INTERNAL REPORT
#16

# Compton Electrons in P&E Range Telescope Scintillator

Probability of Gamma Ray passing through Anti Coincidence Scintillator:

The scintillator is 3/8" ~~Anthracene~~ Plastic (NE102) approx. with Threshold of 1/3 Minimum Ionizing proton

Scintillator Data (From Nuclear Enterprises Ltd NE102 Plastic Phosphor Bulletin # 1004

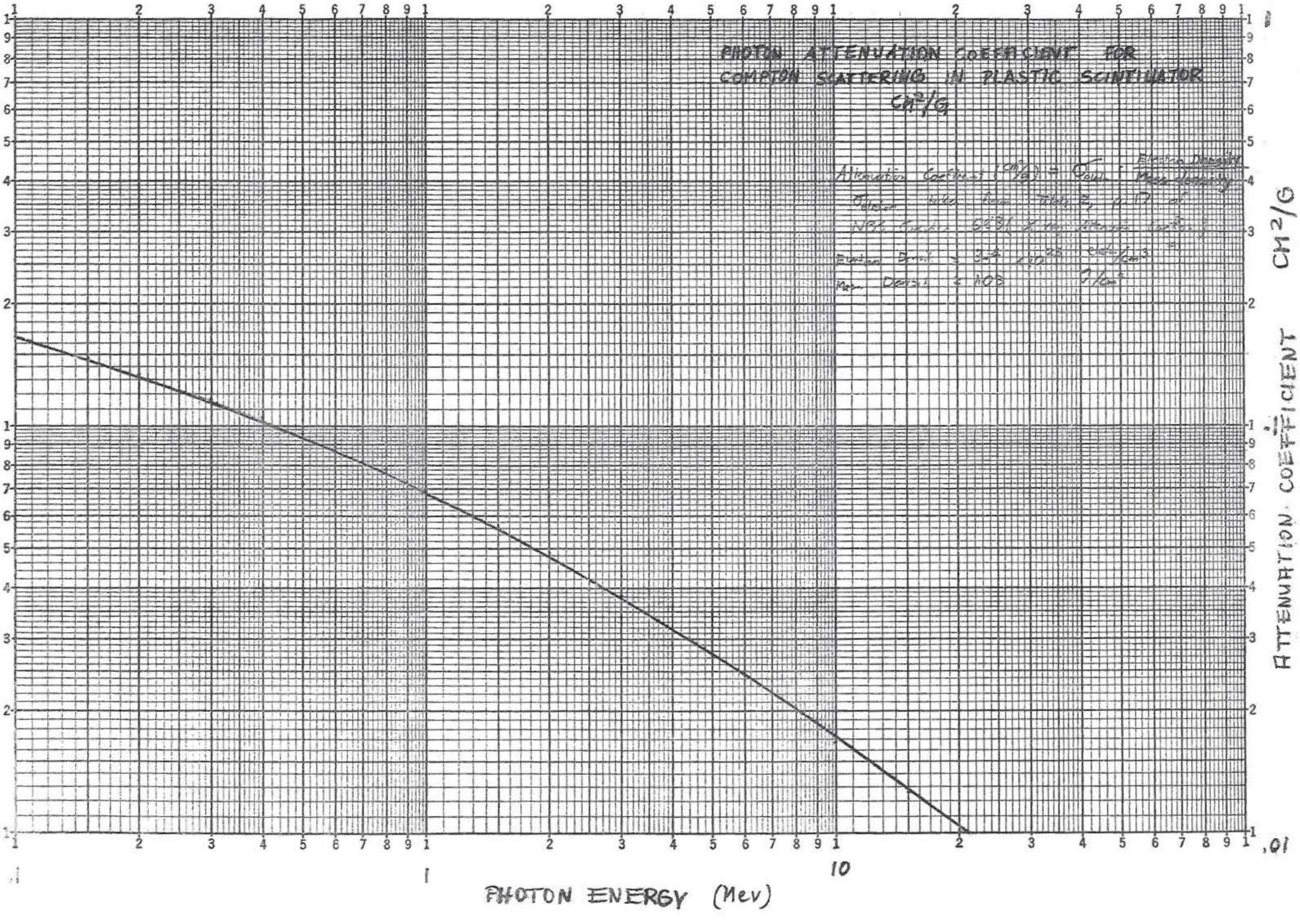
Density = 1.03 gm/cc
Electrons per cc. = $3.4 \times 10^{23}$
Atomic composition
H -- $5.25 \times 10^{22}$ atom/cc
C -- $4.75 \times 10^{22}$ "
N -- $1.8 \times 10^{18}$ "
O -- $1.8 \times 10^{18}$ "

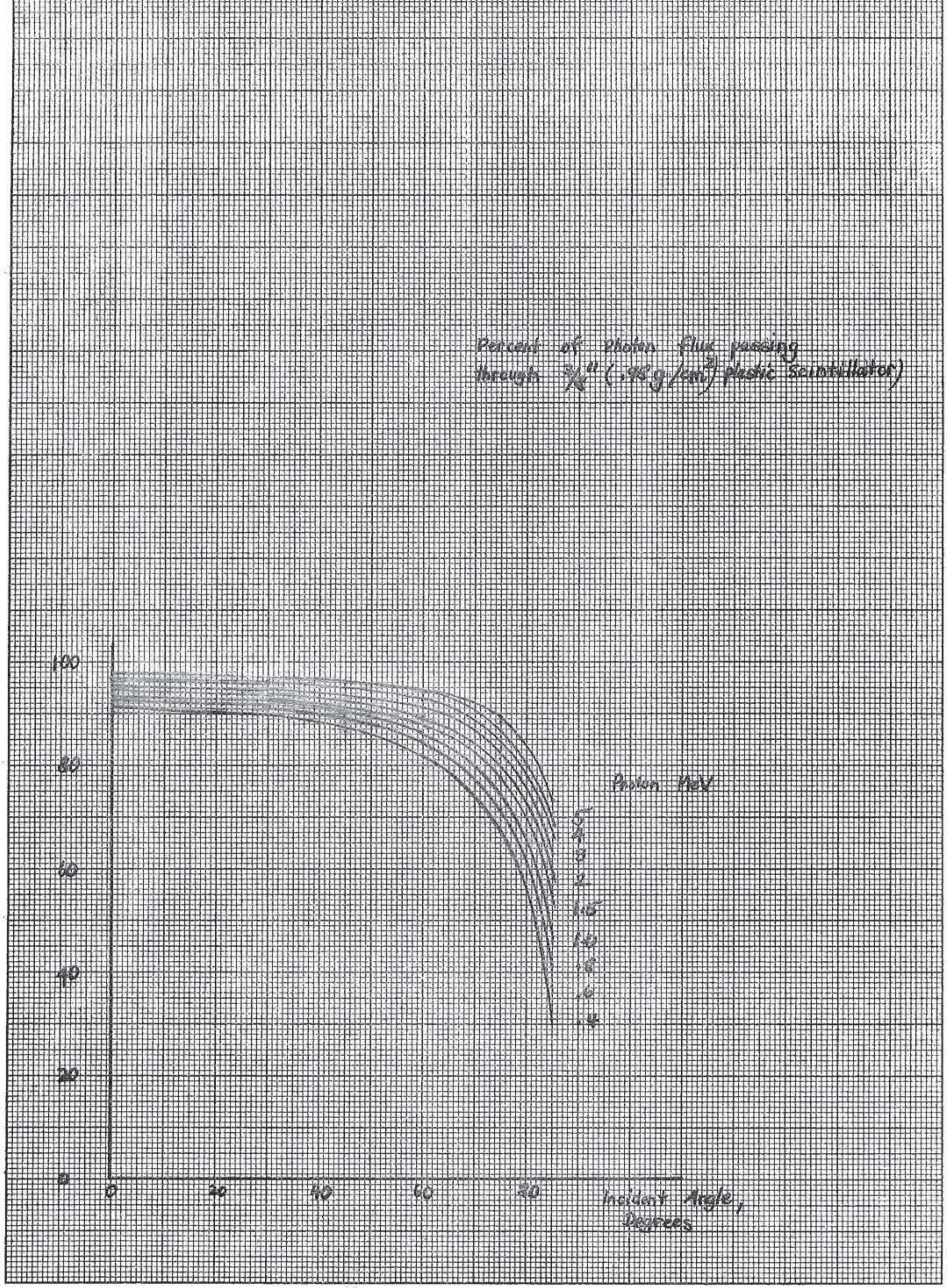
Table 2 p 17 of NBS Circular 583 (X-Ray Atten. Coeffs from 10KeV to [illegible] Give the crosssection calculated from the Klein - Nishina formula for Compton interactions in cm²/electron, converting to cm²/g.

$$\text{ie} \quad \sigma(\text{cm}^2/\text{g}) = \sigma(\text{cm}^2/\text{elect}) \cdot \frac{\text{Electrons}}{\text{cm}^3} \cdot 1/\text{Density}$$

The threshold of the scintillator is $\frac{1}{3}(1.95\ \text{MeV}/\text{Gm/cm}^2)(.98\ \text{g}/\text{cm}^2) = \frac{1.9\ \text{MeV}}{3}$
$= .635\ \text{MeV}$

See Graph Next Page
Graph on next page shows that there is generally less than 10 % chance of gamma interacting with scintillator.


PHOTON ATTENUATION COEFFICIENT FOR
COMPTON SCATTERING IN PLASTIC SCINTILLATOR
CM²/G
ATTENUATION COEFFICIENT CM²/G
.01
1
10
PHOTON ENERGY (Mev)


Percent of photon flux passing
through 3/8" (.98 g/cm²) plastic scintillator)
Photon MeV
5
4
3
2
1.5
1.0
.8
.6
.4
100
80
60
40
20
0
0
20
40
60
80
Incident Angle,
Degrees

## Solid Angle

Solid angle $= \Omega = 2\pi\int_0^{\theta} \sin\theta \, d\theta = 2\pi(1-\cos\theta)$

| $\Omega/4\pi$ | $\theta$ |
|---|---|
| .05 | 25.8° |
| .1 | 36.9 |
| .15 | 45.6 |
| .2 | 53.1 |
| .25 | 60.0 |
| .3 | 66.4 |
| .35 | 72.5 |
| .4 | 78.5 |
| .45 | 84.3 |
| .5 | 90.0 |

Count rate spectrum for D2 single events Assuming no photon attenuation from shielding or anticoincidence.

