ORNL-4002
UC-34 – Physics

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N67-19078
(ACCESSION NUMBER)
31
(PAGES)
(NASA CR OR TMX OR AD NUMBER)
(THRU)
0
(CODE)
(CATEGORY)
FACILITY FORM 602

OAK RIDGE NATIONAL LABORATORY
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ORNL-4002

Contract No. W-7405-eng-26

Neutron Physics Division

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M. Leimdorfer and J. Barish*

NOTE:

This Work Supported by
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Under Order R-104(1)

*Oak Ridge Computer Sciences Center, Oak Ridge Gaseous Diffusion Plant.

JANUARY 1967

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M. Leimdorfer and J. Barish[1]

ABSTRACT

In an attempt to increase the efficiency of an existing Monte Carlo program, the Nucleon Transport Code (NTC), for treating the transport of high-energy nucleons in matter, a method has been developed which is intended to improve the procedure for selecting combinations of the energy and angle of particles released in nuclear interactions. In the present form of NTC, the process of particle emission from nucleon-nucleus collisions is simulated by a Monte Carlo treatment of the intranuclear cascade. In the proposed method, the particle emission data obtained from the intranuclear cascade calculations are represented in the form of tables which are suitable for sampling purposes. The power of the method lies in the fact that the tables are constructed directly from the intranuclear cascade (Monte Carlo) histories.

In an attempt to increase the efficiency of the Nucleon Transport Code (NTC[2]), a Monte Carlo program for dealing with the migration of high-energy nucleons in matter, a method has been developed which is intended to improve the procedure for selecting combinations of the energy and angle of particles released in nuclear interactions. The physical process involved in such interactions is as follows: After a particle hits a nucleus, it is transported inside the nucleus and gives rise to a cascade of binary nucleon-nucleon collisions whereby some nucleons are thrown out of the nucleus (that is, an intranuclear cascade[3] is initiated). When the last cascade particle has been emitted, the excited nucleus evaporates a number of different evaporation particles which are added to the cascade particles.

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1. Oak Ridge Computer Sciences Center, Oak Ridge Gaseous Diffusion Plant.
2. W. E. Kinney, The Nucleon Transport Code, NTC, ORNL-3610 (August 1960).
3. H. W. Bertini, Phys. Rev. 131, 1801 (1963) and 138, AB2 (1965).

This process has been simulated in NTC at each collision. The representation of the physical process given below accelerates the simulation of the nuclear interaction and also permits the application of efficient methods for variance reduction in the Monte Carlo transport analogy.

The material that was used to construct our representation of the two-dimensional probability distribution of each type of outgoing nucleon (neutron or proton) consists of a fairly large record of energies and angles of outgoing particles obtained in previous Monte Carlo studies of high-energy nuclear reactions with monoenergetic nucleon projectiles.[3] Our aim is to represent these distributions, for each type of in- and out-going particle, projectile energy, and target nucleus, in a way which permits interpolation to other projectile energies and target nuclei. In this paper we shall first deal with the distributions of cascade particles and then with the distribution of evaporation particles.

The basic procedure for sampling from a two-dimensional distribution that underlies our reasoning is the following: Assume that the distribution of the stochastic variables x and y can be written as f(x,y). Then x may be chosen from the marginal distribution $\int_{-\infty}^{\infty} f(x,y)\, dy$ by the straightforward method of solving the equation

$$R_1(0,1) = \int_{-\infty}^{x} dx' \int_{-\infty}^{\infty} f(x',y)\, dy \qquad (1)$$

for x with a given value of the random number $R_1(0,1)$ equidistributed on the unit interval. A value of y is then selected by solving the equation

$$R_2(0,1) = \frac{\int_{-\infty}^{y} dy'\ f(x,y')\ dy'}{\int_{-\infty}^{\infty} dy'\ f(x,y')\ dy'} \tag{2}$$

for y with the sampled value of x inserted. As can be seen, a given combination of two random numbers $R_1(0,1)$ and $R_2(0,1)$ implies one combination of values of the variables x,y. Let us assume that x represents the particle angle and y the particle energy. Equation (1) can be solved for a set of values of $R_1(0,1)$ to give a table of corresponding values of the angle x. The sampling procedure then consists of an interpolation in that table to select the value of x corresponding to a given value of $R_1(0,1)$.

If the argument values of $R_1(0,1)$ are equidistributed, this selection is simplified and the necessary computer storage is reduced by a factor of 2. Our first step will be to obtain such a list of angles from our record of energy-angle combinations of cascade particles. Assume that we have access to these data for N outgoing particles of a certain type (either neutron or proton). Assume further that the number of entries in our table of angles is L + 1. We chose to work with cosines and to denote the list of cosine values that will correspond to $R_1(0,1)$ equal to 0, $\frac{1}{L}$, $\frac{2}{L}$, ..., $\frac{\ell}{L}$, ..., $\frac{L}{L}$ by $\omega_0, \omega_1, \omega_2, \ldots, \omega_\ell, \ldots \omega_L$. If ω_ℓ is an increasing sequence $\omega_0 = -1$ and $\omega_L = 1$. Let us now arrange our complete list of N particle angles (cosines) in increasing order so that ω'_ℓ is the cosine corresponding to the $\left[\frac{N\ell}{L}\right]$:th particle in that list. Similarly, we set

ω''_ℓ and ω'''_ℓ to be cosines of the $\left\{\left[\frac{N\ell}{L}\right] + 1\right\}$:th and $\left\{\left[\frac{N\ell}{L}\right] + 2\right\}$:th particles, respectively. The situation is demonstrated in Fig. 1. We now face the problem of determining a value ω_ℓ for which there are $\frac{N\ell}{L}$ particles, with $\omega \leq \omega_\ell$, $\frac{N\ell}{L}$ not being, in general, an integral number. This is the same thing as solving the equation

$$R_1(0,1) = \frac{\ell}{L} = \int_{-1}^{\omega} d\omega' \int_{0}^{E_0} f(\omega,E)\ dE \tag{3}$$

for a value of ω. Equation (3) is an adaptation of Eq. (1) to the present application. We assume, for the time being, that the energy variable E may have values on the interval $(0,E_0)$.

Our particle records do not provide us with a smooth representation of the integral in Eq. (3) but we may easily obtain one by adopting an interpolation convention in the step-curve of Fig. 1 (which constitutes the "empirical" counterpart to N times the said integral). We decide to let the smoothed curve pass through $\omega = -1$ and $\omega = 1$ at both ends and to draw it through the middle of each vertical step. With these definitions $\omega = \omega'_\ell$ corresponds to the value $\frac{1}{N}\left\{\left[\frac{N\ell}{L}\right] - \frac{1}{2}\right\}$ of the integral in Eq. (3). Similarly, $\omega = \omega''_\ell$ corresponds to $\frac{1}{N}\left\{\left[\frac{N\ell}{L}\right] + \frac{1}{2}\right\}$, and ω'''_ℓ corresponds to $\frac{1}{N}\left\{\left[\frac{N\ell}{L}\right] + \frac{3}{2}\right\}$. It is clear that ω_ℓ, which corresponds to to $\frac{\ell}{L}$, will lie somewhere in the range covered by the above-mentioned three values of $\omega(\omega'_\ell, \omega''_\ell, \omega'''_\ell)$. We perform a three-point (parabolic) interpolation to solve for a value of ω_ℓ:

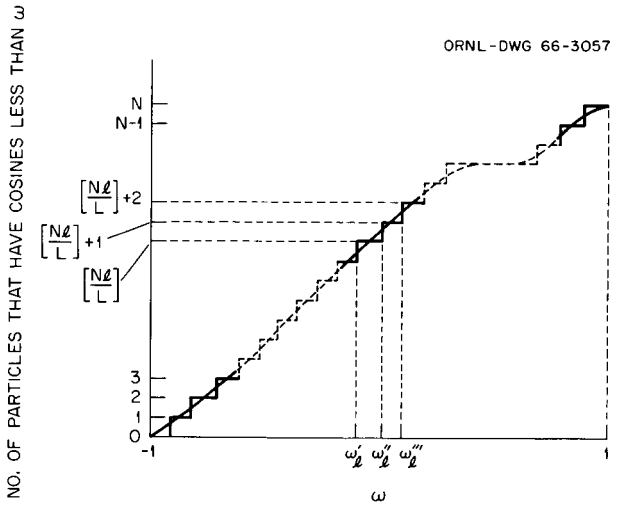

Fig. 1. Representation of the Cumulative Angular Distribution Integrated Over Energy

$$\omega_\ell = \left\{ \frac{N\ell}{L} - \left[\frac{N\ell}{L}\right] - \frac{1}{2} \right\} \times \frac{\omega'_\ell - 2\omega''_\ell + \omega'''_\ell}{2} + \left\{ \frac{N\ell}{L} - \left[\frac{N\ell}{L}\right] - \frac{1}{2} \right\}$$

$$\times \frac{\omega'''_\ell - \omega'_\ell}{2} + \omega''_\ell \text{ for } \ell = 1, 2, \ldots, L - 1 \quad . \qquad (4)$$

By definition, we set $\omega_0 = -1$ and $W_L = 1$. The vector $\left\{\omega_\ell\right\}$ now represents our table of cosines corresponding to values of $R_1(0,1)$ equal to 0, $\frac{1}{L}$, $\frac{2}{L}$, ..., $\frac{\ell}{L}$, ..., 1. This method of interpolation has the well-known difficulty of being able to produce an interpolated value which is either

larger or smaller than any of the three input values. This is the penalty one pays for the increased precision in higher-order interpolation. We may easily avoid any pathological consequences of this effect by setting the constraint that all values of ω that fall outside the interval $(-1,1)$ be changed to the interval limits and by rearranging the elements of the vector $\left\{\omega_\ell\right\}$ so that they lie in increasing order.

