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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

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

by

C. Kalbach

ABSTRACT

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

INTRODUCTION

PRECO refers to a family of programs of increasing sophistication designed to calculate the energy spectra of particles emitted in nuclear reactions within a statistical model framework which includes non-equilibrium processes. The first series of programs (ending with PRECO-8 and PRECOM) ran on a PDP-6 computer with teletype input in the dialogue mode. The present series, which began with the code PRECO-A, is suitable for large computing center machines. The model used was first proposed by Griffin [GR66] and is discussed in detail in [KA77] and references therein. The formalism used here has been modified to include division of the preequilibrium cross section into multi-step direct (MSD) and multi-step compound (MSC) components [KA81]. Subroutines have been included to perform semi-empirical calculations for direct nucleon transfer and for knockout and inelastic processes involving complex particles. Additional subroutines use the total MSD (including direct) and total MSC (including evaporation) cross sections to calculate the angular distributions for the emitted particles. This is done phenomenologically [KA81a].

I. SUMMARY OF THE EXCITON MODEL THEORY

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

I.1 State Densities

The states of the system are enumerated by the number of excited particle, p, and hole, h, degrees of freedom which they contain. The sum p+h is referred to as the exciton number and is denoted as n. The system is assumed to be formed in a unique particle/hole configuration specified by (p_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

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

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

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

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

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

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

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)

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

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

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

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

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

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

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]

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

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

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

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]

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

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

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

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

and the effective single-particle-state densities

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$- 4(n-1)\ X_1^n(p)\ f_1(p) + 4(p-1)(n-2)\ X_2^n(p)\ f_2(p)\Big]\ , \qquad (30)$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\mathcal{S}_d(p) = P_d(p) , \qquad (42a)$$

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

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

and

$$P_d(p+1) = \mathcal{S}_d(p)\ \Gamma_+^{(uu)}(p) \equiv P_d(p)\ \Gamma_+^{(uu)}(p) , \qquad (43a)$$

$$P_u(p+1) = \mathcal{S}_u(p)\ \Gamma_+^{(uu)}(p) + \mathcal{S}_b(p)\ \Gamma_+^{(bu)}(p) , \qquad (43c)$$

$$P_b(p+1) = \mathcal{S}_b(p)\ \Gamma_+^{(bb)}(p) + \mathcal{S}_u(p)\ \Gamma_+^{(ub)}(p) , \qquad (43c)$$

with

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

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

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

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

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

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

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

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

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

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

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

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][GR76]. 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

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

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

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

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

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

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

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

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

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

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

for a = complex , (52a)

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

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

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 σ_{a-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

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

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

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

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

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

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

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

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

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

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

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

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

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]

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

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

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

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

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

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

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

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

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

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

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 $\sigma_{n-NE}(\varepsilon)$ 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	$\left\{ \begin{array}{l} 0 \\ B_n-E_{sym}(Z,A)+E_{sym}(Z-1,A) \end{array} \right.$
B_p	B_p	$B\ -E_{sym}(Z,A)$
B_α	B_α	0
σ_{a-NE}	$\sigma_{a-NE}[2T_o/(2T_o+1)]$	$\sigma_{a-NE}[1/(2T_o+1)]$
$\sigma_{n-NE}(\varepsilon)$	$\sigma_{n-NE}(\varepsilon)$	$\left\{ \begin{array}{l} 0 \\ \sigma_{n-NE}(\varepsilon)[2T_o/(2T_o+1)] \end{array} \right.$
$\sigma_{p-NE}(\varepsilon)$	$\sigma_{p-NE}(\varepsilon)[2T_o/(2T_o+1)]$	$\sigma_{p-NE}(\varepsilon)[1/(2T_o+1)]$
$\sigma_{\alpha-NE}(\varepsilon)$	$\sigma_{\alpha-NE}(\varepsilon)$	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).

g_o — $A/13$ with values for the residual nuclei calculated in the program (the default).

k — 135 MeV^3 (input number is 1.35) (the default).

B_b — from [WA77] or similar mass tables

$\sigma_{n-NE}(\varepsilon)$	from [MA63]	(The default is approximations to these optical model cross sections.)
$\sigma_{p-NE}(\varepsilon)$	from [BE69]	
$\sigma_{\alpha-NE}(\varepsilon)$	from [HU62]	
$\sigma_{b-NE}(\varepsilon)$	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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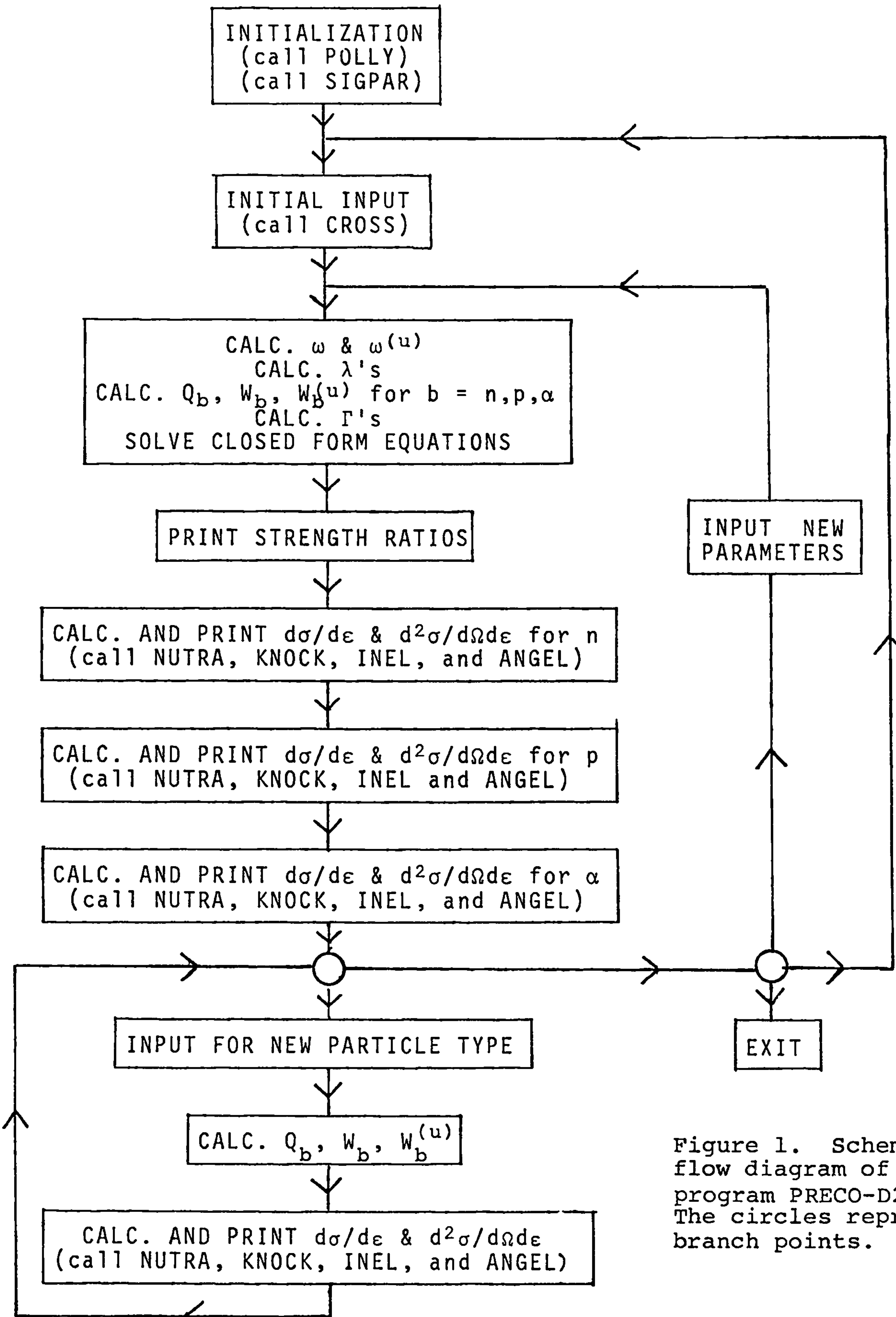

Figure 1. Schematic flow diagram of the program PRECO-D2. The circles represent branch points.

