APR 9 1963

ORNL-3412
UC-34 - Physics
TID-4500 (18th ed., Rev.)

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NUCLEON-MESON CASCADE CALCULATIONS:

TRANSVERSE SHIELDING FOR A 45-Gev

ELECTRON ACCELERATOR (PART III)

R. G. Alsmiller, Jr.
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J. E. Murphy

OAK RIDGE NATIONAL LABORATORY

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Printed in USA. Price: \$0.75 Available from the
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Contract No. W-7405-eng-26

Neutron Physics Division

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FOR A 45-GeV ELECTRON ACCELERATOR (PART III)

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Date Issued

MAR 28 1963

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Abstract

In two previous reports 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 two additional cases.

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I. Introduction

In two previous reports^{1,2} (hereinafter referred to as 1 and 2, respectively) 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 two additional cases. The equations, notation, and method of calculation are the same as in 1 and 2. The physical data used is the same as in 2, and the initial values are obtained in the same manner as in 2.

The results are given in Section II and some details concerning the dose calculation are given in the appendix.

II. Results

The neutron, proton, pion, and muon intensities as a function of energy and distance for $\theta = 50^\circ$ and 110° are given in Tables 1 through 18.

~~The doses for these cases are shown in Figs. 1 and 2.~~ As in 1 and 2, the neutron dose contains an estimated contribution from low-energy neutrons (see the appendix), but the proton, pion, and muon doses are calculated by considering only those particles whose energies exceed 32 Mev.

The doses of Figs. 1 and 2 exhibit much the same general behavior as was found in 2. The single exception to this is the muon dose for $\theta = 50^\circ$ which has a very different slope than do the neutron, proton, and pion doses for this case. This phenomenon that the muon dose begins to become important as one considers cases where high-energy pions are present has been observed before and is markedly shown by the $\theta = 0$ case in 1.

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1. R. G. Alsmiller, Jr., F. S. Alsmiller, and J. E. Murphy, Nucleon-Meson Cascade Calculations: Transverse Shielding for a 45-Gev Electron Accelerator (Part I), ORNL-3289 (1962).
 2. R. G. Alsmiller, Jr., F. S. Alsmiller, and J. E. Murphy, Nucleon-Meson Cascade Calculations: Transverse Shielding for a 45-Gev Electron Accelerator (Part II), ORNL-3365 (1962).

Table 1. Neutron Intensity, $N(E, r)$, for $E_i = 45 \times 10^3$ Mev and $\theta = 50$ deg
 r in 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	8.548×10^{-4}	1.597×10^{-4}	3.453×10^{-5}	8.323×10^{-6}	2.080×10^{-6}	5.220×10^{-7}	1.301×10^{-7}	3.208×10^{-8}
52.9	4.951×10^{-4}	1.383×10^{-4}	3.500×10^{-5}	8.849×10^{-6}	2.241×10^{-6}	5.655×10^{-7}	1.417×10^{-7}	3.517×10^{-8}
77.2	2.996×10^{-4}	9.840×10^{-5}	2.723×10^{-5}	7.249×10^{-6}	1.893×10^{-6}	4.870×10^{-7}	1.236×10^{-7}	3.101×10^{-8}
112.5	1.642×10^{-4}	6.101×10^{-5}	1.793×10^{-5}	4.954×10^{-6}	1.325×10^{-6}	3.466×10^{-7}	8.906×10^{-8}	2.254×10^{-8}
210.9	5.002×10^{-5}	2.144×10^{-5}	6.572×10^{-6}	1.841×10^{-6}	4.937×10^{-7}	1.287×10^{-7}	3.287×10^{-8}	8.250×10^{-9}
307.5	2.173×10^{-5}	9.976×10^{-6}	3.044×10^{-6}	8.361×10^{-7}	2.189×10^{-7}	5.570×10^{-8}	1.388×10^{-8}	3.402×10^{-9}
395.4	1.209×10^{-5}	5.751×10^{-6}	1.733×10^{-6}	4.658×10^{-7}	1.191×10^{-7}	2.959×10^{-8}	7.207×10^{-9}	1.728×10^{-9}
508.5	6.715×10^{-6}	3.056×10^{-6}	8.876×10^{-7}	2.300×10^{-7}	5.682×10^{-8}	1.366×10^{-8}	3.228×10^{-9}	7.522×10^{-10}
653.8	3.564×10^{-6}	1.495×10^{-6}	4.129×10^{-7}	1.023×10^{-7}	2.421×10^{-8}	5.597×10^{-9}	1.274×10^{-9}	2.868×10^{-10}
840.7	1.853×10^{-6}	6.567×10^{-7}	1.685×10^{-7}	3.944×10^{-8}	8.883×10^{-9}	1.962×10^{-9}	4.285×10^{-10}	9.279×10^{-11}
1081	9.431×10^{-7}	2.732×10^{-7}	6.428×10^{-8}	1.413×10^{-8}	3.019×10^{-9}	6.359×10^{-10}	1.329×10^{-10}	2.765×10^{-11}
1576	2.494×10^{-7}	5.769×10^{-8}	1.220×10^{-8}	2.483×10^{-9}	4.978×10^{-10}	9.918×10^{-11}	1.970×10^{-11}	3.908×10^{-12}
2027	9.313×10^{-8}	1.962×10^{-8}	3.941×10^{-9}	7.737×10^{-10}	1.510×10^{-10}	2.940×10^{-11}	5.718×10^{-12}	1.111×10^{-12}
2606	3.550×10^{-8}	7.073×10^{-9}	1.378×10^{-9}	2.669×10^{-10}	5.153×10^{-11}	9.939×10^{-12}	1.917×10^{-12}	3.695×10^{-13}
3351	1.262×10^{-8}	2.418×10^{-9}	4.624×10^{-10}	8.828×10^{-11}	1.686×10^{-11}	3.218×10^{-12}	6.141×10^{-13}	1.172×10^{-13}
3800	7.00×10^{-9}	1.321×10^{-9}	2.492×10^{-10}	4.702×10^{-11}	8.871×10^{-12}	1.574×10^{-12}	3.158×10^{-13}	5.958×10^{-14}

Table 2. Neutron Intensity, $N(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 50$ deg (cont.)

