C/ 325
MAR 7 1963
MASTER

ORNL-3365

UC-34 - Physics

TID-4500 (18th ed., Rev.)

NUCLEON-MESON CASCADE CALCULATIONS:

TRANSVERSE SHIELDING FOR A 45-Gev

ELECTRON ACCELERATOR (PART II)

R. G. Alsmiller, Jr.

F. S. Alsmiller

J. E. Murphy

OAK RIDGE NATIONAL LABORATORY

operated by

UNION CARBIDE CORPORATION

for the

U.S. ATOMIC ENERGY COMMISSION

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Printed in USA. Price: \$1.00 Available from the
Office of Technical Services
U. S. Department of Commerce
Washington 25, D. C.

— LEGAL NOTICE —

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

ORNL-3365

Contract No. W-7405-eng-26

Neutron Physics Division

NUCLEON-MESON CASCADE CALCULATIONS: TRANSVERSE SHIELDING FOR
A 45-Gev ELECTRON ACCELERATOR (PART II)

R. G. Alsmiller, Jr.
F. S. Alsmiller
J. E. Murphy*

Date Issued

FEB 28 1963

*Central Data Processing Facility of the Oak Ridge Gaseous Diffusion Plant.

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Abstract

In a previous report nucleon-meson cascade calculations were carried out for several cases of interest in the design of the transverse shield for the proposed 45-Gev linear electron accelerator at Stanford University. In this report results are given for several additional cases.

Table of Contents

	<u>Page No.</u>
Abstract	iii
I. Introduction	1
II. Physical Data	1
III. Initial Values	1
IV. Results	2
Acknowledgement	3
Appendix	37

I. Introduction

In a previous report¹ (hereinafter referred to as 1) nucleon-meson cascade calculations were carried out for several cases of interest in the design of the transverse shield for the proposed 45-Gev linear electron accelerator at Stanford University. In this report results are given for several additional cases.

The equations, notation, and method of calculation are the same as reported in 1. Also, the same physical data is used except for a few minor changes which are discussed in Section II. The method of computing the dose is unchanged.

The cases presented here differ from those in 1 in that somewhat different initial values are used. These new initial values are discussed in Section III. The results are given in Section IV and some details concerning the dose calculations are given in Appendix I.

II. Physical Data

The proton and charged pion nonelastic cross sections have been changed from those used in 1 to values conforming with the calculations of H. W. Bertini* which recently became available. Since these only extend to 500 Mev for protons and 300 Mev for pions it was necessary to extrapolate to the higher energies. The cross sections used, with the required extrapolation, are shown in Fig. 1. No other changes were made in the physical data used in 1.

III. Initial Values

An electron striking the walls of the copper accelerator tube initiates an electron-photon cascade. The resulting photonucleons and photopions are assumed to be produced at a point, with intensity distributions in energy and angle which depend on the model of photoproduction

-
1. R. G. Alsmiller, Jr., F. S. Alsmiller, and J. E. Murphy, Nucleon-Meson Cascade Calculations: Transverse Shielding for a 45-Gev Electron Accelerator, ORNL-3289 (1962).

*We wish to thank H. W. Bertini for making the results of his Monte Carlo calculations available to us prior to their publication.

used. In 1 the calculations of Dedrick^{2,3,4} were coupled with a photon track length expression obtained from Zerby.⁵ In this report more recent calculations of the photonucleon and photopion intensities by DeStaebler* are used.

The most significant difference between the two calculations is that DeStaebler found a significant number of pions at angles as large as 95 deg (with respect to the direction of the incident electron), while Dedrick found no pions at angles greater than 40 deg.

Graphs of the photonucleon and photopion yields for the three cases considered here are shown in Figs. 2 and 3.

IV. Results

The neutron, proton, pion, and muon intensities as a function of energy and distance for $\theta = 65, 80$, and 95 deg are given in Tables 1 through 27. Since these intensities are very similar to those shown in 1, they have not been plotted.

The doses for these cases are shown in Figs. 4, 5, and 6. As in 1, the neutron dose contains an estimated contribution from low-energy neutrons (see in the appendix, p. 37), but the proton, pion, and muon doses are calculated by considering only those particles whose energies exceed 32 Mev.

Since the angles considered here are not the same as those used in 1, no direct comparison between the results can be made. However, by comparing the over-all results it is clear that the use of the DeStaebler calculations will, in general, yield a larger total dose at a given distance and angle (> 65 deg) than the use of the Dedrick calculations.

2. K. G. Dedrick, Deuteron Model Calculation of Photonucleon Yields, W. W. Hansen Laboratories of Physics Report M-277 (1960).
3. K. G. Dedrick, Calculation of Pion Photoproduction from Electron Accelerators According to the Statistical Model, W. W. Hansen Laboratories of Physics Report M-228 (1960).
4. K. G. Dedrick, More Calculations of Photopion Yields, W. W. Hansen Laboratories of Physics Report M-229 (1960).
5. C. D. Zerby and H. S. Moran, Studies of the Longitudinal Development of High-Energy Electron-Photon Cascade Showers, ORNL-3329 (1962).

*We wish to thank Dr. H. DeStaebler, Jr., for making his results available to us prior to their publication.

In 1 it was found that at small angles when initial pions were present the muons formed from π -mu decay in the air gap between the accelerator tube and the shield were significant. At the large angles considered here the muons formed in the air gap are of sufficiently low energy that they are stopped before traversing any appreciable portion of the shield and thus they need not be considered.

Acknowledgement

It is a pleasure to thank the members of the Data Processing Facility of the Oak Ridge Gaseous Diffusion Plant, particularly, D. S. Marion, R. G. Mashburn, I. R. Parsley, and C. S. Hodge, for their excellent work in doing the numerical computations.

Fig. 1. Nonelastic Cross Section vs. Energy.

UNCLASSIFIED
ORNL-LR-DWG 73146

Fig. 2. Photoneutron Yield vs. Energy.

UNCLASSIFIED
ORNL-LR-DWG 73147

Fig. 3. Yield of Charged Photopions vs. Energy.

Fig. 4. Dose Multiplied by r^2 vs. Distance.

UNCLASSIFIED
ORNL-LR-DWG 75872

Fig. 5. Dose Multiplied by r^2 vs Distance.

UNCLASSIFIED
ORNL-LR-DWG 75873 Fig. 6. Dose Multiplied by r^2 vs. Distance.

Table 1. Neutron Intensities for $E_0 = 45 \times 10^3$ Mev and $\theta = 55$ deg
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Neutron Intensity, $N(E, r)$ [(Nc./Mev.sec.ster)/(elec./sec)]							
	$r = 0$	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	2.665×10^{-4}	5.109×10^{-5}	9.447×10^{-6}	1.963×10^{-6}	4.377×10^{-7}	1.004×10^{-7}	2.324×10^{-8}	5.389×10^{-9}
49.7	2.306×10^{-4}	5.450×10^{-5}	1.134×10^{-5}	2.417×10^{-6}	5.329×10^{-7}	1.203×10^{-7}	2.751×10^{-8}	6.335×10^{-9}
77.2	1.732×10^{-4}	4.406×10^{-5}	9.855×10^{-6}	2.197×10^{-6}	4.952×10^{-7}	1.128×10^{-7}	2.585×10^{-8}	5.950×10^{-9}
107.4	1.199×10^{-4}	3.167×10^{-5}	7.340×10^{-6}	1.681×10^{-6}	3.863×10^{-7}	8.914×10^{-8}	2.063×10^{-8}	4.778×10^{-9}
208.0	2.147×10^{-5}	7.129×10^{-6}	1.806×10^{-6}	4.389×10^{-7}	1.055×10^{-7}	2.523×10^{-8}	5.998×10^{-9}	1.418×10^{-9}
323.1	4.586×10^{-6}	2.005×10^{-6}	5.327×10^{-7}	1.312×10^{-7}	3.168×10^{-8}	7.562×10^{-9}	1.787×10^{-9}	4.187×10^{-10}
402.7	2.353×10^{-6}	1.094×10^{-6}	2.884×10^{-7}	7.002×10^{-8}	1.667×10^{-8}	3.919×10^{-9}	9.125×10^{-10}	2.106×10^{-10}
560.0	9.480×10^{-7}	4.032×10^{-7}	1.007×10^{-7}	2.345×10^{-8}	5.374×10^{-9}	1.219×10^{-9}	2.742×10^{-10}	6.129×10^{-11}
698.3	4.543×10^{-7}	1.728×10^{-7}	4.110×10^{-8}	9.305×10^{-9}	2.074×10^{-9}	4.581×10^{-10}	1.005×10^{-10}	2.192×10^{-11}
971.6	1.552×10^{-7}	4.201×10^{-8}	9.410×10^{-9}	2.043×10^{-9}	4.370×10^{-10}	9.282×10^{-11}	1.961×10^{-11}	4.121×10^{-12}
1509	3.921×10^{-8}	7.971×10^{-9}	1.585×10^{-9}	3.130×10^{-10}	6.171×10^{-11}	1.216×10^{-11}	2.392×10^{-12}	4.701×10^{-13}
2100	1.350×10^{-8}	2.546×10^{-9}	4.800×10^{-10}	9.050×10^{-11}	1.707×10^{-11}	3.218×10^{-12}	6.067×10^{-13}	1.144×10^{-13}

Table 2. Neutron Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = 65$ deg (cont.)