We now use our "empirical" material to obtain a value of the particle energy. This corresponds to solving an equation of type (2) with the value of x set equal to the value ω just selected. If we follow our previous procedure for selecting a value of ω, we now need a vector of energies $E_m(\omega)$ which satisfy the probability equation

$$P[E \leq E_m(\omega)] = \frac{m}{M}, \quad m = 0,1, \ldots, M \quad , \tag{5}$$

where m and M correspond to ℓ and L, respectively, in the previous derivation for ω_ℓ. It is clear that we again have to adopt some convention for interpolating in the given data to obtain values of the cumulative energy distribution at a given angle, as represented by Eq. (5). After applying the same method as before to obtain a set of $(E_m)_\ell$ valid for the intervals $(\omega_{\ell-1},\omega_\ell)$, $\ell = 1,2, \ldots, L$, we could again interpolate in the step-curve of $(E_m)_\ell$ for a given value of m to produce the vector of energies corresponding to a discrete value of ω. We shall proceed in this direction and choose to let the set of discrete angles be the vector $\left\{\omega_\ell\right\}$ already established. This greatly simplifies the use of the representation. We use the variable $\epsilon = \frac{E}{E_0}$ to define particle energy and let the vector $\left\{\bar{\epsilon}_{\ell m}\right\}$

be the values of normalized energy corresponding to the equation

$$P[\epsilon \leq \bar{\epsilon}_{\ell m}(\omega_{\ell-1},\omega_\ell)] = \frac{m}{M} \quad , \tag{6}$$

where each value of $\bar{\epsilon}_{\ell m}$ is an average over the cosine interval $(\omega_{\ell-1},\omega_\ell)$. We now devise a scheme for calculating values of $\bar{\epsilon}_{\ell m}$. Let n_ℓ be the (actual) number of particles with $\omega_{\ell-1} = \omega = \omega_\ell$; n_ℓ will be either $\left[\frac{N}{L}\right]$ of $\left[\frac{N}{L}\right] + 1$. Arrange the n_ℓ values of normalized energy, ϵ, in increasing order. Let $\bar{\epsilon}'_{\ell m}$ be the energy of the $\left[\frac{n_\ell m}{L}\right]$:th of these particles. Correspondingly, $\bar{\epsilon}''_{\ell m}$ and $\bar{\epsilon}'''_{\ell m}$ are values of ϵ of the $\left\{\left[\frac{n_\ell m}{M}\right] + 1\right\}$:th and $\left\{\left[\frac{n_\ell m}{M}\right] + 2\right\}$:th particles, respectively. In the same way as before, we interpolate to solve for $\bar{\epsilon}_{\ell m}$:

$$\bar{\epsilon}_{\ell m} = \left\{\frac{n_\ell m}{M} - \left[\frac{n_\ell m}{M}\right] - \frac{1}{2}\right\}^2 \frac{\bar{\epsilon}'_{\ell m} - 2\bar{\epsilon}''_{\ell m} + \bar{\epsilon}'''_{\ell m}}{2}$$
$$+ \left\{\frac{n_\ell m}{M} - \left[\frac{n_\ell m}{M}\right] - \frac{1}{2}\right\} \frac{\bar{\epsilon}'''_{\ell m} - \bar{\epsilon}'_{\ell m}}{2} + \bar{\epsilon}''_{\ell m} \quad . \tag{7}$$

The result is illustrated in Fig. 2.

We first need to adopt an interpolation convention for solving values of $\epsilon_m(\omega)$ at $\omega = \omega_\ell$, $\ell = 1, 2, \ldots, L - 1$ (the end points $\ell = 0$ and $\ell = L$ will be treated separately). One possible method might be to set $\epsilon_m(\omega_\ell) = \frac{1}{2}(\bar{\epsilon}_{\ell m} + \bar{\epsilon}_{\ell+1,m})$. This would, however, have a strong tendency to smooth out the sometimes very large variations in energy distributions for small changes of observation angle. A better procedure is the following: Double the number of angular intervals to produce twice as many values of $\bar{\epsilon}_{\ell m}$. Call the new set of cosines ω_k ($k = 2$ corresponds to $\ell = 1$ and so on). The cosine $\omega_{k=2\ell}$ will now be

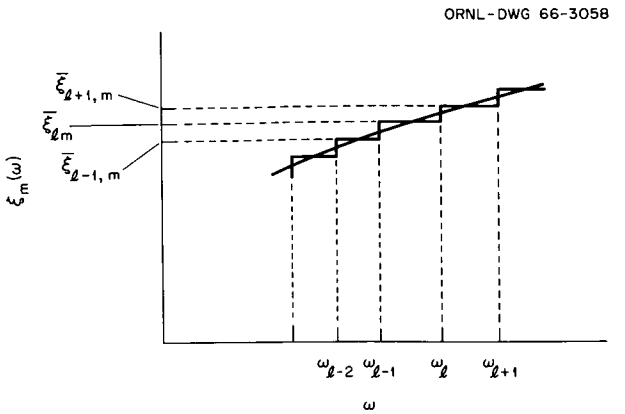

Fig. 2. Solution $\epsilon_m(\omega)$ to Equation $P[\epsilon \leq \epsilon_m(\omega)] = \frac{m}{M}$ vs ω.

equal to the previously calculated cosine ω_ℓ. In the new representation we have 2L values of $\bar{\epsilon}_{km}$, each one defined on the interval $\omega_{k-1} \leq \omega \leq \omega_k$. Let us assume that, in this finer mesh, $\bar{\epsilon}_{km}$ can be taken as being the value at the discrete angle $(\omega_{k-1} + \omega_k)/2$. We may then apply linear interpolation to obtain $\epsilon_{\ell m}$ at the cosine $\omega_{k=2\ell} = \omega_\ell$ from the neighboring values of $\epsilon = \bar{\epsilon}_{k,m}$ at $\omega = (\omega_{k-1} + \omega_k)/2$ and $\epsilon = \bar{\epsilon}_{k+1,m}$ at $\omega = (\omega_k + \omega_{k+1})/2$, giving

$$\epsilon_{\ell m} = \bar{\epsilon}_{km} + \frac{\omega_k - \frac{\omega_{k-1} + \omega_k}{2}}{\frac{\omega_k + \omega_{k+1}}{2} - \frac{\omega_{k-1} + \omega_k}{2}} \left(\bar{\epsilon}_{k+1,m} - \bar{\epsilon}_{k,m}\right) , \qquad (8)$$

which can be simplified to

$$\epsilon_{\ell m} = \frac{\bar{\epsilon}_{km}(\omega_{k+1} - \omega_k) + \bar{\epsilon}_{k+1,m}(\omega_k - \omega_{k-1})}{\omega_{k+1} - \omega_{k-1}} \ , \ \ell = 1,2,\ldots,L-1 \ ,$$

$$k = 2,4,\ldots,2L-2 \ . \qquad (9)$$

In the limiting cases $\omega = \omega_0 = -1$ and $\omega = \omega_L = 1$, we have to extrapolate instead of interpolating. We obtain

$$\epsilon_{0,m} = \frac{\epsilon_{1,m}(2 + \omega_1 + \omega_2) - \epsilon_{2,m}(1 + \omega_1)}{\omega_2 + 1} \ , \qquad (10)$$

where the indices in the right-hand term concern k, as before. Correspondingly,

$$\epsilon_{L,m} = \frac{\bar{\epsilon}_{2L,m}(2 - \omega_{2L-1} - \omega_{2L-2}) + \bar{\epsilon}_{2L-1}(\omega_{2L-1} - 1)}{1 - \omega_{2L-2}} \ . \qquad (11)$$

As indicated once before, we want to make sure that the $\epsilon_{\ell m}$'s are in increasing order; if they are not, the positions of the elements are rearranged. The limit values $\epsilon_{0,m}$ and $\epsilon_{L,m}$ also have to fulfill the constraints $\epsilon_{0,m} \geq \epsilon_c$ (where ϵ_c is zero or some cutoff value with physical significance) and $\epsilon_{L,m} \leq 1$. Any "overshoots" or "undershoots" which might have been caused by the method of interpolation are brought to the limit values ϵ_c and 1, respectively.

Tables 1, 2, and 3* show the results obtained by the computer program in which the above ideas have been implemented. The tables represent the emergent proton distributions when aluminum nuclei are bombarded by 400-, 350-, and 300-MeV protons, respectively. Table 4 shows a linear interpolation (arithmetical averaging) of each element in Tables 1 and 3 to

*All tables are given at the end of the report.

give an interpolated table for 350-MeV projectiles. As can be seen, the agreement between Tables 4 and 2 is good.

We have also made a double interpolation to obtain the 350-MeV aluminum data from 300- and 400-MeV oxygen and chromium data. The results are shown in Table 5 and they compare favorably with those of Table 2. Figures 3 and 4 illustrate the agreement between the two interpolations and the original data.

We have treated the evaporation particles separately, as they have an isotropic angular distribution and much lower energies than most of the cascade particles. Each secondary particle distribution can therefore be represented by a vector of energies of each particle type. Tables 6-8 show the evaporation neutron distributions from 400-, 350-, and 300-MeV protons on aluminum. Table 9 shows the results of a linear interpolation between the elements in Tables 6 and 8 to give an interpolated distribution for evaporation neutrons from 350-MeV protons on aluminum. Table 10 shows the results of double linear interpolation using 300- and 400-MeV data from oxygen and chromium to obtain an approximate evaporation neutron distribution from 350-MeV protons on aluminum. By comparing Tables 9 and 10 with Table 7, it is again seen that the interpolation possibilities appear to be quite favorable.

In the above we have tacitly neglected the fact that multiplicities of outgoing neutrons and protons are different from unity. Our representations of the data concern the distribution functions $f(\omega,E)$ of <u>all</u> outgoing particles of one type. We may write the average number of outgoing protons and neutrons per unit cosine and energy as $\bar{\nu}_p \; f_p(\omega_p,E_p)$

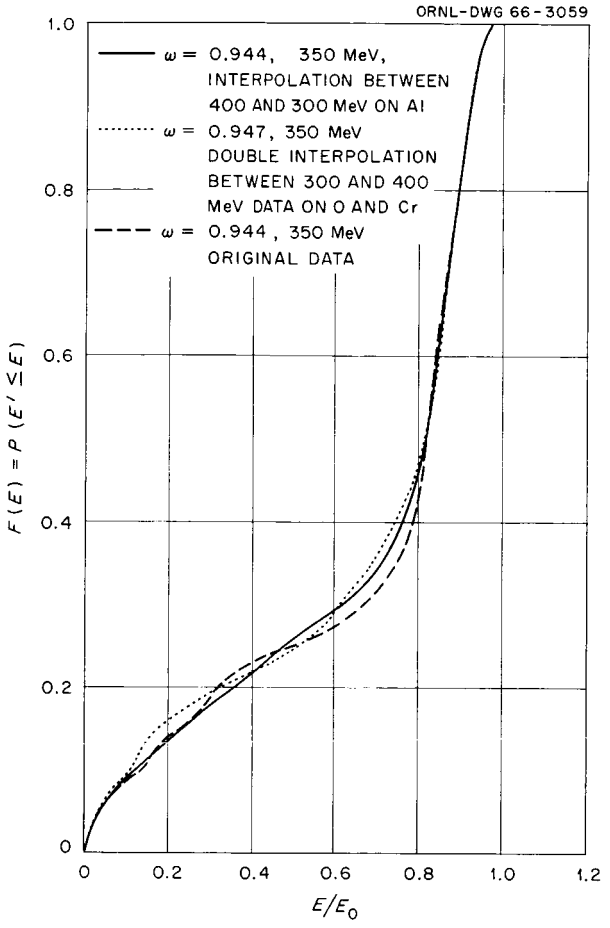

Fig. 3. Cumulative Energy Distribution of Protons Released If $\omega \approx 0.944$.