r in 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	7.833×10^{-9}	1.894×10^{-9}	4.540×10^{-10}	1.079×10^{-10}	2.458×10^{-11}	5.973×10^{-12}	1.392×10^{-12}	3.225×10^{-13}
52.9	8.647×10^{-9}	2.106×10^{-9}	5.083×10^{-10}	1.217×10^{-10}	2.890×10^{-11}	6.815×10^{-12}	1.597×10^{-12}	3.719×10^{-13}
77.2	7.687×10^{-9}	1.886×10^{-9}	4.583×10^{-10}	1.104×10^{-10}	2.637×10^{-11}	6.254×10^{-12}	1.473×10^{-12}	3.448×10^{-13}
112.5	5.628×10^{-9}	1.389×10^{-9}	3.393×10^{-10}	8.208×10^{-11}	1.969×10^{-11}	4.687×10^{-12}	1.108×10^{-12}	2.601×10^{-13}
210.9	2.042×10^{-9}	4.992×10^{-10}	1.207×10^{-10}	2.892×10^{-11}	6.871×10^{-12}	1.620×10^{-12}	3.792×10^{-13}	8.821×10^{-14}
307.5	8.227×10^{-10}	1.967×10^{-10}	4.655×10^{-11}	1.092×10^{-11}	2.542×10^{-12}	5.875×10^{-13}	1.349×10^{-13}	3.080×10^{-14}
395.4	4.093×10^{-10}	9.589×10^{-11}	2.226×10^{-11}	5.125×10^{-12}	1.172×10^{-12}	2.661×10^{-13}	6.007×10^{-14}	1.349×10^{-14}
508.5	1.734×10^{-10}	3.960×10^{-11}	8.972×10^{-12}	2.018×10^{-12}	4.512×10^{-13}	1.003×10^{-13}	2.218×10^{-14}	4.882×10^{-15}
653.8	6.400×10^{-11}	1.417×10^{-11}	3.118×10^{-12}	6.820×10^{-13}	1.484×10^{-13}	3.214×10^{-14}	6.932×10^{-15}	1.489×10^{-15}
840.7	1.997×10^{-11}	4.273×10^{-12}	9.101×10^{-13}	1.930×10^{-13}	4.079×10^{-14}	8.588×10^{-15}	1.803×10^{-15}	3.772×10^{-16}
1081	5.731×10^{-12}	1.183×10^{-12}	2.438×10^{-13}	5.009×10^{-14}	1.027×10^{-14}	2.099×10^{-15}	4.284×10^{-16}	8.723×10^{-17}
1576	7.742×10^{-13}	1.532×10^{-13}	3.030×10^{-14}	5.985×10^{-15}	1.182×10^{-15}	2.330×10^{-16}	4.593×10^{-17}	9.047×10^{-18}
2027	2.159×10^{-13}	4.194×10^{-14}	8.145×10^{-15}	1.581×10^{-15}	3.068×10^{-16}	5.952×10^{-17}	1.154×10^{-17}	2.238×10^{-18}
2606	7.122×10^{-14}	1.372×10^{-14}	2.644×10^{-15}	5.094×10^{-16}	9.810×10^{-17}	1.889×10^{-17}	3.637×10^{-18}	7.000×10^{-19}
3351	2.237×10^{-14}	4.267×10^{-15}	8.141×10^{-16}	1.553×10^{-16}	2.962×10^{-17}	5.649×10^{-18}	1.077×10^{-18}	2.054×10^{-19}
3800	1.124×10^{-14}	2.121×10^{-15}	4.002×10^{-16}	7.550×10^{-17}	1.425×10^{-17}	2.686×10^{-18}	5.071×10^{-19}	9.568×10^{-20}

Table 3. Proton Intensity, $P(E,r)$, for $E_i = 45 \times 10^3$ Mev and $\theta = 50$ deg
 r in 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	8.548×10^{-4}	3.377×10^{-6}	7.856×10^{-7}	1.931×10^{-7}	4.789×10^{-8}	1.181×10^{-8}	2.888×10^{-9}	6.993×10^{-10}
52.9	4.951×10^{-4}	3.781×10^{-6}	8.614×10^{-7}	2.092×10^{-7}	5.151×10^{-8}	1.264×10^{-8}	3.074×10^{-9}	7.412×10^{-10}
77.2	2.996×10^{-4}	3.910×10^{-6}	8.696×10^{-7}	2.081×10^{-7}	5.075×10^{-8}	1.236×10^{-8}	2.989×10^{-9}	7.166×10^{-10}
112.5	1.642×10^{-4}	3.772×10^{-6}	8.095×10^{-7}	1.892×10^{-7}	4.543×10^{-8}	1.093×10^{-8}	2.616×10^{-9}	6.215×10^{-10}
210.9	5.002×10^{-5}	2.869×10^{-6}	5.622×10^{-7}	1.227×10^{-7}	2.809×10^{-8}	6.514×10^{-9}	1.511×10^{-9}	3.490×10^{-10}
307.5	2.173×10^{-5}	2.010×10^{-6}	3.650×10^{-7}	7.462×10^{-8}	1.630×10^{-8}	3.647×10^{-9}	8.213×10^{-10}	1.847×10^{-10}
395.4	1.209×10^{-5}	1.404×10^{-6}	2.397×10^{-7}	4.622×10^{-8}	9.677×10^{-9}	2.098×10^{-9}	4.604×10^{-10}	1.012×10^{-10}
508.5	6.715×10^{-6}	8.740×10^{-7}	1.380×10^{-7}	2.470×10^{-8}	4.896×10^{-9}	1.019×10^{-9}	2.163×10^{-10}	4.627×10^{-11}
653.8	3.564×10^{-6}	4.894×10^{-7}	6.994×10^{-8}	1.146×10^{-8}	2.112×10^{-9}	4.169×10^{-10}	8.500×10^{-11}	1.759×10^{-11}
840.7	1.853×10^{-6}	2.453×10^{-7}	3.129×10^{-8}	4.647×10^{-9}	7.847×10^{-10}	1.449×10^{-10}	2.815×10^{-11}	5.614×10^{-12}
1081	9.431×10^{-7}	1.059×10^{-7}	1.255×10^{-8}	1.665×10^{-9}	2.548×10^{-10}	4.327×10^{-11}	7.926×10^{-12}	1.516×10^{-12}
1576	2.494×10^{-7}	2.614×10^{-8}	2.935×10^{-9}	3.524×10^{-10}	4.612×10^{-11}	6.845×10^{-12}	1.121×10^{-12}	1.946×10^{-13}
2027	9.313×10^{-8}	1.025×10^{-8}	1.158×10^{-9}	1.347×10^{-10}	1.708×10^{-11}	2.352×10^{-12}	2.202×10^{-13}	4.188×10^{-14}
2606	3.550×10^{-8}	3.974×10^{-9}	4.566×10^{-10}	5.441×10^{-11}	1.689×10^{-12}	3.156×10^{-13}	5.993×10^{-14}	1.142×10^{-14}
3351	1.262×10^{-8}	1.414×10^{-9}	6.487×10^{-12}	1.265×10^{-12}	2.422×10^{-13}	4.604×10^{-14}	8.726×10^{-15}	1.652×10^{-15}
3800	7.000×10^{-9}	3.280×10^{-12}	8.105×10^{-13}	1.641×10^{-13}	3.161×10^{-14}	6.002×10^{-15}	1.135×10^{-15}	2.142×10^{-16}

Table 4. Proton Intensity, $P(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 50$ deg (cont.)

