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*PRECOED: Program for Calculating
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Double Differential Cross Sections*

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PRECO-D2: Program for Calculating Preequilibrium and Direct Reaction Double Differential Cross Sections



C. Kalbach*

LOS ALAMOS NATIONAL LABORATORY
3 9338 00318 7597

*Consultant at Los Alamos. Department of Physics, Duke University, Durham, NC 27706.

Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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PRECO-D2: PROGRAM FOR CALCULATING PREEQUILIBRIUM
AND DIRECT REACTION DOUBLE DIFFERENTIAL CROSS SECTIONS

by

C. Kalbach

ABSTRACT

The code PRECO-D2 uses the exciton model for preequilibrium nuclear reactions to describe the emission of particles with mass numbers of 1 to 4 from an equilibrating composite nucleus. A distinction is made between open and closed configurations in this system and between the multi-step direct (MSD) and multi-step compound (MSC) components of the preequilibrium cross section. Additional MSD components are calculated semi-empirically to account for direct nucleon transfer reactions and direct knockout processes involving cluster degrees of freedom. Evaporation from the equilibrated composite nucleus is included in the full MSC cross section. Output of energy differential and double differential cross sections is provided for the first particle emitted from the composite system. Multiple particle emission is not considered. This report describes the reaction models used in writing PRECO-D2 and explains the organization and utilization of the code.

INTRODUCTION

PRECO refers to a family of programs of increasing sophistication designed to calculate the energy spectra of particles emitted in nuclear reactions within a statistical model framework which includes non-equilibrium processes. The first series of programs (ending with PRECO-8 and PRECOM) ran on a PDP-6 computer with teletype input in the dialogue mode. The present series, which began with the code PRECO-A, is suitable for large computing center machines. The model used was first proposed by Griffin [GR66] and is discussed in detail in [KA77] and references therein. The formalism used here has been modified to include division of the preequilibrium cross section into multi-step direct (MSD) and multi-step compound (MSC) components [KA81]. Subroutines have been included to perform semi-empirical calculations for direct nucleon transfer and for knockout and inelastic processes involving complex particles. Additional subroutines use the total MSD (including direct) and total MSC (including evaporation) cross sections to calculate the angular distributions for

the emitted particles. This is done phenomenologically [KA81a].

I. SUMMARY OF THE EXCITON MODEL THEORY

The Griffin or exciton model is a simple statistical model which totally neglects angular momentum and shell structure. The nucleus is pictured with equally spaced single-particle states, and the interactions responsible for creating and destroying particle/hole pairs are assumed to be two-body, energy conserving and residual in nature. Particle emission rates are calculated from microscopic reversibility.

I.1 State Densities

The states of the system are enumerated by the number of excited particle, p , and hole, h , degrees of freedom which they contain. The sum $p+h$ is referred to as the exciton number and is denoted as n . The system is assumed to be formed in a unique particle/hole configuration specified by (p_0, h_0) , and the difference $p-h$ is assumed to remain constant so that $p-h = p_0 - h_0$. This is not true near equilibrium but is adequate for closed-form preequilibrium calculations. Thus once p is specified for a given class of states, h and n are also specified if the initial

configuration is known. The density of equally spaced single-particle states is denoted as g_0 .

For a system with excitation energy E , the overall particle/hole state density is given by

$$\omega(p, h, E) = \frac{g^n(p) [E - A(p, h)]^{n-1}}{p! h! (n-1)!} f(p) , \quad (1)$$

$$A(p, h) = E_{\text{Pauli}}(p, h) - (p^2 + h^2 + n)/4g_0 , \quad (2)$$

$$E_{\text{Pauli}}(p, h) = p_m^2/g_0 , \quad (3)$$

$$p_m = \text{maximum}(p, h) . \quad (4)$$

The quantity $g(p)$ contains corrections to g_0 assuming that in the real nucleus the single-particle-state density varies as the square root of the energy in the well, with g_0 representing the average near the Fermi surface. Thus

$$g(p) \begin{cases} = g_0 \left[\frac{p}{n} \left(\frac{V+E/n}{V} \right)^{1/2} + \frac{h}{n} \left(\frac{V-E/n}{V} \right)^{1/2} \right] & \text{for } h < 2 \\ = g_0 & \text{for } h > 2 . \end{cases} \quad (5)$$

Here V is the depth of the nuclear potential well and is assumed to be 38 MeV. The variable $f(p)$ gives corrections to the state density due to the finite depth of the nuclear potential. It has the form (where alternatives of V may be read in)

$$f(p) \begin{cases} = 1 - h \left(\frac{E-V}{V} \right)^{n-1} \Theta(E-V) + \frac{h(h-1)}{2} \left(\frac{E-2V}{V} \right)^{n-1} \Theta(E-V) & \text{for } h < 2 \\ = 1 & \text{for } h > 2 . \end{cases} \quad (6)$$

Here θ is the Heaviside function, which is zero for a negative argument and unity for a positive one.

In the MSD/MSD formalism, the density of states containing at least one unbound particle degree of freedom is also needed for each class of states. This is referred to simply as the density of unbound states. In order to specify it, we need to define the effective separation energy, S , which determines the excitation energy at which particle degrees of freedom become unbound. In the present model we assume

$$S = \text{minimum}(B_n, B_p + C_p, B_\alpha + C_\alpha) , \quad (7)$$

where the B's are the binding energies and the C's are the Coulomb barriers for the neutron, proton, and alpha particle exit channels. The Coulomb barrier for a particle of type b is given in terms of its proton number, Z_b , and the proton number, Z_B , of the residual nucleus so that

$$C_b = 0.75 \frac{Z_b Z_B}{A^{1/3}} \text{ MeV} . \quad (8)$$

The density of unbound states is written as

$$\omega^{(u)}(p, h, E) = \frac{g_p(p) g_u^{n-1}(p) [E - A_{1,0}(p, h) - S]^{n-1}}{(p-1)! h! (n-1)!} f_1(p), \quad (9)$$

and contains different effective single-particle-state densities, g_p and g_u , for the unbound particle and the remaining degrees of freedom. These are

$$g_u(p) \begin{cases} = g_o \left[\frac{p-1}{n-1} \left(\frac{V+(E-S)/n}{V} \right)^{1/2} + \frac{h}{n-1} \left(\frac{V-(E-S)/n}{V} \right)^{1/2} \right] & \text{for } h \leq 2 \\ = g_o & \text{for } h > 2, \end{cases} \quad (10)$$

$$g_p(p) \begin{cases} = g_o \left(\frac{V+S+(E-S)/n}{V} \right)^{1/2} & \text{for } h \leq 2 \\ = g_o \left(\frac{V+S}{V} \right)^{1/2} & \text{for } h > 2 . \end{cases} \quad (11)$$

The finite well depth corrections are contained in the quantity $f_1(p)$ which, for $h \leq 2$, is given by

$$f_1(p) = \frac{1}{p} \sum_{i=1}^p \sum_{j=0}^h (-1)^{i+j+1} \binom{p}{i} \binom{h}{j} \left(\frac{E-iS-jV}{E-S} \right)^{n-1} \theta(E-iS-jV), \quad (12)$$

while for $h > 2$ only $j=0$ terms are included. The quantity $A_{1,0}(p,h)$ is analogous to $A(p,h)$ and is defined by [KA83]

$$A_{i,0}(p,h) = \frac{p_m^2 + (p_m - i)^2}{2g_o} - \frac{(p-i)^2 + h^2 + n-i}{4g_o} . \quad (13)$$

The density of bound states is also needed and is found by a simple difference

$$\omega^{(b)}(p,h,E) = \omega(p,h,E) - \omega^{(u)}(p,h,E) . \quad (14)$$

I.2 Residual Interaction Rates

The residual interactions which are responsible for changing the exciton number of the system are assumed to be energy conserving and two-body in nature so that allowed transitions are those for which $\Delta p = \Delta h = 0, \pm 1$. The rates for

these three general categories of transitions are denoted λ_0 , λ_+ and λ_- . In addition, the superscripts u and b are used to indicate the unbound or bound character of the initial and final state in the interaction. Thus $\lambda_+^{(ub)}(p,h,E)$ is the average rate for creating a particle/hole pair starting from an unbound state in the class specified by (p,h) and going to a bound final state in the class (p+1,h+1). All of the transition rates have the general form exemplified below:

$$\lambda_+^{(ub)}(p,h,E) = (2\pi/\hbar) M^2(p) \omega_+^{(ub)}(p,h,E), \quad (15)$$

where M^2 is the mean square two-body matrix element and $\omega_+^{(ub)}$ gives the density of accessible final states. The quantity M^2 is given by [KA78]

$$M^2(p) \left\{ \begin{array}{ll} = \frac{k}{A^3} \frac{n}{E} \left[\frac{E/n}{7 \text{ MeV}} \frac{E/n}{2 \text{ MeV}} \right]^{1/2} & \text{for } E/n < 2 \text{ MeV}, \\ = \frac{k}{A^3} \frac{n}{E} \left[\frac{E/n}{7 \text{ MeV}} \right]^{1/2} & \text{for } 2 \text{ MeV} \leq E/n < 7 \text{ MeV}, \\ = \frac{k}{A^3} \frac{n}{E} & \text{for } 7 \text{ MeV} \leq E/n \leq 15 \text{ MeV}, \\ = \frac{k}{A^3} \frac{n}{E} \left[\frac{15 \text{ MeV}}{E/n} \right]^{1/2} & \text{for } 15 \text{ MeV} < E/n, \end{array} \right. \quad (16)$$

where A is the mass number of the composite nucleus and k is an empirical constant usually taken to be 135 MeV^3 .

Several quantities are useful in describing the densities of accessible final states. We therefore define

$$X_i(p) = [E - A_{i,0}(p,h) - iS] \Theta(E - A_{i,0}(p,h) - iS), \quad (17)$$

as well as the correction functions

$$f_+(p) \begin{cases} = 1 - \left(\frac{E-S-V}{E-S}\right)^{n-1} \Theta(E-S-V) - \frac{1}{2} \left(\frac{E-2S}{E-S}\right)^{n-1} \Theta(E-2S) \\ \quad + \frac{1}{2} \left(\frac{E-2S-V}{E-S}\right)^{n-1} \Theta(E-2S-V) & \text{for } h \leq 2, \\ = 1 - \frac{1}{2} \left(\frac{E-2S}{E-S}\right)^{n-1} \Theta(E-2S) & \text{for } h > 2, \end{cases} \quad (18)$$

$$f_0(p) = 1 - \frac{1}{2} \left(\frac{E-2S}{E-S}\right)^{n-1} \Theta(E-2S); \quad (19)$$

and the effective single-particle-state densities

$$g_a(p+1) \begin{cases} = \frac{n-1}{n} g_u(p+1) + \frac{1}{n} g_p(p+1) & \text{for } h \leq 1, \\ = g_o & \text{for } h > 1, \end{cases} \quad (20)$$

$$g_h = g_o [(V-S)/V]^{1/2}, \quad (21)$$

where we have assumed that $V > S$. The fraction of unbound states in a given class which have more than one unbound particle also enters in and is given by

$$m(p) = \frac{\sum_{i=2}^p \sum_{j=0}^h (-1)^{i+j} \binom{p}{i} \binom{h}{j} \Theta(E-iS-jV) (E-iS-jV)^{n-1}}{\sum_{i=1}^p \sum_{j=0}^h (-1)^{i+j+1} \binom{p}{i} \binom{h}{j} \Theta(E-iS-jV) (E-iS-jV)^{n-1}} \quad (22)$$

for $h \leq 2$, while for $h > 2$ only $j=0$ is considered. Finally we need the three miscellaneous quantities

$$f_u(p) = \frac{2f_1(p) m(p)}{p-1} \left(\frac{E-S}{E-2S}\right)^{n-1}, \quad (23)$$

$$G_1 = \text{maximum}(E-V, 0) , \quad (24a)$$

$$G_2 = \text{maximum}(E-V-S, 0) . \quad (24b)$$

In terms of these quantities, the necessary densities of final states for the two-body interactions are given by

$$\omega_+^{(uu)}(p, h, E) = \frac{g_a(p+1) g_u^2(p+1) x_1^{n+1}(p+1) \left\{ \frac{1}{n} f_+(p+1) + \frac{n-1}{n} f(p+1) \right\}}{2n x_1^{n-1}(p)} + \frac{m(p)}{1-m(p)} \omega_+^{(ub)}(p, h, E) , \quad (25)$$

$$\omega_+^{(ub)}(p, h, E) = \frac{1-m(p)}{2n(n+1)} \left\{ g^3(p+1) f(p+1) \right. \\ \left. \left\{ \frac{n^2}{2} [x_0(p+1) - x_1(p)]^2 + \frac{n}{2} [x_0^2(p+1) - x_1^2(p)] + x_0(p+1) x_1(p) \right\} \right. \\ \left. - 2g_p(p+1) g_u^2(p+1) f_+(p+1) \frac{x_1^{n+1}(p+1)}{x_1^{n-1}(p)} \right\} , \quad (26)$$

$$\omega_+^{(bu)}(p, h, E) = \frac{g_p(p+1) g_u^2(p+1) h}{x_0^{n-1}(p) f(p) - p x_1^{n-1}(p) f_1(p)} \\ \left\{ \frac{x_1^{n+1}(p+1) - p x_2^{n+1}(p+1)}{2n(n+1)} - \frac{1}{4n(n+1)} \right. \\ \left. \left\{ G_1^{n-1} [n(n-1)G_1^2 - 2(n+1)(n-1)G_1 x_1(p+1) + n(n+1)x_1^2(p+1)] \right. \right. \\ \left. \left. - p G_2^{n-1} [n(n-1)G_2^2 - 2(n+1)(n-1)G_2 x_2(p+1) + n(n+1)x_2^2(p+1)] \right\} \right\} , \quad (27)$$

$$\begin{aligned}
\omega_+^{(bb)}(p, h, E) = & \frac{1}{2n(n+1)} \frac{1}{x_0^{n-1}(p) f(p) - p x_1^{n-1}(p) f_1(p)} \\
& \left[\begin{aligned}
& n g^3(p+1) x_0^{n+1}(p+1) f(p+1) \\
& - p(n-1) g_u^3(p+1) x_1^{n+1}(p+1) f_1(p+1) \\
& - p g^3(p+1) x_1^{n-1}(p) f_1(p) \\
& \left\{ \frac{n^2}{2} [x_0(p+1) - x_1(p)]^2 + \frac{n}{2} [x_0^2(p+1) - x_1^2(p)] + x_0(p+1) x_1(p) \right\} \\
& - \omega_+^{(bu)}(p, h, E),
\end{aligned} \right] \quad (28)
\end{aligned}$$

$$\begin{aligned}
\omega_0^{(ub)}(p, h, E) = & \frac{[1-m(p)] g_0^2}{n} \left[\begin{aligned}
& \frac{p+2h-1}{2} n [x_0(p) - x_1(p)] f(p) \\
& + (p-1) x_1(p) [f(p) - 2f_0(p)]
\end{aligned} \right], \quad (29)
\end{aligned}$$

$$\begin{aligned}
\omega_0^{(bu)}(p, h, E) = & \frac{g_u(p) g_p(p)}{2n} \frac{1}{x_0^{n-1}(p) f(p) - p x_1^{n-1}(p) f_1(p)} \\
& \left[\begin{aligned}
& (p+2h-1) \{ 2x_1^n(p) + n[x_0(p) - x_1(p)] x_1^{n-1}(p) \} f(p) \\
& - (p-1)(p+2h-1) \{ 2x_2^n(p) + n[x_1(p) - x_2(p)] x_2^{n-1}(p) \} f_1(p) \\
& - 4(n-1) x_1^n(p) f_1(p) + 4(p-1)(n-2) x_2^n(p) f_2(p)
\end{aligned} \right], \quad (30)
\end{aligned}$$

$$\omega_-^{(ub)}(p, h, E) = [1-m(p)] g_h h(h-1)/2, \quad (31)$$

$$\begin{aligned}
\omega_{-}^{(bu)}(p, h, E) &= \frac{g_p(p-1) hp(p-1)}{4} \frac{1}{x_0^{n-1}(p) f(p) - px_1^{n-1}(p) f_1(p)} \\
&\{x_1^{n-3}(p-1) [(n-2)(n-3)x_1^2(p-1) \\
&\quad - 2(n-1)(n-3)x_1(p-1)x_0(p) + (n-1)(n-2)x_0^2(p)] f(p) \\
&- (p-2)x_2^{n-3}(p-1) [(n-2)(n-3)x_2^2(p-1) \\
&\quad - 2(n-1)(n-3)x_2(p-1)x_1(p) + (n-1)(n-2)x_1^2(p)] f_1(p) \\
&- 4[x_1^{n-1}(p) f_1(p) - (p-2)x_2^{n-1}(p) f_u(p)]\} . \tag{32}
\end{aligned}$$

I.3 Particle Emission Rates

The average rate for emitting a particle of type b and energy ϵ from an unbound state specified by (p, h) is derived from microscopic reversibility to be

$$W_b^{(u)}(p, h, \epsilon) d\epsilon = \frac{(2s_b + 1)}{\pi^2 \hbar^3} A_b \epsilon \sigma_b(\epsilon) d\epsilon Q_b(p) \frac{\omega(p - A_b, h, U)}{\omega^{(u)}(p, h, E)} , \tag{33}$$

where s_b and A_b are the spin and mass numbers of the emitted particle. The quantity σ_b is the cross section for the inverse process of composite nucleus formation, while U is the excitation energy of the residual nucleus. The quantity $Q_b(p)$ takes account of the fact that proton and neutron degrees of freedom are distinguishable. It assumes that in each pair-creation interaction protons and neutrons

are excited with the relative probabilities Z/A and N/A , and it has the form

$$Q_b(p) \left\{ \begin{array}{l} = \frac{(p-A_b)!}{p!} \sum_{i=0}^{p-A_a} \frac{(p-A_a)!}{i! (p-A_a-i)!} \left(\frac{Z_T}{A_T}\right)^{i-Z_b} \left(\frac{N_T}{A_T}\right)^{p-A_a-i-N_b} \\ \frac{(Z_a+i)!}{(Z_a+i-Z_b)!} \frac{(p-Z_a-i)!}{(p-Z_a-i-N_b)!} \quad \text{for } n \leq \bar{n} \text{ and } n \leq 20 \\ = 1 \quad \text{for } n > \bar{n} \text{ or } n > 20. \end{array} \right. \quad (34)$$

Here Z_b and N_b are the proton and neutron numbers of the emitted particle, and $A_a = Z_a + N_a$ is the nucleon number of the projectile. The quantities Z_T , N_T and A_T are the proton, neutron and mass numbers of the target. Finally \bar{n} is the most probable number of degrees of freedom at equilibrium (*i.e.*, the number for which $\omega(p, h, E)$ is a maximum).

An alternative to $Q_b(p)$ has been added in this newer version of PRECO-D. It is assumed that proton and neutron particle/hole pairs are excited in proportion to the state densities of the configurations formed [GA77]. This assumption is more consistent with the assumption made in deriving the emission rates from microscopic reversibility (*i.e.*, all configurations of a given p , h , and E are equally likely to be populated). It leads to the Q_b values of

$$Q_b^{(G)}(p) = \frac{\sum_{p_\pi} \binom{Z}{A}^{n_\pi - Z_b} \binom{N}{A}^{n_\nu - N_b} \frac{(p - A_b)!}{(p_\pi - Z_b)! (p_\nu - N_b)!} \frac{h!}{h_\pi! h_\nu!}}{\sum_{p_\pi} \binom{Z}{A}^{n_\pi} \binom{N}{A}^{n_\nu} \frac{p!}{p_\pi! p_\nu!} \frac{h!}{h_\pi! h_\nu!}}, \quad (35)$$

where the subscripts π and ν refer to proton and neutron degrees of freedom, and Z , N , and A are for the composite nucleus. Either form for Q may be chosen by specifying an input parameter.

Particle emission rates for the bound states are, of course, zero.

At equilibrium the emission rates for the full system are calculated from the Weisskopf-Ewing evaporation formula and are given by

$$W_b(\epsilon) d\epsilon = \frac{(2s_b + 1)}{\pi^2 \hbar^3} A_b \epsilon \sigma_b(\epsilon) d\epsilon \frac{\omega(U)}{\omega(E)}, \quad (36)$$

where in the present case the state densities are assumed to be those for a single Fermi gas,

$$\omega(E) \propto E^{-1} \exp[2(aE)^{1/2}], \quad (37)$$

and $a = \pi^2 g_0/6$.

I.4 Fission Rates

In order to facilitate application of the model to very heavy nuclei, fission competition in the equilibrium limit has been considered. Barrier penetration has been neglected

in order to obtain a closed-form integral over the kinetic energy degree of freedom. Thus one obtains

$$W_f(E) = \frac{1}{2\pi\hbar} \int_0^{E-B_f} \frac{\omega(E-B_f-\epsilon_f)}{\omega(E)} d\epsilon_f \quad (38)$$

where ϵ_f is the kinetic energy in the fission degree of freedom.

I.5 Closed-Form Reaction Equations

In the closed-form approach, the strength of the system is imagined to pass sequentially through configurations of increasing complexity until the most probable class of states at equilibrium (specified by $\bar{n}=\bar{p}+\bar{h}$) is reached. Particle emission is allowed at each stage.

In the MSD/MSD formalism it is necessary to know for each class of states how much of the reaction strength passes through unbound states and how much through bound states. These quantities are denoted $S_u(p,h)$ and $S_b(p,h)$, respectively. In addition, it is necessary to know the amount of strength which passes through unbound states of the class (p,h) and which was unbound at all previous stages as well. This is denoted $S_d(p,h)$ and is the strength responsible for the MSD cross section.

Strengths of the three types arriving at the (p,h) stage of the hierarchy through pair creation are denoted $P_u(p,h)$, $P_b(p,h)$ and $P_d(p,h)$, respectively, and differ from the

corresponding S quantities by the effect of the λ_0 and λ_- interactions.

Initially it is assumed that the unbound states are populated in proportion to their relative state densities so that

$$P_u(p_o, h_o) = P_d(p_o, h_o) = \omega^{(u)}(p_o, h_o, E) / \omega(p_o, h_o, E), \quad (39a)$$

$$P_b(p_o, h_o) = 1 - P_u(p_o, h_o). \quad (39b)$$

At this exciton number and at each succeeding exciton number it is assumed that there will be at most one exciton-scattering interaction which takes the system from a bound to an unbound configuration or *vice versa*. Further, it is assumed that there can be at most one pair-annihilation interaction which changes the bound/unbound character of the state and that it will immediately be followed by a pair-creation interaction which does *not* change the bound/unbound character. Thus in effect $\lambda_0^{(ub)}$ and $\lambda_-^{(ub)}$ are treated together, and similarly for $\lambda_0^{(bu)}$ and $\lambda_-^{(bu)}$.

Because of these assumptions, strength arriving for the first time at a given hierarchy is assigned a lifetime of

$$T_u(p, E) = [\lambda_+^{(uu)}(p) + \lambda_+^{(ub)}(p) + \lambda_0^{(ub)}(p) + \lambda_-^{(ub)}(p) + \sum_b \int W_b(p, \epsilon) d\epsilon]^{-1}, \quad (40a)$$

(where the hole label has been suppressed) if it is in unbound states or

$$T_b(p, E) = [\lambda_+^{(bb)}(p) + \lambda_+^{(bu)}(p) + \lambda_0^{(bu)}(p) + \lambda_-^{(bu)}(p)]^{-1} \quad (40b)$$

if it is in bound configurations. Strength which has already

undergone an exciton-scattering or pair-annihilation interaction starting from this hierarchy is assigned a different lifetime, one of the two quantities

$$T'_u(p, E) = [\lambda_+^{(uu)}(p) + \lambda_+^{(ub)}(p) + \sum_b \int W_b(p, \epsilon) d\epsilon]^{-1} , \quad (41a)$$

$$T'_b(p, E) = [\lambda_+^{(bb)}(p) + \lambda_+^{(bu)}(p)]^{-1} \quad (41b)$$

The strengths passing through states of different p values are then found from a set of recursion relations:

$$S_d(p) = P_d(p) , \quad (42a)$$

$$S_u(p) = P_u(p) + P_b(p) \Gamma_0^{(bu)}(p) T'_u(p)/T_u(p) , \quad (42b)$$

$$S_b(p) = P_b(p) + P_u(p) \Gamma_0^{(ub)}(p) T'_b(p)/T_b(p) , \quad (42c)$$

and

$$P_d(p+1) = S_d(p) \Gamma_+^{(uu)}(p) \equiv P_d(p) \Gamma_+^{(uu)}(p) , \quad (43a)$$

$$P_u(p+1) = S_u(p) \Gamma_+^{(uu)}(p) + S_b(p) \Gamma_+^{(bu)}(p) , \quad (43c)$$

$$P_b(p+1) = S_b(p) \Gamma_+^{(bb)}(p) + S_u(p) \Gamma_+^{(ub)}(p) , \quad (43c)$$

with

$$\Gamma_+^{(uu)}(p) = \lambda_+^{(uu)}(p) T_u(p) , \quad (44a)$$

$$\Gamma_+^{(ub)}(p) = \lambda_+^{(ub)}(p) T_u(p) , \quad (44b)$$

$$\Gamma_0^{(ub)}(p) = [\lambda_0^{(ub)}(p) + \lambda_-^{(ub)}(p)] T_u(p) , \quad (44c)$$

and similarly for $\Gamma_+^{(bb)}$, $\Gamma_+^{(bu)}$ and $\Gamma_0^{(bu)}$ but with the u and b labels interchanged.

The preequilibrium energy differential cross sections are then given in terms of the strength variables. The total MSD and MSC preequilibrium cross sections are

$$\frac{d\sigma}{d\epsilon}(a,b)_{\text{PRE}} = \sigma_a(\epsilon_a) \sum_{p=p_0}^{\bar{p}} S_u(p) T_u(p) W_b^{(u)}(p,\epsilon) , \quad (45a)$$

$$\frac{d\sigma}{d\epsilon}(a,b)_{\text{pre-MSD}} = \sigma_a(\epsilon_a) \sum_{p=p_0}^{\bar{p}} S_d(p) T_u(p) W_b^{(u)}(p,\epsilon) , \quad (45b)$$

$$\frac{d\sigma}{d\epsilon}(a,b)_{\text{pre-MSD}} = \frac{d\sigma}{d\epsilon}(a,b)_{\text{PRE}} - \frac{d\sigma}{d\epsilon}(a,b)_{\text{pre-MSD}} , \quad (45c)$$

where $\sigma_a(\epsilon_a)$ is the cross section for forming the composite nucleus when the projectile has energy ϵ_a . The evaporation or equilibrium components are determined by taking all of the input reaction cross section not used in the preequilibrium phase of the reaction and distributing it among the various reaction channels in proportion to their phase space. Only evaporation from the original compound nucleus is presently considered in the program. Subsequent emission from the residual nuclei is left out.

The energy differential evaporation cross section for the first emitted particle in a reaction is

$$\frac{d\sigma}{d\epsilon}(a,b)_{\text{EVAP}} = [\sigma_a(\epsilon_a) - \sigma_{\text{PRE}}] \frac{W_b(\epsilon)}{\sum_b \int W_b(\epsilon) d\epsilon} , \quad (46)$$

where the total preequilibrium cross section, σ_{PRE} , is

$$\sigma_{\text{PRE}} = \sum_b \int \frac{d\sigma}{d\epsilon}(a,b)_{\text{PRE}} d\epsilon . \quad (47)$$

I.6 Pairing Corrections

While preequilibrium pairing corrections are best made and studied in the two-component exciton model, they are

sometimes included in the one-component model.

In the present code, two sets of pairing corrections are used: $\Delta_{\text{pre}}(Z,N)$ is used for states with $h \leq 2$, while the equilibrium pairing correction $\Delta_{\text{eq}}(Z,N)$ is used for $h > 2$. The quantity Δ_{pre} may be zero, the equilibrium value or a special preequilibrium pairing correction, perhaps related to the number of broken proton or neutron pairs in states with $n = n_0$ [GR73][GR76]. Likewise, $\Delta_{\text{eq}}(Z,N)$ may also be taken to be zero.

Whenever pairing energy corrections are used, the quantity E in the state density expressions should be replaced by $(E - \Delta_{\text{pre}})$ or $(E - \Delta_{\text{eq}})$ depending on the value of h , and similarly for U in the state densities for the residual nuclei.

II. DIRECT REACTION MODELS

Two classes of direct reactions which are not included in the Griffin model are nucleon transfer (stripping, pickup and exchange) and knockout or inelastic-scattering processes which involve complex particle degrees of freedom. These are treated semi-empirically in subroutines in PRECO-D. The formulae used are refined somewhat from those in [KA77].

II.1 Nucleon Transfer

The basic equation for the energy differential cross section for nucleon transfer is

$$\frac{d\sigma}{d\varepsilon}(a,b)_{NU} = \frac{(2s_b+1) A_b \varepsilon \sigma_{b-NE}(\varepsilon)}{(2s_a+1) A_a A_a \varepsilon_a} K_{\alpha,p} \left(\frac{A_a}{E_a + V_a} \right)^{2n} \left(\frac{2860}{A_B} \right)^n$$

$$0.0127 \sum_{p_\pi} \left(\frac{2Z_T}{A_T} \right)^{6n_\pi} \frac{p!}{p_\pi! p_\nu!} \frac{h!}{h_\pi! h_\nu!} \frac{g_\pi^{n_\pi} g_\nu^{n_\nu}}{g^n}$$

$$\omega(p,h,U) , \quad (48)$$

where the subscripts a and B refer to the projectile and residual nucleus. The inverse cross sections, $\sigma_b(\varepsilon)$, used in the main program are assumed to be the total composite nucleus formation cross section, while $\sigma_{b-NE}(\varepsilon)$ here is the total nonelastic cross section. The two are assumed to be related by

$$\sigma_b(\varepsilon) \begin{cases} = 0.95 \sigma_{b-NE}(\varepsilon) & \text{for } b = \text{nucleon} \\ = 0.85 \sigma_{b-NE}(\varepsilon) & \text{for } b = \text{complex} . \end{cases} \quad (49)$$

The quantities E_a and ε_a are the laboratory and center of mass energies of the projectile, while V_a is the average potential seen by the projectile in the direct reaction region. It is taken to be one-fourth of the real central well depth or

$$V_a = \frac{50 \text{ MeV } A_a}{4} . \quad (50)$$

The constant $K_{\alpha,p}$ gives a factor of 12 enhancement to the

nucleon transfer whenever the projectile and ejectile are both tightly bound (*i.e.*, a nucleon or an alpha particle). It is unity for all other reactions. The particle and hole numbers are given by $p=p_{\pi}+p_{\nu}$ and $h=h_{\pi}+h_{\nu}$, where p_{π} , p_{ν} , h_{π} , and h_{ν} are the numbers of stripped protons and neutrons and picked-up protons and neutrons, respectively. In general, these variables are uniquely determined by the natures of the incoming and outgoing particles. For inelastic channels of weakly bound projectiles (d, t or ^3He), however, exchange of either a proton or a neutron with the target is allowed. Thus there will be two contributions to the nucleon transfer cross section, one with $p_{\pi}=h_{\pi}=1$ and $p_{\nu}=h_{\nu}=0$, and the other having $p_{\pi}=h_{\pi}=0$ and $p_{\nu}=h_{\nu}=1$. This is the only case where the sum over p_{π} is needed. Finally, g_{π} and g_{ν} are the proton and neutron single-particle-state densities, assumed to be $g_{\pi} = g_{\circ}(Z/A)$ and $g_{\nu} = g_{\circ}(N/A)$ evaluated in the residual nucleus.

The nucleon-transfer cross section as given here will be in mb/MeV. All of the energies are assumed to be in MeV and the nonelastic cross sections in mb.

II.2 Knockout and Inelastic Processes with Complex Particle Degrees of Freedom

In this type of mechanism, a complex projectile is assumed to be able to excite a proton, neutron or alpha cluster particle/hole pair in its initial interaction and

to retain its own cluster identity in the interaction. Nucleon pair excitation by a nucleon projectile is already considered in the exciton model, so only alpha cluster excitation is considered here for incident neutrons and protons. The basic equations for knockout and inelastic scattering are

$$\frac{d\sigma}{d\varepsilon}(a,b)_{\text{KO}} = \frac{\sigma_{a\text{-NE}}}{13.5} (2s_b+1) A_b \varepsilon \sigma_{b\text{-NE}}(\varepsilon) \frac{P_b g_a g_b [U-A(A_a, A_b)]}{\sum_{c=a,b} (2s_c+1) A_c \bar{\sigma}_c (\varepsilon_m+2B_c) (\varepsilon_m-B_c)^2 (g_a g_b^2/6g_c)} , \quad (51)$$

$$\frac{d\sigma}{d\varepsilon}(a,a')_{\text{INEL}} = \frac{\sigma_{a\text{-NE}}}{13.5} (2s_a+1) A_a \varepsilon \sigma_{a\text{-NE}}(\varepsilon) \sum_{i=n,p,\alpha} \frac{P_i g_i^2 [U-A(A_i, A_i)]}{\sum_{c=i,a} (2s_c+1) A_c \bar{\sigma}_c (\varepsilon_m+2B_c) (\varepsilon_m-B_c)^2 (g_a g_i^2/6g_c)} \text{ for } a = \text{complex} , \quad (52a)$$

$$\frac{d\sigma}{d\varepsilon}(a,a')_{\text{INEL}} = \frac{\sigma_{a\text{-NE}}}{13.5} (2s_a+1) A_a \varepsilon \sigma_{a\text{-NE}}(\varepsilon) \frac{P_\alpha g_\alpha [U-A(4,4)]}{\sum_{c=a,\alpha} (2s_c+1) A_c \bar{\sigma}_c (\varepsilon_m+2B_c) (\varepsilon_m-B_c)^2 (g_a g_\alpha^2/6g_c)} \text{ for } a = \text{nucleon} . \quad (52b)$$

The quantity ε_m is the energy of the ground state transition for emission of a particle of type c , while $\sigma_{a\text{-NE}}$ with no energy variable specified is the nonelastic cross section for the entrance channel. The cross section $\bar{\sigma}_c$ is the average for all emission energies above the Coulomb barrier

for particles of type c. The probabilities for exciting the different kinds of particle/hole pairs are

$$P_n = \frac{N_T - f Z_T}{A_T - 2f Z_T + f Z_T/2} \approx \frac{N_T}{A_T} , \quad (53a)$$

$$P_p = \frac{Z_T - f Z_T}{A_T - 2f Z_T + f Z_T/2} \approx \frac{Z_T}{A_T} , \quad (53b)$$

$$P_\alpha = \frac{f Z_T/2}{A_T - 2f Z_T + f Z_T/2} \approx \frac{f Z_T}{2 A_T} . \quad (53c)$$

Here the quantity f is defined as the fraction of the time that four nucleons in correlated orbits will "look like" an alpha cluster or, alternatively, the fraction of the possible alpha clusters that will, on the average, exist at any given time. It has been assumed that $N \geq Z$, so that a maximum of $Z/2$ alpha clusters is possible. In general $f \ll 1$. The exact size and systematics of f are not well known. Here the values obtained from (p, α) reactions by neglecting pickup [MI74] are renormalized slightly and parameterized to give

$$f \begin{cases} = 0.08 & N_T \leq 116 \\ = 0.02 + 0.06(126 - N_T)/10 & 116 < N_T < 126 \\ = 0.02 + 0.06(N_T - 126)/3 & 126 \leq N_T < 129 \\ = 0.08 & 129 \leq N_T . \end{cases} \quad (54)$$

In evaluating the single-particle-state densities for the different types of emitted particles, it is assumed that all of the nucleons of a cluster are in correlated orbits, each holding a maximum of two protons and two neutrons. In addition it should be recognized that a cluster of A_b

nucleons will carry A_b times the energy of a single particle in one of these orbits. Thus we get

$$g_n = g_o N/A = (N/13) \text{ MeV}^{-1} , \quad (55a)$$

$$g_p = g_o Z/A = (Z/13) \text{ MeV}^{-1} , \quad (55b)$$

$$g_d = g_o/4 = (A/52) \text{ MeV}^{-1} , \quad (55c)$$

$$g_t = g_\tau = g_o/12 = (A/156) \text{ MeV}^{-1} , \quad (55d)$$

$$g_\alpha = g_o/16 = (A/208) \text{ MeV}^{-1} . \quad (55e)$$

In each case they are evaluated in the appropriate residual nucleus. Once again, the final cross sections are in mb/MeV.