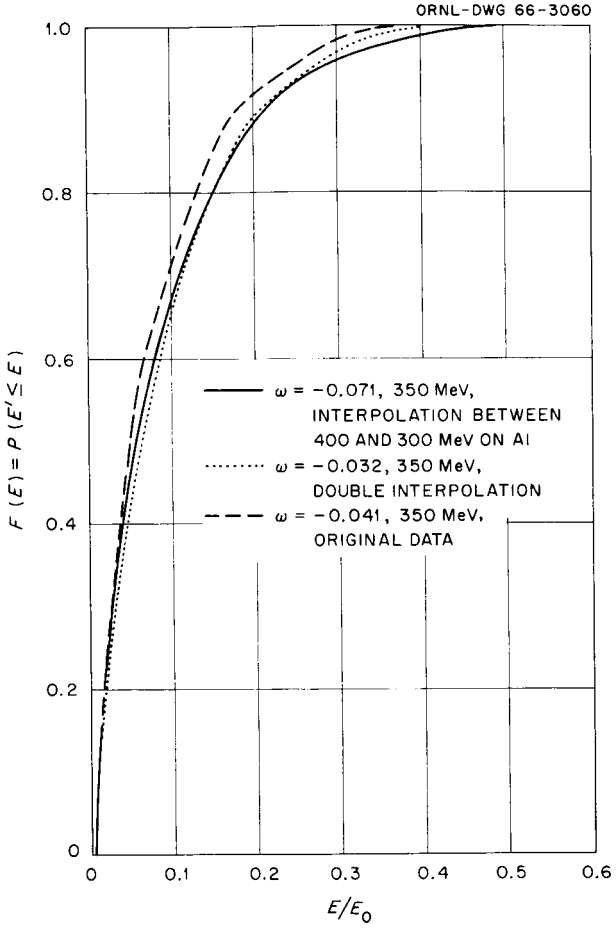

Fig. 4. Cumulative Energy Distribution of Protons Released If $\omega \approx 0$.

and $\bar{\nu}_n f_n(\omega_n, E_n)$, respectively, with $\bar{\nu}_p$ and $\bar{\nu}_n$ denoting the average multiplicities. If we sample on the average $\bar{\nu}_p$ protons from $f_p(\omega_p, E_p)$ and $\bar{\nu}_n$ neutrons from $f_n(\omega_n, E_n)$ at each collision, we will not conserve energy in one collision but will, on the average, in many collisions. It may often be useful to carry the multiplicities as statistical weight factors and just sample once from each distribution. The fact that the functions f_p and f_n are available in a convenient representation opens many possibilities for improving the statistical efficiency of the transport analogue. It may be remarked that one might set

$$f\left(\omega_\ell, \frac{E_{\ell m} + E_{\ell,m+1}}{2}\right)\left(\frac{(\omega_{\ell+1} + \omega_{\ell-1})}{2}\right)(E_{\ell m} - E_{\ell,m+1}) = \frac{1}{ML} \qquad (12)$$

to solve for the distribution function explicitly at the point $\left(\omega_\ell, \frac{E_{\ell m} + E_{\ell,m+1}}{2}\right)$. The terms $\bar{\nu}_p$ and $\bar{\nu}_n$ can be tabulated as functions of projectile energy and type and used for interpolation.

In the examples shown in Tables 1-4 we used L = 10 and M = 40. It may be possible to reduce these values considerably, but this is subject to numerical experimentation.

Table 1. Emergent Proton Distributions for 400-MeV Protons on Aluminum.

m	$\epsilon_{\ell,m}$				
	$\ell = 0$, $\omega_\ell =$ -0.09999999E 01	$\ell = 1$, $\omega_\ell =$ -0.84114602E-01	$\ell = 2$, $\omega_\ell =$ 0.23664957E-00	$\ell = 3$, $\omega_\ell =$ 0.41066683E-00	$\ell = 4$, $\omega_\ell =$ 0.55787671E 00
0	0.40936492E-02	0.40936492E-02	0.40936492E-02	0.40936492E-02	0.40936492E-02
1	0.40936492E-02	0.56800934E-02	0.60691197E-02	0.78280628E-02	0.72461816E-02
2	0.40936492E-02	0.65913462E-02	0.66833666E-02	0.10841671E-01	0.12391104E-01
3	0.40936492E-02	0.77495652E-02	0.78585666E-02	0.13726545E-01	0.18935493E-01
4	0.40936492E-02	0.83996602E-02	0.10148895E-01	0.16707473E-01	0.24669676E-01
5	0.40936492E-02	0.11927252E-01	0.12964134E-01	0.18958680E-01	0.29745346E-01
6	0.40936492E-02	0.14494474E-01	0.15401752E-01	0.22640439E-01	0.38530066E-01
7	0.40936492E-02	0.15927736E-01	0.17654087E-01	0.28337130E-01	0.49854172E-01
8	0.41218275E-02	0.17764875E-01	0.20322657E-01	0.32515837E-01	0.59169406E-01
9	0.43288634E-02	0.19112509E-01	0.23172298E-01	0.39563651E-01	0.70936200E-01
10	0.43789542E-02	0.21592521E-01	0.26883858E-01	0.48430138E-01	0.89146713E-01
11	0.46454770E-02	0.22647983E-01	0.32511902E-01	0.57125247E-01	0.10122994E-00
12	0.47166000E-02	0.24575659E-01	0.35363270E-01	0.64541946E-01	0.11508618E-00
13	0.47272720E-02	0.25911038E-01	0.45187937E-01	0.72050523E-01	0.12410697E-00
14	0.47438533E-02	0.28881412E-01	0.49779249E-01	0.75609103E-01	0.14182913E-00
15	0.47480517E-02	0.32720280E-01	0.52952001E-01	0.84614987E-01	0.14932515E-00
16	0.47597095E-02	0.35580621E-01	0.59296548E-01	0.90711012E-01	0.16747939E-00
17	0.49677704E-02	0.40074617E-01	0.63591675E-01	0.99147157E-01	0.18430345E-00
18	0.50703536E-02	0.42370400E-01	0.71548854E-01	0.10827868E-00	0.19846233E-00
19	0.50829528E-02	0.46905462E-01	0.76775399E-01	0.11858038E-00	0.22078940E-00
20	0.51353858E-02	0.51748600E-01	0.81664382E-01	0.12593541E-00	0.23286682E-00
21	0.54668265E-02	0.53938752E-01	0.87726582E-01	0.13396405E-00	0.24532440E-00
22	0.55789964E-02	0.59161074E-01	0.94728487E-01	0.13973076E-00	0.25883386E-00
23	0.58229314E-02	0.66147403E-01	0.10194733E-00	0.15075192E-00	0.26781721E-00
24	0.61252359E-02	0.67224736E-01	0.11284673E-00	0.16030942E-00	0.28889664E-00
25	0.91451821E-02	0.74158268E-01	0.11767337E-00	0.16941302E-00	0.29664020E-00
26	0.12169865E-01	0.81897164E-01	0.13195818E-00	0.17851482E-00	0.31157700E-00
27	0.15798474E-01	0.87123834E-01	0.14070747E-00	0.18696123E-00	0.32477115E-00
28	0.16407229E-01	0.93105670E-01	0.14977175E-00	0.19516530E-00	0.33927742E-00
29	0.17266585E-01	0.99899816E-01	0.16316853E-00	0.20932515E-00	0.35286490E-00
30	0.19246288E-01	0.10337251E-00	0.18053547E-00	0.22088727E-00	0.37694695E-00
31	0.23235241E-01	0.11267436E-00	0.19301865E-00	0.24334868E-00	0.39871326E-00
32	0.25168698E-01	0.12143635E-00	0.20561854E-00	0.25311455E-00	0.40917814E-00
33	0.25808845E-01	0.13607647E-00	0.23216338E-00	0.26970623E-00	0.42937306E-00
34	0.25926886E-01	0.14485057E-00	0.24853151E-00	0.29384320E-00	0.45696066E-00
35	0.29093430E-01	0.16446839E-00	0.25700521E-00	0.31827068E-00	0.47420570E-00
36	0.29617457E-01	0.18368793E-00	0.27887927E-00	0.35042649E-00	0.50247343E 00
37	0.31202935E-01	0.21701402E-00	0.29263096E-00	0.37123660E-00	0.52384003E 00
38	0.31809993E-01	0.24630047E-00	0.32330183E-00	0.40921874E-00	0.55460356E 00
39	0.92538761E-01	0.33636262E-00	0.36511279E-00	0.47402336E-00	0.61429314E 00
40	0.11530965E-00	0.45760666E-00	0.58877359E 00	0.57877892E 00	0.72899135E 00

Table 1 (contd.)