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)	$\Theta(E-iS)\ (E-iS)/(E-S)$ for i=1,10
F2	Matrix element scale factor, k

FISHW	Equilibrium cross section going into fission
FLOW,SPILL,POUR	10^{-18}, 10^{+18}, and 10^{+35}; comparison numbers for underflow and overflow checks
FRAC(NP)	Fraction of the available strength in states with p=NP which is lost due to n, p and α emission in one unit of time, 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 ε+(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

```
C       PRECO-D
C       WRITTEN BY C. KÀLBACH
C       CLOSED FORM PREEQUILIBRIUM REACTION CALCULATIONS
C       IN GRIFFIN MODEL FORMALISM
C       WITH MULTI-STEP DIRECT EXTRACTED
C
C       SUBROUTINES FOR PHENOMENOLOGICAL DESCRIPTIONS OF
C       1. DIRECT KNOCKOUT AND INELASTIC SCATTERING INVOLVING COMPLEX
C          PARTICLE CLUSTERS
C       2. DIRECT NUCLEON TRANSFER
C       3. ANGULAR DISTRIBUTIONS
C       4. OPTION FOR APPROXIMATE REACTION CROSS SECTIONS INTERNALLY
C       DIRECT REACTION FORMALISM
C       VERIFIED FOR NUCLEON AND ALPHA INCIDENT
C       USE WITH CAUTION FOR D OR 3HE INCIDENT
C       (NO DIRECT RXN CALC FOR HEAVIER PROJECTILES)
C       (NO APPROX RXN CROSS SECTIONS FOR AOUT.GT.4)
C
C       PRAISE THE LORD
C
        COMMON ESUM(4),RHO(31),RHOU(31),NEPS(2),ES(10),DELTA(2)
       1,PROB(4,30),TAUWU(31),RATIO(31,2),FRAC(31),WEISS(4,51),WU(4,31,51)
       2,CLOSD(31),CLOSU(31),EMU(3),FWD(3),FWDU(32),DBL(31),FWDHI(32)
       3,GEL(32),GELU(32),GELUU(32),GF(3),GU(3),GFU(3),GFAV(3),EHOLE(3)
       4,GAMUU(31),GAMUB(31),GAMBU(31),GAMBB(31),GAMZUB(31),GAMZBU(31)
        COMMON /ANGELS/ POL(19,7),TOMSD(51),TOMSC(51),IWRI,IANG
        COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNOUT,JPOUT
        COMMON /DIRECT/ SIGIN(4,51),JPIN,JNIN,BEA,NSD,KP,E,ACOM,G,RZZ
        COMMON /NUTRAN/ SNUTRA(51)
        COMMON /CLUSTR/ SNOCK(51),SIGBAR(5),SIGCN,COUL(5),BNEU,BPRO,BALFA
        COMMON /PAR/ PO(3,3),P1(3,3),P2(3,3),XLO(3,3),XL1(3,3),XMO(3,3)
       1,XM1(3,3),XNO(3,3),XN1(3,3),XN2(3,3)
C
            CALL LINK("UNIT5=PRECOINP,UNIT6=(PRECOUT,CREATE,HC),//")
C
        IREA=5
        IWRI=6
        READ(IREA,5)IANG,IG
        READ(IREA,3)EHOLE(2),EHOLE(3)
        EHOLE(1)=EHOLE(3)
  1     DO 2 NP=1,31
        GEL(NP)=O.
        GELU(NP)=O.
        GELUU(NP)=O.
        RHO(NP)=O.
        RHOU(NP)=O.
        GAMUU(NP)=O.
        GAMUB(NP)=O.
        GAMBU(NP)=O.
        GAMBB(NP)=O.
        GAMZUB(NP)=O.
        GAMZBU(NP)=O.
        FRAC(NP)=O.
  2     CONTINUE
        GEL(32)=O.
        GELU(32)=O.
        GELUU(32)=O.
        DO 4 KP=1,4
        DO 4 NP=1,50
  4     PROB(KP,NP)=O.
        DO 8 KP=1,4
        DO 8 NE=1,51
        SIGIN(KP,NE)=O.
  8     WEISS(KP,NE)=O.
        DO 11 I=1,19
        DO 11 J=1,7
  11    POL(I,J)=O.
C
C       GENERATE TABLE OF LEGENDRE POLYNOMIALS
        CALL POLLY
```

```
C       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)
```

```
      GO TO 27
21    IF(JIN.NE.4)GO TO 22
      SIGBAR(5)=SIGBAR(3)
      GO TO 27
22    JPOUT=JPIN
      JNOUT=JNIN
      JHALF=2
      KP=4
      NEPS1=(E-BEA)*ACOM/(2.*(ACOM-XIN))
      DO 23 NE=2,NEPS1
23    EPS(2,NE)=2*(NE-1)
      CALL CROSS
      EPS(2,1)=1.
      EPS(2,NEPS1+1)=EPS(2,NEPS1)+1.
      ESUM(4)=0.
      DO 25 NE=2,NEPS1
      IF(EPS(2,NE).LT.COUL(5))GO TO 25
      EINT=(EPS(2,NE+1)-EPS(2,NE-1))/2.
      ESUM(4)=ESUM(4)+EINT
      SIGBAR(5)=SIGBAR(5)+SIGIN(4,NE)*EINT
25    SIGIN(4,NE)=0.
      IF(ESUM(4).GT.0.)SIGBAR(5)=SIGBAR(5)/ESUM(4)
      NEPS1=NEPS(1)+1
      JHALF=1
27    IF(SIGCN.GT.0.)GO TO 38
      IF(JPIN.GT.0)GO TO 29
      EC=2.4
      XLAMB=XLO(1,2)/ATHRD+XL1(1,2)
      XMU=XMO(1,2)*ATHRD+XM1(1,2)*ATHRD*ATHRD
      XNU=XNO(1,2)*ATHRD*(RZZ+RNN)+XN1(1,2)*ATHRD*ATHRD+XN2(1,2)
      GO TO 37
29    I=JPIN+1
      J=JNIN+1
      XLAMB=XLO(I,J)*(RZZ+RNN)+XL1(I,J)
      XNU=(RZZ+RNN)**XM1(I,J)
      XMU=XMO(I,J)*XNU
      RA=1.20
      IF(JIN.EQ.1)RA=0.
      EC=1.44*XPIN*RZZ/(1.5*ATHRD+RA)
      XNU=XNU*(XNO(I,J)+XN1(I,J)*EC+XN2(I,J)*EC*EC)
      IF(JIN.EQ.2)RA=0.8
      IF(JIN.EQ.3)RA=0.8
      XNL=XNU/XLAMB
      IF(XNL.GT.SPILL)XNL=0.
      IF(XNL.LT.FLOW)GO TO 37
      ETEST=1.2*SQRT(XNL)
37    ELAB=(E-BEA)*ACOM/(ACOM-XIN)
      SIGCN=XLAMB*ELAB+XMU+XNU/ELAB
      IF(XNL.LT.FLOW)GO TO 40
      IF(ELAB.LT.ETEST)GO TO 40
      GEOM=SQRT(XIN*(E-BEA))
      GEOM=1.23*ATHRD+RA+4.573/GEOM
      GEOM=31.416*GEOM*GEOM
      IF(SIGCN.LT.GEOM)SIGCN=GEOM
      GO TO 38
40    IF(ELAB.GE.EC)GO TO 38
      XP=PO(I,J)+P1(I,J)/EC+P2(I,J)/(EC*EC)
      XA=-2.*XP*EC+XLAMB-XNU/(EC*EC)
      XB=XP*EC*EC+XMU+2.*XNU/EC
      ECUT=0.
      CUT=XA*XA-4.*XP*XB
      IF(CUT.GT.0.)ECUT=SQRT(CUT)
      ECUT=(ECUT-XA)/(2.*XP)
      SIGCN=XP*ELAB*ELAB+XA*ELAB+XB
      IF(ELAB.LT.ECUT)SIGCN=0.
38    READ(IREA,5)NPART,NHOLE
      N=NPART+NHOLE
      IF(N.GT.0)GO TO 39
      NPART=JIN+1
      NHOLE=1
39    READ(IREA,3)G,GNEU,GPRO,GALFA,GFIS
      IF(G.LE.0.)G=ACOM/13.
      READ(IREA,3)F2
      IF(F2.LE.0.)F2=1.35
      SIZE=G*(E-EPAIRC)
      E=E-PAIRC
      NPHD=NPART-NHOLE
      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)=O.
      Y=I-1
      X=NPART-NHOLE+I-1
      IF(X.LT.O.)GO TO 19
      PHNO=X+Y
      IF(PHNO.LE.O.)GO TO 19
      ENEX=E/(PHNO*38.)
      GFP=1.+ENEX
      GFP=SQRT(GFP)
      GFH=1.-ENEX
      IF(GFH.LT.O.)GFH=O.
      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.O.)S=O.
      GFPU=(38.+S)/38.
      GFPU=SQRT(GFPU)*G
      GFHU=(38.-S)/38.
      IF(GFHU.LT.O.)GFHU=O.
      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.O.)GO TO 24
      PHNO=X+Y
      IF(PHNO.LE.O.)GO TO 24
      PHNO1=PHNO-1.
      ENEX=(E-S)/(PHNO*38.)
      GFP=SQRT(1.+ENEX)