r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Neutron Intensity, $N(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	r = 16	r = 18	r = 20	r = 22	r = 24	r = 26	r = 28	r = 30
32.0	1.248×10^{-9}	2.833×10^{-10}	6.640×10^{-11}	1.524×10^{-11}	3.488×10^{-12}	7.955×10^{-13}	1.808×10^{-13}	4.096×10^{-14}
49.7	1.462×10^{-9}	3.375×10^{-10}	7.778×10^{-11}	1.788×10^{-11}	4.100×10^{-12}	7.372×10^{-13}	2.135×10^{-13}	4.850×10^{-14}
77.2	1.372×10^{-9}	3.155×10^{-10}	7.296×10^{-11}	1.679×10^{-11}	3.854×10^{-12}	8.826×10^{-13}	2.015×10^{-13}	4.589×10^{-14}
107.4	1.107×10^{-9}	2.562×10^{-10}	5.922×10^{-11}	1.366×10^{-11}	3.142×10^{-12}	7.207×10^{-13}	1.649×10^{-13}	3.760×10^{-14}
208.0	3.335×10^{-10}	7.801×10^{-11}	1.816×10^{-11}	4.205×10^{-12}	9.692×10^{-13}	2.224×10^{-13}	5.083×10^{-14}	1.157×10^{-14}
323.1	9.734×10^{-11}	2.248×10^{-11}	5.157×10^{-12}	1.176×10^{-12}	2.669×10^{-13}	6.027×10^{-14}	1.355×10^{-14}	3.032×10^{-15}
402.7	4.826×10^{-11}	1.098×10^{-11}	2.484×10^{-12}	5.588×10^{-13}	1.251×10^{-13}	2.787×10^{-14}	6.182×10^{-15}	1.366×10^{-15}
560.0	1.361×10^{-11}	3.007×10^{-12}	6.609×10^{-13}	1.446×10^{-13}	3.151×10^{-14}	6.839×10^{-15}	1.479×10^{-15}	3.188×10^{-16}
698.3	4.755×10^{-12}	1.027×10^{-12}	2.207×10^{-13}	4.727×10^{-14}	1.009×10^{-14}	2.145×10^{-15}	4.548×10^{-16}	9.615×10^{-17}
971.6	8.626×10^{-13}	1.799×10^{-13}	3.737×10^{-14}	7.740×10^{-15}	1.599×10^{-15}	3.293×10^{-16}	6.767×10^{-17}	1.387×10^{-17}
1509	9.230×10^{-14}	1.811×10^{-14}	3.549×10^{-15}	6.952×10^{-16}	1.361×10^{-16}	2.661×10^{-17}	5.199×10^{-18}	1.015×10^{-18}
2100	2.157×10^{-14}	4.068×10^{-15}	7.670×10^{-16}	1.446×10^{-16}	2.727×10^{-17}	5.142×10^{-18}	9.695×10^{-19}	1.828×10^{-19}

Table 3. Proton Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 65$ deg
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Proton Intensity, $P(E,r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 0$	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	2.665×10^{-4}	8.417×10^{-7}	1.632×10^{-7}	3.649×10^{-8}	8.473×10^{-9}	1.972×10^{-9}	4.578×10^{-10}	1.060×10^{-10}
49.7	2.306×10^{-4}	8.977×10^{-7}	1.701×10^{-7}	3.784×10^{-8}	8.792×10^{-9}	2.046×10^{-9}	4.749×10^{-10}	1.099×10^{-10}
77.2	1.733×10^{-4}	8.844×10^{-7}	1.612×10^{-7}	3.551×10^{-8}	8.247×10^{-9}	1.918×10^{-9}	4.447×10^{-10}	1.027×10^{-10}
107.4	1.199×10^{-4}	8.094×10^{-7}	1.409×10^{-7}	3.058×10^{-8}	7.085×10^{-9}	1.644×10^{-9}	3.803×10^{-10}	8.760×10^{-11}
208.0	2.147×10^{-5}	5.305×10^{-7}	7.955×10^{-8}	1.623×10^{-8}	3.682×10^{-9}	8.387×10^{-10}	1.906×10^{-10}	4.315×10^{-11}
323.1	4.586×10^{-6}	3.066×10^{-7}	4.016×10^{-8}	7.722×10^{-9}	1.686×10^{-9}	3.725×10^{-10}	8.239×10^{-11}	1.821×10^{-10}
402.7	2.353×10^{-6}	2.036×10^{-7}	2.455×10^{-8}	4.589×10^{-9}	9.723×10^{-10}	2.102×10^{-10}	4.561×10^{-11}	9.923×10^{-12}
560.0	9.480×10^{-7}	8.880×10^{-8}	9.504×10^{-9}	1.689×10^{-9}	3.339×10^{-10}	6.792×10^{-11}	1.438×10^{-11}	3.038×10^{-12}
698.3	4.543×10^{-7}	4.307×10^{-8}	4.650×10^{-9}	7.542×10^{-10}	1.390×10^{-10}	2.653×10^{-11}	5.484×10^{-12}	1.132×10^{-12}
971.6	1.553×10^{-7}	1.393×10^{-8}	1.574×10^{-9}	2.113×10^{-10}	2.661×10^{-11}	5.291×10^{-12}	1.054×10^{-12}	2.097×10^{-13}
1509	3.921×10^{-8}	3.641×10^{-9}	4.906×10^{-11}	9.084×10^{-12}	1.737×10^{-12}	3.326×10^{-13}	6.368×10^{-14}	1.219×10^{-14}
2100	1.350×10^{-8}	3.643×10^{-12}	7.583×10^{-13}	1.444×10^{-13}	2.725×10^{-14}	5.139×10^{-15}	9.691×10^{-16}	1.827×10^{-16}

Table 4. Proton Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = 65$ deg (cont.)
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Proton Intensity, $P(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 16$	$r = 18$	$r = 20$	$r = 22$	$r = 24$	$r = 26$	$r = 28$	$r = 30$
32.0	2.444×10^{-11}	5.615×10^{-12}	1.286×10^{-12}	2.933×10^{-13}	6.668×10^{-14}	1.511×10^{-14}	3.411×10^{-15}	7.678×10^{-16}
49.7	2.531×10^{-11}	5.809×10^{-12}	1.328×10^{-12}	3.026×10^{-13}	6.870×10^{-14}	1.554×10^{-14}	3.504×10^{-15}	7.877×10^{-16}
77.2	2.362×10^{-11}	5.409×10^{-12}	1.234×10^{-12}	2.804×10^{-13}	6.348×10^{-14}	1.432×10^{-14}	3.221×10^{-15}	7.220×10^{-16}
107.4	2.008×10^{-11}	4.584×10^{-12}	1.042×10^{-12}	2.360×10^{-13}	5.322×10^{-14}	1.196×10^{-14}	2.681×10^{-15}	5.987×10^{-16}
208.0	9.726×10^{-12}	2.182×10^{-12}	4.876×10^{-13}	1.085×10^{-13}	2.407×10^{-14}	5.398×10^{-15}	1.173×10^{-15}	2.577×10^{-16}
323.1	4.010×10^{-12}	8.795×10^{-13}	1.922×10^{-13}	4.188×10^{-14}	9.096×10^{-15}	1.970×10^{-15}	4.256×10^{-16}	9.170×10^{-17}
402.7	2.151×10^{-12}	4.643×10^{-13}	1.001×10^{-13}	2.151×10^{-14}	4.609×10^{-15}	9.851×10^{-16}	2.101×10^{-16}	4.470×10^{-17}
560.0	6.402×10^{-13}	1.346×10^{-13}	2.823×10^{-14}	5.910×10^{-15}	1.235×10^{-15}	2.575×10^{-16}	5.360×10^{-17}	1.114×10^{-17}
698.3	2.332×10^{-13}	4.797×10^{-14}	9.850×10^{-15}	2.020×10^{-15}	4.135×10^{-16}	8.455×10^{-17}	1.727×10^{-17}	3.522×10^{-18}
971.6	4.171×10^{-14}	8.289×10^{-15}	1.646×10^{-15}	3.267×10^{-16}	6.479×10^{-17}	1.284×10^{-17}	2.544×10^{-18}	5.035×10^{-19}
1509	2.333×10^{-15}	4.465×10^{-16}	8.545×10^{-17}	1.635×10^{-17}	3.129×10^{-18}	5.987×10^{-19}	1.145×10^{-19}	2.191×10^{-20}
2100	3.445×10^{-17}	6.497×10^{-18}	1.225×10^{-18}	2.310×10^{-19}	4.355×10^{-20}	8.212×10^{-21}	1.548×10^{-21}	2.920×10^{-22}

Table 5. Pion Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = 65$ deg
 $r = \text{No. of collision lengths (1 collision length} = 1.71 \text{ ft)}$

E (Mev)	Pion Intensity, $\pi(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 0$	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	1.256×10^{-4}	5.203×10^{-7}	3.513×10^{-8}	5.340×10^{-9}	1.061×10^{-9}	2.437×10^{-10}	5.587×10^{-11}	1.276×10^{-11}
49.7	9.735×10^{-5}	6.131×10^{-7}	4.037×10^{-8}	5.941×10^{-9}	1.160×10^{-9}	2.661×10^{-10}	6.096×10^{-11}	1.392×10^{-11}
77.2	7.369×10^{-5}	6.619×10^{-7}	4.251×10^{-8}	5.944×10^{-9}	1.126×10^{-9}	2.579×10^{-10}	5.896×10^{-11}	1.344×10^{-11}
107.4	5.760×10^{-5}	6.656×10^{-7}	4.189×10^{-8}	5.512×10^{-9}	1.006×10^{-9}	2.295×10^{-10}	5.229×10^{-11}	1.188×10^{-11}
208.0	2.933×10^{-5}	6.252×10^{-7}	3.817×10^{-8}	4.010×10^{-9}	6.223×10^{-10}	1.388×10^{-10}	3.099×10^{-11}	6.906×10^{-12}
323.1	1.400×10^{-5}	4.708×10^{-7}	2.974×10^{-8}	1.651×10^{-9}	3.530×10^{-10}	7.644×10^{-11}	1.664×10^{-11}	3.619×10^{-12}
402.7	8.868×10^{-6}	3.576×10^{-7}	2.250×10^{-8}	1.122×10^{-9}	2.352×10^{-10}	5.007×10^{-11}	1.074×10^{-11}	2.304×10^{-11}
560.0	4.096×10^{-6}	2.108×10^{-7}	1.194×10^{-8}	5.136×10^{-10}	1.034×10^{-10}	2.133×10^{-11}	4.454×10^{-12}	9.295×10^{-13}
698.3	2.315×10^{-6}	1.292×10^{-7}	1.430×10^{-9}	2.710×10^{-10}	5.285×10^{-11}	1.070×10^{-11}	2.189×10^{-12}	4.474×10^{-13}
971.6	9.400×10^{-7}	2.447×10^{-9}	4.789×10^{-10}	8.545×10^{-11}	1.623×10^{-11}	3.209×10^{-12}	6.360×10^{-13}	1.260×10^{-13}
1509		2.566×10^{-10}	4.420×10^{-11}	8.198×10^{-12}	1.567×10^{-12}	2.998×10^{-13}	5.736×10^{-14}	1.097×10^{-14}
2100		4.195×10^{-12}	8.483×10^{-13}	1.607×10^{-13}	3.032×10^{-14}	5.717×10^{-15}	1.078×10^{-15}	2.033×10^{-16}

