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

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

by

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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_o,h_o), and the difference p-h is assumed to remain constant so that $p-h = p_o-h_o$. 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_o.

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

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

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

$$E_{Pauli}(p,h) = p_m^2/g_o\ , \tag{3}$$

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

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

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

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)

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

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

In the MSD/MSC 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

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

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

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

The density of unbound states is written as

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

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:

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

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]

$$M^2(p) \begin{cases} = \dfrac{k}{A^3}\dfrac{n}{E}\left(\dfrac{E/n}{7\ \text{MeV}}\dfrac{E/n}{2\ \text{MeV}}\right)^{1/2} & \text{for} \quad E/n < 2\ \text{MeV}\,, \\ = \dfrac{k}{A^3}\dfrac{n}{E}\left(\dfrac{E/n}{7\ \text{MeV}}\right)^{1/2} & \text{for } 2\ \text{MeV} \le E/n < 7\ \text{MeV}\,, \\ = \dfrac{k}{A^3}\dfrac{n}{E} & \text{for } 7\ \text{MeV} \le E/n \le 15\ \text{MeV}, \\ = \dfrac{k}{A^3}\dfrac{n}{E}\left(\dfrac{15\ \text{MeV}}{E/n}\right)^{1/2} & \text{for } 15\ \text{MeV} < E/n\,, \end{cases} \tag{16}$$

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

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

as well as the correction functions

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

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

and the effective single-particle-state densities

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

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

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

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

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

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

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

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

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

$$\omega_+^{(uu)}(p,h,E) = \frac{g_a(p+1)\ g_u^2(p+1)\ X_1^{n+1}(p+1)\left[\frac{1}{n}f_+(p+1)+\frac{n-1}{n}f(p+1)\right]}{2n\ X_1^{n-1}(p)} + \frac{m(p)}{1-m(p)}\ \omega_+^{(ub)}(p,h,E) \ , \tag{25}$$

$$\omega_+^{(ub)}(p,h,E) = \frac{1-m(p)}{2n(n+1)}\Big\{g^3(p+1)\ f(p+1) \left[\frac{n^2}{2}[X_0(p+1)-X_1(p)]^2 + \frac{n}{2}[X_0^2(p+1)-X_1^2(p)] + X_0(p+1)\ X_1(p)\right] - 2g_p(p+1)\ g_u^2(p+1)\ f_+(p+1)\ \frac{X_1^{n+1}(p+1)}{X_1^{n-1}(p)}\Big\} , \tag{26}$$

$$\omega_+^{(bu)}(p,h,E) = \frac{g_p(p+1)}{X_0^{n-1}(p)\ f(p)}\frac{g_u^2(p+1)\ h}{-pX_1^{n-1}(p)\ f_1(p)} \left\{\frac{X_1^{n+1}(p+1)\ -\ pX_2^{n+1}(p+1)}{2n\ (n+1)} - \frac{1}{4n\ (n+1)} \left[G_1^{n-1}[n(n-1)G_1^2\ -\ 2(n+1)(n-1)G_1X_1(p+1)\ +\ n(n+1)X_1^2(p+1)] - pG_2^{n-1}[n(n-1)G_2^2\ -\ 2(n+1)(n-1)G_2X_2(p+1)\ +\ n(n+1)X_2^2(p+1)]\right]\right\} , \tag{27}$$

$$\omega_{+}^{(bb)}(p,h,E) = \frac{1}{2n\ (n+1)}\ \frac{1}{X_0^{n-1}(p)\ f(p) - p\ X_1^{n-1}(p)\ f_1(p)}$$

$$\Bigg\{ ng^3(p+1)\ X_0^{n+1}(p+1)\ f(p+1)$$

$$- p(n-1)\ g_u^3(p+1)\ X_1^{n+1}(p+1)\ f_1(p+1)$$

$$- pg^3(p+1)\ X_1^{n-1}(p)\ f_1(p)$$

$$\left\{\frac{n^2}{2}[X_0(p+1)-X_1(p)]^2 + \frac{n}{2}[X_0^2(p+1)-X_1^2(p)] + X_0(p+1)\ X_1(p)\right\}\Bigg\}$$

$$- \omega_{+}^{(bu)}(p,h,E)\ , \tag{28}$$

$$\omega_0^{(ub)}(p,h,E) = \frac{[1-m(p)]g_0^2}{n}\left\{\frac{p+2h-1}{2}\ n[X_0(p) - X_1(p)]\ f(p)\right.$$

$$\left. + (p-1)\ X_1(p)[f(p)-2f_0(p)]\right\}\ , \tag{29}$$

$$\omega_0^{(bu)}(p,h,E) = \frac{g_u(p)\ g_p(p)}{2n}\ \frac{1}{X_0^{n-1}(p)\ f(p) - pX_1^{n-1}(p)\ f_1(p)}$$

$$\Big\{ (p+2h-1)\{2X_1^n(p) + n[X_0(p)-X_1(p)]X_1^{n-1}(p)\}\ f(p)$$

$$- (p-1)(p+2h-1)\{2X_2^n(p) + n[X_1(p)-X_2(p)]X_2^{n-1}(p)\}\ f_1(p)$$

$$- 4(n-1)\ X_1^n(p)\ f_1(p) + 4(p-1)(n-2)\ X_2^n(p)\ f_2(p)\ \Big)\ . \tag{30}$$

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

$$\omega_{-}^{(bu)}(p,h,E) = \frac{g_p(p-1)\ hp(p-1)}{4} \frac{1}{X_0^{n-1}(p)\ f(p) - pX_1^{n-1}(p)\ f_1(p)}$$

$$\{X_1^{n-3}(p-1)[(n-2)(n-3)X_1^2(p-1)$$

$$- 2(n-1)(n-3)X_1(p-1)\ X_0(p) + (n-1)(n-2)X_0^2(p)]\ f(p)$$

$$- (p-2)X_2^{n-3}(p-1)[(n-2)(n-3)X_2^2(p-1)$$

$$- 2(n-1)(n-3)X_2(p-1)\ X_1(p) + (n-1)(n-2)X_1^2(p)]\ f_1(p)$$

$$- 4[X_1^{n-1}(p)\ f_1(p) - (p-2)X_2^{n-1}(p)\ f_u(p)]\} . \qquad (32)$$

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

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

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

$$Q_b(p)\begin{cases} = \dfrac{(p-A_b)!}{p!}\displaystyle\sum_{i=0}^{p-A_a}\dfrac{(p-A_a)!}{i!\ (p-A_a-i)!}\left(\dfrac{Z_T}{A_T}\right)^{i-Z_b}\left(\dfrac{N_T}{A_T}\right)^{p-A_a-i-N_b} \\ \qquad \dfrac{(Z_a+i)!}{(Z_a+i-Z_b)!}\ \dfrac{(p-Z_a-i)!}{(p-Z_a-i-N_b)!} & \text{for } n\leq\bar{n} \text{ and } n\leq 20 \\ = 1 & \text{for } n>\bar{n} \text{ or } n>20\,. \end{cases} \tag{34}$$

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

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

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

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

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

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

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

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

$$W_f(E) = \frac{1}{2\pi h} \int_0^{E-B_f} \frac{\omega(E-B_f-\varepsilon_f)}{\omega(E)} d\varepsilon_f \quad , \tag{38}$$

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/MSC 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

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

$$P_b(p_o,h_o) = 1 - P_u(p_o,h_o). \tag{39b}$$

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

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

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

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

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

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

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

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

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

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

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

and

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

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

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

with

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

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

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

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

$$\frac{d\sigma}{d\varepsilon}(a,b)_{PRE} = \sigma_a(\varepsilon_a) \sum_{p=p_0}^{\bar{p}} S_u(p)\ T_u(p)\ W_b^{(u)}(p,\varepsilon)\ , \qquad (45a)$$

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

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

where $\sigma_a(\varepsilon_a)$ 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

$$\frac{d\sigma}{d\varepsilon}(a,b)_{EVAP} = [\sigma_a(\varepsilon_a) - \sigma_{PRE}] \frac{W_b(\varepsilon)}{\sum_b \int W_b(\varepsilon)\, d\varepsilon}\ , \qquad (46)$$

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

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

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: $\Delta_{pre}(Z,N)$ is used for states with $h \leq 2$, while the equilibrium pairing correction $\Delta_{eq}(Z,N)$ 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 $n=n_o$ [GR73][GR77]. Likewise, $\Delta_{eq}(Z,N)$ 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 $(E-\Delta_{pre})$ or $(E-\Delta_{eq})$ 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

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

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

$$\omega(p,h,U) \ , \tag{48}$$

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 $\sigma_{b\text{-}NE}(\varepsilon)$ here is the total nonelastic cross section. The two are assumed to be related by

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

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

$$V_a = \frac{50\ \text{MeV}\ A_a}{4} \ . \tag{50}$$

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 ^{3}He), 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 $g_\pi = g_o(Z/A)$ and $g_\nu = g_o(N/A)$ 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

$$\frac{d\sigma}{d\varepsilon}(a,b)_{KO} = \frac{\sigma_{a\text{-}NE}}{13.5}(2s_b+1)\ A_b\ \varepsilon\ \sigma_{b\text{-}NE}(\varepsilon)$$

$$\frac{P_b\ g_a\ g_b[U-A(A_a,A_b)]}{\sum_{c=a,b}(2s_c+1)\ A_c\ \bar{\sigma}_c\ (\varepsilon_m+2B_c)(\varepsilon_m-B_c)^2\ (g_a\ g_b^2/6g_c)} \qquad (51)$$

$$\frac{d\sigma}{d\varepsilon}(a,a')_{INEL} = \frac{\sigma_{a\text{-}NE}}{13.5}(2s_a+1)\ A_a\ \varepsilon\ \sigma_{a\text{-}NE}(\varepsilon)$$

$$\sum_{i=n,p,\alpha}\frac{P_i\ g_i^2[U-A(A_i,A_i)]}{\sum_{c=i,a}(2s_c+1)\ A_c\ \bar{\sigma}_c\ (\varepsilon_m+2B_c)(\varepsilon_m-B_c)^2\ (g_a\ g_i^2/6g_c)}$$

for a = complex , (52a)

$$\frac{d\sigma}{d\varepsilon}(a,a')_{INEL} = \frac{\sigma_{a\text{-}NE}}{13.5}(2s_a+1)\ A_a\ \varepsilon\ \sigma_{a\text{-}NE}(\varepsilon)$$

$$\frac{P_\alpha\ g_\alpha\ [U-A(4,4)]}{\sum_{c=a,\alpha}(2s_c+1)\ A_c\ \bar{\sigma}_c\ (\varepsilon_m+2B_c)(\varepsilon_m-B_c)^2\ (g_a\ g_\alpha^2/6g_c)}$$

for a = nucleon , (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

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

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

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

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

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

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

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

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

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

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

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

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]

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

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

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

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

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

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

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

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

IV. ISOSPIN

For reactions induced by protons or ^{3}He 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

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

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

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

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

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

$$\omega(p,h,E,T_<) = \omega(p,h,E) , \tag{62a}$$

$$\omega(p,h,E,T_>) = \omega(p,h,E-E_{sym}(Z,A) \tag{62b}$$

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

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

at high energies, where R_b is the radius of the particle (0 for b=n,p; 0.8F for b=d,t,τ; and 1.2F for b=α). 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_o,h_o), and the state density, $\omega(p,h,E)$. The difference p-h is assumed to remain constant at p_o-h_o. 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 $(p_o,h_o) = (A_a+1,1)$, 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_o and h_o (2I3). If these are read in as zero, p_o defaults to A_a+1 and h_o defaults to unity.