      GFH=1.-ENEX
      IF(GFH.LT.O.)GFH=O.
      GFH=SQRT(GFH)
      Z=1.+ENEX+S/38.
      GU(I)=G*SQRT(Z)
      IF(PHNO1.LE.O.)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.O.)GO TO 24
      EV2=EV2**PHNO1
      XX=XX+Y*(Y-1..)*O.5*EV2/X
      IF(XX.LT.O.)XX=O.
   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)=O.
      DO 28 I=1,10
      IF(X.LE.O.)GO TO 30
      XI=I
      Y=(E-XI*S)/X
      IF(Y.LE.O.)GO TO 30
```

```
      ES(I)=Y
28    CONTINUE
      E=E+EPAIRC
30    NTERM=I-1
      DO 36 NP=1,30
      NP1=NP+1
      FT2=0.
      FWDU(NP1)=0.
      DBL(NP1)=0.
      FWDHI(NP1)=0.
      P=NP
      NH=NP-NPHD
      H=NH
      IF(H.LT.0.)GO TO 36
      PH1=P+H-1.
      FT=ES(1)
      IF(PH1.LE.0.)GO TO 35
      FT=0.
      LIM=MIN0(NP,NTERM)
      BIN=1./P
      SI=-1.
      IF(NH.GT.2)GO TO 32
      EE=E-PAIRC
      IF(EE.LE.S)GO TO 36
      Y=EE-S
      DO 31 I=1,LIM
      XI=I
      BIN=BIN*(P-XI+1.)/XI
      SI=-SI
      X=(EE-XI*S)/Y
      IF(X.LT.0.)X=0.
      IF(X.GT.0.)X=X**PH1
      IF(X.LT.FLOW)X=0.
      IF(X.GT.SPILL)X=0.
      XX=SI*BIN*X
      X=(EE-XI*S-EHOLE(NH+1))/Y
      IF(X.LT.0.)X=0.
      IF(X.GT.0.)X=X**PH1
      IF(X.LT.FLOW)X=0.
      IF(X.GT.SPILL)X=0.
      XX=XX-SI*BIN*H*X
      X=(EE-XI*S-EHOLE(NH+1)*2.)/Y
      IF(X.LT.0.)X=0.
      IF(X.GT.0.)X=X**PH1
      IF(X.LT.FLOW)X=0.
      IF(X.GT.SPILL)X=0.
      XX=XX+SI*BIN*H*(H-1.)*0.5*X
      IF(I.GT.1)FT2=FT2-XX
31    FT=FT+XX
      GO TO 35
32    DO 34 I=1,LIM
      XI=I
      BIN=BIN*(P-XI+1.)/XI
      SI=-SI
      X=ES(I)**PH1
      IF(X.LT.FLOW)X=0.
      IF(X.GT.SPILL)X=0.
      XX=SI*BIN*X
      IF(I.GT.1)FT2=FT2-XX
34    FT=FT+XX
35    FWDU(NP1)=FT
      IF(FT.GT.0.)FT2=FT2/FT
      DBL(NP1)=FT2
      X=1.
      IF(ES(2).GT.0.)X=1.-0.5*ES(2)**PH1
      IF(NH.GT.2)GO TO 33
      EE=E-PAIRC-S
      SV=S+EHOLE(NH+1)
      X=1.
      IF(EE.LE.S)GO TO 33
      X=1.-0.5*((EE-S)/EE)**PH1
      IF(EE.LE.SV)GO TO 33
      X=X-((EE-SV)/EE)**PH1
      SV=SV+S
      IF(EE.LE.SV)GO TO 33
      X=X+0.5*((EE-SV)/EE)**PH1
33    FWDHI(NP1)=X
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.O.)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.O.)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.O.)GO TO 60
      GELU(NP1)=X+(P*(P+1.)+H*(H+1.))/4.
      IF(P.LE.O.)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.O.)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.O)GO TO 61
      DO 64 NP=1,NDWN
      Y=NP
   64 FAC=FAC+ALOG10(Y)
   61 IF(NHDWN.EQ.O)GO TO 63
      DO 65 NP=1,NHDWN
      Y=NP
   65 FAC=FAC+ALOG10(Y)
   63 LIM=NDWN+NHDWN-1
      IF(LIM.EQ.O)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.O)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.O.)GO TO 59
```

```
      RHOL=(PH-1.)*ALOG10(RHOL)
      RHOL=RHOL-FAC
   53 RHOL=(10.**RHOL)*GFPU
   59 P=NDWN
      RHOU(NDWN1)=RHOL*FWDU(NDWN1)*P
      DO 68 NP=NDWN1,NUP
      NP1=NP+1
      P=NP
      NH=NP-NPHD
      H=NH
      FAC=FAC+ALOG10(P)+ALOG10(H)+ALOG10(P+H-1.)+ALOG10(P+H-2.)
      RHOL=GEL(NP1)
      RHOL=(P+H-1.)*ALOG10(RHOL)
      RHOL=RHOL-FAC
      RHO(NP1)=(10.**RHOL)*G
      IF(RHO(NP1).LT.1.)GO TO 69
      IF(NP.GT.30)GO TO 68
      RHOL=GELU(NP1)
      IF(NH.LE.2)RHOL=RHOL*GFU(NH+1)/G
      IF(RHOL.EQ.O.)GO TO 74
      RHOL=(P+H-1.)*ALOG10(RHOL)
      RHOL=RHOL-FAC
      RHOL=(10.**RHOL)*GFPU
   74 RHOU(NP1)=RHOL*FWDU(NP1)*P
   68 CONTINUE
      GO TO 70
   69 NUP=NP-1
   70 DO 72 NP=NDWN1,31
      IF(RHO(NP+1).LT.RHO(NP))GO TO 73
   72 CONTINUE
   73 JBAR=NP-1
      JHI=MINO(20,JBAR)
      JBAR1=JBAR+1
      DO 81 I=1,3
      NP1=I+NPHD
      RHO(NP1)=RHO(NP1)*FWD(I)*GF(I)/G
   81 RHOU(NP1)=RHOU(NP1)*GU(I)/GFPU
      EE=E*1.35/F2
C
C     CALCULATE TRANSITION RATES
C
      DO 79 NP1=NDWN1,JBAR1
      NP=NP1-1
      P=NP
      NH=NP-NPHD
      H=NH
      PH=P+H
      V=38.
      IF(NH.LE.2)V=EHOLE(NH+1)
C
C     PAIR ANNIHILATION
      TLOUB=O.
      TLOBU=O.
      IF(NP.EQ.NDWN)GO TO 76
      TLOUB=GFHU*H*(H-1.)*(1.-DBL(NP1))*CMAT/2.
      TLOBU=GFPU*P*(P-1.)*H*CMAT/2.
      IF(NH.LE.3)TLOBU=TLOBU*GU(NH)/GFPU
      IF(PH.LT.4.)GO TO 71
      TLOBU=TLOBU/2.
      X=GEL(NP1)/G
      IF(NH.LE.2)X=X*G/GF(NH+1)
      XU1=GELU(NP)/G
      XU=GELU(NP1)/G
      XUU1=GELUU(NP)/G
      XUU=GELUU(NP1)/G
      XX=(PH-2.)*(PH-3.)*XU1*XU1-2.*(PH-1.)*(PH-3.)*X*XU1
      XX=XX+(PH-1.)*(PH-2.)*X*X
      IF(NH.LE.2)XX=XX*FWD(NH+1)
      XX=XX*XU1**(PH-3.)
      Y=X**(PH-1.)
      IF(NH.LE.2)Y=Y*FWD(NH+1)
      Y=Y-P*FWDU(NP1)*XU**(PH-1.)
      X=(PH-2.)*(PH-3.)*XUU1*XUU1-2.*(PH-1.)*(PH-3.)*XU*XUU1
      X=X+(PH-1.)*(PH-2.)*XU*XU
      X=X*(P-2.)*FWDU(NP1)*XUU1**(PH-3.)
      FWDUU=1.
      DEN=O.
      ES2=ES(2)
```

```
      IF(NH.GT.2)GO TO 84
      ES2=E-PAIRC-2.*S
      IF(ES2.LE.O.)ES2=O.
      ES2=ES2/(ES2+S)
84    IF(ES2.GT.O.)DEN=(P-1.)*ES2**(PH-1.)
      IF(DEN.GT.O.)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.O.)X=O.
      TLOBU=TLOBU*X/Y
71    IF(RHOU(NP1).GT.RHO(NP1))RHOU(NP1)=RHO(NP1)
      IF(RHOU(NP1).GE.RHO(NP1))TLOBU=O.
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=O.
      IF(PH.LE.1.)X=1.
      IF(GELU(NP1).GT.O.)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=O.
      THIUU=THIUU+X*DBL(NP1)
      THIUB=X*(1.-DBL(NP1))
      TNOUB=O.
      THIBB=O.
      THIBU=O.
      TNOBU=O.
      IF(RHOU(NP1).GE.RHO(NP1))GO TO 75
      TEST=O.
      IF(NP.GT.O)GO TO 85
      TEST=(E-EPAIRC-H*V)/P
      IF(NH.LE.2)TEST=(E-PAIRC-V)/P
85    IF(TEST.GT.S)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.O.)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.O.)XX1=O.
      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.O.)XX=XX-P*XX1**(PH-1.)*X