Procedure: Consider 5 conical zones such that each has solid angle of $\frac{1}{10} \times 4\pi$

| Zone | Small cone angle | Large cone angle | Median angle |
|---|---|---|---|
| 1 | 0.0 | 36.9 | 25.8 |
| 2 | 36.9 | 53.1 | 45.6 |
| 3 | 53.1 | 66.4 | 60.0 |
| 4 | 66.4 | 78.5 | 72.5 |
| 5 | 78.5 | 90 | 84.3 |

The Countrate for each Zone is determined as follows for a given energy interval

$$R = (\text{Flux})(\text{Energy Interval}) \cdot (\text{Geometric Factor})(\text{Interaction Probability})$$

$$\text{Geometric factor} = \text{Area} \times d\Omega \times \cos(\text{Median Angle})$$

$$\text{Interaction probability} = 1 - e^{-UX\sec(\text{Median angle})}$$

Area = detector area = 4.5 $cm^2$ for D2

U = Attenuation Coefficient (see graph)

X = detector thickness = .242 $g/cm^2$ for D2

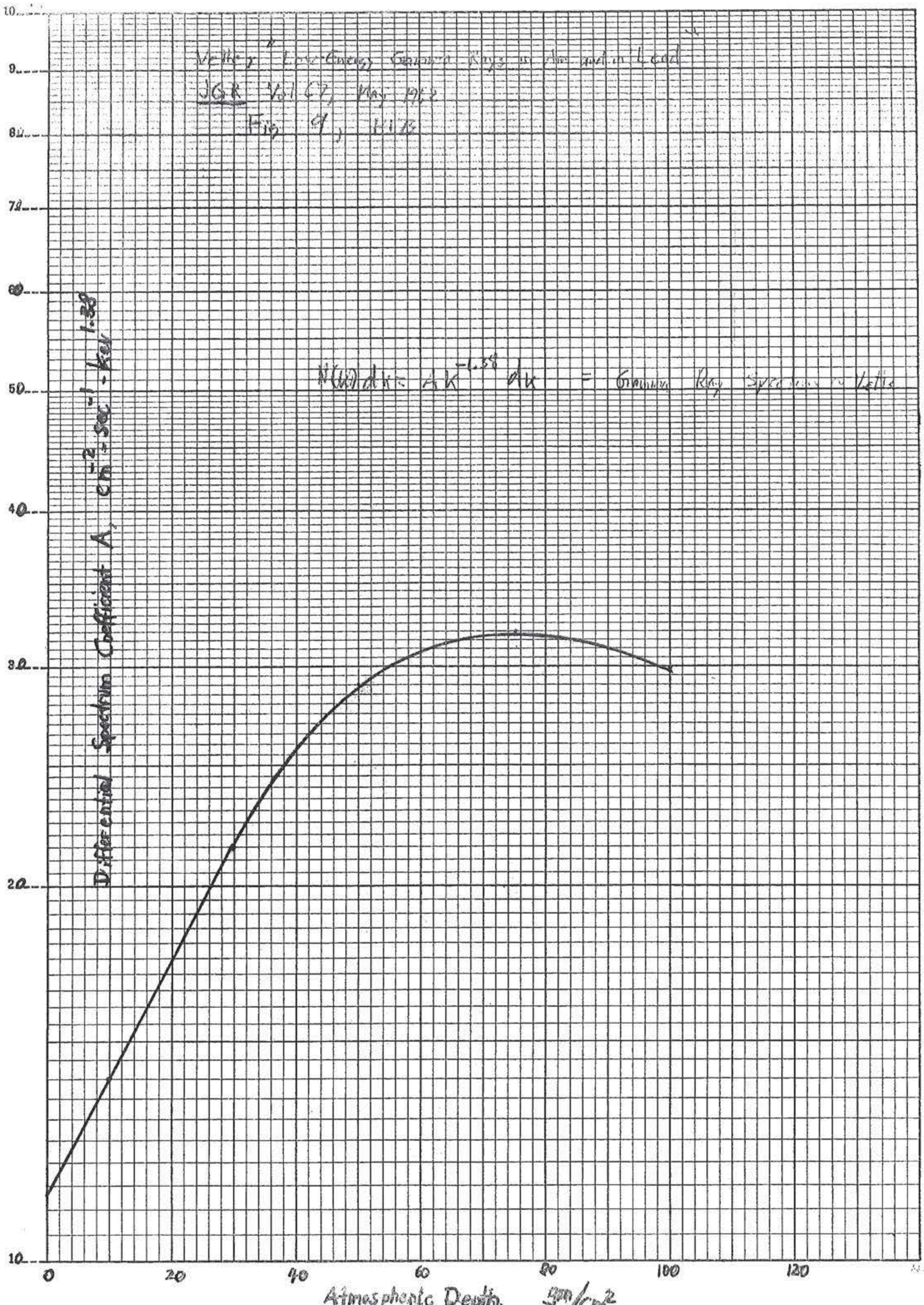
Counting rate through top hemisphere

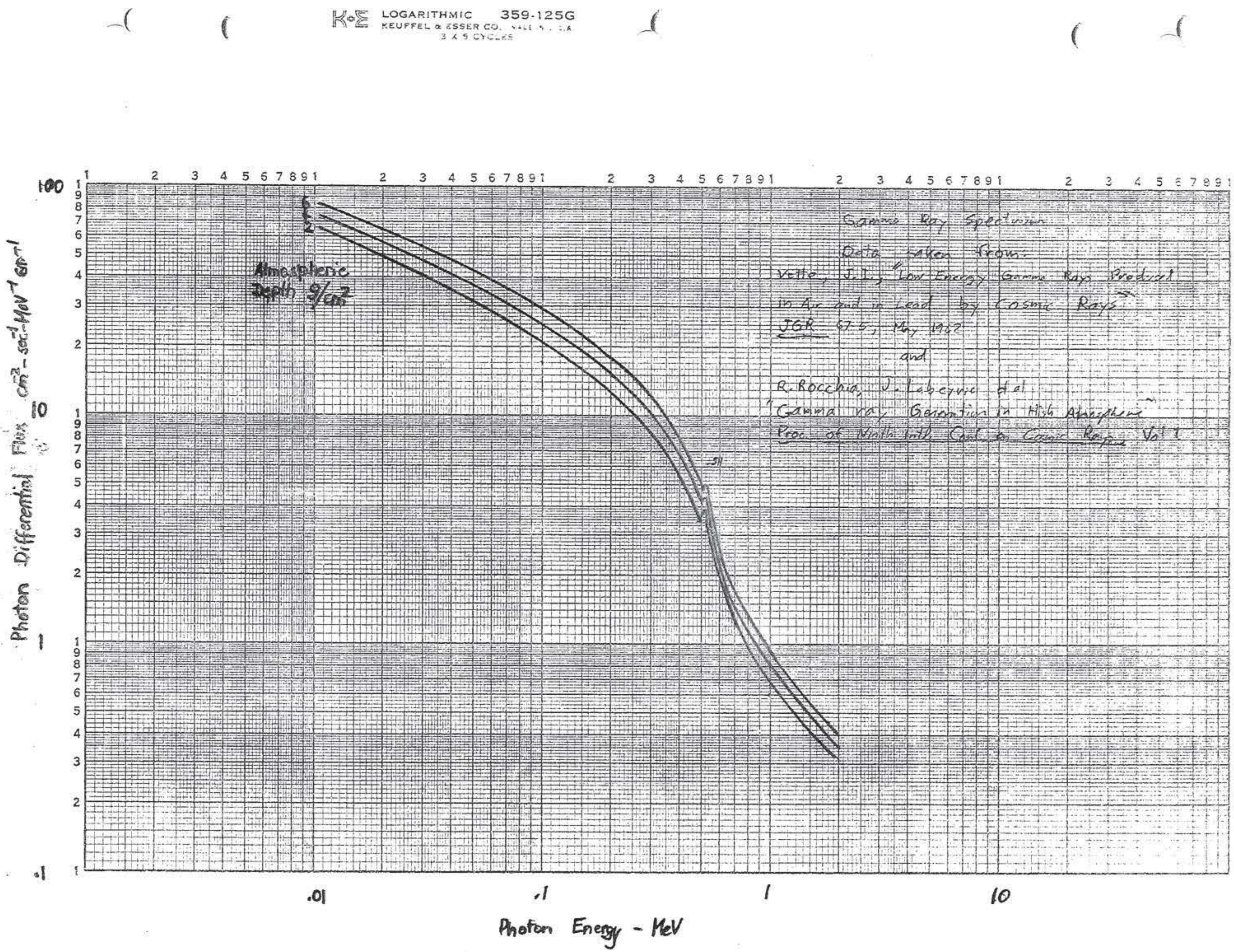
| Zone | | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|
| Solid Angle Increment | | $4\pi/10$ | $4\pi/10$ | $4\pi/10$ | $4\pi/10$ | $4\pi/10$ | |
| Median Angle | | 27.5° | 45.6 | 60 | 72.5 | 84.3 | |
| Geometric factor | | 4.97 | 3.96 | 2.82 | 1.70 | .565 | |
| X · sec(Median Angle) | | .275 | .346 | .485 | .805 | 2.44 | (x = .2[illegible]) |