r in 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	1.678×10^{-10}	3.992×10^{-11}	9.427×10^{-12}	2.211×10^{-12}	5.151×10^{-13}	1.193×10^{-13}	2.750×10^{-14}	6.306×10^{-15}
52.9	1.771×10^{-10}	4.199×10^{-11}	9.880×10^{-12}	2.309×10^{-12}	5.364×10^{-13}	1.239×10^{-13}	2.847×10^{-14}	6.512×10^{-15}
77.2	1.704×10^{-10}	4.020×10^{-11}	9.416×10^{-12}	2.192×10^{-12}	5.070×10^{-13}	1.167×10^{-13}	2.671×10^{-14}	6.087×10^{-15}
112.5	1.465×10^{-10}	3.429×10^{-11}	7.971×10^{-12}	1.842×10^{-12}	4.231×10^{-13}	9.672×10^{-14}	2.200×10^{-14}	4.984×10^{-15}
210.9	8.016×10^{-11}	1.830×10^{-11}	4.156×10^{-12}	9.389×10^{-13}	2.111×10^{-13}	4.725×10^{-14}	1.054×10^{-14}	2.340×10^{-15}
307.5	4.140×10^{-11}	9.239×10^{-12}	2.052×10^{-12}	4.539×10^{-13}	1.000×10^{-13}	2.195×10^{-14}	4.802×10^{-15}	1.047×10^{-15}
395.4	2.223×10^{-11}	4.866×10^{-12}	1.061×10^{-12}	2.306×10^{-13}	4.995×10^{-14}	1.079×10^{-14}	2.322×10^{-15}	4.987×10^{-16}
508.5	9.911×10^{-12}	2.119×10^{-12}	4.520×10^{-13}	9.614×10^{-14}	2.040×10^{-14}	4.320×10^{-15}	9.125×10^{-16}	1.923×10^{-16}
653.8	3.658×10^{-12}	7.611×10^{-13}	1.582×10^{-13}	3.283×10^{-14}	6.805×10^{-15}	1.408×10^{-15}	2.909×10^{-16}	6.000×10^{-17}
840.7	1.132×10^{-12}	2.287×10^{-13}	4.621×10^{-14}	9.358×10^{-15}	1.893×10^{-15}	3.826×10^{-16}	7.724×10^{-17}	1.558×10^{-17}
1081	2.950×10^{-13}	5.737×10^{-14}	1.136×10^{-14}	2.249×10^{-15}	4.450×10^{-16}	8.800×10^{-17}	1.740×10^{-17}	3.437×10^{-18}
1576	3.260×10^{-14}	6.300×10^{-15}	1.218×10^{-15}	2.356×10^{-16}	4.556×10^{-17}	8.807×10^{-18}	1.702×10^{-18}	3.290×10^{-19}
2027	8.017×10^{-15}	1.537×10^{-15}	2.947×10^{-16}	5.651×10^{-17}	1.083×10^{-17}	2.077×10^{-18}	3.982×10^{-19}	7.632×10^{-20}
2606	2.177×10^{-15}	4.151×10^{-16}	7.914×10^{-17}	1.509×10^{-17}	2.876×10^{-18}	5.482×10^{-19}	1.045×10^{-19}	1.992×10^{-20}
3351	3.126×10^{-16}	5.914×10^{-17}	1.119×10^{-17}	2.117×10^{-18}	4.005×10^{-19}	7.577×10^{-20}	1.434×10^{-20}	2.712×10^{-21}
3800	4.042×10^{-17}	7.628×10^{-18}	1.439×10^{-18}	2.715×10^{-19}	5.123×10^{-20}	9.666×10^{-21}	1.824×10^{-21}	3.441×10^{-22}

Table 5. Pion Intensity, $\pi(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 50$ deg

r in 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	1.446×10^{-4}	1.304×10^{-6}	1.736×10^{-7}	3.440×10^{-8}	7.692×10^{-9}	1.787×10^{-9}	4.183×10^{-10}	9.776×10^{-11}
52.9	1.065×10^{-4}	1.537×10^{-6}	1.982×10^{-7}	3.857×10^{-8}	8.542×10^{-9}	1.976×10^{-9}	4.611×10^{-10}	1.076×10^{-10}
77.2	8.392×10^{-5}	1.623×10^{-6}	2.025×10^{-7}	3.855×10^{-8}	8.434×10^{-9}	1.938×10^{-9}	4.505×10^{-10}	1.048×10^{-10}
112.5	6.457×10^{-5}	1.630×10^{-6}	1.949×10^{-7}	3.574×10^{-8}	7.649×10^{-9}	1.737×10^{-9}	4.003×10^{-10}	9.248×10^{-11}
210.9	3.817×10^{-5}	1.577×10^{-6}	1.727×10^{-7}	2.832×10^{-8}	5.608×10^{-9}	1.209×10^{-9}	2.688×10^{-10}	6.027×10^{-11}
307.5	2.318×10^{-5}	1.327×10^{-6}	1.409×10^{-7}	2.123×10^{-8}	3.966×10^{-9}	3.148×10^{-10}	1.751×10^{-10}	3.816×10^{-11}
395.4	1.587×10^{-5}	1.032×10^{-6}	1.098×10^{-7}	1.554×10^{-8}	2.782×10^{-9}	5.521×10^{-10}	1.155×10^{-10}	2.463×10^{-11}
508.5	1.018×10^{-5}	7.359×10^{-7}	7.725×10^{-8}	1.037×10^{-8}	1.729×10^{-9}	3.284×10^{-10}	6.627×10^{-11}	1.375×10^{-11}
653.8	6.099×10^{-6}	4.825×10^{-7}	4.776×10^{-8}	6.256×10^{-9}	9.657×10^{-10}	1.732×10^{-10}	3.345×10^{-11}	6.722×10^{-12}
840.7	3.419×10^{-6}	2.894×10^{-7}	2.870×10^{-8}	3.386×10^{-9}	4.924×10^{-10}	3.218×10^{-11}	1.513×10^{-11}	2.862×10^{-12}
1081	1.831×10^{-6}	1.506×10^{-7}	1.488×10^{-8}	1.689×10^{-9}	2.234×10^{-10}	3.440×10^{-11}	5.451×10^{-12}	1.062×10^{-12}
1576	5.992×10^{-7}	5.083×10^{-7}	4.937×10^{-9}	5.021×10^{-10}	5.876×10^{-11}	4.935×10^{-12}	9.200×10^{-13}	1.750×10^{-13}
2027	2.513×10^{-7}	2.333×10^{-7}	2.213×10^{-9}	4.831×10^{-11}	8.318×10^{-12}	1.504×10^{-12}	2.810×10^{-13}	5.355×10^{-14}
2606	1.029×10^{-7}	1.014×10^{-8}	8.221×10^{-11}	1.453×10^{-11}	2.609×10^{-12}	4.880×10^{-13}	9.273×10^{-14}	1.767×10^{-14}
3351	0	5.851×10^{-11}	1.249×10^{-11}	2.379×10^{-12}	4.520×10^{-13}	8.562×10^{-14}	1.621×10^{-14}	3.066×10^{-15}
3800	0	7.325×10^{-12}	1.703×10^{-12}	3.355×10^{-13}	6.391×10^{-14}	1.209×10^{-14}	2.282×10^{-15}	4.306×10^{-16}