III. ANGULAR DISTRIBUTIONS

The angular distributions are calculated phenomenologically in terms of Legendre polynomials using the formula [KA81a]

$$\begin{aligned} \frac{d^2\sigma}{d\Omega d\epsilon}(a,b) = & a_o(\text{MSD}) \sum_{\ell=0}^6 b_\ell(e) P_\ell(\cos\theta) \\ & + a_o(\text{MSC}) \sum_{\substack{\ell=0 \\ \Delta\ell=2}}^6 b_\ell(e) P_\ell(\cos\theta) , \end{aligned} \quad (56)$$

where $e = \epsilon + I_{\text{ang}} \cdot B_b$ and I_{ang} is either 0 or 1, and where

$$a_o(\text{MSD}) = \frac{1}{4\pi} \left(\frac{d\sigma}{d\epsilon}(a,b)_{\text{pre-MSD}} + \frac{d\sigma}{d\epsilon}(a,b)_{\text{NU}} + \frac{d\sigma}{d\epsilon}(a,b)_{\text{KO}} \right) . \quad (57a)$$

(For the reaction (a,a') the knockout contribution is, of course, replaced by an inelastic contribution.)

$$a_o(\text{MSC}) = \frac{1}{4\pi} \left(\frac{d\sigma}{d\epsilon}(a,b)_{\text{pre-MSC}} + \frac{d\sigma}{d\epsilon}(a,b)_{\text{EVAP}} \right) , \quad (57b)$$

$$b_{\ell}(\varepsilon) \begin{cases} = \frac{(2\ell+1)}{1 + \exp[A_{\ell}(B_{\ell}-e)]} & \text{for } \ell \geq 1 \\ = 1 & \text{for } \ell = 1 \end{cases} \quad (58)$$

$$A_{\ell} = 0.036 \text{ MeV}^{-1} + 0.0039 \text{ MeV}^{-1} \ell(\ell+1) , \quad (59a)$$

$$B_{\ell} = [92 + 6 (I_{\text{ang}})] \text{ MeV} - 90 \text{ MeV} [\ell(\ell+1)]^{-1/2} . \quad (59b)$$

IV. ISOSPIN

For reactions induced by protons or ^3He ions with sufficient energy, states in the composite nucleus with two different total isospins can be populated: $T_{<} = T_z$ and $T_{>} = T_z + 1$. Therefore, it may sometimes be desirable to perform preequilibrium calculations in which the isospin quantum number is conserved [KA74].

To perform such isospin-conserved calculations, it is necessary to know the state densities for both the $T_{<}$ and $T_{>}$ configurations in a given nucleus. At equilibrium it is usually a reasonable approximation to take

$$\omega(E, T_{<}) = \omega(E) , \quad (60a)$$

$$\omega(E, T_{>}) = \omega(E - E_{\text{sym}}(Z, A)) , \quad (60b)$$

where $E_{\text{sym}}(Z, A)$ is the nuclear symmetry energy and can be obtained from the empirical formula [AN65]

$$E_{\text{sym}}(Z, A) = 1.44 \text{ MeV} \frac{Z+1/2}{A^{1/3}} - 1.13 \text{ MeV} + Q_{(p,n)}(Z-1, A) , \quad (61)$$

where $Q_{(p,n)}$ is the Q-value for the (p,n) reaction on the nucleus with the indicated proton and mass numbers.

For particle/hole state densities, a similar approximation has been used [KA74] giving

$$\omega(p, h, E, T_{\leftarrow}) = \omega(p, h, E) , \quad (62a)$$

$$\omega(p, h, E, T_{\rightarrow}) = \omega(p, h, E - E_{\text{sym}}(Z, A)) . \quad (62b)$$

Similar assumptions are assumed to apply for the T-conserving transition-state densities.

While such relations are the only ones which can currently be used in PRECO-D because isospin is not explicitly considered, they have a serious shortcoming for small values of $n=p+h$ where the state densities increase only as E^{n-1} [KA84]. Thus, isospin-dependent calculations are probably better carried out using the two-component exciton model code PRECO-E [KA84a] in which more accurate state density formulae are used.

In either code two calculations are performed, one for each isospin in the composite nucleus. The reaction cross sections are multiplied by the appropriate isospin Clebsch-Gordan coefficients and the state densities are evaluated using excitation energies measured relative to the lowest energy state of the isospin in question.

V. DESCRIPTION OF THE PROGRAM

The program PRECO-D2 is written in simple FORTRAN designed to be compatible with most computer systems. A general flow diagram is contained in Fig. 1; a list of variables is given

in Tables 1 and 2; Appendix A is a FORTRAN listing of the code; Appendix B contains sample input; Appendix C gives the corresponding output; and Appendix D lists the differences between PRECO-D2 and its predecessor, PRECO-D.

Input and output device numbers are assigned as IREA and IWRI, respectively, just following the COMMON statements, so they may be easily altered.

The Griffin, or exciton, model calculations are carried out in the main program, while direct reaction cross sections and angular distributions are calculated in subroutines. The subroutines NUTRA, KNOCK, and INEL handle, respectively, nucleon transfer, knockout involving cluster degrees of freedom, and inelastic scattering involving cluster degrees of freedom. The subroutine POLLY calculates a library of Legendre polynomials, while ANGEL generates the angular distributions for the emitted particles.

Reaction cross sections for the projectile and inverse-reaction cross sections for the emitted particles may, as an option, be calculated internally using an empirical approximation [NA79][CH81]. It has been modified here to go over to the geometrical cross section

$$\sigma_{b\text{-GEO}}(\epsilon) = \pi(1.23A^{1/3} + R_b + \lambda)^2 \quad (63)$$

at high energies, where R_b is the radius of the particle (0 for $b=n,p$; $0.8F$ for $b=d,t,\tau$; and $1.2F$ for $b=\alpha$). The parameter values are set in subroutine SIGPAR, while the entrance and exit channel cross sections are calculated in subroutine CROSS and the main program, respectively.

Initial calculations are always performed for the principal reaction channels of neutron, proton and alpha particle emission. Fission competition is included at equilibrium if a fission barrier has been specified. Spectra for other ejected light ions may be calculated at a later stage in the program. In the setup and calling of the direct reaction subroutines, it is assumed that both the incoming and outgoing particles have mass numbers no larger than 4.

The range of exciton numbers considered is determined from the input initial configuration, (p_0, h_0) , and the state density, $\omega(p, h, E)$. The difference $p-h$ is assumed to remain constant at $p_0 - h_0$. The smallest $n=p+h$ considered is the minimum value consistent with there being at least one degree of freedom to carry the excitation energy and with both p and h being nonnegative. In most cases $(p_0, h_0) = (A_a + 1, 1)$, so the simplest configuration of the system is $(A_a, 0)$. At the other extreme, the most complex configuration considered has its exciton number given by minimum $(\bar{n}, 20)$, where \bar{n} is the exciton number corresponding to the maximum in the $\omega(p, h, E)$ vs p curve and is therefore the most probable equilibrium value of n .

For particle emission to be allowed from a state, its particle number must be greater than or equal to the nucleon number of the emitted particle (*i.e.*, $p \geq A_b$) and n must be large enough for the residual nucleus to be left with at least one exciton (*i.e.*, $n \geq A_b + 1$).

VI. USE OF THE PROGRAM

VI.1 Initial Input

The input information requested for the first phase of the calculations is given below. Each numbered item corresponds to a new card or record of input, and the appropriate formats are given in parentheses. Default values are also indicated where they exist.

- i) Angular distribution parameter, I_{ang} , and Q-factor parameter, IG, (2I3) for all problems in the data file.
- ii) Effective well depths $V(h=1)$ and $V(h=2)$ in MeV (2F10.2) for all problems in the data file.
- 1) Composite nucleus excitation energy and projectile binding energy in MeV (2F10.2).
- 2) Z and N of the target nucleus (2F10.2)
- 3) n, p, and α binding energies and fission barrier height in the composite nucleus, all in MeV (4F10.2). If no fission barrier is specified, no fission is calculated.
- 4) Pairing energies for the n, p, and α residual nuclei and for the composite nucleus to be used in the preequilibrium phase of the calculation for states with $h \leq 2$ (4F10.2).
- 5) Pairing energy corrections for states with $h > 2$ and for equilibrium calculations. These are the conventional pairing energies that would be used in an evaporation model. (4F10.2).
- 6) Entrance channel nonelastic cross section and estimated average, $\bar{\sigma}_a$, for inelastic scattering (2F10.2). If either one is read in as zero, it is calculated internally using a parametric approximation to the optical model potentials indicated in Sect. VI.7 below.
- 7) Number of channel energies considered, NEPS(1), the lowest channel energy in MeV, and the increment in the channel energy also in MeV (1I3,2F10.2). If the lowest channel

energy is greater than zero, the remaining channel energies and all of the inverse reaction cross sections are calculated internally. (If the channel energy increment is zero, it defaults to 1 MeV.) If the lowest channel energy is read in as zero, input according to item 7a, below, is read in.

- 7a) NEPS(1) records, each containing (4F10.2) a channel energy in MeV and the corresponding n, p and α non-elastic cross sections in mb. The energies must be in ascending order.
- 8) Z and N of the projectile (2I3). If preferential excitation of an unpaired target nucleon is considered, then this nucleon should be counted as if it were part of the projectile.
- 9) Initial particle and hole numbers, p_0 and h_0 (2I3). If these are read in as zero, p_0 defaults to A_a+1 and h_0 defaults to unity.
- 10) Single-particle-state densities, g_0 , in MeV^{-1} for the composite system; the n, p and α residual nuclei; and the fission saddle point (5F10.2). If only the value for the composite nucleus is read in, the others are calculated assuming that g_0 is proportional to A. If g_0 for the composite nucleus is read in as zero, it defaults to $A/(13 \text{ MeV})$.
- 11) Matrix element scaling factor divided by 100 (*i.e.*, $k/100$) (1F10.2). If it is read in as zero, it defaults to 1.35 ($k=135 \text{ MeV}$).

VI.2 Initial Calculations

After initial input, the program proceeds to the calculation of state densities, transition rates and particle emission rates. The branching ratios, Γ , are generated and the closed-form calculations are executed.

At this point, the three principal particle types (n, p, and α) are considered in turn. For each, the necessary direct reaction subroutines are called to generate the

appropriate energy spectra. The results of the closed-form exciton model calculations are used to obtain MSD and MSC preequilibrium energy spectra. A first-chance evaporation spectrum is also calculated. For each emission energy the total MSD and MSC cross sections are used in the subroutine ANGEL to calculate an angular distribution. Finally, the single and double differential cross sections are printed out.

VI.3 Initial Output

The first quantities to be printed are S , the average effective separation energy, and the fraction of the total reaction cross section which goes into preequilibrium particle emission. These are part of a heading labelled OCCUPATION PROBABILITIES. Below the heading is a table with the following columns:

P	particle number of the class of states
H	hole number of the class of states
RHOU/RHO	ratio $\omega^{(u)}(p,h,E)/\omega(p,h,E)$ of unbound and total state densities
STRU/STR	ratio $P_u(p)/P(p)$ of strength arriving at states with p particle degrees of freedom which is in unbound states
STRD/STR	ratio $P_d(p)/P(p)$ of MSD strength to total strength arriving at states specified by p

Following this are two pages of output for each particle type, one containing the energy differential spectra and the other the angular distributions for the various outgoing energies. The column headings for the angle-integrated

spectra are

EPS	ϵ , the outgoing channel energy
DIRECT/NUTRA	nucleon transfer cross section from Eq. (48)
DIRECT/KNOCK	knockout or inelastic cross section from Eq. (51) or (52)
PREEQUILIBRIUM/MSD	MSD preequilibrium cross section from Eq. (45b)
PREEQUILIBRIUM/MSC	MSC preequilibrium cross section from Eq. (45c)
EQUIL/WEISS	evaporation cross section from Eq. (46)
TOTAL/MSD	"NUTRA"+"KNOCK"+"PREEQUILIBRIUM/MSD"
TOTAL/MSC	"PREEQUILIBRIUM/MSC"+"EQUIL/WEISS"
TOTAL/MSD+MSC	grand total

At the bottom of each column is the summed cross section for that component of the spectrum. If a fission barrier has been specified, the equilibrium fission cross section is printed below the sum of EQUIL/WEISS for the alpha spectra.

The angular distributions are printed in 10-deg increments. Angles from 0 to 90 deg are in one block of the table, while angles from 100 to 180 deg are in a second block. The first column of each block gives the channel energy; the remaining columns give the double differential cross section at the angle indicated in the column heading. The last column in the second block gives the angle-integrated cross sections and is identical to TOTAL/MSD+MSC above.

VI.4 Secondary Input

After printout of the occupation probabilities and of the neutron, proton and alpha particle spectra, the program reads the secondary input, which contains the following items:

- 12) Z and N of an additional particle type (2I3). (If Z<0, input passes to item 13a below.)
- 13) spin degeneracy, $2s+1$, of the emitted particle (1I3)
- 14) binding energy of emitted particle in MeV and the single-particle-state density in its residual nucleus in MeV^{-1} (2F10.2). If the single-particle-state density is zero, it defaults to $(g_o A_{res}/A_{cn})$.
- 15) preequilibrium ($h<2$) and equilibrium pairing corrections for the residual nucleus in MeV (2F10.2)
- 16) number of emitted particle energies considered = NEPS(2), the lowest emission channel energy, and the channel energy increment (1I3,2F10.2). If the lowest energy is greater than zero, the remaining energies and the inverse cross sections are calculated internally. (A zero channel energy increment defaults to 1 MeV.) If the minimum energy is zero (or less), input item 16a is read in.
- 16a NEPS(2) records, each containing a particle energy in MeV and the corresponding nonelastic cross section in mb (2F10.2). Energies must be in increasing order. [This ends the secondary input.]
- 13a) NEWP (1I3)
If NEWP = 1, input passes to item 8 in the initial input and new parameter values are read in.
If NEWP = 0, input passes to item 1 in the initial input for the beginning of a new problem.
If NEWP = -1, the job is terminated.

VI.5 Secondary Calculations

If a new particle type was chosen in item 12) above, the program uses the stored information on the results of the closed-form calculations to obtain the preequilibrium spectra for this particle type, and the appropriate direct reaction subroutines are called. The single and double differential cross sections are then printed in the same format as for the neutron, proton and alpha particle spectra. After printout, the program returns to item 12) in the secondary input so that an additional particle type may be specified.

VI.6 Calculations with Isospin

Preequilibrium model calculations in which isospin conservation is considered can be accomplished with PRECO-D2 by actually doing two calculations, one for each isospin in the composite nucleus. The changes in the input needed for the isospin-conserved calculations relative to the general (isospin-mixed) calculations just described are indicated in the table below for the initial input. All other quantities in the initial input are as indicated in VI.1 and VI.4 above.

In the table, the second set of input for B_n and $\sigma_{n-NE}(\epsilon)$ for the $T_>$ calculations applies if the neutron channel to the $T_>$ states in the residual nucleus is open.

Neutrons decay from the $T_>$ composite nucleus states to the ground state isospin if the residual nucleus is isospin-forbidden.

Normal	$T_<$	$T_>$
E	E	$E - E_{\text{sym}}(Z, A)$
B_n	B_n	$\begin{cases} 0 \\ B_n - E_{\text{sym}}(Z, A) + E_{\text{sym}}(Z-1, A) \end{cases}$
B_p	B_p	$B - E_{\text{sym}}(Z, A)$
B_α	B_α	0
σ_{a-NE}	$\sigma_{a-NE} [2T_0 / (2T_0 + 1)]$	$\sigma_{a-NE} [1 / (2T_0 + 1)]$
$\sigma_{n-NE}(\epsilon)$	$\sigma_{n-NE}(\epsilon)$	$\begin{cases} 0 \\ \sigma_{n-NE}(\epsilon) [2T_0 / (2T_0 + 1)] \end{cases}$
$\sigma_{p-NE}(\epsilon)$	$\sigma_{p-NE}(\epsilon) [2T_0 / (2T_0 + 1)]$	$\sigma_{p-NE}(\epsilon) [1 / (2T_0 + 1)]$
$\sigma_{\alpha-NE}(\epsilon)$	$\sigma_{\alpha-NE}(\epsilon)$	0
k	k	$k[E - E_{\text{sym}}(Z, A)]/E$

VI.7 Suggested Input

Appropriate values for the various input quantities are summarized below

- (p_0, h_0) $(A_a + 1, 1)$, where A_a is the mass number of the projectile (the default values).
- g_0 $A/13$ with values for the residual nuclei calculated in the program (the default).
- k 135 MeV^3 (input number is 1.35) (the default).
- B_b from [WA77] or similar mass tables

$\sigma_{n-NE}(\epsilon)$	from [MA63]	} (The default is approximations to these optical model cross sections.)
$\sigma_{p-NE}(\epsilon)$	from [BE69]	
$\sigma_{\alpha-NE}(\epsilon)$	from [HU62]	
$\sigma_{b-NE}(\epsilon)$	from [CL72] for $b=d,t, {}^3\text{He}$	

The choice of IANG = 0 or 1 is discussed in the second paper in [Ka81a]. In general, IANG=1 is probably to be preferred.

In addition, there is the choice of whether to use IG = 0, invoking Eq. (34), or IG = 1, invoking Eq. (35), for the Q-factors that account for proton/neutron distinguishability. For reasons of consistency in the model, IG = 1 is to be preferred.

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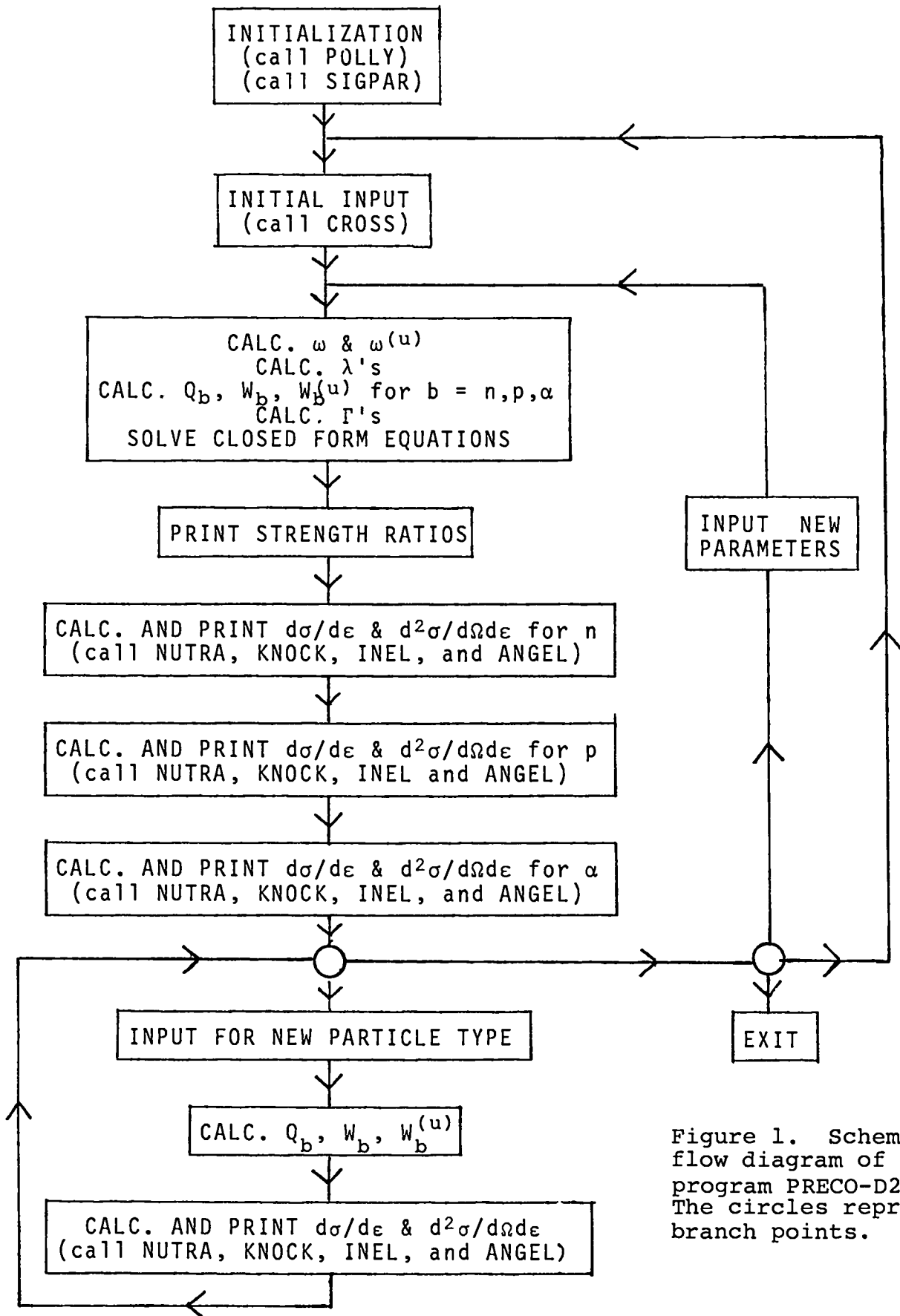


Figure 1. Schematic flow diagram of the program PRECO-D2. The circles represent branch points.

TABLE 1. LIST OF VARIABLES IN PRECO-D2

ACOM	Mass number of composite nucleus
AP	= JOUT, mass number of emitted particle
ASP,ASPR,AFISH	Level spacing parameter, a , for composite and residual nuclei and for top of fission barrier
BEA	Binding energy of projectile in composite nucleus (MeV)
BEN	Binding energy for extra emitted particle types (or temporarily of n , p or α) (MeV)
BF	Height of fission barrier (MeV)
BNEU,BPRO,BALFA	Binding energies of neutrons, protons and alpha particles in the composite nucleus
CLOSD(NP)	Time-integrated strength, $S_d(p) T_u(p)$, responsible for MSD preequilibrium cross section
CLOSU(NP)	Time-integrated strength, $S_u(p) T_u(p)$, responsible for MSD+MSC preequilibrium cross section
COUL(J)	Coulomb barriers for particles of type J , with $J=1-5$ corresponding to n , p , α , extra particle type and projectile, respectively; used in calculating direct reaction cross sections
DBL(NP)	$m(p)$, fraction of multiple unbound states
E	Excitation energy of composite nucleus (MeV)
EC	Coulomb barrier for use in calculating total-reaction cross sections (MeV)
EMU(J)	Maximum possible emission energy for particles of type J with $J=1-3$ for n , p and α
EPS (JHALF,NE)	Particle emission energies (MeV)
ES(I)	$\Theta(E-iS) (E-iS)/(E-S)$ for $i=1,10$
F2	Matrix element scale factor, k

FISHW Equilibrium cross section going into fission

FLOW, SPILL, POUR 10^{-18} , 10^{+18} , and 10^{+35} ; comparison numbers for underflow and overflow checks

FRAC(NP) Fraction of the available strength in states with $p=NP$ which is lost due to n , p and α emission in one unit of time, $\Delta t=TAUWM$

FWD(NH) Correction factor, $f(p)$, applied to $\omega(p,h,E)$ for $h < 2$ to account for the finite potential well depth

FWDHI(NP) $f_+(p)$ and (for $h > 2$) $f_0(p)$

FWDU(NP) $f_1(p)$

G, GNEU, GPRO, GALFA, GR, GFIS Single-particle-state densities in the composite nucleus; in the n , p , α and extra particle residual nuclei; and at the top of the fission barrier

GF, GFU, GU, GFAV $g(p)$, $g_u(p)$, $g_p(p)$ and $g_a(p)$ for $h < 2$

GFPU, GFHU $g_p(p)$ for $h > 2$ and g_h for all h

GAMBB, GAMBU $\Gamma_+^{(bb)}(p)$, $\Gamma_+^{(bu)}(p)$, $\Gamma_+^{(ub)}(p)$, and $\Gamma_+^{(uu)}(p)$
GAMUB, GAMUU

GAMZBU, GAMZUB $\Gamma_0^{(bu)}(p)$ and $\Gamma_0^{(ub)}(p)$

GEL(NP) $g[E-A(p,h)]$

GELU(NP) $g[E-A_{1,0}(p,h)-S]$ or 0, whichever is greater

GELUU(NP) $g[E-A_{2,0}(p,h)-2S]$ or 0, whichever is greater

IANG Angular distribution parameter. Energy parameter is $\epsilon+(IANG)(B_p)$

IG IG=0 invokes $Q_b(p)$; IG=1 invokes $Q_b^{(G)}(p)$

IREA, IWRI Input and output device numbers

JBAR Most probable particle number at equilibrium

JHALF JHALF=1 for primary calculations; JHALF=2 for secondary calculations (for additional emitted particle types)

JHI minimum of 20 and JBAR; maximum p considered in closed-form reaction equations

JLO	Minimum p which can supply the protons and neutrons for the emitted particle
JPIN, JNIN, JIN	Z , N and A of the projectile
JRZ, JRN	Z and N of target
JPOUT, JNOUT, JOUT	Z , N , and A of emitted particle
NE	Index for emission channel energies
NEPS(1), NEPS(2)	Number of emitted particle energies for primary and secondary calculations
NEWP	Control variable for selecting new values of the model parameters or recycling to a new problem
NLOE	Particle number of simplest states which can undergo nucleon emission
NAP1	Particle number of simplest states which can undergo emission of a given type of complex particle
NP	Index for particle number, p , of states
NPART, NHOLE	Initial particle and hole numbers, p_0 and h_0
NPHD, PHD	$p-h=p_0-h_0$
NDWN, NHDWN	Lower limit on particle and hole numbers
NUP	Maximum particle number accessible to system
NSD, SD	Spin degeneracy of emitted particle
PRET2	Full preequilibrium cross section for a given reaction and emission energy
PU, PB, PMSD	$P_u(p)$, $P_b(p)$ and $P_d(p)$; strengths arriving at states of given p by pair creation for the first time
PRMSC, PRMSD	MSC and MSD preequilibrium cross sections
PROB(J, NP)	$Q_b(p)$ or $Q_b^{(G)}(p)$; $J=1,2,3,4$ indicates $b=n,p,\alpha$ and extra particle type, respectively
PTOT	Fraction of strength left at end of preequilibrium calculations
P0, P1, P2, P	Parameters p_0 , p_1 , p_2 , and p for calculating entrance channel and inverse cross sections

RHO (NP)	$\omega(p, h, E)$
RHOU (NP)	$\omega^{(u)}(p, h, E)$
RA	radius of incident or emitted particle (used in calculating total-reaction cross sections)
RNN, RZZ	N and Z of target (same as JRN and JRZ)
RN, RZ	N/A and Z/A of target
S	Average effective separation energy
SIGCN	Entrance channel nonelastic cross section
SIGIN(J, NE)	Inverse nonelastic cross sections; J=1-4 has the same significance as for PROB
SIGBAR(J)	Average nonelastic cross section for channel J; J=1-5 has same significance as for COUL
SIZE	$g_0 E$
SNOCK	Cross section for knockout or inelastic scattering involving cluster degrees of freedom
SNUTRA	Cross section for direct nucleon transfer
STRB	Strength in bound states, = S_b
STRU	Strength in unbound states, = S_u
SUMKE, SUMNE	Energy integrals of the cross sections SNOCK and SNUTRA
SUMSC, SUMSD	Energy integrals of the cross sections PRMSC and PRMSD
SUMW	Energy integral of the cross section WEISS
TAUWM	Time unit, Δt , for evaluating transition rates, = $[20 \lambda_+(p_{\min}, h_{\min})]^{-1}$
TAUWU (NP)	Lifetime of an unbound state against all two-body interactions considered and n, p and α emission; = T_u
THIBB, THIBU, THIUB, THIUU	Pair-creation rates $\lambda_+^{(bb)}$, $\lambda_+^{(bu)}$, $\lambda_+^{(ub)}$, and $\lambda_+^{(uu)}$

TLOBU, TLOUB	Pair-annihilation rates $\lambda_{-}^{(bu)}$ and $\lambda_{-}^{(ub)}$
TNOBU, TNOUB	Exciton-scattering rates $\lambda_{0}^{(bu)}$ and $\lambda_{0}^{(ub)}$
TIMHI	$\lambda_{+}(p_{\min}, h_{\min})$
TOMSC(NE), TOMSD(NE)	Total MSC and MSD cross sections for a given emission energy
U	Residual nucleus excitation energy
WU(J, NP, NE)	$W_{b}^{(u)}(p, h, \epsilon)$ with J=1-4 having the same significance as for PROB
WEISS(J, NE)	Weisskopf-Ewing evaporation cross section; J=1,4 as for PROB
XL0, XL1	Parameters λ_{0} and λ_{1} for calculating entrance-channel and inverse-reaction cross sections
XLAMB	Parameter λ for calculating entrance-channel and inverse-reaction cross sections
XM0, XM1, XMU	Parameters μ_{0} , μ_{1} and μ for calculating entrance-channel and inverse-reaction cross sections
XN0, XN1, XN2, XNU	Parameters ν_{0} , ν_{1} , ν_{2} , and ν for calculating entrance-channel and inverse-reaction cross sections

TABLE 2. ADDITIONAL VARIABLES IN SUBROUTINES

ANGEL

AL,BL	A_ℓ and B_ℓ for calculating Legendre polynomial coefficients
AOMSC,AOMAD	TOMSC and TOMSD from MAIN, each divided by 4π ; = a_0 (MSC) and a_0 (MSD)
EPSCM	EPS (JHALF,NE)
POL(J,L+1)	Legendre polynomial of order L for an angle of $10(J-1)$ degrees; (generated in subroutine POLLY)
SIGMA	Double differential cross section

CROSS

(none)

INEL

EMAX,UMAX	Maximum emission energy and maximum residual nucleus excitation energy
GBN,GBA	Nucleons and alpha particles in the residual nuclei formed by the knock-out of these particles
GII,GIR	Cluster single-particle-state density in the residual nuclei formed from emission of the cluster and from reemission of the projectile

KNOCK

EMAX,UMAX	(as in INEL)
GA,GBR,GBT	Projectile single-particle-state density in the residual nucleus and emitted-particle-state densities in the residual and target nuclei

NUTRA

GN,GP g_ν and g_π in the residual nucleus
JPICKN,JPICKP Number of picked-up neutrons and protons
JSTRIN,JSTRIP Number of stripped neutrons and protons
TRANN,TRANP Number of transferred neutrons and protons
UMAX (as in INEL)
VAB Effective potential, V_a , seen by the
projectile in the interaction region
VELO Projectile velocity in the interaction
region

POLLY

ANG Angle, θ , first in degrees and then in
radians
POL(J,L+1) (as in ANGEL)

SIGPAR

(none)

APPENDIX A

FORTRAN LISTING OF PRECO-D2

Los Alamos Identification No. LP-1654

```

1 C   PRECO-D
2 C   WRITTEN BY C. KALBACH
3 C   CLOSED FORM PREEQUILIBRIUM REACTION CALCULATIONS
4 C   IN GRIFFIN MOOEL FORMALISM
5 C   WITH MULTI-STEP DIRECT EXTRACTED
6 C
7 C   SUBROUTINES FOR PHENOMENOLOGICAL DESCRIPTIONS OF
8 C   1. DIRECT KNOCKOUT AND INELASTIC SCATTERING INVOLVING COMPLEX
9 C     PARTICLE CLUSTERS
10 C  2. DIRECT NUCLEON TRANSFER
11 C  3. ANGULAR DISTRIBUTIONS
12 C  4. OPTION FOR APPROXIMATE REACTION CROSS SECTIONS INTERNALLY
13 C  DIRECT REACTION FORMALISM
14 C  VERIFIED FOR NUCLEON AND ALPHA INCIDENT
15 C  USE WITH CAUTION FOR O OR 3HE INCIDENT
16 C  (NO DIRECT RXN CALC FOR HEAVIER PROJECTILES)
17 C  (NO APPROX RXN CROSS SECTIONS FOR ADUT.GT.4)
18 C
19 C   PRAISE THE LORD
20 C
21   COMMON ESUM(4),RHO(31),RHO(31),NEPS(2),ES(10),DELTA(2)
22   1,PROB(4,30),TAUWU(31),RATIO(31,2),FRAC(31),WEISS(4,51),WU(4,31,51)
23   2,CLOSO(31),CLOSU(31),EMU(3),FWO(3),FWOU(32),OBL(31),FWOHI(32)
24   3,GEL(32),GELU(32),GELUU(32),GF(3),GU(3),GFU(3),GFAV(3),EHOLE(3)
25   4,GAMUU(31),GAMUB(31),GAMBU(31),GAMBB(31),GAMZUB(31),GAMZBU(31)
26   COMMON /ANGELS/ POL(19,7),TOMSO(51),TOMSC(51),IWRI, IANG
27   COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNDOUT,JPOUT
28   COMMON /DIRECT/ SIGIN(4,51),JPIN,JNIN,BEA,NSD,KP,E,ACOM,G,RZZ
29   COMMON /NUTRAN/ SNUTRA(51)
30   COMMON /CLUSTR/ SNOCK(51),SIGBAR(5),SIGCN,COUL(5),BNEU,BPRD,BALFA
31   COMMON /PAR/ PO(3,3),P1(3,3),P2(3,3),XLO(3,3),XL1(3,3),XMO(3,3)
32   1,XM1(3,3),XNO(3,3),XN1(3,3),XN2(3,3)
33 C
34   CALL LINK("UNIT5=PRECOINP,UNIT6=(PRECDUT,CREATE,HC),//")
35 C
36   IREA=5
37   IWRI=6
38   READ(IREA,5)IANG,IG
39   READ(IREA,3)EHOLE(2),EHOLE(3)
40   EHOLE(1)=EHOLE(3)
41 1  DD 2 NP=1,31
42   GEL(NP)=0.
43   GELU(NP)=0.
44   GELUU(NP)=0.
45   RHO(NP)=0.
46   RHO(NP)=0.
47   GAMUU(NP)=0.
48   GAMUB(NP)=0.
49   GAMBU(NP)=0.
50   GAMBB(NP)=0.
51   GAMZUB(NP)=0.
52   GAMZBU(NP)=0.
53   FRAC(NP)=0.
54 2  CONTINUE
55   GEL(32)=0.
56   GELU(32)=0.
57   GELUU(32)=0.
58   DD 4 KP=1,4
59   DD 4 NP=1,50
60 4  PROB(KP,NP)=0.
61   DD 8 KP=1,4
62   DD 8 NE=1,51
63   SIGIN(KP,NE)=0.
64 8  WEISS(KP,NE)=0.
65   DD 11 I=1,19
66   DD 11 J=1,7
67 11 POL(I,J)=0.
68 C
69 C   GENERATE TABLE OF LEGENORE POLYNOMIALS
70   CALL POLLY

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71 C   GENERATE PARAMETERS FOR APPROX SIGMA INVERSE
72     CALL SIGPAR
73 C
74 C   INPUT
75 C
76     READ(IREA,3)E,BEA
77 3    FORMAT(5F10.2)
78     READ(IREA,3)RZZ,RNN
79     RN=RNN/(RNN+RZZ)
80     RZ=1.-RN
81 5    FORMAT(3I3)
82     READ(IREA,3)BNEU,BPRD,BALFA,BF
83     READ(IREA,3)PAIRN,PAIRP,PAIRA,PAIRC
84     READ(IREA,3)EPAIRN,EPAIRP,EPAIRA,EPAIRC
85     READ(IREA,3)SIGCN,SIGBAR(5)
86 6    READ(IREA,13)NEPS(1),EPS(1.2),DELTA(1)
87 13   FORMAT(1I3,2F10.2)
88     IF(NEPS(1).LE.50)GO TO 12
89     WRITE(IWRI,10)
90 10   FORMAT(18H-TOO MANY ENERGIES)
91     GO TO 1000
92 12   IF(NEPS(1).LE.0)NEPS(1)=1
93     NEPS1=NEPS(1)+1
94     IF(EPS(1.2).GT.0.)GO TO 9
95     DELTA(1)=-1.
96     DO 7 NE=2,NEPS1
97     READ(IREA,3)EPS(1,NE),SIGIN(1,NE),SIGIN(2,NE),SIGIN(3,NE)
98 7    CONTINUE
99 9    READ(IREA,5)JPIN,UNIN
100    JIN=JPIN+UNIN
101    XIN=JIN
102    ACOM=RNN+RZZ+XIN
103    IF(DELTA(1).LT.0.)GO TO 17
104    IF(DELTA(1).LE.0.)DELTA(1)=1.
105    DO 15 NE=3,NEPS1
106    OEL=NE-2
107 15   EPS(1,NE)=EPS(1.2)+OEL*DELTA(1)
108    JHALF=1
109    JNOUT=1
110    JPOUT=0
111    KP=1
112    CALL CROSS
113    JNOUT=0
114    JPOUT=1
115    KP=2
116    CALL CROSS
117    JNOUT=2
118    JPOUT=2
119    KP=3
120    CALL CROSS
121 17   EPS(1,1)=EPS(1.2)-1.
122    IF(EPS(1,1).LT.0.)EPS(1,1)=0.
123    EPS(1,NEPS1+1)=EPS(1,NEPS1)+1.
124    ATHRD=(ACOM-1.)*0.33
125    COUL(1)=0.
126    XPIN=JPIN
127    COUL(2)=0.75*(RZZ+XPIN-1.)/ATHRD
128    ATHRD=(ACOM-4.)*0.33
129    COUL(3)=1.50*(RZZ+XPIN-2.)/ATHRD
130    ATHRD=(RZZ+RNN)*0.33
131    COUL(5)=0.75*XPIN*RZZ/ATHRD
132    DO 14 KP=1,3
133    ESUM(KP)=0.
134 14   SIGBAR(KP)=0.
135     EMU(1)=E-BNEU
136     EMU(2)=E-BPRD
137     EMU(3)=E-BALFA
138     DO 18 KP=1,3
139     DO 16 NE=2,NEPS1
140     IF(EPS(1,NE).LT.COUL(KP))GO TO 16
141     IF(EPS(1,NE).GT.EMU(KP))GO TO 18
142     EINT=(EPS(1,NE+1)-EPS(1,NE-1))/2.
143     ESUM(KP)=ESUM(KP)+EINT
144     SIGBAR(KP)=SIGBAR(KP)+SIGIN(KP,NE)*EINT
145 16   CONTINUE
146 18   IF(ESUM(KP).GT.0.)SIGBAR(KP)=SIGBAR(KP)/ESUM(KP)
147     IF(SIGBAR(5).GT.0.)GO TO 27
148     IF(JIN.NE.1)GO TO 21
149     SIGBAR(5)=SIGBAR(JPIN+1)

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150      GO TO 27
151 21    IF(JIN.NE.4)GO TO 22
152      SIGBAR(5)=SIGBAR(3)
153      GO TO 27
154 22    JPOUT=JPIN
155      JNOUT=JNIN
156      JHALF=2
157      KP=4
158      NEPS1=(E-BEA)*ACOM/(2.*(ACOM-XIN))
159      DO 23 NE=2,NEPS1
160 23    EPS(2,NE)=2*(NE-1)
161      CALL CROSS
162      EPS(2,1)=1.
163      EPS(2,NEPS1+1)=EPS(2,NEPS1)+1.
164      ESUM(4)=0.
165      DO 25 NE=2,NEPS1
166      IF(EPS(2,NE).LT.COUL(5))GO TO 25
167      EINT=(EPS(2,NE+1)-EPS(2,NE-1))/2.
168      ESUM(4)=ESUM(4)+EINT
169      SIGBAR(5)=SIGBAR(5)+SIGIN(4,NE)*EINT
170 25    SIGIN(4,NE)=0.
171      IF(ESUM(4).GT.O.)SIGBAR(5)=SIGBAR(5)/ESUM(4)
172      NEPS1=NEPS1+1
173      JHALF=1
174 27    IF(SIGCN.GT.O.)GO TO 38
175      IF(JPIN.GT.O)GO TO 29
176      EC=2.4
177      XLAMB=XLO(1,2)/ATHRD+XL1(1,2)
178      XMU=XMO(1,2)=ATHRD+XM1(1,2)=ATHRD=ATHRD
179      XNU=XNO(1,2)=ATHRD*(RZZ+RNN)+XN1(1,2)=ATHRD=ATHRD+XN2(1,2)
180      GO TO 37
181 29    I=JPIN+1
182      J=JNIN+1
183      XLAMB=XLO(I,J)*(RZZ+RNN)+XL1(I,J)
184      XNU=(RZZ+RNN)**XM1(I,J)
185      XMU=XMO(I,J)*XNU
186      RA=1.20
187      IF(JIN.EQ.1)RA=0.
188      EC=1.44*XPIN=RZZ/(1.5*ATHRD+RA)
189      XNU=XNU*(XNO(I,J)+XN1(I,J)*EC+XN2(I,J)*EC*EC)
190      IF(JIN.EQ.2)RA=0.8
191      IF(JIN.EQ.3)RA=0.8
192      XNL=XNU/XLAMB
193      IF(XNL.GT.SPILL)XNL=0.
194      IF(XNL.LT.FLOW)GO TO 37
195      ETEST=1.2*SQRT(XNL)
196 37    ELAB=(E-BEA)*ACOM/(ACOM*XIN)
197      SIGCN=XLAMB*ELAB+XMU+XNU/ELAB
198      IF(XNL.LT.FLOW)GO TO 40
199      IF(ELAB.LT.ETEST)GO TO 40
200      GEOM=SQRT(XIN*(E-BEA))
201      GEOM=1.23*ATHRD+RA+4.573/GEOM
202      GEOM=31.416*GEOM=GEOM
203      IF(SIGCN.LT.GEOM)SIGCN=GEOM
204      GO TO 38
205 40    IF(ELAB.GE.EC)GO TO 38
206      XP=PO(I,J)+P1(I,J)/EC+P2(I,J)/(EC*EC)
207      XA=-2.*XP*EC+XLAMB-XNU/(EC*EC)
208      XB=XP*EC*EC+XMU+2.*XNU/EC
209      ECUT=0.
210      CUT=XA*XA-4.*XP*XB
211      IF(CUT.GT.O.)ECUT=SQRT(CUT)
212      ECUT=(ECUT-XA)/(2.*XP)
213      SIGCN=XP*ELAB=ELAB+XA*ELAB+XB
214      IF(ELAB.LT.ECUT)SIGCN=0.
215 38    READ(IREA,5)NPART,NHOLE
216      N=NPART+NHOLE
217      IF(N.GT.O)GO TO 39
218      NPART=JIN+1
219      NHOLE=1
220 39    READ(IREA,3)G,GNEU,GPRD,GALFA,GFIS
221      IF(G.LE.O.)G=ACOM/13.
222      READ(IREA,3)F2
223      IF(F2.LE.O.)F2=1.35
224      SIZE=G*(E-EPAIRC)
225      E=E-PAIRC
226      NPHO=NPART-NHOLE
227      PHO=NPHO