 78   X=(GELUU(NP2)/G)**(PH+1.)
      X=(GELU(NP2)/G)**(PH+1.)-P*X-O.5*XX
      X=X*G*G
      Y=Y-P*YY*FWDU(NP1)
      IF(Y.LE.O.)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.-O.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=O.
      ES2=ES(2)
      IF(NH.GT.2)GO TO 86
      ES2=E-PAIRC-2.*S
      IF(ES2.LE.O.)ES2=O.
      ES2=ES2/(ES2+S)
 86   IF(ES2.GT.O.)DEN=(P-1.)*ES2**(PH-1.)
      IF(DEN.GT.O.)FWDUU=2.*FWDU(NP1)*DBL(NP1)/DEN
      TNOBU=TNOBU+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*2O.)
      DO 80 NP1=NDWN1,JBAR1
      GAMUU(NP1)=GAMUU(NP1)*TAUWM
      IF(GAMUU(NP1).LT.FLOW)GAMUU(NP1)=O.
      IF(GAMUU(NP1).GT.SPILL)GAMUU(NP1)=O.
      GAMUB(NP1)=GAMUB(NP1)*TAUWM
      IF(GAMUB(NP1).LT.FLOW)GAMUB(NP1)=O.
      IF(GAMUB(NP1).GT.SPILL)GAMUB(NP1)=O.
      GAMZUB(NP1)=GAMZUB(NP1)*TAUWM
      IF(GAMZUB(NP1).LT.FLOW)GAMZUB(NP1)=O.
      IF(GAMZUB(NP1).GT.SPILL)GAMZUB(NP1)=O.
      GAMBU(NP1)=GAMBU(NP1)*TAUWM
      IF(GAMBU(NP1).LT.FLOW)GAMBU(NP1)=O.
      IF(GAMBU(NP1).GT.SPILL)GAMBU(NP1)=O.
      GAMBB(NP1)=GAMBB(NP1)*TAUWM
      IF(GAMBB(NP1).LT.FLOW)GAMBB(NP1)=O.
      IF(GAMBB(NP1).GT.SPILL)GAMBB(NP1)=O.
      GAMZBU(NP1)=GAMZBU(NP1)*TAUWM
      IF(GAMZBU(NP1).LT.FLOW)GAMZBU(NP1)=O.
      IF(GAMZBU(NP1).GT.SPILL)GAMZBU(NP1)=O.
```

```
 80     CONTINUE
        ACUBE=ACOM*ACOM*ACOM
        TWOPI=1.05E-12
        TAUWM=TAUWM*TWOPI*ACUBE/1.35
C
C       CALCULATE FISSION RATES
C
        IF(GFIS.EQ.O.)GFIS=G
        FISHW=O.
        IF(BF.EQ.O.)GO TO 136
        E=E-EPAIRC
        NFISH=E-BF+1.
        AFISH=1.645*GFIS
        ASP=1.645*G
        REF=SQRT(ASP*E)
        DO 134 K=1,NFISH
        XK1=K-1
        EX=(E-BF-XK1)*AFISH
        IF(EX.LE.O.)EX=O.
        EX=SQRT(EX)
        EX=2.*(EX-REF)
        EX=E*EXP(EX)/(E-BF-XK1)
        IF(EX.LT.FLOW)EX=O.
        IF(EX.GT.SPILL)EX=O.
 134    FISHW=FISHW+EX
 136    FISHW=FISHW*2.42E+08
        E=E+EPAIRC
C
C       CALCULATE PROBABILITY FACTORS AND EMISSION RATES
C
        JNOUT=1
        JPOUT=O
        JOUT=1
        JHALF=1
        NSD=2
        BEN=BNEU
        GR=GNEU
        EPAIR=EPAIRN
        PAIR=PAIRN
        GO TO 550
 150    IF(JPOUT.EQ.1)GO TO 152
        IF(JPOUT.EQ.2)GO TO 154
        NLOE=NAP1
        JNOUT=O
        JPOUT=1
        BEN=BPRO
        GR=GPRO
        EPAIR=EPAIRP
        PAIR=PAIRP
        GO TO 550
 152    NLOE=MINO(NLOE,NAP1)
        JNOUT=2
        JPOUT=2
        JOUT=4
        NSD=1
        BEN=BALFA
        GR=GALFA
        EPAIR=EPAIRA
        PAIR=PAIRA
        GO TO 550
C
C       CALCULATE FRACTIONAL STRENGTH LOSSES
C
 154    DO 156 NP1=1,31
 156    FRAC(NP1)=O.
        DO 158 NP=NLOE,JBAR
        NP1=NP+1
        DO 158 NE=2,NEPS1
        WNP=WU(1,NP,NE)+WU(2,NP,NE)+WU(3,NP,NE)
 158    FRAC(NP1)=FRAC(NP1)+WNP*(EPS(1,NE+1)-EPS(1,NE-1))/2.
        DO 186 NP1=NDWN1,JBAR1
        YU=GAMUU(NP1)+GAMUB(NP1)+FRAC(NP1)
        XU=YU+GAMZUB(NP1)
        YB=GAMBB(NP1)+GAMBU(NP1)
        XB=YB+GAMZBU(NP1)
        IF(XU.LE.O.)GO TO 164
        XU=1./XU
```

```
      GAMUU(NP1)=GAMUU(NP1)*XU
      GAMUB(NP1)=GAMUB(NP1)*XU
      GAMZUB(NP1)=GAMZUB(NP1)*XU
      GAMZBU(NP1)=GAMZBU(NP1)/(XU*YU)
      FRAC(NP1)=FRAC(NP1)*XU
164   TAUWU(NP1)=XU
      IF(XB.LE.O.)GO TO 186
      XB=1./XB
      GAMBB(NP1)=GAMBB(NP1)*XB
      GAMBU(NP1)=GAMBU(NP1)*XB
      GAMZBU(NP1)=GAMZBU(NP1)*XB
      GAMZUB(NP1)=GAMZUB(NP1)/(XB*YB)
186   CONTINUE
      WRITE(IWRI,185)
185   FORMAT(1H1)
C
C     CLOSED FORM CALCULATIONS
C
      USED=O.
      PU=RHOU(NPART+1)/RHO(NPART+1)
      IF(PU.GT.1.)PU=1.
      PMSD=PU
      PB=1.-PU
      IF(NPART.EQ.NDWN)GO TO 202
      DO 208 NP1=1,NPART
      RATIO(NP1,1)=O.
      RATIO(NP1,2)=O.
      CLOSU(NP1)=O.
208   CLOSD(NP1)=O.
202   DO 204 NP=NPART,JBAR
      NP1=NP+1
      RATIO(NP1,1)=PU/(PU+PB)
      RATIO(NP1,2)=PMSD/(PU+PB)
      STRU=PU+PB*GAMZBU(NP1)
      STRB=PB+PU*GAMZUB(NP1)
      CLOSD(NP1)=PMSD*TAUWU(NP1)
      CLOSU(NP1)=STRU*TAUWU(NP1)
      USED=USED+PMSD*FRAC(NP1)
      PMSD=PMSD*GAMUU(NP1)
      IF(PMSD.LT.O.OO1)PMSD=O.
      IF(PMSD.GT.SPILL)PMSD=O.
      PU=STRU*GAMUU(NP1)+STRB*GAMBU(NP1)
      IF(PU.LT.FLOW)PU=O.
      IF(PU.GT.SPILL)PU=O.
      PB=STRB*GAMBB(NP1)+STRU*GAMUB(NP1)
      IF(PB.LT.FLOW)PB=O.
      IF(PB.GT.SPILL)PB=O.
204   CONTINUE
      PTOT=PU+PB
      TWEIS=O.
      DO 272 NE=2,NEPS1
      EINT=(EPS(1,NE+1)-EPS(1,NE-1))/2.
      DO 272 KP=1,3
272   TWEIS=TWEIS+WEISS(KP,NE)*EINT
      TWEIS=TWEIS+FISHW
      FWEIS=PTOT/TWEIS
C
C     PRINT OCCUPATION PROBABILITIES
C
      JRZ=RZZ+O.5
      JRN=RNN+O.5
      WRITE(IWRI,351)S
351   FORMAT(3H-S=,1F7.2,4H MEV)
      WRITE(IWRI,352)NPART,NHOLE
352   FORMAT(30H-OCCUPATION PROBABILITIES  PO=,1I2,5H, HO=,1I2)
      WRITE(IWRI,353)JRZ,JRN,JPIN,JNIN
353   FORMAT(11H TARGET  Z=,1I3,4H, N=,1I3,12H    PROJ  Z=,1I3,4H, N=,1I
     13)
      WRITE(IWRI,354)G,E
354   FORMAT(3H G=,1F6.3,4H, E=,1F6.3)
      PTOT=1.-PTOT
      WRITE(IWRI,355)F2,PTOT
355   FORMAT(14H SCALE FACTOR=,1F8.3,13H, FRAC PREEQ=,1F6.3)
      WRITE(IWRI,360)
360   FORMAT(41H- P  H   RHOU/RHO    STRU/STR    STRD/STR)
      WRITE(IWRI,361)
361   FORMAT(1H )
      DO 364 NP1=NDWN1,JBAR1
```

```
      NP=NP1-1
      NH=NP-NPHD
      X=RHOU(NP1)/RHO(NP1)
      Y=RATIO(NP1,1)
      Z=RATIO(NP1,2)
      WRITE(IWRI,362)NP,NH,X,Y,Z
  362 FORMAT(2I3,8(1PE12.3))
  364 CONTINUE
C
C     PRINT PARTICLE SPECTRA
C
      JPOUT=0
      JNOUT=1
      JOUT=1
      NSD=2
      BEN=BNEU
      KP=1
  450 NEPS1=NEPS(JHALF)+1
      IF(JOUT.GT.1)GO TO 451
      NI=NLOE
      IF(PROB(KP,NI).EQ.O.)NI=NI+1
  451 WRITE(IWRI,454)JPOUT,JNOUT
  454 FORMAT(21H1PARTICLE SPECTRA  Z=,1I2,4H, N=,1I2)
      WRITE(IWRI,456)NI
  456 FORMAT(21H FIRST EMISSION AT P=,1I2)