10) Single-particle-state densities, g_o, 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_o is proportional to A. If g_o for the composite nucleus is read in as zero, it defaults to A/(13 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 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 ($h \leq 2$) 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 $\sigma_{n\text{-}NE}(\varepsilon)$ 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	$E-E_{sym}(Z,A)$
B_n	B_n	$\begin{cases}0\\B_n-E_{sym}(Z,A)+E_{sym}(Z-1,A)\end{cases}$
B_p	B_p	$B_p-E_{sym}(Z,A)$
B_α	B_α	0
σ_{a-NE}	$\sigma_{a-NE}[2T_o/(2T_o+1)]$	$\sigma_{a-NE}[1/(2T_o+1)]$
$\sigma_{n-NE}(\varepsilon)$	$\sigma_{n-NE}(\varepsilon)$	$\begin{cases}0\\\sigma_{n-NE}(\varepsilon)[2T_o/(2T_o+1)]\end{cases}$
$\sigma_{p-NE}(\varepsilon)$	$\sigma_{p-NE}(\varepsilon)[2T_o/(2T_o+1)]$	$\sigma_{p-NE}(\varepsilon)[1/(2T_o+1)]$
$\sigma_{\alpha-NE}(\varepsilon)$	$\sigma_{\alpha-NE}(\varepsilon)$	0
k	k	$k[E-E_{sym}(Z,A)]/E$

VI.7 Suggested Input

Appropriate values for the various input quantities are summarized below

(p_o,h_o)	$(A_a+1,1)$, where A_a is the mass number of the projectile (the default values).
$T_>$	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

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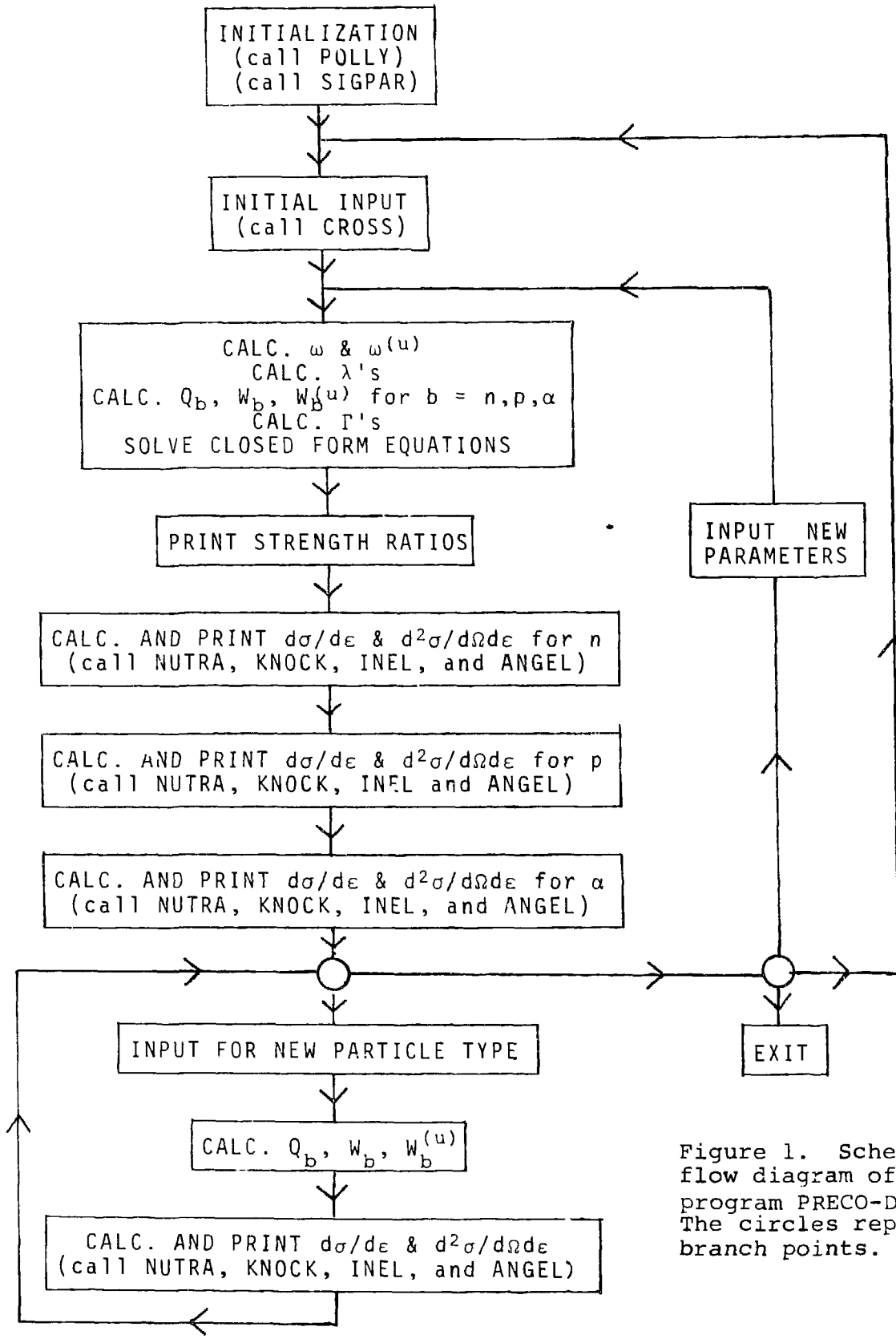

Figure 1. Schematic flow diagram of the program PRECO-D2. The circles represent branch points.

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)	Θ(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, Δt=TAUWM
FWD(NH)	Correction factor, f(p), applied to $\omega(p,h,E)$ for $h\leq 2$ 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 $h\leq 2$
GFPU,GFHU	$g_p(p)$ for h>2 and g_h for all h
GAMBB,GAMBU GAMUB,GAMUU	$\Gamma_+^{(bb)}(p)$, $\Gamma_+^{(bu)}(p)$, $\Gamma_+^{(ub)}(p)$, and $\Gamma_+^{(uu)}(p)$
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 $\varepsilon+$(IANG)(B_b)
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_o and h_o
NPHD,PHD	$p-h=p_o-h_o$
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,α 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	$g_o E$
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)	$W_b^{(u)}(p,h,\varepsilon)$ 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
A0MSC,A0MAD	TOMSC and TOMSD from MAIN, each divided by 4π; = a_o(MSC) and a_o(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 MODEL 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 D OR 3HE INCIDENT
16 C      (NO DIRECT RXN CALC FOR HEAVIER PROJECTILES)
17 C      (NO APPROX RXN CROSS SECTIONS FOR AOUT.GT.4)
18 C
19 C      PRAISE THE LORD
20 C
21         COMMON ESUM(4),RHO(31),RHOU(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,CLDSD(31),CLOSU(31),EMU(3),FWD(3),FWDU(32),DBL(31),FWDHI(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),TOMSD(51),TOMSC(51),IWRI,IANG
27         COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNOUT,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,BPRO,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=(PRECOUT,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      DO 2 NP=1,31
42         GEL(NP)=0.
43         GELU(NP)=0.
44         GELUU(NP)=0.
45         RHO(NP)=0.
46         RHOU(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         DO 4 KP=1,4
59         DO 4 NP=1,50
60  4      PROB(KP,NP)=0
61         DO 8 KP=1,4
62         DO 8 NE=1,51
63         SIGIN(KP,NE)=0.
64  8      WEISS(KP,NE)=0.
65         DO 11 I=1,19
66         DO 11 J=1,7
67  11     POL(I,J)=0.
68 C
69 C       GENERATE TABLE OF LEGENDRE POLYNOMIALS
70         CALL POLLY
```

```
      GENERATE PARAMETERS FOR APPROX SIGMA INVERSE
      CALL SIGPAR
C
C     INPUT
C
      READ(IREA,3)E,BEA
3     FORMAT(5F10.2)
      READ(IREA,3)RZZ,RNN
      RN=RNN,'(RNN+RZZ)
      RZ=1.-RN
5     FORMAT(3I3)
      READ(IREA,3)BNEU,BPRO,BALFA,BF
      READ(IREA,3)PAIRN,PAIRP,PAIRA,PAIRC
      READ(IREA,3)EPAIRN,EPAIRP,EPAIRA,EPAIRC
      READ(IREA,3)SIGCN,SIGBAR(5)
6     READ(IREA,13)NEPS(1),EPS(1,2),DELTA(1)
13    FORMAT(1I3,2F10.2)
      IF(NEPS(1).LE.50)GO TO 12
      WRITE(IWRI,10)
10    FORMAT(18H-TOO MANY ENERGIES)
      GO TO 1000
12    IF(NEPS(1).LE.0)NEPS(1)=1
      NEPS1=NEPS(1)+1
      IF(EPS(1,2).GT.0.)GO TO 9
      DELTA(1)=-1.
      DO 7 NE=2,NEPS1
      READ(IREA,3)EPS(1,NE),SIGIN(1,NE),SIGIN(2,NE),SIGIN(3,NE)
7     CONTINUE
9     READ(IREA,5)JPIN,JNIN
      JIN=JPIN+JNIN
      XIN=JIN
      ACOM=RNN+RZZ+XIN
      IF(DELTA(1).LT.0.)GO TO 17
      IF(DELTA(1).LE.0.)DELTA(1)=1.
      DO 15 NE=3,NEPS1
      DEL=NE-2
15    EPS(1,NE)=EPS(1,2)+DEL*DELTA(1)
      JHALF=1
      JNOUT=1
      JPOUT=0
      KP=1
      CALL CROSS
      JNOUT=0
      JPOUT=1
      KP=2
      CALL CROSS
      JNOUT=2
      JPOUT=2
      KP=3
      CALL CROSS
17    EPS(1,1)=EPS(1,2)-1.
      IF(EPS(1,1).LT.0.)EPS(1,1)=0.
      EPS(1,NEPS1+1)=EPS(1,NEPS1)+1.
      ATHRD=(ACOM-1.)**0.33
      COUL(1)=0.
      XPIN=JPIN
      COUL(2)=0.75*(RZZ+XPIN-1.)/ATHRD
      ATHRD=(ACOM-4.)**0.33
      COUL(3)=1.50*(RZZ+XPIN-2.)/ATHRD
      ATHRD=(RZZ+RNN)**0.33
      COUL(5)=0.75*XPIN*RZZ/ATHRD
      DO 14 KP=1,3
      ESUM(KP)=0.
14    SIGBAR(KP)=0.
      EMU(1)=E-BNEU
      EMU(2)=E-BPRO
      EMU(3)=E-BALFA
      DO 18 KP=1,3
      DO 16 NE=2,NEPS1
      IF(EPS(1,NE).LT.COUL(KP))GO TO 16
      IF(EPS(1,NE).GT.EMU(KP))GO TO 18
      EINT=(EPS(1,NE+1)-EPS(1,NE-1))/2.
      ESUM(KP)=ESUM(KP)+EINT
      SIGBAR(KP)=SIGBAR(KP)+SIGIN(KP,NE)*EINT
16    CONTINUE
18    IF(ESUM(KP).GT.0.)SIGBAR(KP)=SIGBAR(KP)/ESUM(KP)
      IF(SIGBAR(5).GT.0.)GO TO 27
      IF(JIN.NE.1)GO TO 21
      SIGBAR(5)=SIGBAR(JPIN+1)
```