```

```

228 FLOW=1.E-18
229 SPILL=1.E+18
230 V=38.
231 C
232 C EFFECTIVE G VALUES
233 C
234 DO 19 I=1,3
235 GF(I)=0.
236 Y=I-1
237 X=NPART-NHOLE+I-1
238 IF(X.LT.O.)GO TO 19
239 PHND=X+Y
240 IF(PHND.LE.O.)GO TO 19
241 ENEX=E/(PHND*38.)
242 GFP=1.+ENEX
243 GFP=SQRT(GFP)
244 GFH=1.-ENEX
245 IF(GFH.LT.O.)GFH=0.
246 GFH=SQRT(GFH)
247 GF(I)=G*(X*GFP+Y*GFH)/PHND
248 19 CONTINUE
249 COULP=BPRO+COUL(2)
250 COULA=BALFA+COUL(3)
251 S=AMIN1(BNEU,COULP,COULA)
252 IF(S.LT.O.)S=0.
253 GFPU=(38.+S)/38.
254 GFPU=SQRT(GFPU)*G
255 GFHU=(38.-S)/38.
256 IF(GFHU.LT.O.)GFHU=0.
257 GFHU=SQRT(GFHU)*G
258 DO 24 I=1,3
259 XX=1.
260 GU(I)=G
261 GFU(I)=G
262 GFAV(I)=G
263 Y=I-1
264 X=NPART-NHOLE+I-1
265 IF(X.LT.O.)GO TO 24
266 PHND=X+Y
267 IF(PHND.LE.O.)GO TO 24
268 PHND1=PHND-1.
269 ENEX=(E*S)/(PHND*38.)
270 GFP=SQRT(1.+ENEX)
271 GFH=1.-ENEX
272 IF(GFH.LT.O.)GFH=0.
273 GFH=SQRT(GFH)
274 Z=1.+ENEX+S/38.
275 GU(I)=G*SQRT(Z)
276 IF(PHND1.LE.O.)GO TO 20
277 GFU(I)=G*((X-1.)*GFP+Y*GFH)/PHND1
278 20 IF(PHND.GT.2.)GFAV(I)=((PHND*3.)*GFU(I)+GU(I))/(PHND-2.)
279 C
280 C FWD CORRECTION FOR FULL STATE DENSITY
281 C
282 V=EHDLE(I)
283 IF(E.LE.V)GO TO 24
284 IF(I.EQ.1)GO TO 24
285 X=E**PHND1
286 EV=(E-V)**PHND1
287 XX=1.-Y*EV/X
288 EV2=E-V-V
289 IF(EV2.LE.O.)GO TO 24
290 EV2=EV2**PHND1
291 XX=XX+Y*(Y-1.)*0.5*EV2/X
292 IF(XX.LT.O.)XX=0.
293 24 FWD(I)=XX
294 E=E+PAIRC-EPAIRC
295 C
296 C UNBOUND STATE CORRECTION FUNCTION
297 C AND MULTIPLE UNBOUND CORRECTION. M(P)
298 C
299 X=E-S
300 DO 26 I=1,10
301 26 ES(I)=0.
302 DO 28 I=1,10
303 IF(X.LE.O.)GO TO 30
304 XI=I
305 Y=(E-XI*S)/X
306 IF(Y.LE.O.)GO TO 30

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307      ES(I)=Y
308 28   CONTINUE
309      E=E+EPAIRC
310 30   NTERM=I-1
311      DO 36 NP=1,30
312      NP1=NP+1
313      FT2=0.
314      FWDU(NP1)=0.
315      OBL(NP1)=0.
316      FWDHI(NP1)=0.
317      P=NP
318      NH=NP-NPHD
319      H=NH
320      IF(H.LT.O.)GO TO 36
321      PH1=P+H-1.
322      FT=ES(1)
323      IF(PH1.LE.O.)GO TO 35
324      FT=0.
325      LIM=MINO(NP,NTERM)
326      BIN=1./P
327      SI=-1.
328      IF(NH.GT.2)GO TO 32
329      EE=E-PAIRC
330      IF(EE.LE.S)GO TO 36
331      Y=EE-S
332      DO 31 I=1,LIM
333      XI=I
334      BIN=BIN*(P-XI+1.)/XI
335      SI=-SI
336      X=(EE-XI*S)/Y
337      IF(X.LT.O.)X=0.
338      IF(X.GT.O.)X=X**PH1
339      IF(X.LT.FLOW)X=0.
340      IF(X.GT.SPILL)X=0.
341      XX=SI*BIN*X
342      X=(EE-XI*S-EHDLE(NH+1))/Y
343      IF(X.LT.O.)X=0.
344      IF(X.GT.O.)X=X**PH1
345      IF(X.LT.FLOW)X=0.
346      IF(X.GT.SPILL)X=0.
347      XX=XX-SI*BIN*H*X
348      X=(EE-XI*S-EHOLE(NH+1)=2.)/Y
349      IF(X.LT.O.)X=0.
350      IF(X.GT.O.)X=X**PH1
351      IF(X.LT.FLOW)X=0.
352      IF(X.GT.SPILL)X=0.
353      XX=XX+SI*BIN*H*(H-1.)=0.5*X
354      IF(I.GT.1)FT2=FT2-XX
355 31   FT=FT+XX
356      GO TO 35
357 32   DO 34 I=1,LIM
358      XI=I
359      BIN=BIN*(P-XI+1.)/XI
360      SI=-SI
361      X=ES(I)**PH1
362      IF(X.LT.FLOW)X=0.
363      IF(X.GT.SPILL)X=0.
364      XX=SI*BIN*X
365      IF(I.GT.1)FT2=FT2-XX
366 34   FT=FT+XX
367 35   FWDU(NP1)=FT
368      IF(FT.GT.O.)FT2=FT2/FT
369      OBL(NP1)=FT2
370      X=1.
371      IF(ES(2).GT.O.)X=1.-0.5*ES(2)**PH1
372      IF(NH.GT.2)GO TO 33
373      EE=E-PAIRC-S
374      SV=S+EHOLE(NH+1)
375      X=1.
376      IF(EE.LE.S)GO TO 33
377      X=1.-0.5*((EE-S)/EE)**PH1
378      IF(EE.LE.SV)GO TO 33
379      X=X-((EE-SV)/EE)**PH1
380      SV=SV+S
381      IF(EE.LE.SV)GO TO 33
382      X=X+0.5*((EE-SV)/EE)**PH1
383 33   FWDHI(NP1)=X
384 36   CONTINUE

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385      FWDU(1)=1.
386      OBL(1)=0.
387      FWDHI(1)=1.
388      FWDU(32)=1.
389      FWDHI(32)=1.
390 C
391 C      CALCULATE G*E FACTORS
392 C
393      POUR=1.E+35
394      IF(NPHD)54,55,56
395 54      NOWN=0
396      GO TO 58
397 55      NOWN=1
398      GO TO 58
399 56      NOWN=NPHD
400 58      NHOWN=NOWN-NPHD
401      NDWN1=NOWN+1
402      DO 60 NP1=NOWN1,32
403      NP=NP1-1
404      P=NP
405      NH=NP-NPHD
406      H=NH
407      Q=AMAX1(P,H)
408      X=SIZE-Q*Q
409      IF(X.LT.O.)GO TO 62
410      IF(NH.LE.2)X=GF(NH+1)*(E-PAIRC)-Q*Q
411      GEL(NP1)=X+(P*(P+1.)+H*(H+1.))/4.
412      IF(NP.GT.31)GO TO 60
413      GELU(NP1)=0.
414      GELUU(NP1)=0.
415      IF(P.LE.O.)GO TO 60
416      IF(E.LE.S)GO TO 60
417      P=P-1.
418      Q2=Q*Q+0.5
419      X=SIZE-Q2-G*S
420      IF(NH.LE.2)X=G*(E-PAIRC)-Q2-G*S
421      IF(X.LT.O.)GO TO 60
422      GELU(NP1)=X+(P*(P+1.)+H*(H+1.))/4.
423      IF(P.LE.O.)GO TO 60
424      P=P-1.
425      Q2=Q*Q-2.*Q+2.
426      X=SIZE-Q2-2.*G*S
427      IF(NH.LE.2)X=G*(E-PAIRC)-Q2-2.*G*S
428      IF(X.LT.O.)GO TO 60
429      GELUU(NP1)=X+(P*(P+1.)+H*(H+1.))/4.
430 60      CONTINUE
431 62      NUP=NP-1
432 C
433 C      CALCULATE STATE DENSITIES
434 C
435      FAC=0.
436      PH=NOWN+NHOWN
437      IF(NDOWN.EQ.O)GO TO 61
438      DO 64 NP=1,NDWN
439      Y=NP
440 64      FAC=FAC+ALOG10(Y)
441 61      IF(NHOWN.EQ.O)GO TO 63
442      DO 65 NP=1,NHOWN
443      Y=NP
444 65      FAC=FAC+ALOG10(Y)
445 63      LIM=NDOWN+NHOWN-1
446      IF(LIM.EQ.O)GO TO 67
447      DO 66 NP=1,LIM
448      Y=NP
449 66      FAC=FAC+ALOG10(Y)
450 67      RHOL=GEL(NOWN1)
451      RHOL=(PH-1.)*ALOG10(RHOL)
452      RHOL=RHOL-FAC
453      RHO(NOWN1)=(10.**RHOL)*G
454      IF(NDOWN.GT.O)GO TO 51
455      RHOL=0.
456      GO TO 59
457 51      IF(PH.GT.1.)GO TO 57
458      RHOL=0.
459      GO TO 53
460 57      RHOL=GELU(NOWN1)
461      IF(NHOWN.LE.2)RHOL=RHOL*GFU(NHOWN+1)/G
462      IF(RHOL.EQ.O.)GO TO 59

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463      RHOL=(PH-1.)=ALOG10(RHOL)
464      RHDL=RHOL-FAC
465 53    RHDL=(10.**RHOL)*GFPU
466 59    P=NDWN
467      RHOU(NOWN1)=RHOL*FWOU(NOWN1)=P
468      OO 68 NP=NOWN1,NUP
469      NP1=NP+1
470      P=NP
471      NH=NP-NPHD
472      H=NH
473      FAC=FAC+ALDG10(P)+ALDG10(H)+ALOG10(P+H-1.)+ALOG10(P+H-2.)
474      RHDL=GEL(NP1)
475      RHDL=(P+H-1.)*ALOG10(RHDL)
476      RHDL=RHDL-FAC
477      RHO(NP1)=(10.**RHDL)*G
478      IF(RHO(NP1).LT.1.)GO TO 69
479      IF(NP.GT.30)GO TO 68
480      RHOL=GELU(NP1)
481      IF(NH.LE.2)RHDL=RHDL*GFU(NH+1)/G
482      IF(RHDL.EQ.O.)GO TO 74
483      RHDL=(P+H-1.)*ALOG10(RHDL)
484      RHDL=RHDL-FAC
485      RHDL=(10.**RHDL)*GFPU
486 74    RHOU(NP1)=RHDL*FWOU(NP1)=P
487 68    CONTINUE
488      GO TO 70
489 69    NUP=NP-1
490 70    OO 72 NP=NOWN1,31
491      IF(RHO(NP+1).LT.RHO(NP))GO TO 73
492 72    CONTINUE
493 73    JBAR=NP-1
494      JHI=MINO(20,JBAR)
495      JBAR1=JBAR+1
496      OO 81 I=1,3
497      NP1=I+NPHD
498      RHO(NP1)=RHO(NP1)*FWD(I)*GF(I)/G
499 81    RHOU(NP1)=RHOU(NP1)*GU(I)/GFPU
500      EE=E*1.35/F2
501 C
502 C      CALCULATE TRANSITION RATES
503 C
504      OO 79 NP1=NOWN1,JBAR1
505      NP=NP1-1
506      P=NP
507      NH=NP-NPHD
508      H=NH
509      PH=P+H
510      V=38.
511      IF(NH.LE.2)V=EHOLE(NH+1)
512 C
513 C      PAIR ANNIHILATION
514      TLOUB=O.
515      TLOBU=O.
516      IF(NP.EQ.NOWN)GO TO 76
517      TLOUB=GFHU*H*(H-1.)*(1.-OBL(NP1))*CMAT/2.
518      TLOBU=GFPU*P*(P-1.)*H*CMAT/2.
519      IF(NH.LE.3)TLOBU=TLOBU*GU(NH)/GFPU
520      IF(PH.LT.4.)GO TO 71
521      TLOBU=TLOBU/2.
522      X=GEL(NP1)/G
523      IF(NH.LE.2)X=X=G/GF(NH+1)
524      XU1=GELU(NP)/G
525      XU=GELU(NP1)/G
526      XU1=GELUU(NP)/G
527      XU=GELUU(NP1)/G
528      XX=(PH-2.)*(PH-3.)*XU1*XU1-2.*(PH-1.)*(PH-3.)*X=XU1
529      XX=XX+(PH-1.)*(PH-2.)*X*X
530      IF(NH.LE.2)XX=XX=FWD(NH+1)
531      XX=XX*XU1**(PH-3.)
532      Y=X**(PH-1.)
533      IF(NH.LE.2)Y=Y=FWD(NH+1)
534      Y=Y-P*FWOU(NP1)*XU**(PH-1.)
535      X=(PH-2.)*(PH-3.)*XUU1*XUU1-2.*(PH-1.)*(PH-3.)*XU*XUU1
536      X=X+(PH-1.)*(PH-2.)*XU=XU
537      X=X*(P-2.)*FWOU(NP1)*XUU1**(PH-3.)
538      FWOUU=1.
539      OEN=O.
540      ES2=ES(2)

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541 IF(NH.GT.2)GO TO 84
542 ES2=E-PAIRC-2.*S
543 IF(ES2.LE.O.)ES2=O.
544 ES2=ES2/(ES2+S)
545 84 IF(ES2.GT.O.)DEN=(P-1.)*ES2**(PH-1.)
546 IF(DEN.GT.O.)FWOUU=2.*FWOU(NP1)*DBL(NP1)/DEN
547 XT=4.*(FWOU(NP1)*XU**(PH-1.)-(P-2.)*FWOUU*XUU**(PH-1.))
548 X=XX-X-XT
549 IF(X.LT.O.)X=O.
550 TLOBU=TLOBU*X/Y
551 71 IF(RHOU(NP1).GT.RHO(NP1))RHOU(NP1)=RHO(NP1)
552 IF(RHOU(NP1).GE.RHO(NP1))TLOBU=O.
553 C
554 C PAIR CREATION
555 76 CMAT=PH/EE
556 EPH=EE/PH
557 IF(EPH.LT.7.)CMAT=CMAT*SQR(EPH/7.)
558 IF(EPH.LT.2.)CMAT=CMAT*SQR(EPH/2.)
559 IF(EPH.GT.15.)CMAT=CMAT*SQR(15./EPH)
560 NP2=NP1+1
561 X=GEL(NP1)
562 IF(NH.LE.2)X=X*G/GF(NH+1)
563 XT=X
564 Y=GEL(NP2)
565 IF(NP.GT.NDOWN)GO TO 77
566 IF(NH.LE.1)Y=Y*G/GF(NH+2)
567 X=(Y/X)**(PH-1.)
568 TIMHI *X*G=GEL(NP2)*GEL(NP2)=CMAT/(2.*(PH+1.))
569 IF(NH.LE.1)TIMHI *TIMHI *FWD(NH+2)*GF(NH+2)/G
570 77 Y=GELU(NP2)
571 X=O.
572 IF(PH.LE.1.)X=1.
573 IF(GELU(NP1).GT.O.)X=(Y/GELU(NP1))**(PH-1.)
574 FW=1.
575 IF(NH.LE.1)FW=FWD(NH+2)
576 FW=(FWDHI(NP2)+(PH-1.)*FW)/PH
577 THIIU=X*G*Y=Y*FW*CMAT/(2.*PH)
578 IF(NH.LE.1)THIIU=THIIU*GFU(NH+2)*GFU(NH+2)*GFAV(NH+2)/(G*G*G)
579 X=GEL(NP2)
580 XX=GELU(NP1)
581 IF(NH.LE.1)X=X*G/GF(NH+2)
582 Y=PH*(X-XX)*(X-XX)+X=X-XX=XX
583 X=X*XX+O.5*PH *Y
584 IF(NH.LE.1)X=X*GF(NH+2)*GF(NH+2)*GF(NH+2)/(G*G*G)
585 THIB=X*G
586 IF(NH.LE.1)X=X*FWD(NH+2)
587 X=G*X*CMAT/(2.*PH*(PH+1.))
588 XX=THIIU*GFPU*FWDHI(NP2)/(G*FW)
589 IF(NH.LE.1)XX=THIIU*GU(NH+2)*FWDHI(NP2)/(GFAV(NH+2)*FW)
590 X=X-2.*XX/(PH+1.)
591 IF(RHOU(NP2).GE.RHO(NP2))X=O.
592 THIIU=THIIU+X*DBL(NP1)
593 THIU=X*(1.-DBL(NP1))
594 TNOUB=O.
595 THIBB=O.
596 THIBU=O.
597 TNOBU=O.
598 IF(RHOU(NP1).GE.RHO(NP1))GO TO 75
599 TEST=O.
600 IF(NP.GT.O)GO TO 85
601 TEST=(E-EPAIRC-H*V)/P
602 IF(NH.LE.2)TEST=(E-PAIRC-V)/P
603 85 IF(TEST.GT.S)GO TO 75
604 Y=(XT/G)**(PH-1.)
605 YY=1.
606 YYY=1.
607 IF(PH.LE.1.)GO TO 82
608 YY=(GELU(NP1)/G)**(PH-1.)
609 YYY=(GELUU(NP1)/G)**(PH-1.)
610 82 Z=GEL(NP2)/G
611 IF(NH.LE.1)Z=Z*G/GF(NH+2)
612 Z=Z**(PH+1.)
613 ZZ=(GELU(NP2)/G)**(PH+1.)
614 IF(NH.LE.2)Y=Y*FWD(NH+1)
615 XX1=E-EPAIRC-V
616 IF(NH.LE.2)XX1=E-PAIRC-V
617 IF(XX1.LE.O.)GO TO 78
618 XX=PH*(PH-1.)*XX1*XX1-2.*(PH+1.)*(PH-1.)*XX1=GELU(NP2)/G

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619 XX=XX+PH*(PH+1.)=GELU(NP2)*GELU(NP2)/(G=G)
620 XX*XX1**=(PH-1.)=XX
621 XX1=XX1-S
622 IF (XX1.LT.O.)XX1=O.
623 X=PH*(PH-1.)=XX1*XX1-2.*(PH+1.)*(PH-1.)*XX1*GELUU(NP2)/G
624 X=X+PH*(PH+1.)*GELUU(NP2)*GELUU(NP2)/(G=G)
625 IF (XX1.GT.O.)XX=XX-P*XX1**=(PH-1.)*X
626 78 X=(GELUU(NP2)/G)**(PH+1.)
627 X=(GELU(NP2)/G)**(PH+1.)-P*X-O.5*XX
628 X=X*G*G
629 Y=Y-P*Y*FWDU(NP1)
630 IF (Y.LE.O.)GO TO 75
631 THIBU=G*H*X*CMAT/(Y*2.*PH*(PH+1.))
632 IF (NH.LE.1)THIBU=THIBU*GFU(NH+2)*GFU(NH+2)=GU(NH+2)/(G*G*G)
633 X=PH*Z=G*G*G
634 IF (NH.LE.1)X=X*(GF(NH+2)**3.)*FWD(NH+2)/(G*G*G)
635 ZZ=P*(PH-1.)*ZZ=G*G*G*FWDU(NP2)
636 IF (NH.LE.1)ZZ=ZZ*(GFU(NH+2)**3.)/(G*G*G)
637 X=X-ZZ-P*THIB*Y*FWDU(NP1)
638 X*X*CMAT/(Y*2.*PH*(PH+1.))
639 THIBB=X-THIBU
640 C
641 C SCATTERING
642 X=GELU(NP1)
643 XT=XT-X
644 TNOUB=XT*G*(PH+H-1.)/2.
645 IF (NH.LE.2)TNOUB=TNOUB*FWD(NH+1)
646 FW=1.-2.*FWDHI(NP1)
647 IF (NH.LE.2)FW=FWD(NH+1)-2.*(1.-O.5*ES(2)**(PH-1.))
648 TNOUB=TNOUB+(P-1.)*G*GELU(NP1)=FW/PH
649 TNOUB=TNOUB*CMAT*(1.-OBL(NP1))
650 TNOBU=(PH+H-1.)*Y*(2.*GELU(NP1)+PH*XT)
651 IF (NH.LE.2)TNOBU=TNOBU*FWD(NH+1)
652 TNOBU=TNOBU-4.*(PH-1.)*Y*GELU(NP1)*FWDU(NP1)
653 XT=GELU(NP1)-GELUU(NP1)
654 TNOBU=TNOBU-(P-1.)*(PH+H-1.)*YYY*(2.*GELUU(NP1)+PH*XT)*FWDU(NP1)
655 FWDUU=1.
656 DEN=O.
657 ES2=ES(2)
658 IF (NH.GT.2)GO TO 86
659 ES2=E-PAIRC-2.=S
660 IF (ES2.LE.O.)ES2=O.
661 ES2=ES2/(ES2+S)
662 86 IF (ES2.GT.O.)DEN=(P-1.)=ES2***(PH-1.)
663 IF (DEN.GT.O.)FWDUU=2.*FWDU(NP1)*OBL(NP1)/DEN
664 TNOBU=TNOBU+4.*(P-1.)*(PH-2.)*YYY*GELUU(NP1)*FWDUU
665 TNOBU=TNOBU*P*GFPU=CMAT/(2.*PH*Y)
666 IF (NH.LE.2)TNOBU=TNOBU*GU(NH+1)*GFU(NH+1)/(G=GFPU)
667 C
668 C TRANSITION BRANCHING RATIOS (NUMERATORS)
669 75 GAMUU(NP1)=THIUU
670 GAMUB(NP1)=THIUB
671 GAMZUB(NP1)=TNOUB+TLOUB
672 GAMBB(NP1)=THIBB
673 GAMBU(NP1)=THIBU
674 GAMZBU(NP1)=TNOBU+TLOBU
675 79 CONTINUE
676 C
677 C NORMALIZATION
678 TAUWM=1./(TIMHI*2O.)
679 DO 80 NP1=NDWN1,JBAR1
680 GAMUU(NP1)=GAMUU(NP1)*TAUWM
681 IF (GAMUU(NP1).LT.FLOW)GAMUU(NP1)=O.
682 IF (GAMUU(NP1).GT.SPILL)GAMUU(NP1)=O.
683 GAMUB(NP1)=GAMUB(NP1)*TAUWM
684 IF (GAMUB(NP1).LT.FLOW)GAMUB(NP1)=O.
685 IF (GAMUB(NP1).GT.SPILL)GAMUB(NP1)=O.
686 GAMZUB(NP1)=GAMZUB(NP1)*TAUWM
687 IF (GAMZUB(NP1).LT.FLOW)GAMZUB(NP1)=O.
688 IF (GAMZUB(NP1).GT.SPILL)GAMZUB(NP1)=O.
689 GAMBU(NP1)=GAMBU(NP1)*TAUWM
690 IF (GAMBU(NP1).LT.FLOW)GAMBU(NP1)=O.
691 IF (GAMBU(NP1).GT.SPILL)GAMBU(NP1)=O.
692 GAMBB(NP1)=GAMBB(NP1)*TAUWM
693 IF (GAMBB(NP1).LT.FLOW)GAMBB(NP1)=O.
694 IF (GAMBB(NP1).GT.SPILL)GAMBB(NP1)=O.
695 GAMZBU(NP1)=GAMZBU(NP1)*TAUWM
696 IF (GAMZBU(NP1).LT.FLOW)GAMZBU(NP1)=O.
697 IF (GAMZBU(NP1).GT.SPILL)GAMZBU(NP1)=O.

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898 80 CONTINUE
699 ACUBE=ACDM*ACDM*ACDM
700 TWOPI=1.05E-12
701 TAUWM=TAUWM*TWOPI*ACUBE/1.35
702 C
703 C CALCULATE FISSION RATES
704 C
705 IF(GFIS.EQ.O.)GFIS=G
706 FISHW=O.
707 IF(BF.EQ.O.)GO TO 136
708 E=E-EPAIRC
709 NFISH=E-BF+1.
710 AFISH=1.645*GFIS
711 ASP=1.645*G
712 REF=SQRT(ASP=E)
713 DD 134 K=1,NFISH
714 XK1=K-1
715 EX=(E-BF-XK1)*AFISH
716 IF(EX.LE.O.)EX=O.
717 EX=SQRT(EX)
718 EX=2.*(EX-REF)
719 EX=E*EXP(EX)/(E-BF-XK1)
720 IF(EX.LT.FLOW)EX=O.
721 IF(EX.GT.SPILL)EX=O.
722 134 FISHW=FISHW+EX
723 136 FISHW=FISHW*2.42E+08
724 E=E+EPAIRC
725 C
726 C CALCULATE PROBABILITY FACTORS AND EMISSION RATES
727 C
728 JNOUT=1
729 JPOUT=O
730 JOUT=1
731 JHALF=1
732 NSO=2
733 BEN=BNEU
734 GR=GNEU
735 EPAIR=EPAIRN
736 PAIR=PAIRN
737 GO TO 550
738 150 IF(JPOUT.EQ.1)GO TO 152
739 IF(JPOUT.EQ.2)GO TO 154
740 NLDE=NAP1
741 JNDUT=O
742 JPOUT=1
743 BEN=BPPO
744 GR=GPRO
745 EPAIR=EPAIRP
746 PAIR=PAIRP
747 GO TO 550
748 152 NLOE=MINO(NLOE,NAP1)
749 JNDUT=2
750 JPOUT=2
751 JOUT=4
752 NSO=1
753 BEN=BALFA
754 GR=GALFA
755 EPAIR=EPAIRA
756 PAIR=PAIRA
757 GO TO 550
758 C
759 C CALCULATE FRACTIONAL STRENGTH LOSSES
760 C
761 154 DD 156 NP1=1.31
762 156 FRAC(NP1)=O.
763 DD 158 NP=NLOE,JBAR
764 NP1=NP+1
765 DD 158 NE=2,NEPS1
766 WNP=WU(1,NP,NE)+WU(2,NP,NE)+WU(3,NP,NE)
767 158 FRAC(NP1)=FRAC(NP1)+WNP*(EPS(1,NE+1)-EPS(1,NE-1))/2.
768 DD 186 NP1=NOWN1,JBAR1
769 YU=GAMUU(NP1)+GAMUB(NP1)+FRAC(NP1)
770 XU=YU+GAMZUB(NP1)
771 YB=GAMBB(NP1)+GAMBU(NP1)
772 XB=YB+GAMZBU(NP1)
773 IF(XU.LE.O.)GO TO 164
774 XU=1./XU

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775      GAMUU(NP1)=GAMUU(NP1)*XU
776      GAMUB(NP1)=GAMUB(NP1)*XU
777      GAMZUB(NP1)=GAMZUB(NP1)*XU
778      GAMZBU(NP1)=GAMZBU(NP1)/(XU=YU)
779      FRAC(NP1)=FRAC(NP1)*XU
780 164   TAUWU(NP1)=XU
781      IF(XB.LE.O.)GO TO 186
782      XB=1./XB
783      GAMBB(NP1)=GAMBB(NP1)*XB
784      GAMBU(NP1)=GAMBU(NP1)*XB
785      GAMZBU(NP1)=GAMZBU(NP1)*XB
786      GAMZUB(NP1)=GAMZUB(NP1)/(XB=YB)
787 186   CONTINUE
788      WRITE(IWRI,185)
789 185   FORMAT(1H1)
790 C
791 C     CLOSED FORM CALCULATIONS
792 C
793      USED=O.
794      PU=RHO(NPART+1)/RHD(NPART+1)
795      IF(PU.GT.1.)PU=1.
796      PMSO=PU
797      PB=1.-PU
798      IF(NPART.EQ.NDOWN)GO TO 202
799      DD 208 NP1=1,NPART
800      RATIO(NP1,1)=O.
801      RATIO(NP1,2)=O.
802      CLOSU(NP1)=O.
803 208   CLOSD(NP1)=O.
804 202   DD 204 NP=NPART,JBAR
805      NP1=NP+1
806      RATIO(NP1,1)=PU/(PU+PB)
807      RATIO(NP1,2)=PMSO/(PU+PB)
808      STRU=PU+PB*GAMZBU(NP1)
809      STRB=PB+PU*GAMZUB(NP1)
810      CLOSD(NP1)=PMSO*TAUWU(NP1)
811      CLOSU(NP1)=STRU*TAUWU(NP1)
812      USED=USED+PMSO*FRAC(NP1)
813      PMSO=PMSO*GAMUU(NP1)
814      IF(PMSO.LT.O.OO1)PMSO=O.
815      IF(PMSO.GT.SPILL)PMSO=O.
816      PU=STRU*GAMUU(NP1)+STRB*GAMBU(NP1)
817      IF(PU.LT.FLDW)PU=O.
818      IF(PU.GT.SPILL)PU=O.
819      PB=STRB*GAMBB(NP1)+STRU*GAMUB(NP1)
820      IF(PB.LT.FLOW)PB=O.
821      IF(PB.GT.SPILL)PB=O.
822 204   CONTINUE
823      PTOT=PU+PB
824      TWEIS=O.
825      DD 272 NE=2,NEPS1
826      EINT=(EPS(1,NE+1)-EPS(1,NE-1))/2.
827      DD 272 KP=1,3
828 272   TWEIS=TWEIS+WEISS(KP,NE)=EINT
829      TWEIS=TWEIS+FISHW
830      FWEIS=PTOT/TWEIS
831 C
832 C     PRINT OCCUPATION PROBABILITIES
833 C
834      JRZ=RZZ+O.5
835      JRN=RNN+O.5
836      WRITE(IWRI,351)S
837 351   FORMAT(3H-S=,1F7.2,4H MEV)
838      WRITE(IWRI,352)NPART,NHOLE
839 352   FORMAT(3OH-OCCUPATION PROBABILITIES PO=,1I2,5H, HO=,1I2)
840      WRITE(IWRI,353)JRZ,JRN,JPIN,JNIN
841 353   FORMAT(11H TARGET Z=,1I3,4H, N=,1I3,12H PROJ Z=,1I3,4H, N=.1I
842      13)
843      WRITE(IWRI,354)G,E
844 354   FORMAT(3H G=,1F6.3,4H, E=,1F6.3)
845      PTOT=1.-PTOT
846      WRITE(IWRI,355)F2,PTOT
847 355   FORMAT(14H SCALE FACTOR=.1F8.3,13H, FRAC PREEQ=.1F6.3)
848      WRITE(IWRI,360)
849 360   FORMAT(41H- P H RHO/RHO STRU/STR STRO/STR)
850      WRITE(IWRI,361)
851 361   FORMAT(1H )
852      DD 364 NP1=NDWN1,JBAR1

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853      NP=NP1-1
854      NH=NP-NPHO
855      X=RHOU(NP1)/RHO(NP1)
856      Y=RATIO(NP1,1)
857      Z=RATIO(NP1,2)
858      WRITE(IWRI,362)NP,NH,X,Y,Z
859 362   FORMAT(2I3,8(1PE12.3))
860 364   CONTINUE
861 C
862 C     PRINT PARTICLE SPECTRA
863 C
864      JPOUT=0
865      JNOUT=1
866      JOUT=1
867      NSO=2
868      BEN=BNEU
869      KP=1
870 450   NEPS1=NEPS(JHALF)+1
871      IF(JOUT.GT.1)GO TO 451
872      NI=NLOE
873      IF(PROB(KP,NI).EQ.O.)NI=NI+1
874 451   WRITE(IWRI,454)JPOUT,JNOUT
875 454   FORMAT(21H1PARTICLE SPECTRA Z=,1I2,4H. N=,1I2)
876      WRITE(IWRI,456)NI
877 456   FORMAT(21H FIRST EMISSION AT P=,1I2)
878      WRITE(IWRI,353)JRZ,JRN,JPIN,UNIN
879      WRITE(IWRI,458)NPART,NHOLE,G,E
880 458   FORMAT(4H PO=,1I2,5H. HO=,1I2,4H. G=,1F6.3,4H. E=,1F6.3)
881      IF(IG.EQ.O)WRITE(IWRI,457)
882 457   FORMAT(37H PAIR EXCIT. ACCORDING TO Z/A AND N/A)
883      IF(IG.GT.O)WRITE(IWRI,459)
884 459   FORMAT(47H PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES)
885      WRITE(IWRI,460)SIGCN
886 460   FORMAT(25H REACTION CROSS SECTION =,1F7.1)
887      WRITE(IWRI,355)F2,PTOT
888      X=RHOU(NPART+1)/RHO(NPART+1)
889      WRITE(IWRI,462)X,USED
890 462   FORMAT(14H MSD POSSIBLE=,1F6.3,7H. USED=,1F6.3)
891      NIC=MAXO(NI,NPART)
892      WRITE(IWRI,470)NIC
893 470   FORMAT(29H CLOSED FORM SUM STARTS AT P=,1I2)
894      WRITE(IWRI,474)
895 474   FORMAT(86H- EPS --          DIRECT          -- PREEQUILIBRIUM -- EQ
896 1UIIL --          TOTAL (MB/MEV))
897      WRITE(IWRI,476)
898 476   FORMAT(6X,87H- - NUTRA          KNOCK --          MSD          MSC --          WEISS
899 1 --          MSD          MSC          MSD+MSC)
900      WRITE(IWRI,477)
901 477   FORMAT(1H )
902      SUMNU=O.
903      SUMKE=O.
904      SUMSO=O.
905      SUMSC=O.
906      SUMW=O.
907 C
908 C     DIRECT REACTION CALCULATIONS
909      DD 471 NE=1,51
910      SNUTRA(NE)=O.
911 471   SNOCK(NE)=O.
912      IF(JIN.GT.4) GO TO 473
913      IF(JOUT.EQ.JIN)GO TO 472
914      CALL NUTRA
915      IF(JHALF.EQ.1)CALL KNOCK
916      GO TO 473
917 472   IF(JPOUT.EQ.JPIN)CALL INEL
918      IF(JHALF.EQ.2)CALL NUTRA
919 473   SIGCN=SIGCN*O.95
920      IF(JIN.GT.1)SIGCN=SIGCN*O.89
921      DD 480 NE=2,NEPS1
922      PRMSO=O.
923      PRET2=O.
924      DD 466 NP=NIC,JBAR
925      NP1=NP+1
926      X=WU(KP,NP,NE)
927      PRMSO=PRMSO+X*CLOSD(NP1)
928 466   PRET2=PRET2+X*CLOSU(NP1)
929      PRMSO=PRMSO+SIGCN
930      PRET2=PRET2+SIGCN

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931 PRMSC=PRET2-PRMSO
932 WEISS(KP,NE)*WEISS(KP,NE)*SIGCN*FWEIS
933 TOMSO(NE)=PRMSO+SNUTRA(NE)+SNOCK(NE)
934 TOMSC(NE)=PRMSC+WEISS(KP,NE)
935 TOTAL=TOMSO(NE)+TOMSC(NE)
936 IF(TOTAL.LE.O.)GO TO 480
937 EINT=(EPS(JHALF,NE+1)-EPS(JHALF,NE-1))/2.
938 SUMNU=SUMNU+SNUTRA(NE)*EINT
939 SUMKE=SUMKE+SNOCK(NE)*EINT
940 SUMSO=SUMSO+PRMSO*EINT
941 SUMSC=SUMSC+PRMSC*EINT
942 SUMW=SUMW+WEISS(KP,NE)*EINT
943 WRITE(IWRI,482)EPS(JHALF,NE),SNUTRA(NE),SNOCK(NE),PRMSO,PRMSC,WEI
944 1SS(KP,NE),TOMSO(NE),TOMSC(NE),TOTAL
945 480 CONTINUE
946 482 FORMAT(1F6.2,9(1PE11.3))
947 WRITE(IWRI,481)SUMNU,SUMKE,SUMSO,SUMSC,SUMW
948 481 FORMAT(6HOSUMS,6(1PE11.3))
949 IF(JDOUT.NE.4)GO TO 483
950 IF(BF.EQ.O.)GO TO 483
951 FISBO=0.
952 FISSO=0.
953 FISCL=0.
954 FISMA=0.
955 FISHW=FISHW*SIGCN*FWEIS
956 WRITE(IWRI,490)FISBO,FISSO,FISCL,FISMA,FISHW
957 490 FORMAT(6H-FISS,6(1PE11.3))
958 483 SIGCN=SIGCN/O.95
959 IF(JIN.GT.1)SIGCN=SIGCN/O.89
960 C
961 C CALCULATE AND PRINT ANGULAR DISTRIBUTIONS
962 CALL ANGEL
963 C
964 IF(JPOUT.GT.O)GO TO 484
965 JPOUT=1
966 JNOUT=0
967 JOUT=1
968 BEN=BPRD
969 KP=2
970 JHALF=1
971 GO TO 450
972 484 IF(JNOUT.GT.O)GO TO 500
973 JPOUT=2
974 JNOUT=2
975 JOUT=4
976 NSD=1
977 BEN=BALFA
978 KP=3
979 NI=NAP1
980 JHALF=1
981 GO TO 450
982 C
983 C RECYCLE OPTIONS
984 C
985 500 READ(IREA,5)JPOUT,JNOUT
986 JOUT=JPOUT+JNOUT
987 IF(JPOUT.GE.O)GO TO 504
988 READ(IREA,5)NEWP
989 IF(NEWP)1000,1,502
990 502 NEPS1=NEPS(1)+1
991 GO TO 9
992 504 READ(IREA,5)NSD
993 READ(IREA,3)BEN,GR
994 READ(IREA,3)PAIR,EPAIR
995 READ(IREA,13)NEPS(2),EPS(2,2),DELTA(2)
996 IF(NEPS(2).LE.50)GO TO 505
997 WRITE(IWRI,10)
998 GO TO 1000
999 505 IF(NEPS(2).LE.O)NEPS(2)=1
1000 NEPS1=NEPS(2)+1
1001 IF(EPS(2,2).LE.O.)GO TO 510
1002 IF(DELTA(2).LE.O.)DELTA(2)=1.
1003 DO 514 NE=3,NEPS1
1004 X=NE-2
1005 514 EPS(2,NE)=EPS(2,2)+X*DELTA(2)
1006 JHALF=2
1007 KP=4
1008 CALL CROSS

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1009      GO TO 512
1010 510  DD 506 NE=2, NEPS1
1011      READ(IREA,3)EPS(2,NE).SIGIN(4,NE)
1012 506  CONTINUE
1013 512  EPS(2,1)=EPS(2,2)-1.
1014      IF(EPS(2,1).LT.0.)EPS(2,1)=0.
1015      EPS(2,NEPS1+1)=EPS(2,NEPS1)+1.
1016      XOUT=JOUT
1017      XPOUT=JPOUT
1018      ATHRD=(ACOM·XOUT)**0.33
1019      COUL(4)=0.75·XPOUT*(RZZ+XPIN-XPOUT)/ATHRD
1020      SIGBAR(4)=0.
1021      ESUM(4)=0.
1022      DD 508 NE=2, NEPS1
1023      IF(EPS(2,NE).LT.COUL(4))GO TO 508
1024      EINT=(EPS(2,NE+1)-EPS(2,NE-1))/2.
1025      ESUM(4)=ESUM(4)+EINT
1026      SIGBAR(4)=SIGBAR(4)+SIGIN(4,NE)*EINT
1027 508  CONTINUE
1028      SIGBAR(4)=SIGBAR(4)/ESUM(4)
1029      JHALF=2
1030 C
1031 C      CALCULATE PROBABILITY FACTORS
1032 C
1033 550  JTA=JPOUT+JNIN
1034      JTB=JNOUT+JPIN
1035      JLO=MAXO(JIN,JOUT,JTA,JTB)
1036      KP=2+JHALF
1037      IF(JOUT.EQ.1)KP=JPOUT+1
1038      IF(IG.EQ.1)GO TO 551
1039 C
1040 C      1.  PROB. FROM Z/A AND N/A
1041      JPDF=1
1042      IF(JPOUT.LT.2)GO TO 524
1043      DD 522 J=2,JPOUT
1044 522  JPDF=JPDF·J
1045 524  XPDF=JPDF
1046      JNDF=1
1047      IF(JNOUT.LT.2)GO TO 528
1048      DD 526 J=2,JNOUT
1049 526  JNDF=JNDF·J
1050 528  XNOF=JNOF
1051      APFAC=1.
1052      DD 529 N=1,JOUT
1053      X=N
1054 529  APFAC=APFAC·X
1055      XPOUT=JPOUT
1056      XNOUT=JNOUT
1057      CONEW=(RZ**XPOUT)*(RN**XNOUT)
1058      CONEW=XPOF·XNOF/(APFAC·CONEW)
1059      DD 532 J=2,NPART
1060      JJ=J-1
1061 532  PROB(KP,JJ)=1.
1062      DD 548 J=NPART,JHI
1063      XJ=J
1064      PROB(KP,J)=0.
1065      IF(J.LT.JOUT)GO TO 548
1066      XSUM=0.
1067      JMAX=J-JIN
1068      XNORM=1.
1069      DD 530 I=1,JOUT
1070      XI=I
1071 530  XNORM=XNORM*(XJ-XI+1.)/XI
1072      XMAX=JMAX
1073      JMAX1=JMAX+1
1074      DD 546 I2=1,JMAX1
1075      I=I2-1
1076      XI=I
1077      JP=JPIN+I
1078      JN=JNIN+JMAX-I
1079      JP1=JP+1
1080      JN1=JN+1
1081      PROBI=1.
1082      IF(I.EQ.0)GO TO 536
1083      DD 534 II=1,I
1084      XII=II
1085 534  PROBI=PROBI*(XMAX-XII+1.)/XII
1086 536  PROBI=PROBI*(RZ**XI)*(RN**(XMAX·XI))

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1087      XSUM=XSUM+PROBI
1088      PROBI=PROBI/(XPDF*XNOF)
1089      IF(JP.LT.JPOUT)GO TO 546
1090      IF(JN.LT.JNOUT)GO TO 546
1091      IF(JPOUT.EQ.O)GO TO 540
1092      DD 538 II=1,JPOUT
1093      X=JP1-II
1094 538    PROBI=PROBI*X
1095 540    IF(JNOUT.EQ.O)GO TO 544
1096      DD 542 II=1,JNOUT
1097      X=JN1-II
1098 542    PROBI=PROBI*X
1099 544    PROB(KP,J)=PROB(KP,J)+PROBI
1100 546    CONTINUE
1101      PROB(KP,J)=PROB(KP,J)=CONEW
1102      PROB(KP,J)=PROB(KP,J)/(XNORM=XSUM)
1103 548    CONTINUE
1104      GO TO 575
1105 C
1106 C      2.  PROB. FROM AVAILABLE PHASE SPACE (GADIOLI)
1107 551    JPLO=MAXO(JPIN,JPOUT)
1108      JNLO=MAXO(JNIN,JNOUT)
1109      XPOUT=JPOUT
1110      XNOUT=JNOUT
1111      XDOUT=JOUT
1112      XPFAC=1.
1113      XHFAC=1.
1114      DD 552 J=2,NPART
1115      JJ=J-1
1116      XJJ=JJ
1117      XPFAC=XPFAC*XJJ
1118 552    PROB(KP,JJ)=1.
1119      IF(NHOLE.LT.2)GO TO 556
1120      DD 554 J=2,NHOLE
1121      XJ=J-1
1122 554    XHFAC=XHFAC*XJ
1123 556    DD 574 JP=NPART,JHI
1124      XP=JP
1125      PROB(KP,JP)=Q.
1126      IF(JP.LT.JOUT)GO TO 574
1127      XPFAC=XPFAC*XP
1128      XH=JP-NPHO
1129      XHFAC=XHFAC*XH
1130      XNORM=XPFAC*XHFAC
1131      XNUM=XHFAC
1132      IMAX=JP-JOUT
1133      IF(IMAX.LT.2) GO TO 559
1134      DD 558 I=2,IMAX
1135      XI=I
1136 558    XNUM=XNUM*XI
1137 559    SUMN=O.
1138      SUMD=O.
1139      JPMAX=JP-JNIN
1140      DD 572 JPPI=JPIN,JPMAX
1141      JPNU=JP-JPPI
1142      JHPI=JPPI-JPIN
1143      JHNU=JPNU-JNIN
1144      XPI=JPPI+JHPI
1145      XNU=JPNU+JHNU
1146      FACN=1.
1147      IF(JHPI.LT.2)GO TO 561
1148      DD 560 I=2,JHPI
1149      XI=I
1150 560    FACN=FACN*XI
1151 561    IF(JHNU.LT.2)GO TO 563
1152      DD 562 I=2,JHNU
1153      XI=I
1154 562    FACN=FACN*XI
1155 563    FACD=FACN
1156      IF(JPPI.LT.2)GO TO 565
1157      DD 564 I=2,JPPI
1158      XI=I
1159 564    FACD=FACD*XI
1160 565    IF(JPNU.LT.2)GO TO 567
1161      DD 566 I=2,JPNU
1162      XI=I
1163 566    FACD=FACD*XI
1164 567    FACD=XNORM/FACD

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1165     FACD=FACD=RZ**XPI=RN**XNU
1166     SUMD=SUMD+FACD
1167     IF(JPPI.LT.JPLD)GO TO 572
1168     IF(JPNU.LT.JNLD)GO TO 572
1169     IMAX=JPPI-JPOUT
1170     IF(IMAX.LT.2)GO TO 569
1171     DO 568 I=2,IMAX
1172     XI=I
1173 568   FACN=FACN=XI
1174 569   IMAX=JPNU-JNDUT
1175     IF(IMAX.LT.2)GO TO 571
1176     DO 570 I=2,IMAX
1177     XI=I
1178 570   FACN=FACN*XI
1179 571   FACN=XNUM/FACN
1180     FACN=FACN*RZ**(XPI-XPOUT)=RN**(XNU-XNDUT)
1181     SUMN=SUMN+FACN
1182 572   CONTINUE
1183     IF(SUMD.GT.O.)PROB(KP,JP)=SUMN/SUMD
1184 574   CONTINUE
1185 575   AP=JOUT
1186     IF(JHI.GE.JBAR)GO TO 620
1187     JHI1=JHI+1
1188     DO 582 J=JHI1,JBAR
1189 582   PROB(KP,J)=1.
1190 C
1191 C     CALCULATE EMISSION RATES
1192 C
1193 620   SO=NSD
1194     CNNE=0.85
1195     IF(JOUT.EQ.1)CNNE=0.95
1196     REL=SD*AP*372000.*CNNE
1197     IF(GR.EQ.O.)GR=G*(ACDM*AP)/ACDM
1198     ASPR=1.645*GR
1199     NAP1=MAXO(JLD,NDWN)-1
1200 606   NAP1=NAP1+1
1201     NTEST=2*NAP1-NPHD
1202     IF(NTEST.LT.JOUT+1)GO TO 606
1203     REF=SQRT(1.645*SIZE)
1204     DO 612 NE=2,NEPS1
1205     U=E-EPAIR-BEN-EPS(JHALF,NE)
1206     DO 602 NP=1,30
1207 602   WU(KP,NP,NE)=0.
1208     WEISS(KP,NE)=0.
1209     IF(U.LE.O.)GO TO 612
1210     QUD=U/(E-EPAIRC)
1211     PROD=EPS(JHALF,NE)*SIGIN(KP,NE)=REL
1212     PREX=PROD/QUO
1213     EX=SQRT(ASPR*U)
1214     EX=2.*(EX*REF)
1215     WEISS(KP,NE)=PREX*EXP(EX)
1216     IF(WEISS(KP,NE).LT.FLOW)WEISS(KP,NE)=0.
1217     IF(WEISS(KP,NE).GT.SPILL)WEISS(KP,NE)=0.
1218     FAC=1.
1219     IT=JOUT+3
1220     IF(NAP1.LT.IT)GO TO 601
1221     DO 600 I=IT,NAP1
1222     Y=I-JOUT-1
1223 600   FAC=FAC*Y
1224 601   NH=NAP1-NPHD
1225     IF(NH.LT.3)GO TO 604
1226     DO 603 I=3,NH
1227     Y=I-1
1228 603   FAC=FAC*Y
1229 604   NPH=NAP1+NH
1230     IT=JOUT+5
1231     IF(NPH.LT.IT)GO TO 607
1232     DO 605 I=IT,NPH
1233     Y=I-JOUT-3
1234 605   FAC=FAC*Y
1235 607   FAC=ALOG10(FAC)
1236     AP2=JOUT+2
1237     DO 622 NP=NAP1,JBAR
1238     NP1=NP+1
1239     P=NP
1240     IF(NP.EQ.JOUT)GO TO 608
1241     FAC=FAC+ALOG10(P-AP)
1242 608   H=NP-NPHD

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1243      IF(H.EQ.O.)GO TO 609
1244      FAC=FAC+ALOG10(H)
1245 609    PH=P+H
1246      IF(PH.LE.AP2)GO TO 610
1247      FAC=FAC+ALOG10(PH-AP-1.)+ALOG10(PH-AP-2.)
1248 610    PTT=P-AP
1249      Q=AMAX1(PTT,H)
1250      RHOL=GR=U-Q=Q
1251      IF(NH.LE.2)RHOL*GR=(U+EPAIR-PAIR)-Q=Q
1252      IF(RHOL.GE.O.)GO TO 611
1253      RHOL=O.
1254      GO TO 613
1255 611    RHOL=RHOL+(PTT*(PTT+1.)+H*(H+1.))/4.
1256      RHOL=(PH-AP-1.)*ALOG10(RHOL)
1257      RHOL=RHOL-FAC
1258      RHOL=(10.**RHOL)=GR
1259      IF(RHOL.LE.1.)RHOL=O.
1260      IF(RHOL.GT.POUR)RHOL=O.
1261      IF(H.LE.O.)GO TO 613
1262      IF(H.GT.2.)GO TO 613
1263      I=NP-NPH0+1
1264      UU=U+EPAIR-PAIR
1265      IF(UU.LE.EHOLE(I))GO TO 613
1266      X=(UU-EHOLE(I))/UU
1267      X=H*X*(PH-AP-1.)
1268      Y=O.
1269      EH2=EHOLE(I)+EHOLE(I)
1270      IF(UU.LE.EH2)GO TO 614
1271      Y=(UU-EH2)/UU
1272      Y=O.5*H*(H-1.)*Y*(PH-AP-1.)
1273 614    RHOL=RHOL*(1.-X+Y)
1274 613    WR=RHOL*PR00*PROB(KP,NP)*TAUWM
1275      X=O.
1276      IF(RHOU(NP1).GT.O.)X=WR/RHOU(NP1)
1277      IF(X.LT.FLOW)X=O.
1278      IF(X.GT.SPILL)X=O.
1279      WU(KP,NP,NE)=X
1280 622    CONTINUE
1281 612    CONTINUE
1282      IF(JHALF.EQ.1)GO TO 150
1283      NI=NAP1
1284      GO TO 450
1285 1000   CALL EXIT
1286 C
1287 C      HALLELUJAH
1288 C
1289      END

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1290      SUBROUTINE ANGEL
1291 C
1292 C      CALCULATE ANGULAR DISTRIBUTIONS
1293 C      FROM SYSTEMATIC LEGENDRE COEFFICIENTS
1294 C      PROGRAM - MARCH 1979
1295 C      SUBROUTINE - JANUARY 1980
1296 C
1297 C      LIBRARY OF POLYNOMIALS GENERATED IN SUBROUTINE POLLY OF MAIN
1298 C
1299      DIMENSION SIGMA(10),B(7),JANG(10)
1300      COMMON /ANGELS/ POL(19,7),TOMSD(51),TOMSC(51),IWRI,IANG
1301      COMMON /ENERGY/ BEN,NEPS1,EPS(2.52),JHALF,JNOUT,JPOUT
1302      DO 10 I=1,10
1303      JANG(I)=0
1304 10      SIGMA(I)=0.
1305      DO 11 I=1,7
1306 11      B(I)=0.
1307      WRITE(IWRI,12)JPOUT,JNOUT
1308 12      FORMAT(26H1ANGULAR DISTRIBUTIONS Z=,1I2.4H N=,1I2)
1309      IF(IANG.EQ.0)WRITE(IWRI,6)
1310 6      FORMAT(20H ENERGY PARAM. = EPS)
1311      IF(IANG.EQ.1)WRITE(IWRI,8)
1312 8      FORMAT(25H ENERGY PARAM. = EPS+B.E.)
1313      ANG=IANG
1314      WRITE(IWRI,14)
1315 14      FORMAT(29H CROSS SECTIONS IN MB/STR-MEV)
1316      DO 15 J=1,10
1317 15      JANG(J)=10*J*10
1318      WRITE(IWRI,16)(JANG(J),J=1,10)
1319 16      FORMAT(5H EPS. 1I7,9I9)
1320      WRITE(IWRI,18)
1321 18      FORMAT(1H )
1322      B(1)=1.
1323      DO 28 NE=2,NEPS1
1324      EPSCM=EPS(JHALF,NE)+ANG*BEN
1325      AOMSD=TOMSD(NE)/12.5664
1326      AOMSC=TOMSC(NE)/12.5664
1327      TOTAL=AOMSD+AOMSC
1328      IF(TOTAL.LE.0.)GO TO 28
1329      DO 19 L=2,7
1330      XL=L-1
1331      BL=XL*(XL+1.)
1332      AL=0.036+0.0039*BL
1333      BL=92.+ANG*6.-90./SQRT(BL)
1334      X=AL*(BL-EPSCM)
1335      X=1.+EXP(X)
1336 19      B(L)=(2.*XL+1.)/X
1337      DO 24 I=1,10
1338      SIG=0.
1339      DO 20 L=1,7
1340 20      SIG=SIG+B(L)*POL(I,L)
1341      SIGMA(I)=SIG*AOMSD
1342      SIG=0.
1343      DO 22 LL=1,4
1344      L=2*LL-1
1345 22      SIG=SIG+B(L)*POL(I,L)
1346 24      SIGMA(I) =SIGMA(I)+SIG*AOMSC
1347      WRITE(IWRI,26)EPS(JHALF,NE),(SIGMA(I),I=1,10)
1348 26      FORMAT(1F6.2,10(1PE9.2))
1349 28      CONTINUE
1350      DO 27 J=1,9
1351 27      JANG(J)=10*J+90
1352      WRITE(IWRI,29)(JANG(J),J=1,9)
1353      WRITE(IWRI,18)
1354 29      FORMAT(5H EPS. 1I7,8I9,10H      TOTAL)
1355      DO 38 NE=2,NEPS1
1356      EPSCM=EPS(JHALF,NE)+ANG*BEN
1357      AOMSD=TOMSD(NE)/12.5664
1358      AOMSC=TOMSC(NE)/12.5664
1359      TOTAL=TOMSD(NE)+TOMSC(NE)
1360      IF(TOTAL.LE.0.)GO TO 38
1361      DO 30 L=2,7
1362      XL=L-1
1363      BL=XL*(XL+1.)
1364      AL=0.036+0.0039*BL
1365      BL=92.+ANG*6.-90./SQRT(BL)
1366      X=AL*(BL-EPSCM)
1367      X=1.+EXP(X)
1368 30      B(L)=(2.*XL+1.)/X
1369      DO 36 J=1,9

