 |
| 4.255 | 6.618E+03 |
| 4.265 | 6.868E+03 |
| 4.275 | 1.944E+03 |
| 4.285 | 1.961E+03 |
| 4.295 | 1.979E+03 |
| 4.305 | 1.997E+03 |
| 4.315 | 2.016E+03 |
| 4.325 | 2.036E+03 |
| 4.335 | 2.056E+03 |
| 4.345 | 2.076E+03 |
| 4.355 | 2.098E+03 |
| 4.365 | 2.119E+03 |
| 4.375 | 2.142E+03 |
| 4.385 | 2.165E+03 |
| 4.395 | 2.189E+03 |
| 4.405 | 2.214E+03 |
| 4.415 | 2.239E+03 |
| 4.425 | 2.265E+03 |
| 4.435 | 2.292E+03 |
| 4.445 | 2.320E+03 |
| 4.455 | 2.349E+03 |
| 4.465 | 2.378E+03 |
| 4.475 | 2.407E+03 |
| 4.485 | 2.435E+03 |
| 4.495 | 2.465E+03 |
| 4.505 | 2.504E+03 |
| 4.515 | 2.544E+03 |
| 4.525 | 2.587E+03 |
| 4.535 | 2.631E+03 |
| 4.545 | 2.677E+03 |
| 4.555 | 2.725E+03 |
| 4.565 | 2.775E+03 |
| 4.575 | 2.828E+03 |
| 4.585 | 2.883E+03 |
| 4.595 | 2.941E+03 |
| 4.605 | 3.002E+03 |
| 4.615 | 3.066E+03 |
| 4.625 | 3.133E+03 |
| 4.635 | 3.205E+03 |
| 4.645 | 3.280E+03 |
| 4.655 | 3.361E+03 |
| 4.665 | 3.446E+03 |
| 4.675 | 3.536E+03 |
| 4.685 | 3.632E+03 |
| 4.695 | 3.735E+03 |
| 4.705 | 3.845E+03 |
| 4.715 | 3.964E+03 |
| 4.725 | 4.092E+03 |
| 4.735 | 4.229E+03 |
| 4.745 | 4.379E+03 |
| 4.755 | 4.541E+03 |
| 4.765 | 4.718E+03 |
| 4.775 | 1.196E+03 |
| 4.785 | 1.209E+03 |
| 4.795 | 1.223E+03 |
| 4.805 | 1.237E+03 |
| 4.815 | 1.251E+03 |
| 4.825 | 1.266E+03 |
| 4.835 | 1.281E+03 |
| 4.845 | 1.296E+03 |
| 4.855 | 1.312E+03 |

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| 4.865 | 1.329E+03 |
| 4.875 | 1.346E+03 |
| 4.885 | 1.364E+03 |
| 4.895 | 1.382E+03 |
| 4.905 | 1.401E+03 |
| 4.915 | 1.420E+03 |
| 4.925 | 1.440E+03 |
| 4.935 | 1.461E+03 |
| 4.945 | 1.483E+03 |
| 4.955 | 1.505E+03 |
| 4.965 | 1.528E+03 |
| 4.975 | 1.551E+03 |
| 4.985 | 1.575E+03 |
| 4.995 | 1.600E+03 |
| 5.005 | 1.628E+03 |
| 5.015 | 1.659E+03 |
| 5.025 | 1.690E+03 |
| 5.035 | 1.723E+03 |
| 5.045 | 1.757E+03 |
| 5.055 | 1.793E+03 |
| 5.065 | 1.830E+03 |
| 5.075 | 1.870E+03 |
| 5.085 | 1.911E+03 |
| 5.095 | 1.955E+03 |
| 5.105 | 2.000E+03 |
| 5.115 | 2.049E+03 |
| 5.125 | 2.100E+03 |
| 5.135 | 2.154E+03 |
| 5.145 | 2.211E+03 |
| 5.155 | 2.271E+03 |
| 5.165 | 2.336E+03 |
| 5.175 | 2.405E+03 |
| 5.185 | 2.478E+03 |
| 5.195 | 2.556E+03 |
| 5.205 | 2.641E+03 |
| 5.215 | 2.731E+03 |
| 5.225 | 2.829E+03 |
| 5.235 | 2.934E+03 |
| 5.245 | 3.049E+03 |
| 5.255 | 3.174E+03 |
| 5.265 | 3.310E+03 |
| 5.275 | 4.570E+02 |
| 5.285 | 4.621E+02 |
| 5.295 | 4.674E+02 |
| 5.305 | 4.728E+02 |
| 5.315 | 4.783E+02 |
| 5.325 | 4.840E+02 |
| 5.335 | 4.899E+02 |
| 5.345 | 4.960E+02 |
| 5.355 | 5.022E+02 |
| 5.365 | 5.087E+02 |
| 5.375 | 5.153E+02 |
| 5.385 | 5.222E+02 |
| 5.395 | 5.292E+02 |
| 5.405 | 5.365E+02 |
| 5.415 | 5.441E+02 |
| 5.425 | 5.519E+02 |
| 5.435 | 5.599E+02 |
| 5.445 | 5.682E+02 |
| 5.455 | 5.767E+02 |
| 5.465 | 5.855E+02 |
| 5.475 | 5.944E+02 |