```
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.0.)SIGBAR(5)=SIGBAR(5)/ESUM(4)
172         NEPS1=NEPS(1)+1
173         JHALF=1
174  27     IF(SIGCN.GT.0.)GO TO 38
175         IF(JPIN.GT.0)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=P0(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.0.)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.0)GO TO 39
218         NPART=JIN+1
219         NHOLE=1
220  39     READ(IREA,3)G,GNEU,GPRO,GALFA,GFIS
221         IF(G.LE.0.)G=ACOM/13.
222         READ(IREA,3)F2
223         IF(F2.LE.0.)F2=1.35
224         SIZE=G*(E-EPAIRC)
225         E=E-PAIRC
226         NPHD=NPART-NHOLE
227         PHD=NPHD
```

```
      FLOW=1.E-18
      SPILL=1.E+18
      V=38.
C
C     EFFECTIVE G VALUES
C
      DO 19 I=1,3
      GF(I)=0
      Y=I-1
      X=NPART-NHOLE+I-1
      IF(X.LT.0.)GO TO 19
      PHNO=X+Y
      IF(PHNO.LE.0.)GO TO 19
      ENEX=E/(PHNO*38.)
      GFP=1.+ENEX
      GFP=SQRT(GFP)
      GFH=1.-ENEX
      IF(GFH.LT.0.)GFH=0.
      GFH=SQRT(GFH)
      GF(I)=G*(X*GFP+Y*GFH)/PHNO
19    CONTINUE
      COULP=BPRO+COUL(2)
      COULA=BALFA+COUL(3)
      S=AMIN1(BNEU,COULP,COULA)
      IF(S.LT.0.)S=0.
      GFPU=(38.+S)/38.
      GFPU=SQRT(GFPU)*G
      GFHU=(38.-S)/38.
      IF(GFHU.LT.0.)GFHU=0.
      GFHU=SQRT(GFHU)*G
      DO 24 I=1,3
      XX=1.
      GU(I)=G
      GFU(I)=G
      GFAV(I)=G
      Y=I-1
      X=NPART-NHOLE+I-1
      IF(X.LT.0.)GO TO 24
      PHNO=X+Y
      IF(PHNO.LE.0.)GO TO 24
      PHNO1=PHNO-1.
      ENEX=(E-S)/(PHNO*38.)
      GFP=SQRT(1.+ENEX)
      GFH=1.-ENEX
      IF(GFH.LT.0.)GFH=0.
      GFH=SQRT(GFH)
      Z=1.+ENEX+S/38.
      GU(I)=G*SQRT(Z)
      IF(PHNO1.LE.0.)GO TO 20
      GFU(I)=G*((X-1.)*GFP+Y*GFH)/PHNO1
20    IF(PHNO.GT.2.)GFAV(I)=((PHNO-3.)*GFU(I)+GU(I))/(PHNO-2.)
C
C     FWD CORRECTION FOR FULL STATE DENSITY
C
      V=EHOLE(I)
      IF(E.LE.V)GO TO 24
      IF(I.EQ.1)GO TO 24
      X=E**PHNO1
      EV=(E-V)**PHNO1
      XX=1.-Y*EV/X
      EV2=E-V-V
      IF(EV2.LE.0.)GO TO 24
      EV2=EV2**PHNO1
      XX=XX+Y*(Y-1.)*0.5*EV2/X
      IF(XX.LT.0.)XX=0.
24    FWD(I)=XX
      E=E+PAIRC-EPAIRC
C
C     UNBOUND STATE CORRECTION FUNCTION
C     AND MULTIPLE UNBOUND CORRECTION, M(P)
C
      X=E-S
      DO 26 I=1,10
26    ES(I)=0.
      DO 28 I=1,10
      IF(X.LE.0.)GO TO 30
      XI=I
      Y=(E-XI*S)/X
      IF(Y.LE.0.)GO TO 30
```

```
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         DBL(NP1)=0.
316         FWDHI(NP1)=0.
317         P=NP
318         NH=NP-NPHD
319         H=NH
320         IF(H.LT.0.)GO TO 36
321         PH1=P+H-1.
322         FT=ES(1)
323         IF(PH1.LE.0.)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.0.)X=0.
338         IF(X.GT.0.)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-EHOLE(NH+1))/Y
343         IF(X.LT.0.)X=0.
344         IF(X.GT.0.)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.0.)X=0.
350         IF(X.GT.0.)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.0.)FT2=FT2/FT
369         DBL(NP1)=FT2
370         X=1.
371         IF(ES(2).GT.0.)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
```

```
      FWDU(1)=1.
      DBL(1)=0.
      FWDHI(1)=1.
      FWDU(32)=1.
      FWDHI(32)=1.
C
C     CALCULATE G*E FACTORS
C
      POUR=1.E+35
      IF(NPHD)54,55,56
54    NDWN=0
      GO TO 58
55    NDWN=1
      GO TO 58
56    NDWN=NPHD
58    NHDWN=NDWN-NPHD
      NDWN1=NDWN+1
      DO 60 NP1=NDWN1,32
      NP=NP1-1
      P=NP
      NH=NP-NPHD
      H=NH
      Q=AMAX1(P,H)
      X=SIZE-Q*Q
      IF(X.LT.0.)GO TO 62
      IF(NH.LE.2)X=GF(NH+1)*(E-PAIRC)-Q*Q
      GEL(NP1)=X+(P*(P+1.)+H*(H+1.))/4.
      IF(NP.GT.31)GO TO 60
      GELU(NP1)=0.
      GELUU(NP1)=0.
      IF(P.LE.0.)GO TO 60
      IF(E.LE.S)GO TO 60
      P=P-1.
      Q2=Q*Q-Q+0.5
      X=SIZE-Q2-G*S
      IF(NH.LE.2)X=G*(E-PAIRC)-Q2-G*S
      IF(X.LT.0.)GO TO 60
      GELU(NP1)=X+(P*(P+1.)+H*(H+1.))/4.
      IF(P.LE.0.)GO TO 60
      P=P-1.
      Q2=Q*Q-2.*Q+2.
      X=SIZE-Q2-2.*G*S
      IF(NH.LE.2)X=G*(E-PAIRC)-Q2-2.*G*S
      IF(X.LT.0.)GO TO 60
      GELUU(NP1)=X+(P*(P+1.)+H*(H+1.))/4.
60    CONTINUE
62    NUP=NP-1
C
C     CALCULATE STATE DENSITIES
C
      FAC=0.
      PH=NDWN+NHDWN
      IF(NDWN.EQ.0)GO TO 61
      DO 64 NP=1,NDWN
      Y=NP
64    FAC=FAC+ALOG10(Y)
61    IF(NHDWN.EQ.0)GO TO 63
      DO 65 NP=1,NHDWN
      Y=NP
65    FAC=FAC+ALOG10(Y)
63    LIM=NDWN+NHDWN-1
      IF(LIM.EQ.0)GO TO 67
      DO 66 NP=1,LIM
      Y=NP
66    FAC=FAC+ALOG10(Y)
67    RHOL=GEL(NDWN1)
      RHOL=(PH-1.)*ALOG10(RHOL)
      RHOL=RHOL-FAC
      RHO(NDWN1)=(10.**RHOL)*G
      IF(NDWN.GT.0)GO TO 51
      RHOL=0.
      GO TO 59
51    IF(PH.GT.1.)GO TO 57
      RHOL=0.
      GO TO 53
57    RHOL=GELU(NDWN1)
      IF(NHDWN.LE.2)RHOL=RHOL*GFU(NHDWN+1)/G
      IF(RHOL.EQ.0.)GO TO 59
```

```
463         RHOL=(PH-1.)*ALOG10(RHOL)
464         RHOL=RHOL-FAC
465 53      RHOL=(10.**RHOL)*GFPU
466 59      P=NDWN
467         RHOU(NDWN1)=RHOL*FWDU(NDWN1)*P
468         DO 68 NP=NDWN1,NUP
469         NP1=NP+1
470         P=NP
471         NH=NP-NPHD
472         H=NH
473         FAC=FAC+ALOG10(P)+ALOG10(H)+ALOG10(P+H-1.)+ALOG10(P+H-2.)
474         RHOL=GEL(NP1)
475         RHOL=(P+H-1.)*ALOG10(RHOL)
476         RHOL=RHOL-FAC
477         RHO(NP1)=(10.**RHOL)*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)RHOL=RHOL*GFU(NH+1)/G
482         IF(RHOL.EQ.0.)GO TO 74
483         RHOL=(P+H-1.)*ALOG10(RHOL)
484         RHOL=RHOL-FAC
485         RHOL=(10.**RHOL)*GFPU
486 74      RHOU(NP1)=RHOL*FWDU(NP1)*P
487 68      CONTINUE
488         GO TO 70
489 69      NUP=NP-1
490 70      DO 72 NP=NDWN1,31
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         DO 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         DO 79 NP1=NDWN1,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=0.
515         TLOBU=0.
516         IF(NP.EQ.NDWN)GO TO 76
517         TLOUB=GFHU*H*(H-1.)*(1.-DBL(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         XUU1=GELUU(NP)/G
527         XUU=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*FWDU(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.)*FWDU(NP1)*XUU1**(PH-3.)
538         FWDUU=1.
539         DEN=0.
540         ES2=ES(2)
```