```

```

1370      I=J+10
1371      SIG=0.
1372      DD 32 L=1,7
1373 32    SIG=SIG+B(L)*PDL(I,L)
1374      SIGMA(J)=SIG*AOMSO
1375      SIG=0.
1376      DD 34 LL=1,4
1377      L=2*LL-1
1378 34    SIG=SIG+B(L)*PDL(I,L)
1379 36    SIGMA(J)=SIGMA(J)+SIG*AOMSC
1380      WRITE(IWRI,26)EPS(JHALF,NE),(SIGMA(I),I=1,9),TOTAL
1381 38    CONTINUE
1382      RETURN
1383      END

```

```

1384      SUBROUTINE CROSS

```

```

1385 C

```

```

1386 C      CALCULATE OPTICAL MODEL REACTION CROSS SECTIONS

```

```

1387 C      WITH EMPIRICAL PARAMETERIZATION OF

```

```

1388 C      NARASIMHA MURTHY, CHATTERJEE, AND GUPTA

```

```

1389 C

```

```

1390 C      PARAMETER VALUES SET IN SUBROUTINE SIGPAR

```

```

1391 C

```

```

1392      COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNOUT,JPOUT

```

```

1393      COMMON /DIRECT/ SIGIN(4,51),JPIN,UNIN,BEA,NSO,KP,E,ACOM,G,RZZ

```

```

1394      COMMON /PAR/ PO(3,3),P1(3,3),P2(3,3),XLO(3,3),XL1(3,3),XMO(3,3)

```

```

1395      1,XM1(3,3),XNO(3,3),XN1(3,3),XN2(3,3)

```

```

1396      FLOW=1.E-18

```

```

1397      SPILL=1.E+18

```

```

1398      JDOUT=JPOUT+JNOUT

```

```

1399      XDOUT=JDOUT

```

```

1400      ATAR=ACOM-XDOUT

```

```

1401      ATHRO=ATAR**0.333

```

```

1402      IF(JPOUT.GT.0.)GO TO 2

```

```

1403      XLAMB=XLO(1,2)/ATHRO+XL1(1,2)

```

```

1404      XMU=XMO(1,2)+ATHRO+XM1(1,2)+ATHRO*ATHRO

```

```

1405      XNU=XNO(1,2)+ATHRO+XN1(1,2)+ATHRO*ATHRO+XN2(1,2)

```

```

1406      EC=2.4

```

```

1407      P=PO(1,2)

```

```

1408      NCDU=2

```

```

1409      ETEST=32.

```

```

1410      GO TO 3

```

```

1411 2

```

```

1412      IF(JOUT.EQ.1)RA=0.

```

```

1413      XPOUT=JPOUT

```

```

1414      RZ=JPIN-JPOUT

```

```

1415      RZ=RZ+RZZ

```

```

1416      EC=1.44*XPOUT=RZ/(1.5*ATHRO+RA)

```

```

1417      I=JPOUT+1

```

```

1418      J=JNOUT+1

```

```

1419      P=PO(I,J)+P1(I,J)/EC+P2(I,J)/(EC*EC)

```

```

1420      XLAMB=XLO(I,J)+ATHRO+XL1(I,J)

```

```

1421      A=ATAR**XM1(I,J)

```

```

1422      XMU=XMO(I,J)*A

```

```

1423      XNU=A*(XNO(I,J)+XN1(I,J)*EC+XN2(I,J)*EC*EC)

```

```

1424      IF(JOUT.EQ.2)RA=0.8

```

```

1425      IF(JDOUT.EQ.3)RA=0.8

```

```

1426      XNL=XNU/XLAMB

```

```

1427      IF(XNL.GT.SPILL)XNL=0.

```

```

1428      IF(XNL.LT.FLOW)GO TO 3

```

```

1429      ETEST=1.2*SQR(XNL)

```

```

1430 3      A=-2.*P*EC+XLAMB-XNU/(EC*EC)

```

```

1431      B=P*EC*EC+XMU+2.*XNU/EC

```

```

1432      ECUT=0.

```

```

1433      CUT=A*A-4.*P*B

```

```

1434      IF(CUT.GT.0.)ECUT=SQR(CUT)

```

```

1435      ECUT=(ECUT-A)/(2.*P)

```

```

1436      DD 4 NE=2,NEPS1

```

```

1437      IF(EPS(JHALF,NE).GT.EC)GO TO 6

```

```

1438 4      CONTINUE

```

```

1439 6      NCOU=NE

```

```

1440      IF(NCOU.LT.3)GO TO 10

```

```

1441      NC=NCOU-1

```

```

1442      DD 8 NE=2,NC

```

```

1443      ELAB=EPS(JHALF,NE)*ACOM/ATAR

```

```

1444      SIGIN(KP,NE)=P*ELAB*ELAB+A*ELAB+B

```

```

1445 8      IF(ELAB.LT.ECUT)SIGIN(KP,NE)=0.
1446 10     DD 12 NE=NCOU,NEPS1
1447      ELAB=EPS(JHALF,NE)*ACOM/ATARG
1448      SIG=XLAMB*ELAB+XMU+XNU/ELAB
1449      GEOM=0.
1450      IF(XNL.LT.FLOW)GO TO 12
1451      IF(ELAB.LT.EATEST)GO TO 12
1452      GEOM=SQRT(XOUT*EPS(JHALF,NE))
1453      GEOM=1.23*ATHRO+RA+4.573/GEOM
1454      GEOM=31.416*GEOM*GEOM
1455 12     SIGIN(KP,NE)=AMAX1(GEOM,SIG)
1456      RETURN
1457      END

1458      SUBROUTINE INEL
1459 C
1460 C      PHENOMENOLOGICAL ENERGY SPECTRA
1461 C      INELASTIC SCATTERING
1462 C      (RXN MUST INVOLVE AT LEAST ONE COMPLEX PARTICLE)
1463 C      FEBRUARY 1980
1464 C
1465      COMMON /ENERGY/ BEN,NEPS1, EPS(2,52),JHALF,JNDOUT,JPOUT
1466      COMMON /DIRECT/ SIGIN(4,51),JPIN,JNIN,BEA,NSD,KP,E,ACOM,G,RZZ
1467      COMMON /CLUSTR/ SNOCK(51),SIGBAR(5),SIGCN,COUL(5),BNEU,BPRO,BALFA
1468      XPIN=JPIN
1469      XNIN=JNIN
1470      JIN=JPIN+JNIN
1471      XIN=JIN
1472      ATARG=ACOM-XIN
1473      RNN=ATARG-RZZ
1474 C
1475 C      CALCULATE NORMALIZATION
1476 C
1477      XNDR=JIN*NSD
1478      XNORM=XNDR*SIGCN/16.
1479 C
1480 C      1. PROJECTILE=EJECTILE DENOMINATOR
1481      XNDR=XNDR*SIGBAR(KP)/6.
1482      COUP=COUL(KP)
1483      EMAX=E-BEN
1484      XNDR=XNDR*(EMAX+2.*COUP)/(EMAX-COUP)*(EMAX-COUP)
1485      IF(JIN.GT.1)GO TO 2
1486      GBA=(RZZ-1.)/13.
1487      IF(JNIN.EQ.1)GBA=(RNN-1.)/13.
1488      GO TO 10
1489 2      IF(JIN-3)4,5,6
1490 4      GBN=(ACOM-1.)/52.
1491      GBA=(ACOM-4.)/52.
1492      GO TO 8
1493 5      GBN=(ACOM-1.)/156.
1494      GBA=(ACOM-4.)/156.
1495      GO TO 8
1496 6      GBN=(ACOM-1.)/208.
1497      GBA=(ACOM-4.)/208.
1498 C
1499 C      2. NEUTRON EXCITATION
1500 8      GII=(RNN+XNIN-1.)/13.
1501      GIR=RNN/13.
1502      P=RNN/ATARG
1503      XNORI=2.*SIGBAR(1)*GII*GBN/6.
1504      EMAX=E-BNEU
1505      COUP=COUL(1)
1506      XNORI=XNORI*(EMAX+2.*COUP)/(EMAX-COUP)*(EMAX-COUP)
1507      XNORB=XNOR=GIR*GIR
1508      XN=GIR*GIR*P/(XNORI+XNORB)
1509      EPN=1./GIR
1510      UAON=1./GIR
1511 C
1512 C      3. PROTON EXCITATION
1513      GII=(RZZ+XPIN-1.)/13.
1514      GIR=RZZ/13.
1515      P=RZZ/ATARG
1516      XNORI=2.*SIGBAR(2)*GII*GBN/6.
1517      EMAX=E-BPRO
1518      COUP=COUL(2)
1519      XNORI=XNORI*(EMAX+2.*COUP)/(EMAX-COUP)*(EMAX-COUP)
1520      XNORB=XNOR=GIR*GIR
1521      XP=GIR*GIR*P/(XNORI+XNORB)

```

```

1522      EPP=1./GIR
1523      UAOP=1./GIR
1524 C
1525 C      4. ALPHA EXCITATION
1526 10      GII=(ACOM-4.)/208.
1527      GIR=ATARG/208.
1528      P=0.08*RZZ/(2.*ATARG)
1529      IF(RNN.LE.116.)GO TO 14
1530      IF(RNN.GE.129.)GO TO 14
1531      IF(RNN-126.)12,12,13
1532 12      Y=0.02+0.06*(126.-RNN)/10.
1533      P=P*Y/0.08
1534      GO TO 14
1535 13      Y=0.02+0.06*(RNN-126.)/3.
1536      P=P*Y/0.08
1537 14      XNORI=4.*SIGBAR(3)*GII*GBA/6.
1538      EMAX=E-BALFA
1539      COUP=COUL(3)
1540      XNORI=XNORI*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
1541      XNORB=XNOR*GIR=GIR
1542      XA=GIR*GIR*P/(XNORI+XNORS)
1543      EPA=52./RZZ+52./RNN
1544      UADA=1./GIR
1545 C
1546 C      CALCULATE ENERGY SPECTRUM
1547 C
1548      UMAX=E-BEN
1549      FLOW=1.E-18
1550      SPILL=1.E+18
1551      DD 16 NE=2.NEPS1
1552      U=UMAX-EPS(JHALF,NE)
1553      IF(U.LE.O.)GO TO 18
1554      X=0.
1555      IF(JIN.LE.1)GO TO 22
1556      UN=U-EPN
1557      IF(UN.LE.O.)GO TO 20
1558      UN=UN+UADN
1559      X=X+XN*UN
1560 20      UP=U-EPP
1561      IF(UP.LE.O.)GO TO 22
1562      UP=UP+UAOP
1563      X=X+XP*UP
1564 22      UA=U-EPA
1565      IF(UA.LE.O.)GO TO 24
1566      UA=UA+UADA
1567      X=X+XA*UA
1568 24      SIG=XNORM*EPS(JHALF,NE)*SIGIN(KP,NE)*X
1569      IF(SIG.LT.FLOW)SIG=0.
1570      IF(SIG.GT.SPILL)SIG=0.
1571 16      SNOCK(NE)=SIG
1572 18      RETURN
1573      END

1574      SUBROUTINE KNOCK
1575 C
1576 C      PHENOMENOLOGICAL ENERGY SPECTRA
1577 C      KNOCKOUT OF N, P, OR ALPHA
1578 C      (RXN MUST HAVE AT LEAST ONE COMPLEX PARTICLE)
1579 C      FEBRUARY 1980
1580 C
1581      COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNOUT,JPOUT
1582      COMMON /DIRECT/ SIGIN(4,51),JPIN,UNIN,BEA,NSO,KP,E,ACOM,G,RZZ
1583      COMMON /CLUSTER/ SNOCK(51),SIGBAR(5),SIGCN,COUL(5),BNEU,BPRO,BALFA
1584      JIN=JPIN+UNIN
1585      XIN=XIN
1586      XPIN=JPIN
1587      XNIN=UNIN
1588      JOUT=JPOUT+JNOUT
1589      XOUT=XJOUT
1590      XPOUT=XJPOUT
1591      XNOUT=XJNOUT
1592      ATARG=ACOM-XIN
1593      RNN=ATARG-RZZ
1594      ARES=ACOM-XOUT

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1595 C
1596 C CALCULATE S. P. STATE DENSITIES
1597 C AND (2S+1)*A TYPE FACTORS
1598 C
1599 IF(JIN.GT.1)GO TO 2
1600 REL=2.
1601 GA=(RZZ+1.-XPOUT)/13.
1602 IF(JNIN.EQ.1)GA=(RNN+1.-XNOUT)/13.
1603 GO TO 8
1604 2 IF(JIN*3)4,5,6
1605 4 REL=6.
1606 GA=ARES/52.
1607 GO TO 8
1608 5 REL=6.
1609 GA=ARES/156.
1610 GO TO 8
1611 6 REL=4.
1612 GA=ARES/208.
1613 8 IF(JDOUT.GT.1)GO TO 10
1614 GBT=RZZ/13.
1615 GBR=(RZZ+XPIN-1.)/13.
1616 IF(JNOUT.EQ.0)GO TO 12
1617 GBT=RNN/13.
1618 GBR=(RNN+XNIN-1.)/13.
1619 GO TO 12
1620 10 GBT*ATARG/208.
1621 GBR=ARES/208.
1622 C
1623 C CALCULATE NORMALIZATION
1624 C
1625 12 XNORM=SIGCN/16.
1626 XNORB=JDOUT*NSO
1627 XNORM=XNORM*XNORB
1628 XNORB=XNORB*SIGBAR(KP)*GA*GBR/6.
1629 EMAX=E-BEN
1630 COUP=COUL(KP)
1631 XNORB=XNORB*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
1632 XNORA=REL*SIGBAR(5)*GBT*GBT/6.
1633 EMAX=E-BEA
1634 COUP=COUL(5)
1635 XNORA=XNORA*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
1636 XNORM=XNORM*GA*GBR/(XNORA+XNORB)
1637 IF(JPOUT-1)14,15,16
1638 14 XNORM=XNORM*(1.-RZZ/ATARG)
1639 GO TO 20
1640 15 XNORM=XNORM=RZZ/ATARG
1641 GO TO 20
1642 16 XNORM=XNORM*0.08*RZZ/(2.*ATARG)
1643 IF(RNN.LE.116.)GO TO 20
1644 IF(RNN.GE.129.)GO TO 20
1645 IF(RNN-126.)18,18,19
1646 18 X=0.02+0.06*(126.-RNN)/10.
1647 XNORM=XNORM*X/O.08
1648 GO TO 20
1649 19 X=0.02+0.06*(RNN-126.)/3.
1650 XNORM=XNORM*X/O.08
1651 C
1652 C CALCULATE ENERGY SPECTRUM
1653 C
1654 20 FLOW=1.E-18
1655 SPILL=1.E+18
1656 UMAX=E-BEN
1657 Q=JPIN+JPOUT
1658 UPAUL=Q*Q*13./((RZZ+XPIN-XPOUT)
1659 Q=JNIN+JNOUT
1660 UPAUL-UPAUL+Q*Q=13./((RNN+XNIN-XNOUT)
1661 UADD=0.5/GBR+0.5/GA
1662 DD 22 NE=2,NEPS1
1663 U=UMAX-EPS(1,NE)
1664 U=U-UPAUL
1665 IF(U.LT.O.)GO TO 24
1666 U=U+UADD
1667 SIG=XNORM*U*EPS(1,NE)*SIGIN(KP,NE)
1668 IF(SIG.LT.FLOW)SIG=0.
1669 IF(SIG.GT.SPILL)SIG=0.
1670 22 SNOCK(NE)=SIG
1671 24 RETURN
1672 END