	$\epsilon_{\ell,m}$					
m	$\ell = 5,\ \omega_\ell =$ 0.65643723E 00	$\ell = 6,\ \omega_\ell =$ 0.74833374E 00	$\ell = 7,\ \omega_\ell =$ 0.82562906E 00	$\ell = 8,\ \omega_\ell =$ 0.88854297E 00	$\ell = 9,\ \omega_\ell =$ 0.94761558E 00	$\ell = 10,\ \omega_\ell =$ 0.09999999E 01
0	0.40936492E-02	0.40936492E-02	0.40936492E-02	0.40936492E-02	0.40936492E-02	0.40936492E-02
1	0.68603262E-02	0.10738946E-01	0.11064718E-01	0.16955566E-01	0.11634045E-01	0.20369399E-01
2	0.86972211E-02	0.24608919E-01	0.22694475E-01	0.32835309E-01	0.27930190E-01	0.33106302E-01
3	0.14274578E-01	0.43283059E-01	0.39764413E-01	0.41856768E-01	0.76078548E-01	0.14881499E-00
4	0.20509037E-01	0.65311812E-01	0.74844246E-01	0.63718957E-01	0.10929377E-00	0.29211569E-00
5	0.27203078E-01	0.77429128E-01	0.88749243E-01	0.86106962E-01	0.17034972E-00	0.29421277E-00
6	0.39124112E-01	0.94837636E-01	0.11695666E-00	0.12654430E-00	0.22932316E-00	0.42436704E-00
7	0.48514106E-01	0.10977199E-00	0.17968812E-00	0.17127050E-00	0.26555866E-00	0.53923909E 00
8	0.62840400E-01	0.14178993E-00	0.24358962E-00	0.23455340E-00	0.33765174E-00	0.63211106E 00
9	0.81176576E-01	0.17504264E-00	0.29881714E-00	0.27602383E-00	0.44534567E-00	0.66375825E 00
10	0.98279946E-01	0.21713956E-00	0.32890196E-00	0.33880733E-00	0.49574409E-00	0.72505040E 00
11	0.11713582E-00	0.24289183E-00	0.37778455E-00	0.41334052E-00	0.57657231E 00	0.76556402E 00
12	0.13868391E-00	0.28020729E-00	0.40494946E-00	0.46919423E-00	0.66400279E 00	0.80735935E 00
13	0.16427911E-00	0.29845054E-00	0.43487392E-00	0.48255053E-00	0.72072177E 00	0.88821158E 00
14	0.18697007E-00	0.32687434E-00	0.46162784E-00	0.51500970E 00	0.74575414E 00	0.92008839E 00
15	0.20971503E-00	0.36312333E-00	0.48214416E-00	0.57455885E 00	0.76651197E 00	0.93027023E 00
16	0.22784604E-00	0.37245340E-00	0.50466070E 00	0.58839966E 00	0.79606914E 00	0.94118413E 00
17	0.25380630E-00	0.38786352E-00	0.51746022E 00	0.60857555E 00	0.80704419E 00	0.94342367E 00
18	0.27135260E-00	0.40777405E-00	0.52828815E 00	0.63739146E 00	0.81306777E 00	0.94859870E 00
19	0.28614967E-00	0.41915756E-00	0.54215113E 00	0.65480961E 00	0.81869383E 00	0.95625347E 00
20	0.29910377E-00	0.43979769E-00	0.55501398E 00	0.66650835E 00	0.82845810E 00	0.95785082E 00
21	0.31246985E-00	0.45217635E-00	0.56584604E 00	0.68057807E 00	0.83682626E 00	0.96364012E 00
22	0.32228946E-00	0.47537155E-00	0.58392616E 00	0.69188267E 00	0.84236547E 00	0.96580979E 00
23	0.33394970E-00	0.48886330E-00	0.59373723E 00	0.70256933E 00	0.84752452E 00	0.97630801E 00
24	0.34709956E-00	0.49864765E-00	0.60213968E 00	0.71184652E 00	0.85322614E 00	0.97630954E 00
25	0.36031139E-00	0.51127791E 00	0.60892297E 00	0.72102404E 00	0.85870434E 00	0.97798152E 00
26	0.38063583E-00	0.51687457E 00	0.61916456E 00	0.73252679E 00	0.87270022E 00	0.97981957E 00
27	0.39649447E-00	0.52836180E 00	0.63600910E 00	0.74100663E 00	0.88161334E 00	0.98005684E 00
28	0.40371662E-00	0.54113615E 00	0.64106958E 00	0.75492960E 00	0.88936370E 00	0.98076784E 00
29	0.41134727E-00	0.55430374E 00	0.64967679E 00	0.76996359E 00	0.89613709E 00	0.98215288E 00
30	0.42091635E-00	0.56592245E 00	0.66189808E 00	0.77530415E 00	0.89925814E 00	0.98306263E 00
31	0.43892905E-00	0.57528751E 00	0.66898674E 00	0.78319564E 00	0.90326986E 00	0.98406227E 00
32	0.45332869E-00	0.59040635E 00	0.68111734E 00	0.79939576E 00	0.90899285E 00	0.98589034E 00
33	0.47612287E-00	0.60916081E 00	0.69729550E 00	0.80889728E 00	0.91563659E 00	0.99004912E 00
34	0.48259379E-00	0.62287484E 00	0.72053498E 00	0.82019492E 00	0.92042442E 00	0.99249084E 00
35	0.49653208E-00	0.63094170E 00	0.73250558E 00	0.83122589E 00	0.92707987E 00	0.99259538E 00
36	0.52340211E 00	0.64260053E 00	0.75026736E 00	0.84969147E 00	0.93493969E 00	0.99892057E 00
37	0.55204006E 00	0.67454735E 00	0.77184964E 00	0.86689611E 00	0.94078793E 00	0.99962162E 00
38	0.58723672E 00	0.69895500E 00	0.79713698E 00	0.89425781E 00	0.94725475E 00	0.09999999E 01
39	0.64193294E 00	0.73373453E 00	0.83008069E 00	0.93341108E 00	0.95757252E 00	0.09999999E 01
40	0.71223802E 00	0.84102423E 00	0.88595472E 00	0.95972925E 00	0.97899122E 00	0.09999999E 01

Table 2. Emergent Proton Distributions for 350-MeV Protons on Aluminum.

m	$\epsilon_{\ell,m}$				
	$\ell = 0$, $\omega_\ell =$ -0.09999999E 01	$\ell = 1$, $\omega_\ell =$ -0.40951083E-01	$\ell = 2$, $\omega_\ell =$ 0.26069238E-00	$\ell = 3$, $\omega_\ell =$ 0.45163740E-00	$\ell = 4$, $\omega_\ell =$ 0.56789378E 00
0	0.46784562E-02	0.46784562E-02	0.46784562E-02	0.46784562E-02	0.46784562E-02
1	0.48181415E-02	0.58349961E-02	0.73997942E-02	0.68449558E-02	0.10239883E-01
2	0.48472822E-02	0.71065837E-02	0.93747918E-02	0.10169657E-01	0.15495581E-01
3	0.57309493E-02	0.81709970E-02	0.10945537E-01	0.13709358E-01	0.24394352E-01
4	0.62953047E-02	0.97333386E-02	0.13292125E-01	0.17451618E-01	0.33271600E-01
5	0.64432503E-02	0.11693653E-01	0.16999088E-01	0.25574026E-01	0.36560344E-01
6	0.66241577E-02	0.13633411E-01	0.22197646E-01	0.32339814E-01	0.41933864E-01
7	0.78683631E-02	0.15491009E-01	0.27053250E-01	0.41585256E-01	0.50652941E-01
8	0.87798219E-02	0.16475531E-01	0.30120088E-01	0.50032286E-01	0.62821526E-01
9	0.97698620E-02	0.18752938E-01	0.35054062E-01	0.59342363E-01	0.80526912E-01
10	0.10172192E-01	0.20824917E-01	0.41593941E-01	0.73135901E-01	0.94168805E-01
11	0.10303297E-01	0.24382397E-01	0.51596978E-01	0.79558637E-01	0.11013927E-00
12	0.11562534E-01	0.26296379E-01	0.54193121E-01	0.89182684E-01	0.12909616E-00
13	0.13605554E-01	0.28232626E-01	0.60090697E-01	0.96213801E-01	0.14609677E-00
14	0.15105222E-01	0.30247037E-01	0.66914191E-01	0.10413489E-00	0.15893011E-00
15	0.16044298E-01	0.33054800E-01	0.75481889E-01	0.11725613E-00	0.17017896E-00
16	0.16805674E-01	0.34684593E-01	0.83573557E-01	0.12416835E-00	0.17682559E-00
17	0.17500529E-01	0.38176787E-01	0.91045626E-01	0.13364215E-00	0.19553263E-00
18	0.17720060E-01	0.42916312E-01	0.96965797E-01	0.14381300E-00	0.21807621E-00
19	0.19104382E-01	0.45467085E-01	0.10369128E-00	0.15751799E-00	0.23136924E-00
20	0.22160983E-01	0.49239014E-01	0.10654653E-00	0.16300091E-00	0.24264038E-00
21	0.22167663E-01	0.52206060E-01	0.11170078E-00	0.17587662E-00	0.25559073E-00
22	0.22425766E-01	0.54999332E-01	0.11790837E-00	0.18530419E-00	0.26608205E-00
23	0.22583184E-01	0.60084391E-01	0.12115820E-00	0.19703523E-00	0.28017215E-00
24	0.22709377E-01	0.63886974E-01	0.12648764E-00	0.21279534E-00	0.28732774E-00
25	0.23538426E-01	0.73365174E-01	0.13194782E-00	0.21791534E-00	0.30249429E-00
26	0.24092811E-01	0.84454833E-01	0.14601234E-00	0.22706740E-00	0.31258968E-00
27	0.30727931E-01	0.89990596E-01	0.15338238E-00	0.23531210E-00	0.32486009E-00
28	0.33090790E-01	0.93680589E-01	0.16069440E-00	0.24422728E-00	0.33906294E-00
29	0.33355699E-01	0.10221811E-00	0.17523942E-00	0.25350308E-00	0.35927343E-00
30	0.37649883E-01	0.11098510E-00	0.18718110E-00	0.26091007E-00	0.37228028E-00
31	0.42733868E-01	0.11745441E-00	0.20316220E-00	0.28072040E-00	0.39057411E-00
32	0.50047845E-01	0.12967737E-00	0.21651618E-00	0.30620642E-00	0.40365521E-00
33	0.81322894E-01	0.14139849E-00	0.23629670E-00	0.33014987E-00	0.41300586E-00
34	0.83797341E-01	0.14710972E-00	0.24990178E-00	0.34921487E-00	0.43572886E-00
35	0.99927247E-01	0.15597949E-00	0.27087530E-00	0.37619438E-00	0.45571336E-00
36	0.12101867E-00	0.17683905E-00	0.28645887E-00	0.39797167E-00	0.47793169E-00
37	0.14197703E-00	0.21138720E-00	0.31600475E-00	0.43439855E-00	0.51573753E 00
38	0.15917717E-00	0.24030685E-00	0.36134546E-00	0.46405060E-00	0.53780823E 00
39	0.29291469E-00	0.28137904E-00	0.40439106E-00	0.49897173E-00	0.59501085E 00
40	0.35931432E-00	0.37071045E-00	0.57610500E 00	0.57840475E 00	0.69731691E 00

Table 2 (contd.)