Table 6. Pion Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 65$ deg (cont.)

r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Pion Intensity, $\pi(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	r = 16	r = 18	r = 20	r = 22	r = 24	r = 26	r = 28	r = 30
32.0	2.905×10^{-12}	6.586×10^{-13}	1.488×10^{-13}	3.349×10^{-14}	7.515×10^{-15}	1.681×10^{-15}	3.749×10^{-16}	8.336×10^{-17}
49.7	3.164×10^{-12}	7.168×10^{-13}	1.618×10^{-13}	3.640×10^{-14}	8.161×10^{-15}	1.824×10^{-15}	4.065×10^{-16}	9.035×10^{-17}
77.2	3.050×10^{-12}	6.897×10^{-13}	1.554×10^{-13}	3.491×10^{-14}	7.814×10^{-15}	1.744×10^{-15}	3.881×10^{-16}	8.614×10^{-17}
107.4	2.630×10^{-12}	6.065×10^{-13}	1.363×10^{-13}	3.054×10^{-14}	6.819×10^{-15}	1.518×10^{-15}	3.370×10^{-16}	7.462×10^{-17}
208.0	1.534×10^{-12}	3.395×10^{-13}	7.491×10^{-14}	1.648×10^{-14}	3.616×10^{-15}	7.913×10^{-16}	1.727×10^{-16}	3.762×10^{-17}
323.1	7.850×10^{-13}	1.698×10^{-13}	3.662×10^{-14}	7.880×10^{-15}	1.692×10^{-15}	3.624×10^{-16}	7.747×10^{-17}	1.653×10^{-17}
402.7	4.929×10^{-13}	1.052×10^{-13}	2.240×10^{-14}	4.759×10^{-15}	1.009×10^{-15}	2.136×10^{-16}	4.512×10^{-17}	9.516×10^{-18}
560.0	1.936×10^{-13}	4.027×10^{-14}	8.361×10^{-15}	1.734×10^{-15}	3.589×10^{-16}	7.419×10^{-17}	1.532×10^{-17}	3.158×10^{-18}
698.3	9.134×10^{-14}	1.862×10^{-14}	3.792×10^{-15}	7.715×10^{-16}	1.568×10^{-16}	3.182×10^{-17}	6.454×10^{-18}	1.307×10^{-18}
971.6	2.494×10^{-14}	4.935×10^{-15}	9.758×10^{-16}	1.929×10^{-16}	3.810×10^{-17}	7.522×10^{-18}	1.484×10^{-18}	2.928×10^{-19}
1509	2.099×10^{-15}	4.014×10^{-16}	7.678×10^{-17}	1.468×10^{-17}	2.808×10^{-18}	5.369×10^{-19}	1.027×10^{-19}	1.963×10^{-20}
2100	3.833×10^{-17}	7.227×10^{-18}	1.363×10^{-18}	2.569×10^{-19}	4.845×10^{-20}	9.135×10^{-21}	1.722×10^{-21}	3.248×10^{-22}

Table 7. Muon Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 65^\circ$
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intensity, $\mu(E,r)$ [(No./Mev.sec.ster)/(elec./sec)]				
	$r = 0.2$	$r = 0.4$	$r = 0.6$	$r = 0.8$	$r = 1.0$
32.0	6.036×10^{-7}	5.968×10^{-7}	5.030×10^{-7}	4.019×10^{-7}	3.169×10^{-7}
49.7	5.257×10^{-7}	5.633×10^{-7}	4.944×10^{-7}	4.055×10^{-7}	3.272×10^{-7}
77.2	3.814×10^{-7}	4.466×10^{-7}	4.106×10^{-7}	3.510×10^{-7}	2.945×10^{-7}
107.4	2.644×10^{-7}	3.257×10^{-7}	3.132×10^{-7}	2.801×10^{-7}	2.441×10^{-7}
208.0	8.234×10^{-8}	1.171×10^{-7}	1.257×10^{-7}	1.215×10^{-7}	1.116×10^{-7}
323.1	2.744×10^{-8}	4.105×10^{-8}	4.651×10^{-8}	4.727×10^{-8}	4.541×10^{-8}
402.7	1.431×10^{-8}	2.200×10^{-8}	2.556×10^{-8}	2.656×10^{-8}	2.605×10^{-8}
560.0	4.887×10^{-9}	7.809×10^{-9}	9.393×10^{-9}	1.006×10^{-8}	1.009×10^{-8}
698.3	2.302×10^{-9}	3.667×10^{-9}	4.347×10^{-9}	4.555×10^{-9}	4.403×10^{-9}
971.6	8.206×10^{-13}	2.480×10^{-12}	4.382×10^{-12}	6.186×10^{-12}	7.714×10^{-12}
1509	2.379×10^{-14}	6.067×10^{-14}	1.036×10^{-13}	1.417×10^{-13}	1.713×10^{-13}

Table 8. Muon Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 65$ deg (cont.)
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intensity, $\mu(E, r)$ [(No./Mev sec.ster)/(elec./sec)]						
	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	1.104×10^{-7}	1.770×10^{-8}	2.571×10^{-9}	2.300×10^{-10}	2.682×10^{-11}	4.898×10^{-12}	1.051×10^{-12}
49.7	1.205×10^{-7}	1.983×10^{-8}	2.948×10^{-9}	2.484×10^{-10}	2.865×10^{-11}	5.208×10^{-12}	1.115×10^{-12}
77.2	1.172×10^{-7}	2.011×10^{-8}	2.895×10^{-9}	2.361×10^{-10}	2.704×10^{-11}	4.906×10^{-12}	1.047×10^{-12}
107.4	1.037×10^{-7}	1.859×10^{-8}	2.557×10^{-9}	2.021×10^{-10}	2.324×10^{-11}	4.234×10^{-12}	9.024×10^{-13}
208.0	5.658×10^{-8}	1.132×10^{-8}	1.239×10^{-9}	9.418×10^{-11}	1.167×10^{-11}	2.215×10^{-12}	4.729×10^{-13}
323.1	2.698×10^{-8}	5.331×10^{-9}	4.272×10^{-10}	3.484×10^{-11}	5.037×10^{-12}	1.016×10^{-12}	2.181×10^{-13}
402.7	1.667×10^{-8}	2.844×10^{-9}	1.938×10^{-10}	1.759×10^{-11}	2.878×10^{-12}	6.016×10^{-13}	1.294×10^{-13}
560.0	6.265×10^{-9}	5.578×10^{-10}	3.813×10^{-11}	5.031×10^{-12}	1.015×10^{-12}	2.211×10^{-13}	4.742×10^{-14}
698.3	1.885×10^{-9}	1.006×10^{-10}	1.001×10^{-11}	1.913×10^{-12}	4.243×10^{-13}	9.312×10^{-14}	1.983×10^{-14}
971.6	1.026×10^{-11}	4.735×10^{-12}	1.325×10^{-12}	3.219×10^{-13}	7.299×10^{-14}	1.576×10^{-14}	3.287×10^{-15}
1509	1.978×10^{-13}	7.769×10^{-14}	2.048×10^{-14}	4.682×10^{-15}	9.977×10^{-16}	2.041×10^{-16}	4.072×10^{-17}

Table 9. Muon Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = 65$ deg (cont.) $r =$ No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intensity, $\mu(E, r)$ [(No./Mev-sec-ster)/(elec./sec)]							
	$r = 16$	$r = 18$	$r = 20$	$r = 22$	$r = 24$	$r = 26$	$r = 28$	$r = 30$
32.0	2.307×10^{-13}	5.032×10^{-14}	1.088×10^{-14}	2.339×10^{-15}	5.003×10^{-16}	1.067×10^{-16}	2.272×10^{-17}	4.834×10^{-18}
49.7	2.440×10^{-13}	5.304×10^{-14}	1.143×10^{-14}	2.446×10^{-15}	5.208×10^{-16}	1.106×10^{-16}	2.343×10^{-17}	4.962×10^{-18}
77.2	2.283×10^{-13}	4.936×10^{-14}	1.057×10^{-14}	2.247×10^{-15}	4.751×10^{-16}	1.001×10^{-16}	2.105×10^{-17}	4.423×10^{-18}
107.4	1.958×10^{-13}	4.210×10^{-14}	8.959×10^{-15}	1.890×10^{-15}	3.966×10^{-16}	8.288×10^{-17}	1.728×10^{-17}	3.600×10^{-18}
208.0	1.015×10^{-13}	2.149×10^{-14}	4.490×10^{-15}	9.288×10^{-16}	1.907×10^{-16}	3.896×10^{-17}	7.932×10^{-18}	1.612×10^{-18}
323.1	4.640×10^{-14}	9.701×10^{-15}	1.998×10^{-15}	4.067×10^{-16}	8.210×10^{-17}	1.647×10^{-17}	3.292×10^{-18}	6.563×10^{-19}
402.7	2.738×10^{-14}	5.682×10^{-15}	1.161×10^{-15}	2.344×10^{-16}	4.689×10^{-17}	9.324×10^{-18}	1.846×10^{-18}	3.643×10^{-19}
560.0	9.929×10^{-15}	2.036×10^{-15}	4.108×10^{-16}	8.191×10^{-17}	1.619×10^{-17}	3.179×10^{-18}	6.215×10^{-19}	1.211×10^{-19}
698.3	4.111×10^{-15}	8.350×10^{-16}	1.670×10^{-16}	3.302×10^{-17}	6.475×10^{-18}	1.262×10^{-18}	2.449×10^{-19}	4.739×10^{-20}
971.6	6.681×10^{-16}	1.333×10^{-16}	2.626×10^{-17}	5.124×10^{-18}	9.928×10^{-19}	1.914×10^{-19}	3.678×10^{-20}	7.050×10^{-21}
1509	7.990×10^{-16}	1.550×10^{-16}	2.983×10^{-19}	5.711×10^{-20}	1.089×10^{-20}	2.071×10^{-21}	3.932×10^{-22}	7.452×10^{-23}