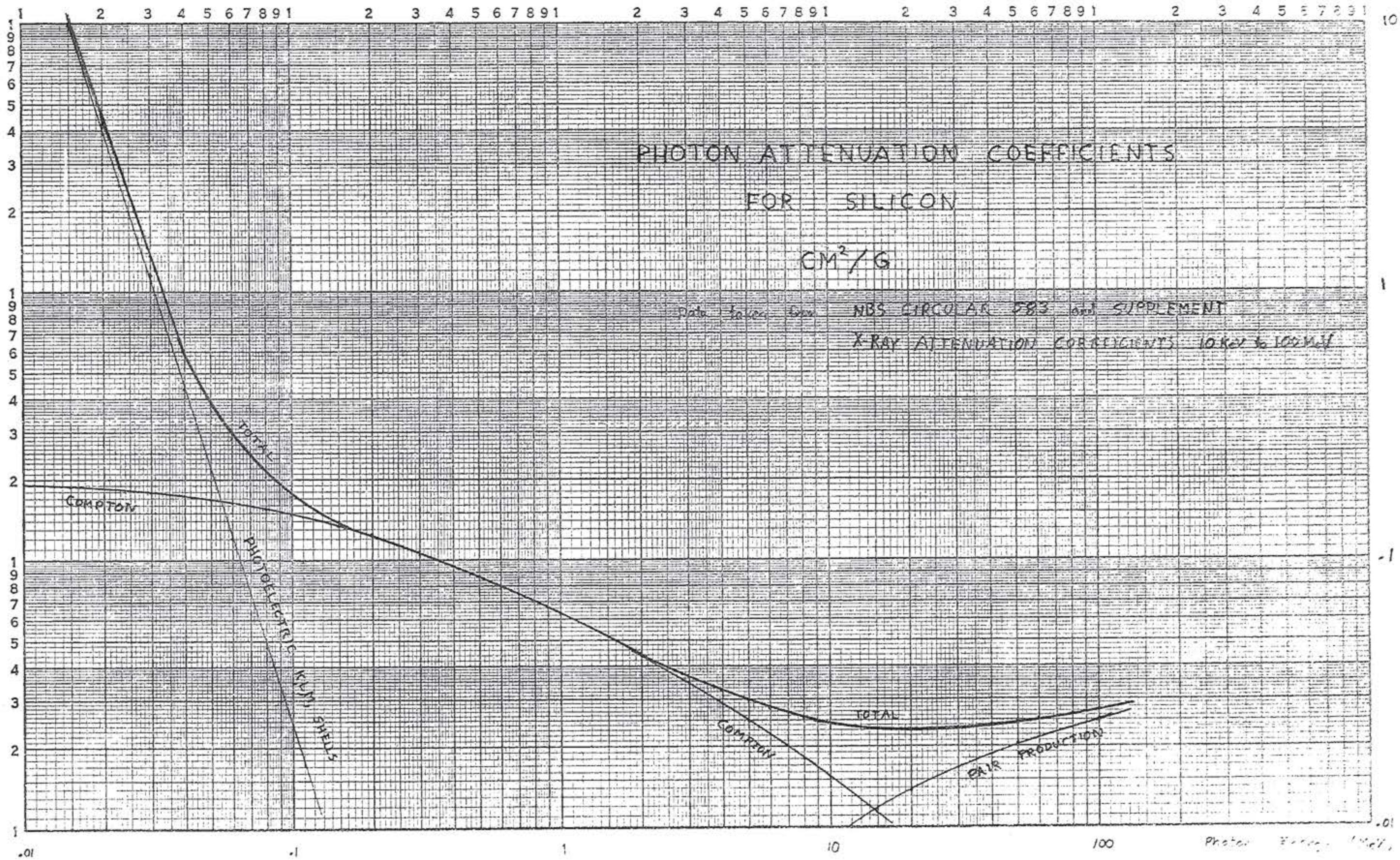
| Photon Energy | Atten. Coef U | Interaction Probability $= 1 - e^{-UX\sec(\text{Median Angle})}$ Zone 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| .4 MeV | .096 | .027 | .033 | .043 | .074 | .209 |
| .6 | .080 | .022 | .027 | .038 | .062 | .173 |
| .8 | .070 | .019 | .024 | .034 | .055 | .157 |
| 1.0 | .064 | .017 | .022 | .031 | .051 | .144 |
| 1.3 | .056 | .015 | .019 | .027 | .045 | .128 |
| 2 | .045 | .012 | .016 | .022 | .036 | .104 |
| 3 | .035 | .010 | .012 | .017 | .028 | .082 |
| 4 | .029 | .008 | .010 | .014 | .023 | .068 |
| 5 | .025 | .007 | .009 | .012 | .020 | .058 |

| Photon Energy Interval | Flux $sec^{-1}$ Photons in Energy Interval | Counting rate $sec^{-1}$, [illegible] @ 4g/cm² altitude 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|
| .4 ±.1 | 1.40 | .187 | .182 | .169 | .175 | .165 | .878 |
| .6 ±.1 | .44 | .048 | .047 | .047 | .046 | .043 | .231 |
| .8 ±.1 | .22 | .021 | .020 | .021 | .020 | .019 | .101 |
| 1.0 ±.1 | .16 | .013 | .014 | .014 | .014 | .013 | .068 |
| 1.3 ±.2 | .21 | .013 | .016 | .016 | .016 | .015 | .076 |
| 2 ±.5 | .35 | .021 | .022 | .022 | .022 | .020 | .107 |
| 3 ±.5 | .27 | .013 | .013 | .013 | .013 | .012 | .069 |
| 4 ±.5 | .23 | .009 | .009 | .009 | .009 | .009 | .045 |
| 5 ±.5 | .20 | .007 | .007 | .007 | .007 | .007 | .035 |
| | | | | | | | 1.705 |

Note that compton interactions are almost isotropic for the thin detector case


Vette, "Low Energy Gamma Rays in Air and in Lead"
JGR Vol 67, May 1962
Fig 9,
N(k) dk = A k^-1.38 dk = Gamma Ray Spectrum in Vette
Differential Spectrum Coefficient A, cm^-2 - sec^-1 - kev^1.38
Atmospheric Depth gm/cm^2
10
9
8
7
6
5
4
3
2
10
0
20
40
60
80
100
120


K+E LOGARITHMIC 359-125G
KEUFFEL & ESSER CO.
3 X 5 CYCLES
Gamma Ray Spectrum
Data taken from:
Vette, J.I., "Low Energy Gamma Rays Produced in Air and in Lead by Cosmic Rays"
JGR 67.5, May 1962
and
R. Rocchia, J. Labeyrie et al.
"Gamma ray Generation in High Atmosphere"
Proc. of Ninth Intl. Conf. on Cosmic Rays Vol 1
Atmospheric Depth g/cm²
6
4
2
.31
Photon Differential Flux cm⁻² - sec⁻¹ - MeV⁻¹ - cm⁻¹
100
10
1
.1
.01
.1
1
10
Photon Energy - MeV


PHOTON ATTENUATION COEFFICIENTS
FOR SILICON
CM²/G
Data taken from NBS CIRCULAR 583 and SUPPLEMENT
X-RAY ATTENUATION COEFFICIENTS 10 KeV to 100 MeV
TOTAL
COMPTON
PHOTOELECTRIC K,L,M SHELLS
TOTAL
COMPTON
PAIR PRODUCTION
10
1
.1
.01
.01
.1
1
10
100
Attenuation Coefficient, cm²/g

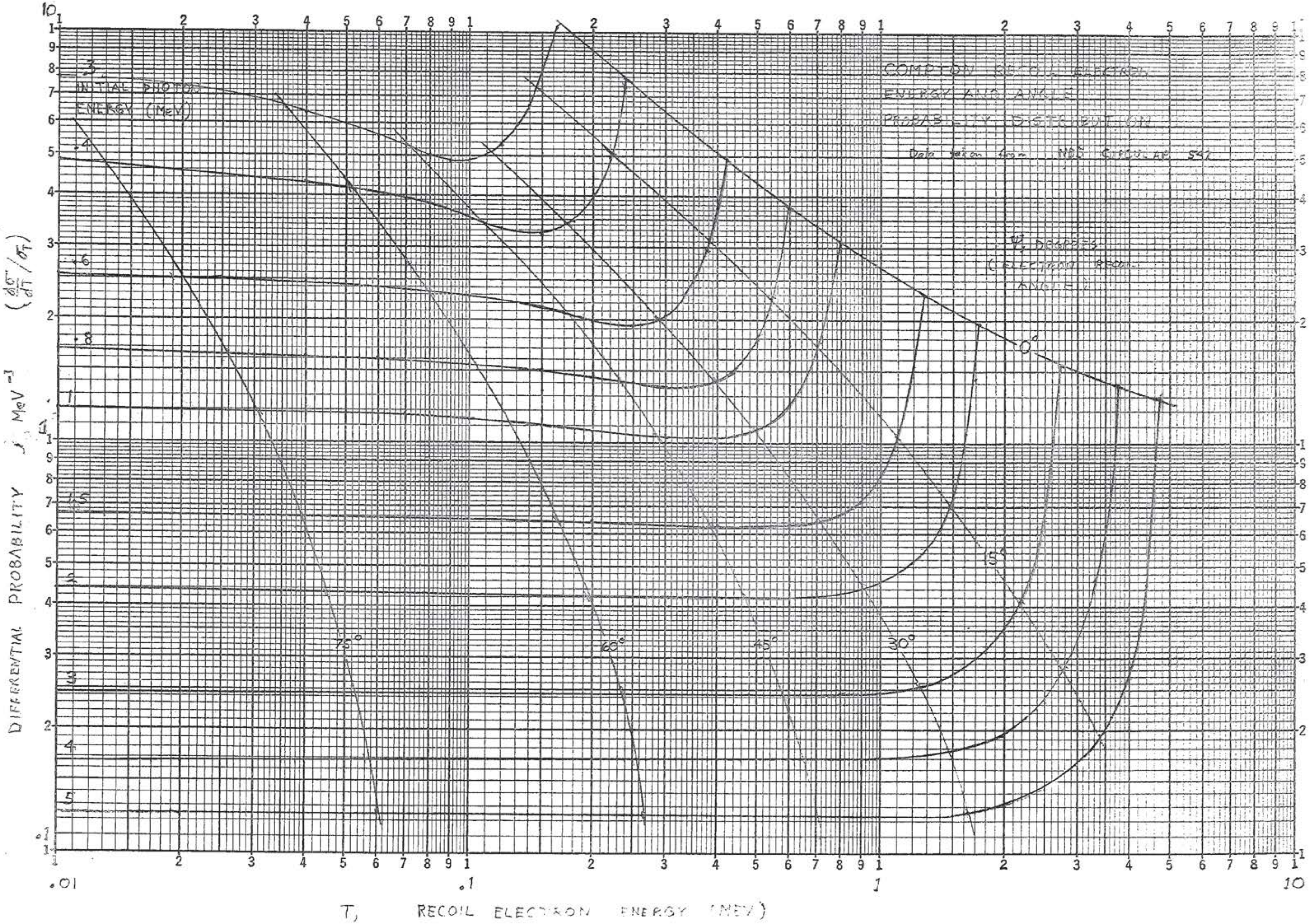
Now find distribution of recoil Electron Energy by using the Energy, Angle probability graph

| Electron Energy | (MeV) 0–.5 | .5–1 | 1–1.5 | 1.5–2 | 2–2.5 | 2.5–3 | 3–3.5 | 3.5–4 | 4–4.5 |
|---|---|---|---|---|---|---|---|---|---|
| Photon Energy | Counts Per Second in each interval | | | | | | | | |
| .4 ±.1 | .578 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| .6 ±.1 | .231 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| .8 ±.1 | .076 | .025 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 1 ±.1 | .034 | .034 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 1.3 ±.2 | .030 | .040 | .006 | 0 | 0 | 0 | 0 | 0 | |
| 2 ±.5 | .023 | .023 | .030 | .028 | 0 | 0 | 0 | 0 | 0 |
| 3 ±.5 | .008 | .008 | .008 | .010 | .015 | .015 | 0 | 0 | 0 |
| 4 ±.5 | .004 | .004 | .004 | .004 | .005 | .006 | .009 | .010 | |
| 5 ±.5 | .002 | .002 | .002 | .002 | .002 | .003 | .003 | .004 | [illegible] |
| | 1.286 | .136 | .050 | .044 | .022 | .024 | .012 | .014 | .05 |