m	$\epsilon_{\ell,m}$					
	$\ell = 5$, $\omega_\ell =$ 0.66581202E 00	$\ell = 6$, $\omega_\ell =$ 0.75678636E 00	$\ell = 7$, $\omega_\ell =$ 0.82684824E 00	$\ell = 8$, $\omega_\ell =$ 0.89156642E 00	$\ell = 9$, $\omega_\ell =$ 0.94406850E 00	$\ell = 10$, $\omega_\ell =$ 0.09999999E 01
0	0.46784562E-02	0.46784562E-02	0.46784562E-02	0.46784562E-02	0.46784562E-02	0.46784562E-02
1	0.82822271E-02	0.11649473E-01	0.16080077E-01	0.15234645E-01	0.17657088E-01	0.14363361E-01
2	0.12937225E-01	0.17633791E-01	0.23543920E-01	0.20044941E-01	0.37444139E-01	0.27507259E-01
3	0.18163256E-01	0.29754789E-01	0.38814549E-01	0.23917844E-01	0.79560906E-01	0.38064676E-01
4	0.24310774E-01	0.49374314E-01	0.56021876E-01	0.56663801E-01	0.13639326E-00	0.66231272E-01
5	0.30327427E-01	0.77548308E-01	0.78498788E-01	0.79744525E-01	0.16721606E-00	0.12265395E-00
6	0.52168017E-01	0.10369196E-00	0.92677146E-01	0.11265432E-00	0.22348651E-00	0.12554868E-00
7	0.61026357E-01	0.13046868E-00	0.13126910E-00	0.14857112E-00	0.27139367E-00	0.16836093E-00
8	0.74217780E-01	0.15260613E-00	0.17050018E-00	0.21754289E-00	0.31235536E-00	0.22373007E-00
9	0.86442089E-01	0.18044271E-00	0.20935723E-00	0.27288338E-00	0.37962894E-00	0.26556125E-00
10	0.10003259E-00	0.20813849E-00	0.25616067E-00	0.36372516E-00	0.51772264E 00	0.26568201E-00
11	0.11411863E-00	0.23118972E-00	0.30800831E-00	0.44878236E-00	0.60877297E 00	0.27300388E-00
12	0.13177025E-00	0.26892858E-00	0.34774165E-00	0.48350573E-00	0.67617726E 00	0.35393761E-00
13	0.14556392E-00	0.29722194E-00	0.39408069E-00	0.51081964E 00	0.71248862E 00	0.51159655E 00
14	0.16721895E-00	0.31255745E-00	0.40846497E-00	0.54257299E 00	0.74561517E 00	0.57766592E 00
15	0.18108094E-00	0.32426064E-00	0.45146319E-00	0.57172732E 00	0.77272988E 00	0.66381496E 00
16	0.20451847E-00	0.35208119E-00	0.47419889E-00	0.59580287E 00	0.78842459E 00	0.72474454E 00
17	0.21656026E-00	0.37715354E-00	0.49435678E-00	0.62204251E 00	0.79698915E 00	0.79443898E 00
18	0.23532710E-00	0.39819917E-00	0.51492129E 00	0.65211668E 00	0.80449212E 00	0.84026035E 00
19	0.25897307E-00	0.41361510E-00	0.53054287E 00	0.67104053E 00	0.81837612E 00	0.86994180E 00
20	0.26954006E-00	0.42172377E-00	0.53792964E 00	0.68447474E 00	0.82526731E 00	0.88401522E 00
21	0.28764084E-00	0.43679267E-00	0.54641713E 00	0.70212400E 00	0.83173721E 00	0.89923847E 00
22	0.29907970E-00	0.45575568E-00	0.56132206E 00	0.70822674E 00	0.83967228E 00	0.90551209E 00
23	0.30982053E-00	0.46250422E-00	0.57335769E 00	0.71556486E 00	0.84420620E 00	0.91985866E 00
24	0.32562072E-00	0.48253973E-00	0.58923508E 00	0.72730588E 00	0.85193690E 00	0.92876001E 00
25	0.33163881E-00	0.49668010E-00	0.60530329E 00	0.73545775E 00	0.85717998E 00	0.93228275E 00
26	0.34946622E-00	0.50569897E 00	0.61639585E 00	0.73964383E 00	0.86303690E 00	0.94127773E 00
27	0.35473459E-00	0.52627596E 00	0.62944347E 00	0.74955215E 00	0.86823192E 00	0.94329936E 00
28	0.37298623E-00	0.54171230E 00	0.63983956E 00	0.76285648E 00	0.87056044E 00	0.95418035E 00
29	0.38751129E-00	0.55818985E 00	0.65694308E 00	0.77313153E 00	0.87613144E 00	0.96474961E 00
30	0.40367937E-00	0.57119655E 00	0.66573119E 00	0.78039860E 00	0.87986211E 00	0.97234305E 00
31	0.42133000E-00	0.57950072E 00	0.68288640E 00	0.79288516E 00	0.88909608E 00	0.98420590E 00
32	0.43302504E-00	0.60492302E 00	0.69572854E 00	0.80283043E 00	0.89316209E 00	0.98936500E 00
33	0.45259130E-00	0.60985291E 00	0.70808454E 00	0.81077752E 00	0.90331683E 00	0.99005970E 00
34	0.46359940E-00	0.63211245E 00	0.71788352E 00	0.82722866E 00	0.91007339E 00	0.99208645E 00
35	0.49016172E-00	0.65032231E 00	0.74158892E 00	0.83781113E 00	0.92092202E 00	0.99278099E 00
36	0.50926109E 00	0.66659802E 00	0.75705819E 00	0.84769177E 00	0.92637760E 00	0.99334756E 00
37	0.53535944E 00	0.70097507E 00	0.78022012E 00	0.87399586E 00	0.93829364E 00	0.99738756E 00
38	0.57536907E 00	0.72622735E 00	0.81071264E 00	0.89936393E 00	0.94871680E 00	0.09999999E 01
39	0.65261637E 00	0.76973741E 00	0.85209705E 00	0.92448393E 00	0.95777891E 00	0.09999999E 01
40	0.70102580E 00	0.86653932E 00	0.89620519E 00	0.96499740E 00	0.98034735E 00	0.09999999E 01

Table 3. Emergent Proton Distributions for 300-MeV Protons on Aluminum.

m	$\epsilon_{\ell,m}$				
	$\ell = 0$, $\omega_\ell =$ -0.09999999E 01	$\ell = 1$, $\omega_\ell =$ -0.58765034E-01	$\ell = 2$, $\omega_\ell =$ 0.25023832E-00	$\ell = 3$, $\omega_\ell =$ 0.42624677E-00	$\ell = 4$, $\omega_\ell =$ 0.55515438E 00
0	0.54581989E-02	0.54581989E-02	0.54581989E-02	0.54581989E-02	0.54581989E-02
1	0.54581989E-02	0.63988741E-02	0.88530490E-02	0.76378074E-02	0.94320396E-02
2	0.54581989E-02	0.82083029E-02	0.97267108E-02	0.11692670E-01	0.14908919E-01
3	0.54581989E-02	0.91655986E-02	0.12609315E-01	0.17215921E-01	0.25956193E-01
4	0.54581989E-02	0.10662568E-01	0.14511243E-01	0.20348250E-01	0.29116839E-01
5	0.54581989E-02	0.13046830E-01	0.16788539E-01	0.27829261E-01	0.42465317E-01
6	0.54581989E-02	0.14378433E-01	0.18689930E-01	0.35645405E-01	0.51251961E-01
7	0.54581989E-02	0.16351364E-01	0.20997400E-01	0.39813020E-01	0.61743353E-01
8	0.54581989E-02	0.18464921E-01	0.25506590E-01	0.43800611E-01	0.71138637E-01
9	0.54581989E-02	0.20773835E-01	0.30787896E-01	0.51357941E-01	0.78350887E-01
10	0.78738769E-02	0.22088940E-01	0.34902901E-01	0.56108189E-01	0.98716331E-01
11	0.78798220E-02	0.25010028E-01	0.39836231E-01	0.68688282E-01	0.10578658E-00
12	0.79076686E-02	0.28032260E-01	0.44935459E-01	0.80150891E-01	0.11701386E-00
13	0.79965487E-02	0.34235734E-01	0.51850971E-01	0.93102849E-01	0.12844338E-00
14	0.82086793E-02	0.36666675E-01	0.61012808E-01	0.10690670E-00	0.13262171E-00
15	0.82521033E-02	0.42343017E-01	0.64789926E-01	0.11936661E-00	0.14026632E-00
16	0.83131572E-02	0.45367556E-01	0.70038946E-01	0.13168084E-00	0.15059385E-00
17	0.84310036E-02	0.49285632E-01	0.78129258E-01	0.14710426E-00	0.16651765E-00
18	0.86877681E-02	0.51333141E-01	0.86242694E-01	0.15411212E-00	0.17844506E-00
19	0.88540427E-02	0.57487439E-01	0.96226015E-01	0.16350055E-00	0.19853100E-00
20	0.89381286E-02	0.63649228E-01	0.10176510E-00	0.17389673E-00	0.21496081E-00
21	0.93911928E-02	0.75863250E-01	0.10660681E-00	0.18102150E-00	0.23046892E-00
22	0.98114478E-02	0.81406032E-01	0.11490922E-00	0.19337425E-00	0.24727798E-00
23	0.99548230E-02	0.91005269E-01	0.12005503E-00	0.20131293E-00	0.25598121E-00
24	0.10107293E-01	0.94432453E-01	0.12568006E-00	0.21392955E-00	0.26453473E-00
25	0.10335004E-01	0.10155684E-00	0.14144797E-00	0.23071954E-00	0.27785539E-00
26	0.10689850E-01	0.10726350E-00	0.15532231E-00	0.23682256E-00	0.29666307E-00
27	0.11138393E-01	0.11944771E-00	0.17369488E-00	0.24720484E-00	0.31633380E-00
28	0.11238021E-01	0.13532515E-00	0.17995591E-00	0.25919080E-00	0.33172222E-00
29	0.11866091E-01	0.14974041E-00	0.19016149E-00	0.26526091E-00	0.35286489E-00
30	0.11976188E-01	0.16483887E-00	0.19767255E-00	0.28199743E-00	0.37569197E-00
31	0.12498459E-01	0.17438196E-00	0.21380050E-00	0.29556397E-00	0.39569706E-00
32	0.12527256E-01	0.18079717E-00	0.23098756E-00	0.30563805E-00	0.40347188E-00
33	0.12600213E-01	0.19026899E-00	0.24356996E-00	0.33777472E-00	0.43483047E-00
34	0.13485751E-01	0.20500210E-00	0.28034810E-00	0.36445495E-00	0.44783396E-00
35	0.47543896E-01	0.22992003E-00	0.29879466E-00	0.38611955E-00	0.46308660E-00
36	0.53942706E-01	0.23979703E-00	0.31743445E-00	0.41289973E-00	0.50986622E 00
37	0.54763742E-01	0.27583700E-00	0.35048427E-00	0.45208993E-00	0.53112400E 00
38	0.75872523E-01	0.31618983E-00	0.37449540E-00	0.49756896E-00	0.56339669E 00
39	0.13400025E-00	0.36334492E-00	0.42287415E-00	0.53621738E 00	0.60152851E 00
40	0.14395177E-00	0.50888118E 00	0.49287177E-00	0.68368132E 00	0.77815513E 00

Table 3 (contd.)