      WRITE(IWRI,353)JRZ,JRN,JPIN,JNIN
      WRITE(IWRI,458)NPART,NHOLE,G,E
  458 FORMAT(4H PO=,1I2,5H, HO=,1I2,4H, G=,1F6.3,4H, E=,1F6.3)
      IF(IG.EQ.O)WRITE(IWRI,457)
  457 FORMAT(37H PAIR EXCIT. ACCORDING TO Z/A AND N/A)
      IF(IG.GT.O)WRITE(IWRI,459)
  459 FORMAT(47H PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES)
      WRITE(IWRI,460)SIGCN
  460 FORMAT(25H REACTION CROSS SECTION =,1F7.1)
      WRITE(IWRI,355)F2,PTOT
      X=RHOU(NPART+1)/RHO(NPART+1)
      WRITE(IWRI,462)X,USED
  462 FORMAT(14H MSD POSSIBLE=,1F6.3,7H, USED=,1F6.3)
      NIC=MAXO(NI,NPART)
      WRITE(IWRI,470)NIC
  470 FORMAT(29H CLOSED FORM SUM STARTS AT P=,1I2)
      WRITE(IWRI,474)
  474 FORMAT(86H- EPS --       DIRECT        --    PREEQUILIBRIUM    --  EQ
     1UIL   --         TOTAL   (MB/MEV))
      WRITE(IWRI,476)
  476 FORMAT(6X,87H--  NUTRA      KNOCK  --    MSD         MSC    --  WEISS
     1  --    MSD         MSC      MSD+MSC)
      WRITE(IWRI,477)
  477 FORMAT(1H )
      SUMNU=O.
      SUMKE=O.
      SUMSD=O.
      SUMSC=O.
      SUMW=O.
C
C     DIRECT REACTION CALCULATIONS
      DO 471 NE=1,51
      SNUTRA(NE)=O.
  471 SNOCK(NE)=O.
      IF(JIN.GT.4) GO TO 473
      IF(JOUT.EQ.JIN)GO TO 472
      CALL NUTRA
      IF(JHALF.EQ.1)CALL KNOCK
      GO TO 473
  472 IF(JPOUT.EQ.JPIN)CALL INEL
      IF(JHALF.EQ.2)CALL NUTRA
  473 SIGCN=SIGCN*O.95
      IF(JIN.GT.1)SIGCN=SIGCN*O.89
      DO 480 NE=2,NEPS1
      PRMSD=O.
      PRET2=O.
      DO 466 NP=NIC,JBAR
      NP1=NP+1
      X=WU(KP,NP,NE)
      PRMSD=PRMSD+X*CLOSD(NP1)
  466 PRET2=PRET2+X*CLOSU(NP1)
      PRMSD=PRMSD*SIGCN
      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.O.)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.O.)GO TO 483
      FISBO=O.
      FISSD=O.
      FISCL=O.
      FISMA=O.
      FISHW=FISHW*SIGCN*FWEIS
      WRITE(IWRI,490)FISBO,FISSD,FISCL,FISMA,FISHW
  490 FORMAT(6H-FISS.,6(1PE11.3))
  483 SIGCN=SIGCN/O.95
      IF(JIN.GT.1)SIGCN=SIGCN/O.89
C
C     CALCULATE AND PRINT ANGULAR DISTRIBUTIONS
      CALL ANGEL
C
      IF(JPOUT.GT.O)GO TO 484
      JPOUT=1
      JNOUT=O
      JOUT=1
      BEN=BPRO
      KP=2
      JHALF=1
      GO TO 450
  484 IF(JNOUT.GT.O)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.O)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.O)NEPS(2)=1
      NEPS1=NEPS(2)+1
      IF(EPS(2,2).LE.O.)GO TO 510
      IF(DELTA(2).LE.O.)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
```

```
      GO TO 512
  510 DO 506 NE=2,NEPS1
      READ(IREA,3)EPS(2,NE),SIGIN(4,NE)
  506 CONTINUE
  512 EPS(2,1)=EPS(2,2)-1.
      IF(EPS(2,1).LT.0.)EPS(2,1)=0.
      EPS(2,NEPS1+1)=EPS(2,NEPS1)+1.
      XOUT=JOUT
      XPOUT=JPOUT
      ATHRD=(ACOM-XOUT)**0.33
      COUL(4)=0.75*XPOUT*(RZZ+XPIN-XPOUT)/ATHRD
      SIGBAR(4)=0.
      ESUM(4)=0.
      DO 508 NE=2,NEPS1
      IF(EPS(2,NE).LT.COUL(4))GO TO 508
      EINT=(EPS(2,NE+1)-EPS(2,NE-1))/2.
      ESUM(4)=ESUM(4)+EINT
      SIGBAR(4)=SIGBAR(4)+SIGIN(4,NE)*EINT
  508 CONTINUE
      SIGBAR(4)=SIGBAR(4)/ESUM(4)
      JHALF=2
C
C     CALCULATE PROBABILITY FACTORS
C
  550 JTA=JPOUT+JNIN
      JTB=JNOUT+JPIN
      JLO=MAXO(JIN,JOUT,JTA,JTB)
      KP=2+JHALF
      IF(JOUT.EQ.1)KP=JPOUT+1
      IF(IG.EQ.1)GO TO 551
C
C     1.  PROB. FROM Z/A AND N/A
      JPOF=1
      IF(JPOUT.LT.2)GO TO 524
      DO 522 J=2,JPOUT
  522 JPOF=JPOF*J
  524 XPOF=JPOF
      JNOF=1
      IF(JNOUT.LT.2)GO TO 528
      DO 526 J=2,JNOUT
  526 JNOF=JNOF*J
  528 XNOF=JNOF
      APFAC=1.
      DO 529 N=1,JOUT
      X=N
  529 APFAC=APFAC*X
      XPOUT=JPOUT
      XNOUT=JNOUT
      CONEW=(RZ**XPOUT)*(RN**XNOUT)
      CONEW=XPOF*XNOF/(APFAC*CONEW)
      DO 532 J=2,NPART
      JJ=J-1
  532 PROB(KP,JJ)=1.
      DO 548 J=NPART,JHI
      XJ=J
      PROB(KP,J)=0.
      IF(J.LT.JOUT)GO TO 548
      XSUM=0.
      JMAX=J-JIN
      XNORM=1.
      DO 530 I=1,JOUT
      XI=I
  530 XNORM=XNORM*(XJ-XI+1.)/XI
      XMAX=JMAX
      JMAX1=JMAX+1
      DO 546 I2=1,JMAX1
      I=I2-1
      XI=I
      JP=JPIN+I
      JN=JNIN+JMAX-I
      JP1=JP+1
      JN1=JN+1
      PROBI=1.
      IF(I.EQ.0)GO TO 536
      DO 534 II=1,I
      XII=II
  534 PROBI=PROBI*(XMAX-XII+1.)/XII
  536 PROBI=PROBI*(RZ**XI)*(RN**(XMAX-XI))
```

```
      XSUM=XSUM+PROBI
      PROBI=PROBI/(XPOF*XNOF)
      IF(JP.LT.JPOUT)GO TO 546
      IF(JN.LT.JNOUT)GO TO 546
      IF(JPOUT.EQ.0)GO TO 540
      DO 538 II=1,JPOUT
      X=JP1-II
538   PROBI=PROBI*X
540   IF(JNOUT.EQ.0)GO TO 544
      DO 542 II=1,JNOUT
      X=JN1-II
542   PROBI=PROBI*X
544   PROB(KP,J)=PROB(KP,J)+PROBI
546   CONTINUE
      PROB(KP,J)=PROB(KP,J)*CONEW
      PROB(KP,J)=PROB(KP,J)/(XNORM*XSUM)
548   CONTINUE
      GO TO 575
C
C     2.  PROB. FROM AVAILABLE PHASE SPACE (GADIOLI)
551   JPLO=MAX0(JPIN,JPOUT)
      JNLO=MAX0(JNIN,JNOUT)
      XPOUT=JPOUT
      XNOUT=JNOUT
      XOUT=JOUT
      XPFAC=1.
      XHFAC=1.
      DO 552 J=2,NPART
      JJ=J-1
      XJJ=JJ
      XPFAC=XPFAC*XJJ
552   PROB(KP,JJ)=1.
      IF(NHOLE.LT.2)GO TO 556
      DO 554 J=2,NHOLE
      XJ=J-1
554   XHFAC=XHFAC*XJ
556   DO 574 JP=NPART,JHI
      XP=JP
      PROB(KP,JP)=0.
      IF(JP.LT.JOUT)GO TO 574
      XPFAC=XPFAC*XP
      XH=JP-NPHD
      XHFAC=XHFAC*XH
      XNORM=XPFAC*XHFAC
      XNUM=XHFAC
      IMAX=JP-JOUT
      IF(IMAX.LT.2) GO TO 559
      DO 558 I=2,IMAX
      XI=I
558   XNUM=XNUM*XI
559   SUMN=0.
      SUMD=0.
      JPMAX=JP-JNIN
      DO 572 JPPI=JPIN,JPMAX
      JPNU=JP-JPPI
      JHPI=JPPI-JPIN
      JHNU=JPNU-JNIN
      XPI=JPPI+JHPI
      XNU=JPNU+JHNU
      FACN=1.
      IF(JHPI.LT.2)GO TO 561
      DO 560 I=2,JHPI
      XI=I
560   FACN=FACN*XI
561   IF(JHNU.LT.2)GO TO 563
      DO 562 I=2,JHNU
      XI=I
562   FACN=FACN*XI
563   FACD=FACN
      IF(JPPI.LT.2)GO TO 565