```
      IF(NH.GT.2)GO TO 84
      ES2=E-PAIRC-2.*S
      IF(ES2.LE.0.)ES2=0.
      ES2=ES2/(ES2+S)
84    IF(ES2.GT.0.)DEN=(P-1.)*ES2**(PH-1.)
      IF(DEN.GT.0.)FWDUU=2.*FWDU(NP1)*DBL(NP1)/DEN
      XT=4.*(FWDU(NP1)*XU**(PH-1.)-(P-2.)*FWDUU*XUU**(PH-1.))
      X=XX-X-XT
      IF(X.LT.0.)X=0.
      TLOBU=TLOBU*X/Y
71    IF(RHOU(NP1).GT.RHO(NP1))RHOU(NP1)=RHO(NP1)
      IF(RHOU(NP1).GE.RHO(NP1))TLOBU=0.
C
C     PAIR CREATION
76    CMAT=PH/EE
      EPH=EE/PH
      IF(EPH.LT.7.)CMAT=CMAT*SQRT(EPH/7.)
      IF(EPH.LT.2.)CMAT=CMAT*SQRT(EPH/2.)
      IF(EPH.GT.15.)CMAT=CMAT*SQRT(15./EPH)
      NP2=NP1+1
      X=GEL(NP1)
      IF(NH.LE.2)X=X*G/GF(NH+1)
      XT=X
      Y=GEL(NP2)
      IF(NP.GT.NDWN)GO TO 77
      IF(NH.LE.1)Y=Y*G/GF(NH+2)
      X=(Y/X)**(PH-1.)
      TIMHI      =X*G*GEL(NP2)*GEL(NP2)*CMAT/(2.*(PH+1.))
      IF(NH.LE.1)TIMHI      =TIMHI      *FWD(NH+2)*GF(NH+2)/G
77    Y=GELU(NP2)
      X=0.
      IF(PH.LE.1.)X=1.
      IF(GELU(NP1).GT.0.)X=(Y/GELU(NP1))**(PH-1.)
      FW=1.
      IF(NH.LE.1)FW=FWD(NH+2)
      FW=(FWDHI(NP2)+(PH-1.)*FW)/PH
      THIUU=X*G*Y*Y*FW*CMAT/(2.*PH)
      IF(NH.LE.1)THIUU=THIUU*GFU(NH+2)*GFU(NH+2)*GFAV(NH+2)/(G*G*G)
      X=GEL(NP2)
      XX=GELU(NP1)
      IF(NH.LE.1)X=X*G/GF(NH+2)
      Y=PH*(X-XX)*(X-XX)+X*X-XX*XX
      X=X*XX+0.5*PH*Y
      IF(NH.LE.1)X=X*GF(NH+2)*GF(NH+2)*GF(NH+2)/(G*G*G)
      THIB=X*G
      IF(NH.LE.1)X=X*FWD(NH+2)
      X=G*X*CMAT/(2.*PH*(PH+1.))
      XX=THIUU*GFPU*FWDHI(NP2)/(G*FW)
      IF(NH.LE.1)XX=THIUU*GU(NH+2)*FWDHI(NP2)/(GFAV(NH+2)*FW)
      X=X-2.*XX/(PH+1.)
      IF(RHOU(NP2).GE.RHO(NP2))X=0.
      THIUU=THIUU+X*DBL(NP1)
      THIUB=X*(1.-DBL(NP1))
      TNOUB=0.
      THIBB=0.
      THIBU=0.
      TNOBU=0.
      IF(RHOU(NP1).GE.RHO(NP1))GO TO 75
      TEST=0.
      IF(NP.GT.0)GO TO 85
      TEST=(E-EPAIRC-H*V)/P
      IF(NH.LE.2)TEST=(E-PAIRC-V)/P
85    IF(TEST.GT.5)GO TO 75
      Y=(XT/G)**(PH-1.)
      YY=1.
      YYY=1.
      IF(PH.LE.1.)GO TO 82
      YY=(GELU(NP1)/G)**(PH-1.)
      YYY=(GELUU(NP1)/G)**(PH-1.)
82    Z=GEL(NP2)/G
      IF(NH.LE.1)Z=Z*G/GF(NH+2)
      Z=Z**(PH+1.)
      ZZ=(GELU(NP2)/G)**(PH+1.)
      IF(NH.LE.2)Y=Y*FWD(NH+1)
      XX1=E-EPAIRC-V
      IF(NH.LE.2)XX1=E-PAIRC-V
      IF(XX1.LE.0.)GO TO 78
      XX=PH*(PH-1.)*XX1*XX1-2.*(PH+1.)*(PH-1.)*XX1*GELU(NP2)/G
```

```
      XX=XX+PH*(PH+1.)*GELU(NP2)*GELU(NP2)/(G*G)
      XX=XX1**(PH-1.)*XX
      XX1=XX1-S
      IF(XX1.LT.0.)XX1=0.
      X=PH*(PH-1.)*XX1*XX1-2.*(PH+1.)*(PH-1.)*XX1*GELUU(NP2)/G
      X=X+PH*(PH+1.)*GELUU(NP2)*GELUU(NP2)/(G*G)
      IF(XX1.GT.0.)XX=XX-P*XX1**(PH-1.)*X
   78 X=(GELUU(NP2)/G)**(PH+1.)
      X=(GELU(NP2)/G)**(PH+1.)-P*X-0.5*XX
      X=X*G*G
      Y=Y-P*YY*FWDU(NP1)
      IF(Y.LE.0.)GO TO 75
      THIBU=G*H*X*CMAT/(Y*2.*PH*(PH+1.))
      IF(NH.LE.1)THIBU=THIBU*GFU(NH+2)*GFU(NH+2)*GU(NH+2)/(G*G*G)
      X=PH*Z*G*G*G
      IF(NH.LE.1)X=X*(GF(NH+2)**3.)*FWD(NH+2)/(G*G*G)
      ZZ=P*(PH-1.)*ZZ*G*G*G*FWDU(NP2)
      IF(NH.LE.1)ZZ=ZZ*(GFU(NH+2)**3.)/(G*G*G)
      X=X-ZZ-P*THIB*YY*FWDU(NP1)
      X=X*CMAT/(Y*2.*PH*(PH+1.))
      THIBB=X-THIBU
C
C     SCATTERING
      X=GELU(NP1)
      XT=XT-X
      TNOUB=XT*G*(PH+H-1.)/2.
      IF(NH.LE.2)TNOUB=TNOUB*FWD(NH+1)
      FW=1.-2.*FWDHI(NP1)
      IF(NH.LE.2)FW=FWD(NH+1)-2.*(1.-0.5*ES(2)**(PH-1.))
      TNOUB=TNOUB+(P-1.)*G*GELU(NP1)*FW/PH
      TNOUB=TNOUB*CMAT*(1.-DBL(NP1))
      TNOBU=(PH+H-1.)*YY*(2.*GELU(NP1)+PH*XT)
      IF(NH.LE.2)TNOBU=TNOBU*FWD(NH+1)
      TNOBU=TNOBU-4.*(PH-1.)*YY*GELU(NP1)*FWDU(NP1)
      XT=GELU(NP1)-GELUU(NP1)
      TNOBU=TNOBU-(P-1.)*(PH+H-1.)*YYY*(2.*GELUU(NP1)+PH*XT)*FWDU(NP1)
      FWDUU=1.
      DEN=0.
      ES2=ES(2)
      IF(NH.GT.2)GO TO 86
      ES2=E-PAIRC-2.*S
      IF(ES2.LE.0.)ES2=0.
      ES2=ES2/(ES2+S)
   86 IF(ES2.GT.0.)DEN=(P-1.)*ES2**(PH-1.)
      IF(DEN.GT.0.)FWDUU=2.*FWDU(NP1)*DBL(NP1)/DEN
      TNDBU=TNDBU+4.*(P-1.)*(PH-2.)*YYY*GELUU(NP1)*FWDUU
      TNOBU=TNOBU*P*GFPU*CMAT/(2.*PH*Y)
      IF(NH.LE.2)TNOBU=TNOBU*GU(NH+1)*GFU(NH+1)/(G*GFPU)
C
C     TRANSITION BRANCHING RATIOS  (NUMERATORS)
   75 GAMUU(NP1)=THIUU
      GAMUB(NP1)=THIUB
      GAMZUB(NP1)=TNOUB+TLOUB
      GAMBB(NP1)=THIBB
      GAMBU(NP1)=THIBU
      GAMZBU(NP1)=TNOBU+TLOBU
   79 CONTINUE
C
C     NORMALIZATION
      TAUWM=1./(TIMHI*20.)
      DO 80 NP1=NDWN1,JBAR1
      GAMUU(NP1)=GAMUU(NP1)*TAUWM
      IF(GAMUU(NP1).LT.FLOW)GAMUU(NP1)=0.
      IF(GAMUU(NP1).GT.SPILL)GAMUU(NP1)=0.
      GAMUB(NP1)=GAMUB(NP1)*TAUWM
      IF(GAMUB(NP1).LT.FLOW)GAMUB(NP1)=0.
      IF(GAMUB(NP1).GT.SPILL)GAMUB(NP1)=0.
      GAMZUB(NP1)=GAMZUB(NP1)*TAUWM
      IF(GAMZUB(NP1).LT.FLOW)GAMZUB(NP1)=0.
      IF(GAMZUB(NP1).GT.SPILL)GAMZUB(NP1)=0.
      GAMBU(NP1)=GAMBU(NP1)*TAUWM
      IF(GAMBU(NP1).LT.FLOW)GAMBU(NP1)=0.
      IF(GAMBU(NP1).GT.SPILL)GAMBU(NP1)=0.
      GAMBB(NP1)=GAMBB(NP1)*TAUWM
      IF(GAMBB(NP1).LT.FLOW)GAMBB(NP1)=0.
      IF(GAMBB(NP1).GT.SPILL)GAMBB(NP1)=0.
      GAMZBU(NP1)=GAMZBU(NP1)*TAUWM
      IF(GAMZBU(NP1).LT.FLOW)GAMZBU(NP1)=0.
      IF(GAMZBU(NP1).GT.SPILL)GAMZBU(NP1)=0.
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698 80     CONTINUE
699        ACUBE=ACOM*ACOM*ACOM
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.0.)GFIS=G
706        FISHW=0.
707        IF(BF.EQ.0.)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        DO 134 K=1,NFISH
714        XK1=K-1
715        EX=(E-BF-XK1)*AFISH
716        IF(EX.LE.0.)EX=0.
717        EX=SQRT(EX)
718        EX=2.*(EX-REF)
719        EX=E*EXP(EX)/(E-BF-XK1)
720        IF(EX.LT.FLOW)EX=0.
721        IF(EX.GT.SPILL)EX=0.
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=0
730        JOUT=1
731        JHALF=1
732        NSD=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        NLOE=NAP1
741        JNOUT=0
742        JPOUT=1
743        BEN=BPRO
744        GR=GPRO
745        EPAIR=EPAIRP
746        PAIR=PAIRP
747        GO TO 550
748 152    NLOE=MINO(NLOE,NAP1)
749        JNOUT=2
750        JPOUT=2
751        JOUT=4
752        NSD=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    DO 156 NP1=1,31
762 156    FRAC(NP1)=0.
763        DO 158 NP=NLOE,JBAR
764        NP1=NP+1
765        DO 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        DO 186 NP1=NDWN1,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.0.)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.0.)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         U.ED=0.
794         PU.RHOU(NPART+1)/RHO(NPART+1)
795         IF(PU.GT.1.)PU=1.
796         PMSD=PU
797         PB=1.-PU
798         IF(NPART.EQ.NDWN)GO TO 202
799         DO 208 NP1=1,NPART
800         RATIO(NP1,1)=0.
801         RATIO(NP1,2)=0.
802         CLOSU(NP1)=0.
803  208    CLOSD(NP1)=0.
804  202    DO 204 NP=NPART,JBAR
805         NP1=NP+1
806         RATIO(NP1,1)=PU/(PU+PB)
807         RATIO(NP1,2)=PMSD/(PU+PB)
808         STRU=PU+PB*GAMZBU(NP1)
809         STRB=PB+PU*GAMZUB(NP1)
810         CLOSD(NP1)=PMSD*TAUWU(NP1)
811         CLOSU(NP1)=STRU*TAUWU(NP1)
812         USED=USED+PMSD*FRAC(NP1)
813         PMSD=PMSD*GAMUU(NP1)
814         IF(PMSD.LT.0.001)PMSD=0.
815         IF(PMSD.GT.SPILL)PMSD=0.
816         PU=STRU*GAMUU(NP1)+STRB*GAMBU(NP1)
817         IF(PU.LT.FLOW)PU=0.
818         IF(PU.GT.SPILL)PU=0.
819         PB=STRB*GAMBB(NP1)+STRU*GAMUB(NP1)
820         IF(PB.LT.FLOW)PB=0.
821         IF(PB.GT.SPILL)PB=0
822  204    CONTINUE
823         PTOT=PU+PB
824         TWEIS=0.
825         DO 272 NE=2,NEPS1
826         EINT=(EPS(1,NE+1)-EPS(1,NE-1))/2.
827         DO 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+0.5
835         JRN=RNN+0.5
836         WRITE(IWRI,351)S
837  351    FORMAT(3H-S=,1F7.2,4H MEV)
838         WRITE(IWRI,352)NPART,NHOLE
839  352    FORMAT(30H-OCCUPATION PROBABILITIES  PO=,I12,5H, HO=,I12)
840         WRITE(IWRI,353)JRZ,JRN,JPIN,JNIN
841  353    FORMAT(11H TARGET  Z=,I3,4H, N=,I3,12H     PROJ  Z=,I3,4H, N=,I1
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    RHOU/RHO     STRU/STR     STRD/STR)
850         WRITE(IWRI,361)
851  361    FORMAT(1H )
852         DO 364 NP1=NDWN1,JBAR1
```