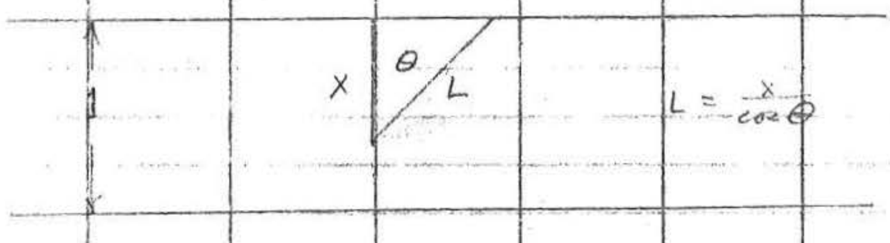
(This is for Top Hemisphere only)

Recoil Electron Energy spectrum for Gamma incident isotropically over 4π steradians

| Recoil Electron Energy (MeV) | 0–.5 | .5–1 | 1–1.5 | 1.5–2 | 2–2.5 | 2.5–3 | 3–3.5 | 3.5–4 | 4–4.5 |
|---|---|---|---|---|---|---|---|---|---|
| Counting Rate Mev$^{-1}$, Sec$^{-1}$ | 5.05 | .545 | .200 | .176 | .088 | .096 | .047 | .056 | .06 |


COMPTON RECOIL ELECTRON
ENERGY AND ANGLE
PROBABILITY DISTRIBUTION
Data taken from NBS Circular 542
INITIAL PHOTON ENERGY (MeV)
ψ, DEGREES
(ELECTRON RECOIL ANGLE)
0°
15°
30°
45°
60°
75°
DIFFERENTIAL PROBABILITY MeV$^{-1}$
$(\frac{d\sigma}{dT}/\sigma_T)$
T, RECOIL ELECTRON ENERGY (MEV)
.01
.1
1
10

Exit path length probability for events occurring isotropically in a slab of unit thickness and infinite extent.




Assume L is constant, then the probability of an exit length L at a depth X is

$$P(L)_x \, dL = P(\theta)\frac{d\theta}{dL}\, dL$$

For isotropic distribution of events, $P(\theta) = \dfrac{\sin\theta}{2} = \dfrac{d\Omega}{4\pi} = \dfrac{2\pi \sin\theta \, d\theta}{4\pi}$

$$\frac{d\theta}{dL} = \frac{X}{L^2 \sin\theta}$$

Thus $\quad P(L)_x \, dL = \dfrac{X}{2L^3}\, dL$

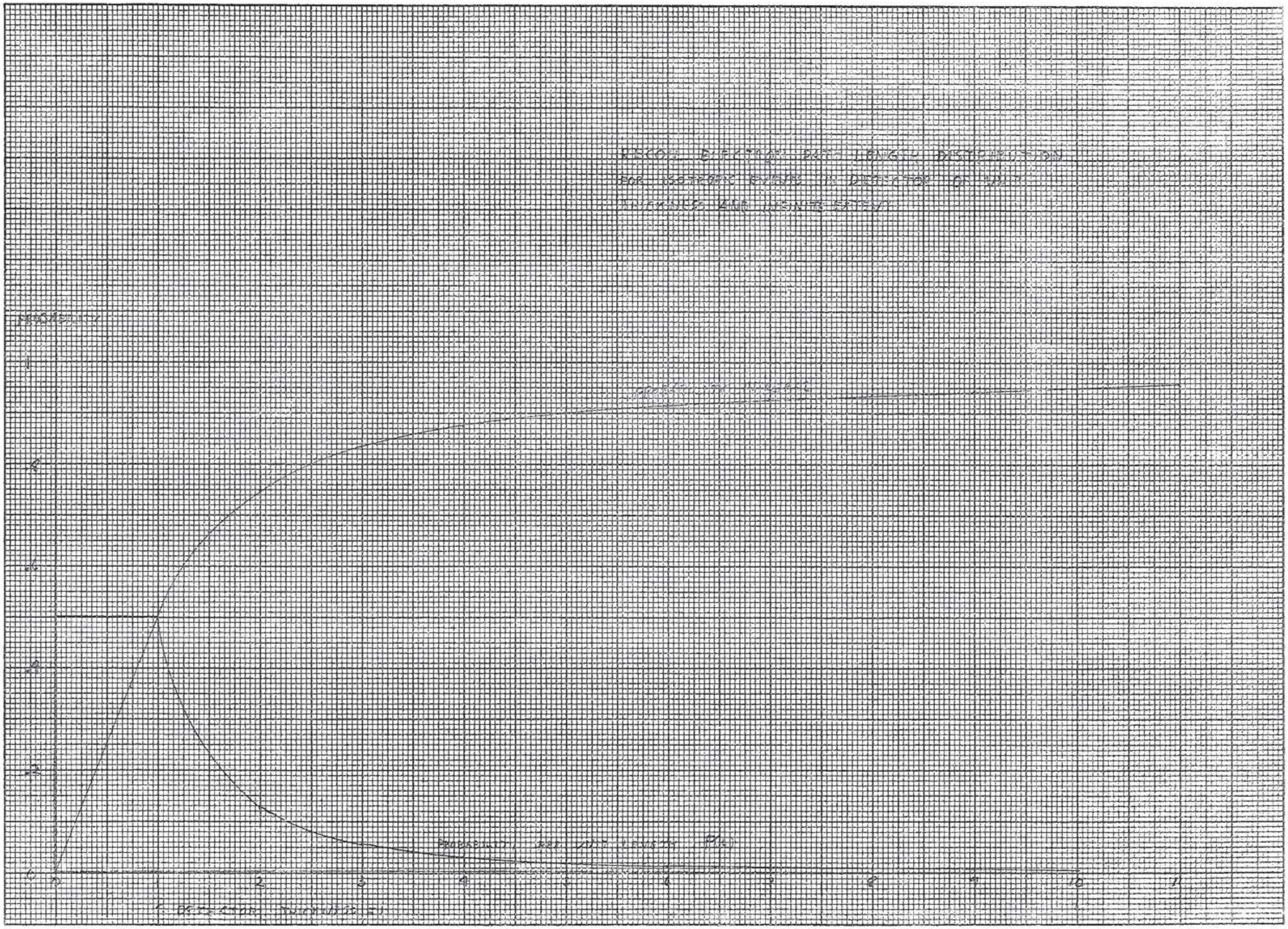
Clearly X must be $\leq L$ so there are two cases for the integral over X, namely

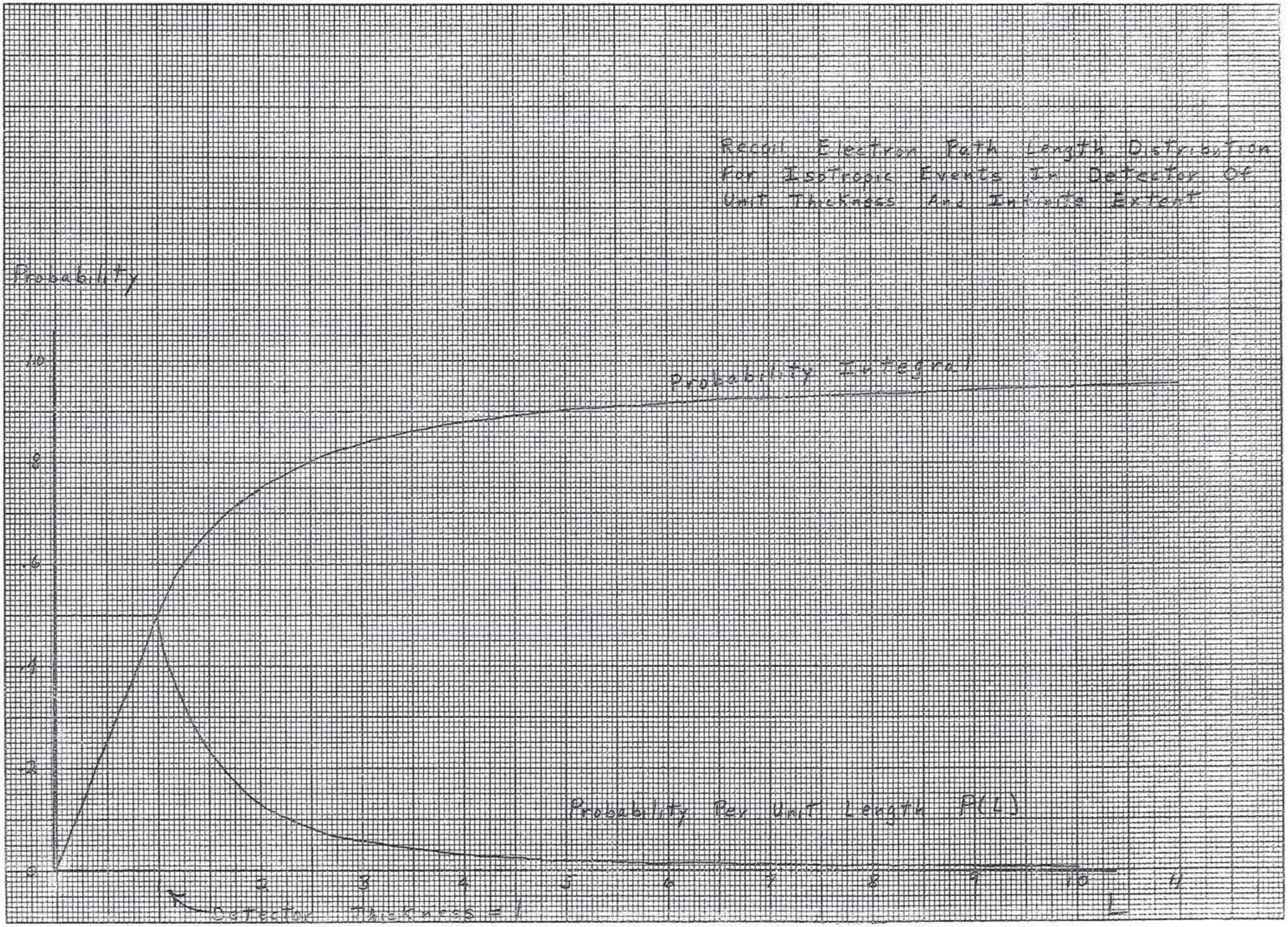
1. $L < 1$ then $P(L) = 2\int_0^L \dfrac{X}{2L^3}\, dx = \dfrac{1}{2}$ $\qquad L<1$

This 2 takes into account that $X < L$ near both edges of the detector

2. $L \geq 1$ $\qquad P(L) = 2\int_0^1 \dfrac{X\, dx}{2L^3} = \dfrac{1}{2L^2}$ $\qquad L \geq 1$

This 2 takes into account lower semisphere events.