m	$\varepsilon_{\ell,m}$					
	$\ell = 5,\ \omega_\ell =$	$\ell = 6,\ \omega_\ell =$	$\ell = 7,\ \omega_\ell =$	$\ell = 8,\ \omega_\ell =$	$\ell = 9,\ \omega_\ell =$	$\ell = 10,\ \omega_\ell$
	0.67415034E 00	0.75703403E 00	0.82492933E 00	0.88490138E 00	0.94131263E 00	0.09999999E 01
0	0.54581989E-02	0.54581989E-02	0.54581989E-02	0.54581989E-02	0.54581989E-02	0.54581989E-02
1	0.10141987E-01	0.16259663E-01	0.14472573E-01	0.15796284E-01	0.18594965E-01	0.54581989E-02
2	0.13667557E-01	0.29558370E-01	0.20250250E-01	0.30787124E-01	0.49848679E-01	0.54581989E-02
3	0.25826721E-01	0.44734861E-01	0.28641535E-01	0.36644563E-01	0.78254864E-01	0.54581989E-02
4	0.35128418E-01	0.52986961E-01	0.42825234E-01	0.64281721E-01	0.12035207E-00	0.54581989E-02
5	0.46933015E-01	0.67893830E-01	0.68800595E-01	0.10514665E-00	0.18042493E-00	0.54581989E-02
6	0.63096125E-01	0.10327072E-00	0.11219747E-00	0.15243932E-00	0.22561306E-00	0.54581989E-02
7	0.83540915E-01	0.11833964E-00	0.13472297E-00	0.21230397E-00	0.29384837E-00	0.54581989E-02
8	0.10145852E-00	0.13513640E-00	0.15789849E-00	0.25279430E-00	0.35823790E-00	0.54581989E-02
9	0.12033780E-00	0.16258081E-00	0.19991964E-00	0.31138272E-00	0.43161631E-00	0.54581989E-02
10	0.14496662E-00	0.18826719E-00	0.26201543E-00	0.37060685E-00	0.47191910E-00	0.54581989E-02
11	0.16943916E-00	0.21493154E-00	0.31067521E-00	0.45687294E-00	0.53129391E 00	0.54581989E-02
12	0.18118632E-00	0.23683736E-00	0.33270409E-00	0.49642697E-00	0.58535203E 00	0.39924741E-01
13	0.20472494E-00	0.26439431E-00	0.38416931E-00	0.53791814E 00	0.62110619E 00	0.69482297E-01
14	0.22884332E-00	0.31186327E-00	0.39935505E-00	0.56982736E 00	0.69437329E 00	0.10497895E-00
15	0.23545095E-00	0.32482680E-00	0.41706947E-00	0.58278265E 00	0.71655490E 00	0.13649602E-00
16	0.24201219E-00	0.34857012E-00	0.43903800E-00	0.59894201E 00	0.74173696E 00	0.17053679E-00
17	0.25161037E-00	0.36901236E-00	0.46519541E-00	0.61781475E 00	0.75379720E 00	0.28584450E-00
18	0.26809005E-00	0.38699201E-00	0.50126871E 00	0.64027827E 00	0.76557446E 00	0.39798997E-00
19	0.27968412E-00	0.40509611E-00	0.52965243E 00	0.65773906E 00	0.77899503E 00	0.53681216E 00
20	0.29817130E-00	0.42311741E-00	0.54032096E 00	0.67046525E 00	0.78921320E 00	0.63181363E 00
21	0.30603904E-00	0.43460442E-00	0.56574540E 00	0.68136723E 00	0.80268908E 00	0.67002379E 00
22	0.31703637E-00	0.46097719E-00	0.58063041E 00	0.68988908E 00	0.81016295E 00	0.77017961E 00
23	0.33190279E-00	0.46990339E-00	0.59344925E 00	0.70348964E 00	0.82067493E 00	0.83885504E 00
24	0.34447746E-00	0.48097549E-00	0.60754869E 00	0.71396974E 00	0.82800861E 00	0.86675981E 00
25	0.36021861E-00	0.49738519E-00	0.62056508E 00	0.72491769E 00	0.83722765E 00	0.88480683E 00
26	0.39010108E-00	0.51042827E 00	0.62448137E 00	0.73462051E 00	0.84561457E 00	0.91373785E 00
27	0.41120297E-00	0.52211501E 00	0.63070617E 00	0.74814840E 00	0.85034798E 00	0.92128468E 00
28	0.42484488E-00	0.53751260E 00	0.63920342E 00	0.75612442E 00	0.85911005E 00	0.93004668E 00
29	0.44333328E-00	0.55852094E 00	0.65543634E 00	0.76900102E 00	0.86644827E 00	0.94814221E 00
30	0.44678572E-00	0.57431044E 00	0.67337272E 00	0.78037383E 00	0.87575074E 00	0.95263054E 00
31	0.46440975E-00	0.58760894E 00	0.68220669E 00	0.78734452E 00	0.87960038E 00	0.95638455E 00
32	0.49407014E-00	0.59655096E 00	0.69441172E 00	0.79887150E 00	0.88727992E 00	0.96092378E 00
33	0.50397141E 00	0.60903829E 00	0.71865972E 00	0.81367678E 00	0.90058544E 00	0.96224806E 00
34	0.52419773E 00	0.62121497E 00	0.73225988E 00	0.82793394E 00	0.90861101E 00	0.97012910E 00
35	0.55348761E 00	0.66520873E 00	0.75377113E 00	0.84817997E 00	0.91419129E 00	0.97942773E 00
36	0.58109552E 00	0.67970886E 00	0.76819592E 00	0.85512362E 00	0.92181759E 00	0.98271788E 00
37	0.61172076E 00	0.69255118E 00	0.78872332E 00	0.86977774E 00	0.92673869E 00	0.98804552E 00
38	0.63687689E 00	0.73881810E 00	0.81103297E 00	0.89299402E 00	0.93780429E 00	0.98943599E 00
39	0.68226358E 00	0.79443449E 00	0.83917294E 00	0.92784289E 00	0.94585987E 00	0.09999999E 01
40	0.75444493E 00	0.85933185E 00	0.90223635E 00	0.96769328E 00	0.98111401E 00	0.09999999E 01

Table 4. Emergent Proton Distributions for 350-MeV Protons on Aluminum (Obtained by Interpolation of Each Matrix Element in Tables 1 and 3)

m	$\epsilon_{\ell,m}$				
	$\ell = 0$, $\omega_\ell =$ -0.09999999E 01	$\ell = 1$, $\omega_\ell =$ -0.71437818E-01	$\ell = 2$, $\omega_\ell =$ 0.24344394E-00	$\ell = 3$, $\omega_\ell =$ 0.41845680E-00	$\ell = 4$, $\omega_\ell =$ 0.55651554E 00
0	0.47759240E-02	0.47759240E-02	0.47759240E-02	0.47759240E-02	0.47759240E-02
1	0.47759240E-02	0.60394838E-02	0.74610843E-02	0.77329351E-02	0.83391106E-02
2	0.47759240E-02	0.73998246E-02	0.82050387E-02	0.11267170E-01	0.13650012E-01
3	0.47759240E-02	0.84575819E-02	0.10233941E-01	0.15471233E-01	0.22445843E-01
4	0.47759240E-02	0.95311145E-02	0.12330069E-01	0.18527862E-01	0.26893257E-01
5	0.47759240E-02	0.12487041E-01	0.14876387E-01	0.23393970E-01	0.36105331E-01
6	0.47759240E-02	0.14436454E-01	0.17045341E-01	0.29142922E-01	0.44891013E-01
7	0.47759240E-02	0.16139550E-01	0.19325744E-01	0.34075075E-01	0.55798762E-01
8	0.47900132E-02	0.18114898E-01	0.22914674E-01	0.38158224E-01	0.65154021E-01
9	0.48935312E-02	0.19943172E-01	0.26980097E-01	0.45460796E-01	0.74643543E-01
10	0.61264156E-02	0.21840730E-01	0.30893380E-01	0.52269164E-01	0.93931522E-01
11	0.62626495E-02	0.23829006E-01	0.36174366E-01	0.62906764E-01	0.10350826E-00
12	0.63121343E-02	0.26303960E-01	0.40149365E-01	0.72346418E-01	0.11605002E-00
13	0.63619104E-02	0.30073386E-01	0.48519453E-01	0.82576685E-01	0.12627517E-00
14	0.64762663E-02	0.32774043E-01	0.55396329E-01	0.91257905E-01	0.13722542E-00
15	0.65000775E-02	0.37531649E-01	0.58870964E-01	0.10199080E-00	0.14479574E-00
16	0.65364334E-02	0.40474088E-01	0.64667747E-01	0.11119592E-00	0.15903662E-00
17	0.66993870E-02	0.44680125E-01	0.70860466E-01	0.12312571E-00	0.17541055E-00
18	0.68790609E-02	0.46851771E-01	0.78895774E-01	0.13119540E-00	0.18845370E-00
19	0.69684977E-02	0.52196451E-01	0.86500707E-01	0.14104047E-00	0.20966020E-00
20	0.70367572E-02	0.57698914E-01	0.91714741E-01	0.14991607E-00	0.22391382E-00
21	0.74290096E-02	0.64901000E-01	0.97166597E-01	0.15749277E-00	0.23789666E-00
22	0.76952221E-02	0.70283552E-01	0.10481885E-00	0.16655251E-00	0.25305592E-00
23	0.78888772E-02	0.78576335E-01	0.11100119E-00	0.17603242E-00	0.26189921E-00
24	0.81162646E-02	0.80828594E-01	0.11926340E-00	0.18711948E-00	0.27671568E-00
25	0.97400934E-02	0.87857553E-01	0.12956066E-00	0.20006628E-00	0.28724779E-00
26	0.11429857E-01	0.94580331E-01	0.14364024E-00	0.20766868E-00	0.30412003E-00
27	0.13468434E-01	0.10328577E-00	0.15720118E-00	0.21708303E-00	0.32055248E-00
28	0.13822625E-01	0.11421541E-00	0.16486382E-00	0.22717804E-00	0.33549982E-00
29	0.14566338E-01	0.12482011E-00	0.17666501E-00	0.23729303E-00	0.35286489E-00
30	0.15611238E-01	0.13410569E-00	0.18910401E-00	0.25144235E-00	0.37631946E-00
31	0.17866850E-01	0.14352816E-00	0.20340957E-00	0.26945633E-00	0.39720516E-00
32	0.18847978E-01	0.15111677E-00	0.21830305E-00	0.27937630E-00	0.40632501E-00
33	0.19204529E-01	0.16317272E-00	0.23786666E-00	0.30374048E-00	0.43210176E-00
34	0.19706319E-01	0.17492633E-00	0.26443981E-00	0.32914908E-00	0.45239731E-00
35	0.38318663E-01	0.19719420E-00	0.27789994E-00	0.35219511E-00	0.46864615E-00
36	0.41780081E-01	0.21174248E-00	0.29815686E-00	0.38166311E-00	0.50616983E 00
37	0.42983338E-01	0.24642551E-00	0.32155761E-00	0.41166326E-00	0.52748202E 00
38	0.53841258E-01	0.28124515E-00	0.34889862E-00	0.45339385E-00	0.55900013E 00
39	0.11326950E-00	0.34985377E-00	0.39399347E-00	0.50512037E 00	0.60791083E 00
40	0.12963071E-00	0.48324392E-00	0.54082268E 00	0.63123012E 00	0.75357324E 00