Table 6. Pion Intensity, $\pi(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 50$ deg (cont.)
 r in 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	2.275×10^{-11}	5.266×10^{-12}	1.213×10^{-12}	2.778×10^{-13}	6.337×10^{-14}	1.439×10^{-14}	3.254×10^{-15}	7.331×10^{-16}
52.9	2.498×10^{-11}	5.774×10^{-12}	1.328×10^{-12}	3.038×10^{-13}	6.921×10^{-14}	1.570×10^{-14}	3.546×10^{-15}	7.981×10^{-16}
77.2	2.427×10^{-11}	5.595×10^{-12}	1.284×10^{-12}	2.932×10^{-13}	6.666×10^{-14}	1.509×10^{-14}	3.404×10^{-15}	7.647×10^{-16}
112.5	2.131×10^{-11}	4.888×10^{-12}	1.116×10^{-12}	2.538×10^{-13}	5.746×10^{-14}	1.296×10^{-14}	2.911×10^{-15}	6.518×10^{-16}
210.9	1.352×10^{-11}	3.026×10^{-12}	6.753×10^{-13}	1.502×10^{-13}	3.328×10^{-14}	7.350×10^{-15}	1.618×10^{-15}	3.554×10^{-16}
307.5	8.354×10^{-12}	1.826×10^{-12}	3.987×10^{-13}	8.680×10^{-14}	1.884×10^{-14}	4.079×10^{-15}	8.809×10^{-16}	1.898×10^{-16}
395.4	5.278×10^{-12}	1.136×10^{-12}	2.441×10^{-13}	5.230×10^{-14}	1.118×10^{-14}	2.385×10^{-15}	5.078×10^{-16}	1.079×10^{-16}
508.5	2.876×10^{-12}	6.062×10^{-13}	1.276×10^{-13}	2.683×10^{-14}	5.629×10^{-15}	1.179×10^{-15}	2.466×10^{-16}	5.148×10^{-17}
653.8	1.363×10^{-12}	2.805×10^{-13}	5.772×10^{-14}	1.187×10^{-14}	2.437×10^{-15}	4.998×10^{-16}	1.024×10^{-16}	2.095×10^{-17}
840.7	5.744×10^{-13}	1.155×10^{-13}	2.325×10^{-14}	4.676×10^{-15}	9.400×10^{-16}	1.888×10^{-16}	3.790×10^{-17}	7.600×10^{-18}
1081	2.085×10^{-13}	4.109×10^{-14}	8.108×10^{-15}	1.600×10^{-15}	3.155×10^{-16}	6.219×10^{-17}	1.226×10^{-17}	2.414×10^{-18}
1576	3.367×10^{-14}	6.502×10^{-15}	1.256×10^{-15}	2.425×10^{-16}	4.684×10^{-17}	9.044×10^{-18}	1.746×10^{-18}	3.370×10^{-19}
2027	1.026×10^{-14}	1.965×10^{-15}	3.766×10^{-16}	7.217×10^{-17}	1.383×10^{-17}	2.649×10^{-18}	5.076×10^{-19}	9.724×10^{-20}
2606	3.367×10^{-15}	6.418×10^{-16}	1.223×10^{-16}	2.331×10^{-17}	4.442×10^{-18}	8.464×10^{-19}	1.613×10^{-19}	3.073×10^{-20}
3351	5.801×10^{-16}	1.097×10^{-16}	2.076×10^{-17}	3.928×10^{-18}	7.430×10^{-19}	1.406×10^{-19}	2.659×10^{-20}	5.030×10^{-21}
3800	8.124×10^{-17}	1.533×10^{-17}	2.892×10^{-18}	5.456×10^{-19}	1.030×10^{-19}	1.912×10^{-20}	3.665×10^{-21}	6.915×10^{-22}

Table 7. Muon Intensity, $\mu(E, r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 50$ deg

r in collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intensity, $\mu(E, r)$ [(No./Mev sec ster)/(elec./sec)]				
	$r = 0.2$	$r = 0.4$	$r = 0.6$	$r = 0.8$	$r = 1$
32.0	6.972×10^{-7}	7.200×10^{-7}	6.404×10^{-7}	5.541×10^{-7}	4.735×10^{-7}
52.9	5.953×10^{-7}	6.744×10^{-7}	6.355×10^{-7}	5.684×10^{-7}	4.951×10^{-7}
77.2	4.569×10^{-7}	5.636×10^{-7}	5.609×10^{-7}	5.170×10^{-7}	4.593×10^{-7}
112.5	3.127×10^{-7}	4.207×10^{-7}	4.379×10^{-7}	4.158×10^{-7}	3.817×10^{-7}
210.9	1.232×10^{-7}	1.824×10^{-7}	2.064×10^{-7}	2.106×10^{-7}	2.037×10^{-7}
307.5	5.687×10^{-8}	8.851×10^{-8}	1.036×10^{-7}	1.089×10^{-7}	1.080×10^{-7}
395.4	3.078×10^{-8}	4.889×10^{-8}	5.851×10^{-8}	6.252×10^{-8}	6.292×10^{-8}
508.5	1.528×10^{-8}	2.468×10^{-8}	3.010×10^{-8}	3.278×10^{-8}	3.360×10^{-8}
653.8	7.094×10^{-9}	1.170×10^{-8}	1.451×10^{-8}	1.605×10^{-8}	1.668×10^{-8}
840.7	3.088×10^{-9}	5.118×10^{-9}	6.372×10^{-9}	7.071×10^{-9}	7.381×10^{-9}
1081	1.145×10^{-9}	1.950×10^{-9}	2.494×10^{-9}	2.838×10^{-9}	3.024×10^{-9}
1576	2.480×10^{-10}	4.256×10^{-10}	5.487×10^{-10}	6.298×10^{-10}	6.789×10^{-10}
2027	8.120×10^{-11}	1.399×10^{-10}	1.772×10^{-10}	1.983×10^{-10}	2.076×10^{-10}
2606	1.883×10^{-12}	2.106×10^{-12}	1.936×10^{-12}	1.790×10^{-12}	1.661×10^{-12}
3351	8.971×10^{-17}	2.807×10^{-16}	5.139×10^{-16}	7.522×10^{-16}	9.733×10^{-16}