RECOIL ELECTRON PATH LENGTH DISTRIBUTION
FOR ISOTROPIC EVENTS IN DETECTOR OF UNIT
THICKNESS AND INFINITE EXTENT
PROBABILITY
1
.8
.6
.4
.2
0
PROBABILITY PER UNIT LENGTH P(L)
0
1
2
3
4
5
6
7
8
9
10
11
1 = DETECTOR THICKNESS = 1


Recoil Electron Path Length Distribution
For Isotropic Events In Detector Of
Unit Thickness And Infinite Extent
Probability
1.0
.8
.6
.4
.2
0
Probability Integral
Probability Per Unit Length P(L)
1
2
3
4
5
6
7
8
9
10
11
Detector Thickness = 1
L

Redistribution of Compton Electron Energy loss due to Escaping from Detector

| Initial Recoil Energy | Range $g\text{-}cm^{-2}$ | Detector Stopping Power | Energy Loss in Detector .0 – .5 | .5 – 1 | 1 – 1.5 | 1.5 – 2 | 2 – 2.5 | 2.5 – 3 | 3 – 3.5 | 3.5 – 4 | 4 – 4.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 – .5 | 0 – .243 | 1.66 – 1.60 | 100% | | | | | | | | |
| .5 – 1 | .243 – .549 | 1.60 – 1.47 | 50 | 50 | | | | | | | |
| 1 – 1.5 | .549 – .825 | 1.47 – 1.46 | 50 | 22 | 22% | | | | | | |
| 1.5 – 2 | .825 1.212 | 1.44 – 1.47 | 52 | 10 | 7 | 15% | | | | | |
| 2 – 2.5 | 1.21 1.55 | 1.47 – 1.49 | 60 | 20 | 7 | 3 | 10% | | | | |
| 2.5 – 3 | 1.55 1.85 | 1.49 – 1.50 | 60 | 20 | 7 | 3 | 2 | 8% | | | |
| 3 – 3.5 | 1.85 2.16 | 1.50 – 1.52 | 61 | 20 | 6 | 3 | 2 | 1 | 7% | | |
| 3.5 – 4 | 2.16 2.47 | 1.52 – 1.54 | 61 | 20 | 6 | 3 | 2 | 1 | 1 | 6% | |
| 4 – 4.5 | 2.42 2.77 | 1.54 – 1.55 | 61 | 20 | 6 | 3 | 2 | 1 | 1 | 1 | 5% |

It was assumed that Energy loss is constant along the path in the above redistribution.

| Energy Loss Interval MeV | Counting Rate per Interval, Top Scintillator | Counting Rate Whole Sphere $MeV^{-1}\ Sec^{-1}$ |
|---|---|---|
| 0 – .5 | 1.459 | 5.836 |
| .5 – 1 | .102 | .408 |
| 1 – 1.5 | .0198 | .079 |
| 1.5 – 2 | .0092 | .037 |
| 2 – 2.5 | .0035 | .014 |
| 2.5 – 3 | .0023 | .009 |
| 3 – 3.5 | .0011 | .005 |
| 3.5 – 4 | .0010 | .004 |
| 4 – 4.5 | .0007 | .003 |

Considerations:

Will Escaping Electrons trigger other Detectors, or Scintillator ?

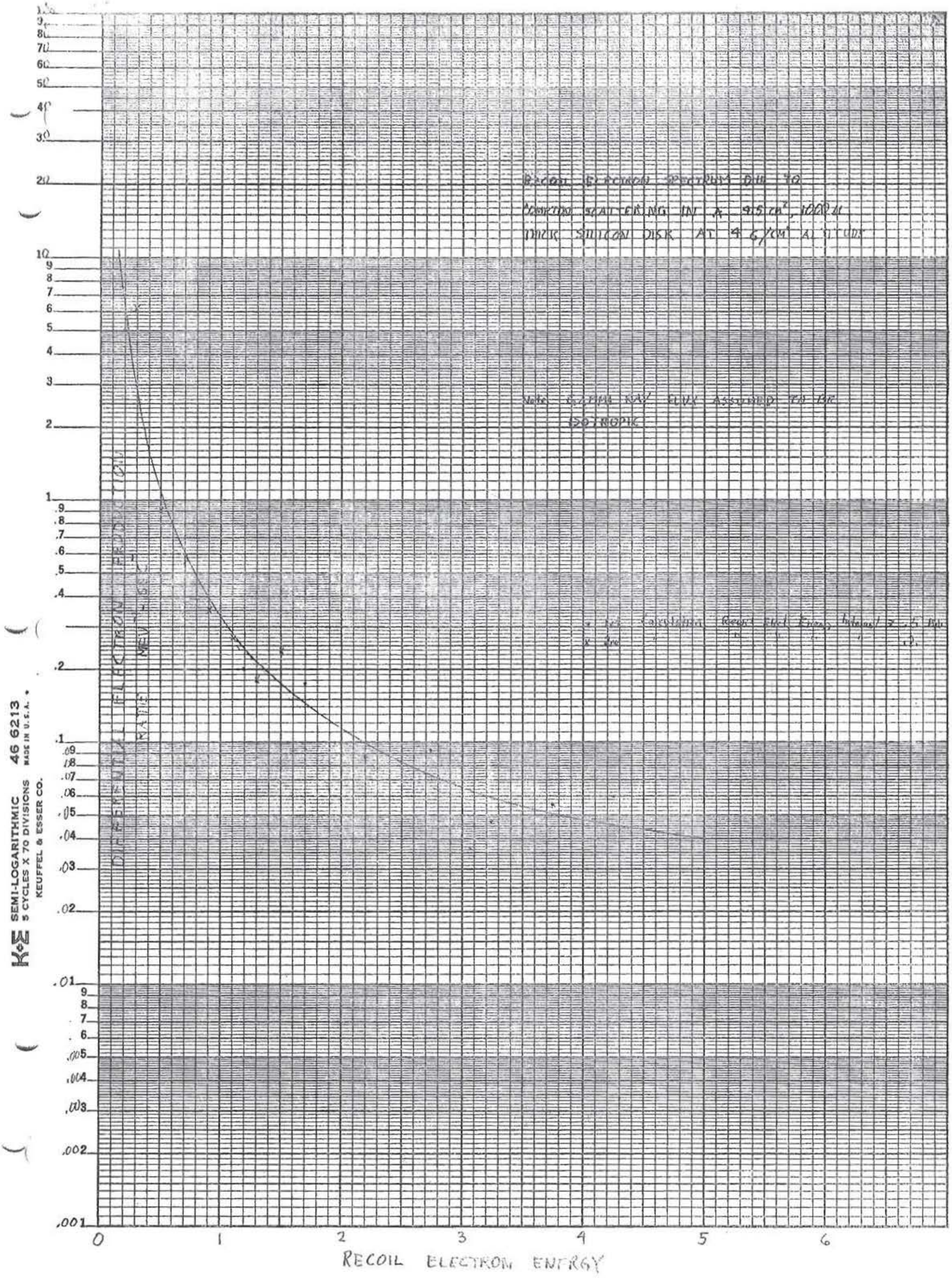
| Repeat to obtain | Much of above calculation for Smaller Recoil Electron Energy … more data on low end of spectrum. |
| --- | --- |

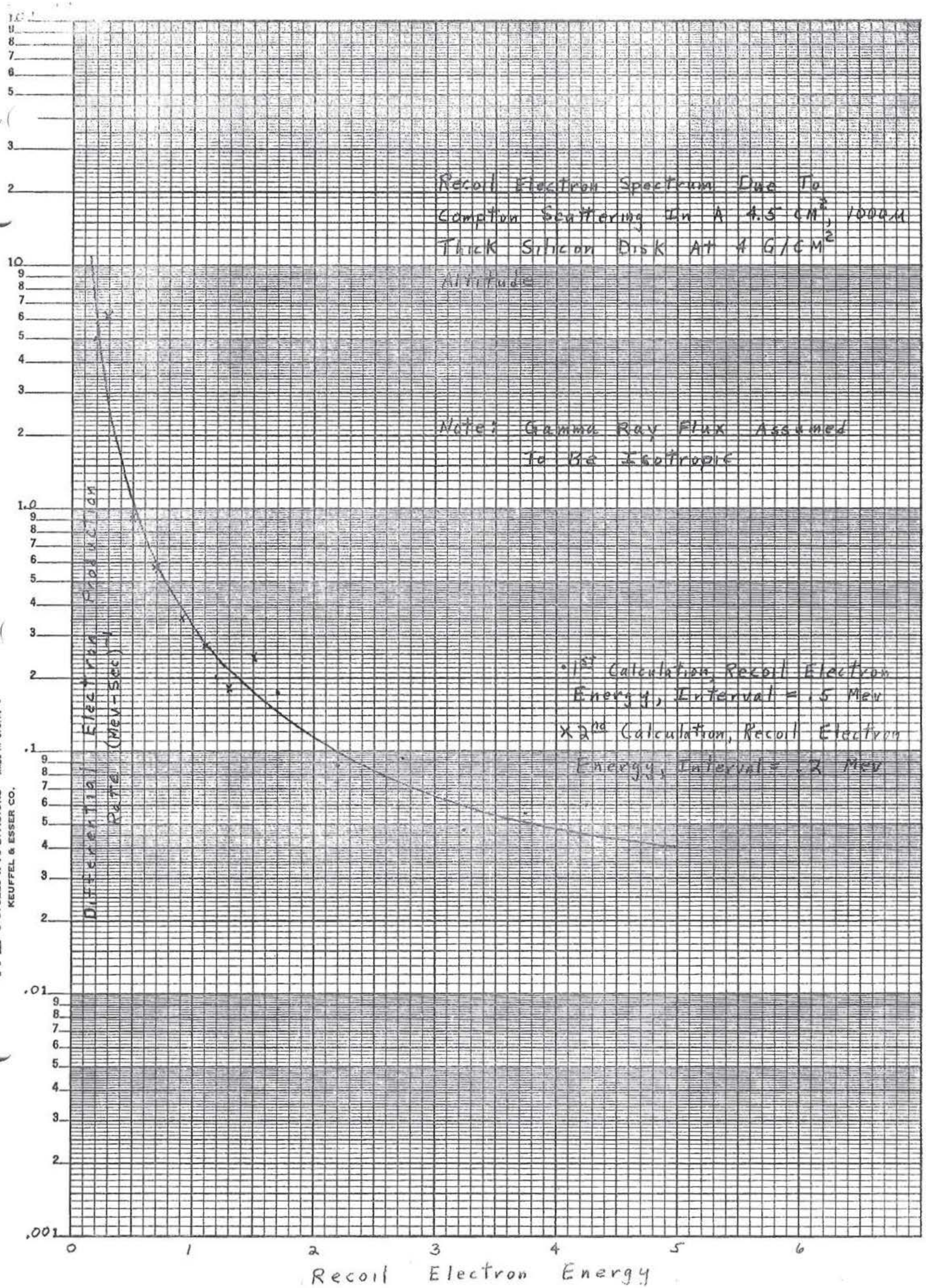
| Photon Interval (MeV) | Total Photons counted/sec in interval | Compton Recoil Electron Energy MeV .2-.4 | .4-.6 | .6-.8 | .8-1.0 | 1.0-1.2 | 1.2-1.4 | 1.4-1.6 | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| .3-.5 | .878 | .438 | – | – | – | – | – | – | |
| .5-.7 | .231 | .110 | .010 | – | | | | | |
| .7-.9 | .101 | .028 | .040 | .005 | – | | | | |
| .9-1.1 | .068 | .014 | .015 | .024 | .002 | – | | | |
| 1.1-1.5 | .076 | .011 | .011 | .013 | .017 | .010 | – | | |
| 1.5-2.5 | .107 | .009 | .009 | .009 | .010 | .011 | .012 | .017 | .021 |
| 2.5-3.5 | .069 | .003 | .003 | .003 | .003 | .003 | .003 | .004 | [illegible] |
| 3.5-4.5 | .095 | .002 | .002 | .002 | .002 | .002 | .002 | [illegible] | [illegible] |
| 4.5-5.5 | .035 | .001 | .001 | .001 | .001 | .001 | .001 | .001 | [illegible] |
| Counting rate for 2π shadowing for each interval | 1.605 | .616 | .091 | .057 | .035 | .027 | .018 | .029 | |
| Counting rate for 4π MeV$^{-1}$, Sec$^{-1}$ | | 6.16 | .91 | .57 | .35 | .27 | .18 | .24 | |