```
853         NP=NP1-1
854         NH=NP-NPHD
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         NSD=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.0.)NI=NI+1
874 451     WRITE(IWRI,454)JPOUT,JNOUT
875 454     FORMAT(21H1PARTICLE SPECTRA  Z=,I2,4H, N=,I2)
876         WRITE(IWRI,456)NI
877 456     FORMAT(21H FIRST EMISSION AT P=,I2)
878         WRITE(IWRI,353)JRZ,JRN,JPIN,JNIN
879         WRITE(IWRI,458)NPART,NHOLE,G,E
880 458     FORMAT(4H PO=,I2,5H, HO=,I2,4H, G=,F6.3,4H, E=,F6.3)
881         IF(IG.EQ.0)WRITE(IWRI,457)
882 457     FORMAT(37H PAIR EXCIT. ACCORDING TO Z/A AND N/A)
883         IF(IG.GT.0)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 =,F7.1)
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=,F6.3,7H, USED=,F6.3)
891         NIC=MAXO(NI,NPART)
892         WRITE(IWRI,470)NIC
893 470     FORMAT(29H CLOSED FORM SUM STARTS AT P=,I2)
894         WRITE(IWRI,474)
895 474     FORMAT(86H- EPS --        DIRECT        --    PREEQUILIBRIUM    --  EQ
896        1UIL  --          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=0.
903         SUMKE=0.
904         SUMSD=0.
905         SUMSC=0.
906         SUMW=0.
907 C
908 C       DIRECT REACTION CALCULATIONS
909         DO 471 NE=1,51
910         SNUTRA(NE)=0.
911 471     SNOCK(NE)=0.
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*0.95
920         IF(JIN.GT.1)SIGCN=SIGCN*0.89
921         DO 480 NE=2,NEPS1
922         PRMSD=0.
923         PRET2=0.
924         DO 466 NP=NIC,JBAR
925         NP1=NP+1
926         X=WU(KP,NP,NE)
927         PRMSD=PRMSD+X*CLOSD(NP1)
928 466     PRET2=PRET2+X*CLOSU(NP1)
929         PRMSD=PRMSD*SIGCN
930         PRET2=PRET2*SIGCN
```

```
      PRMSC=PRET2-PRMSD
      WEISS(KP,NE)=WEISS(KP,NE)*SIGCN*FWEIS
      TOMSD(NE)=PRMSD+SNUTRA(NE)+SNOCK(NE)
      TOMSC(NE)=PRMSC+WEISS(KP,NE)
      TOTAL=TOMSD(NE)+TOMSC(NE)
      IF(TOTAL.LE.0.)GO TO 480
      EINT=(EPS(JHALF,NE+1)-EPS(JHALF,NE-1))/2.
      SUMNU=SUMNU+SNUTRA(NE)*EINT
      SUMKE=SUMKE+SNOCK(NE)*EINT
      SUMSD=SUMSD+PRMSD*EINT
      SUMSC=SUMSC+PRMSC*EINT
      SUMW=SUMW+WEISS(KP,NE)*EINT
      WRITE(IWRI,482)EPS(JHALF,NE),SNUTRA(NE),SNOCK(NE) ,PRMSD,PRMSC,WEI
     1SS(KP,NE),TOMSD(NE),TOMSC(NE),TOTAL
480   CONTINUE
482   FORMAT(1F6.2,9(1PE11.3))
      WRITE(IWRI,481)SUMNU,SUMKE,SUMSD,SUMSC,SUMW
481   FORMAT(6HOSUMS ,6(1PE11.3))
      IF(JOUT.NE.4)GO TO 483
      IF(BF.EQ.0.)GO TO 483
      FISBO=0.
      FISSD=0.
      FISCL=0.
      FISMA=0.
      FISHW=FISHW*SIGCN*FWEIS
      WRITE(IWRI,490)FISBO,FISSD,FISCL,FISMA,FISHW
490   FORMAT(6H-FISS.,6(1PE11.3))
483   SIGCN=SIGCN/0.95
      IF(JIN.GT.1)SIGCN=SIGCN/0.89
C
C     CALCULATE AND PRINT ANGULAR DISTRIBUTIONS
      CALL ANGEL
C
      IF(JPOUT.GT.0)GO TO 484
      JPOUT=1
      JNOUT=0
      JOUT=1
      BEN=BPRO
      KP=2
      JHALF=1
      GO TO 450
484   IF(JNOUT.GT.0)GO TO 500
      JPOUT=2
      JNOUT=2
      JOUT=4
      NSD=1
      BEN=BALFA
      KP=3
      NI=NAP1
      JHALF=1
      GO TO 450
C
C     RECYCLE OPTIONS
C
500   READ(IREA,5)JPOUT,JNOUT
      JOUT=JPOUT+JNOUT
      IF(JPOUT.GE.0)GO TO 504
      READ(IREA,5)NEWP
      IF(NEWP)1000,1,502
502   NEPS1=NEPS(1)+1
      GO TO 9
504   READ(IREA,5)NSD
      READ(IREA,3)BEN,GR
      READ(IREA,3)PAIR,EPAIR
      READ(IREA,13)NEPS(2),EPS(2,2),DELTA(2)
      IF(NEPS(2).LE.50)GO TO 505
      WRITE(IWRI,10)
      GO TO 1000
505   IF(NEPS(2).LE.0)NEPS(2)=1
      NEPS1=NEPS(2)+1
      IF(EPS(2,2).LE.0.)GO TO 510
      IF(DELTA(2).LE.0.)DELTA(2)=1.
      DO 514 NE=3,NEPS1
      X=NE-2
514   EPS(2,NE)=EPS(2,2)+X*DELTA(2)
      JHALF=2
      KP=4
      CALL CROSS
```

```
1009          GO TO 512
1010  510     DO 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          DO 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          JPOF=1
1042          IF(JPOUT.LT.2)GO TO 524
1043          DO 522 J=2,JPOUT
1044  522     JPOF=JPOF*J
1045  524     XPOF=JPOF
1046          JNOF=1
1047          IF(JNOUT.LT.2)GO TO 528
1048          DO 526 J=2,JNOUT
1049  526     JNOF=JNOF*J
1050  528     XNOF=JNOF
1051          APFAC=1.
1052          DO 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          DO 532 J=2,NPART
1060          JJ=J-1
1061  532     PROB(KP,JJ)=1.
1062          DO 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          DO 530 I=1,JOUT
1070          XI=I
1071  530     XNORM=XNORM*(XJ-XI+1.)/XI
1072          XMAX=JMAX
1073          JMAX1=JMAX+1
1074          DO 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          DO 534 II=1,I
1084          XII=II
1085  534     PROBI=PROBI*(XMAX-XII+1.)/XII
1086  536     PROBI=PROBI*(RZ**XI)*(RN**(XMAX-XI))
```

```
1087          XSUM=XSUM+PROBI
1088          PROBI=PROBI/(XPOF*XNOF)
1089          IF(JP.LT.JPOUT)GO TO 546
1090          IF(JN.LT.JNOUT)GO TO 546
1091          IF(JPOUT.EQ.0)GO TO 540
1092          DO 538 II=1,JPOUT
1093          X=JP1-II
1094   538    PROBI=PROBI*X
1095   540    IF(JNOUT.EQ.0)GO TO 544
1096          DO 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          XOUT=JOUT
1112          XPFAC=1.
1113          XHFAC=1
1114          DO 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          DO 554 J=2,NHOLE
1121          XJ=J-1
1122   554    XHFAC=XHFAC*XJ
1123   556    DO 574 JP=NPART,JH1
1124          XP=JP
1125          PROB(KP,JP)=0.
1126          IF(JP.LT.JOUT)GO TO 574
1127          XPFAC=XPFAC*XP
1128          XH=JP-NPHD
1129          XHFAC=XHFAC*XH
1130          XNORM=XPFAC*XHFAC
1131          XNUM=XHFAC
1132          IMAX=JP-JOUT
1133          IF(IMAX.LT.2) GO TO 559
1134          DO 558 I=2,IMAX
1135          XI=I
1136   558    XNUM=XNUM*XI
1137   559    SUMN=0.
1138          SUMD=0.
1139          JPMAX=JP-JNIN
1140          DO 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          DO 560 I=2,JHPI
1149          XI=I
1150   560    FACN=FACN*XI
1151   561    IF(JHNU.LT.2)GO TO 563
1152          DO 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          DO 564 I=2,JPPI
1158          XI=I
1159   564    FACD=FACD*XI
1160   565    IF(JPNU.LT.2)GO TO 567
1161          DO 566 I=2,JPNU
1162          XI=I
1163   566    FACD=FACD*XI
1164   567    FACD=XNORM/FACD
```