Table 10. Neutron Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = 80$ deg
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Neutron Intensity, $N(E,r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 0$	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	1.115×10^{-3}	9.745×10^{-5}	9.914×10^{-6}	1.310×10^{-6}	2.173×10^{-7}	4.110×10^{-8}	8.255×10^{-9}	1.702×10^{-9}
49.7	6.742×10^{-4}	9.954×10^{-5}	1.475×10^{-5}	2.305×10^{-6}	3.832×10^{-7}	6.764×10^{-8}	1.258×10^{-8}	2.431×10^{-9}
77.2	2.091×10^{-4}	4.238×10^{-5}	8.080×10^{-6}	1.559×10^{-6}	3.051×10^{-7}	6.056×10^{-8}	1.216×10^{-8}	2.468×10^{-9}
107.4	1.031×10^{-4}	2.355×10^{-5}	4.891×10^{-6}	1.014×10^{-6}	2.109×10^{-7}	4.399×10^{-8}	9.197×10^{-9}	1.927×10^{-9}
208.0	1.539×10^{-5}	4.031×10^{-6}	8.808×10^{-7}	1.903×10^{-7}	4.106×10^{-8}	8.847×10^{-9}	1.904×10^{-9}	4.090×10^{-10}
323.1	2.661×10^{-6}	7.777×10^{-7}	1.698×10^{-7}	3.643×10^{-8}	7.791×10^{-9}	1.662×10^{-9}	3.537×10^{-10}	7.508×10^{-11}
402.7	1.066×10^{-6}	3.168×10^{-7}	6.785×10^{-8}	1.429×10^{-8}	3.001×10^{-9}	6.292×10^{-10}	1.316×10^{-10}	2.749×10^{-11}
560.3	1.709×10^{-7}	5.333×10^{-8}	1.098×10^{-8}	2.237×10^{-9}	4.550×10^{-10}	9.244×10^{-11}	1.876×10^{-11}	3.801×10^{-12}
698.3	3.559×10^{-8}	1.089×10^{-8}	2.149×10^{-9}	4.239×10^{-10}	8.352×10^{-11}	1.644×10^{-11}	3.236×10^{-12}	6.362×10^{-13}
971.6	0	2.236×10^{-11}	4.258×10^{-12}	8.109×10^{-13}	1.544×10^{-13}	2.941×10^{-14}	5.601×10^{-15}	1.067×10^{-15}

Table 11. Neutron Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 80$ deg (cent.)

r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Neutron Intensity, $N(E, r)$ [(Nc./Mev.sec.ster)/(elec.sec)]							
	$r = 16$	$r = 18$	$r = 20$	$r = 22$	$r = 24$	$r = 26$	$r = 28$	$r = 30$
32.0	3.550×10^{-10}	7.446×10^{-11}	1.566×10^{-11}	3.301×10^{-12}	6.964×10^{-13}	1.470×10^{-13}	3.102×10^{-14}	6.547×10^{-15}
49.7	4.859×10^{-10}	9.893×10^{-11}	2.042×10^{-11}	4.251×10^{-12}	8.901×10^{-13}	1.870×10^{-13}	3.936×10^{-14}	8.293×10^{-15}
77.2	5.052×10^{-10}	1.041×10^{-10}	2.158×10^{-11}	4.494×10^{-12}	9.391×10^{-13}	1.968×10^{-13}	4.130×10^{-14}	8.682×10^{-15}
107.4	4.045×10^{-10}	8.505×10^{-11}	1.790×10^{-11}	3.772×10^{-12}	7.954×10^{-13}	1.678×10^{-13}	3.542×10^{-14}	7.476×10^{-15}
208.0	8.777×10^{-11}	1.880×10^{-11}	4.023×10^{-12}	8.595×10^{-13}	1.834×10^{-13}	3.906×10^{-14}	8.311×10^{-15}	1.766×10^{-15}
323.1	1.590×10^{-11}	3.362×10^{-12}	7.094×10^{-13}	1.494×10^{-13}	3.141×10^{-14}	6.591×10^{-15}	1.381×10^{-15}	2.889×10^{-16}
402.7	5.731×10^{-12}	1.193×10^{-12}	2.478×10^{-13}	5.142×10^{-14}	1.065×10^{-14}	2.204×10^{-15}	4.552×10^{-16}	9.394×10^{-17}
560.3	7.692×10^{-13}	1.555×10^{-13}	3.140×10^{-14}	6.334×10^{-15}	1.276×10^{-15}	2.570×10^{-16}	5.169×10^{-17}	1.039×10^{-17}
698.3	1.250×10^{-13}	2.455×10^{-14}	4.818×10^{-15}	9.452×10^{-16}	1.853×10^{-16}	3.631×10^{-17}	7.112×10^{-18}	1.392×10^{-18}
971.6	2.031×10^{-16}	3.869×10^{-17}	7.367×10^{-18}	1.403×10^{-18}	2.672×10^{-19}	5.089×10^{-20}	9.691×10^{-21}	1.846×10^{-21}

Table 12. Proton Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = 80$ deg
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Proton Intensity, $P(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 0$	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	1.115×10^{-3}	3.673×10^{-7}	6.673×10^{-8}	1.371×10^{-8}	2.861×10^{-9}	5.999×10^{-10}	1.262×10^{-10}	2.660×10^{-11}
49.7	6.742×10^{-4}	3.508×10^{-7}	6.337×10^{-8}	1.319×10^{-8}	2.776×10^{-9}	5.855×10^{-10}	1.236×10^{-10}	2.613×10^{-11}
77.2	2.091×10^{-4}	3.005×10^{-7}	5.242×10^{-8}	1.098×10^{-8}	2.327×10^{-9}	4.932×10^{-10}	1.045×10^{-10}	2.215×10^{-11}
107.4	1.031×10^{-4}	2.358×10^{-7}	3.896×10^{-8}	8.162×10^{-9}	1.735×10^{-9}	3.687×10^{-10}	7.826×10^{-11}	1.660×10^{-11}
208.0	1.539×10^{-5}	9.349×10^{-8}	1.226×10^{-8}	2.532×10^{-9}	5.349×10^{-10}	1.128×10^{-10}	2.375×10^{-11}	4.993×10^{-12}
323.1	2.661×10^{-6}	3.241×10^{-8}	3.238×10^{-9}	6.591×10^{-10}	1.362×10^{-10}	2.811×10^{-11}	5.795×10^{-12}	1.193×10^{-12}
402.7	1.066×10^{-6}	1.472×10^{-8}	1.227×10^{-9}	2.483×10^{-10}	5.056×10^{-11}	1.029×10^{-11}	2.091×10^{-12}	4.247×10^{-13}
560.3	1.709×10^{-7}	2.079×10^{-9}	1.528×10^{-10}	3.015×10^{-11}	5.973×10^{-12}	1.183×10^{-12}	2.340×10^{-13}	4.630×10^{-14}
698.3	3.559×10^{-8}	2.077×10^{-10}	1.637×10^{-11}	3.156×10^{-12}	6.106×10^{-13}	1.181×10^{-13}	2.285×10^{-14}	4.420×10^{-15}
971.6	0	1.982×10^{-13}	1.094×10^{-14}	2.058×10^{-15}	3.920×10^{-16}	7.464×10^{-17}	1.422×10^{-17}	2.707×10^{-18}

Table 13. Proton Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 80$ deg (cont.)

r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Proton Intensity, $P(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 16$	$r = 18$	$r = 20$	$r = 22$	$r = 24$	$r = 26$	$r = 28$	$r = 30$
32.0	5.613×10^{-12}	1.185×10^{-12}	2.504×10^{-13}	5.290×10^{-14}	1.117×10^{-14}	2.359×10^{-15}	4.978×10^{-16}	1.050×10^{-16}
49.7	5.523×10^{-12}	1.168×10^{-12}	2.468×10^{-13}	5.217×10^{-14}	1.102×10^{-14}	2.327×10^{-15}	4.911×10^{-16}	1.036×10^{-16}
77.2	4.692×10^{-12}	9.932×10^{-13}	2.101×10^{-13}	4.443×10^{-14}	9.387×10^{-15}	1.982×10^{-15}	4.181×10^{-16}	8.812×10^{-17}
107.4	3.518×10^{-12}	7.449×10^{-13}	1.576×10^{-13}	3.330×10^{-14}	7.031×10^{-15}	1.483×10^{-15}	3.125×10^{-16}	6.578×10^{-17}
208.0	1.048×10^{-12}	2.197×10^{-13}	4.601×10^{-14}	9.620×10^{-15}	2.009×10^{-15}	4.191×10^{-16}	8.733×10^{-17}	1.818×10^{-17}
323.1	2.455×10^{-13}	5.044×10^{-14}	1.035×10^{-14}	2.123×10^{-15}	4.350×10^{-16}	8.905×10^{-17}	1.821×10^{-17}	3.722×10^{-18}
402.7	8.617×10^{-14}	1.747×10^{-14}	3.540×10^{-15}	7.166×10^{-16}	1.450×10^{-16}	2.931×10^{-17}	5.921×10^{-18}	1.195×10^{-18}
560.3	9.155×10^{-15}	1.810×10^{-15}	3.576×10^{-16}	7.062×10^{-17}	1.394×10^{-17}	2.752×10^{-18}	5.430×10^{-19}	1.071×10^{-19}
698.3	8.549×10^{-16}	1.653×10^{-16}	3.197×10^{-17}	6.182×10^{-18}	1.195×10^{-18}	2.311×10^{-19}	4.467×10^{-20}	8.635×10^{-21}
971.6	5.156×10^{-19}	9.819×10^{-20}	1.870×10^{-20}	3.561×10^{-21}	6.782×10^{-22}	1.292×10^{-22}	2.460×10^{-23}	4.684×10^{-24}