Table 8. Muon Intensity, $\mu(E, r)$, for $E_i = 45 \times 10^3$ Mev and $\theta = 50$ deg
 r in 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	2.175×10^{-7}	5.097×10^{-8}	1.348×10^{-8}	4.056×10^{-9}	1.402×10^{-9}	5.295×10^{-10}	2.031×10^{-10}
52.9	2.400×10^{-7}	5.750×10^{-8}	1.537×10^{-8}	4.669×10^{-9}	1.627×10^{-9}	6.179×10^{-10}	2.374×10^{-10}
77.2	2.364×10^{-7}	5.815×10^{-8}	1.576×10^{-8}	4.847×10^{-9}	1.707×10^{-9}	6.517×10^{-10}	2.506×10^{-10}
112.5	2.105×10^{-7}	5.379×10^{-8}	1.488×10^{-8}	4.668×10^{-9}	1.669×10^{-9}	6.420×10^{-10}	2.469×10^{-10}
210.9	1.269×10^{-7}	3.622×10^{-8}	1.066×10^{-8}	3.546×10^{-9}	1.319×10^{-9}	5.151×10^{-10}	1.970×10^{-10}
307.5	7.345×10^{-8}	2.333×10^{-8}	7.325×10^{-9}	2.575×10^{-9}	9.896×10^{-10}	3.886×10^{-10}	1.469×10^{-10}
395.4	4.583×10^{-8}	1.576×10^{-8}	5.251×10^{-9}	1.929×10^{-9}	7.573×10^{-10}	2.968×10^{-10}	1.106×10^{-10}
508.5	2.629×10^{-8}	9.763×10^{-9}	3.501×10^{-9}	1.348×10^{-9}	5.374×10^{-10}	2.082×10^{-10}	7.592×10^{-11}
653.8	1.368×10^{-8}	5.562×10^{-9}	2.153×10^{-9}	8.658×10^{-10}	3.457×10^{-10}	1.306×10^{-10}	4.613×10^{-11}
840.7	6.344×10^{-9}	2.904×10^{-9}	1.209×10^{-9}	4.973×10^{-10}	1.935×10^{-10}	6.991×10^{-11}	2.368×10^{-11}
1081	2.764×10^{-9}	1.377×10^{-9}	6.004×10^{-10}	2.399×10^{-10}	8.735×10^{-11}	2.958×10^{-11}	9.510×10^{-12}
1576	6.634×10^{-10}	3.345×10^{-10}	1.236×10^{-10}	4.027×10^{-11}	1.248×10^{-11}	3.761×10^{-12}	1.119×10^{-12}
2027	1.722×10^{-10}	5.218×10^{-11}	1.473×10^{-11}	4.198×10^{-12}	1.213×10^{-12}	3.558×10^{-13}	1.062×10^{-13}
2606	1.158×10^{-12}	5.041×10^{-13}	1.931×10^{-13}	7.007×10^{-14}	2.484×10^{-14}	8.722×10^{-15}	3.054×10^{-15}
3351	1.587×10^{-15}	1.212×10^{-15}	5.950×10^{-16}	2.545×10^{-16}	1.030×10^{-16}	4.072×10^{-17}	1.591×10^{-17}

Table 9. Muon Intensity, $\mu(E,r)$, for $E_i = 45 \times 10^3$ Mev and $\theta = 50$ deg (cont.)

r in 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	7.496×10^{-11}	2.616×10^{-11}	8.674×10^{-12}	2.762×10^{-12}	8.543×10^{-13}	2.595×10^{-13}	7.808×10^{-14}	2.346×10^{-14}
52.9	8.754×10^{-11}	3.051×10^{-11}	1.010×10^{-11}	3.214×10^{-12}	9.935×10^{-13}	3.017×10^{-13}	9.077×10^{-14}	2.727×10^{-14}
77.2	9.227×10^{-11}	3.209×10^{-11}	1.061×10^{-11}	3.369×10^{-12}	1.040×10^{-12}	3.157×10^{-13}	9.499×10^{-14}	2.855×10^{-14}
112.5	9.059×10^{-11}	3.138×10^{-11}	1.034×10^{-12}	3.274×10^{-12}	1.010×10^{-12}	3.060×10^{-13}	9.205×10^{-14}	2.767×10^{-14}
210.9	7.131×10^{-11}	2.437×10^{-11}	7.934×10^{-12}	2.492×10^{-12}	7.642×10^{-13}	2.310×10^{-13}	6.944×10^{-14}	2.089×10^{-14}
307.5	5.231×10^{-11}	1.760×10^{-11}	5.665×10^{-12}	1.765×10^{-12}	5.383×10^{-13}	1.623×10^{-13}	4.877×10^{-14}	1.470×10^{-14}
395.4	3.874×10^{-11}	1.286×10^{-11}	4.094×10^{-12}	1.266×10^{-12}	3.846×10^{-13}	1.157×10^{-13}	3.478×10^{-14}	1.050×10^{-14}
508.5	2.603×10^{-11}	8.489×10^{-12}	2.668×10^{-12}	8.182×10^{-13}	2.473×10^{-13}	7.430×10^{-14}	2.235×10^{-14}	6.767×10^{-15}
653.8	1.539×10^{-11}	4.912×10^{-12}	1.521×10^{-12}	4.620×10^{-13}	1.390×10^{-13}	4.174×10^{-14}	1.259×10^{-14}	3.831×10^{-15}
840.7	7.635×10^{-12}	2.378×10^{-12}	7.247×10^{-13}	2.182×10^{-13}	6.545×10^{-14}	1.969×10^{-14}	5.971×10^{-15}	1.833×10^{-15}
1081	2.953×10^{-12}	8.969×10^{-13}	2.694×10^{-13}	8.064×10^{-14}	2.423×10^{-14}	7.341×10^{-15}	2.252×10^{-15}	7.013×10^{-16}
1576	3.318×10^{-13}	9.873×10^{-14}	2.964×10^{-14}	9.009×10^{-15}	2.780×10^{-15}	8.726×10^{-16}	2.786×10^{-16}	9.050×10^{-17}
2027	3.226×10^{-14}	9.984×10^{-15}	3.148×10^{-15}	1.010×10^{-15}	3.299×10^{-16}	1.094×10^{-16}	3.683×10^{-17}	1.256×10^{-17}
2606	1.071×10^{-15}	3.764×10^{-16}	1.329×10^{-16}	4.711×10^{-17}	1.678×10^{-17}	6.006×10^{-18}	2.160×10^{-18}	7.803×10^{-19}
3351	6.186×10^{-18}	2.398×10^{-18}	9.287×10^{-19}	3.594×10^{-19}	1.390×10^{-19}	5.378×10^{-20}	2.080×10^{-20}	8.045×10^{-21}

Table 10. Neutron Intensity, $N(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 110$ deg
 r in 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	9.756×10^{-4}	7.656×10^{-5}	6.645×10^{-6}	6.974×10^{-7}	9.108×10^{-8}	1.415×10^{-8}	2.464×10^{-9}	4.526×10^{-10}
53.5	4.124×10^{-4}	5.992×10^{-5}	8.700×10^{-6}	1.295×10^{-6}	1.936×10^{-7}	3.147×10^{-8}	5.161×10^{-9}	8.758×10^{-10}
77.2	1.711×10^{-4}	3.040×10^{-5}	5.281×10^{-6}	9.256×10^{-7}	1.638×10^{-7}	2.927×10^{-8}	5.285×10^{-9}	9.638×10^{-10}
111.4	5.512×10^{-5}	1.112×10^{-5}	2.134×10^{-6}	4.107×10^{-7}	7.927×10^{-8}	1.535×10^{-8}	2.979×10^{-9}	5.800×10^{-10}
149.4	1.626×10^{-5}	3.554×10^{-6}	7.075×10^{-7}	1.410×10^{-7}	2.815×10^{-8}	5.629×10^{-9}	1.127×10^{-9}	2.258×10^{-10}
200.3	4.463×10^{-6}	1.064×10^{-6}	2.185×10^{-7}	4.485×10^{-8}	9.198×10^{-9}	1.885×10^{-9}	3.860×10^{-10}	7.900×10^{-11}
289.1	7.424×10^{-7}	1.832×10^{-7}	3.717×10^{-8}	7.533×10^{-9}	1.524×10^{-9}	3.080×10^{-10}	6.216×10^{-11}	1.253×10^{-11}
387.8	1.659×10^{-7}	3.592×10^{-8}	6.850×10^{-9}	1.306×10^{-9}	2.491×10^{-10}	4.751×10^{-11}	9.062×10^{-12}	1.729×10^{-12}
483.2	0	1.003×10^{-10}	1.906×10^{-11}	3.625×10^{-12}	6.893×10^{-13}	1.311×10^{-13}	2.492×10^{-14}	4.739×10^{-15}