      DO 564 I=2,JPPI
      XI=I
564   FACD=FACD*XI
565   IF(JPNU.LT.2)GO TO 567
      DO 566 I=2,JPNU
      XI=I
566   FACD=FACD*XI
567   FACD=XNORM/FACD
```

```
      FACD=FACD*RZ**XPI*RN**XNU
      SUMD=SUMD+FACD
      IF(JPPI.LT.JPLO)GO TO 572
      IF(JPNU.LT.JNLO)GO TO 572
      IMAX=JPPI-JPOUT
      IF(IMAX.LT.2)GO TO 569
      DO 568 I=2,IMAX
      XI=I
568   FACN=FACN*XI
569   IMAX=JPNU-JNOUT
      IF(IMAX.LT.2)GO TO 571
      DO 570 I=2,IMAX
      XI=I
570   FACN=FACN*XI
571   FACN=XNUM/FACN
      FACN=FACN*RZ**(XPI-XPOUT)*RN**(XNU-XNOUT)
      SUMN=SUMN+FACN
572   CONTINUE
      IF(SUMD.GT.O.)PROB(KP,JP)=SUMN/SUMD
574   CONTINUE
575   AP=JOUT
      IF(JHI.GE.JBAR)GO TO 620
      JHI1=JHI+1
      DO 582 J=JHI1,JBAR
582   PROB(KP,J)=1.
C
C     CALCULATE EMISSION RATES
C
620   SD=NSD
      CNNE=0.85
      IF(JOUT.EQ.1)CNNE=0.95
      REL=SD*AP*372000. *CNNE
      IF(GR.EQ.O.)GR=G*(ACOM-AP)/ACOM
      ASPR=1.645*GR
      NAP1=MAXO(JLO,NDWN)-1
606   NAP1=NAP1+1
      NTEST=2*NAP1-NPHD
      IF(NTEST.LT.JOUT+1)GO TO 606
      REF=SQRT(1.645*SIZE)
      DO 612 NE=2,NEPS1
      U=E-EPAIR-BEN-EPS(JHALF,NE)
      DO 602 NP=1,30
602   WU(KP,NP,NE)=O.
      WEISS(KP,NE)=O.
      IF(U.LE.O.)GO TO 612
      QUO=U/(E-EPAIRC)
      PROD=EPS(JHALF,NE)*SIGIN(KP,NE)*REL
      PREX=PROD/QUO
      EX=SQRT(ASPR*U)
      EX=2.*(EX-REF)
      WEISS(KP,NE)=PREX*EXP(EX)
      IF(WEISS(KP,NE).LT.FLOW)WEISS(KP,NE)=O.
      IF(WEISS(KP,NE).GT.SPILL)WEISS(KP,NE)=O.
      FAC=1.
      IT=JOUT+3
      IF(NAP1.LT.IT)GO TO 601
      DO 600 I=IT,NAP1
      Y=I-JOUT-1
600   FAC=FAC*Y
601   NH=NAP1-NPHD
      IF(NH.LT.3)GO TO 604
      DO 603 I=3,NH
      Y=I-1
603   FAC=FAC*Y
604   NPH=NAP1+NH
      IT=JOUT+5
      IF(NPH.LT.IT)GO TO 607
      DO 605 I=IT,NPH
      Y=I-JOUT-3
605   FAC=FAC*Y
607   FAC=ALOG10(FAC)
      AP2=JOUT+2
      DO 622 NP=NAP1,JBAR
      NP1=NP+1
      P=NP
      IF(NP.EQ.JOUT)GO TO 608
      FAC=FAC+ALOG10(P-AP)
608   H=NP-NPHD
```

```
      IF(H.EQ.O.)GO TO 609
      FAC=FAC+ALOG10(H)
609   PH=P+H
      IF(PH.LE.AP2)GO TO 610
      FAC=FAC+ALOG10(PH-AP-1.)+ALOG10(PH-AP-2.)
610   PTT=P-AP
      Q=AMAX1(PTT,H)
      RHOL=GR*U-Q*Q
      IF(NH.LE.2)RHOL=GR*(U+EPAIR-PAIR)-Q*Q
      IF(RHOL.GE.O.)GO TO 611
      RHOL=O.
      GO TO 613
611   RHOL=RHOL+(PTT*(PTT+1.)+H*(H+1.))/4.
      RHOL=(PH-AP-1.)*ALOG10(RHOL)
      RHOL=RHOL-FAC
      RHOL=(10.**RHOL)*GR
      IF(RHOL.LE.1.)RHOL=O.
      IF(RHOL.GT.POUR)RHOL=O.
      IF(H.LE.O.)GO TO 613
      IF(H.GT.2.)GO TO 613
      I=NP-NPHD+1
      UU=U+EPAIR-PAIR
      IF(UU.LE.EHOLE(I))GO TO 613
      X=(UU-EHOLE(I))/UU
      X=H*X**(PH-AP-1.)
      Y=O.
      EH2=EHOLE(I)+EHOLE(I)
      IF(UU.LE.EH2)GO TO 614
      Y=(UU-EH2)/UU
      Y=0.5*H*(H-1.)*Y**(PH-AP-1.)
614   RHOL=RHOL*(1.-X+Y)
613   WR=RHOL*PROD*PROB(KP,NP)*TAUWM
      X=O.
      IF(RHOU(NP1).GT.O.)X=WR/RHOU(NP1)
      IF(X.LT.FLOW)X=O.
      IF(X.GT.SPILL)X=O.
      WU(KP,NP,NE)=X
622   CONTINUE
612   CONTINUE
      IF(JHALF.EQ.1)GO TO 150
      NI=NAP1
      GO TO 450
1000  CALL EXIT
C
C     HALLELUJAH
C
      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=,1I2,4H  N=,1I2)
      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
```

```
      I=J+10
      SIG=0.
      DO 32 L=1,7
   32 SIG=SIG+B(L)*POL(I,L)
      SIGMA(J)=SIG*AOMSD
      SIG=0.
      DO 34 LL=1,4
      L=2*LL-1
   34 SIG=SIG+B(L)*POL(I,L)
   36 SIGMA(J)=SIGMA(J)+SIG*AOMSC
      WRITE(IWRI,26)EPS(JHALF,NE),(SIGMA(I),I=1,9),TOTAL
   38 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CROSS
C
C     CALCULATE OPTICAL MODEL REACTION CROSS SECTIONS
C     WITH EMPIRICAL PARAMETERIZATION OF
C     NARASIMHA MURTHY, CHATTERJEE, AND GUPTA
C
C     PARAMETER VALUES SET IN SUBROUTINE SIGPAR
C
      COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNOUT,JPOUT
      COMMON /DIRECT/ SIGIN(4,51),JPIN,JNIN,BEA,NSD,KP,E,ACOM,G,RZZ
      COMMON /PAR/ P0(3,3),P1(3,3),P2(3,3),XL0(3,3),XL1(3,3),XM0(3,3)
     1,XM1(3,3),XN0(3,3),XN1(3,3),XN2(3,3)
      FLOW=1.E-18
      SPILL=1.E+18
      JOUT=JPOUT+JNOUT
      XOUT=JOUT
      ATAR=ACOM-XOUT
      ATHRD=ATAR**0.333
      IF(JPOUT.GT.0.)GO TO 2
      XLAMB=XL0(1,2)/ATHRD+XL1(1,2)
      XMU=XM0(1,2)*ATHRD+XM1(1,2)*ATHRD*ATHRD
      XNU=XN0(1,2)*ATHRD*ATAR+XN1(1,2)*ATHRD*ATHRD+XN2(1,2)
      EC=2.4
      P=P0(1,2)
      NCOU=2
      ETEST=32.
      GO TO 3
    2 RA=1.20
      IF(JOUT.EQ.1)RA=0.
      XPOUT=JPOUT
      RZ=JPIN-JPOUT
      RZ=RZ+RZZ
      EC=1.44*XPOUT*RZ/(1.5*ATHRD+RA)
      I=JPOUT+1
      J=JNOUT+1
      P=P0(I,J)+P1(I,J)/EC+P2(I,J)/(EC*EC)
      XLAMB=XL0(I,J)*ATAR+XL1(I,J)
      A=ATAR**XM1(I,J)
      XMU=XM0(I,J)*A
      XNU=A*(XN0(I,J)+XN1(I,J)*EC+XN2(I,J)*EC*EC)
      IF(JOUT.EQ.2)RA=0.8
      IF(JOUT.EQ.3)RA=0.8
      XNL=XNU/XLAMB
      IF(XNL.GT.SPILL)XNL=0.
      IF(XNL.LT.FLOW)GO TO 3
      ETEST=1.2*SQRT(XNL)
    3 A=-2.*P*EC+XLAMB-XNU/(EC*EC)
      B=P*EC*EC+XMU+2.*XNU/EC
      ECUT=0.
      CUT=A*A-4.*P*B
      IF(CUT.GT.0.)ECUT=SQRT(CUT)
      ECUT=(ECUT-A)/(2.*P)
      DO 4 NE=2,NEPS1
      IF(EPS(JHALF,NE).GT.EC)GO TO 6
    4 CONTINUE
    6 NCOU=NE
      IF(NCOU.LT.3)GO TO 10
      NC=NCOU-1
      DO 8 NE=2,NC
      ELAB=EPS(JHALF,NE)*ACOM/ATAR
      SIGIN(KP,NE)=P*ELAB*ELAB+A*ELAB+B
```

```
8     IF(ELAB.LT.ECUT)SIGIN(KP,NE)=0.
10    DO 12 NE=NCOU,NEPS1
      ELAB=EPS(JHALF,NE)*ACOM/ATAR
      SIG=XLAMB*ELAB+XMU+XNU/ELAB
      GEOM=0.
      IF(XNL.LT.FLOW)GO TO 12
      IF(ELAB.LT.ETEST)GO TO 12
      GEOM=SQRT(XOUT*EPS(JHALF,NE))
      GEOM=1.23*ATHRD+RA+4.573/GEOM
      GEOM=31.416*GEOM*GEOM
12    SIGIN(KP,NE)=AMAX1(GEOM,SIG)
      RETURN
      END


      SUBROUTINE INEL
C
C     PHENOMENOLOGICAL ENERGY SPECTRA