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| 5.485 | 6.031E+02 |
| 5.495 | 6.123E+02 |
| 5.505 | 6.237E+02 |
| 5.515 | 6.355E+02 |
| 5.525 | 6.478E+02 |
| 5.535 | 6.606E+02 |
| 5.545 | 6.741E+02 |
| 5.555 | 6.881E+02 |
| 5.565 | 7.028E+02 |
| 5.575 | 7.182E+02 |
| 5.585 | 7.344E+02 |
| 5.595 | 7.513E+02 |
| 5.605 | 7.692E+02 |
| 5.615 | 7.880E+02 |
| 5.625 | 8.078E+02 |
| 5.635 | 8.288E+02 |
| 5.645 | 8.510E+02 |
| 5.655 | 8.745E+02 |
| 5.665 | 8.995E+02 |
| 5.675 | 9.261E+02 |
| 5.685 | 9.544E+02 |
| 5.695 | 9.847E+02 |
| 5.705 | 1.017E+03 |
| 5.715 | 1.052E+03 |
| 5.725 | 1.090E+03 |
| 5.735 | 1.130E+03 |
| 5.745 | 1.174E+03 |
| 5.755 | 1.222E+03 |
| 5.765 | 1.819E+02 |
| 5.775 | 1.844E+02 |
| 5.785 | 1.870E+02 |
| 5.795 | 1.896E+02 |
| 5.805 | 1.924E+02 |
| 5.815 | 1.952E+02 |
| 5.825 | 1.981E+02 |
| 5.835 | 2.011E+02 |
| 5.845 | 2.042E+02 |
| 5.855 | 2.074E+02 |
| 5.865 | 2.107E+02 |
| 5.875 | 2.141E+02 |
| 5.885 | 2.176E+02 |
| 5.895 | 2.213E+02 |
| 5.905 | 2.251E+02 |
| 5.915 | 2.290E+02 |
| 5.925 | 2.331E+02 |
| 5.935 | 2.373E+02 |
| 5.945 | 2.417E+02 |
| 5.955 | 2.463E+02 |
| 5.965 | 2.510E+02 |
| 5.975 | 2.559E+02 |
| 5.985 | 2.611E+02 |
| 5.995 | 2.664E+02 |
| 6.005 | 2.720E+02 |
| 6.015 | 2.778E+02 |
| 6.025 | 2.839E+02 |
| 6.035 | 2.903E+02 |
| 6.045 | 2.970E+02 |
| 6.055 | 3.040E+02 |
| 6.065 | 3.113E+02 |
| 6.075 | 3.190E+02 |
| 6.085 | 3.271E+02 |
| 6.095 | 3.357E+02 |

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| 6.105 | 3.447E+02 |
| 6.115 | 3.542E+02 |
| 6.125 | 3.642E+02 |
| 6.135 | 3.748E+02 |
| 6.145 | 3.861E+02 |
| 6.155 | 3.981E+02 |
| 6.165 | 4.109E+02 |
| 6.175 | 4.245E+02 |
| 6.185 | 4.391E+02 |
| 6.195 | 4.546E+02 |
| 6.205 | 4.714E+02 |
| 6.215 | 4.894E+02 |
| 6.225 | 5.089E+02 |
| 6.235 | 5.299E+02 |
| 6.245 | 5.528E+02 |
| 6.255 | 5.777E+02 |
| 6.265 | 0.000E+00 |
| 6.275 | 0.000E+00 |
| 6.285 | 0.000E+00 |
| 6.295 | 0.000E+00 |
| 6.305 | 0.000E+00 |
| 6.315 | 0.000E+00 |
| 6.325 | 0.000E+00 |
| 6.335 | 0.000E+00 |
| 6.345 | 0.000E+00 |
| 6.355 | 0.000E+00 |
| 6.365 | 0.000E+00 |
| 6.375 | 0.000E+00 |
| 6.385 | 0.000E+00 |
| 6.395 | 0.000E+00 |
| 6.405 | 0.000E+00 |
| 6.415 | 0.000E+00 |
| 6.425 | 0.000E+00 |
| 6.435 | 0.000E+00 |
| 6.445 | 0.000E+00 |
| 6.455 | 0.000E+00 |
| 6.465 | 0.000E+00 |
| 6.475 | 0.000E+00 |
| 6.485 | 0.000E+00 |
| 6.495 | 0.000E+00 |
| 6.505 | 0.000E+00 |