```
1165          FACD=FACD*RZ**XPI*RN**XNU
1166          SUMD=SUMD+FACD
1167          IF(JPPI.LT.JPLO)GO TO 572
1168          IF(JPNU.LT.JNLO)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-JNOUT
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-XNOUT)
1181          SUMN=SUMN+FACN
1182  572     CONTINUE
1183          IF(SUMD.GT.0.)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     SD=NSD
1194          CNNE=0.85
1195          IF(JOUT.EQ.1)CNNE=0.95
1196          REL=SD*AP*372000.  *CNNE
1197          IF(GR.EQ.0.)GR=G*(ACOM-AP)/ACOM
1198          ASPR=1.645*GR
1199          NAP1=MAXO(JLO,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.0.)GO TO 612
1210          QUO=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
```

```
1243          IF(H.EQ.0.)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.0.)GO TO 611
1253          RHOL=0.
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=0
1260          IF(RHOL.GT.POUR)RHOL=0.
1261          IF(H.LE.0.)GO TO 613
1262          IF(H.GT.2.)GO TO 613
1263          I=NP-NPHO+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=0.
1269          EH2=EHOLE(I)+EHOLE(I)
1270          IF(UU.LE.EH2)GO TO 614
1271          Y=(UU-EH2)/UU
1272          Y=0.5*H*(H-1.)*Y**(PH-AP-1.)
1273  614     RHOL=RHOL*(1.-X+Y)
1274  613     WR=RHOL*PROD*PROB(KP,NP)*TAUWM
1275          X=0.
1276          IF(RHOU(NP1).GT.0.)X=WR/RHOU(NP1)
1277          IF(X.LT.FLOW)X=0.
1278          IF(X.GT.SPILL)X=0.
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
```

```
      SUBROUTINE ANGEL
C
C     CALCULATE ANGULAR DISTRIBUTIONS
C     FROM SYSTEMATIC LEGENDRE COEFFICIENTS
C     PROGRAM - MARCH 1979
C     SUBROUTINE - JANUARY 1980
C
C     LIBRARY OF POLYNOMIALS GENERATED IN SUBROUTINE POLLY OF MAIN
C
      DIMENSION SIGMA(10),B(7),JANG(10)
      COMMON /ANGELS/ POL(19,7),TOMSD(51),TOMSC(51),IWRI,IANG
      COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNOUT,JPOUT
      DO 10 I=1,10
      JANG(I)=0
10    SIGMA(I)=0.
      DO 11 I=1,7
11    B(I)=0.
      WRITE(IWRI,12)JPOUT,JNOUT
12    FORMAT(26H1ANGULAR DISTRIBUTIONS  Z=,I2,4H  N=,I2)
      IF(IANG.EQ.0)WRITE(IWRI,6)
6     FORMAT(20H ENERGY PARAM. = EPS)
      IF(IANG.EQ.1)WRITE(IWRI,8)
8     FORMAT(25H ENERGY PARAM. = EPS+B.E.)
      ANG=IANG
      WRITE(IWRI,14)
14    FORMAT(29H CROSS SECTIONS IN MB/STR-MEV)
      DO 15 J=1,10
15    JANG(J)=10*J-10
      WRITE(IWRI,16)(JANG(J),J=1,10)
16    FORMAT(5H- EPS,1I7,9I9)
      WRITE(IWRI,18)
18    FORMAT(1H )
      B(1)=1.
      DO 28 NE=2,NEPS1
      EPSCM=EPS(JHALF,NE)+ANG*BEN
      AOMSD=TOMSD(NE)/12.5664
      AOMSC=TOMSC(NE)/12.5664
      TOTAL=AOMSD+AOMSC
      IF(TOTAL.LE.0.)GO TO 28
      DO 19 L=2,7
      XL=L-1
      BL=XL*(XL+1.)
      AL=0.036+0.0039*BL
      BL=92.+ANG*6.-90./SQRT(BL)
      X=AL*(BL-EPSCM)
      X=1.+EXP(X)
19    B(L)=(2.*XL+1.)/X
      DO 24 I=1,10
      SIG=0.
      DO 20 L=1,7
20    SIG=SIG+B(L)*POL(I,L)
      SIGMA(I)=SIG*AOMSD
      SIG=0.
      DO 22 LL=1,4
      L=2*LL-1
22    SIG=SIG+B(L)*POL(I,L)
24    SIGMA(I) =SIGMA(I)+SIG*AOMSC
      WRITE(IWRI,26)EPS(JHALF,NE),(SIGMA(I),I=1,10)
26    FORMAT(1F6.2,10(1PE9.2))
28    CONTINUE
      DO 27 J=1,9
27    JANG(J)=10*J+90
      WRITE(IWRI,29)(JANG(J),J=1,9)
      WRITE(IWRI,18)
29    FORMAT(5H- EPS,1I7,8I9,10H      TOTAL)
      DO 38 NE=2,NEPS1
      EPSCM=EPS(JHALF,NE)+ANG*BEN
      AOMSD=TOMSD(NE)/12.5664
      AOMSC=TOMSC(NE)/12.5664
      TOTAL=TOMSD(NE)+TOMSC(NE)
      IF(TOTAL.LE.0.)GO TO 38
      DO 30 L=2,7
      XL=L-1
      BL=XL*(XL+1.)
      AL=0.036+0.0039*BL
      BL=92.+ANG*6.-90./SQRT(BL)
      X=AL*(BL-EPSCM)
      X=1.+EXP(X)
30    B(L)=(2.*XL+1.)/X
      DO 36 J=1,9
```

```
1370          I=J+10
1371          SIG=0.
1372          DO 32 L=1,7
1373  32      SIG=SIG+B(L)*POL(I,L)
1374          SIGMA(J)=SIG*AOMSD
1375          SIG=0.
1376          DO 34 LL=1,4
1377          L=2*LL-1
1378  34      SIG=SIG+B(L)*POL(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,JNIN,BEA,NSD,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          JOUT=JPOUT+JNOUT
1399          XOUT=JOUT
1400          ATAR=ACOM-XOUT
1401          ATHRD=ATAR**0.333
1402          IF(JPOUT.GT.0.)GO TO 2
1403          XLAMB=XLO(1,2)/ATHRD+XL1(1,2)
1404          XMU=XMO(1,2)*ATHRD+XM1(1,2)*ATHRD*ATHRD
1405          XNU=XNO(1,2)*ATHRD*ATAR+XN1(1,2)*ATHRD*ATHRD+XN2(1,2)
1406          EC=2.4
1407          P=PO(1,2)
1408          NCOU=2
1409          ETEST=32.
1410          GO TO 3
1411  2       RA=1.20
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*ATHRD+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)*ATAR+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(JOUT.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*SQRT(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=SQRT(CUT)
1435          ECUT=(ECUT-A)/(2.*P)
1436          DO 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          DO 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     DO 12 NE=NCOU,NEPS1
1447        ELAB=EPS(JHALF,NE)*ACOM/ATAR
1448        SIG=XLAMB*ELAB+XMU+XNU/ELAB
1449        GEOM=0.
1450        IF(XNL.LT.FLOW)GO TO 12
1451        IF(ELAB.LT.ETEST)GO TO 12
1452        GEOM=SQRT(XOUT*EPS(JHALF,NE))
1453        GEOM=1.23*ATHRD+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,JNOUT,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        XNOR=JIN*NSD
1478        XNORM=XNOR*SIGCN/16.
1479 C
1480 C      1. PROJECTILE=EJECTILE DENOMINATOR
1481        XNOR=XNOR*SIGBAR(KP)/6.
1482        COUP=COUL(KP)
1483        EMAX=E-BEN
1484        XNOR=XNOR*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
1485        IF(JIN.GT.1)GO TO 2
1486        GBA=(RZZ-1.)/13.
1487        IF(JNIN.EQ.0)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          UADP=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)
154           XNORB=XNOR*GIR*GIR
1542          XA=GIR*GIR*P/(XNORI+XNORB)
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          DO 16 NE=2,NEPS1
1552          U=UMAX-EPS(JHALF,NE)
1553          IF(U.LE.0.)GO TO 18
1554          X=0.
1555          IF(JIN.LE.1)GO TO 22
1556          UN=U-EPN
1557          IF(UN.LE.0.)GO TO 20
1558          UN=UN+UADN
1559          X=X+XN*UN
1560  20      UP=U-EPP
1561          IF(UP.LE.0.)GO TO 22
1562          UP=UP+UADP
1563          X=X+XP*UP
1564  22      UA=U-EPA
1565          IF(UA.LE.0.)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,JNIN,BEA,NSD,KP,E,ACOM,G,RZZ
1583          COMMON /CLUSTR/ SNOCK(51),SIGBAR(5),SIGCN,COUL(5),BNEU,BPRO,BALFA
1584          JIN=JPIN+JNIN
1585          XIN=JIN
1586          XPIN=JPIN
1587          XNIN=JNIN
1588          JOUT=JPOUT+JNOUT
1589          XOUT=JOUT
1590          XPOUT=JPOUT
1591          XNOUT=JNOUT
1592          ATARG=ACOM-XIN
1593          RNN=ATARG-RZZ
1594          ARES=ACOM-XOUT
```

```
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(JOUT.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=JOUT*NSD
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/0.08
1648        GO TO 20
1649 19     X=0.02+0.06*(RNN-126.)/3.
1650        XNORM=XNORM*X/0.08
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        DO 22 NE=2,NEPS1
1663        U=UMAX-EPS(1,NE)
1664        U=U-UPAUL
1665        IF(U.LT.0.)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,JNOUT,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=JNOUT+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(JNOUT-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*VELO**(2.*PH)
1718         X=X*ZA**(6.*TRANP)
1719         JP=JPIN-JPOUT
1720         Y=JP
1721         GP=(RZZ+Y)/13.
1722         JN=JNIN-JNOUT
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         DO 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         DO 8 N=2,JSTRIP
1735         Y=N
1736  8      X=X/Y
1737  10     JPICKN=MAXO(JN,0)
1738         IF(JPICKN.LT.2)GO TO 14
1739         DO 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         DO 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          DO 20 I=1,IMAX
1758          XI=I
1759  20      IF(I.GT.1)X=X/(XI-1.)
1760          PPI=JSTRIP
1761          PNU=JSTRIM
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          UADD=UADD+(PPI*(PPI+1.)+HPI*(HPI+1.))/(4.*GP)
1770          DO 40 NE=2,NEPS1
1771          U=UMAX-EPS(JHALF,NE)
1772          IF(U.LT.0.)GO TO 40
1773          U=U+UADD
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/ POL(19,7),TOMSD(51),TOMSC(51),IWRI,IANG
1792          DO 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 IGO
1819  C       D FROM O.M. OF PEREY AND PEREY
1820  C       T FROM O.M. OF HAFELE, FLYNN ET AL
1821  C       3HE FROM O.M. OF GIBSON ET AL
```