C     INELASTIC SCATTERING
C     (RXN MUST INVOLVE AT LEAST ONE COMPLEX PARTICLE)
C     FEBRUARY 1980
C
      COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNOUT,JPOUT
      COMMON /DIRECT/ SIGIN(4,51),JPIN,JNIN,BEA,NSD,KP,E,ACOM,G,RZZ
      COMMON /CLUSTR/ SNOCK(51),SIGBAR(5),SIGCN,COUL(5),BNEU,BPRO,BALFA
      XPIN=JPIN
      XNIN=JNIN
      JIN=JPIN+JNIN
      XIN=JIN
      ATARG=ACOM-XIN
      RNN=ATARG-RZZ
C
C     CALCULATE NORMALIZATION
C
      XNOR=JIN*NSD
      XNORM=XNOR*SIGCN/16.
C
C     1. PROJECTILE=EJECTILE DENOMINATOR
      XNOR=XNOR*SIGBAR(KP)/6.
      COUP=COUL(KP)
      EMAX=E-BEN
      XNOR=XNOR*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
      IF(JIN.GT.1)GO TO 2
      GBA=(RZZ-1.)/13.
      IF(JNIN.EQ.1)GBA=(RNN-1.)/13.
      GO TO 10
2     IF(JIN-3)4,5,6
4     GBN=(ACOM-1.)/52.
      GBA=(ACOM-4.)/52.
      GO TO 8
5     GBN=(ACOM-1.)/156.
      GBA=(ACOM-4.)/156.
      GO TO 8
6     GBN=(ACOM-1.)/208.
      GBA=(ACOM-4.)/208.
C
C     2. NEUTRON EXCITATION
8     GII=(RNN+XNIN-1.)/13.
      GIR=RNN/13.
      P=RNN/ATARG
      XNORI=2.*SIGBAR(1)*GII*GBN/6.
      EMAX=E-BNEU
      COUP=COUL(1)
      XNORI=XNORI*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
      XNORB=XNOR*GIR*GIR
      XN=GIR*GIR*P/(XNORI+XNORB)
      EPN=1./GIR
      UADN=1./GIR
C
C     3. PROTON EXCITATION
      GII=(RZZ+XPIN-1.)/13.
      GIR=RZZ/13.
      P=RZZ/ATARG
      XNORI=2.*SIGBAR(2)*GII*GBN/6.
      EMAX=E-BPRO
      COUP=COUL(2)
      XNORI=XNORI*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
      XNORB=XNOR*GIR*GIR
      XP=GIR*GIR*P/(XNORI+XNORB)
```

```
      EPP=1./GIR
      UADP=1./GIR
C
C     4. ALPHA EXCITATION
   10 GII=(ACOM-4.)/208.
      GIR=ATARG/208.
      P=0.08*RZZ/(2.*ATARG)
      IF(RNN.LE.116.)GO TO 14
      IF(RNN.GE.129.)GO TO 14
      IF(RNN-126.)12,12,13
   12 Y=0.02+0.06*(126.-RNN)/10.
      P=P*Y/0.08
      GO TO 14
   13 Y=0.02+0.06*(RNN-126.)/3.
      P=P*Y/0.08
   14 XNORI=4.*SIGBAR(3)*GII*GBA/6.
      EMAX=E-BALFA
      COUP=COUL(3)
      XNORI=XNORI*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
      XNORB=XNOR*GIR*GIR
      XA=GIR*GIR*P/(XNORI+XNORB)
      EPA=52./RZZ+52./RNN
      UADA=1./GIR
C
C     CALCULATE ENERGY SPECTRUM
C
      UMAX=E-BEN
      FLOW=1.E-18
      SPILL=1.E+18
      DO 16 NE=2,NEPS1
      U=UMAX-EPS(JHALF,NE)
      IF(U.LE.0.)GO TO 18
      X=0.
      IF(JIN.LE.1)GO TO 22
      UN=U-EPN
      IF(UN.LE.0.)GO TO 20
      UN=UN+UADN
      X=X+XN*UN
   20 UP=U-EPP
      IF(UP.LE.0.)GO TO 22
      UP=UP+UADP
      X=X+XP*UP
   22 UA=U-EPA
      IF(UA.LE.0.)GO TO 24
      UA=UA+UADA
      X=X+XA*UA
   24 SIG=XNORM*EPS(JHALF,NE)*SIGIN(KP,NE)*X
      IF(SIG.LT.FLOW)SIG=0.
      IF(SIG.GT.SPILL)SIG=0.
   16 SNOCK(NE)=SIG
   18 RETURN
      END
```

```
      SUBROUTINE KNOCK
C
C     PHENOMENOLOGICAL ENERGY SPECTRA
C     KNOCKOUT OF N, P, OR ALPHA
C     (RXN MUST HAVE AT LEAST ONE COMPLEX PARTICLE)
C     FEBRUARY 1980
C
      COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNOUT,JPOUT
      COMMON /DIRECT/ SIGIN(4,51),JPIN,JNIN,BEA,NSD,KP,E,ACOM,G,RZZ
      COMMON /CLUSTR/ SNOCK(51),SIGBAR(5),SIGCN,COUL(5),BNEU,BPRO,BALFA
      JIN=JPIN+JNIN
      XIN=JIN
      XPIN=JPIN
      XNIN=JNIN
      JOUT=JPOUT+JNOUT
      XOUT=JOUT
      XPOUT=JPOUT
      XNOUT=JNOUT
      ATARG=ACOM-XIN
      RNN=ATARG-RZZ
      ARES=ACOM-XOUT
```

```
C
C     CALCULATE S. P. STATE DENSITIES
C     AND (2S+1)*A TYPE FACTORS
C
      IF(JIN.GT.1)GO TO 2
      REL=2.
      GA=(RZZ+1.-XPOUT)/13.
      IF(JNIN.EQ.1)GA=(RNN+1.-XNOUT)/13.
      GO TO 8
2     IF(JIN-3)4,5,6
4     REL=6.
      GA=ARES/52.
      GO TO 8
5     REL=6.
      GA=ARES/156.
      GO TO 8
6     REL=4.
      GA=ARES/208.
8     IF(JOUT.GT.1)GO TO 10
      GBT=RZZ/13.
      GBR=(RZZ+XPIN-1.)/13.
      IF(JNOUT.EQ.0)GO TO 12
      GBT=RNN/13.
      GBR=(RNN+XNIN-1.)/13.
      GO TO 12
10    GBT=ATARG/208.
      GBR=ARES/208.
C
C     CALCULATE NORMALIZATION
C
12    XNORM=SIGCN/16.
      XNORB=JOUT*NSD
      XNORM=XNORM*XNORB
      XNORB=XNORB*SIGBAR(KP)*GA*GBR/6.
      EMAX=E-BEN
      COUP=COUL(KP)
      XNORB=XNORB*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
      XNORA=REL*SIGBAR(5)*GBT*GBT/6.
      EMAX=E-BEA
      COUP=COUL(5)
      XNORA=XNORA*(EMAX+2.*COUP)*(EMAX-COUP)*(EMAX-COUP)
      XNORM=XNORM*GA*GBR/(XNORA+XNORB)
      IF(JPOUT-1)14,15,16
14    XNORM=XNORM*(1.-RZZ/ATARG)
      GO TO 20
15    XNORM=XNORM*RZZ/ATARG
      GO TO 20
16    XNORM=XNORM*0.08*RZZ/(2.*ATARG)
      IF(RNN.LE.116.)GO TO 20
      IF(RNN.GE.129.)GO TO 20
      IF(RNN-126.)18,18,19
18    X=0.02+0.06*(126.-RNN)/10.
      XNORM=XNORM*X/0.08
      GO TO 20
19    X=0.02+0.06*(RNN-126.)/3.
      XNORM=XNORM*X/0.08
C
C     CALCULATE ENERGY SPECTRUM
C
20    FLOW=1.E-18
      SPILL=1.E+18
      UMAX=E-BEN
      Q=JPIN+JPOUT
      UPAUL=Q*Q*13./(RZZ+XPIN-XPOUT)
      Q=JNIN+JNOUT
      UPAUL=UPAUL+Q*Q*13./(RNN+XNIN-XNOUT)
      UADD=0.5/GBR+0.5/GA
      DO 22 NE=2,NEPS1
      U=UMAX-EPS(1,NE)
      U=U-UPAUL
      IF(U.LT.0.)GO TO 24
      U=U+UADD
      SIG=XNORM*U*EPS(1,NE)*SIGIN(KP,NE)
      IF(SIG.LT.FLOW)SIG=0.
      IF(SIG.GT.SPILL)SIG=0.
22    SNOCK(NE)=SIG
24    RETURN
      END
```

```
      SUBROUTINE NUTRA
C
C     PHENOMENOLOGICAL ENERGY SPECTRA
C     NUCLEON TRANSFER
C     PROGRAM - FEBRUARY 1979
C     SUBROUTINE (SIMPLIFIED) - FEBRUARY 1980
C
      COMMON /ENERGY/ BEN,NEPS1,EPS(2,52),JHALF,JNOUT,JPOUT
      COMMON /DIRECT/ SIGIN(4,51),JPIN,JNIN,BEA,NSD,KP,E,ACOM,G,RZZ
      COMMON /NUTRAN/ SNUTRA(51)
      FLOW=1.E-18
      SPILL=1.E+18
      JIN=JNIN+JPIN
      XIN=JIN
      JOUT=JNOUT+JPOUT
      XOUT=JOUT
      ATARG=ACOM-XIN
      ECOM=E-BEA
      ELABI=ECOM*ACOM/ATARG