```



```

1673      SUBROUTINE NUTRA
1674 C
1675 C      PHENOMENOLOGICAL ENERGY SPECTRA
1676 C      NUCLEON TRANSFER
1677 C      PROGRAM - FEBRUARY 1979
1678 C      SUBROUTINE (SIMPLIFIED) - FEBRUARY 1980
1679 C
1680      COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNDOUT,JPOUT
1681      COMMON /DIRECT/ SIGIN(4,51),JPIN,JNIN,BEA,NSD,KP,E,ACOM,G,RZZ
1682      COMMON /NUTRAN/ SNUTRA(51)
1683      FLOW=1.E-18
1684      SPILL=1.E+18
1685      JIN=JNIN+JPIN
1686      XIN=JIN
1687      JOUT=JNDOUT+JPOUT
1688      XOUT=JOUT
1689      ATARG=ACOM-XIN
1690      ECOM=E-BEA
1691      ELABI=ECOM*ACOM/ATARG
1692      ARES=ACOM-XOUT
1693      UMAX=E-BEN
1694      VAB=0.25*50.*XIN
1695      KAB=1.
1696      IF(JHALF.EQ.2)GO TO 2
1697      IF(JIN.EQ.2)GO TO 2
1698      IF(JIN.EQ.3)GO TO 2
1699      KAB=12.
1700 2      VELO=XIN/(ELABI+VAB)
1701      X=JOUT*NSD
1702      X=X*KAB
1703      Y=6.
1704      IF(JIN.EQ.1)Y=2.
1705      IF(JIN.EQ.4)Y=4.
1706      XHOLD=0.0127*X/(Y*ECOM*XIN)
1707      TRANP=IABS(JPOUT-JPIN)
1708      ZA=2.*RZZ/ATARG
1709      TRANN=IABS(JNDOUT-JNIN)
1710      PH=TRANN+TRANP
1711      NEX=0
1712      IF (PH .GT. 0.) GO TO 5
1713      NEX=1.
1714      PH=2.
1715      TRANP=2.
1716 5      X=XHOLD*(2860./ARES)**PH
1717      X=X*VELD**(2.*PH)
1718      X=X*ZA**(6.*TRANP)
1719      JP=JPIN-JPOUT
1720      Y=JP
1721      GP=(RZZ+Y)/13.
1722      JN=JNIN-JNDOUT
1723      Y=JN
1724      RNN=ATARG-RZZ
1725      GN=(RNN+Y)/13.
1726      X=X*(GP**TRANP)*(GN**TRANN)
1727      JPICKP=MAXO(JP,0).
1728      IF(JPICKP.LT.2)GO TO 6
1729      DD 4 N=2,JPICKP
1730      Y=N
1731 4      X=X/Y
1732 6      JSTRIP=JPICKP-JP
1733      IF(JSTRIP.LT.2)GO TO 10
1734      DD 8 N=2,JSTRIP
1735      Y=N
1736 8      X=X/Y
1737 10     JPICKN=MAXO(JN,0)
1738      IF(JPICKN.LT.2)GD TO 14
1739      DD 12 N=2,JPICKN
1740      Y=N
1741 12     X=X/Y
1742 14     JSTRIN=JPICKN-JN
1743      IF(JSTRIN.LT.2)GO TO 18
1744      DD 16 N=2,JSTRIN
1745      Y=N
1746 16     X=X/Y
1747 18     J=JPICKP+JPICKN
1748      IF (NEX .GT. 0) J=1
1749      H=J
1750      JMAX=JSTRIP+JSTRIN
1751      IF (NEX .GT. 0)JMAX=1
1752      P=JMAX

```

```

1753     IMAX=PH
1754     GR=ARES/13.
1755     W=0.
1756     FAC=1.
1757     DD 20 I=1,IMAX
1758     XI=I
1759 20   IF(I.GT.1)X=X/(XI-1.)
1760     PPI=JSTRIP
1761     PNU=JSTRIN
1762     HPI=JPICKP
1763     HNU=JPICKN
1764     Q=AMAX1(PNU,HNU)
1765     UMAX=UMAX-Q*Q/GN
1766     Q=AMAX1(PPI,HPI)
1767     UMAX=UMAX-Q*Q/GP
1768     UADD=(PNU*(PNU+1.)+HNU*(HNU+1.))/(4.*GN)
1769     UAOD=UADD+(PPI*(PPI+1.)+HPI*(HPI+1.))/(4.*GP)
1770     DD 40 NE=2,NEPS1
1771     U=UMAX-EPS(JHALF,NE)
1772     IF(U.LT.O.)GO TO 40
1773     U=U+UAOD
1774     W=X*U*(PH-1.)
1775     SIG=W*EPS(JHALF,NE)*SIGIN(KP,NE)
1776     IF(SIG.LT.FLOW)SIG=0.
1777     IF(SIG.GT.SPILL)SIG=0.
1778     SNUTRA(NE)=SIG+SNUTRA(NE)
1779 40   CONTINUE
1780     IF (NEX .NE. 1) GO TO 42
1781     NEX=2
1782     TRANP=0.
1783     TRANN=2.
1784     GO TO 5
1785 42   RETURN
1786     END

```

```

1787     SUBROUTINE POLLY
1788 C
1789 C     GENERATE LIBRARY OF LEGENDRE POLYNOMIALS
1790 C
1791     COMMON /ANGELS/ PDL(19,7),TOMSO(51),TOMSC(51),IWRI,IANG
1792     DD 4 J=1,19
1793     ANG=(J-1)*10
1794     ANG=ANG*3.1413/180.
1795     COSX=COS(ANG)
1796     COSX2=COSX*COSX
1797     COSX3=COSX*COSX2
1798     COSX4=COSX*COSX3
1799     COSX5=COSX*COSX4
1800     COSX6=COSX*COSX5
1801     POL(J,1)=1.
1802     POL(J,2)=COSX
1803     POL(J,3)=(3.*COSX2-1.)/2.
1804     POL(J,4)=(5.*COSX3-3.*COSX)/2.
1805     POL(J,5)=(35.*COSX4-30.*COSX2+3.)/8.
1806     POL(J,6)=(63.*COSX5-70.*COSX3+15.*COSX)/8.
1807     POL(J,7)=(231.*COSX6-315.*COSX4+105.*COSX2-5.)/16.
1808 4   CONTINUE
1809     RETURN
1810     END

```

```

1811     SUBROUTINE SIGPAR
1812 C
1813 C     STORE PARAMETERS FOR CALCULATING APPROXIMATE
1814 C     OPTICAL MODEL REACTION CROSS SECTIONS
1815 C
1816 C     NEUTRON FROM MANI ET AL
1817 C     PROTON FROM BECCHETTI-GREENLEES
1818 C     ALPHA FROM HUIZENGA AND IGD
1819 C     D FROM D.M. OF PEREY AND PEREY
1820 C     T FROM D.M. OF HAFELE, FLYNN ET AL
1821 C     3HE FROM D.M. OF GIBSON ET AL

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```

1822 C      COMMON /PAR/ PO(3,3),P1(3,3),P2(3,3),XLO(3,3),XL1(3,3),XMO(3,3)
1823      1,XM1(3,3),XNO(3,3),XN1(3,3),XN2(3,3)
1824      DD 2 I=1,3
1825      DD 2 J=1,3
1826      PO(I,J)=0.
1827      P1(I,J)=0.
1828      P2(I,J)=0.
1829      XLO(I,J)=0.
1830      XL1(I,J)=0.
1831      XMO(I,J)=0.
1832      XM1(I,J)=0.
1833      XNO(I,J)=0.
1834      XN1(I,J)=0.
1835      XN2(I,J)=0.
1836 2      PO(1,2)=-312.
1837      PO(2,1)=15.72
1838      PO(2,2)=0.798
1839      PO(2,3)=-21.45
1840      PO(3,2)=-2.88
1841      PO(3,3)=10.95
1842      P1(2,1)=9.65
1843      P1(2,2)=420.3
1844      P1(2,3)=484.7
1845      P1(3,2)=205.6
1846      P1(3,3)=-85.21
1847      P2(2,1)=-449.
1848      P2(2,2)=-1651.
1849      P2(2,3)=-1608.
1850      P2(3,2)=-1487.
1851      P2(3,3)=1146.
1852      XLO(1,2)=12.10
1853      XLO(2,1)=0.00437
1854      XLO(2,2)=0.00619
1855      XLO(2,3)=0.0186
1856      XLO(3,2)=0.00459
1857      XLO(3,3)=0.0643
1858      XL1(1,2)=-11.27
1859      XL1(2,1)=-16.58
1860      XL1(2,2)=-7.54
1861      XL1(2,3)=-8.90
1862      XL1(3,2)=-8.93
1863      XL1(3,3)=-13.96
1864      XMO(1,2)=234.1
1865      XMO(2,1)=244.7
1866      XMO(2,2)=583.5
1867      XMO(2,3)=686.3
1868      XMO(3,2)=611.2
1869      XMO(3,3)=781.2
1870      XM1(1,2)=38.26
1871      XM1(2,1)=0.503
1872      XM1(2,2)=0.337
1873      XM1(2,3)=0.325
1874      XM1(3,2)=0.35
1875      XM1(3,3)=0.29
1876      XNO(1,2)=1.55
1877      XNO(2,1)=273.1
1878      XNO(2,2)=421.8
1879      XNO(2,3)=368.9
1880      XNO(3,2)=473.8
1881      XNO(3,3)=-304.7
1882      XN1(1,2)=-106.1
1883      XN1(2,1)=-182.4
1884      XN1(2,2)=-474.5
1885      XN1(2,3)=-522.2
1886      XN1(3,2)=-468.2
1887      XN1(3,3)=-470.
1888      XN2(1,2)=1280.8
1889      XN2(2,1)=-1.872
1890      XN2(2,2)=-3.592
1891      XN2(2,3)=-4.998
1892      XN2(3,2)=-2.225
1893      XN2(3,3)=-8.582
1894      RETURN
1895      END
1896

```

APPENDIX B

SAMPLE INPUT

1	1				
		38.00	38.00		
		33.50	5.05		
		26.00	28.00		
		14.08	5.05	8.20	0.00
		0.0			
		0.00			
		966.00	780.		
16					
		1.00	740.00	0.00	0.00
		2.00	1651.00	4.00	0.00
		3.00	1484.00	36.00	0.00
		4.00	1383.00	123.00	0.00
		5.00	1372.00	258.00	2.00
		6.00	1383.00	402.00	26.00
		7.00	1388.00	517.00	140.00
		8.00	1384.00	596.00	350.00
		9.00	1374.00	655.00	570.00
		10.00	1361.00	702.00	730.00
		12.00	1340.00	779.00	980.00
		14.00	1326.00	834.00	1170.00
		16.00	1315.00	881.00	1300.00
		20.00	1282.00	932.00	1420.00
		24.00	1263.00	957.00	1500.00
		26.00	1225.00	966.00	1520.00
2		0			
2		0			
		4.23			
		1.35			
-1		0			
1					
1		0			
2		1			
		4.23			
		1.35			
-1		0			
0					
		66.00	5.05		
		26.00	28.0		
		14.08	5.05	8.20	0.00
		0.00			
		0.00			
		0.00			
30		2.00	2.00		
1		0			
0					
		0.00			
		0.00			
1		1			
3					
		16.21			
		0.00			
24		2.00	2.00		
1		2			
2					
		20.63			
		0.00			
22		3.00	2.00		
2		1			
2					
		18.24			
		0.00			
21		6.00	2.00		
-1		0			
0					
		20.04	4.79		
		92.00	143.00		
		5.69	4.79	-5.24	5.75
		0.00			
		0.00			
		0.00			
24		1.00			
1		0			
0					
		16.62	16.57	17.13	17.49
		0.00			17.97
-1		0			
-1					

APPENDIX C

SAMPLE OUTPUT

1
-S= 10.45 MEV
-OCCUPATION PROBABILITIES PO= 2, HO= 0
TARGET Z= 26, N= 28 PROJ Z= 2, N= 0
G= 4.230, E=33.500
SCALE FACTOR= 1.350, FRAC PREEQ= 0.043
- P H RHO/RHO STRU/STR STRD/STR
2 0 9.896E-01 9.896E-01 9.896E-01
3 1 8.373E-01 8.206E-01 8.206E-01
4 2 5.637E-01 5.722E-01 5.240E-01
5 3 3.264E-01 3.079E-01 2.333E-01
6 4 1.509E-01 1.353E-01 6.615E-02
7 5 5.744E-02 5.872E-02 1.043E-02

1PARTICLE SPECTRA Z= 0, N= 1
 FIRST EMISSION AT P= 3
 TARGET Z= 26, N= 28 PROJ Z= 2, N= 0
 PO= 2, HO= 0, G= 4.230, E=33.500
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 966.0
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.043
 MSD POSSIBLE= 0.990, USED= 0.006
 CLOSED FORM SUM STARTS AT P= 3

EPS	DIRECT			PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
	NUTRA	KNOCK		MSD	MSC	WEISS	MSD	MSC	MSD+MSC	
1.00	8.383E-03	2.629E-02	0.	0.	0.	4.379E+00	3.467E-02	4.379E+00	4.413E+00	
2.00	3.314E-02	1.103E-01	0.	0.	0.	1.114E+01	1.435E-01	1.114E+01	1.128E+01	
3.00	3.928E-02	1.393E-01	0.	0.	0.	8.440E+00	1.786E-01	8.440E+00	8.618E+00	
4.00	4.252E-02	1.614E-01	0.	0.	0.	5.799E+00	2.039E-01	5.799E+00	6.003E+00	
5.00	4.547E-02	1.857E-01	0.	0.	0.	3.908E+00	2.311E-01	3.908E+00	4.139E+00	
6.00	4.688E-02	2.070E-01	0.	0.	0.	2.520E+00	2.539E-01	2.520E+00	2.774E+00	
7.00	4.614E-02	2.218E-01	0.	0.	0.	1.541E+00	2.680E-01	1.541E+00	1.809E+00	
8.00	4.347E-02	2.294E-01	0.	0.	0.	8.953E-01	2.729E-01	8.953E-01	1.168E+00	
9.00	3.934E-02	2.300E-01	0.	0.	0.	4.967E-01	2.694E-01	4.967E-01	7.661E-01	
10.00	3.423E-02	2.244E-01	0.	0.	0.	2.636E-01	2.586E-01	2.636E-01	5.222E-01	
12.00	2.278E-02	1.971E-01	0.	0.	0.	6.503E-02	2.199E-01	6.503E-02	2.849E-01	
14.00	1.173E-02	1.490E-01	0.	0.	0.	1.297E-02	1.607E-01	1.297E-02	1.737E-01	
16.00	3.353E-03	7.988E-02	0.	0.	0.	1.907E-03	8.323E-02	1.907E-03	8.513E-02	
OSUMS	4.750E-01	2.780E+00	0.	0.	0.	3.968E+01				

ANGULAR DISTRIBUTIONS Z= 0 N= 1
 ENERGY PARAM. = EPS+B.E.

CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
1.00	4.63E-01	4.57E-01	4.42E-01	4.20E-01	3.93E-01	3.64E-01	3.38E-01	3.18E-01	3.04E-01	2.99E-01
2.00	1.20E+00	1.19E+00	1.15E+00	1.09E+00	1.01E+00	9.36E-01	8.65E-01	8.08E-01	7.71E-01	7.57E-01
3.00	9.38E-01	9.27E-01	8.93E-01	8.43E-01	7.82E-01	7.19E-01	6.61E-01	6.15E-01	5.84E-01	5.72E-01
4.00	6.70E-01	6.62E-01	6.37E-01	5.99E-01	5.53E-01	5.06E-01	4.62E-01	4.27E-01	4.04E-01	3.94E-01
5.00	4.78E-01	4.71E-01	4.52E-01	4.24E-01	3.90E-01	3.54E-01	3.21E-01	2.95E-01	2.77E-01	2.69E-01
6.00	3.35E-01	3.30E-01	3.16E-01	2.95E-01	2.69E-01	2.43E-01	2.19E-01	1.99E-01	1.85E-01	1.78E-01
7.00	2.32E-01	2.28E-01	2.18E-01	2.02E-01	1.84E-01	1.64E-01	1.46E-01	1.31E-01	1.20E-01	1.14E-01
8.00	1.62E-01	1.59E-01	1.52E-01	1.40E-01	1.27E-01	1.12E-01	9.83E-02	8.68E-02	7.81E-02	7.28E-02
9.00	1.18E-01	1.16E-01	1.10E-01	1.01E-01	9.01E-02	7.88E-02	6.82E-02	5.90E-02	5.18E-02	4.71E-02
10.00	8.97E-02	8.80E-02	8.33E-02	7.61E-02	6.75E-02	5.83E-02	4.96E-02	4.20E-02	3.59E-02	3.16E-02
12.00	6.00E-02	5.87E-02	5.53E-02	5.00E-02	4.37E-02	3.70E-02	3.06E-02	2.49E-02	2.02E-02	1.66E-02
14.00	4.16E-02	4.07E-02	3.81E-02	3.42E-02	2.95E-02	2.46E-02	1.99E-02	1.58E-02	1.24E-02	9.76E-03
16.00	2.21E-02	2.15E-02	2.01E-02	1.79E-02	1.53E-02	1.26E-02	1.00E-02	7.80E-03	5.98E-03	4.58E-03
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
1.00	3.03E-01	3.16E-01	3.36E-01	3.61E-01	3.89E-01	4.15E-01	4.37E-01	4.52E-01	4.57E-01	4.41E+00
2.00	7.68E-01	8.01E-01	8.55E-01	9.23E-01	9.97E-01	1.07E+00	1.13E+00	1.17E+00	1.18E+00	1.13E+01
3.00	5.80E-01	6.06E-01	6.49E-01	7.02E-01	7.62E-01	8.19E-01	8.66E-01	8.98E-01	9.09E-01	8.62E+00
4.00	3.99E-01	4.17E-01	4.48E-01	4.86E-01	5.29E-01	5.70E-01	6.05E-01	6.28E-01	6.36E-01	6.00E+00
5.00	2.71E-01	2.83E-01	3.04E-01	3.31E-01	3.61E-01	3.90E-01	4.15E-01	4.31E-01	4.37E-01	4.14E+00
6.00	1.78E-01	1.86E-01	1.99E-01	2.17E-01	2.37E-01	2.57E-01	2.73E-01	2.85E-01	2.88E-01	2.77E+00
7.00	1.13E-01	1.17E-01	1.25E-01	1.36E-01	1.49E-01	1.61E-01	1.72E-01	1.79E-01	1.81E-01	1.81E+00
8.00	7.10E-02	7.23E-02	7.64E-02	8.26E-02	8.99E-02	9.72E-02	1.04E-01	1.08E-01	1.09E-01	1.17E+00
9.00	4.46E-02	4.44E-02	4.60E-02	4.90E-02	5.29E-02	5.69E-02	6.04E-02	6.28E-02	6.37E-02	7.66E-01
10.00	2.89E-02	2.78E-02	2.79E-02	2.90E-02	3.08E-02	3.28E-02	3.45E-02	3.58E-02	3.62E-02	5.22E-01
12.00	1.41E-02	1.23E-02	1.13E-02	1.09E-02	1.08E-02	1.10E-02	1.12E-02	1.14E-02	1.15E-02	2.85E-01
14.00	7.77E-03	6.35E-03	5.36E-03	4.71E-03	4.29E-03	4.03E-03	3.89E-03	3.83E-03	3.81E-03	1.74E-01
16.00	3.53E-03	2.77E-03	2.23E-03	1.85E-03	1.59E-03	1.41E-03	1.29E-03	1.22E-03	1.20E-03	8.51E-02

1PARTICLE SPECTRA Z= 1. N= 0
 FIRST EMISSION AT P= 3
 TARGET Z= 26. N= 28 PROJ Z= 2. N= 0
 PO= 2. HO= 0. G= 4.230. E=33.500
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 966.0
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.043
 MSD POSSIBLE= 0.990. USED= 0.006
 CLOSED FORM SUM STARTS AT P= 3

EPS	DIRECT		PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
	NUTRA	KNOCK	MSD	MSC	WEISS	MSD	MSC	MSD+MSC	
2.00	6.902E-05	3.742E-04	0.	0.	2.823E+00	4.433E-04	2.823E+00	2.823E+00	
3.00	9.317E-04	4.831E-03	0.	0.	2.370E+01	5.763E-03	2.370E+01	2.371E+01	
4.00	4.244E-03	2.100E-02	0.	0.	6.660E+01	2.524E-02	6.660E+01	6.663E+01	
5.00	1.113E-02	5.242E-02	0.	0.	1.067E+02	6.355E-02	1.067E+02	1.068E+02	
6.00	2.081E-02	9.306E-02	0.	0.	1.208E+02	1.139E-01	1.208E+02	1.209E+02	
7.00	3.122E-02	1.322E-01	0.	0.	1.085E+02	1.634E-01	1.085E+02	1.087E+02	
8.00	4.113E-02	1.644E-01	0.	0.	8.473E+01	2.056E-01	8.473E+01	8.493E+01	
9.00	5.086E-02	1.912E-01	0.	0.	6.134E+01	2.421E-01	6.134E+01	6.158E+01	
10.00	6.056E-02	2.133E-01	0.	0.	4.224E+01	2.739E-01	4.224E+01	4.251E+01	
12.00	8.065E-02	2.458E-01	0.	0.	1.803E+01	3.264E-01	1.803E+01	1.836E+01	
14.00	1.007E-01	2.591E-01	0.	0.	6.776E+00	3.598E-01	6.776E+00	7.136E+00	
16.00	1.216E-01	2.550E-01	0.	0.	2.280E+00	3.766E-01	2.280E+00	2.657E+00	
20.00	1.608E-01	1.845E-01	0.	0.	1.723E-01	3.453E-01	1.723E-01	5.176E-01	
24.00	1.981E-01	3.907E-02	0.	0.	6.234E-03	2.372E-01	6.234E-03	2.434E-01	
26.00	2.167E-01	0.	0.	0.	7.194E-04	2.167E-01	7.194E-04	2.174E-01	
OSUMS	2.541E+00	3.610E+00	0.	0.	6.957E+02				

ANGULAR DISTRIBUTIONS Z= 1 N= 0
 ENERGY PARAM. = EPS+B.E.

CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
2.00	2.68E-01	2.66E-01	2.61E-01	2.52E-01	2.41E-01	2.30E-01	2.19E-01	2.11E-01	2.05E-01	2.03E-01
3.00	2.28E+00	2.26E+00	2.21E+00	2.13E+00	2.03E+00	1.93E+00	1.84E+00	1.76E+00	1.71E+00	1.70E+00
4.00	6.46E+00	6.41E+00	6.25E+00	6.02E+00	5.73E+00	5.43E+00	5.15E+00	4.93E+00	4.79E+00	4.74E+00
5.00	1.05E+01	1.04E+01	1.01E+01	9.71E+00	9.23E+00	8.72E+00	8.25E+00	7.87E+00	7.63E+00	7.54E+00
6.00	1.20E+01	1.19E+01	1.16E+01	1.11E+01	1.05E+01	9.88E+00	9.32E+00	8.87E+00	8.58E+00	8.48E+00
7.00	1.09E+01	1.08E+01	1.05E+01	1.00E+01	9.48E+00	8.90E+00	8.37E+00	7.94E+00	7.66E+00	7.56E+00
8.00	8.64E+00	8.55E+00	8.29E+00	7.91E+00	7.45E+00	6.97E+00	6.53E+00	6.17E+00	5.94E+00	5.86E+00
9.00	6.35E+00	6.28E+00	6.09E+00	5.79E+00	5.44E+00	5.07E+00	4.72E+00	4.45E+00	4.28E+00	4.21E+00
10.00	4.45E+00	4.40E+00	4.26E+00	4.04E+00	3.78E+00	3.51E+00	3.26E+00	3.06E+00	2.93E+00	2.88E+00
12.00	1.99E+00	1.97E+00	1.90E+00	1.79E+00	1.66E+00	1.53E+00	1.41E+00	1.31E+00	1.24E+00	1.22E+00
14.00	8.20E-01	8.08E-01	7.76E-01	7.28E-01	6.69E-01	6.09E-01	5.53E-01	5.07E-01	4.77E-01	4.63E-01
16.00	3.38E-01	3.33E-01	3.18E-01	2.96E-01	2.69E-01	2.41E-01	2.14E-01	1.92E-01	1.77E-01	1.68E-01
20.00	1.00E-01	9.84E-02	9.28E-02	8.44E-02	7.42E-02	6.34E-02	5.30E-02	4.39E-02	3.64E-02	3.08E-02
24.00	6.13E-02	5.99E-02	5.59E-02	5.00E-02	4.30E-02	3.56E-02	2.86E-02	2.24E-02	1.73E-02	1.34E-02
26.00	5.84E-02	5.70E-02	5.30E-02	4.71E-02	4.00E-02	3.27E-02	2.58E-02	1.99E-02	1.51E-02	1.14E-02
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
2.00	2.05E-01	2.11E-01	2.19E-01	2.30E-01	2.41E-01	2.52E-01	2.61E-01	2.66E-01	2.68E-01	2.82E+00
3.00	1.71E+00	1.76E+00	1.84E+00	1.93E+00	2.03E+00	2.13E+00	2.21E+00	2.26E+00	2.28E+00	2.37E+01
4.00	4.79E+00	4.93E+00	5.15E+00	5.43E+00	5.73E+00	6.01E+00	6.25E+00	6.41E+00	6.46E+00	6.66E+01
5.00	7.62E+00	7.87E+00	8.24E+00	8.71E+00	9.22E+00	9.70E+00	1.01E+01	1.04E+01	1.05E+01	1.07E+02
6.00	8.57E+00	8.86E+00	9.31E+00	9.87E+00	1.05E+01	1.11E+01	1.15E+01	1.19E+01	1.20E+01	1.21E+02
7.00	7.66E+00	7.93E+00	8.36E+00	8.89E+00	9.47E+00	1.00E+01	1.05E+01	1.08E+01	1.09E+01	1.09E+02
8.00	5.94E+00	6.16E+00	6.51E+00	6.95E+00	7.43E+00	7.89E+00	8.27E+00	8.52E+00	8.61E+00	8.49E+01
9.00	4.27E+00	4.44E+00	4.71E+00	5.04E+00	5.41E+00	5.76E+00	6.05E+00	6.24E+00	6.31E+00	6.16E+01
10.00	2.92E+00	3.04E+00	3.24E+00	3.48E+00	3.75E+00	4.00E+00	4.22E+00	4.36E+00	4.41E+00	4.25E+01
12.00	1.24E+00	1.29E+00	1.38E+00	1.50E+00	1.63E+00	1.75E+00	1.85E+00	1.92E+00	1.94E+00	1.84E+01
14.00	4.68E-01	4.89E-01	5.26E-01	5.73E-01	6.25E-01	6.76E-01	7.18E-01	7.47E-01	7.57E-01	7.14E+00
16.00	1.67E-01	1.73E-01	1.85E-01	2.01E-01	2.20E-01	2.38E-01	2.54E-01	2.64E-01	2.68E-01	2.66E+00
20.00	2.69E-02	2.45E-02	2.35E-02	2.34E-02	2.40E-02	2.49E-02	2.58E-02	2.65E-02	2.67E-02	5.18E-01
24.00	1.04E-02	8.26E-03	6.70E-03	5.61E-03	4.84E-03	4.32E-03	3.98E-03	3.80E-03	3.74E-03	2.43E-01
26.00	8.67E-03	6.69E-03	5.26E-03	4.24E-03	3.50E-03	2.99E-03	2.64E-03	2.44E-03	2.38E-03	2.17E-01

1PARTICLE SPECTRA Z= 2, N= 2
 FIRST EMISSION AT P= 4
 TARGET Z= 26, N= 28 PROJ Z= 2, N= 0
 PO= 2, HO= 0, G= 4.230, E=33.500
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 966.0
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.043
 MSD POSSIBLE= 0.990, USED= 0.006
 CLOSED FORM SUM STARTS AT P= 4

- EPS	DIRECT		PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
	-- NUTRA	KNOCK	-- MSD	MSC	-- WEISS	-- MSD	MSC	MSD+MSC	
5.00	3.109E-04	4.894E-05	4.307E-03	6.932E-02	1.531E-01	4.667E-03	2.224E-01	2.271E-01	
6.00	4.596E-03	7.038E-04	4.898E-02	7.152E-01	1.419E+00	5.428E-02	2.134E+00	2.188E+00	
7.00	2.727E-02	4.046E-03	2.225E-01	2.903E+00	5.230E+00	2.539E-01	8.133E+00	8.387E+00	
8.00	7.335E-02	1.049E-02	4.563E-01	5.222E+00	8.652E+00	5.402E-01	1.387E+01	1.441E+01	
9.00	1.260E-01	1.726E-02	5.957E-01	5.857E+00	9.049E+00	7.390E-01	1.491E+01	1.564E+01	
10.00	1.674E-01	2.177E-02	5.999E-01	4.948E+00	7.237E+00	7.891E-01	1.218E+01	1.297E+01	
12.00	2.313E-01	2.608E-02	4.754E-01	2.543E+00	3.493E+00	7.328E-01	6.036E+00	6.769E+00	
14.00	2.687E-01	2.380E-02	3.191E-01	9.870E-01	1.342E+00	6.116E-01	2.329E+00	2.941E+00	
16.00	2.733E-01	0.	1.915E-01	3.163E-01	4.241E-01	4.648E-01	7.404E-01	1.205E+00	
20.00	1.877E-01	0.	5.414E-02	2.721E-02	2.273E-02	2.419E-01	4.995E-02	2.918E-01	
24.00	0.	0.	6.450E-03	1.521E-03	3.195E-04	6.450E-03	1.840E-03	8.290E-03	
OSUMS	3.053E+00	1.649E-01	4.627E+00	3.031E+01	4.639E+01				

ANGULAR DISTRIBUTIONS Z= 2 N= 2

ENERGY PARAM. = EPS+B.E.

CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
5.00	2.34E-02	2.32E-02	2.25E-02	2.14E-02	2.01E-02	1.88E-02	1.76E-02	1.66E-02	1.59E-02	1.56E-02
6.00	2.29E-01	2.27E-01	2.20E-01	2.09E-01	1.96E-01	1.82E-01	1.69E-01	1.59E-01	1.52E-01	1.49E-01
7.00	8.95E-01	8.85E-01	8.55E-01	8.11E-01	7.57E-01	7.01E-01	6.49E-01	6.07E-01	5.79E-01	5.68E-01
8.00	1.57E+00	1.55E+00	1.50E+00	1.41E+00	1.32E+00	1.21E+00	1.12E+00	1.04E+00	9.88E-01	9.66E-01
9.00	1.74E+00	1.72E+00	1.66E+00	1.56E+00	1.45E+00	1.33E+00	1.22E+00	1.13E+00	1.06E+00	1.04E+00
10.00	1.48E+00	1.46E+00	1.41E+00	1.32E+00	1.22E+00	1.11E+00	1.01E+00	9.31E-01	8.76E-01	8.51E-01
12.00	8.28E-01	8.16E-01	7.81E-01	7.29E-01	6.65E-01	5.99E-01	5.38E-01	4.87E-01	4.51E-01	4.33E-01
14.00	4.02E-01	3.95E-01	3.76E-01	3.48E-01	3.14E-01	2.78E-01	2.45E-01	2.16E-01	1.95E-01	1.83E-01
16.00	1.94E-01	1.90E-01	1.80E-01	1.65E-01	1.47E-01	1.27E-01	1.09E-01	9.32E-02	8.10E-02	7.27E-02
20.00	6.68E-02	6.53E-02	6.12E-02	5.49E-02	4.75E-02	3.96E-02	3.22E-02	2.57E-02	2.04E-02	1.63E-02
24.00	2.06E-03	2.00E-03	1.86E-03	1.65E-03	1.40E-03	1.14E-03	8.99E-04	6.97E-04	5.38E-04	4.23E-04
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
5.00	1.58E-02	1.64E-02	1.73E-02	1.84E-02	1.97E-02	2.09E-02	2.19E-02	2.25E-02	2.28E-02	2.27E-01
6.00	1.51E-01	1.57E-01	1.66E-01	1.77E-01	1.90E-01	2.02E-01	2.12E-01	2.19E-01	2.21E-01	2.19E+00
7.00	5.73E-01	5.96E-01	6.32E-01	6.78E-01	7.29E-01	7.78E-01	8.19E-01	8.46E-01	8.56E-01	8.39E+00
8.00	9.75E-01	1.01E+00	1.08E+00	1.16E+00	1.25E+00	1.34E+00	1.42E+00	1.47E+00	1.48E+00	1.44E+01
9.00	1.05E+00	1.09E+00	1.16E+00	1.26E+00	1.36E+00	1.46E+00	1.54E+00	1.60E+00	1.62E+00	1.56E+01
10.00	8.57E-01	8.93E-01	9.54E-01	1.03E+00	1.12E+00	1.21E+00	1.28E+00	1.33E+00	1.35E+00	1.30E+01
12.00	4.33E-01	4.50E-01	4.81E-01	5.24E-01	5.72E-01	6.19E-01	6.59E-01	6.85E-01	6.95E-01	6.77E+00
14.00	1.79E-01	1.84E-01	1.95E-01	2.12E-01	2.31E-01	2.51E-01	2.68E-01	2.79E-01	2.83E-01	2.94E+00
16.00	6.83E-02	6.76E-02	6.98E-02	7.44E-02	8.04E-02	8.67E-02	9.22E-02	9.60E-02	9.73E-02	1.21E+00
20.00	1.34E-02	1.15E-02	1.02E-02	9.62E-03	9.39E-03	9.40E-03	9.52E-03	9.64E-03	9.69E-03	2.92E-01
24.00	3.45E-04	2.99E-04	2.77E-04	2.73E-04	2.81E-04	2.96E-04	3.11E-04	3.22E-04	3.26E-04	8.29E-03

1
 -S= 10.28 MEV
 -OCCUPATION PROBABILITIES PO= 2, HO= 1
 TARGET Z= 26, N= 28 PRDJ Z= 1, N= 0
 G= 4.230, E=33.500
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.537
 - P H RHOU/RHO STRU/STR STRD/STR

 1 0 1.000E+00 0. 0.
 2 1 8.680E-01 8.680E-01 8.680E-01
 3 2 6.725E-01 6.594E-01 5.956E-01
 4 3 4.489E-01 4.075E-01 3.082E-01
 5 4 2.498E-01 2.030E-01 1.112E-01
 6 5 1.201E-01 9.209E-02 2.593E-02
 7 6 4.876E-02 4.558E-02 3.496E-03

1PARTICLE SPECTRA Z= 0, N= 1
 FIRST EMISSION AT P= 2
 TARGET Z= 26, N= 28 PROJ Z= 1, N= 0
 PO= 2, HO= 1, G= 4.230, E=33.500
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 966.0
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.537
 MSD POSSIBLE= 0.868, USED= 0.405
 CLOSED FORM SUM STARTS AT P= 2

EPS	DIRECT	PREEQUILIBRIUM	EQUIL	TOTAL (MB/MEV)				
NUTRA	KNOCK	MSD	WEISS	MSC	MSD+MSC			
1.00	0.	0.	1.134E+00	6.178E-01	2.381E+00	1.134E+00	2.999E+00	4.133E+00
2.00	0.	0.	4.321E+00	1.756E+00	6.059E+00	4.321E+00	7.815E+00	1.214E+01
3.00	0.	0.	4.993E+00	1.527E+00	4.591E+00	4.993E+00	6.117E+00	1.111E+01
4.00	0.	0.	5.335E+00	1.240E+00	3.155E+00	5.335E+00	4.395E+00	9.730E+00
5.00	0.	0.	5.704E+00	1.020E+00	2.126E+00	5.704E+00	3.146E+00	8.850E+00
6.00	0.	0.	5.958E+00	8.293E-01	1.371E+00	5.958E+00	2.201E+00	8.159E+00
7.00	0.	0.	6.030E+00	6.594E-01	8.384E-01	6.030E+00	1.498E+00	7.528E+00
8.00	0.	0.	5.938E+00	5.138E-01	4.873E-01	5.938E+00	1.001E+00	6.939E+00
9.00	0.	0.	5.722E+00	3.935E-01	2.704E-01	5.722E+00	6.639E-01	6.385E+00
10.00	0.	0.	5.415E+00	2.967E-01	1.435E-01	5.415E+00	4.402E-01	5.855E+00
12.00	0.	0.	4.637E+00	1.613E-01	3.541E-02	4.637E+00	1.968E-01	4.833E+00
14.00	0.	0.	3.677E+00	8.137E-02	7.067E-03	3.677E+00	8.844E-02	3.765E+00
16.00	0.	0.	2.524E+00	3.672E-02	1.039E-03	2.524E+00	3.776E-02	2.562E+00
OSUMS	0.	0.	7.746E+01	9.598E+00	2.158E+01			

ANGULAR DISTRIBUTIONS Z= 0 N= 1
 ENERGY PARAM. = EPS+B.E.
 CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
1.00	5.18E-01	5.11E-01	4.92E-01	4.63E-01	4.28E-01	3.90E-01	3.54E-01	3.22E-01	2.97E-01	2.80E-01
2.00	1.63E+00	1.60E+00	1.54E+00	1.44E+00	1.33E+00	1.20E+00	1.07E+00	9.65E-01	8.77E-01	8.14E-01
3.00	1.60E+00	1.58E+00	1.51E+00	1.41E+00	1.29E+00	1.15E+00	1.02E+00	9.05E-01	8.09E-01	7.38E-01
4.00	1.51E+00	1.49E+00	1.42E+00	1.32E+00	1.20E+00	1.06E+00	9.32E-01	8.14E-01	7.15E-01	6.39E-01
5.00	1.48E+00	1.45E+00	1.39E+00	1.28E+00	1.15E+00	1.02E+00	8.82E-01	7.60E-01	6.56E-01	5.74E-01
6.00	1.46E+00	1.43E+00	1.36E+00	1.25E+00	1.12E+00	9.82E-01	8.43E-01	7.17E-01	6.09E-01	5.23E-01
7.00	1.42E+00	1.40E+00	1.33E+00	1.22E+00	1.09E+00	9.43E-01	8.02E-01	6.74E-01	5.64E-01	4.76E-01
8.00	1.38E+00	1.36E+00	1.28E+00	1.18E+00	1.04E+00	8.98E-01	7.58E-01	6.30E-01	5.21E-01	4.33E-01
9.00	1.33E+00	1.30E+00	1.23E+00	1.12E+00	9.91E-01	8.49E-01	7.11E-01	5.86E-01	4.79E-01	3.92E-01
10.00	1.27E+00	1.24E+00	1.17E+00	1.06E+00	9.35E-01	7.96E-01	6.62E-01	5.40E-01	4.37E-01	3.54E-01
12.00	1.12E+00	1.09E+00	1.03E+00	9.29E-01	8.08E-01	6.81E-01	5.58E-01	4.48E-01	3.56E-01	2.82E-01
14.00	9.24E-01	9.04E-01	8.46E-01	7.59E-01	6.55E-01	5.45E-01	4.41E-01	3.48E-01	2.72E-01	2.11E-01
16.00	6.66E-01	6.51E-01	6.07E-01	5.41E-01	4.62E-01	3.80E-01	3.03E-01	2.35E-01	1.80E-01	1.38E-01
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
1.00	2.72E-01	2.71E-01	2.78E-01	2.89E-01	3.04E-01	3.19E-01	3.32E-01	3.41E-01	3.44E-01	4.13E+00
2.00	7.78E-01	7.66E-01	7.75E-01	8.01E-01	8.37E-01	8.75E-01	9.08E-01	9.31E-01	9.39E-01	1.21E+01
3.00	6.91E-01	6.69E-01	6.67E-01	6.81E-01	7.04E-01	7.32E-01	7.57E-01	7.75E-01	7.81E-01	1.11E+01
4.00	5.86E-01	5.55E-01	5.43E-01	5.45E-01	5.57E-01	5.74E-01	5.90E-01	6.01E-01	6.06E-01	9.73E+00
5.00	5.15E-01	4.76E-01	4.55E-01	4.48E-01	4.51E-01	4.59E-01	4.68E-01	4.75E-01	4.77E-01	8.85E+00
6.00	4.59E-01	4.14E-01	3.86E-01	3.72E-01	3.67E-01	3.68E-01	3.71E-01	3.74E-01	3.76E-01	8.16E+00
7.00	4.09E-01	3.61E-01	3.28E-01	3.09E-01	2.98E-01	2.94E-01	2.93E-01	2.94E-01	2.94E-01	7.53E+00
8.00	3.65E-01	3.15E-01	2.80E-01	2.58E-01	2.44E-01	2.36E-01	2.33E-01	2.31E-01	2.31E-01	6.94E+00
9.00	3.26E-01	2.76E-01	2.41E-01	2.17E-01	2.01E-01	1.92E-01	1.86E-01	1.83E-01	1.83E-01	6.39E+00
10.00	2.90E-01	2.42E-01	2.07E-01	1.83E-01	1.67E-01	1.56E-01	1.50E-01	1.47E-01	1.46E-01	5.85E+00
12.00	2.26E-01	1.84E-01	1.53E-01	1.31E-01	1.16E-01	1.06E-01	9.93E-02	9.57E-02	9.45E-02	4.83E+00
14.00	1.66E-01	1.32E-01	1.08E-01	9.01E-02	7.78E-02	6.94E-02	6.39E-02	6.08E-02	5.98E-02	3.77E+00
16.00	1.06E-01	8.28E-02	6.62E-02	5.44E-02	4.61E-02	4.04E-02	3.66E-02	3.44E-02	3.38E-02	2.56E+00

1PARTICLE SPECTRA Z= 1, N= 0
 FIRST EMISSION AT P= 2
 TARGET Z= 26, N= 28 PRDJ Z= 1, N= 0
 PO= 2, HO= 1, G= 4.230, E=33.500
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 966.0
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.537
 MSD POSSIBLE= 0.868, USED= 0.405
 CLOSED FORM SUM STARTS AT P= 2

- EPS	--	DIRECT		PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
		-- NUTRA	KNOCK	-- MSD	MSC	-- WEISS	--	MSD	MSC	MSD+MSC
2.00	0.		7.104E-06	7.376E-02	3.037E-01	1.534E+00	7.377E-02	1.838E+00	1.911E+00	
3.00	0.		9.228E-05	8.329E-01	2.677E+00	1.288E+01	8.330E-01	1.556E+01	1.639E+01	
4.00	0.		4.039E-04	3.191E+00	7.890E+00	3.620E+01	3.191E+00	4.409E+01	4.728E+01	
5.00	0.		1.016E-03	7.073E+00	1.327E+01	5.801E+01	7.074E+00	7.128E+01	7.836E+01	
6.00	0.		1.818E-03	1.124E+01	1.582E+01	6.565E+01	1.124E+01	8.148E+01	9.272E+01	
7.00	0.		2.606E-03	1.441E+01	1.508E+01	5.901E+01	1.441E+01	7.409E+01	8.850E+01	
8.00	0.		3.273E-03	1.630E+01	1.261E+01	4.607E+01	1.631E+01	5.867E+01	7.498E+01	
9.00	0.		3.849E-03	1.739E+01	9.917E+00	3.335E+01	1.739E+01	4.327E+01	6.066E+01	
10.00	0.		4.348E-03	1.794E+01	7.566E+00	2.297E+01	1.794E+01	3.054E+01	4.848E+01	
12.00	0.		5.162E-03	1.813E+01	4.282E+00	9.810E+00	1.813E+01	1.409E+01	3.222E+01	
14.00	0.		5.664E-03	1.736E+01	2.411E+00	3.687E+00	1.736E+01	6.098E+00	2.346E+01	
16.00	0.		5.891E-03	1.612E+01	1.384E+00	1.241E+00	1.613E+01	2.624E+00	1.875E+01	
20.00	0.		5.286E-03	1.227E+01	4.382E-01	9.379E-02	1.228E+01	5.320E-01	1.281E+01	
24.00	0.		3.428E-03	7.248E+00	1.163E-01	3.397E-03	7.252E+00	1.197E-01	7.372E+00	
26.00	0.		0.	4.263E+00	5.051E-02	3.921E-04	4.263E+00	5.091E-02	4.314E+00	
OSUMS	0.		9.034E-02	2.940E+02	1.086E+02	3.783E+02				

1 ANGULAR DISTRIBUTIONS Z= 1 N= 0
 ENERGY PARAM. = EPS+B.E.
 CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
2.00	1.86E-01	1.85E-01	1.80E-01	1.74E-01	1.66E-01	1.58E-01	1.50E-01	1.44E-01	1.40E-01	1.38E-01
3.00	1.62E+00	1.61E+00	1.57E+00	1.51E+00	1.44E+00	1.36E+00	1.29E+00	1.23E+00	1.19E+00	1.17E+00
4.00	4.78E+00	4.74E+00	4.62E+00	4.44E+00	4.21E+00	3.97E+00	3.75E+00	3.56E+00	3.43E+00	3.36E+00
5.00	8.14E+00	8.06E+00	7.84E+00	7.51E+00	7.10E+00	6.67E+00	6.26E+00	5.91E+00	5.67E+00	5.53E+00
6.00	9.94E+00	9.84E+00	9.56E+00	9.12E+00	8.59E+00	8.02E+00	7.48E+00	7.03E+00	6.69E+00	6.50E+00
7.00	9.87E+00	9.77E+00	9.46E+00	9.00E+00	8.43E+00	7.83E+00	7.25E+00	6.76E+00	6.38E+00	6.16E+00
8.00	8.78E+00	8.68E+00	8.39E+00	7.95E+00	7.41E+00	6.83E+00	6.28E+00	5.79E+00	5.42E+00	5.17E+00
9.00	7.52E+00	7.43E+00	7.17E+00	6.76E+00	6.27E+00	5.73E+00	5.22E+00	4.76E+00	4.40E+00	4.15E+00
10.00	6.43E+00	6.34E+00	6.10E+00	5.73E+00	5.28E+00	4.79E+00	4.31E+00	3.88E+00	3.54E+00	3.29E+00
12.00	4.94E+00	4.87E+00	4.66E+00	4.34E+00	3.94E+00	3.51E+00	3.09E+00	2.71E+00	2.39E+00	2.14E+00
14.00	4.11E+00	4.05E+00	3.85E+00	3.56E+00	3.20E+00	2.81E+00	2.42E+00	2.07E+00	1.77E+00	1.52E+00
16.00	3.65E+00	3.59E+00	3.40E+00	3.12E+00	2.78E+00	2.41E+00	2.04E+00	1.71E+00	1.42E+00	1.19E+00
20.00	2.88E+00	2.82E+00	2.66E+00	2.41E+00	2.11E+00	1.78E+00	1.47E+00	1.19E+00	9.54E-01	7.62E-01
24.00	1.86E+00	1.82E+00	1.70E+00	1.52E+00	1.31E+00	1.08E+00	8.68E-01	6.80E-01	5.26E-01	4.06E-01
26.00	1.15E+00	1.13E+00	1.05E+00	9.30E-01	7.91E-01	6.46E-01	5.11E-01	3.94E-01	2.99E-01	2.27E-01
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
2.00	1.38E-01	1.41E-01	1.46E-01	1.53E-01	1.60E-01	1.67E-01	1.72E-01	1.76E-01	1.77E-01	1.91E+00
3.00	1.18E+00	1.20E+00	1.25E+00	1.30E+00	1.37E+00	1.43E+00	1.48E+00	1.51E+00	1.52E+00	1.64E+01
4.00	3.37E+00	3.44E+00	3.57E+00	3.73E+00	3.92E+00	4.10E+00	4.25E+00	4.35E+00	4.39E+00	4.73E+01
5.00	5.53E+00	5.64E+00	5.84E+00	6.12E+00	6.44E+00	6.74E+00	7.00E+00	7.17E+00	7.22E+00	7.84E+01
6.00	6.46E+00	6.57E+00	6.81E+00	7.13E+00	7.50E+00	7.86E+00	8.17E+00	8.37E+00	8.44E+00	9.27E+01
7.00	6.09E+00	6.16E+00	6.36E+00	6.65E+00	7.00E+00	7.33E+00	7.62E+00	7.81E+00	7.88E+00	8.85E+01
8.00	5.07E+00	5.10E+00	5.24E+00	5.46E+00	5.73E+00	6.00E+00	6.23E+00	6.39E+00	6.44E+00	7.50E+01
9.00	4.02E+00	4.00E+00	4.08E+00	4.23E+00	4.42E+00	4.62E+00	4.79E+00	4.91E+00	4.95E+00	6.07E+01
10.00	3.13E+00	3.08E+00	3.10E+00	3.19E+00	3.31E+00	3.44E+00	3.56E+00	3.64E+00	3.67E+00	4.85E+01
12.00	1.96E+00	1.85E+00	1.81E+00	1.80E+00	1.83E+00	1.88E+00	1.92E+00	1.95E+00	1.96E+00	3.22E+01
14.00	1.34E+00	1.21E+00	1.12E+00	1.08E+00	1.06E+00	1.05E+00	1.06E+00	1.07E+00	1.07E+00	2.35E+01
16.00	1.00E+00	8.70E-01	7.75E-01	7.11E-01	6.71E-01	6.48E-01	6.36E-01	6.31E-01	6.29E-01	1.88E+01
20.00	6.14E-01	5.03E-01	4.21E-01	3.63E-01	3.22E-01	2.94E-01	2.76E-01	2.66E-01	2.63E-01	1.28E+01
24.00	3.15E-01	2.48E-01	2.00E-01	1.65E-01	1.41E-01	1.24E-01	1.13E-01	1.07E-01	1.05E-01	7.37E+00
26.00	1.73E-01	1.34E-01	1.06E-01	8.65E-02	7.26E-02	6.30E-02	5.67E-02	5.31E-02	5.19E-02	4.31E+00

1PARTICLE SPECTRA Z= 2, N= 2
 FIRST EMISSION AT P= 4
 TARGET Z= 26, N= 28 PROJ Z= 1, N= 0
 PO= 2, HO= 1, G= 4.230, E=33.500
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 966.0
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.537
 MSD POSSIBLE= 0.868, USED= 0.405
 CLOSED FORM SUM STARTS AT P= 4

- EPS --	DIRECT		PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
	-- NUTRA	KNOCK	-- MSD	MSC	-- WEISS	--	MSD	MSC	MSD+MSC
5.00	2.009E-03	7.507E-05	4.608E-04	8.793E-03	8.224E-02		2.545E-03	9.103E-02	9.357E-02
6.00	2.809E-02	1.098E-03	5.232E-03	8.289E-02	7.624E-01		3.442E-02	8.453E-01	8.797E-01
7.00	1.572E-01	6.433E-03	2.383E-02	3.071E-01	2.812E+00		1.875E-01	3.119E+00	3.306E+00
8.00	3.972E-01	1.706E-02	4.920E-02	5.051E-01	4.654E+00		4.635E-01	5.159E+00	5.622E+00
9.00	6.385E-01	2.883E-02	6.490E-02	5.208E-01	4.869E+00		7.323E-01	5.390E+00	6.122E+00
10.00	7.899E-01	3.759E-02	6.624E-02	4.090E-01	3.895E+00		8.938E-01	4.304E+00	5.198E+00
12.00	9.302E-01	4.946E-02	5.420E-02	1.934E-01	1.882E+00		1.034E+00	2.076E+00	3.110E+00
14.00	8.933E-01	5.345E-02	3.745E-02	7.912E-02	7.240E-01		9.842E-01	8.031E-01	1.787E+00
16.00	7.183E-01	4.825E-02	2.268E-02	3.051E-02	2.290E-01		7.892E-01	2.595E-01	1.049E+00
20.00	2.321E-01	0.	5.071E-03	3.595E-03	1.231E-02		2.372E-01	1.590E-02	2.531E-01
24.00	0.	0.	0.	0.	1.737E-04		0.	1.737E-04	1.737E-04
OSUMS	9.138E+00	4.605E-01	5.146E-01	2.689E+00	2.497E+01				

1ANGULAR DISTRIBUTIONS Z= 2 N= 2
 ENERGY PARAM. = EPS+B.E.
 CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
5.00	9.70E-03	9.60E-03	9.31E-03	8.87E-03	8.34E-03	7.78E-03	7.26E-03	6.84E-03	6.56E-03	6.45E-03
6.00	9.32E-02	9.21E-02	8.92E-02	8.47E-02	7.94E-02	7.37E-02	6.85E-02	6.42E-02	6.13E-02	6.01E-02
7.00	3.60E-01	3.55E-01	3.43E-01	3.25E-01	3.03E-01	2.80E-01	2.59E-01	2.41E-01	2.29E-01	2.24E-01
8.00	6.32E-01	6.24E-01	6.02E-01	5.68E-01	5.27E-01	4.85E-01	4.44E-01	4.11E-01	3.88E-01	3.77E-01
9.00	7.18E-01	7.08E-01	6.81E-01	6.41E-01	5.92E-01	5.40E-01	4.91E-01	4.51E-01	4.22E-01	4.06E-01
10.00	6.43E-01	6.34E-01	6.08E-01	5.70E-01	5.23E-01	4.73E-01	4.27E-01	3.87E-01	3.58E-01	3.41E-01
12.00	4.44E-01	4.37E-01	4.17E-01	3.87E-01	3.50E-01	3.11E-01	2.74E-01	2.42E-01	2.16E-01	1.99E-01
14.00	3.04E-01	2.99E-01	2.83E-01	2.60E-01	2.32E-01	2.02E-01	1.73E-01	1.48E-01	1.27E-01	1.11E-01
16.00	2.09E-01	2.05E-01	1.93E-01	1.76E-01	1.55E-01	1.33E-01	1.11E-01	9.18E-02	7.58E-02	6.33E-02
20.00	6.12E-02	5.98E-02	5.60E-02	5.02E-02	4.33E-02	3.61E-02	2.92E-02	2.31E-02	1.81E-02	1.42E-02
24.00	2.49E-05	2.44E-05	2.28E-05	2.04E-05	1.76E-05	1.48E-05	1.23E-05	1.04E-05	9.25E-06	8.85E-06
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
5.00	6.51E-03	6.73E-03	7.10E-03	7.56E-03	8.07E-03	8.56E-03	8.97E-03	9.24E-03	9.33E-03	9.36E-02
6.00	6.06E-02	6.27E-02	6.62E-02	7.07E-02	7.57E-02	8.05E-02	8.45E-02	8.71E-02	8.80E-02	8.80E-01
7.00	2.25E-01	2.33E-01	2.46E-01	2.63E-01	2.83E-01	3.01E-01	3.17E-01	3.27E-01	3.31E-01	3.31E+00
8.00	3.77E-01	3.90E-01	4.12E-01	4.42E-01	4.75E-01	5.07E-01	5.34E-01	5.52E-01	5.58E-01	5.62E+00
9.00	4.04E-01	4.16E-01	4.39E-01	4.70E-01	5.06E-01	5.41E-01	5.70E-01	5.90E-01	5.97E-01	6.12E+00
10.00	3.36E-01	3.44E-01	3.61E-01	3.86E-01	4.15E-01	4.44E-01	4.68E-01	4.85E-01	4.90E-01	5.20E+00
12.00	1.90E-01	1.89E-01	1.94E-01	2.05E-01	2.18E-01	2.32E-01	2.44E-01	2.53E-01	2.56E-01	3.11E+00
14.00	1.01E-01	9.54E-02	9.40E-02	9.57E-02	9.94E-02	1.04E-01	1.08E-01	1.11E-01	1.12E-01	1.79E+00
16.00	5.42E-02	4.82E-02	4.46E-02	4.29E-02	4.26E-02	4.31E-02	4.39E-02	4.45E-02	4.48E-02	1.05E+00
20.00	1.12E-02	9.13E-03	7.65E-03	6.64E-03	5.98E-03	5.57E-03	5.33E-03	5.21E-03	5.17E-03	2.53E-01
24.00	9.25E-06	1.04E-05	1.23E-05	1.48E-05	1.76E-05	2.04E-05	2.28E-05	2.44E-05	2.49E-05	1.74E-04

1
-S= 10.28 MEV
-OCCUPATION PROBABILITIES PO= 2. HO= 1
TARGET Z= 26, N= 28 PROJ Z= 1, N= 0
G= 4.231, E=66.000
SCALE FACTOR= 1.350, FRAC PREEQ= 0.916
- P H RHOU/RHO STRU/STR STRD/STR

1	0	1.000E+00	0.	0.
2	1	1.000E+00	1.000E+00	1.000E+00
3	2	1.000E+00	1.000E+00	1.000E+00
4	3	1.000E+00	1.000E+00	1.000E+00
5	4	9.581E-01	9.387E-01	9.387E-01
6	5	8.680E-01	8.558E-01	8.151E-01
7	6	7.513E-01	7.499E-01	6.399E-01
8	7	6.175E-01	6.154E-01	4.353E-01
9	8	4.794E-01	4.751E-01	2.442E-01

1PARTICLE SPECTRA Z= 0, N= 1
 FIRST EMISSION AT P= 2
 TARGET Z= 26, N= 28 PRDJ Z= 1, N= 0
 PO= 2, HO= 1, G= 4.231, E=66.000
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 840.8
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.916
 MSD POSSIBLE= 1.000, USED= 0.882
 CLOSED FORM SUM STARTS AT P= 2

- EPS	DIRECT			PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
	-- NUTRA	KNOCK	--	MSD	MSC	-- WEISS	--	MSD	MSC	MSD+MSC
2.00	0.	0.	0.	2.657E+00	3.926E-01	1.026E+00	2.657E+00	1.419E+00	4.076E+00	
4.00	0.	0.	0.	4.255E+00	4.440E-01	1.016E+00	4.255E+00	1.460E+00	5.714E+00	
6.00	0.	0.	0.	5.112E+00	3.653E-01	7.289E-01	5.112E+00	1.094E+00	6.206E+00	
8.00	0.	0.	0.	5.580E+00	2.653E-01	4.591E-01	5.580E+00	7.244E-01	6.304E+00	
10.00	0.	0.	0.	5.821E+00	1.793E-01	2.670E-01	5.821E+00	4.463E-01	6.267E+00	
12.00	0.	0.	0.	5.933E+00	1.155E-01	1.466E-01	5.933E+00	2.621E-01	6.195E+00	
14.00	0.	0.	0.	5.971E+00	7.187E-02	7.689E-02	5.971E+00	1.488E-01	6.120E+00	
16.00	0.	0.	0.	5.811E+00	4.351E-02	3.873E-02	5.811E+00	8.224E-02	5.893E+00	
18.00	0.	0.	0.	5.605E+00	2.573E-02	1.880E-02	5.605E+00	4.453E-02	5.649E+00	
20.00	0.	0.	0.	5.366E+00	1.489E-02	8.804E-03	5.366E+00	2.369E-02	5.390E+00	
22.00	0.	0.	0.	5.105E+00	8.414E-03	3.981E-03	5.105E+00	1.240E-02	5.118E+00	
24.00	0.	0.	0.	4.828E+00	4.634E-03	1.737E-03	4.828E+00	6.371E-03	4.834E+00	
26.00	0.	0.	0.	4.538E+00	2.475E-03	7.298E-04	4.538E+00	3.205E-03	4.541E+00	
28.00	0.	0.	0.	4.239E+00	1.274E-03	2.947E-04	4.239E+00	1.568E-03	4.240E+00	
30.00	0.	0.	0.	3.931E+00	6.260E-04	1.140E-04	3.931E+00	7.400E-04	3.932E+00	
32.00	0.	0.	0.	3.616E+00	2.905E-04	4.205E-05	3.616E+00	3.325E-04	3.616E+00	
34.00	0.	0.	0.	3.294E+00	1.253E-04	1.471E-05	3.294E+00	1.400E-04	3.294E+00	
36.00	0.	0.	0.	2.965E+00	4.917E-05	4.845E-06	2.965E+00	5.401E-05	2.965E+00	
38.00	0.	0.	0.	2.629E+00	1.702E-05	1.488E-06	2.629E+00	1.851E-05	2.629E+00	
40.00	0.	0.	0.	2.284E+00	4.956E-06	4.204E-07	2.284E+00	5.376E-06	2.284E+00	
42.00	0.	0.	0.	1.931E+00	1.123E-06	1.072E-07	1.931E+00	1.230E-06	1.931E+00	
44.00	0.	0.	0.	1.568E+00	1.720E-07	2.399E-08	1.568E+00	1.960E-07	1.568E+00	
46.00	0.	0.	0.	1.193E+00	1.313E-08	4.505E-09	1.193E+00	1.763E-08	1.193E+00	
48.00	0.	0.	0.	8.051E-01	2.136E-10	6.536E-10	8.051E-01	8.672E-10	8.051E-01	
50.00	0.	0.	0.	4.025E-01	0.	6.121E-11	4.025E-01	6.121E-11	4.025E-01	
OSUMS	0.	0.	0.	1.895E+02	3.676E+00	7.074E+00				

ANGULAR DISTRIBUTIONS Z= 0 N= 1

ENERGY PARAM. = EPS+B.E.

CROSS SECTIONS IN MB/STR-MEV

EPS	0	10	20	30	40	50	60	70	80	90
2.00	6.42E-01	6.32E-01	6.05E-01	5.64E-01	5.13E-01	4.58E-01	4.03E-01	3.52E-01	3.09E-01	2.73E-01
4.00	9.83E-01	9.67E-01	9.23E-01	8.54E-01	7.70E-01	6.79E-01	5.88E-01	5.05E-01	4.34E-01	3.75E-01
6.00	1.16E+00	1.14E+00	1.08E+00	9.98E-01	8.92E-01	7.77E-01	6.64E-01	5.60E-01	4.71E-01	3.98E-01
8.00	1.27E+00	1.25E+00	1.18E+00	1.08E+00	9.59E-01	8.26E-01	6.96E-01	5.77E-01	4.76E-01	3.93E-01
10.00	1.36E+00	1.33E+00	1.26E+00	1.14E+00	1.00E+00	8.54E-01	7.09E-01	5.79E-01	4.68E-01	3.79E-01
12.00	1.43E+00	1.40E+00	1.32E+00	1.19E+00	1.04E+00	8.72E-01	7.15E-01	5.74E-01	4.56E-01	3.62E-01
14.00	1.50E+00	1.47E+00	1.37E+00	1.23E+00	1.06E+00	8.86E-01	7.16E-01	5.66E-01	4.42E-01	3.44E-01
16.00	1.53E+00	1.50E+00	1.40E+00	1.24E+00	1.06E+00	8.74E-01	6.96E-01	5.41E-01	4.15E-01	3.17E-01
18.00	1.56E+00	1.52E+00	1.41E+00	1.25E+00	1.05E+00	8.56E-01	6.71E-01	5.13E-01	3.86E-01	2.89E-01
20.00	1.57E+00	1.53E+00	1.42E+00	1.24E+00	1.04E+00	8.32E-01	6.42E-01	4.81E-01	3.55E-01	2.61E-01
22.00	1.59E+00	1.54E+00	1.42E+00	1.23E+00	1.02E+00	8.03E-01	6.08E-01	4.47E-01	3.23E-01	2.32E-01
24.00	1.59E+00	1.54E+00	1.41E+00	1.22E+00	9.92E-01	7.69E-01	5.71E-01	4.11E-01	2.90E-01	2.05E-01
26.00	1.59E+00	1.54E+00	1.40E+00	1.19E+00	9.59E-01	7.30E-01	5.31E-01	3.73E-01	2.57E-01	1.77E-01
28.00	1.58E+00	1.53E+00	1.38E+00	1.16E+00	9.21E-01	6.88E-01	4.88E-01	3.34E-01	2.25E-01	1.52E-01
30.00	1.56E+00	1.51E+00	1.35E+00	1.13E+00	8.77E-01	6.41E-01	4.43E-01	2.95E-01	1.93E-01	1.27E-01
32.00	1.54E+00	1.48E+00	1.31E+00	1.08E+00	8.26E-01	5.89E-01	3.96E-01	2.55E-01	1.62E-01	1.05E-01
34.00	1.50E+00	1.44E+00	1.27E+00	1.03E+00	7.70E-01	5.34E-01	3.48E-01	2.17E-01	1.33E-01	8.44E-02
36.00	1.45E+00	1.38E+00	1.21E+00	9.66E-01	7.06E-01	4.76E-01	2.99E-01	1.79E-01	1.07E-01	6.66E-02
38.00	1.38E+00	1.32E+00	1.14E+00	8.93E-01	6.36E-01	4.14E-01	2.49E-01	1.43E-01	8.25E-02	5.13E-02
40.00	1.30E+00	1.23E+00	1.05E+00	8.08E-01	5.60E-01	3.50E-01	2.01E-01	1.10E-01	6.16E-02	3.86E-02
42.00	1.19E+00	1.12E+00	9.46E-01	7.11E-01	4.76E-01	2.85E-01	1.55E-01	8.02E-02	4.40E-02	2.85E-02
44.00	1.04E+00	9.83E-01	8.18E-01	6.00E-01	3.86E-01	2.19E-01	1.12E-01	5.47E-02	2.99E-02	2.06E-02
46.00	8.66E-01	8.11E-01	6.64E-01	4.73E-01	2.92E-01	1.55E-01	7.29E-02	3.38E-02	1.92E-02	1.45E-02
48.00	6.39E-01	5.95E-01	4.78E-01	3.30E-01	1.93E-01	9.49E-02	4.05E-02	1.79E-02	1.13E-02	9.53E-03
50.00	3.51E-01	3.24E-01	2.56E-01	1.70E-01	9.32E-02	4.15E-02	1.56E-02	6.92E-03	5.32E-03	4.89E-03
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
2.00	2.47E-01	2.29E-01	2.19E-01	2.14E-01	2.13E-01	2.14E-01	2.17E-01	2.19E-01	2.20E-01	4.08E+00
4.00	3.31E-01	2.99E-01	2.78E-01	2.66E-01	2.60E-01	2.58E-01	2.59E-01	2.60E-01	2.60E-01	5.71E+00
6.00	3.41E-01	3.00E-01	2.71E-01	2.53E-01	2.42E-01	2.36E-01	2.34E-01	2.33E-01	2.33E-01	6.21E+00
8.00	3.29E-01	2.81E-01	2.47E-01	2.24E-01	2.09E-01	2.00E-01	1.95E-01	1.93E-01	1.92E-01	6.30E+00
10.00	3.10E-01	2.58E-01	2.21E-01	1.95E-01	1.77E-01	1.65E-01	1.58E-01	1.55E-01	1.54E-01	6.27E+00
12.00	2.89E-01	2.36E-01	1.96E-01	1.69E-01	1.49E-01	1.36E-01	1.28E-01	1.24E-01	1.22E-01	6.20E+00
14.00	2.69E-01	2.15E-01	1.75E-01	1.47E-01	1.27E-01	1.13E-01	1.04E-01	9.94E-02	9.78E-02	6.12E+00
16.00	2.44E-01	1.90E-01	1.52E-01	1.25E-01	1.06E-01	9.24E-02	8.36E-02	7.87E-02	7.71E-02	5.89E+00
18.00	2.18E-01	1.67E-01	1.31E-01	1.06E-01	8.79E-02	7.53E-02	6.69E-02	6.21E-02	6.06E-02	5.65E+00
20.00	1.93E-01	1.46E-01	1.13E-01	8.93E-02	7.27E-02	6.11E-02	5.34E-02	4.89E-02	4.74E-02	5.39E+00
22.00	1.69E-01	1.26E-01	9.57E-02	7.48E-02	5.99E-02	4.94E-02	4.23E-02	3.82E-02	3.68E-02	5.12E+00
24.00	1.46E-01	1.07E-01	8.06E-02	6.22E-02	4.90E-02	3.96E-02	3.32E-02	2.95E-02	2.83E-02	4.83E+00
26.00	1.25E-01	9.02E-02	6.73E-02	5.14E-02	3.99E-02	3.16E-02	2.59E-02	2.25E-02	2.14E-02	4.54E+00
28.00	1.05E-01	7.52E-02	5.58E-02	4.23E-02	3.24E-02	2.50E-02	1.99E-02	1.69E-02	1.59E-02	4.24E+00
30.00	8.69E-02	6.21E-02	4.60E-02	3.47E-02	2.62E-02	1.97E-02	1.51E-02	1.23E-02	1.14E-02	3.93E+00
32.00	7.09E-02	5.08E-02	3.79E-02	2.85E-02	2.11E-02	1.53E-02	1.12E-02	8.74E-03	7.93E-03	3.62E+00
34.00	5.71E-02	4.14E-02	3.12E-02	2.34E-02	1.70E-02	1.18E-02	8.05E-03	5.88E-03	5.17E-03	3.29E+00
36.00	4.54E-02	3.36E-02	2.58E-02	1.93E-02	1.36E-02	8.87E-03	5.53E-03	3.65E-03	3.06E-03	2.97E+00
38.00	3.58E-02	2.74E-02	2.14E-02	1.59E-02	1.08E-02	6.45E-03	3.51E-03	1.98E-03	1.53E-03	2.63E+00
40.00	2.81E-02	2.23E-02	1.77E-02	1.30E-02	8.32E-03	4.42E-03	1.93E-03	8.11E-04	5.37E-04	2.28E+00
42.00	2.19E-02	1.81E-02	1.45E-02	1.04E-02	6.18E-03	2.71E-03	7.55E-04	1.31E-04	6.57E-05	1.93E+00
44.00	1.69E-02	1.44E-02	1.16E-02	8.10E-03	4.29E-03	1.32E-03	3.81E-05	9.93E-05	7.20E-05	1.57E+00
46.00	1.25E-02	1.09E-02	8.78E-03	5.90E-03	2.65E-03	2.49E-04	4.68E-04	3.68E-05	4.42E-04	1.19E+00
48.00	8.42E-03	7.29E-03	5.91E-03	3.82E-03	1.32E-03	4.23E-04	5.67E-04	3.60E-04	9.25E-04	8.05E-01
50.00	4.19E-03	3.57E-03	2.95E-03	1.86E-03	3.97E-04	5.75E-04	3.89E-04	5.30E-04	1.04E-03	4.02E-01

1PARTICLE SPECTRA Z= 1, N= 0
 FIRST EMISSION AT P= 2
 TARGET Z= 26, N= 28 PROJ Z= 1, N= 0
 PO= 2, HO= 1, G= 4.231, E=66.000
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 840.8
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.916
 MSD POSSIBLE= 1.000, USED= 0.882
 CLOSED FORM SUM STARTS AT P= 2