```
1822 C
1823       COMMON /PAR/ PO(3,3),P1(3,3),P2(3,3),XLO(3,3),XL1(3,3),XMO(3,3)
1824      1,XM1(3,3),XNO(3,3),XN1(3,3),XN2(3,3)
1825       DO 2 I=1,3
1826       DO 2 J=1,3
1827       PO(I,J)=0.
1828       P1(I,J)=0.
1829       P2(I,J)=0.
1830       XLO(I,J)=0.
1831       XL1(I,J)=0.
1832       XMO(I,J)=0.
1833       XM1(I,J)=0.
1834       XNO(I,J)=0.
1835       XN1(I,J)=0.
1836 2     XN2(I,J)=0.
1837       PO(1,2)=-312.
1838       PO(2,1)=15.72
1839       PO(2,2)=0.798
1840       PO(2,3)=-21.45
1841       PO(3,2)=-2.88
1842       PO(3,3)=10.95
1843       P1(2,1)=9.65
1844       P1(2,2)=420.3
1845       P1(2,3)=484.7
1846       P1(3,2)=105.6
1847       P1(3,3)=-85.21
1848       P2(2,1)=-449.
1849       P2(2,2)=-1651.
1850       P2(2,3)=-1608.
1851       P2(3,2)=-1487.
1852       P2(3,3)=1146.
1853       XLO(1,2)=12.10
1854       XLO(2,1)=0.00437
1855       XLO(2,2)=0.00619
1856       XLO(2,3)=0.0186
1857       XLO(3,2)=0.00459
1858       XLO(3,3)=0.0643
1859       XL1(1,2)=-11.27
1860       XL1(2,1)=-16.58
1861       XL1(2,2)=-7.54
1862       XL1(2,3)=-8.90
1863       XL1(3,2)=-8.93
1864       XL1(3,3)=-13.96
1865       XMO(1,2)=234.1
1866       XMO(2,1)=244.7
1867       XMO(2,2)=583.5
1868       XMO(2,3)=686.3
1869       XMO(3,2)=611.2
1870       XMO(3,3)=781.2
1871       XM1(1,2)=38.26
1872       XM1(2,1)=0.503
1873       XM1(2,2)=0.337
1874       XM1(2,3)=0.325
1875       XM1(3,2)=0.35
1876       XM1(3,3)=0.29
1877       XNO(1,2)=1.55
1878       XNO(2,1)=273.1
1879       XNO(2,2)=421.8
1880       XNO(2,3)=368.9
1881       XNO(3,2)=473.8
1882       XNO(3,3)=-304.7
1883       XN1(1,2)=-106.1
1884       XN1(2,1)=-182.4
1885       XN1(2,2)=-474.5
1886       XN1(2,3)=-522.2
1887       XN1(3,2)=-468.2
1888       XN1(3,3)=-470.
1889       XN2(1,2)=1280.8
1890       XN2(2,1)=-1.872
1891       XN2(2,2)=-3.592
1892       XN2(2,3)=-4.998
1893       XN2(3,2)=-2.225
1894       XN2(3,3)=-8.582
1895       RETURN
1896       END
```

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   0
     16.62      16.57       17.13       17.49       17.97
      0.00
-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   RHOU/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.	4.379E+00	3.467E-02	4.379E+00	4.413E+00
2.00	3.314E-02	1.103E-01	0.	0.	1.114E+01	1.435E-01	1.114E+01	1.128E+01
3.00	3.928E-02	1.393E-01	0.	0.	8.440E+00	1.786E-01	8.440E+00	8.618E+00
4.00	4.252E-02	1.614E-01	0.	0.	5.799E+00	2.039E-01	5.799E+00	6.003E+00
5.00	4.547E-02	1.857E-01	0.	0.	3.908E+00	2.311E-01	3.908E+00	4.139E+00
6.00	4.688E-02	2.070E-01	0.	0.	2.520E+00	2.539E-01	2.520E+00	2.774E+00
7.00	4.614E-02	2.218E-01	0.	0.	1.541E+00	2.680E-01	1.541E+00	1.809E+00
8.00	4.347E-02	2.294E-01	0.	0.	8.953E-01	2.729E-01	8.953E-01	1.168E+00
9.00	3.934E-02	2.300E-01	0.	0.	4.967E-01	2.694E-01	4.967E-01	7.661E-01
10.00	3.423E-02	2.244E-01	0.	0.	2.636E-01	2.586E-01	2.636E-01	5.222E-01
12.00	2.278E-02	1.971E-01	0.	0.	6.503E-02	2.199E-01	6.503E-02	2.849E-01
14.00	1.173E-02	1.490E-01	0.	0.	1.297E-02	1.607E-01	1.297E-02	1.737E-01
16.00	3.353E-03	7.988E-02	0.	0.	1.907E-03	8.323E-02	1.907E-03	8.513E-02
OSUMS	4.750E-01	2.780E+00	0.	0.	3.968E+01			

1ANGULAR DISTRIBUTIONS Z= 0 N= 1
ENERGY PARAM = EPS+E.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	3.254E-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+E.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	1.95E+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= 2
PO= 2, HO= 0, G= 4.230, E=33.500
PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENS TIES
REACTION CROSS SECTION = 966.0
SCALE FACTOR= 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	8.139E+00	8.387E+00
8.00	7.335E-02	1.049E-02	4.563E-01	5.222E+00	8.652E+00	5.402E-01	1.367E+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	7.691E-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 PROJ 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	MSC	WEISS	MSD	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			

1ANGULAR 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	8.15E+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	5.39E+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 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	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			

1ANGULAR DISTRIBUTIONS Z= 1 N= 0
ENERGY PARAM = EPS+P.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	9.84E-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 --	DIREC	T --	PREEQUILIBRIUM	-	EQUIL	-	TOTAL (ME/MEV)		
--	NUTRA	KNOCK	-- MSD	MSC	WEISS	--	MSD	MSC	MSD+MSC
5.00	2.009E-03	7.507E-05	4.508E-04	8.793E-03	8.224E-01		2.545E-03	9.103E-01	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		1.575E-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+E 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

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-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   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
2.00	0.	0.	2.657E+00	3.926E-01	1.026E+00	2.657E+00	1.419E+00	4.076E+00
4.00	0.	0.	4.255E+00	4.440E-01	1.016E+00	4.255E+00	1.460E+00	5.714E+00
6.00	0.	0.	5.112E+00	3.653E-01	7.289E-01	5.112E+00	1.094E+00	6.206E+00
8.00	0.	0.	5.580E+00	2.653E-01	4.591E-01	5.580E+00	7.244E-01	6.304E+00
10.00	0.	0.	5.821E+00	1.793E-01	2.570E-01	5.821E+00	4.463E-01	6.267E+00
12.00	0.	0.	5.933E+00	1.155E-01	1.466E-01	5.933E+00	2.621E-01	6.195E+00
14.00	0.	0.	5.971E+00	7.187E-02	7.689E-02	5.971E+00	1.488E-01	6.120E+00
16.00	0.	0.	5.811E+00	4.351E-02	3.873E-02	5.811E+00	8.224E-02	5.893E+00
18.00	0.	0.	5.605E+00	2.573E-02	1.880E-02	5.605E+00	4.453E-02	5.649E+00
20.00	0.	0.	5.366E+00	1.489E-02	8.804E-03	5.366E+00	2.369E-02	5.390E+00
22.00	0.	0.	5.105E+00	8.414E-03	3.981E-03	5.105E+00	1.240E-02	5.118E+00
24.00	0.	0.	4.828E+00	4.634E-03	1.737E-03	4.828E+00	6.371E-03	4.834E+00
26.00	0.	0.	4.538E+00	2.475E-03	7.298E-04	4.538E+00	3.205E-03	4.541E+00
28.00	0.	0.	4.239E+00	1.274E-03	2.947E-04	4.239E+00	1.568E-03	4.240E+00
30.00	0.	0.	3.931E+00	6.260E-04	1.140E-04	3.931E+00	7.400E-04	3.932E+00
32.00	0.	0.	3.616E+00	2.905E-04	4.205E-05	3.616E+00	3.325E-04	3.616E+00
34.00	0.	0.	3.294E+00	1.253E-04	1.471E-05	3.294E+00	1.400E-04	3.294E+00
36.00	0.	0.	2.965E+00	4.917E-05	4.845E-06	2.965E+00	5.401E-05	2.965E+00
38.00	0.	0.	2.629E+00	1.702E-05	1.488E-06	2.629E+00	1.851E-05	2.629E+00
40.00	0.	0.	2.284E+00	4.956E-06	4.204E-07	2.284E+00	5.376E-06	2.284E+00
42.00	0.	0	1.931E+00	1.123E-06	1.072E-07	1.931E+00	1.230E-06	1.931E+00
44.00	0.	0.	1.568E+00	1.720E-07	2.399E-08	1.568E+00	1.960E-07	1.568E+00
46.00	0.	0.	1.193E+00	1.313E-08	4.505E-09	1.193E+00	1.763E-08	1.193E+00
48.00	0.	0.	8.051E-01	2.136E-10	6.536E-10	8.051E-01	8.672E-10	8.051E-01
50.00	0.	0.	4.025E-01	0.	6.121E-11	4.025E-01	6.121E-11	4.025E-01
OSUMS	0.	0.	1.895E+02	3.676E+00	7.074E+00			

1ANGULAR DISTRIBUTIONS Z= 0 N= 1
ENERGY PARAM. = EPS+E.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	1.51E-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	5.85E-03	5.17E-03	3.29E+00
36.00	4.54E-02	3.36E-02	2.58E-02	1.93E-02	1.36E-02	9.87E-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	-1.20E-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 -- NUTRA	KNOCK	-- PREEQUILIBRIUM -- MSD	MSC	-- EQUIL -- WEISS	-- TOTAL (MB/MEV) 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			

1ANGULAR 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	4.04E-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	9.69E-03	6.35E-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	6.20E-03	3.60E-03	1.89E-03	4.76E+00