Table 14. Pion Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = 80$ deg
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Pion Intensity, $\pi(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 0$	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	1.075×10^{-4}	2.951×10^{-7}	8.780×10^{-9}	1.118×10^{-9}	2.238×10^{-10}	4.759×10^{-11}	1.011×10^{-11}	2.146×10^{-12}
49.7	8.826×10^{-5}	3.480×10^{-7}	9.874×10^{-9}	1.207×10^{-9}	2.398×10^{-10}	5.099×10^{-11}	8.923×10^{-12}	2.298×10^{-12}
77.2	6.911×10^{-5}	3.634×10^{-7}	9.938×10^{-9}	1.049×10^{-9}	2.231×10^{-10}	4.742×10^{-11}	8.293×10^{-12}	2.135×10^{-12}
107.4	5.358×10^{-5}	3.466×10^{-7}	9.088×10^{-9}	8.726×10^{-10}	1.854×10^{-10}	3.936×10^{-11}	6.877×10^{-12}	1.769×10^{-12}
208.0	2.442×10^{-5}	2.648×10^{-7}	5.632×10^{-9}	3.278×10^{-10}	6.888×10^{-11}	1.446×10^{-11}	2.495×10^{-12}	6.353×10^{-13}
323.1	1.005×10^{-5}	1.380×10^{-7}	2.849×10^{-9}	9.955×10^{-11}	2.044×10^{-11}	4.196×10^{-12}	7.056×10^{-13}	1.762×10^{-13}
402.7	5.381×10^{-6}	8.236×10^{-8}	2.262×10^{-10}	4.380×10^{-11}	8.880×10^{-12}	1.799×10^{-12}	2.984×10^{-13}	7.371×10^{-14}
560.3	1.625×10^{-6}	2.754×10^{-8}	3.424×10^{-11}	6.630×10^{-12}	1.310×10^{-12}	2.589×10^{-13}	4.175×10^{-14}	1.010×10^{-14}
698.3	5.964×10^{-7}	7.077×10^{-11}	4.400×10^{-12}	8.403×10^{-13}	1.625×10^{-13}	3.141×10^{-14}	4.944×10^{-15}	1.174×10^{-15}
971.6	9.594×10^{-8}	9.238×10^{-14}	4.615×10^{-15}	8.637×10^{-16}	1.645×10^{-16}	3.132×10^{-17}	4.848×10^{-18}	1.136×10^{-18}

Table 15. Pion Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 80$ deg (cont.) $r =$ No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Pion Intensity, $\pi(E, r)$ [(No./Mev·sec·ster)/(elec./sec)]							
	$r = 16$	$r = 18$	$r = 20$	$r = 22$	$r = 24$	$r = 26$	$r = 28$	$r = 30$
32.0	4.550×10^{-13}	9.637×10^{-14}	2.039×10^{-14}	4.309×10^{-15}	9.098×10^{-16}	1.919×10^{-16}	4.042×10^{-17}	8.508×10^{-18}
49.7	4.871×10^{-13}	1.032×10^{-13}	2.182×10^{-14}	4.610×10^{-15}	9.730×10^{-16}	2.052×10^{-16}	4.321×10^{-17}	9.092×10^{-18}
77.2	4.522×10^{-13}	9.570×10^{-14}	2.023×10^{-14}	4.272×10^{-15}	9.011×10^{-16}	1.899×10^{-16}	3.997×10^{-17}	8.405×10^{-18}
107.4	3.744×10^{-13}	7.913×10^{-14}	1.671×10^{-14}	3.525×10^{-15}	7.427×10^{-16}	1.563×10^{-16}	3.287×10^{-17}	6.904×10^{-18}
208.0	1.329×10^{-13}	2.777×10^{-14}	5.795×10^{-15}	1.208×10^{-15}	2.516×10^{-16}	5.234×10^{-17}	1.088×10^{-17}	2.258×10^{-18}
323.1	3.606×10^{-14}	7.374×10^{-15}	1.506×10^{-15}	3.075×10^{-16}	6.273×10^{-17}	1.278×10^{-17}	2.604×10^{-18}	5.300×10^{-19}
402.7	1.490×10^{-14}	3.011×10^{-15}	6.078×10^{-16}	1.226×10^{-16}	2.473×10^{-17}	4.983×10^{-18}	1.004×10^{-18}	2.020×10^{-19}
560.3	1.992×10^{-15}	3.931×10^{-16}	7.752×10^{-17}	1.528×10^{-17}	3.012×10^{-18}	5.935×10^{-19}	1.169×10^{-19}	2.302×10^{-20}
698.3	2.269×10^{-16}	4.384×10^{-17}	8.473×10^{-18}	1.637×10^{-18}	3.164×10^{-19}	6.113×10^{-20}	1.181×10^{-20}	2.282×10^{-21}
971.6	2.163×10^{-19}	4.120×10^{-20}	7.846×10^{-21}	1.494×10^{-21}	2.846×10^{-22}	5.419×10^{-23}	1.032×10^{-23}	1.965×10^{-24}

Table 16. Muon Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 80$ deg
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intensity, $\mu(E,r)$ [(No./Mev.sec.ster)/(elec./sec)]				
	$r = 0.2$	$r = 0.4$	$r = 0.6$	$r = 0.8$	$r = 1.0$
32.0	5.628×10^{-7}	5.432×10^{-7}	4.368×10^{-7}	3.328×10^{-7}	2.512×10^{-7}
49.7	4.869×10^{-7}	5.069×10^{-7}	4.216×10^{-7}	3.309×10^{-7}	2.557×10^{-7}
77.2	3.475×10^{-7}	3.862×10^{-7}	3.400×10^{-7}	2.790×10^{-7}	2.225×10^{-7}
107.4	2.290×10^{-7}	2.710×10^{-7}	2.510×10^{-7}	2.138×10^{-7}	1.752×10^{-7}
208.0	6.200×10^{-8}	8.208×10^{-8}	8.237×10^{-8}	7.419×10^{-8}	6.307×10^{-8}
323.1	1.510×10^{-8}	2.091×10^{-8}	2.170×10^{-8}	2.007×10^{-8}	1.747×10^{-8}
402.7	5.968×10^{-9}	8.310×10^{-9}	8.738×10^{-9}	8.223×10^{-9}	7.298×10^{-9}
560.3	1.075×10^{-9}	1.545×10^{-9}	1.664×10^{-9}	1.588×10^{-9}	1.414×10^{-9}
698.3	2.670×10^{-10}	3.322×10^{-10}	3.228×10^{-10}	2.816×10^{-10}	1.890×10^{-10}

Table 17. Muon Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 80$ deg (cont.)

r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intensity, $\mu(E,r)$ [(No./Mev.sec.ster)/(elec./sec)]						
	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	6.233×10^{-8}	3.648×10^{-9}	1.764×10^{-10}	1.088×10^{-11}	1.650×10^{-12}	3.337×10^{-13}	6.997×10^{-14}
49.7	6.627×10^{-8}	3.942×10^{-9}	1.829×10^{-10}	1.068×10^{-11}	1.565×10^{-12}	3.143×10^{-13}	6.576×10^{-14}
77.2	6.109×10^{-8}	3.726×10^{-9}	1.617×10^{-10}	8.709×10^{-12}	1.208×10^{-12}	2.398×10^{-13}	4.995×10^{-14}
107.4	5.038×10^{-8}	3.143×10^{-9}	1.267×10^{-10}	6.276×10^{-12}	8.181×10^{-13}	1.601×10^{-13}	3.315×10^{-14}
208.0	2.011×10^{-8}	1.315×10^{-9}	4.178×10^{-11}	1.684×10^{-12}	1.844×10^{-13}	3.434×10^{-14}	6.942×10^{-15}
323.1	6.200×10^{-9}	3.440×10^{-10}	9.120×10^{-12}	3.166×10^{-13}	3.054×10^{-14}	5.454×10^{-15}	1.078×10^{-15}
402.7	2.733×10^{-9}	1.143×10^{-10}	2.805×10^{-12}	8.828×10^{-14}	7.763×10^{-15}	1.344×10^{-15}	2.616×10^{-16}
560.3	3.989×10^{-10}	8.966×10^{-12}	1.861×10^{-13}	4.717×10^{-15}	3.087×10^{-16}	4.818×10^{-17}	9.080×10^{-18}
698.3	2.576×10^{-11}	4.790×10^{-13}	9.004×10^{-15}	1.843×10^{-16}	6.577×10^{-18}	7.227×10^{-19}	1.282×10^{-19}

Table 18. Muon Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 80$ deg (cont.)
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intersity, $\mu(E,r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 16$	$r = 18$	$r = 20$	$r = 22$	$r = 24$	$r = 26$	$r = 28$	$r = 30$
32.0	1.471×10^{-14}	3.091×10^{-15}	6.490×10^{-16}	1.361×10^{-16}	2.853×10^{-17}	5.974×10^{-18}	1.250×10^{-18}	2.613×10^{-19}
49.7	1.380×10^{-14}	2.896×10^{-15}	6.069×10^{-16}	1.271×10^{-16}	2.660×10^{-17}	5.560×10^{-18}	1.161×10^{-18}	2.424×10^{-19}
77.2	1.045×10^{-14}	2.184×10^{-15}	4.564×10^{-16}	1.051×10^{-16}	1.987×10^{-17}	4.141×10^{-18}	8.622×10^{-19}	1.794×10^{-19}
107.4	6.899×10^{-15}	1.435×10^{-15}	2.984×10^{-16}	6.199×10^{-17}	1.287×10^{-17}	2.669×10^{-18}	5.532×10^{-19}	1.146×10^{-19}
208.0	1.414×10^{-15}	2.881×10^{-16}	5.866×10^{-17}	1.194×10^{-17}	2.428×10^{-18}	4.936×10^{-19}	1.003×10^{-19}	2.036×10^{-20}
323.1	2.153×10^{-16}	4.301×10^{-17}	8.590×10^{-18}	1.715×10^{-18}	3.423×10^{-19}	6.829×10^{-20}	1.362×10^{-20}	2.715×10^{-21}
402.7	5.156×10^{-17}	1.017×10^{-17}	2.006×10^{-18}	3.956×10^{-19}	7.800×10^{-20}	1.537×10^{-20}	3.030×10^{-21}	5.968×10^{-22}
560.3	1.747×10^{-18}	3.369×10^{-19}	6.497×10^{-20}	1.253×10^{-20}	2.416×10^{-21}	4.659×10^{-22}	8.982×10^{-23}	1.732×10^{-23}
698.3	2.433×10^{-20}	4.648×10^{-21}	8.888×10^{-22}	1.700×10^{-22}	3.250×10^{-23}	6.214×10^{-24}	1.188×10^{-24}	2.272×10^{-25}