EPS	DIRECT	PREEQUILIBRIUM	EQUIL	TOTAL (MB/MEV)				
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EPS	NUTRA	KNOCK	MSD	MSC	MSD+MSC			
2.00	0.	1.957E-09	8.526E-05	3.661E-05	1.522E-04	8.526E-05	1.888E-04	2.741E-04
4.00	0.	8.199E-05	2.764E+00	9.473E-01	3.438E+00	2.764E+00	4.386E+00	7.150E+00
6.00	0.	2.685E-04	7.151E+00	1.894E+00	6.013E+00	7.151E+00	7.906E+00	1.506E+01
8.00	0.	5.313E-04	1.143E+01	2.262E+00	6.288E+00	1.143E+01	8.550E+00	1.998E+01
10.00	0.	7.667E-04	1.364E+01	1.951E+00	4.745E+00	1.364E+01	6.696E+00	2.034E+01
12.00	0.	9.713E-04	1.463E+01	1.462E+00	3.108E+00	1.463E+01	4.570E+00	1.920E+01
14.00	0.	1.146E-03	1.496E+01	1.012E+00	1.874E+00	1.496E+01	2.887E+00	1.785E+01
16.00	0.	1.293E-03	1.494E+01	6.649E-01	1.067E+00	1.494E+01	1.732E+00	1.667E+01
18.00	0.	1.414E-03	1.475E+01	4.203E-01	5.802E-01	1.475E+01	1.001E+00	1.575E+01
20.00	0.	1.508E-03	1.449E+01	2.580E-01	3.038E-01	1.449E+01	5.618E-01	1.505E+01
22.00	0.	1.578E-03	1.421E+01	1.548E-01	1.537E-01	1.422E+01	3.084E-01	1.452E+01
24.00	0.	1.626E-03	1.372E+01	9.102E-02	7.527E-02	1.372E+01	1.663E-01	1.389E+01
26.00	0.	1.652E-03	1.301E+01	5.258E-02	3.574E-02	1.301E+01	8.832E-02	1.310E+01
28.00	0.	1.657E-03	1.227E+01	2.985E-02	1.645E-02	1.227E+01	4.629E-02	1.232E+01
30.00	0.	1.644E-03	1.152E+01	1.662E-02	7.331E-03	1.152E+01	2.395E-02	1.154E+01
32.00	0.	1.613E-03	1.076E+01	9.055E-03	3.162E-03	1.076E+01	1.222E-02	1.077E+01
34.00	0.	1.565E-03	9.994E+00	4.804E-03	1.317E-03	9.996E+00	6.122E-03	1.000E+01
36.00	0.	1.503E-03	9.228E+00	2.467E-03	5.288E-04	9.229E+00	2.996E-03	9.232E+00
38.00	0.	1.427E-03	8.461E+00	1.216E-03	2.038E-04	8.462E+00	1.420E-03	8.464E+00
40.00	0.	1.339E-03	7.695E+00	5.697E-04	7.515E-05	7.696E+00	6.448E-04	7.697E+00
42.00	0.	1.239E-03	6.932E+00	2.502E-04	2.637E-05	6.933E+00	2.765E-04	6.933E+00
44.00	0.	1.130E-03	6.172E+00	1.011E-04	8.747E-06	6.173E+00	1.099E-04	6.173E+00
46.00	0.	1.013E-03	5.416E+00	3.667E-05	2.719E-06	5.417E+00	3.939E-05	5.417E+00
48.00	0.	9.055E-04	4.758E+00	1.171E-05	7.986E-07	4.758E+00	1.251E-05	4.758E+00
50.00	0.	7.935E-04	4.107E+00	3.065E-06	2.155E-07	4.108E+00	3.280E-06	4.108E+00
52.00	0.	6.713E-04	3.432E+00	5.902E-07	5.190E-08	3.433E+00	6.421E-07	3.433E+00
54.00	0.	5.388E-04	2.729E+00	6.854E-08	1.078E-08	2.730E+00	7.932E-08	2.730E+00
56.00	0.	3.961E-04	1.993E+00	2.978E-09	1.819E-09	1.993E+00	4.797E-09	1.993E+00
58.00	0.	0.	1.220E+00	0.	2.219E-10	1.220E+00	2.219E-10	1.220E+00
60.00	0.	0.	4.039E-01	0.	1.461E-11	4.039E-01	1.461E-11	4.039E-01
OSUMS	0.	6.055E-02	5.134E+02	2.247E+01	5.542E+01			

ANGULAR DISTRIBUTIONS Z= 1 N= 0
 ENERGY PARAM. = EPS+B.E.
 CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
2.00	3.10E-05	3.07E-05	2.99E-05	2.86E-05	2.70E-05	2.53E-05	2.35E-05	2.20E-05	2.07E-05	1.97E-05
4.00	8.66E-01	8.57E-01	8.30E-01	7.90E-01	7.40E-01	6.86E-01	6.31E-01	5.82E-01	5.40E-01	5.08E-01
6.00	1.97E+00	1.95E+00	1.88E+00	1.78E+00	1.65E+00	1.51E+00	1.38E+00	1.25E+00	1.14E+00	1.06E+00
8.00	2.85E+00	2.81E+00	2.70E+00	2.54E+00	2.34E+00	2.12E+00	1.90E+00	1.69E+00	1.52E+00	1.38E+00
10.00	3.16E+00	3.12E+00	2.99E+00	2.79E+00	2.55E+00	2.28E+00	2.01E+00	1.77E+00	1.55E+00	1.38E+00
12.00	3.26E+00	3.21E+00	3.06E+00	2.84E+00	2.57E+00	2.27E+00	1.98E+00	1.71E+00	1.47E+00	1.28E+00
14.00	3.28E+00	3.23E+00	3.07E+00	2.83E+00	2.54E+00	2.22E+00	1.91E+00	1.62E+00	1.37E+00	1.16E+00
16.00	3.30E+00	3.24E+00	3.08E+00	2.82E+00	2.51E+00	2.17E+00	1.84E+00	1.53E+00	1.27E+00	1.05E+00
18.00	3.34E+00	3.27E+00	3.09E+00	2.82E+00	2.49E+00	2.13E+00	1.78E+00	1.46E+00	1.19E+00	9.68E-01
20.00	3.39E+00	3.33E+00	3.13E+00	2.84E+00	2.48E+00	2.10E+00	1.73E+00	1.40E+00	1.12E+00	8.96E-01
22.00	3.47E+00	3.40E+00	3.19E+00	2.87E+00	2.49E+00	2.08E+00	1.70E+00	1.35E+00	1.06E+00	8.33E-01
24.00	3.52E+00	3.44E+00	3.21E+00	2.87E+00	2.47E+00	2.04E+00	1.64E+00	1.28E+00	9.93E-01	7.64E-01
26.00	3.51E+00	3.43E+00	3.19E+00	2.83E+00	2.41E+00	1.97E+00	1.55E+00	1.20E+00	9.10E-01	6.88E-01
28.00	3.50E+00	3.41E+00	3.15E+00	2.78E+00	2.34E+00	1.88E+00	1.47E+00	1.11E+00	8.27E-01	6.14E-01
30.00	3.47E+00	3.38E+00	3.11E+00	2.72E+00	2.26E+00	1.80E+00	1.37E+00	1.02E+00	7.45E-01	5.42E-01
32.00	3.44E+00	3.34E+00	3.06E+00	2.65E+00	2.18E+00	1.70E+00	1.28E+00	9.29E-01	6.64E-01	4.73E-01
34.00	3.39E+00	3.29E+00	2.99E+00	2.57E+00	2.08E+00	1.60E+00	1.18E+00	8.37E-01	5.84E-01	4.08E-01
36.00	3.33E+00	3.22E+00	2.92E+00	2.48E+00	1.98E+00	1.49E+00	1.07E+00	7.44E-01	5.07E-01	3.46E-01
38.00	3.25E+00	3.14E+00	2.82E+00	2.37E+00	1.86E+00	1.38E+00	9.66E-01	6.52E-01	4.32E-01	2.89E-01
40.00	3.16E+00	3.04E+00	2.72E+00	2.25E+00	1.74E+00	1.25E+00	8.57E-01	5.61E-01	3.62E-01	2.36E-01
42.00	3.05E+00	2.92E+00	2.59E+00	2.12E+00	1.60E+00	1.13E+00	7.47E-01	4.74E-01	2.96E-01	1.89E-01
44.00	2.91E+00	2.78E+00	2.44E+00	1.97E+00	1.46E+00	9.97E-01	6.38E-01	3.90E-01	2.36E-01	1.49E-01
46.00	2.74E+00	2.62E+00	2.27E+00	1.80E+00	1.30E+00	8.63E-01	5.31E-01	3.12E-01	1.83E-01	1.14E-01
48.00	2.60E+00	2.47E+00	2.12E+00	1.65E+00	1.16E+00	7.41E-01	4.36E-01	2.45E-01	1.39E-01	8.66E-02
50.00	2.42E+00	2.29E+00	1.95E+00	1.48E+00	1.01E+00	6.19E-01	3.46E-01	1.85E-01	1.02E-01	6.49E-02
52.00	2.19E+00	2.07E+00	1.73E+00	1.29E+00	8.47E-01	4.94E-01	2.61E-01	1.32E-01	7.19E-02	4.77E-02
54.00	1.90E+00	1.78E+00	1.47E+00	1.06E+00	6.71E-01	3.69E-01	1.81E-01	8.64E-02	4.79E-02	3.44E-02
56.00	1.51E+00	1.41E+00	1.15E+00	8.04E-01	4.83E-01	2.48E-01	1.12E-01	5.05E-02	2.98E-02	2.38E-02
58.00	1.01E+00	9.39E-01	7.49E-01	5.07E-01	2.88E-01	1.35E-01	5.46E-02	2.40E-02	1.64E-02	1.45E-02
60.00	3.69E-01	3.40E-01	2.65E-01	1.73E-01	9.14E-02	3.83E-02	1.34E-02	6.15E-03	5.39E-03	5.04E-03
- EPS	100	110	120	130	140	150	160	170	180	TOTAL

2.00	1.92E-05	1.89E-05	1.90E-05	1.93E-05	1.98E-05	2.03E-05	2.07E-05	2.10E-05	2.11E-05	2.74E-04
4.00	4.87E-01	4.77E-01	4.75E-01	4.80E-01	4.90E-01	5.01E-01	5.11E-01	5.19E-01	5.21E-01	7.15E+00
6.00	9.96E-01	9.60E-01	9.46E-01	9.48E-01	9.61E-01	9.79E-01	9.97E-01	1.01E+00	1.01E+00	1.51E+01
8.00	1.28E+00	1.21E+00	1.17E+00	1.16E+00	1.16E+00	1.18E+00	1.19E+00	1.21E+00	1.21E+00	2.00E+01
10.00	1.25E+00	1.15E+00	1.09E+00	1.06E+00	1.05E+00	1.06E+00	1.06E+00	1.07E+00	1.07E+00	2.03E+01
12.00	1.12E+00	1.01E+00	9.40E-01	8.94E-01	8.69E-01	8.58E-01	8.56E-01	8.56E-01	8.57E-01	1.92E+01
14.00	9.96E-01	8.75E-01	7.89E-01	7.32E-01	6.96E-01	6.75E-01	6.65E-01	6.60E-01	6.59E-01	1.78E+01
16.00	8.86E-01	7.58E-01	6.66E-01	6.01E-01	5.58E-01	5.30E-01	5.14E-01	5.06E-01	5.03E-01	1.67E+01
18.00	7.95E-01	6.64E-01	5.68E-01	5.00E-01	4.53E-01	4.21E-01	4.01E-01	3.91E-01	3.87E-01	1.58E+01
20.00	7.20E-01	5.89E-01	4.92E-01	4.23E-01	3.73E-01	3.40E-01	3.18E-01	3.06E-01	3.03E-01	1.51E+01
22.00	6.57E-01	5.26E-01	4.31E-01	3.62E-01	3.13E-01	2.79E-01	2.57E-01	2.44E-01	2.40E-01	1.45E+01
24.00	5.92E-01	4.65E-01	3.74E-01	3.08E-01	2.61E-01	2.28E-01	2.07E-01	1.94E-01	1.90E-01	1.39E+01
26.00	5.23E-01	4.04E-01	3.19E-01	2.58E-01	2.15E-01	1.85E-01	1.64E-01	1.53E-01	1.49E-01	1.31E+01
28.00	4.59E-01	3.48E-01	2.71E-01	2.16E-01	1.76E-01	1.49E-01	1.30E-01	1.20E-01	1.16E-01	1.23E+01
30.00	3.98E-01	2.98E-01	2.28E-01	1.79E-01	1.44E-01	1.19E-01	1.03E-01	9.33E-02	9.01E-02	1.15E+01
32.00	3.41E-01	2.51E-01	1.90E-01	1.47E-01	1.17E-01	9.52E-02	8.05E-02	7.19E-02	6.90E-02	1.08E+01
34.00	2.89E-01	2.10E-01	1.57E-01	1.21E-01	9.43E-02	7.53E-02	6.23E-02	5.47E-02	5.21E-02	1.00E+01
36.00	2.41E-01	1.74E-01	1.29E-01	9.81E-02	7.56E-02	5.91E-02	4.77E-02	4.09E-02	3.86E-02	9.23E+00
38.00	1.98E-01	1.42E-01	1.05E-01	7.95E-02	6.04E-02	4.60E-02	3.59E-02	2.99E-02	2.79E-02	8.46E+00
40.00	1.61E-01	1.15E-01	8.53E-02	6.42E-02	4.80E-02	3.55E-02	2.66E-02	2.13E-02	1.95E-02	7.70E+00
42.00	1.28E-01	9.22E-02	6.90E-02	5.19E-02	3.81E-02	2.71E-02	1.92E-02	1.45E-02	1.30E-02	6.93E+00
44.00	1.01E-01	7.37E-02	5.59E-02	4.20E-02	3.00E-02	2.03E-02	1.33E-02	9.29E-03	8.01E-03	6.17E+00
46.00	7.83E-02	5.88E-02	4.54E-02	3.40E-02	2.35E-02	1.48E-02	8.68E-03	5.35E-03	4.34E-03	5.42E+00
48.00	6.15E-02	4.79E-02	3.77E-02	2.79E-02	1.84E-02	1.05E-02	5.20E-03	2.60E-03	1.89E-03	4.76E+00
50.00	4.84E-02	3.92E-02	3.13E-02	2.28E-02	1.41E-02	6.90E-03	2.55E-03	8.20E-04	4.75E-04	4.11E+00
52.00	3.78E-02	3.18E-02	2.56E-02	1.82E-02	1.02E-02	3.90E-03	6.33E-04	6.53E-05	2.70E-05	3.43E+00
54.00	2.89E-02	2.49E-02	2.02E-02	1.38E-02	6.82E-03	1.48E-03	5.71E-04	1.39E-04	4.27E-04	2.73E+00
56.00	2.09E-02	1.81E-02	1.46E-02	9.66E-03	3.89E-03	2.61E-04	1.10E-03	3.69E-04	1.36E-03	1.99E+00
58.00	1.27E-02	1.10E-02	8.94E-03	5.70E-03	1.63E-03	1.14E-03	1.02E-03	9.79E-04	2.13E-03	1.22E+00
60.00	4.16E-03	3.50E-03	2.98E-03	1.87E-03	2.57E-04	7.92E-04	4.36E-04	7.91E-04	1.46E-03	4.04E-01

1PARTICLE SPECTRA Z= 2, N= 2
 FIRST EMISSION AT P= 4
 TARGET Z= 26, N= 28 PROJ Z= 1, N= 0
 PO= 2, HO= 1, G= 4.231, E=66.000
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 840.8
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.916
 MSD POSSIBLE= 1.000, USED= 0.882
 CLOSED FORM SUM STARTS AT P= 4

- EPS --	DIRECT		PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)				
--	NUTRA	KNOCK	--	MSD	MSC	--	WEISS	--	MSD	MSC	MSD+MSC
6.00	3.860E-03	2.125E-04	9.239E-03	1.035E-02	8.395E-02	1.331E-02	9.430E-02	1.076E-01			
8.00	3.047E-02	1.743E-03	5.062E-02	5.212E-02	3.665E-01	8.283E-02	4.187E-01	5.015E-01			
10.00	8.499E-02	5.057E-03	9.770E-02	9.127E-02	5.601E-01	1.878E-01	6.513E-01	8.391E-01			
12.00	1.453E-01	9.007E-03	1.154E-01	9.639E-02	5.192E-01	2.697E-01	6.156E-01	8.853E-01			
14.00	1.927E-01	1.247E-02	1.059E-01	7.779E-02	3.698E-01	3.111E-01	4.476E-01	7.587E-01			
16.00	2.284E-01	1.546E-02	8.714E-02	5.525E-02	2.328E-01	3.310E-01	2.880E-01	6.190E-01			
18.00	2.536E-01	1.799E-02	6.747E-02	3.624E-02	1.356E-01	3.391E-01	1.719E-01	5.109E-01			
20.00	2.693E-01	2.007E-02	5.035E-02	2.247E-02	7.468E-02	3.397E-01	9.714E-02	4.369E-01			
22.00	2.767E-01	2.171E-02	3.670E-02	1.335E-02	3.926E-02	3.351E-01	5.261E-02	3.877E-01			
24.00	2.767E-01	2.293E-02	2.634E-02	7.672E-03	1.982E-02	3.260E-01	2.749E-02	3.534E-01			
26.00	2.704E-01	2.373E-02	1.873E-02	4.299E-03	9.634E-03	3.129E-01	1.393E-02	3.268E-01			
28.00	2.588E-01	2.414E-02	1.323E-02	2.363E-03	4.515E-03	2.961E-01	6.877E-03	3.030E-01			
30.00	2.428E-01	2.416E-02	9.309E-03	1.279E-03	2.040E-03	2.762E-01	3.318E-03	2.796E-01			
32.00	2.233E-01	2.380E-02	6.530E-03	6.825E-04	8.872E-04	2.536E-01	1.570E-03	2.552E-01			
34.00	2.012E-01	2.309E-02	4.566E-03	3.592E-04	3.709E-04	2.288E-01	7.301E-04	2.295E-01			
36.00	1.773E-01	2.203E-02	3.182E-03	1.858E-04	1.486E-04	2.025E-01	3.344E-04	2.028E-01			
38.00	1.524E-01	2.063E-02	2.205E-03	9.393E-05	5.679E-05	1.753E-01	1.507E-04	1.754E-01			
40.00	1.273E-01	1.891E-02	1.515E-03	4.601E-05	2.060E-05	1.478E-01	6.662E-05	1.478E-01			
42.00	1.028E-01	1.688E-02	1.028E-03	2.157E-05	7.046E-06	1.207E-01	2.862E-05	1.207E-01			
44.00	7.949E-02	1.456E-02	6.830E-04	9.488E-06	2.250E-06	9.473E-02	1.174E-05	9.475E-02			
46.00	5.807E-02	1.195E-02	4.390E-04	3.790E-06	6.618E-07	7.045E-02	4.452E-06	7.046E-02			
48.00	3.916E-02	9.068E-03	2.671E-04	1.295E-06	1.761E-07	4.849E-02	1.471E-06	4.849E-02			
50.00	2.336E-02	5.929E-03	1.475E-04	3.331E-07	4.125E-08	2.944E-02	3.743E-07	2.944E-02			
52.00	1.123E-02	0.	6.745E-05	4.612E-08	8.129E-09	1.130E-02	5.425E-08	1.130E-02			
54.00	3.302E-03	0.	1.926E-05	0.	1.243E-09	3.321E-03	1.243E-09	3.321E-03			
56.00	0.	0.	0.	0.	1.232E-10	0.	1.232E-10	1.232E-10			
OSUMS	7.466E+00	7.311E-01	1.418E+00	9.445E-01	4.839E+00						

1PARTICLE SPECTRA Z= 1, N= 1
 FIRST EMISSION AT P= 2
 TARGET Z= 26, N= 28 PROJ Z= 1, N= 0
 PO= 2, HO= 1, G= 4.231, E=66.000
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 840.8
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.916
 MSD POSSIBLE= 1.000, USED= 0.882
 CLOSED FORM SUM STARTS AT P= 2

- EPS	DIRECT		PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
	-- NUTRA	KNOCK	-- MSD	MSC	-- WEISS	-- MSD	MSC	MSD+MSC	
4.00	1.295E-02	0.	1.546E-01	3.806E-02	1.651E-01	1.676E-01	2.032E-01	3.708E-01	
6.00	5.881E-02	0.	5.105E-01	9.544E-02	3.616E-01	5.693E-01	4.571E-01	1.026E+00	
8.00	1.122E-01	0.	7.180E-01	9.946E-02	3.275E-01	8.302E-01	4.270E-01	1.257E+00	
10.00	1.648E-01	0.	7.880E-01	7.911E-02	2.246E-01	9.529E-01	3.037E-01	1.257E+00	
12.00	2.167E-01	0.	8.757E-01	5.589E-02	1.353E-01	1.092E+00	1.912E-01	1.284E+00	
14.00	2.678E-01	0.	8.531E-01	3.689E-02	7.518E-02	1.121E+00	1.121E-01	1.233E+00	
16.00	3.182E-01	0.	8.119E-01	2.328E-02	3.931E-02	1.130E+00	6.259E-02	1.193E+00	
18.00	3.678E-01	0.	7.636E-01	1.421E-02	1.955E-02	1.131E+00	3.375E-02	1.165E+00	
20.00	4.167E-01	0.	7.140E-01	8.432E-03	9.290E-03	1.131E+00	1.772E-02	1.148E+00	
22.00	4.648E-01	0.	6.665E-01	4.873E-03	4.230E-03	1.131E+00	9.104E-03	1.140E+00	
24.00	5.121E-01	0.	6.225E-01	2.738E-03	1.846E-03	1.135E+00	4.584E-03	1.139E+00	
26.00	5.587E-01	0.	5.829E-01	1.489E-03	7.714E-04	1.142E+00	2.260E-03	1.144E+00	
28.00	6.046E-01	0.	5.479E-01	7.783E-04	3.079E-04	1.152E+00	1.086E-03	1.154E+00	
30.00	6.497E-01	0.	5.174E-01	3.871E-04	1.169E-04	1.167E+00	5.040E-04	1.168E+00	
32.00	6.940E-01	0.	4.915E-01	1.806E-04	4.205E-05	1.185E+00	2.226E-04	1.186E+00	
34.00	7.376E-01	0.	4.699E-01	7.746E-05	1.422E-05	1.208E+00	9.168E-05	1.208E+00	
36.00	7.804E-01	0.	4.526E-01	2.965E-05	4.476E-06	1.233E+00	3.413E-05	1.233E+00	
38.00	8.225E-01	0.	4.396E-01	9.665E-06	1.295E-06	1.262E+00	1.096E-05	1.262E+00	
40.00	8.638E-01	0.	4.307E-01	2.478E-06	3.379E-07	1.294E+00	2.816E-06	1.294E+00	
42.00	9.044E-01	0.	4.261E-01	4.295E-07	7.728E-08	1.330E+00	5.068E-07	1.330E+00	
44.00	9.442E-01	0.	4.259E-01	3.545E-08	1.479E-08	1.370E+00	5.025E-08	1.370E+00	
46.00	9.832E-01	0.	4.304E-01	0.	2.179E-09	1.414E+00	2.179E-09	1.414E+00	
48.00	1.022E+00	0.	4.400E-01	0.	2.046E-10	1.462E+00	2.046E-10	1.462E+00	
OSUMS	2.444E+01	0.	2.605E+01	9.227E-01	2.730E+00				

ANGULAR DISTRIBUTIONS Z= 1 N= 1
 ENERGY PARAM. = EPS+B.E.
 CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
4.00	5.70E-02	5.61E-02	5.34E-02	4.94E-02	4.46E-02	3.94E-02	3.44E-02	2.99E-02	2.63E-02	2.37E-02
6.00	1.75E-01	1.72E-01	1.63E-01	1.50E-01	1.34E-01	1.16E-01	9.97E-02	8.50E-02	7.29E-02	6.39E-02
8.00	2.38E-01	2.34E-01	2.21E-01	2.01E-01	1.77E-01	1.52E-01	1.28E-01	1.07E-01	8.92E-02	7.59E-02
10.00	2.63E-01	2.58E-01	2.43E-01	2.20E-01	1.92E-01	1.62E-01	1.34E-01	1.09E-01	8.89E-02	7.32E-02
12.00	2.97E-01	2.91E-01	2.72E-01	2.44E-01	2.11E-01	1.76E-01	1.43E-01	1.14E-01	9.02E-02	7.19E-02
14.00	3.10E-01	3.03E-01	2.82E-01	2.52E-01	2.15E-01	1.77E-01	1.41E-01	1.10E-01	8.52E-02	6.61E-02
16.00	3.23E-01	3.15E-01	2.92E-01	2.58E-01	2.18E-01	1.77E-01	1.39E-01	1.06E-01	8.04E-02	6.08E-02
18.00	3.38E-01	3.29E-01	3.04E-01	2.66E-01	2.22E-01	1.78E-01	1.37E-01	1.03E-01	7.61E-02	5.61E-02
20.00	3.55E-01	3.45E-01	3.17E-01	2.76E-01	2.28E-01	1.79E-01	1.36E-01	9.97E-02	7.20E-02	5.19E-02
22.00	3.75E-01	3.64E-01	3.33E-01	2.87E-01	2.34E-01	1.81E-01	1.34E-01	9.65E-02	6.81E-02	4.80E-02
24.00	4.00E-01	3.87E-01	3.51E-01	3.00E-01	2.41E-01	1.83E-01	1.33E-01	9.32E-02	6.42E-02	4.43E-02
26.00	4.28E-01	4.13E-01	3.73E-01	3.14E-01	2.49E-01	1.85E-01	1.31E-01	8.98E-02	6.03E-02	4.06E-02
28.00	4.60E-01	4.44E-01	3.97E-01	3.31E-01	2.58E-01	1.88E-01	1.30E-01	8.62E-02	5.62E-02	3.71E-02
30.00	4.98E-01	4.79E-01	4.26E-01	3.50E-01	2.67E-01	1.90E-01	1.28E-01	8.21E-02	5.20E-02	3.36E-02
32.00	5.42E-01	5.20E-01	4.58E-01	3.71E-01	2.77E-01	1.92E-01	1.25E-01	7.75E-02	4.76E-02	3.01E-02
34.00	5.93E-01	5.67E-01	4.94E-01	3.94E-01	2.88E-01	1.94E-01	1.21E-01	7.24E-02	4.30E-02	2.69E-02
36.00	6.52E-01	6.21E-01	5.36E-01	4.20E-01	2.99E-01	1.94E-01	1.16E-01	6.66E-02	3.83E-02	2.38E-02
38.00	7.20E-01	6.83E-01	5.83E-01	4.48E-01	3.09E-01	1.93E-01	1.10E-01	6.02E-02	3.37E-02	2.12E-02
40.00	7.99E-01	7.55E-01	6.36E-01	4.78E-01	3.19E-01	1.90E-01	1.03E-01	5.32E-02	2.92E-02	1.89E-02
42.00	8.92E-01	8.39E-01	6.97E-01	5.10E-01	3.28E-01	1.85E-01	9.38E-02	4.58E-02	2.51E-02	1.74E-02
44.00	1.00E+00	9.36E-01	7.66E-01	5.45E-01	3.35E-01	1.77E-01	8.29E-02	3.83E-02	2.18E-02	1.66E-02
46.00	1.13E+00	1.05E+00	8.44E-01	5.81E-01	3.38E-01	1.65E-01	7.01E-02	3.10E-02	1.97E-02	1.67E-02
48.00	1.28E+00	1.18E+00	9.33E-01	6.18E-01	3.38E-01	1.49E-01	5.56E-02	2.47E-02	1.93E-02	1.78E-02
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
4.00	2.21E-02	2.14E-02	2.15E-02	2.21E-02	2.32E-02	2.44E-02	2.55E-02	2.62E-02	2.65E-02	3.71E-01
6.00	5.79E-02	5.47E-02	5.38E-02	5.47E-02	5.68E-02	5.94E-02	6.18E-02	6.35E-02	6.41E-02	1.03E+00
8.00	6.66E-02	6.09E-02	5.83E-02	5.80E-02	5.93E-02	6.14E-02	6.36E-02	6.51E-02	6.57E-02	1.26E+00
10.00	6.20E-02	5.47E-02	5.06E-02	4.89E-02	4.89E-02	4.98E-02	5.11E-02	5.20E-02	5.24E-02	1.26E+00
12.00	5.86E-02	4.95E-02	4.38E-02	4.05E-02	3.90E-02	3.87E-02	3.88E-02	3.91E-02	3.93E-02	1.28E+00
14.00	5.21E-02	4.25E-02	3.61E-02	3.21E-02	2.98E-02	2.86E-02	2.81E-02	2.80E-02	2.79E-02	1.23E+00
16.00	4.66E-02	3.68E-02	3.01E-02	2.58E-02	2.30E-02	2.13E-02	2.04E-02	1.99E-02	1.98E-02	1.19E+00
18.00	4.20E-02	3.22E-02	2.56E-02	2.11E-02	1.82E-02	1.63E-02	1.51E-02	1.44E-02	1.42E-02	1.17E+00
20.00	3.80E-02	2.85E-02	2.21E-02	1.77E-02	1.47E-02	1.27E-02	1.14E-02	1.07E-02	1.04E-02	1.15E+00
22.00	3.44E-02	2.53E-02	1.93E-02	1.51E-02	1.22E-02	1.02E-02	8.84E-03	8.07E-03	7.82E-03	1.14E+00
24.00	3.11E-02	2.26E-02	1.69E-02	1.31E-02	1.03E-02	8.34E-03	6.99E-03	6.21E-03	5.95E-03	1.14E+00
26.00	2.81E-02	2.02E-02	1.50E-02	1.15E-02	8.85E-03	6.93E-03	5.60E-03	4.81E-03	4.56E-03	1.14E+00
28.00	2.53E-02	1.81E-02	1.35E-02	1.02E-02	7.71E-03	5.84E-03	4.51E-03	3.73E-03	3.47E-03	1.15E+00
30.00	2.27E-02	1.63E-02	1.22E-02	9.17E-03	6.81E-03	4.96E-03	3.63E-03	2.85E-03	2.59E-03	1.17E+00
32.00	2.04E-02	1.48E-02	1.12E-02	8.40E-03	6.09E-03	4.22E-03	2.89E-03	2.11E-03	1.86E-03	1.19E+00
34.00	1.84E-02	1.36E-02	1.04E-02	7.83E-03	5.50E-03	3.58E-03	2.22E-03	1.46E-03	1.23E-03	1.21E+00
36.00	1.67E-02	1.28E-02	9.98E-03	7.43E-03	5.01E-03	2.99E-03	1.61E-03	8.98E-04	6.92E-04	1.23E+00
38.00	1.54E-02	1.23E-02	9.76E-03	7.16E-03	4.56E-03	2.40E-03	1.03E-03	4.22E-04	2.76E-04	1.26E+00
40.00	1.46E-02	1.21E-02	9.73E-03	6.98E-03	4.11E-03	1.77E-03	4.70E-04	7.05E-05	3.62E-05	1.29E+00
42.00	1.43E-02	1.22E-02	9.86E-03	6.86E-03	3.60E-03	1.07E-03	-6.61E-05	-8.63E-05	7.49E-05	1.33E+00
44.00	1.44E-02	1.25E-02	1.01E-02	6.76E-03	3.00E-03	2.26E-04	-5.67E-04	6.43E-05	5.55E-04	1.37E+00
46.00	1.48E-02	1.28E-02	1.04E-02	6.70E-03	2.27E-03	-8.17E-04	-1.02E-03	6.90E-04	1.72E-03	1.41E+00
48.00	1.52E-02	1.29E-02	1.07E-02	6.76E-03	1.38E-03	-2.19E-03	-1.43E-03	2.04E-03	3.96E-03	1.46E+00

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1PARTICLE SPECTRA Z= 1, N= 2
 FIRST EMISSION AT P= 3
 TARGET Z= 26, N= 28 PROJ Z= 1, N= 0
 PO= 2, HO= 1, G= 4.231, E=66.000
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 840.8
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.916
 MSD POSSIBLE= 1.000, USED= 0.882
 CLOSED FORM SUM STARTS AT P= 3

- EPS	DIRECT		PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
	-- NUTRA	KNOCK	-- MSD	MSC	-- WEISS	-- MSD	MSC	MSD+MSC	
3.00	6.604E-04	0.	2.172E-03	8.519E-04	4.362E-03	2.832E-03	5.214E-03	8.047E-03	
5.00	1.489E-02	0.	3.440E-02	1.083E-02	4.886E-02	4.928E-02	5.969E-02	1.090E-01	
7.00	3.562E-02	0.	5.861E-02	1.447E-02	5.723E-02	9.424E-02	7.170E-02	1.659E-01	
9.00	5.384E-02	0.	6.383E-02	1.212E-02	4.166E-02	1.177E-01	5.378E-02	1.715E-01	
11.00	6.948E-02	0.	6.020E-02	8.627E-03	2.546E-02	1.297E-01	3.409E-02	1.638E-01	
13.00	8.261E-02	0.	5.310E-02	5.640E-03	1.407E-02	1.357E-01	1.972E-02	1.554E-01	
15.00	9.328E-02	0.	4.518E-02	3.498E-03	7.242E-03	1.385E-01	1.074E-02	1.492E-01	
17.00	1.015E-01	0.	3.764E-02	2.089E-03	3.515E-03	1.392E-01	5.605E-03	1.448E-01	
19.00	1.074E-01	0.	3.096E-02	1.210E-03	1.620E-03	1.384E-01	2.830E-03	1.412E-01	
21.00	1.110E-01	0.	2.527E-02	6.811E-04	7.104E-04	1.362E-01	1.391E-03	1.376E-01	
23.00	1.123E-01	0.	2.053E-02	3.715E-04	2.965E-04	1.328E-01	6.680E-04	1.335E-01	
25.00	1.113E-01	0.	1.661E-02	1.952E-04	1.175E-04	1.280E-01	3.127E-04	1.283E-01	
27.00	1.082E-01	0.	1.341E-02	9.790E-05	4.410E-05	1.216E-01	1.420E-04	1.218E-01	
29.00	1.030E-01	0.	1.078E-02	4.617E-05	1.556E-05	1.138E-01	6.173E-05	1.139E-01	
31.00	9.573E-02	0.	8.622E-03	2.002E-05	5.127E-06	1.044E-01	2.515E-05	1.044E-01	
33.00	8.642E-02	0.	6.840E-03	7.699E-06	1.558E-06	9.326E-02	9.257E-06	9.327E-02	
35.00	7.513E-02	0.	5.350E-03	2.469E-06	4.296E-07	8.048E-02	2.899E-06	8.048E-02	
37.00	6.192E-02	0.	4.078E-03	5.869E-07	1.049E-07	6.599E-02	6.918E-07	6.599E-02	
39.00	4.683E-02	0.	2.957E-03	7.914E-08	2.181E-08	4.979E-02	1.009E-07	4.979E-02	
41.00	2.992E-02	0.	1.926E-03	2.564E-09	3.606E-09	3.184E-02	6.170E-09	3.184E-02	
43.00	1.122E-02	0.	9.170E-04	0.	4.115E-10	1.214E-02	4.115E-10	1.214E-02	
45.00	0.	0.	0.	0.	2.313E-11	0.	2.313E-11	2.313E-11	
OSUMS	3.024E+00	0.	1.006E+00	1.211E-01	4.083E-01				

1 ANGULAR DISTRIBUTIONS Z= 1 N= 2

ENERGY PARAM. = EPS+B.E.

CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
3.00	1.25E-03	1.23E-03	1.16E-03	1.07E-03	9.53E-04	8.31E-04	7.16E-04	6.17E-04	5.41E-04	4.90E-04
5.00	1.89E-02	1.85E-02	1.75E-02	1.59E-02	1.40E-02	1.20E-02	1.02E-02	8.56E-03	7.29E-03	6.42E-03
7.00	3.24E-02	3.17E-02	2.98E-02	2.69E-02	2.34E-02	1.98E-02	1.63E-02	1.34E-02	1.11E-02	9.41E-03
9.00	3.77E-02	3.69E-02	3.44E-02	3.08E-02	2.65E-02	2.20E-02	1.78E-02	1.42E-02	1.14E-02	9.31E-03
11.00	4.03E-02	3.93E-02	3.65E-02	3.24E-02	2.75E-02	2.25E-02	1.79E-02	1.39E-02	1.08E-02	8.47E-03
13.00	4.22E-02	4.11E-02	3.80E-02	3.34E-02	2.81E-02	2.26E-02	1.76E-02	1.33E-02	1.00E-02	7.62E-03
15.00	4.41E-02	4.29E-02	3.94E-02	3.44E-02	2.85E-02	2.26E-02	1.72E-02	1.28E-02	9.35E-03	6.88E-03
17.00	4.61E-02	4.48E-02	4.10E-02	3.54E-02	2.90E-02	2.26E-02	1.69E-02	1.22E-02	8.71E-03	6.23E-03
19.00	4.83E-02	4.68E-02	4.25E-02	3.64E-02	2.94E-02	2.25E-02	1.64E-02	1.16E-02	8.07E-03	5.62E-03
21.00	5.03E-02	4.86E-02	4.40E-02	3.72E-02	2.96E-02	2.22E-02	1.58E-02	1.09E-02	7.39E-03	5.02E-03
23.00	5.22E-02	5.03E-02	4.51E-02	3.78E-02	2.95E-02	2.17E-02	1.51E-02	1.01E-02	6.66E-03	4.42E-03
25.00	5.36E-02	5.16E-02	4.59E-02	3.79E-02	2.91E-02	2.09E-02	1.41E-02	9.18E-03	5.87E-03	3.81E-03
27.00	5.45E-02	5.23E-02	4.62E-02	3.76E-02	2.83E-02	1.98E-02	1.30E-02	8.14E-03	5.04E-03	3.21E-03
29.00	5.47E-02	5.24E-02	4.58E-02	3.67E-02	2.70E-02	1.83E-02	1.16E-02	7.01E-03	4.21E-03	2.64E-03
31.00	5.40E-02	5.15E-02	4.46E-02	3.51E-02	2.52E-02	1.65E-02	1.00E-02	5.82E-03	3.38E-03	2.10E-03
33.00	5.20E-02	4.94E-02	4.23E-02	3.27E-02	2.28E-02	1.44E-02	8.36E-03	4.62E-03	2.61E-03	1.63E-03
35.00	4.85E-02	4.59E-02	3.89E-02	2.94E-02	1.98E-02	1.20E-02	6.60E-03	3.47E-03	1.91E-03	1.22E-03
37.00	4.32E-02	4.07E-02	3.39E-02	2.50E-02	1.63E-02	9.35E-03	4.83E-03	2.40E-03	1.31E-03	8.88E-04
39.00	3.55E-02	3.32E-02	2.73E-02	1.96E-02	1.22E-02	6.59E-03	3.16E-03	1.48E-03	8.31E-04	6.14E-04
41.00	2.48E-02	2.31E-02	1.86E-02	1.30E-02	7.67E-03	3.85E-03	1.68E-03	7.51E-04	4.58E-04	3.78E-04
43.00	1.04E-02	9.59E-03	7.60E-03	5.09E-03	2.84E-03	1.29E-03	5.03E-04	2.21E-04	1.61E-04	1.46E-04
45.00	1.09E-11	1.00E-11	7.73E-12	4.95E-12	2.58E-12	1.09E-12	4.29E-13	2.63E-13	2.75E-13	2.94E-13
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
3.00	4.64E-04	4.62E-04	4.80E-04	5.14E-04	5.56E-04	6.00E-04	6.38E-04	6.64E-04	6.73E-04	8.05E-03
5.00	5.92E-03	5.76E-03	5.90E-03	6.25E-03	6.74E-03	7.27E-03	7.74E-03	8.06E-03	8.18E-03	1.09E-01
7.00	8.37E-03	7.89E-03	7.87E-03	8.21E-03	8.77E-03	9.41E-03	1.00E-02	1.04E-02	1.06E-02	1.66E-01
9.00	7.94E-03	7.17E-03	6.90E-03	7.00E-03	7.34E-03	7.79E-03	8.22E-03	8.54E-03	8.65E-03	1.71E-01
11.00	6.91E-03	5.95E-03	5.46E-03	5.32E-03	5.41E-03	5.63E-03	5.88E-03	6.06E-03	6.13E-03	1.64E-01
13.00	5.95E-03	4.88E-03	4.26E-03	3.95E-03	3.85E-03	3.89E-03	3.97E-03	4.05E-03	4.09E-03	1.55E-01
15.00	5.18E-03	4.07E-03	3.38E-03	2.97E-03	2.76E-03	2.68E-03	2.66E-03	2.66E-03	2.67E-03	1.49E-01
17.00	4.55E-03	3.45E-03	2.75E-03	2.31E-03	2.04E-03	1.88E-03	1.80E-03	1.76E-03	1.75E-03	1.45E-01
19.00	4.00E-03	2.96E-03	2.29E-03	1.85E-03	1.55E-03	1.36E-03	1.24E-03	1.18E-03	1.16E-03	1.41E-01
21.00	3.51E-03	2.55E-03	1.93E-03	1.51E-03	1.22E-03	1.02E-03	8.86E-04	8.10E-04	7.85E-04	1.38E-01
23.00	3.03E-03	2.18E-03	1.64E-03	1.26E-03	9.85E-04	7.82E-04	6.43E-04	5.62E-04	5.36E-04	1.33E-01
25.00	2.59E-03	1.86E-03	1.39E-03	1.06E-03	8.04E-04	6.08E-04	4.70E-04	3.89E-04	3.63E-04	1.28E-01
27.00	2.17E-03	1.57E-03	1.19E-03	8.96E-04	6.61E-04	4.74E-04	3.40E-04	2.63E-04	2.38E-04	1.22E-01
29.00	1.79E-03	1.32E-03	1.01E-03	7.60E-04	5.43E-04	3.65E-04	2.38E-04	1.67E-04	1.45E-04	1.14E-01
31.00	1.46E-03	1.11E-03	8.60E-04	6.43E-04	4.41E-04	2.73E-04	1.57E-04	9.50E-05	7.67E-05	1.04E-01
33.00	1.17E-03	9.22E-04	7.29E-04	5.38E-04	3.50E-04	1.93E-04	9.09E-05	4.30E-05	3.07E-05	9.33E-02
35.00	9.26E-04	7.59E-04	6.09E-04	4.41E-04	2.66E-04	1.23E-04	4.01E-05	1.05E-05	5.96E-06	8.05E-02
37.00	7.16E-04	6.07E-04	4.90E-04	3.45E-04	1.88E-04	6.42E-05	4.49E-06	3.13E-06	1.55E-06	6.60E-02
39.00	5.24E-04	4.54E-04	3.67E-04	2.49E-04	1.17E-04	1.79E-05	1.56E-05	6.88E-07	1.32E-05	4.98E-02
41.00	3.33E-04	2.89E-04	2.34E-04	1.52E-04	5.68E-05	1.11E-05	2.04E-05	1.02E-05	2.95E-05	3.18E-02
43.00	1.27E-04	1.08E-04	8.90E-05	5.64E-05	1.39E-05	1.46E-05	1.11E-05	1.30E-05	2.66E-05	1.21E-02
45.00	2.75E-13	2.63E-13	4.28E-13	1.09E-12	2.58E-12	4.94E-12	7.72E-12	1.00E-11	1.09E-11	2.31E-11

1PARTICLE SPECTRA Z= 2. N= 1
 FIRST EMISSION AT P= 3
 TARGET Z= 26. N= 28 PROJ Z= 1. N= 0
 PO= 2. HO= 1. G= 4.231. E=66.000
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 840.8
 SCALE FACTOR= 1.350. FRAC PREEQ= 0.916
 MSD POSSIBLE= 1.000. USED= 0.882
 CLOSED FORM SUM STARTS AT P= 3

- EPS	DIRECT			PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
	NUTRA	KNOCK		MSD	MSC	WEISS		MSD	MSC	MSD+MSC
8.00	1.442E-02	0.		2.340E-02	6.324E-03	2.349E-02		3.782E-02	2.981E-02	6.763E-02
10.00	4.048E-02	0.		4.772E-02	9.930E-03	3.208E-02		8.820E-02	4.201E-02	1.302E-01
12.00	6.898E-02	0.		5.978E-02	9.407E-03	2.617E-02		1.288E-01	3.558E-02	1.643E-01
14.00	9.352E-02	0.		6.055E-02	7.066E-03	1.669E-02		1.541E-01	2.375E-02	1.778E-01
16.00	1.142E-01	0.		5.616E-02	4.771E-03	9.404E-03		1.704E-01	1.418E-02	1.845E-01
18.00	1.311E-01	0.		4.979E-02	3.027E-03	4.880E-03		1.809E-01	7.907E-03	1.888E-01
20.00	1.443E-01	0.		4.303E-02	1.839E-03	2.374E-03		1.873E-01	4.213E-03	1.915E-01
22.00	1.539E-01	0.		3.664E-02	1.080E-03	1.092E-03		1.905E-01	2.171E-03	1.927E-01
24.00	1.599E-01	0.		3.091E-02	6.132E-04	4.764E-04		1.908E-01	1.090E-03	1.919E-01
26.00	1.625E-01	0.		2.592E-02	3.362E-04	1.973E-04		1.884E-01	5.335E-04	1.890E-01
28.00	1.618E-01	0.		2.164E-02	1.768E-04	7.741E-05		1.834E-01	2.542E-04	1.837E-01
30.00	1.578E-01	0.		1.799E-02	8.827E-05	2.866E-05		1.758E-01	1.169E-04	1.759E-01
32.00	1.506E-01	0.		1.488E-02	4.112E-05	9.951E-06		1.655E-01	5.107E-05	1.655E-01
34.00	1.403E-01	0.		1.221E-02	1.743E-05	3.212E-06		1.525E-01	2.064E-05	1.525E-01
36.00	1.270E-01	0.		9.906E-03	6.441E-06	9.518E-07		1.369E-01	7.393E-06	1.369E-01
38.00	1.108E-01	0.		7.878E-03	1.927E-06	2.542E-07		1.186E-01	2.182E-06	1.186E-01
40.00	9.170E-02	0.		6.050E-03	4.029E-07	5.947E-08		9.775E-02	4.623E-07	9.775E-02
42.00	6.988E-02	0.		4.349E-03	4.083E-08	1.165E-08		7.423E-02	5.249E-08	7.423E-02
44.00	4.539E-02	0.		2.696E-03	0.	1.758E-09		4.809E-02	1.758E-09	4.809E-02
46.00	1.833E-02	0.		1.008E-03	0.	1.696E-10		1.934E-02	1.696E-10	1.934E-02
OSUMS	4.304E+00	0.		1.065E+00	8.945E-02	2.340E-01				

ANGULAR DISTRIBUTIONS Z= 2 N= 1
 ENERGY PARAM. = EPS+B.E.
 CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
8.00	1.27E-02	1.24E-02	1.17E-02	1.06E-02	9.31E-03	7.93E-03	6.63E-03	5.50E-03	4.59E-03	3.94E-03
10.00	2.75E-02	2.69E-02	2.52E-02	2.27E-02	1.96E-02	1.65E-02	1.35E-02	1.09E-02	8.82E-03	7.29E-03
12.00	3.88E-02	3.79E-02	3.53E-02	3.15E-02	2.70E-02	2.23E-02	1.79E-02	1.41E-02	1.10E-02	8.80E-03
14.00	4.62E-02	4.51E-02	4.19E-02	3.70E-02	3.13E-02	2.55E-02	2.00E-02	1.54E-02	1.18E-02	9.06E-03
16.00	5.23E-02	5.09E-02	4.70E-02	4.12E-02	3.45E-02	2.76E-02	2.13E-02	1.60E-02	1.19E-02	8.88E-03
18.00	5.76E-02	5.60E-02	5.15E-02	4.48E-02	3.70E-02	2.91E-02	2.20E-02	1.62E-02	1.18E-02	8.53E-03
20.00	6.27E-02	6.08E-02	5.55E-02	4.78E-02	3.90E-02	3.02E-02	2.24E-02	1.61E-02	1.14E-02	8.05E-03
22.00	6.74E-02	6.53E-02	5.92E-02	5.05E-02	4.06E-02	3.09E-02	2.24E-02	1.57E-02	1.08E-02	7.48E-03
24.00	7.17E-02	6.93E-02	6.25E-02	5.27E-02	4.17E-02	3.11E-02	2.20E-02	1.50E-02	1.01E-02	6.81E-03
26.00	7.54E-02	7.27E-02	6.51E-02	5.42E-02	4.22E-02	3.08E-02	2.12E-02	1.41E-02	9.20E-03	6.06E-03
28.00	7.84E-02	7.54E-02	6.70E-02	5.51E-02	4.20E-02	2.99E-02	2.01E-02	1.29E-02	8.17E-03	5.27E-03
30.00	8.05E-02	7.71E-02	6.80E-02	5.51E-02	4.12E-02	2.85E-02	1.85E-02	1.15E-02	7.05E-03	4.46E-03
32.00	8.13E-02	7.77E-02	6.78E-02	5.41E-02	3.95E-02	2.65E-02	1.66E-02	9.91E-03	5.89E-03	3.68E-03
34.00	8.07E-02	7.68E-02	6.64E-02	5.20E-02	3.70E-02	2.40E-02	1.44E-02	8.23E-03	4.73E-03	2.94E-03
36.00	7.82E-02	7.42E-02	6.33E-02	4.86E-02	3.36E-02	2.09E-02	1.20E-02	6.52E-03	3.64E-03	2.29E-03
38.00	7.33E-02	6.93E-02	5.84E-02	4.38E-02	2.93E-02	1.74E-02	9.42E-03	4.87E-03	2.67E-03	1.73E-03
40.00	6.56E-02	6.17E-02	5.13E-02	3.75E-02	2.41E-02	1.36E-02	6.88E-03	3.36E-03	1.84E-03	1.28E-03
42.00	5.43E-02	5.08E-02	4.15E-02	2.95E-02	1.81E-02	9.59E-03	4.48E-03	2.07E-03	1.18E-03	8.99E-04
44.00	3.84E-02	3.58E-02	2.87E-02	1.98E-02	1.15E-02	5.62E-03	2.38E-03	1.05E-03	6.69E-04	5.70E-04
46.00	1.70E-02	1.57E-02	1.23E-02	8.18E-03	4.46E-03	1.97E-03	7.32E-04	3.26E-04	2.55E-04	2.36E-04
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
8.00	3.53E-03	3.33E-03	3.31E-03	3.43E-03	3.64E-03	3.88E-03	4.10E-03	4.26E-03	4.31E-03	6.76E-02
10.00	6.27E-03	5.69E-03	5.46E-03	5.51E-03	5.74E-03	6.05E-03	6.36E-03	6.58E-03	6.66E-03	1.30E-01
12.00	7.25E-03	6.28E-03	5.77E-03	5.61E-03	5.67E-03	5.86E-03	6.09E-03	6.26E-03	6.32E-03	1.64E-01
14.00	7.16E-03	5.92E-03	5.18E-03	4.80E-03	4.67E-03	4.69E-03	4.77E-03	4.85E-03	4.89E-03	1.78E-01
16.00	6.77E-03	5.37E-03	4.48E-03	3.96E-03	3.67E-03	3.55E-03	3.51E-03	3.51E-03	3.51E-03	1.85E-01
18.00	6.31E-03	4.83E-03	3.87E-03	3.26E-03	2.89E-03	2.67E-03	2.55E-03	2.49E-03	2.48E-03	1.89E-01
20.00	5.81E-03	4.33E-03	3.36E-03	2.73E-03	2.31E-03	2.04E-03	1.87E-03	1.78E-03	1.75E-03	1.92E-01
22.00	5.28E-03	3.86E-03	2.93E-03	2.31E-03	1.88E-03	1.59E-03	1.39E-03	1.28E-03	1.25E-03	1.93E-01
24.00	4.72E-03	3.40E-03	2.55E-03	1.97E-03	1.56E-03	1.26E-03	1.05E-03	9.33E-04	8.94E-04	1.92E-01
26.00	4.14E-03	2.97E-03	2.22E-03	1.69E-03	1.30E-03	1.00E-03	7.98E-04	6.77E-04	6.37E-04	1.89E-01
28.00	3.57E-03	2.56E-03	1.92E-03	1.45E-03	1.09E-03	8.04E-04	6.01E-04	4.82E-04	4.44E-04	1.84E-01
30.00	3.02E-03	2.19E-03	1.66E-03	1.25E-03	9.11E-04	6.38E-04	4.43E-04	3.30E-04	2.93E-04	1.76E-01
32.00	2.51E-03	1.87E-03	1.43E-03	1.07E-03	7.58E-04	4.96E-04	3.11E-04	2.08E-04	1.76E-04	1.66E-01
34.00	2.06E-03	1.58E-03	1.23E-03	9.19E-04	6.21E-04	3.71E-04	2.02E-04	1.14E-04	8.90E-05	1.53E-01
36.00	1.67E-03	1.33E-03	1.06E-03	7.77E-04	4.95E-04	2.60E-04	1.12E-04	4.68E-05	3.12E-05	1.37E-01
38.00	1.34E-03	1.11E-03	8.92E-04	6.40E-04	3.76E-04	1.62E-04	4.28E-05	6.65E-06	3.74E-06	1.19E-01
40.00	1.05E-03	8.96E-04	7.24E-04	5.03E-04	2.64E-04	7.75E-05	5.32E-06	6.23E-06	5.90E-06	9.77E-02
42.00	7.79E-04	6.76E-04	5.46E-04	3.66E-04	1.62E-04	1.15E-05	3.11E-05	3.79E-06	3.07E-05	7.42E-02
44.00	5.03E-04	4.35E-04	3.53E-04	2.28E-04	7.67E-05	2.84E-05	3.50E-05	2.39E-05	5.95E-05	4.81E-02
46.00	2.01E-04	1.71E-04	1.42E-04	8.95E-05	1.80E-05	2.92E-05	1.90E-05	2.73E-05	5.29E-05	1.93E-02

100

1
-S= 5.69 MEV
-OCCUPATION PROBABILITIES PO= 2, HO= 1
TARGET Z= 92, N=143 PROJ Z= 1, N= 0
G=16.620, E=20.040
SCALE FACTOR= 1.350, FRAC PREEQ= 0.255
- P H RHOU/RHO STRU/STR STRD/STR
1 0 1.000E+00 0. 0.
2 1 8.741E-01 8.741E-01 8.741E-01
3 2 7.182E-01 6.998E-01 6.662E-01
4 3 5.258E-01 5.045E-01 4.229E-01
5 4 3.387E-01 3.060E-01 2.183E-01
6 5 1.997E-01 1.611E-01 9.085E-02
7 6 1.091E-01 7.821E-02 3.004E-02
8 7 5.519E-02 3.832E-02 7.700E-03
9 8 2.570E-02 2.048E-02 1.477E-03
10 9 1.087E-02 1.202E-02 0.

1PARTICLE SPECTRA Z= 0, N= 1
 FIRST EMISSION AT P= 2
 TARGET Z= 92, N=143 PROJ Z= 1, N= 0
 PO= 2, HO= 1, G=16.620, E=20.040
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 743.2
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.255
 MSD POSSIBLE= 0.874, USED= 0.214
 CLOSED FORM SUM STARTS AT P= 2

			TOTAL (MB/MEV)						
- EPS --	DIRECT	--	PREEQUILIBRIUM	--	EQUIL	--	MSD	MSC	MSD+MSC
-- NUTRA	KNOCK	--	MSD	MSC	-- WEISS	--	MSD	MSC	MSD+MSC
1.00	0.	0.	8.506E+00	7.638E+00	8.488E+01	8.506E+00	9.252E+01	1.010E+02	
2.00	0.	0.	1.579E+01	7.858E+00	5.678E+01	1.579E+01	6.463E+01	8.043E+01	
3.00	0.	0.	1.768E+01	5.205E+00	2.123E+01	1.768E+01	2.644E+01	4.412E+01	
4.00	0.	0.	1.736E+01	3.241E+00	6.436E+00	1.736E+01	9.677E+00	2.704E+01	
5.00	0.	0.	1.614E+01	2.010E+00	1.696E+00	1.614E+01	3.707E+00	1.985E+01	
6.00	0.	0.	1.454E+01	1.243E+00	3.949E-01	1.454E+01	1.638E+00	1.618E+01	
7.00	0.	0.	1.281E+01	7.590E-01	8.119E-02	1.281E+01	8.402E-01	1.366E+01	
8.00	0.	0.	1.108E+01	4.533E-01	1.459E-02	1.108E+01	4.678E-01	1.155E+01	
9.00	0.	0.	9.388E+00	2.616E-01	2.243E-03	9.388E+00	2.638E-01	9.651E+00	
10.00	0.	0.	7.729E+00	1.439E-01	2.851E-04	7.729E+00	1.442E-01	7.873E+00	
11.00	0.	0.	6.083E+00	7.401E-02	2.825E-05	6.083E+00	7.403E-02	6.157E+00	
12.00	0.	0.	4.408E+00	3.471E-02	1.966E-06	4.408E+00	3.471E-02	4.442E+00	
13.00	0.	0.	2.647E+00	1.407E-02	7.680E-08	2.647E+00	1.407E-02	2.661E+00	
14.00	0.	0.	7.266E-01	3.087E-03	8.253E-10	7.266E-01	3.087E-03	7.297E-01	
OSUMS	0.	0.	1.449E+02	2.894E+01	1.715E+02				

ANGULAR DISTRIBUTIONS Z= 0 N= 1
 ENERGY PARAM. = EPS+B.E.
 CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
1.00	1.01E+01	9.98E+00	9.75E+00	9.40E+00	8.96E+00	8.50E+00	8.07E+00	7.70E+00	7.43E+00	7.29E+00
2.00	8.63E+00	8.55E+00	8.33E+00	7.99E+00	7.56E+00	7.11E+00	6.66E+00	6.27E+00	5.97E+00	5.77E+00
3.00	5.35E+00	5.29E+00	5.13E+00	4.89E+00	4.58E+00	4.24E+00	3.91E+00	3.60E+00	3.34E+00	3.14E+00
4.00	3.75E+00	3.70E+00	3.58E+00	3.38E+00	3.14E+00	2.86E+00	2.59E+00	2.33E+00	2.10E+00	1.91E+00
5.00	3.02E+00	2.99E+00	2.88E+00	2.70E+00	2.49E+00	2.25E+00	2.01E+00	1.78E+00	1.57E+00	1.40E+00
6.00	2.61E+00	2.57E+00	2.47E+00	2.32E+00	2.13E+00	1.91E+00	1.69E+00	1.48E+00	1.29E+00	1.13E+00
7.00	2.29E+00	2.25E+00	2.16E+00	2.02E+00	1.85E+00	1.65E+00	1.45E+00	1.26E+00	1.09E+00	9.45E-01
8.00	1.99E+00	1.96E+00	1.88E+00	1.76E+00	1.60E+00	1.42E+00	1.25E+00	1.08E+00	9.24E-01	7.93E-01
9.00	1.71E+00	1.69E+00	1.61E+00	1.50E+00	1.36E+00	1.21E+00	1.05E+00	9.04E-01	7.71E-01	6.56E-01
10.00	1.43E+00	1.41E+00	1.35E+00	1.25E+00	1.13E+00	9.99E-01	8.66E-01	7.40E-01	6.27E-01	5.30E-01
11.00	1.15E+00	1.13E+00	1.08E+00	9.99E-01	9.00E-01	7.92E-01	6.83E-01	5.80E-01	4.89E-01	4.11E-01
12.00	8.50E-01	8.36E-01	7.97E-01	7.36E-01	6.61E-01	5.79E-01	4.96E-01	4.19E-01	3.51E-01	2.93E-01
13.00	5.22E-01	5.13E-01	4.88E-01	4.50E-01	4.02E-01	3.51E-01	2.99E-01	2.52E-01	2.09E-01	1.73E-01
14.00	1.46E-01	1.44E-01	1.37E-01	1.26E-01	1.12E-01	9.73E-02	8.26E-02	6.90E-02	5.70E-02	4.70E-02
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
1.00	7.28E+00	7.40E+00	7.62E+00	7.92E+00	8.25E+00	8.58E+00	8.85E+00	9.02E+00	9.09E+00	1.01E+02
2.00	5.68E+00	5.70E+00	5.81E+00	5.98E+00	6.19E+00	6.41E+00	6.59E+00	6.71E+00	6.76E+00	8.04E+01
3.00	3.01E+00	2.94E+00	2.92E+00	2.94E+00	3.00E+00	3.06E+00	3.12E+00	3.16E+00	3.18E+00	4.41E+01
4.00	1.77E+00	1.66E+00	1.59E+00	1.55E+00	1.53E+00	1.52E+00	1.53E+00	1.53E+00	1.53E+00	2.70E+01
5.00	1.25E+00	1.14E+00	1.05E+00	9.90E-01	9.48E-01	9.21E-01	9.05E-01	8.97E-01	8.95E-01	1.98E+01
6.00	9.93E-01	8.84E-01	8.00E-01	7.37E-01	6.91E-01	6.58E-01	6.38E-01	6.26E-01	6.22E-01	1.62E+01
7.00	8.22E-01	7.23E-01	6.45E-01	5.86E-01	5.42E-01	5.10E-01	4.89E-01	4.78E-01	4.74E-01	1.37E+01
8.00	6.83E-01	5.95E-01	5.26E-01	4.73E-01	4.33E-01	4.04E-01	3.85E-01	3.74E-01	3.71E-01	1.16E+01
9.00	5.62E-01	4.85E-01	4.25E-01	3.79E-01	3.44E-01	3.19E-01	3.02E-01	2.93E-01	2.90E-01	9.65E+00
10.00	4.50E-01	3.86E-01	3.36E-01	2.97E-01	2.68E-01	2.47E-01	2.33E-01	2.24E-01	2.22E-01	7.87E+00
11.00	3.46E-01	2.95E-01	2.54E-01	2.23E-01	2.00E-01	1.83E-01	1.72E-01	1.65E-01	1.63E-01	6.16E+00
12.00	2.45E-01	2.07E-01	1.78E-01	1.55E-01	1.38E-01	1.26E-01	1.17E-01	1.13E-01	1.11E-01	4.44E+00
13.00	1.44E-01	1.21E-01	1.03E-01	8.95E-02	7.92E-02	7.18E-02	6.67E-02	6.38E-02	6.29E-02	2.66E+00
14.00	3.89E-02	3.24E-02	2.74E-02	2.36E-02	2.08E-02	1.88E-02	1.74E-02	1.66E-02	1.63E-02	7.30E-01

1PARTICLE SPECTRA Z= 1. N= 0
 FIRST EMISSION AT P= 2
 TARGET Z= 92. N=143 PRDJ Z= 1. N= 0
 PO= 2. HO= 1. G=16.620. E=20.040
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 743.2
 SCALE FACTOR= 1.350. FRAC PREEQ= 0.255
 MSD POSSIBLE= 0.874. USEQ= 0.214
 CLOSED FORM SUM STARTS AT P= 2

		DIRECT		PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
EPS		NUTRA	KNOCK	MSD	MSC	WEISS	MSD	MSC	MSD+MSC	
9.00	0.		1.570E-03	1.182E-01	3.811E-03	9.428E-05	1.197E-01	3.905E-03	1.237E-01	
10.00	0.		7.964E-03	5.501E-01	1.206E-02	7.402E-05	5.581E-01	1.214E-02	5.702E-01	
11.00	0.		1.586E-02	1.024E+00	1.513E-02	1.967E-05	1.039E+00	1.515E-02	1.055E+00	
12.00	0.		2.300E-02	1.410E+00	1.399E-02	3.136E-06	1.433E+00	1.399E-02	1.447E+00	
13.00	0.		2.632E-02	1.562E+00	1.055E-02	3.026E-07	1.588E+00	1.055E-02	1.599E+00	
14.00	0.		2.200E-02	1.295E+00	6.371E-03	1.443E-08	1.317E+00	6.371E-03	1.323E+00	
15.00	0.		0.	3.628E-01	1.529E-03	1.443E-10	3.628E-01	1.529E-03	3.643E-01	
OSUMS	0.		9.671E-02	6.322E+00	6.345E-02	1.914E-04				

ANGULAR DISTRIBUTIONS Z= 1 N= 0
 ENERGY PARAM. = EPS+B.E.
 CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
9.00	2.15E-02	2.12E-02	2.03E-02	1.89E-02	1.72E-02	1.53E-02	1.34E-02	1.15E-02	9.90E-03	8.48E-03
10.00	1.02E-01	1.00E-01	9.58E-02	8.91E-02	8.08E-02	7.16E-02	6.23E-02	5.35E-02	4.56E-02	3.87E-02
11.00	1.93E-01	1.90E-01	1.81E-01	1.68E-01	1.52E-01	1.34E-01	1.16E-01	9.92E-02	8.40E-02	7.10E-02
12.00	2.71E-01	2.67E-01	2.54E-01	2.36E-01	2.12E-01	1.87E-01	1.61E-01	1.36E-01	1.15E-01	9.64E-02
13.00	3.07E-01	3.02E-01	2.87E-01	2.65E-01	2.38E-01	2.09E-01	1.79E-01	1.51E-01	1.26E-01	1.05E-01
14.00	2.60E-01	2.56E-01	2.43E-01	2.24E-01	2.00E-01	1.75E-01	1.49E-01	1.25E-01	1.04E-01	8.62E-02
15.00	7.33E-02	7.21E-02	6.84E-02	6.29E-02	5.61E-02	4.87E-02	4.13E-02	3.45E-02	2.85E-02	2.34E-02
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
9.00	7.29E-03	6.34E-03	5.58E-03	5.00E-03	4.56E-03	4.25E-03	4.04E-03	3.91E-03	3.87E-03	1.24E-01
10.00	3.31E-02	2.85E-02	2.49E-02	2.22E-02	2.01E-02	1.86E-02	1.76E-02	1.70E-02	1.68E-02	5.70E-01
11.00	6.02E-02	5.15E-02	4.47E-02	3.95E-02	3.55E-02	3.27E-02	3.07E-02	2.96E-02	2.92E-02	1.05E+00
12.00	8.12E-02	6.90E-02	5.95E-02	5.22E-02	4.67E-02	4.27E-02	4.00E-02	3.84E-02	3.79E-02	1.45E+00
13.00	8.82E-02	7.45E-02	6.38E-02	5.56E-02	4.94E-02	4.50E-02	4.19E-02	4.02E-02	3.96E-02	1.60E+00
14.00	7.17E-02	6.01E-02	5.12E-02	4.43E-02	3.92E-02	3.55E-02	3.30E-02	3.15E-02	3.11E-02	1.32E+00
15.00	1.94E-02	1.61E-02	1.37E-02	1.18E-02	1.04E-02	9.33E-03	8.64E-03	8.24E-03	8.11E-03	3.64E-01

1PARTICLE SPECTRA Z= 2, N= 2
 FIRST EMISSION AT P= 4
 TARGET Z= 92, N=143 PROJ Z= 1, N= 0
 PO= 2, HO= 1, G=16.620, E=20.040
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION = 743.2
 SCALE FACTOR= 1.350, FRAC PREEQ= 0.255
 MSD POSSIBLE= 0.874, USED= 0.214
 CLOSED FORM SUM STARTS AT P= 4

- EPS --	DIRECT		PREEQUILIBRIUM		EQUIL		TOTAL (MB/MEV)		
	-- NUTRA	KNOCK --	MSD	MSC	-- WEISS --	MSD	MSC	MSD+MSC	
21.00	5.665E-02	8.147E-02	1.319E-04	6.297E-05	2.667E-05	1.383E-01	8.964E-05	1.383E-01	
22.00	8.886E-02	1.555E-01	1.570E-04	5.829E-05	6.133E-06	2.445E-01	6.442E-05	2.446E-01	
23.00	7.333E-02	1.553E-01	1.055E-04	3.221E-05	6.527E-07	2.287E-01	3.286E-05	2.288E-01	
24.00	2.867E-02	0.	3.577E-05	9.743E-06	3.202E-08	2.870E-02	9.775E-06	2.871E-02	
OSUMS	2.475E-01	3.923E-01	4.302E-04	1.632E-04	3.348E-05				
-FISS.	0.	0.	0.	0.	3.543E+02				

1 ANGULAR DISTRIBUTIONS Z= 2 N= 2

ENERGY PARAM. = EPS+B.E.

CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
21.00	2.54E-02	2.50E-02	2.39E-02	2.22E-02	2.00E-02	1.77E-02	1.53E-02	1.31E-02	1.10E-02	9.31E-03
22.00	4.60E-02	4.52E-02	4.32E-02	3.99E-02	3.60E-02	3.16E-02	2.72E-02	2.31E-02	1.94E-02	1.63E-02
23.00	4.40E-02	4.33E-02	4.12E-02	3.81E-02	3.42E-02	2.99E-02	2.56E-02	2.16E-02	1.81E-02	1.51E-02
24.00	5.65E-03	5.55E-03	5.28E-03	4.87E-03	4.36E-03	3.80E-03	3.24E-03	2.72E-03	2.26E-03	1.87E-03
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
21.00	7.88E-03	6.72E-03	5.81E-03	5.10E-03	4.56E-03	4.17E-03	3.90E-03	3.74E-03	3.69E-03	1.38E-01
22.00	1.37E-02	1.16E-02	9.99E-03	8.72E-03	7.77E-03	7.07E-03	6.60E-03	6.32E-03	6.23E-03	2.45E-01
23.00	1.26E-02	1.06E-02	9.08E-03	7.89E-03	6.99E-03	6.34E-03	5.89E-03	5.64E-03	5.55E-03	2.29E-01
24.00	1.55E-03	1.30E-03	1.11E-03	9.56E-04	8.44E-04	7.62E-04	7.07E-04	6.74E-04	6.64E-04	2.87E-02

APPENDIX D

NEW FEATURES IN PRECO-D2

1. Pairing energies are read in separately for the preequilibrium and equilibrium phases of the reaction. (No pairing energies were read in in PRECO-D.)

2. Different effective well depths for states with $h=1$ and $h=2$ may be read in. (The well depth was always 38 MeV in PRECO-D.)

3. Default values are supplied for p_0 , h_0 , g_0 , and K .

4. The composite nucleus-formation cross section and the inverse-reaction cross sections may be generated internally using a parametric approximation to the optical-model cross sections. See Section VI.7 for the optical potentials which are approximated.

5. For nucleon transfer reactions, the residual configurations in which transfer produces passive particles and/or holes are not explicitly considered, because they are already counted in the general-state density formula.

6. For knockout and inelastic-scattering reactions involving cluster degrees of freedom, the single-cluster-state densities have been reduced. In PRECO-D they were derived by considering the number of ways in which the constituent nucleons could be put into correlated single-nucleon states. The desired quantity is, instead, given as $[\# \text{ cluster states}]/[\text{MeV carried by cluster}]$, which adds

a factor of $1/A_{\text{cluster}}$. In addition, the quantity of interest is really the number of clusters that can be accommodated per MeV of cluster energy, not the number of ways of putting the constituent nucleons in a given cluster into the correlated single-nucleon states. This adds a factor of 1/2 for deuterons, tritons and ${}^3\text{He}$ ions. See Section II.2 for the current single-cluster-state densities.

7. The closed-form reaction equations have been corrected to guarantee conservation of strength.

8. Either ϵ or $\epsilon + B_b$ may be used as the energy parameter for calculating angular distributions. (In PRECO-D the energy parameter was always taken to be ϵ .)

9. Either $Q_b(p)$ or $Q_b^{(G)}(p)$ may be used for handling proton/neutron distinguishability in calculating particle emission rates. (In PRECO-D only $Q_b(p)$ was available.)

10. For each particle spectrum, output for a given ϵ is suppressed if all of the component cross sections are zero.

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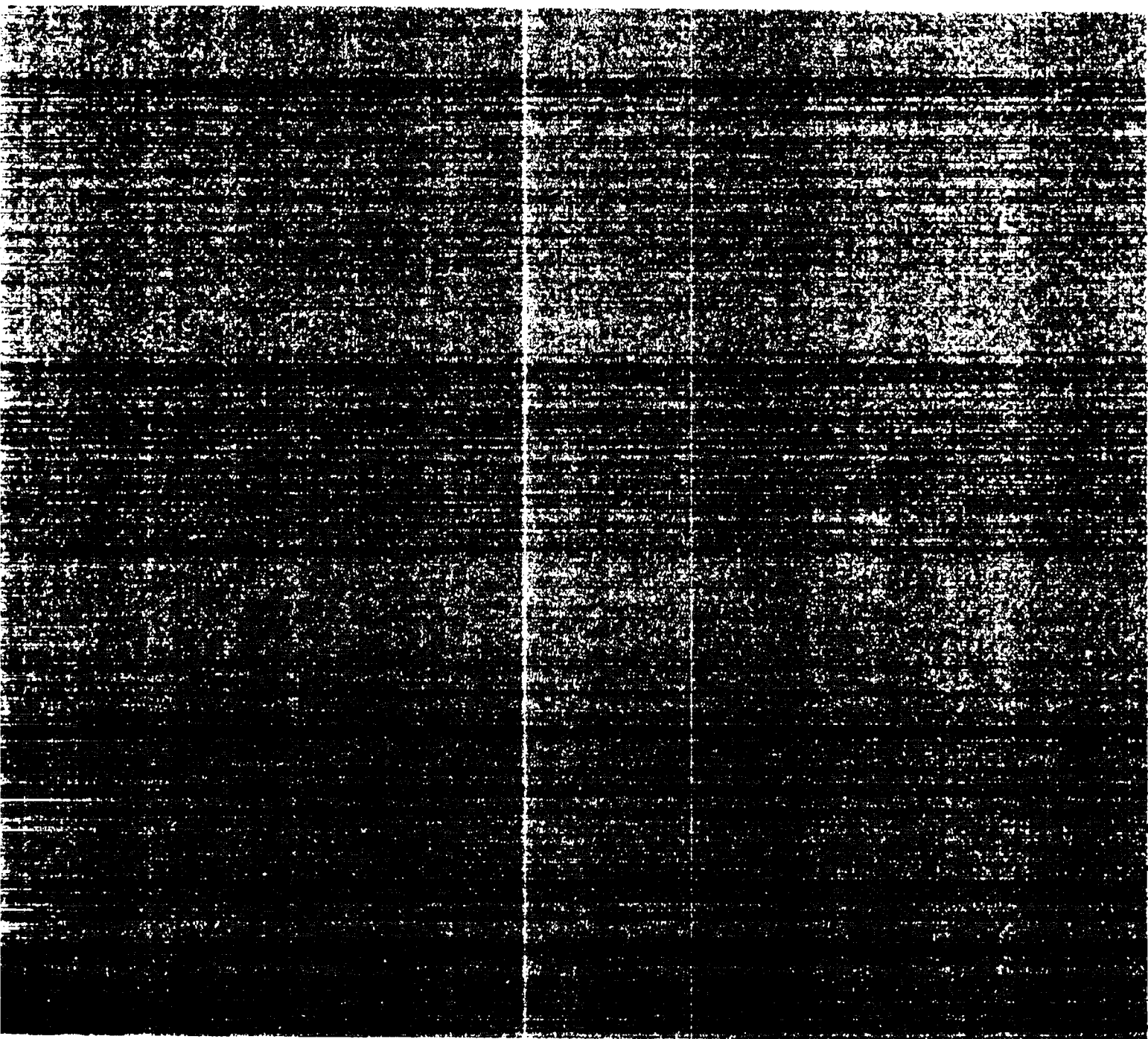
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