Table 4 (contd.)

m	$\epsilon_{\ell,m}$					
	$\ell = 0$, $\omega_\ell =$ 0.66529378E 00	$\ell = 1$, $\omega_\ell =$ 0.75268389E 00	$\ell = 2$, $\omega_\ell =$ 0.82527919E 00	$\ell = 3$, $\omega_\ell =$ 0.88672218E 00	$\ell = 4$, $\omega_\ell =$ 0.94446410E 00	$\ell = 10$, $\omega_\ell =$ 0.09999999E 01
0	0.47759240E-02	0.47759240E-02	0.47759240E-02	0.47759240E-02	0.47759240E-02	0.47759240E-02
1	0.85011564E-02	0.13499304E-01	0.12768646E-01	0.16375925E-01	0.15114505E-01	0.12913799E-01
2	0.11182389E-01	0.27083644E-01	0.21472362E-01	0.31811216E-01	0.38889434E-01	0.19282250E-01
3	0.20050649E-01	0.44008960E-01	0.34202974E-01	0.39250665E-01	0.77166705E-01	0.77136593E-01
4	0.27818727E-01	0.59149386E-01	0.58834740E-01	0.64000339E-01	0.11482292E-00	0.14878694E-00
5	0.37068047E-01	0.72661479E-01	0.78774919E-01	0.95626806E-01	0.17538732E-00	0.14983548E-00
6	0.51110119E-01	0.99054178E-01	0.11457706E-00	0.13949181E-00	0.22746810E-00	0.21491262E-00
7	0.66027511E-01	0.11405581E-00	0.15720554E-00	0.19178724E-00	0.27970351E-00	0.27234864E-00
8	0.82149462E-01	0.13846316E-00	0.20074405E-00	0.24367385E-00	0.34794483E-00	0.31878462E-00
9	0.10075718E-00	0.16881173E-00	0.24936838E-00	0.29370327E-00	0.43848099E-00	0.33460822E-00
10	0.12162329E-00	0.20270337E-00	0.29545870E-00	0.35470709E-00	0.48383159E-00	0.36525429E-00
11	0.14328749E-00	0.22891168E-00	0.34422988E-00	0.43510673E-00	0.55393311E 00	0.38551110E-00
12	0.15993512E-00	0.25852232E-00	0.36882578E-00	0.48281060E-00	0.62467740E 00	0.42364205E-00
13	0.18450202E-00	0.28142242E-00	0.40952162E-00	0.51023433E 00	0.67091397E 00	0.47884694E-00
14	0.20790670E-00	0.31936880E-00	0.43049144E-00	0.54241852E 00	0.72006371E 00	0.51253366E 00
15	0.22258299E-00	0.34397506E-00	0.44960681E-00	0.57867075E 00	0.74153343E 00	0.53338312E 00
16	0.23492911E-00	0.36051176E-00	0.47184935E-00	0.59367084E 00	0.76890305E 00	0.55586046E 00
17	0.25270833E-00	0.37843794E-00	0.49132781E-00	0.61319515E 00	0.78042069E 00	0.61463409E 00
18	0.26972132E-00	0.39738303E-00	0.51477843E 00	0.63883486E 00	0.78932111E 00	0.67329433E 00
19	0.28291689E-00	0.41212684E-00	0.53590178E 00	0.65627433E 00	0.79884443E 00	0.74653281E 00
20	0.29863753E-00	0.43145755E-00	0.54766747E 00	0.66848680E 00	0.80883565E 00	0.79483222E 00
21	0.30925444E-00	0.44339039E-00	0.56579572E 00	0.68097264E 00	0.81975767E 00	0.81683195E 00
22	0.31966291E-00	0.46817437E-00	0.58227828E 00	0.69088587E 00	0.82626421E 00	0.86799470E 00
23	0.33292624E-00	0.47938335E-00	0.59359324E 00	0.70302948E 00	0.83409972E 00	0.90758152E 00
24	0.34578851E-00	0.48981157E-00	0.60484418E 00	0.71290813E 00	0.84061737E 00	0.92153467E 00
25	0.36026500E-00	0.50433154E 00	0.61474402E 00	0.72297087E 00	0.84796599E 00	0.93139417E 00
26	0.38536845E-00	0.51365142E 00	0.62182297E 00	0.73357365E 00	0.85915740E 00	0.94677871E 00
27	0.40384872E-00	0.52523840E 00	0.63335763E 00	0.74457751E 00	0.86598066E 00	0.95067076E 00
28	0.41428075E-00	0.53932437E 00	0.64013650E 00	0.75552701E 00	0.87423687E 00	0.95540725E 00
29	0.42734028E-00	0.55641234E 00	0.65255657E 00	0.76948231E 00	0.88129268E 00	0.96514754E 00
30	0.43385103E-00	0.57011645E 00	0.66763540E 00	0.77783899E 00	0.88750444E 00	0.96784659E 00
31	0.45166940E-00	0.58144823E 00	0.67559571E 00	0.78527008E 00	0.89143512E 00	0.97022340E 00
32	0.47369941E-00	0.59347866E 00	0.68776453E 00	0.79913363E 00	0.89813638E 00	0.97340705E 00
33	0.49004714E-00	0.60909954E 00	0.70797761E 00	0.81128703E 00	0.90811101E 00	0.97614859E 00
34	0.50339576E 00	0.62204491E 00	0.72639742E 00	0.82406443E 00	0.91451771E 00	0.98130997E 00
35	0.52500984E 00	0.64807522E 00	0.74313836E 00	0.83970293E 00	0.92063558E 00	0.98601156E 00
36	0.55224881E 00	0.66115469E 00	0.75923164E 00	0.85240754E 00	0.92837864E 00	0.99081922E 00
37	0.58188041E 00	0.68354926E 00	0.78028648E 00	0.86833692E 00	0.93376331E 00	0.99383357E 00
38	0.61205681E 00	0.71888655E 00	0.80408497E 00	0.89362592E 00	0.94252952E 00	0.99471799E 00
39	0.66209826E 00	0.76408450E 00	0.83462681E 00	0.93062698E 00	0.95171619E 00	0.09999999E 01
40	0.73334148E 00	0.85017804E 00	0.89409553E 00	0.96371127E 00	0.98005261E 00	0.09999999E 01

Table 5. Emergent Proton Distributions for 350-MeV Protons on Aluminum (Obtained by Double Interpolation of 300- and 400-MeV Oxygen and Chromium Data)

m	$\epsilon_{\ell,m}$				
	$\ell = 0$, $\omega_\ell =$ -0.09999999E 01	$\ell = 1$, $\omega_\ell =$ -0.32426178E-01	$\ell = 2$, $\omega_\ell =$ 0.26267701E-00	$\ell = 3$, $\omega_\ell =$ 0.43846066E-00	$\ell = 4$, $\omega_\ell =$ 0.57137123E 00
0	0.46111996E-02	0.46111996E-02	0.46111996E-02	0.46111996E-02	0.46111996E-02
1	0.53538699E-02	0.58137933E-02	0.61876577E-02	0.70125165E-02	0.90443784E-02
2	0.54691356E-02	0.71751992E-02	0.88607738E-02	0.10611212E-01	0.12186604E-01
3	0.55389955E-02	0.95154267E-02	0.11226531E-01	0.13775150E-01	0.17477529E-01
4	0.56050567E-02	0.11120834E-01	0.14069259E-01	0.17698862E-01	0.29274517E-01
5	0.57537975E-02	0.13430559E-01	0.18014916E-01	0.24176174E-01	0.38027080E-01
6	0.62618712E-02	0.15117779E-01	0.22443978E-01	0.27680424E-01	0.53659373E-01
7	0.64241048E-02	0.17052912E-01	0.26444532E-01	0.36370867E-01	0.68089858E-01
8	0.69376443E-02	0.19178756E-01	0.32351275E-01	0.41923460E-01	0.84243542E-01
9	0.71239692E-02	0.22382900E-01	0.38272791E-01	0.49674762E-01	0.10097948E-00
10	0.72751694E-02	0.25831681E-01	0.41871505E-01	0.56968235E-01	0.11861449E-00
11	0.79417993E-02	0.28119593E-01	0.47698109E-01	0.65457357E-01	0.13193353E-00
12	0.83446242E-02	0.30492537E-01	0.53116371E-01	0.74157685E-01	0.14616834E-00
13	0.85971908E-02	0.35512436E-01	0.57451580E-01	0.87373814E-01	0.16409751E-00
14	0.89949670E-02	0.40144441E-01	0.64359684E-01	0.99106421E-01	0.17464126E-00
15	0.94205660E-02	0.43746331E-01	0.73076751E-01	0.10945976E-00	0.18441836E-00
16	0.98790194E-02	0.47156225E-01	0.79205446E-01	0.12711420E-00	0.19657850E-00
17	0.10113119E-01	0.50415295E-01	0.87147707E-01	0.13960437E-00	0.21245681E-00
18	0.10328629E-01	0.54667551E-01	0.95219479E-01	0.15359595E-00	0.22311862E-00
19	0.10725801E-01	0.58287400E-01	0.10270248E-00	0.16676858E-00	0.23558059E-00
20	0.11551551E-01	0.64061636E-01	0.10947019E-00	0.17443702E-00	0.24552958E-00
21	0.12865017E-01	0.69305537E-01	0.11662373E-00	0.18112552E-00	0.25602421E-00
22	0.14587114E-01	0.72615836E-01	0.12313202E-00	0.19046288E-00	0.27354425E-00
23	0.16566881E-01	0.78557447E-01	0.13178122E-00	0.19910654E-00	0.28628641E-00
24	0.19806025E-01	0.85457449E-01	0.14135729E-00	0.20878627E-00	0.29732443E-00
25	0.22192885E-01	0.91864979E-01	0.14753321E-00	0.21874995E-00	0.30797355E-00
26	0.23956294E-01	0.99688352E-01	0.15602414E-00	0.22909413E-00	0.31690207E-00
27	0.27214278E-01	0.10513112E-00	0.16546933E-00	0.24102641E-00	0.33186293E-00
28	0.33330990E-01	0.11424080E-00	0.17674238E-00	0.25510886E-00	0.34546357E-00
29	0.38727008E-01	0.12322605E-00	0.18632884E-00	0.26926501E-00	0.35997684E-00
30	0.43937097E-01	0.13163743E-00	0.19639316E-00	0.27774838E-00	0.37396677E-00
31	0.47696159E-01	0.14117090E-00	0.20587680E-00	0.29205165E-00	0.38438270E-00
32	0.52188538E-01	0.15035210E-00	0.22018345E-00	0.31125339E-00	0.39803714E-00
33	0.61227664E-01	0.16289026E-00	0.23612551E-00	0.32623395E-00	0.41688178E-00
34	0.67295332E-01	0.17159417E-00	0.25284909E-00	0.34609219E-00	0.43396430E-00
35	0.82779028E-01	0.18795773E-00	0.27336746E-00	0.36215549E-00	0.45134933E-00
36	0.88769816E-01	0.21467920E-00	0.29582945E-00	0.38712797E-00	0.46539570E-00
37	0.12837106E-00	0.24144952E-00	0.31486516E-00	0.40520874E-00	0.50159750E 00
38	0.15925323E-00	0.26260667E-00	0.35980602E-00	0.43369690E-00	0.52851835E 00
39	0.18328852E-00	0.30623481E-00	0.44530075E-00	0.50283676E 00	0.58194369E 00
40	0.23772312E-00	0.39560059E-00	0.53873915E 00	0.62297736E 00	0.70890652E 00