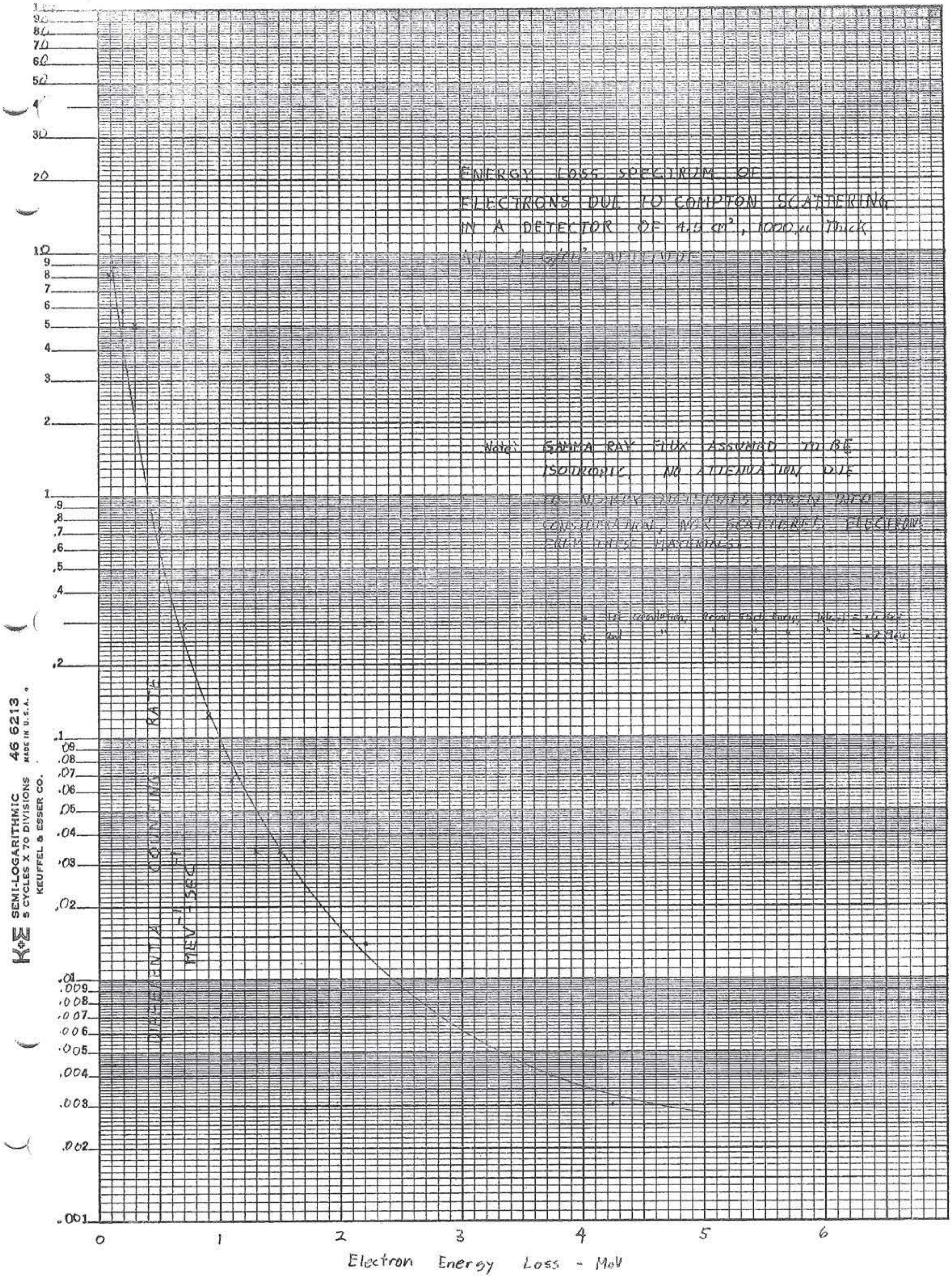
| Compton Recoil Electron Energy (MeV) | Rate sec$^{-1}$ | Range | Stopping Power | Energy lost in detector by escaping electrons: <.2 | .2-.4 | .4-.6 | .6-.8 | .8-1.0 | 1.0-1.2 | 1.2-1.4 | 1.4-1.6 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| .2-.4 | .616 | .107 | 1.85 | 23 | 77% | | | | | | |
| .4-.6 | .091 | .224 | 1.60 | 23 | 24 | 53% | | | | | |
| .6-.8 | .057 | .351 | 1.52 | 25 | 23 | 17 | 35% | | | | |
| .8-1.0 | .035 | .483 | 1.98 | 25 | 25 | 16 | 9 | 25% | | | |
| 1.0-1.2 | .027 | .616 | 1.48 | 26 | 25 | 16 | 8 | 5 | 20% | | |
| 1.2-1.4 | .018 | .749 | 1.46 | 26 | 26 | 15 | 8 | 6 | 3 | 16% | |
| 1.4-1.6 | .024 | .883 | 1.46 | 26 | 25 | 16 | 8 | 6 | 3 | 2 | 14% |

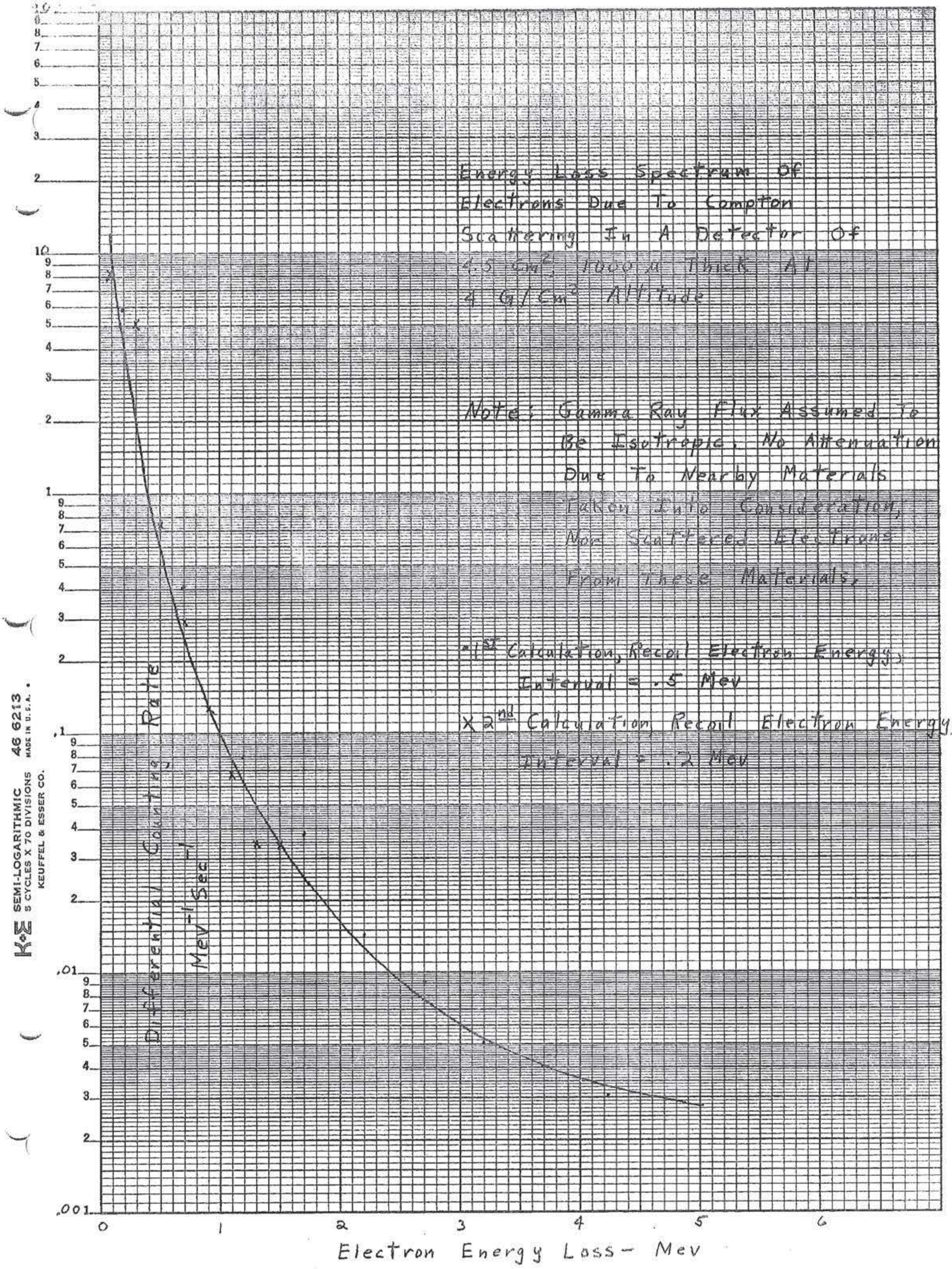
| Electron Energy Int. | .2-.4 | .4-.6 | .6-.8 | .8-1.0 | 1.0-1.2 | 1.2-1.4 | 1.4-1.6 |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Counting Rate half space | .505 | .074 | .029 | .0126 | .0067 | .0034 | .0034 |
| Counting Rate whole space - MeV$^{-1}$, Sec$^{-1}$ | 5.05 | .74 | .29 | .126 | .067 | .034 | .034 |

Contribution of higher initial … electrons probably renders low …


RECOIL ELECTRON SPECTRUM DUE TO
COMPTON SCATTERING IN A 9.5 CM², 1000 μ
THICK SILICON DISK AT 4 G/CM² ALTITUDE
Note GAMMA RAY FLUX ASSUMED TO BE
ISOTROPIC
DIFFERENTIAL ELECTRON PRODUCTION
RECOIL ELECTRON ENERGY
0
1
2
3
4
5
6
K+E SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.