Table 11. Neutron Intensity, $N(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 110$ deg (cont.)

r in collision lengths (1 collision length = 1.71 f)

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	8.564×10^{-11}	1.648×10^{-11}	3.203×10^{-12}	6.273×10^{-13}	1.235×10^{-13}	2.441×10^{-14}	4.840×10^{-15}	9.623×10^{-16}
53.5	1.534×10^{-10}	2.763×10^{-11}	5.097×10^{-12}	9.584×10^{-13}	1.830×10^{-13}	3.536×10^{-14}	6.896×10^{-15}	1.354×10^{-15}
77.2	1.775×10^{-10}	3.301×10^{-11}	6.196×10^{-12}	1.173×10^{-12}	2.238×10^{-13}	4.300×10^{-14}	8.316×10^{-15}	1.618×10^{-15}
111.4	1.132×10^{-10}	2.217×10^{-11}	4.350×10^{-12}	8.556×10^{-13}	1.687×10^{-13}	3.332×10^{-14}	6.596×10^{-15}	1.308×10^{-15}
149.4	4.531×10^{-11}	9.099×10^{-12}	1.829×10^{-12}	3.679×10^{-13}	7.405×10^{-14}	1.491×10^{-14}	3.005×10^{-15}	6.057×10^{-16}
200.3	1.615×10^{-11}	3.301×10^{-12}	6.740×10^{-13}	1.375×10^{-13}	2.804×10^{-14}	5.712×10^{-15}	1.163×10^{-15}	2.366×10^{-16}
289.1	2.522×10^{-12}	5.072×10^{-13}	1.019×10^{-13}	2.044×10^{-14}	4.098×10^{-15}	8.207×10^{-16}	1.642×10^{-16}	3.283×10^{-17}
387.8	3.297×10^{-13}	6.289×10^{-14}	1.200×10^{-14}	2.289×10^{-15}	4.367×10^{-16}	8.332×10^{-17}	1.590×10^{-17}	3.033×10^{-18}
483.2	9.010×10^{-16}	1.713×10^{-16}	3.258×10^{-17}	6.194×10^{-18}	1.178×10^{-18}	2.240×10^{-19}	4.258×10^{-20}	8.097×10^{-21}

Table 12. Proton Intensity, $P(E,r)$, for $E_i = 45 \times 10^3$ Mev and $\theta = 110$ deg
 r in 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	9.756×10^{-4}	1.187×10^{-7}	2.121×10^{-8}	3.959×10^{-9}	7.517×10^{-10}	1.445×10^{-10}	2.805×10^{-11}	5.482×10^{-12}
53.5	4.124×10^{-4}	8.814×10^{-8}	1.660×10^{-8}	3.226×10^{-9}	6.305×10^{-10}	1.238×10^{-10}	2.441×10^{-11}	4.828×10^{-12}
77.2	1.711×10^{-4}	6.029×10^{-8}	1.158×10^{-8}	2.302×10^{-9}	4.584×10^{-10}	9.143×10^{-11}	1.826×10^{-11}	3.653×10^{-12}
111.4	5.512×10^{-5}	3.240×10^{-8}	6.295×10^{-9}	1.270×10^{-9}	2.564×10^{-10}	5.175×10^{-11}	1.045×10^{-11}	2.110×10^{-12}
149.4	1.626×10^{-5}	1.569×10^{-8}	3.090×10^{-9}	6.268×10^{-10}	1.271×10^{-10}	2.574×10^{-11}	5.213×10^{-12}	1.055×10^{-12}
200.3	4.463×10^{-6}	5.967×10^{-9}	1.197×10^{-9}	2.411×10^{-10}	4.852×10^{-11}	9.757×10^{-12}	1.961×10^{-12}	3.938×10^{-13}
289.1	7.424×10^{-7}	9.632×10^{-10}	1.891×10^{-10}	3.710×10^{-11}	7.278×10^{-12}	1.427×10^{-12}	2.798×10^{-13}	5.484×10^{-14}
387.8	1.659×10^{-7}	2.318×10^{-11}	4.437×10^{-12}	8.496×10^{-13}	1.627×10^{-13}	3.115×10^{-14}	5.964×10^{-15}	1.142×10^{-15}

Table 13. Proton Intensity, $P(E,r)$, for $E_i = 45 \times 10^3$ Mev and $\theta = 110$ deg (cont.)

r in 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	1.077×10^{-12}	2.126×10^{-13}	4.211×10^{-14}	8.363×10^{-15}	1.665×10^{-15}	3.321×10^{-16}	6.636×10^{-17}	1.328×10^{-17}
53.5	9.577×10^{-13}	1.905×10^{-13}	3.795×10^{-14}	7.575×10^{-15}	1.514×10^{-15}	3.031×10^{-16}	6.072×10^{-17}	1.218×10^{-17}
77.2	7.315×10^{-13}	1.466×10^{-13}	2.941×10^{-14}	5.904×10^{-15}	1.186×10^{-15}	2.383×10^{-16}	4.791×10^{-17}	9.634×10^{-18}
111.4	4.259×10^{-13}	8.599×10^{-14}	1.736×10^{-14}	3.504×10^{-15}	7.07×10^{-16}	1.427×10^{-16}	2.879×10^{-17}	5.806×10^{-18}
149.4	2.134×10^{-13}	4.314×10^{-14}	8.715×10^{-15}	1.760×10^{-15}	3.552×10^{-16}	7.164×10^{-17}	1.444×10^{-17}	2.910×10^{-18}
200.3	7.904×10^{-14}	1.585×10^{-14}	3.178×10^{-15}	6.366×10^{-16}	1.275×10^{-16}	2.551×10^{-17}	5.101×10^{-18}	1.020×10^{-18}
289.1	1.074×10^{-14}	2.104×10^{-15}	4.120×10^{-16}	8.065×10^{-17}	1.578×10^{-17}	3.088×10^{-18}	6.039×10^{-19}	1.181×10^{-19}
387.8	2.187×10^{-16}	4.187×10^{-17}	8.018×10^{-18}	1.535×10^{-18}	2.940×10^{-19}	5.629×10^{-20}	1.078×10^{-20}	2.064×10^{-21}
483.2	5.329×10^{-18}	1.013×10^{-18}	1.927×10^{-20}	3.664×10^{-21}	6.967×10^{-22}	1.325×10^{-22}	2.519×10^{-23}	4.790×10^{-24}