Table 5 (contd.)

m	$\epsilon_{\ell,m}$					
	$\ell = 5,\ \omega_\ell =$ 0.66922588E 00	$\ell = 6,\ \omega_\ell =$ 0.75591387E 00	$\ell = 7,\ \omega_\ell =$ 0.82771753E 00	$\ell = 8,\ \omega_\ell =$ 0.89062528E 00	$\ell = 9,\ \omega_\ell =$ 0.94694467E 00	$\ell = 10,\ \omega_\ell =$ 0.09999999E 01
0	0.46111996E-02	0.46111996E-02	0.46111996E-02	0.46111996E-02	0.46111996E-02	0.46111996E-02
1	0.12498260E-01	0.14716202E-01	0.11899373E-01	0.26038231E-01	0.14669680E-01	0.97569023E-02
2	0.19729771E-01	0.24166249E-01	0.20128618E-01	0.51535891E-01	0.33473086E-01	0.22390135E-01
3	0.30128838E-01	0.43810864E-01	0.36160903E-01	0.68829227E-01	0.60967588E-01	0.47345661E-01
4	0.47418547E-01	0.67298063E-01	0.75958280E-01	0.10692541E-00	0.10684577E-00	0.56007537E-01
5	0.63872246E-01	0.94628746E-01	0.10480241E-00	0.14423757E-00	0.13719091E-00	0.79188804E-01
6	0.76828892E-01	0.12327044E-00	0.14388035E-00	0.18907669E-00	0.16528299E-00	0.10247739E-00
7	0.95879434E-01	0.15764433E-00	0.19150946E-00	0.25437523E-00	0.24531920E-00	0.14192758E-00
8	0.11490031E-00	0.18665459E-00	0.22143719E-00	0.30803188E-00	0.32833510E-00	0.17377544E-00
9	0.13344197E-00	0.22286823E-00	0.26324840E-00	0.37155595E-00	0.44019364E-00	0.19563097E-00
10	0.15479860E-00	0.25039507E-00	0.31412017E-00	0.40970312E-00	0.51137263E 00	0.24821454E-00
11	0.18206188E-00	0.28124100E-00	0.35061522E-00	0.45901199E-00	0.57518939E 00	0.31808221E-00
12	0.20488825E-00	0.29906545E-00	0.39022953E-00	0.49708375E-00	0.61136024E 00	0.44784500E-00
13	0.22607955E-00	0.32044315E-00	0.41846209E-00	0.52917855E 00	0.65558137E 00	0.48477691E-00
14	0.24604017E-00	0.34581827E-00	0.44878323E-00	0.56490308E 00	0.69483460E 00	0.57495409E 00
15	0.26296743E-00	0.36844850E-00	0.47038848E-00	0.58847623E 00	0.71741180E 00	0.70994765E 00
16	0.28162812E-00	0.38356215E-00	0.48729137E-00	0.61449377E 00	0.75058152E 00	0.75083632E 00
17	0.29201724E-00	0.39686519E-00	0.51099499E 00	0.63222939E 00	0.77010843E 00	0.81416331E 00
18	0.30690555E-00	0.41037683E-00	0.52405147E 00	0.65382898E 00	0.79313450E 00	0.85267535E 00
19	0.31991865E-00	0.42381219E-00	0.54100218E 00	0.66431254E 00	0.80551162E 00	0.88887801E 00
20	0.33647014E-00	0.43990286E-00	0.55657383E 00	0.67754375E 00	0.81799655E 00	0.91398047E 00
21	0.35121156E-00	0.45443501E-00	0.57199933E 00	0.69098813E 00	0.82676060E 00	0.92978165E 00
22	0.36602972E-00	0.46715888E-00	0.58358942E 00	0.70779740E 00	0.83392275E 00	0.93960731E 00
23	0.38097966E-00	0.47728103E-00	0.59198502E 00	0.72114938E 00	0.84042384E 00	0.94375428E 00
24	0.38998050E-00	0.49131536E-00	0.60763815E 00	0.73111895E 00	0.84634469E 00	0.94788326E 00
25	0.40032944E-00	0.50365353E 00	0.61623330E 00	0.74049311E 00	0.85493686E 00	0.95464464E 00
26	0.41049548E-00	0.52012987E 00	0.63145167E 00	0.74707625E 00	0.86203630E 00	0.96040595E 00
27	0.42361487E-00	0.53528923E 00	0.64573383E 00	0.75544378E 00	0.86880890E 00	0.96634590E 00
28	0.43537074E-00	0.54842190E 00	0.65944275E 00	0.76473574E 00	0.87455466E 00	0.96967043E 00
29	0.44543455E-00	0.55489376E 00	0.66754971E 00	0.77359331E 00	0.88112459E 00	0.97319394E 00
30	0.46140479E-00	0.56946604E 00	0.67863259E 00	0.78289636E 00	0.88737608E 00	0.97715768E 00
31	0.47696465E-00	0.57977422E 00	0.69067612E 00	0.78962860E 00	0.89351374E 00	0.98183514E 00
32	0.48994216E-00	0.59385525E 00	0.70181692E 00	0.79894461E 00	0.89977365E 00	0.98438291E 00
33	0.49958261E-00	0.61129058E 00	0.71351104E 00	0.80921748E 00	0.90530711E 00	0.98714948E 00
34	0.51425194E 00	0.62832944E 00	0.72894040E 00	0.82384077E 00	0.91266142E 00	0.98893201E 00
35	0.53530098E 00	0.64109930E 00	0.74562366E 00	0.83419190E 00	0.91742788E 00	0.99005991E 00
36	0.55542105E 00	0.66015536E 00	0.75949529E 00	0.84580427E 00	0.92404457E 00	0.99245831E 00
37	0.57543729E 00	0.69182008E 00	0.77894455E 00	0.86469616E 00	0.93062093E 00	0.99500559E 00
38	0.61093465E 00	0.72163147E 00	0.79885808E 00	0.89473309E 00	0.94216037E 00	0.99591012E 00
39	0.66639129E 00	0.76537494E 00	0.82097306E 00	0.91845230E 00	0.95900616E 00	0.99840788E 00
40	0.76947685E 00	0.81343072E 00	0.88338804E 00	0.95333554E 00	0.98212393E 00	0.99878220E 00

Table 6. Evaporation Neutron Distributions for 400-MeV Protons on Aluminum.

P*	E*
0.	0.
0.050000	0.242971
0.100000	0.528617
0.150000	0.805674
0.200000	1.102738
0.250000	1.394248
0.300000	1.702047
0.350000	2.109275
0.400000	2.460849
0.450000	2.756023
0.500000	3.174702
0.550000	3.672033
0.600000	4.297472
0.650000	5.035330
0.700000	5.851216
0.750000	6.653659
0.800000	7.709945
0.850000	9.093304
0.900000	11.086615
0.950000	14.959952
1.000000	24.999982

*P is equal to the probability that the emitted evaporation neutron has an energy smaller than E.

Table 7. Evaporation Neutron Distributions for 350-MeV Protons on Aluminum.

P *	E*
0.	0.
0.050000	0.293087
0.100000	0.562567
0.150000	0.807336
0.200000	1.102254
0.250000	1.419897
0.300000	1.793837
0.350000	2.099699
0.400000	2.426741
0.450000	2.821841
0.500000	3.184797
0.550000	3.629092
0.600000	4.237905
0.650000	4.910406
0.700000	5.511161
0.750000	6.339100
0.800000	7.168942
0.850000	8.422408
0.900000	10.609965
0.950000	13.082948
1.000000	24.999982

*P is equal to the probability that the emitted evaporation neutron has an energy smaller than E.

Table 8. Evaporation Neutron Distributions for 300-MeV Protons on Aluminum.

P*	E*
0.	0.
0.050000	0.234350
0.100000	0.463628
0.150000	0.645041
0.200000	0.959650
0.250000	1.237941
0.300000	1.553484
0.350000	1.847746
0.400000	2.177493
0.450000	2.497552
0.500000	2.980991
0.550000	3.436995
0.600000	3.901162
0.650000	4.382915
0.700000	4.913221
0.750000	5.700002
0.800000	6.691948
0.850000	7.806635
0.900000	9.989971
0.950000	12.619955
1.000000	24.999982

*P is equal to the probability that the emitted evaporation neutron has an energy smaller than E.

Table 9. Evaporation Neutron Distributions for 350-MeV Protons on Aluminum (Obtained by Interpolation of Each Vector Element in Tables 6 and 8)

P *	E *
0.	0.
0.050000	0.238661
0.100000	0.496123
0.150000	0.725357
0.200000	1.031194
0.250000	1.316094
0.300000	1.627766
0.350000	1.978511
0.400000	2.319171
0.450000	2.626788
0.500000	3.077847
0.550000	3.554514
0.600000	4.099317
0.650000	4.709123
0.700000	5.382218
0.750000	6.176831
0.800000	7.200947
0.850000	8.449970
0.900000	10.538293
0.950000	13.789953
1.000000	24.549983

*P is equal to the probability that the emitted evaporation neutron has an energy smaller than E.

Table 10. Evaporation Neutron Distributions for 350-MeV Protons on Aluminum (Obtained by Double Interpolation of 300- and 400-MeV Oxygen and Chromium Data)

P*	E*
0.050000	0.280896
0.100000	0.584112
0.150000	0.856610
0.200000	1.143275
0.250000	1.424283
0.300000	1.712656
0.350000	2.096413
0.400000	2.541940
0.450000	2.974754
0.500000	3.410723
0.550000	3.836002
0.600000	4.540059
0.650000	5.344350
0.700000	6.020800
0.750000	6.966859
0.800000	8.179244
0.850000	9.616714
0.900000	11.659332
0.950000	14.669194
1.000000	24.715260

*P is equal to the probability that the emitted evaporation neutron has an energy smaller than E.