Recoil Electron Spectrum Due To Compton Scattering In A 4.5 CM², 1000μ Thick Silicon Disk At 4 G/CM² Altitude
Note: Gamma Ray Flux Assumed To Be Isotropic
• 1st Calculation, Recoil Electron Energy, Interval = .5 Mev
× 2nd Calculation, Recoil Electron Energy, Interval = .2 Mev
Differential Electron Production Rate (Mev-Sec)⁻¹
Recoil Electron Energy
10
1.0
.1
.01
.001
0
1
2
3
4
5
6
K&E SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.


ENERGY LOSS SPECTRUM OF
ELECTRONS DUE TO COMPTON SCATTERING
IN A DETECTOR OF 4.5 cm², 1000μ Thick
Note: GAMMA RAY FLUX ASSUMED TO BE
ISOTROPIC, NO ATTENUATION DUE
DIFFERENTIAL COUNTING RATE
MEV⁻¹ SEC⁻¹
Electron Energy Loss - MeV
0
1
2
3
4
5
6
10
9
8
7
6
5
4
3
2
1
.9
.8
.7
.6
.5
.4
.2
.1
.09
.08
.07
.06
.05
.04
.03
.02
.01
.009
.008
.007
.006
.005
.004
.003
.002
.001
K+E SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.


Energy Loss Spectrum Of Electrons Due To Compton Scattering In A Detector Of 4.5 Cm², 1000 μ Thick At 4 G/Cm² Altitude
Note: Gamma Ray Flux Assumed To Be Isotropic. No Attenuation Due To Nearby Materials Taken Into Consideration, Nor Scattered Electrons From These Materials.
• 1st Calculation, Recoil Electron Energy, Interval = .5 Mev
x 2nd Calculation, Recoil Electron Energy, Interval = .2 Mev
Differential Counting Rate, Mev⁻¹ Sec⁻¹
Electron Energy Loss - Mev
0
1
2
3
4
5
6
10
1
.1
.01
.001
K+E SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

8/12/[illegible]

## D2 · D3 Events for [illegible] Compton Electrons

Problem: What are the energy loss spectra in D2 and D3 of electrons scattered by Compton process in D2?

The Geometry of the detectors is as follows

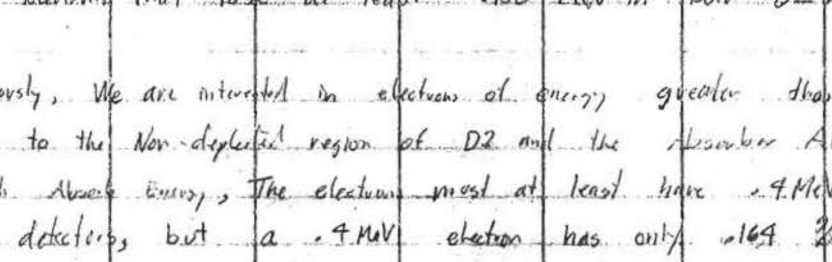

| | | | |
|---|---|---|---|
| D2 Depleted | .242 | g/cm² | SI |
| D2 N-D | .100 | | SI |
| Al | .077 | | Al |
| D3 Window | .012 | | SI |
| D3 Depleted | .242 | | Al |

The Compton Recoil Electrons Are scattered Isotropically in D2 with Known Energy Spectrum. How much energy is lost in D2 + D3 For Electrons that lose at least .150 MeV in Both D2 + D3 ?

Obviously, We are interested in electrons of energy greater than .3 MeV, and Owing to the Non-depleted region of D2 and the Absorber Al and Window which Absorb Energy, The electron must at least have .4 MeV to trigger Both detectors, but a .4 MeV electron has only .164 g/cm² range which would not get it through the material between detectors.

The Calculation will proceed as follows.

Devide Top detector into 5 Zones of equal depth, and the angular distribution of recoil electrons into 5 Zones of equal Solid angle $\left(\frac{4\pi}{10}\right)$ Apply the initial recoil spectrum to each of the 20 Zones and calculate the energy loss for both detectors. ( Ignore 5th Solid Angle Zone)