Table 14. Pion Intensity, $\pi(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 110$ deg
 r in 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	9.163×10^{-5}	7.883×10^{-8}	7.714×10^{-10}	1.567×10^{-10}	3.181×10^{-11}	6.457×10^{-12}	1.310×10^{-12}	2.657×10^{-13}
53.5	6.675×10^{-5}	8.978×10^{-8}	8.127×10^{-10}	1.651×10^{-10}	3.351×10^{-11}	6.802×10^{-12}	1.380×10^{-12}	2.799×10^{-13}
77.2	5.066×10^{-5}	8.707×10^{-8}	7.367×10^{-10}	1.496×10^{-10}	3.038×10^{-11}	6.154×10^{-12}	1.250×10^{-12}	2.536×10^{-13}
111.4	3.950×10^{-5}	7.478×10^{-8}	5.583×10^{-10}	1.134×10^{-10}	2.301×10^{-11}	4.659×10^{-12}	9.469×10^{-13}	1.919×10^{-13}
149.4	2.216×10^{-5}	5.946×10^{-8}	3.441×10^{-10}	6.984×10^{-11}	1.417×10^{-11}	2.872×10^{-12}	5.817×10^{-13}	1.178×10^{-13}
200.3	1.276×10^{-5}	3.590×10^{-8}	1.382×10^{-10}	2.787×10^{-11}	5.614×10^{-12}	1.130×10^{-12}	2.272×10^{-13}	4.566×10^{-14}
289.1	4.833×10^{-6}	1.082×10^{-10}	2.098×10^{-11}	4.119×10^{-12}	8.084×10^{-13}	1.586×10^{-13}	3.111×10^{-14}	6.098×10^{-15}
387.8	1.573×10^{-6}	2.647×10^{-12}	5.048×10^{-13}	9.668×10^{-14}	1.852×10^{-14}	3.546×10^{-15}	6.791×10^{-16}	1.301×10^{-16}
483.2	4.960×10^{-7}	9.316×10^{-15}	1.769×10^{-15}	3.363×10^{-16}	6.395×10^{-17}	1.216×10^{-17}	2.312×10^{-18}	4.396×10^{-19}

Table 15. Pion Intensity $\pi(E,r)$, for $E_i = 45 \times 10^3$ Mev and $\theta = 110$ deg (cont.)

r in 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	5.387×10^{-14}	1.092×10^{-14}	2.211×10^{-15}	4.476×10^{-16}	9.058×10^{-17}	1.832×10^{-17}	3.704×10^{-18}	7.486×10^{-19}
53.5	5.673×10^{-14}	1.149×10^{-14}	2.328×10^{-15}	4.712×10^{-16}	9.535×10^{-17}	1.923×10^{-17}	3.898×10^{-18}	7.876×10^{-19}
77.2	5.139×10^{-14}	1.041×10^{-14}	2.108×10^{-15}	4.266×10^{-16}	8.630×10^{-17}	1.745×10^{-17}	3.526×10^{-18}	7.123×10^{-19}
111.4	3.888×10^{-14}	7.872×10^{-15}	1.593×10^{-15}	3.223×10^{-16}	6.515×10^{-17}	1.317×10^{-17}	2.659×10^{-18}	5.367×10^{-19}
149.4	2.383×10^{-14}	4.818×10^{-15}	9.737×10^{-16}	1.966×10^{-16}	3.969×10^{-17}	8.007×10^{-18}	1.614×10^{-18}	3.253×10^{-19}
200.3	9.171×10^{-15}	1.841×10^{-15}	3.692×10^{-16}	7.401×10^{-17}	1.483×10^{-17}	2.968×10^{-18}	5.940×10^{-19}	1.188×10^{-19}
289.1	1.195×10^{-15}	2.342×10^{-16}	4.587×10^{-17}	8.982×10^{-18}	1.758×10^{-18}	3.441×10^{-19}	6.733×10^{-20}	1.317×10^{-20}
387.8	2.491×10^{-17}	4.770×10^{-18}	9.136×10^{-19}	1.750×10^{-19}	3.351×10^{-20}	6.418×10^{-21}	1.229×10^{-21}	2.354×10^{-22}
483.2	8.360×10^{-20}	1.590×10^{-20}	3.022×10^{-21}	5.747×10^{-22}	1.093×10^{-22}	2.078×10^{-23}	3.951×10^{-24}	7.513×10^{-25}

Table 16. Muon Intensity, $\mu(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 110$ deg
 r in collision lengths (1 collision length = 1.71 ft)

E (Mev)	Muon Intensity, $\mu(E,r)$ [(No./Mev.sec.ster)/(elec./sec)]				
	$r = 0.2$	$r = 0.4$	$r = 0.6$	$r = 0.8$	$r = 1$
32.0	4.096×10^{-7}	3.454×10^{-7}	2.347×10^{-7}	1.615×10^{-7}	1.110×10^{-7}
53.5	3.320×10^{-7}	2.822×10^{-7}	2.103×10^{-7}	1.520×10^{-7}	1.068×10^{-7}
77.2	2.084×10^{-7}	2.026×10^{-7}	1.631×10^{-7}	1.220×10^{-7}	8.723×10^{-8}
111.4	1.116×10^{-7}	1.224×10^{-7}	1.040×10^{-7}	7.960×10^{-8}	5.782×10^{-8}
149.4	5.986×10^{-8}	6.836×10^{-8}	5.906×10^{-8}	4.604×10^{-8}	3.417×10^{-8}
200.3	2.527×10^{-8}	2.953×10^{-8}	2.638×10^{-8}	2.091×10^{-8}	1.533×10^{-8}
289.1	5.533×10^{-9}	6.522×10^{-9}	5.521×10^{-9}	3.764×10^{-9}	1.972×10^{-9}
387.8	4.267×10^{-10}	1.587×10^{-10}	5.458×10^{-11}	1.876×10^{-11}	6.453×10^{-12}
483.2	0	0	0	0	0

Table 17. Muon Intensity, $\mu(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 110$ deg

r in 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	1.452×10^{-8}	2.535×10^{-11}	3.954×10^{-12}	8.012×10^{-13}	1.623×10^{-13}	3.287×10^{-14}	6.652×10^{-15}
53.5	1.436×10^{-8}	2.125×10^{-11}	3.318×10^{-12}	6.719×10^{-13}	1.360×10^{-13}	2.752×10^{-14}	5.565×10^{-15}
77.2	1.181×10^{-8}	1.435×10^{-11}	2.267×10^{-12}	4.585×10^{-13}	9.270×10^{-14}	1.873×10^{-14}	3.783×10^{-15}
111.4	7.416×10^{-9}	6.606×10^{-12}	1.068×10^{-12}	2.152×10^{-13}	4.336×10^{-14}	8.729×10^{-15}	1.756×10^{-15}
149.4	3.471×10^{-9}	2.318×10^{-12}	3.842×10^{-13}	7.678×10^{-14}	1.534×10^{-14}	3.063×10^{-15}	6.113×10^{-16}
200.3	7.017×10^{-10}	4.660×10^{-13}	7.993×10^{-14}	1.573×10^{-14}	3.094×10^{-15}	6.033×10^{-16}	1.196×10^{-16}
289.1	1.986×10^{-11}	8.874×10^{-15}	1.523×10^{-15}	2.921×10^{-16}	5.602×10^{-17}	1.075×10^{-17}	2.061×10^{-18}
387.8	3.103×10^{-14}	5.224×10^{-18}	8.573×10^{-19}	1.630×10^{-19}	3.100×10^{-20}	5.894×10^{-21}	1.121×10^{-21}