50.00	4.84E-02	3.93E-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	1.29E-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	4.38E-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= 0.892
CLOSED FORM SUM STARTS AT P= 4

- EPS --	DIRECT		PREEQUILIBRIUM		EQUIL	TOTAL (ME/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	5.025E-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	8.871E-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	1.485E-04	2.025E-01	3.344E-04	2.028E-01
38.00	1.524E-01	2.063E-02	2.205E-03	9.391E-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	1.029E-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	7.045E-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			

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
6.00	1.21E-02	1.19E-02	1.15E-02	1.09E-02	1.02E-02	9.41E-03	8.68E-03	8.06E-03	7.60E-03	7.35E-03
8.00	5.97E-02	5.89E-02	5.67E-02	5.34E-02	4.94E-02	4.51E-02	4.11E-02	3.77E-02	3.51E-02	3.36E-02
10.00	1.07E-01	1.06E-01	1.02E-01	9.50E-02	8.70E-02	7.85E-02	7.05E-02	6.36E-02	5.83E-02	5.50E-02
12.00	1.24E-01	1.22E-01	1.17E-01	1.08E-01	9.81E-02	8.73E-02	7.70E-02	6.81E-02	6.12E-02	5.66E-02
14.00	1.19E-01	1.17E-01	1.11E-01	1.02E-01	9.13E-02	8.00E-02	6.93E-02	5.99E-02	5.24E-02	4.72E-02
16.00	1.09E-01	1.07E-01	1.01E-01	9.25E-02	8.18E-02	7.06E-02	5.98E-02	5.04E-02	4.29E-02	3.74E-02
18.00	1.02E-01	9.97E-02	9.38E-02	8.49E-02	7.43E-02	6.31E-02	5.24E-02	4.30E-02	3.55E-02	2.98E-02
20.00	9.73E-02	9.52E-02	8.92E-02	8.01E-02	6.93E-02	5.79E-02	4.72E-02	3.78E-02	3.02E-02	2.45E-02
22.00	9.53E-02	9.30E-02	8.68E-02	7.73E-02	6.61E-02	5.45E-02	4.36E-02	3.42E-02	2.65E-02	2.08E-02
24.00	9.45E-02	9.21E-02	8.55E-02	7.56E-02	6.39E-02	5.19E-02	4.08E-02	3.13E-02	2.37E-02	1.80E-02
26.00	9.40E-02	9.15E-02	8.45E-02	7.42E-02	6.20E-02	4.96E-02	3.83E-02	2.87E-02	2.13E-02	1.57E-02
28.00	9.33E-02	9.07E-02	8.33E-02	7.24E-02	5.98E-02	4.71E-02	3.57E-02	2.62E-02	1.90E-02	1.37E-02
30.00	9.18E-02	8.91E-02	8.14E-02	7.01E-02	5.71E-02	4.43E-02	3.29E-02	2.36E-02	1.67E-02	1.18E-02
32.00	8.94E-02	8.65E-02	7.86E-02	6.70E-02	5.38E-02	4.10E-02	2.97E-02	2.09E-02	1.44E-02	9.92E-03
34.00	8.57E-02	8.28E-02	7.47E-02	6.30E-02	4.99E-02	3.72E-02	2.64E-02	1.80E-02	1.21E-02	8.16E-03
36.00	8.09E-02	7.80E-02	6.98E-02	5.82E-02	4.53E-02	3.30E-02	2.28E-02	1.52E-02	9.89E-03	6.52E-03
38.00	7.48E-02	7.19E-02	6.39E-02	5.26E-02	4.01E-02	2.86E-02	1.92E-02	1.23E-02	7.82E-03	5.04E-03
40.00	6.76E-02	6.48E-02	5.71E-02	4.63E-02	3.46E-02	2.40E-02	1.56E-02	9.67E-03	5.94E-03	3.76E-03
42.00	5.93E-02	5.66E-02	4.94E-02	3.94E-02	2.88E-02	1.94E-02	1.21E-02	7.24E-03	4.30E-03	2.69E-03
44.00	5.01E-02	4.77E-02	4.12E-02	3.23E-02	2.30E-02	1.49E-02	8.95E-03	5.12E-03	2.95E-03	1.83E-03
46.00	4.09E-02	3.81E-02	3.25E-02	2.50E-02	1.73E-02	1.08E-02	6.17E-03	3.36E-03	1.88E-03	1.18E-03
48.00	2.99E-02	2.83E-02	2.38E-02	1.79E-02	1.20E-02	7.13E-03	3.86E-03	2.00E-03	1.09E-03	7.10E-04
50.00	1.97E-02	1.86E-02	1.54E-02	1.13E-02	7.26E-03	4.10E-03	2.08E-03	1.01E-03	5.56E-04	3.85E-04
52.00	8.25E-03	7.72E-03	6.31E-03	4.49E-03	2.76E-03	1.46E-03	6.84E-04	3.16E-04	1.80E-04	1.37E-04
54.00	2.65E-03	2.47E-03	1.98E-03	1.36E-03	7.95E-04	3.89E-04	1.65E-04	7.29E-05	4.63E-05	3.93E-05
56.00	5.41E-11	5.00E-11	3.92E-11	2.59E-11	1.43E-11	6.57E-12	2.80E-12	1.59E-12	1.45E-12	1.50E-12
- EPS	100	110	120	130	140	150	160	170	180	TOTAL
6.00	7.31E-03	7.47E-03	7.80E-03	8.26E-03	8.77E-03	9.28E-03	9.71E-03	9.99E-03	1.01E-02	1.08E-01
8.00	3.32E-02	3.38E-02	3.53E-02	3.75E-02	4.00E-02	4.25E-02	4.46E-02	4.60E-02	4.65E-02	5.02E-01
10.00	5.38E-02	5.44E-02	5.67E-02	6.02E-02	6.44E-02	6.86E-02	7.22E-02	7.46E-02	7.54E-02	8.39E-01
12.00	5.44E-02	5.44E-02	5.63E-02	5.96E-02	6.37E-02	6.80E-02	7.17E-02	7.42E-02	7.50E-02	8.85E-01
14.00	4.42E-02	4.33E-02	4.42E-02	4.64E-02	4.94E-02	5.26E-02	5.54E-02	5.74E-02	5.81E-02	7.59E-01
16.00	3.38E-02	3.21E-02	3.20E-02	3.30E-02	3.47E-02	3.68E-02	3.86E-02	4.00E-02	4.04E-02	6.19E-01
18.00	2.59E-02	2.36E-02	2.27E-02	2.28E-02	2.35E-02	2.46E-02	2.56E-02	2.64E-02	2.67E-02	5.11E-01
20.00	2.04E-02	1.78E-02	1.64E-02	1.58E-02	1.58E-02	1.62E-02	1.66E-02	1.70E-02	1.72E-02	4.37E-01
22.00	1.67E-02	1.39E-02	1.22E-02	1.12E-02	1.08E-02	1.07E-02	1.08E-02	1.09E-02	1.10E-02	3.88E-01
24.00	1.40E-02	1.12E-02	9.36E-03	8.24E-03	7.59E-03	7.26E-03	7.12E-03	7.08E-03	7.07E-03	3.53E-01
26.00	1.18E-02	9.18E-03	7.40E-03	6.24E-03	5.50E-03	5.05E-03	4.80E-03	4.67E-03	4.63E-03	3.27E-01
28.00	1.01E-02	7.59E-03	5.94E-03	4.83E-03	4.10E-03	3.61E-03	3.31E-03	3.15E-03	3.09E-03	3.03E-01
30.00	8.45E-03	6.24E-03	4.78E-03	3.79E-03	3.10E-03	2.63E-03	2.33E-03	2.15E-03	2.10E-03	2.80E-01
32.00	6.98E-03	5.08E-03	3.83E-03	2.97E-03	2.37E-03	1.94E-03	1.65E-03	1.48E-03	1.43E-03	2.55E-01
34.00	5.65E-03	4.06E-03	3.03E-03	2.32E-03	1.81E-03	1.43E-03	1.17E-03	1.02E-03	9.66E-04	2.30E-01
36.00	4.45E-03	3.19E-03	2.37E-03	1.80E-03	1.37E-03	1.05E-03	8.19E-04	6.84E-04	6.40E-04	2.03E-01
38.00	3.42E-03	2.45E-03	1.83E-03	1.38E-03	1.03E-03	7.56E-04	5.60E-04	4.44E-04	4.06E-04	1.75E-01
40.00	2.55E-03	1.85E-03	1.40E-03	1.05E-03	7.64E-04	5.33E-04	3.68E-04	2.72E-04	2.41E-04	1.48E-01
42.00	1.84E-03	1.36E-03	1.05E-03	7.84E-04	5.53E-04	3.62E-04	2.27E-04	1.51E-04	1.28E-04	1.21E-01
44.00	1.28E-03	9.62E-04	7.68E-04	5.72E-04	3.86E-04	2.31E-04	1.26E-04	7.15E-05	5.57E-05	9.47E-02
46.00	8.61E-04	6.85E-04	5.45E-04	4.00E-04	2.55E-04	1.35E-04	5.86E-05	2.47E-05	1.66E-05	7.05E-02
48.00	5.47E-04	4.53E-04	3.65E-04	2.62E-04	1.54E-04	6.68E-05	1.81E-05	3.09E-06	1.80E-06	4.85E-02
50.00	3.16E-04	2.70E-04	2.18E-04	1.52E-04	7.98E-05	2.37E-05	-1.31E-06	-1.79E-06	1.76E-06	2.94E-02
52.00	1.19E-04	1.03E-04	8.32E-05	5.57E-05	2.48E-05	1.91E-06	-4.65E-06	5.34E-07	4.57E-06	1.13E-02
54.00	3.47E-05	3.00E-05	2.44E-05	1.57E-05	5.34E-06	-1.90E-06	-2.40E-06	1.61E-06	4.03E-06	3.32E-03
56.00	1.45E-12	1.59E-12	2.79E-12	6.56E-12	1.43E-11	2.59E-11	3.92E-11	5.00E-11	5.41E-11	1.23E-10

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	2.107E-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			

1ANGULAR 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	6.96E-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	1.12E-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

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	6.318E-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			

1ANGULAR 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	7.67E-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-0	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			

1ANGULAR 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

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

EPS	DIRECT NUTRA	DIRECT KNOCK	PREEQUILIBRIUM MSD	PREEQUILIBRIUM MSC	EQUIL WEISS	TOTAL (MB/MEV) MSD	TOTAL (MB/MEV) MSC	TOTAL (MB/MEV) 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			

1ANGULAR 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   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

EPS	DIRECT		PREEQUILIBRIUM		EQUIL	TOTAL (MB/MEV)		
	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			

1ANGULAR 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			

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
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_o, h_o, g_o, 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 [# cluster states]/[MeV *carried by cluster*], which adds

a factor of $1/A_{cluster}$. 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}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 $\varepsilon+B_b$ 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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