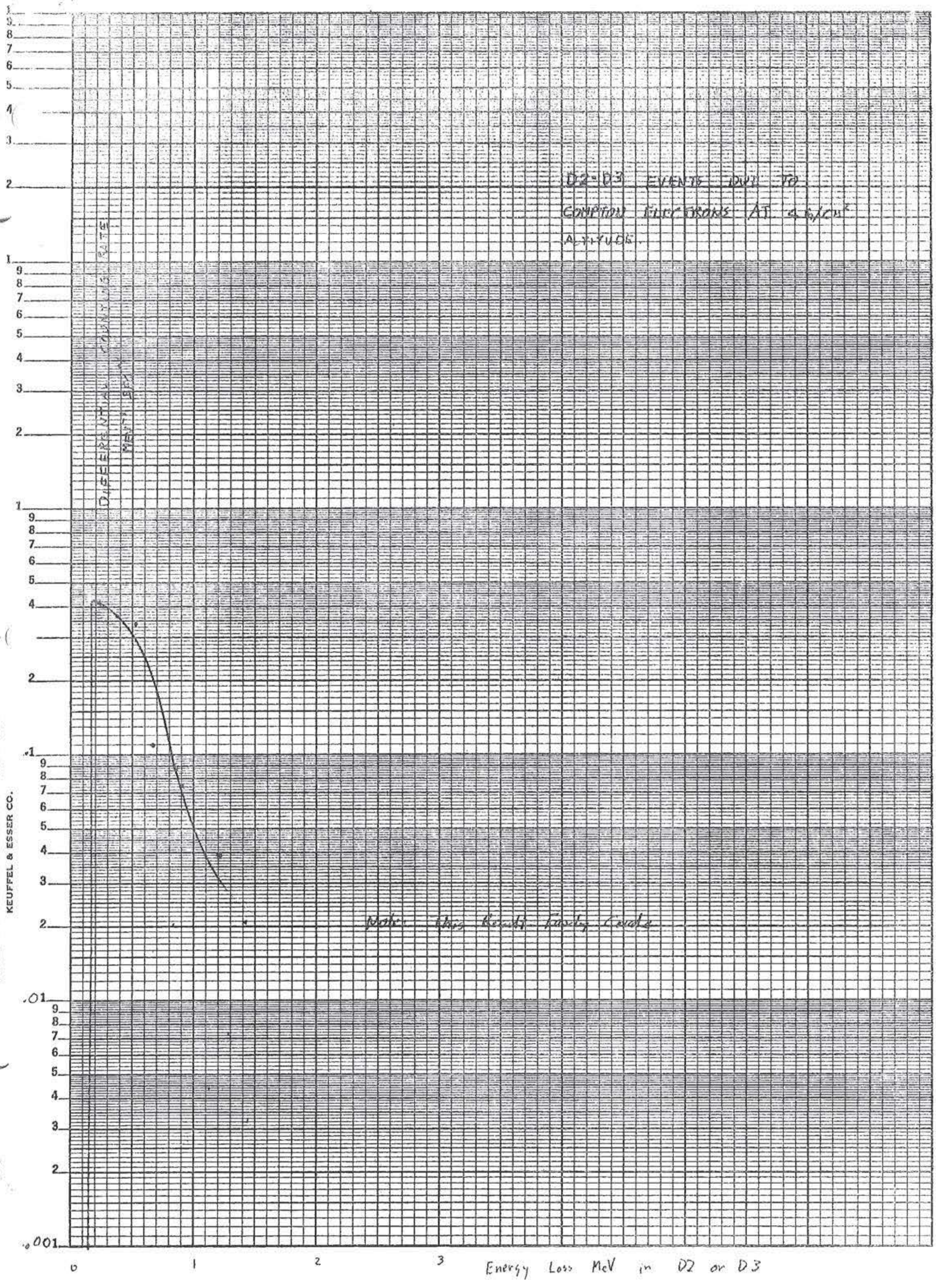


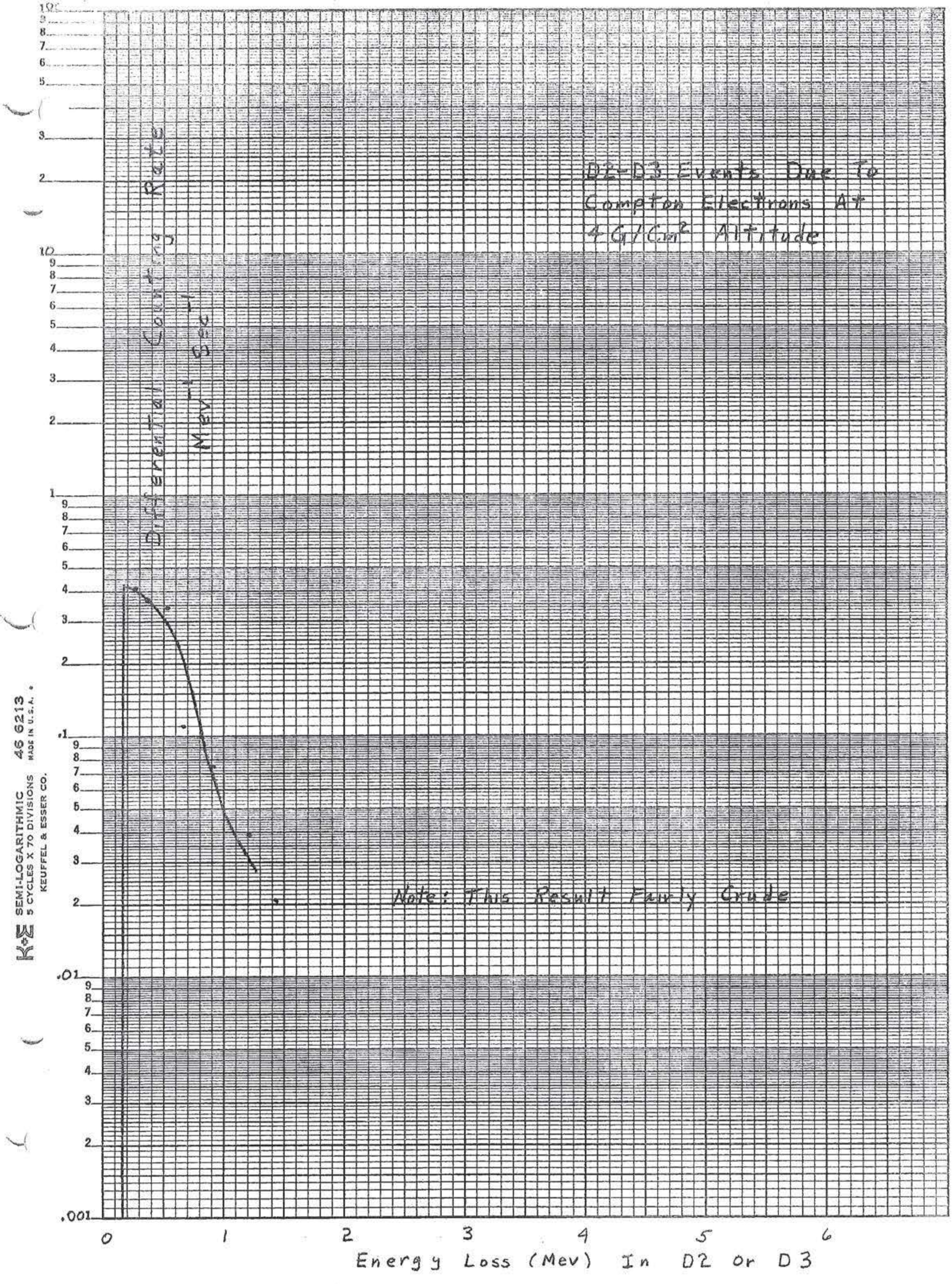
| Zone Number | Median Path Angle to Normal | Path length in D2 Depl. | Path length in D3 Depleted | Path length in absorbing layer between D1 & D2 | Initial Recoil Electron Energy .5 - 1 | | 1 - 1.5 | | 1.5-2 | | 2 - 2.5 | | 2.5 - 3.5 | | 3.5 - 4.5 | | 4.5 - 5.5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Range and Stopping Power of Electron with center of interval Energy | | | | | R .384 | SP 1.53 | R .683 | SP 1.5 | R 1.04 | SP 1.51 | R 1.37 | SP 1.54 | R 1.68 | SP 1.59 | R 2.41 | SP 1.64 | R 3.07 | SP 1.69 |
| 1/50 Compton Electron Production Rate (Each zone contains 1/50 of total isotropically produced electrons in D2) | | | | | .0055 | | .0023 | | .0014 | | .00085 | | .0013 | | .00096 | | .00060 | |
| Energy Loss (MeV) | | | | | D2 | D3 | D2 | D3 | D2 | D3 | D2 | D3 | D2 | D3 | D2 | D3 | D2 | D3 |
| A1 | 25.8 | .248 | .275 | .215 | .38 | .01 | .37 | .41 | .37 | .41 | .38 | .42 | .39 | .43 | .41 | .45 | .42 | .46 |
| A2 | 45.6 | .312 | .346 | .249 | .48 | 0 | .47 | .40 | .47 | .52 | .48 | .53 | .49 | .55 | .51 | .57 | .53 | .57 |
| A3 | 60.0 | .436 | .485 | .378 | .67 | 0 | .65 | .03 | .65 | .53 | .67 | .75 | .69 | .77 | .71 | .79 | .79 | .82 |
| A4 | 72.5 | .725 | .805 | .629 | All | 0 | 1.10 | 0 | 1.10 | 0 | 1.13 | .16 | 1.14 | .88 | 1.19 | 1.32 | 1.28 | 1.36 |
| B1 | 25.9 | .192 | .275 | .215 | .29 | .11 | .29 | .41 | .29 | .41 | .29 | .42 | .30 | .43 | .31 | .45 | .32 | .46 |
| B2 | 45.6 | .242 | .346 | .249 | .37 | 0 | .35 | .52 | .35 | .52 | .37 | .53 | .38 | .55 | .40 | .57 | .41 | .59 |
| B3 | 60.0 | .339 | .485 | .378 | .52 | 0 | .51 | .17 | .51 | .67 | .52 | .75 | .54 | .77 | .56 | .79 | .57 | .82 |
| B4 | 72.5 | .549 | .805 | .629 | .86 | 0 | .85 | 0 | .85 | 0 | .86 | .43 | .89 | 1.13 | .12 | 1.32 | .75 | 1.36 |
| C1 | 25.4 | .121 | .275 | .215 | .18 | .29 | .18 | .41 | .18 | .41 | .18 | .42 | .19 | .43 | .20 | .45 | .20 | .46 |
| C2 | 45.6 | .173 | .346 | .249 | .26 | .10 | .26 | .52 | .26 | .52 | .26 | .53 | .27 | .55 | .28 | .57 | [illegible] | [illegible] |
| C3 | 60 | .292 | .485 | .378 | .37 | 0 | .36 | .33 | .36 | .73 | .37 | .75 | .38 | .77 | .40 | .79 | [illegible] | .82 |
| C4 | 72.5 | .903 | .805 | .629 | .62 | 0 | .60 | 0 | .60 | .21 | .62 | .67 | .64 | 1.27 | .66 | 1.32 | .68 | 1.36 |
| D1 | 25.8 | .082 | .275 | .215 | .13 | .29 | .12 | .41 | .12 | .41 | .13 | .42 | .13 | .43 | .13 | .45 | .14 | .46 |
| D2 | 45.6 | .104 | .346 | .249 | .16 | .21 | .16 | .52 | .16 | .52 | .16 | .53 | .16 | .55 | .17 | .57 | .18 | .59 |
| D3 | 60 | .146 | .485 | .378 | .22 | 0 | .22 | .47 | .22 | .73 | .22 | .75 | .23 | .77 | .24 | .79 | .25 | .82 |
| D4 | 72.5 | .242 | .805 | .629 | .37 | 0 | .36 | 0 | .36 | .95 | .37 | .92 | .38 | 1.27 | .40 | 1.32 | .41 | 1.36 |
| E1 | 25.8 | .028 | .275 | .215 | .043 | .38 | .042 | .41 | .04 | .41 | .04 | .42 | .04 | .43 | .05 | .45 | .05 | .46 |
| E2 | 45.6 | .035 | .346 | .249 | .054 | .34 | .053 | .52 | .05 | .52 | .05 | .53 | .05 | .55 | .06 | .57 | .06 | .59 |
| E3 | 60 | .049 | .485 | .378 | .075 | .10 | .073 | .62 | .07 | .73 | .07 | .55 | .07 | .77 | .08 | .79 | .08 | .82 |
| E4 | 72.5 | .081 | .805 | .629 | .12 | 0 | .12 | .18 | .12 | .73 | .12 | 1.17 | .13 | 1.27 | .13 | 1.32 | .14 | 1.36 |

D2 D3 study (Events for which the energy loss in D2 and D3 is ≥ .15 MeV)

| Energy loss spectrum D2 for Compton Events occurring in D2 | | Energy loss spectrum D3 for Compton Events occurring in D2 | | Sum of D2 D3 spectrum | Energy | Counts MeV⁻¹ |
|---|---|---|---|---|---|---|
| Energy | | | | | | |
| .15 – .3 | .0960 | .15 – .3 | .0156 | .0616 | .22 | .41 |
| .3 – .45 | .0312 | .3 – .45 | .0245 | .0557 | .37 | .37 |
| .45 – .6 | .0152 | .45 – .6 | .0356 | .0508 | .52 | .34 |
| .6 – .75 | .0106 | .6 – .75 | .0051 | .0157 | .67 | .11 |
| .75 – .9 | .0036 | .75 – .9 | .0169 | .0205 | .82 | [illegible] |
| .9 – 1.05 | .0018 | .9 – 1.05 | .0009 | .0027 | .90 | .077 |
| 1.05 – 1.20 | .0031 | 1.05 – 1.20 | .0013 | .0044 | | |
| 1.20 – 1.35 | .0008 | 1.20 – 1.35 | .0064 | .0072 | 1.20 | .039 |
| 1.35 – 1.50 | 0 | 1.35 – 1.50 | .0032 | .0032 | 1.42 | .021 |

Since Compton scattering may also occur in D3 the scattered electron go into D2, must add D2 + D3 above to get the total spectrum in either D2 or D3.


D2-D3 EVENTS DUE TO
COMPTON ELECTRONS AT 4 g/cm²
ALTITUDE
DIFFERENTIAL COUNTING RATE
MeV⁻¹ SEC⁻¹
Note: This Result Fairly Crude
Energy Loss MeV in D2 or D3
0
1
2
3
.001
.01
.1
1


D2-D3 Events Due To
Compton Electrons At
4 G/Cm² Altitude
Differential Counting Rate
Mev⁻¹ Sec⁻¹
Note: This Result Fairly Crude
Energy Loss (Mev) In D2 or D3
0
1
2
3
4
5
6
.001
.01
.1
1
10
100
K&E SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

References:

Gamma Ray Spectrum:

Vette, J. I. "Low Energy Gamma Rays Produced in Air and in Lead by Cosmic Rays" JGR 67-5 May 1962

R. Rocchia, J. Labeyrie et al. "Gamma Ray Generation in High Atmosphere", Proc. of Ninth International Conference on Cosmic Rays, Vol 1.

Photon attenuation data:

NBS Circular 583 and Supplement "X-Ray attenuation Coefficients 10 KeV to 100 MeV"

Compton Scattering Data:

NBS Circular 542 "Graphs of the Compton Energy-Angle Relationship and the Klein-Nishina Formula from 10 KeV to 500 MeV"

Electron Range and Stopping power Data:

Berger and Seltzer: Tables of Energy Losses and Ranges of Electrons and Positrons, N.A.S.A. SP-3012, 1964