Table 19. Neutron Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 95$ deg
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Neutron Intensity, $N(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 0$	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	1.022×10^{-3}	3.354×10^{-5}	7.796×10^{-6}	9.190×10^{-7}	1.371×10^{-7}	2.394×10^{-8}	4.539×10^{-9}	8.934×10^{-10}
49.7	6.180×10^{-4}	3.653×10^{-5}	1.224×10^{-5}	1.805×10^{-6}	2.801×10^{-7}	4.588×10^{-8}	7.918×10^{-9}	1.431×10^{-9}
77.2	1.634×10^{-4}	3.130×10^{-5}	5.777×10^{-6}	1.077×10^{-6}	2.033×10^{-7}	3.881×10^{-8}	7.488×10^{-9}	1.459×10^{-9}
107.4	8.590×10^{-5}	1.805×10^{-5}	3.591×10^{-6}	7.150×10^{-7}	1.428×10^{-7}	2.862×10^{-8}	5.751×10^{-9}	1.159×10^{-9}
208.0	9.266×10^{-6}	2.221×10^{-6}	4.677×10^{-7}	9.777×10^{-8}	2.042×10^{-8}	4.265×10^{-9}	8.903×10^{-10}	1.858×10^{-10}
323.1	1.006×10^{-6}	2.845×10^{-7}	6.025×10^{-8}	1.255×10^{-8}	2.611×10^{-9}	5.427×10^{-10}	1.127×10^{-10}	2.337×10^{-11}
402.7	2.626×10^{-7}	8.733×10^{-8}	1.845×10^{-8}	3.814×10^{-9}	7.873×10^{-10}	1.623×10^{-10}	3.342×10^{-11}	6.873×10^{-12}
560.3	2.467×10^{-8}	1.149×10^{-8}	2.328×10^{-9}	4.643×10^{-10}	9.261×10^{-11}	1.847×10^{-11}	3.683×10^{-12}	7.344×10^{-13}
698.3	0	1.468×10^{-9}	2.906×10^{-10}	5.746×10^{-11}	1.136×10^{-11}	2.243×10^{-12}	4.428×10^{-13}	8.736×10^{-14}
971.6	0	9.372×10^{-12}	1.785×10^{-12}	3.399×10^{-13}	6.474×10^{-14}	1.233×10^{-14}	2.348×10^{-15}	4.471×10^{-16}

Table 20. Neutron Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = 95$ deg (cont.)

r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Neutron Intensity, $N(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 16$	$r = 18$	$r = 20$	$r = 22$	$r = 24$	$r = 26$	$r = 28$	$r = 30$
32.0	1.790×10^{-10}	3.621×10^{-11}	7.365×10^{-12}	1.503×10^{-12}	3.076×10^{-13}	6.307×10^{-14}	1.295×10^{-14}	2.662×10^{-15}
49.7	2.683×10^{-10}	5.176×10^{-11}	1.019×10^{-11}	2.035×10^{-12}	4.103×10^{-13}	8.331×10^{-14}	1.699×10^{-14}	3.478×10^{-15}
77.2	2.869×10^{-10}	5.683×10^{-11}	1.133×10^{-11}	2.274×10^{-12}	4.583×10^{-13}	9.277×10^{-14}	1.885×10^{-14}	3.839×10^{-15}
107.4	2.312×10^{-10}	4.743×10^{-11}	9.629×10^{-12}	1.959×10^{-12}	3.991×10^{-13}	8.147×10^{-14}	1.666×10^{-14}	3.409×10^{-15}
208.0	3.874×10^{-11}	8.075×10^{-12}	1.682×10^{-12}	3.503×10^{-13}	7.291×10^{-14}	1.517×10^{-14}	3.153×10^{-15}	6.553×10^{-16}
323.1	4.844×10^{-12}	1.003×10^{-12}	2.075×10^{-13}	4.288×10^{-14}	8.854×10^{-15}	1.827×10^{-15}	3.766×10^{-16}	7.757×10^{-17}
402.7	1.412×10^{-12}	2.898×10^{-13}	5.941×10^{-14}	1.217×10^{-14}	2.490×10^{-15}	5.090×10^{-16}	1.040×10^{-16}	2.122×10^{-17}
560.3	1.464×10^{-13}	2.919×10^{-14}	5.817×10^{-15}	1.159×10^{-15}	2.310×10^{-16}	4.601×10^{-17}	9.164×10^{-18}	1.825×10^{-18}
698.3	1.723×10^{-14}	3.395×10^{-15}	6.687×10^{-16}	1.317×10^{-16}	2.591×10^{-17}	5.097×10^{-18}	1.002×10^{-18}	1.970×10^{-19}
971.6	8.515×10^{-17}	1.622×10^{-17}	3.088×10^{-18}	5.882×10^{-19}	1.120×10^{-19}	2.133×10^{-20}	4.062×10^{-21}	7.736×10^{-22}

Table 21. Proton Intensities for $E_1 = 45 \times 10^3$ and $\theta = 95$ deg
 $r = \text{No. of collision lengths (1 collision length} = 1.71 \text{ ft)}$

E (Mev)	Proton Intensity, $P(E,r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 0$	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	1.022×10^{-3}	2.099×10^{-7}	3.805×10^{-8}	7.508×10^{-9}	1.506×10^{-9}	3.043×10^{-10}	6.179×10^{-11}	1.260×10^{-11}
49.7	6.180×10^{-4}	1.880×10^{-7}	3.447×10^{-8}	5.933×10^{-9}	1.409×10^{-9}	2.872×10^{-10}	5.870×10^{-11}	1.202×10^{-11}
77.2	1.634×10^{-4}	1.479×10^{-7}	2.651×10^{-8}	5.338×10^{-9}	1.107×10^{-9}	2.275×10^{-10}	4.681×10^{-11}	9.640×10^{-12}
107.4	8.590×10^{-5}	1.039×10^{-7}	1.792×10^{-8}	3.656×10^{-9}	7.555×10^{-10}	1.562×10^{-10}	3.229×10^{-11}	6.678×10^{-12}
208.0	9.266×10^{-6}	3.046×10^{-8}	4.036×10^{-9}	8.128×10^{-10}	1.683×10^{-10}	3.482×10^{-11}	7.200×10^{-12}	1.488×10^{-12}
323.1	1.006×10^{-6}	8.870×10^{-9}	7.761×10^{-10}	1.543×10^{-10}	3.152×10^{-11}	6.435×10^{-12}	1.313×10^{-12}	2.676×10^{-13}
402.7	2.626×10^{-7}	3.898×10^{-9}	2.502×10^{-10}	4.983×10^{-11}	1.006×10^{-11}	2.032×10^{-12}	4.099×10^{-13}	8.265×10^{-14}
560.3	2.467×10^{-8}	6.328×10^{-10}	2.314×10^{-11}	4.535×10^{-12}	8.986×10^{-13}	1.780×10^{-13}	3.525×10^{-14}	6.978×10^{-15}
698.3	0	6.336×10^{-11}	2.625×10^{-12}	5.057×10^{-13}	9.836×10^{-14}	1.913×10^{-14}	3.719×10^{-15}	7.231×10^{-16}
971.6	0	8.313×10^{-12}	4.588×10^{-13}	8.628×10^{-14}	1.643×10^{-14}	3.129×10^{-15}	5.959×10^{-16}	1.135×10^{-16}

Table 22. Proton Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = 95$ deg (cont.)
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Proton Intensity, $P(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 16$	$r = 18$	$r = 20$	$r = 22$	$r = 24$	$r = 26$	$r = 28$	$r = 30$
32.0	2.575×10^{-12}	5.275×10^{-13}	1.082×10^{-13}	2.224×10^{-14}	4.573×10^{-15}	9.413×10^{-16}	1.939×10^{-16}	3.994×10^{-17}
49.7	2.466×10^{-12}	5.065×10^{-13}	1.041×10^{-13}	2.143×10^{-14}	4.413×10^{-15}	9.092×10^{-16}	1.874×10^{-16}	3.864×10^{-17}
77.2	1.986×10^{-12}	4.095×10^{-13}	8.446×10^{-14}	1.743×10^{-14}	3.596×10^{-15}	7.421×10^{-16}	1.532×10^{-16}	3.162×10^{-17}
107.4	1.581×10^{-12}	2.856×10^{-13}	5.905×10^{-14}	1.221×10^{-14}	2.524×10^{-15}	5.216×10^{-16}	1.078×10^{-16}	2.227×10^{-17}
208.0	3.072×10^{-13}	6.339×10^{-14}	1.307×10^{-14}	2.693×10^{-15}	5.547×10^{-16}	1.142×10^{-16}	2.348×10^{-17}	4.826×10^{-18}
323.1	5.452×10^{-14}	1.110×10^{-14}	2.258×10^{-15}	4.591×10^{-16}	9.328×10^{-17}	1.894×10^{-17}	3.844×10^{-18}	7.798×10^{-19}
402.7	1.666×10^{-14}	3.355×10^{-15}	6.755×10^{-16}	1.359×10^{-16}	2.734×10^{-17}	5.495×10^{-18}	1.104×10^{-18}	2.218×10^{-19}
560.3	1.381×10^{-15}	2.732×10^{-16}	5.402×10^{-17}	1.068×10^{-17}	2.111×10^{-18}	4.170×10^{-19}	8.236×10^{-20}	1.626×10^{-20}
598.3	1.406×10^{-16}	2.732×10^{-17}	5.308×10^{-18}	1.031×10^{-18}	2.004×10^{-19}	3.892×10^{-20}	7.559×10^{-21}	1.468×10^{-21}
971.6	2.161×10^{-19}	4.116×10^{-20}	7.838×10^{-21}	1.493×10^{-21}	2.843×10^{-22}	5.414×10^{-23}	1.031×10^{-23}	1.964×10^{-24}