Table 18. Muon Intensity, $\mu(E,r)$, for $E_1 = 45 \times 10^3$ Mev and $\theta = 110$ deg (cont.)

r in 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	1.346×10^{-15}	2.721×10^{-16}	5.499×10^{-17}	1.111×10^{-17}	2.243×10^{-18}	4.527×10^{-19}	9.132×10^{-20}	1.841×10^{-20}
53.5	1.125×10^{-15}	2.273×10^{-16}	4.589×10^{-17}	9.263×10^{-18}	1.868×10^{-18}	3.768×10^{-19}	7.595×10^{-20}	1.530×10^{-20}
77.2	7.635×10^{-16}	1.540×10^{-16}	3.106×10^{-17}	6.260×10^{-18}	1.261×10^{-18}	2.539×10^{-19}	5.111×10^{-20}	1.028×10^{-20}
111.4	3.532×10^{-16}	7.099×10^{-17}	1.426×10^{-17}	2.864×10^{-18}	5.748×10^{-19}	1.153×10^{-19}	2.312×10^{-20}	4.633×10^{-21}
149.4	1.219×10^{-16}	2.431×10^{-17}	4.845×10^{-18}	9.652×10^{-19}	1.922×10^{-19}	3.826×10^{-20}	7.611×10^{-21}	1.514×10^{-21}
200.3	2.350×10^{-17}	4.617×10^{-18}	9.069×10^{-19}	1.781×10^{-19}	3.496×10^{-20}	6.862×10^{-21}	1.345×10^{-21}	2.641×10^{-22}
289.1	3.952×10^{-19}	7.581×10^{-20}	1.454×10^{-20}	2.789×10^{-21}	5.348×10^{-22}	1.026×10^{-22}	1.967×10^{-23}	3.772×10^{-24}
387.8	2.131×10^{-22}	4.052×10^{-23}	7.704×10^{-24}	1.465×10^{-24}	2.785×10^{-25}	5.296×10^{-26}	1.007×10^{-26}	1.914×10^{-27}
483.2								

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Fig. 1. Dose Multiplied by r^2 vs. Distance. $E_i = 45 \times 10^3 \text{ Mev}$,
 $\theta = 50 \text{ deg.}$

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Fig. 2. Dose Multiplied by r^2 vs. Distance. $E_i = 45 \times 10^3 \text{ Mev}$, $\theta = 110 \text{ deg}$.

Appendix

In obtaining the neutron dose given in Figs. 1 and 2 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 is chosen since at this energy the calculated neutron intensity and the measured cosmic-ray spectrum have approximately the same shape.

Table A.1. Neutron Dose for $E_i = 45 \times 10^3$ Mev and $\theta = 50$ deg

r (collision lengths)	$r^2 \times \text{Dose} \left\{ (\text{collision lengths})^2 \frac{\text{rads/hr}}{\text{electrons/sec}} \right\}$					
	$r^2 d_{NC},$ $\Gamma = 109 \text{ Mev}$		$r^2 (d_{NA} + d_{NE}),$ $\Gamma = 109 \text{ Mev}$		$r^2 (d_{NA} + d_{NE}),$ $\Gamma = 32 \text{ Mev}$	
10	487.2	$\times 10^{-14}$	106.4	$\times 10^{-14}$	155.3	$\times 10^{-14}$
12	125.2	$\times 10^{-14}$	26.30	$\times 10^{-14}$	38.67	$\times 10^{-14}$
14	31.67	$\times 10^{-14}$	6.418	$\times 10^{-14}$	9.510	$\times 10^{-14}$
16	7.908	$\times 10^{-14}$	1.550	$\times 10^{-14}$	2.314	$\times 10^{-14}$
18	1.952	$\times 10^{-14}$	0.3709	$\times 10^{-14}$	0.5579	$\times 10^{-14}$
20	0.4768	$\times 10^{-14}$	0.08801	$\times 10^{-14}$	0.1333	$\times 10^{-14}$
22	0.1154	$\times 10^{-14}$	0.02073	$\times 10^{-14}$	0.03162	$\times 10^{-14}$
24	276.8	$\times 10^{-18}$	48.50	$\times 10^{-18}$	74.47	$\times 10^{-18}$
26	65.89	$\times 10^{-18}$	11.28	$\times 10^{-18}$	17.42	$\times 10^{-18}$
28	15.57	$\times 10^{-18}$	2.608	$\times 10^{-18}$	4.053	$\times 10^{-18}$
30	3.658	$\times 10^{-18}$	0.5999	$\times 10^{-18}$	0.9374	$\times 10^{-18}$

Table A.2. Neutron Dose for $E_i = 45 \times 10^3$ Mev and $\theta = 110$ deg

r (collision lengths)	$r^2 \times \text{Dose} \left\{ (\text{collision lengths})^2 \frac{\text{rads/hr}}{\text{electrons/sec}} \right\}$					
	$r^2 d_{NC},$ $\Gamma = 109 \text{ Mev}$	$r^2 (d_{NA} + d_{NE}),$ $\Gamma = 109 \text{ Mev}$	$r^2 (d_{NA} + d_{NE}),$ $\Gamma = 32 \text{ Mev}$			
10	221.4 $\times 10^{-15}$	12.45 $\times 10^{-15}$	38.43 $\times 10^{-15}$			
12	42.72 $\times 10^{-15}$	2.485 $\times 10^{-15}$	7.051 $\times 10^{-15}$			
14	8.327 $\times 10^{-15}$	0.4966 $\times 10^{-15}$	1.320 $\times 10^{-15}$			
16	1.622 $\times 10^{-15}$	0.09937 $\times 10^{-15}$	0.2507 $\times 10^{-15}$			
18	0.3168 $\times 10^{-15}$	0.01991 $\times 10^{-15}$	0.04816 $\times 10^{-15}$			
20	0.06205 $\times 10^{-15}$	0.003991 $\times 10^{-15}$	0.009335 $\times 10^{-15}$			
22	0.01218 $\times 10^{-15}$	0.0008008 $\times 10^{-15}$	0.001822 $\times 10^{-15}$			
24	23.97 $\times 10^{-19}$	1.608 $\times 10^{-19}$	3.576 $\times 10^{-19}$			
26	4.729 $\times 10^{-19}$	0.3231 $\times 10^{-19}$	0.7050 $\times 10^{-19}$			
28	0.9348 $\times 10^{-19}$	0.06494 $\times 10^{-19}$	0.1395 $\times 10^{-19}$			
30	0.1851 $\times 10^{-19}$	0.01306 $\times 10^{-19}$	0.02768 $\times 10^{-19}$			

Acknowledgement

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

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