Table 23. Pion Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 95$ deg
 $r = Nc$. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Pion Intensity, $\pi(E,r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	r = 0	r = 2	r = 4	r = 6	r = 8	r = 10	r = 12	r = 14
32.0	9.691×10^{-5}	1.320×10^{-7}	3.634×10^{-9}	4.792×10^{-10}	9.357×10^{-11}	1.940×10^{-11}	4.023×10^{-12}	8.339×10^{-13}
49.7	7.626×10^{-5}	1.532×10^{-7}	4.028×10^{-9}	5.138×10^{-10}	9.952×10^{-11}	2.064×10^{-11}	4.279×10^{-12}	8.869×10^{-13}
77.2	5.601×10^{-5}	1.537×10^{-7}	3.913×10^{-9}	4.393×10^{-10}	9.105×10^{-11}	1.888×10^{-11}	3.914×10^{-12}	8.113×10^{-13}
107.4	4.013×10^{-5}	1.452×10^{-7}	3.507×10^{-9}	3.541×10^{-10}	7.341×10^{-11}	1.522×10^{-11}	3.156×10^{-12}	6.541×10^{-13}
208.0	1.394×10^{-5}	1.015×10^{-7}	2.000×10^{-9}	1.008×10^{-10}	2.08×10^{-11}	4.299×10^{-12}	8.873×10^{-13}	1.830×10^{-13}
323.1	4.769×10^{-6}	5.308×10^{-8}	1.053×10^{-9}	2.207×10^{-11}	4.489×10^{-12}	9.130×10^{-13}	1.856×10^{-13}	3.770×10^{-14}
402.7	2.253×10^{-6}	2.931×10^{-8}	4.621×10^{-11}	8.478×10^{-12}	1.707×10^{-12}	3.435×10^{-13}	6.912×10^{-14}	1.390×10^{-14}
560.3	6.264×10^{-7}	1.041×10^{-8}	5.341×10^{-12}	1.000×10^{-12}	1.978×10^{-13}	3.911×10^{-14}	7.732×10^{-15}	1.528×10^{-15}
698.3	2.134×10^{-7}	2.319×10^{-11}	7.381×10^{-13}	1.392×10^{-13}	2.703×10^{-14}	5.252×10^{-15}	1.020×10^{-15}	1.981×10^{-16}
971.6	3.950×10^{-8}	3.876×10^{-14}	1.934×10^{-15}	3.620×10^{-16}	6.894×10^{-17}	1.313×10^{-17}	2.500×10^{-18}	4.762×10^{-19}

Table 24. Pion Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 95$ deg (cont.)
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Pion Intensity, $\pi(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	$r = 16$	$r = 18$	$r = 20$	$r = 22$	$r = 24$	$r = 26$	$r = 28$	$r = 30$
32.0	1.728×10^{-13}	3.580×10^{-14}	7.416×10^{-15}	1.536×10^{-15}	3.179×10^{-16}	6.577×10^{-17}	1.360×10^{-17}	2.813×10^{-18}
49.7	1.838×10^{-13}	3.808×10^{-14}	7.887×10^{-15}	1.633×10^{-15}	3.380×10^{-16}	6.993×10^{-17}	1.446×10^{-17}	2.990×10^{-18}
77.2	1.681×10^{-13}	3.483×10^{-14}	7.212×10^{-15}	1.493×10^{-15}	3.090×10^{-16}	6.391×10^{-17}	1.322×10^{-17}	2.732×10^{-18}
107.4	1.355×10^{-13}	2.807×10^{-14}	5.811×10^{-15}	1.203×10^{-15}	2.488×10^{-16}	5.144×10^{-17}	1.063×10^{-17}	2.197×10^{-18}
208.0	3.773×10^{-14}	7.772×10^{-15}	1.600×10^{-15}	3.293×10^{-16}	6.771×10^{-17}	1.392×10^{-17}	2.858×10^{-18}	5.868×10^{-19}
323.1	7.653×10^{-15}	1.553×10^{-15}	3.149×10^{-16}	6.381×10^{-17}	1.293×10^{-17}	2.617×10^{-18}	5.296×10^{-19}	1.071×10^{-19}
402.7	2.794×10^{-15}	5.613×10^{-16}	1.127×10^{-16}	2.263×10^{-17}	4.540×10^{-18}	9.106×10^{-19}	1.826×10^{-19}	3.658×10^{-20}
560.3	3.019×10^{-16}	5.963×10^{-17}	1.177×10^{-17}	2.324×10^{-18}	4.586×10^{-19}	9.046×10^{-20}	1.784×10^{-20}	3.518×10^{-21}
698.3	3.847×10^{-17}	7.470×10^{-18}	1.450×10^{-18}	2.815×10^{-19}	5.464×10^{-20}	1.060×10^{-20}	2.058×10^{-21}	3.992×10^{-22}
971.6	9.068×10^{-20}	1.727×10^{-20}	3.289×10^{-21}	6.263×10^{-22}	1.193×10^{-22}	2.272×10^{-23}	4.326×10^{-24}	8.239×10^{-25}

Table 25. Muon Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 95^\circ$

r = No. of collision lengths (1 collision length = 1.71 ft.)

E (Mev)	Muon Intensity, $\mu(E,r)$ [No./Mev.sec.ster)/(elec./sec)]				
	$r = 0.2$	$r = 0.4$	$r = 0.6$	$r = 0.8$	$r = 1.0$
32.0	4.371×10^{-7}	3.716×10^{-7}	2.708×10^{-7}	1.909×10^{-7}	1.359×10^{-7}
49.7	3.601×10^{-7}	3.313×10^{-7}	2.531×10^{-7}	1.854×10^{-7}	1.355×10^{-7}
77.2	2.323×10^{-7}	2.363×10^{-7}	1.936×10^{-7}	1.502×10^{-7}	1.137×10^{-7}
107.4	1.403×10^{-7}	1.546×10^{-7}	1.356×10^{-7}	1.097×10^{-7}	8.511×10^{-8}
208.0	3.061×10^{-8}	3.848×10^{-8}	3.714×10^{-8}	3.221×10^{-8}	2.652×10^{-8}
323.1	6.201×10^{-9}	8.388×10^{-9}	8.551×10^{-9}	7.810×10^{-9}	6.748×10^{-9}
402.7	2.302×10^{-9}	3.197×10^{-9}	3.353×10^{-9}	3.136×10^{-9}	2.761×10^{-9}
560.3	3.884×10^{-10}	5.636×10^{-10}	6.131×10^{-10}	5.911×10^{-10}	5.322×10^{-10}
698.3	1.049×10^{-10}	1.314×10^{-10}	1.287×10^{-10}	1.137×10^{-10}	7.358×10^{-12}

Table 26. Muon Intensities for $E_i = 45 \times 10^3$ Mev and $\theta = .95$ deg (cont.)
 r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intensity, $\mu(E, r)$ [(No./Mev·sec·ster)/(elec./sec)]						
	$r = 2$	$r = 4$	$r = 6$	$r = 8$	$r = 10$	$r = 12$	$r = 14$
32.0	2.664×10^{-8}	1.369×10^{-9}	6.765×10^{-11}	4.030×10^{-12}	5.850×10^{-13}	1.155×10^{-13}	2.376×10^{-14}
49.7	2.799×10^{-8}	1.476×10^{-9}	6.978×10^{-11}	3.885×10^{-12}	5.385×10^{-13}	1.054×10^{-13}	2.167×10^{-14}
77.2	2.531×10^{-8}	1.391×10^{-9}	6.128×10^{-11}	3.066×10^{-12}	3.921×10^{-13}	7.563×10^{-14}	1.550×10^{-14}
107.4	2.045×10^{-8}	1.171×10^{-9}	4.772×10^{-11}	2.123×10^{-12}	2.450×10^{-13}	4.625×10^{-14}	9.436×10^{-15}
208.0	7.760×10^{-9}	4.953×10^{-10}	1.568×10^{-11}	5.223×10^{-13}	4.276×10^{-14}	7.342×10^{-15}	1.462×10^{-15}
323.1	2.318×10^{-9}	1.325×10^{-10}	3.468×10^{-12}	9.700×10^{-14}	6.184×10^{-15}	9.670×10^{-16}	1.877×10^{-16}
402.7	1.019×10^{-9}	4.454×10^{-11}	1.080×10^{-12}	2.748×10^{-14}	1.509×10^{-15}	2.206×10^{-16}	4.204×10^{-17}
560.3	5.603×10^{-10}	3.589×10^{-12}	7.428×10^{-14}	1.662×10^{-14}	7.418×10^{-17}	9.642×10^{-18}	1.777×10^{-18}
698.3	1.048×10^{-11}	1.970×10^{-13}	3.727×10^{-15}	7.656×10^{-17}	2.725×10^{-18}	2.981×10^{-19}	5.283×10^{-20}

Table 27. Muon Intensities for $E_1 = 45 \times 10^3$ Mev and $\theta = 95$ deg (cont.)

r = No. of collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intensity, $\mu(E, r)$ [(No./Mev.sec.ster)/(elec./sec)]							
	r = 16	r = 18	r = 20	r = 22	r = 24	r = 26	r = 28	r = 30
32.0	4.909×10^{-15}	1.014×10^{-15}	2.095×10^{-16}	4.326×10^{-17}	8.929×10^{-18}	1.842×10^{-18}	3.799×10^{-19}	7.832×10^{-20}
49.7	4.474×10^{-15}	9.238×10^{-16}	1.907×10^{-16}	3.934×10^{-17}	8.115×10^{-18}	1.673×10^{-18}	3.448×10^{-19}	7.103×10^{-20}
77.2	3.195×10^{-15}	6.587×10^{-16}	1.358×10^{-16}	2.797×10^{-17}	5.759×10^{-18}	1.186×10^{-18}	2.439×10^{-19}	5.017×10^{-20}
107.4	1.940×10^{-15}	3.989×10^{-16}	8.200×10^{-17}	1.685×10^{-17}	3.461×10^{-18}	7.104×10^{-19}	1.458×10^{-19}	2.990×10^{-20}
208.0	2.958×10^{-16}	5.991×10^{-17}	1.213×10^{-17}	2.455×10^{-18}	4.967×10^{-19}	1.005×10^{-19}	2.031×10^{-20}	4.103×10^{-21}
323.1	3.731×10^{-17}	7.434×10^{-18}	1.481×10^{-18}	2.950×10^{-19}	5.874×10^{-20}	1.169×10^{-20}	2.327×10^{-21}	4.631×10^{-22}
402.7	8.268×10^{-18}	1.631×10^{-18}	3.216×10^{-19}	6.342×10^{-20}	1.250×10^{-20}	2.465×10^{-21}	4.857×10^{-22}	9.571×10^{-23}
560.3	3.421×10^{-19}	6.615×10^{-20}	1.280×10^{-20}	2.475×10^{-21}	4.787×10^{-22}	9.258×10^{-23}	1.790×10^{-23}	3.462×10^{-24}
698.3	1.003×10^{-20}	1.916×10^{-21}	3.663×10^{-22}	7.004×10^{-23}	1.339×10^{-23}	2.561×10^{-24}	4.897×10^{-25}	9.364×10^{-26}

Appendix

In obtaining the neutron doses given in Figs. 4, 5, and 6, the dose from neutrons with energies less than 109 Mev was obtained from the measured cosmic-ray neutron spectrum as outlined in 1.* Since this method of estimating the low-energy dose is not entirely satisfactory, we give separately in this appendix the contribution to the total neutron dose obtained from the cosmic-ray spectrum alone and the contribution obtained from our calculated neutron intensity above 109 Mev (i.e., $\Gamma = 109$ Mev).

Also for purposes of comparison we shall give the neutron dose obtained from our calculated intensity using all neutrons with energy greater than 32 Mev (i.e., $\Gamma = 32$ Mev).

*An energy of 109 Mev was chosen because at this energy the calculated neutron intensity and the measured cosmic-ray spectrum have approximately the same shape.

Table A-1. Neutron Doses for $E_i = 45 \times 10^3$ Mev and $\theta = 65$ deg

r (collision lengths)	$r^2 \times \text{Dose} \left\{ (\text{collision lengths})^2 [(\text{rads/hr})/(\text{elec./sec})] \right\}$		
	$r^2 d_{\text{NC}},$ $\Gamma = 109 \text{ Mev}$	$r^2 (d_{\text{NA}} + d_{\text{NE}}),$ $\Gamma = 109 \text{ Mev}$	$r^2 (d_{\text{NA}} + d_{\text{NE}}),$ $\Gamma = 32 \text{ Mev}$
10.	1176. $\times 10^{-15}$	152.4 $\times 10^{-15}$	263.4 $\times 10^{-15}$
12	272.1 $\times 10^{-15}$	35.57 $\times 10^{-15}$	61.07 $\times 10^{-15}$
14	63.04 $\times 10^{-15}$	8.268 $\times 10^{-15}$	14.15 $\times 10^{-15}$
16	14.61 $\times 10^{-15}$	1.914 $\times 10^{-15}$	3.273 $\times 10^{-15}$
18	3.382 $\times 10^{-15}$	0.4413 $\times 10^{-15}$	0.7551 $\times 10^{-15}$
20	0.7816 $\times 10^{-15}$	0.1014 $\times 10^{-15}$	0.1737 $\times 10^{-15}$
22	0.1802 $\times 10^{-15}$	0.02319 $\times 10^{-15}$	0.03984 $\times 10^{-15}$
24	414.7 $\times 10^{-19}$	52.86 $\times 10^{-19}$	91.09 $\times 10^{-19}$
26	95.13 $\times 10^{-19}$	12.00 $\times 10^{-19}$	20.76 $\times 10^{-19}$
28	21.76 $\times 10^{-19}$	2.717 $\times 10^{-19}$	4.714 $\times 10^{-19}$
30	4.964 $\times 10^{-19}$	0.6128 $\times 10^{-19}$	1.067 $\times 10^{-19}$

Table A-2. Neutron Doses for $E_i = 45 \times 10^3$ Mev and $\theta = 80$ deg

r (collision lengths)	$r^2 \times \text{Dose} \left\{ (\text{collision lengths})^2 [(\text{rads/hr})/(\text{elec./sec})] \right\}$		
	$r^2 d_{NC},$ $\Gamma = 109 \text{ Mev}$	$r^2 (d_{NA} + d_{NE}),$ $\Gamma = 109 \text{ Mev}$	$r^2 (d_{NA} + d_{NE}),$ $\Gamma = 32 \text{ Mev}$
10	5782. $\times 10^{-16}$	473.8 $\times 10^{-16}$	1046. $\times 10^{-16}$
12	1209. $\times 10^{-16}$	100.5 $\times 10^{-16}$	214.6 $\times 10^{-16}$
14	253.5 $\times 10^{-16}$	21.31 $\times 10^{-16}$	44.47 $\times 10^{-16}$
16	53.22 $\times 10^{-16}$	4.519 $\times 10^{-16}$	9.277 $\times 10^{-16}$
18	11.19 $\times 10^{-16}$	0.9580 $\times 10^{-16}$	1.944 $\times 10^{-16}$
20	2.356 $\times 10^{-16}$	0.2030 $\times 10^{-16}$	0.4084 $\times 10^{-16}$
22	4966. $\times 10^{-20}$	429.9 $\times 10^{-20}$	859.8 $\times 10^{-20}$
24	1047. $\times 10^{-20}$	91.00 $\times 10^{-20}$	181.2 $\times 10^{-20}$
26	220.9 $\times 10^{-20}$	19.25 $\times 10^{-20}$	38.21 $\times 10^{-20}$
28	46.64 $\times 10^{-20}$	4.069 $\times 10^{-20}$	8.060 $\times 10^{-20}$
30	9.846 $\times 10^{-20}$	0.8595 $\times 10^{-20}$	1.700 $\times 10^{-20}$

Table A-3. Neutron Doses for $E_1 = 45 \times 10^3$ Mev and $\theta = 95$ deg

r (collision lengths)	$r^2 \times \text{Dose} \left\{ (\text{collision lengths})^2 [(\text{rads/hr})/(\text{elec./sec})] \right\}$		
	$r^2 d_{NC},$ $\Gamma = 109 \text{ Mev}$	$r^2 (d_{NA} + d_{NE}),$ $\Gamma = 109 \text{ Mev}$	$r^2 (d_{NA} + d_{NE}),$ $\Gamma = 32 \text{ Mev}$
10	3744. $\times 10^{-16}$	233.9 $\times 10^{-16}$	602.7 $\times 10^{-16}$
12	752.9 $\times 10^{-16}$	48.10 $\times 10^{-16}$	118.1 $\times 10^{-16}$
14	151.8 $\times 10^{-16}$	9.910 $\times 10^{-16}$	23.48 $\times 10^{-16}$
16	30.69 $\times 10^{-16}$	2.042 $\times 10^{-16}$	4.712 $\times 10^{-16}$
18	6.219 $\times 10^{-16}$	0.4209 $\times 10^{-16}$	0.9520 $\times 10^{-17}$
20	1.263 $\times 10^{-16}$	0.08682 $\times 10^{-16}$	0.1933 $\times 10^{-17}$
22	2570. $\times 10^{-20}$	179.1 $\times 10^{-20}$	393.8 $\times 10^{-20}$
24	524.0 $\times 10^{-20}$	36.97 $\times 10^{-20}$	80.47 $\times 10^{-20}$
26	107.0 $\times 10^{-20}$	7.634 $\times 10^{-20}$	16.48 $\times 10^{-20}$
28	21.88 $\times 10^{-20}$	1.576 $\times 10^{-20}$	3.380 $\times 10^{-20}$
30	4.480 $\times 10^{-20}$	0.3255 $\times 10^{-20}$	0.6941 $\times 10^{-20}$

ORNL-3365
 UC-34 - Physics
 TID-4500 (18th ed., Rev.)

INTERNAL DISTRIBUTION

1. Biology Library	75. C. E. Larson
2-3. Central Research Library	76. R. S. Livingston
4. Reactor Division Library	77. F. C. Maienschein
5-6. ORNL - Y-12 Technical Library	78. J. E. Murphy
Document Reference Section	79. M. J. Skinner
7-56. Laboratory Records Department	80. J. A. Swartout
57. Laboratory Records, ORNL R.C.	81. J. E. Turner
58. F. S. Alsmiller	82. A. M. Weinberg
59-68. R. G. Alsmiller, Jr.	83-97. C. D. Zerby
69. E. P. Blizard	98. R. A. Charpie (consultant)
70. D. R. Gilfillan	99. P. F. Gast (consultant)
71. A. A. Grau	100. R. F. Taschek (consultant)
72. F. T. Howard	101. T. J. Thompson (consultant)
73. W. H. Jordan	102. Gale Young (consultant)
74. W. E. Kinney	

EXTERNAL DISTRIBUTION

- 103. E. A. Cosbie, Argonne National Laboratory, Argonne, Illinois
- 104-106. University of California, Lawrence Radiation Laboratory, Berkeley, California (1 copy each to B. J. Moyer, R. Wallace, and W. Patterson)
- 107-110. Stanford Linear Accelerator Center, Stanford University, Stanford, California (1 copy each to K. G. Dedrick, H. DeStaebler, Jr., R. F. Mozley, and W. K. H. Panofsky)
- 111. H. B. Knowles, Yale University, Sloane Laboratory, New Haven, Connecticut
- 112-113. Brookhaven National Laboratory, Upton, Long Island, New York (1 copy each to F. P. Cowan and S. J. Lindenbaum)
- 114. S. P. Shen, New York University, New York, New York
- 115. M. Stanley Livingston, Cambridge Electron Accelerator, Cambridge, Massachusetts
- 116. Herman J. Schaefer, U.S. Naval School of Aviation, Pensacola, Florida
- 117. Wilmot N. Hess, NASA, Goddard Space Flight Center, Greenbelt, Maryland
- 118. O. L. Tiffany, Bendix Systems Division, The Bendix Corporation, Ann Arbor, Michigan
- 119. R. L. Childers, University of Tennessee, Knoxville, Tennessee
- 120. Aaron Galonsky, Midwestern Universities Research Association, Madison, Wisconsin
- 121. Research and Development Division, AEC, ORO
- 122-750. Given distribution as shown in TID-4500 (18th ed., Rev.) under Physics category (75 copies - OTS)