      ARES=ACOM-XOUT
      UMAX=E-BEN
      VAB=0.25*50.*XIN
      KAB=1.
      IF(JHALF.EQ.2)GO TO 2
      IF(JIN.EQ.2)GO TO 2
      IF(JIN.EQ.3)GO TO 2
      KAB=12.
    2 VELO=XIN/(ELABI+VAB)
      X=JOUT*NSD
      X=X*KAB
      Y=6.
      IF(JIN.EQ.1)Y=2.
      IF(JIN.EQ.4)Y=4.
      XHOLD=0.0127*X/(Y*ECOM*XIN)
      TRANP=IABS(JPOUT-JPIN)
      ZA=2.*RZZ/ATARG
      TRANN=IABS(JNOUT-JNIN)
      PH=TRANN+TRANP
      NEX=0
      IF (PH .GT. 0.) GO TO 5
      NEX=1.
      PH=2.
      TRANP=2.
    5 X=XHOLD*(2860./ARES)**PH
      X=X*VELO**(2.*PH)
      X=X*ZA**(6.*TRANP)
      JP=JPIN-JPOUT
      Y=JP
      GP=(RZZ+Y)/13.
      JN=JNIN-JNOUT
      Y=JN
      RNN=ATARG-RZZ
      GN=(RNN+Y)/13.
      X=X*(GP**TRANP)*(GN**TRANN)
      JPICKP=MAX0(JP,0)
      IF(JPICKP.LT.2)GO TO 6
      DO 4 N=2,JPICKP
      Y=N
    4 X=X/Y
    6 JSTRIP=JPICKP-JP
      IF(JSTRIP.LT.2)GO TO 10
      DO 8 N=2,JSTRIP
      Y=N
    8 X=X/Y
   10 JPICKN=MAX0(JN,0)
      IF(JPICKN.LT.2)GO TO 14
      DO 12 N=2,JPICKN
      Y=N
   12 X=X/Y
   14 JSTRIN=JPICKN-JN
      IF(JSTRIN.LT.2)GO TO 18
      DO 16 N=2,JSTRIN
      Y=N
   16 X=X/Y
   18 J=JPICKP+JPICKN
      IF (NEX .GT. 0) J=1
      H=J
      JMAX=JSTRIP+JSTRIN
      IF (NEX .GT. 0)JMAX=1
      P=JMAX
```

```
      IMAX=PH
      GR=ARES/13.
      W=0.
      FAC=1.
      DO 20 I=1,IMAX
      XI=I
   20 IF(I.GT.1)X=X/(XI-1.)
      PPI=JSTRIP
      PNU=JSTRIN
      HPI=JPICKP
      HNU=JPICKN
      Q=AMAX1(PNU,HNU)
      UMAX=UMAX-Q*Q/GN
      Q=AMAX1(PPI,HPI)
      UMAX=UMAX-Q*Q/GP
      UADD=(PNU*(PNU+1.)+HNU*(HNU+1.))/(4.*GN)
      UADD=UADD+(PPI*(PPI+1.)+HPI*(HPI+1.))/(4.*GP)
      DO 40 NE=2,NEPS1
      U=UMAX-EPS(JHALF,NE)
      IF(U.LT.0.)GO TO 40
      U=U+UADD
      W=X*U**(PH-1.)
      SIG=W*EPS(JHALF,NE)*SIGIN(KP,NE)
      IF(SIG.LT.FLOW)SIG=0.
      IF(SIG.GT.SPILL)SIG=0.
      SNUTRA(NE)=SIG+SNUTRA(NE)
   40 CONTINUE
      IF (NEX .NE. 1) GO TO 42
      NEX=2
      TRANP=0.
      TRANN=2.
      GO TO 5
   42 RETURN
      END
```

```
      SUBROUTINE POLLY
C
C     GENERATE LIBRARY OF LEGENDRE POLYNOMIALS
C
      COMMON /ANGELS/ POL(19,7),TOMSD(51),TOMSC(51),IWRI,IANG
      DO 4 J=1,19
      ANG=(J-1)*10
      ANG=ANG*3.1413/180.
      COSX=COS(ANG)
      COSX2=COSX*COSX
      COSX3=COSX*COSX2
      COSX4=COSX*COSX3
      COSX5=COSX*COSX4
      COSX6=COSX*COSX5
      POL(J,1)=1.
      POL(J,2)=COSX
      POL(J,3)=(3.*COSX2-1.)/2.
      POL(J,4)=(5.*COSX3-3.*COSX)/2.
      POL(J,5)=(35.*COSX4-30.*COSX2+3.)/8.
      POL(J,6)=(63.*COSX5-70.*COSX3+15.*COSX)/8.
      POL(J,7)=(231.*COSX6-315.*COSX4+105.*COSX2-5.)/16.
    4 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SIGPAR
C
C     STORE PARAMETERS FOR CALCULATING APPROXIMATE
C     OPTICAL MODEL REACTION CROSS SECTIONS
C
C     NEUTRON FROM MANI ET AL
C     PROTON FROM BECCHETTI-GREENLEES
C     ALPHA FROM HUIZENGA AND IGO
C     D FROM O.M. OF PEREY AND PEREY
C     T FROM O.M. OF HAFELE, FLYNN ET AL
C     3HE FROM O.M. OF GIBSON ET AL
```

```
C
      COMMON /PAR/ PO(3,3),P1(3,3),P2(3,3),XLO(3,3),XL1(3,3),XMO(3,3)
     1,XM1(3,3),XNO(3,3),XN1(3,3),XN2(3,3)
      DO 2 I=1,3
      DO 2 J=1,3
      PO(I,J)=O.
      P1(I,J)=O.
      P2(I,J)=O.
      XLO(I,J)=O.
      XL1(I,J)=O.
      XMO(I,J)=O.
      XM1(I,J)=O.
      XNO(I,J)=O.
      XN1(I,J)=O.
    2 XN2(I,J)=O.
      PO(1,2)=-312.
      PO(2,1)=15.72
      PO(2,2)=0.798
      PO(2,3)=-21.45
      PO(3,2)=-2.88
      PO(3,3)=10.95
      P1(2,1)=9.65
      P1(2,2)=420.3
      P1(2,3)=484.7
      P1(3,2)=205.6
      P1(3,3)=-85.21
      P2(2,1)=-449.
      P2(2,2)=-1651.
      P2(2,3)=-1608.
      P2(3,2)=-1487.
      P2(3,3)=1146.
      XLO(1,2)=12.10
      XLO(2,1)=0.00437
      XLO(2,2)=0.00619
      XLO(2,3)=0.0186
      XLO(3,2)=0.00459
      XLO(3,3)=0.0643
      XL1(1,2)=-11.27
      XL1(2,1)=-16.58
      XL1(2,2)=-7.54
      XL1(2,3)=-8.90
      XL1(3,2)=-8.93
      XL1(3,3)=-13.96
      XMO(1,2)=234.1
      XMO(2,1)=244.7
      XMO(2,2)=583.5
      XMO(2,3)=686.3
      XMO(3,2)=611.2
      XMO(3,3)=781.2
      XM1(1,2)=38.26
      XM1(2,1)=0.503
      XM1(2,2)=0.337
      XM1(2,3)=0.325
      XM1(3,2)=0.35
      XM1(3,3)=0.29
      XNO(1,2)=1.55
      XNO(2,1)=273.1
      XNO(2,2)=421.8
      XNO(2,3)=368.9
      XNO(3,2)=473.8
      XNO(3,3)=-304.7
      XN1(1,2)=-106.1
      XN1(2,1)=-182.4
      XN1(2,2)=-474.5
      XN1(2,3)=-522.2
      XN1(3,2)=-468.2
      XN1(3,3)=-470.
      XN2(1,2)=1280.8
      XN2(2,1)=-1.872
      XN2(2,2)=-3.592
      XN2(2,3)=-4.998
      XN2(3,2)=-2.225
      XN2(3,3)=-8.582
      RETURN
      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+B.E.
CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
1.00	4.63E-01	4.57E-01	4.42E-01	4.20E-01	3.93E-01	3.64E-01	3.38E-01	3.18E-01	3.04E-01	2.99E-01
2.00	1.20E+00	1.19E+00	1.15E+00	1.09E+00	1.01E+00	9.36E-01	8.65E-01	8.08E-01	7.71E-01	7.57E-01
3.00	9.38E-01	9.27E-01	8.93E-01	8.43E-01	7.82E-01	7.19E-01	6.61E-01	6.15E-01	5.84E-01	5.72E-01
4.00	6.70E-01	6.62E-01	6.37E-01	5.99E-01	5.53E-01	5.06E-01	4.62E-01	4.27E-01	4.04E-01	3.94E-01
5.00	4.78E-01	4.71E-01	4.52E-01	4.24E-01	3.90E-01	3.54E-01	3.21E-01	2.95E-01	2.77E-01	2.69E-01
6.00	3.35E-01	3.30E-01	3.16E-01	2.95E-01	2.69E-01	2.43E-01	2.19E-01	1.99E-01	1.85E-01	1.78E-01
7.00	2.32E-01	2.28E-01	2.18E-01	2.02E-01	1.84E-01	1.64E-01	1.46E-01	1.31E-01	1.20E-01	1.14E-01
8.00	1.62E-01	1.59E-01	1.52E-01	1.40E-01	1.27E-01	1.12E-01	9.83E-02	8.68E-02	7.81E-02	7.28E-02
9.00	1.18E-01	1.16E-01	1.10E-01	1.01E-01	9.01E-02	7.88E-02	6.82E-02	5.90E-02	5.18E-02	4.71E-02
10.00	8.97E-02	8.80E-02	8.33E-02	7.61E-02	6.75E-02	5.83E-02	4.96E-02	4.20E-02	3.59E-02	3.16E-02
12.00	6.00E-02	5.87E-02	5.53E-02	5.00E-02	4.37E-02	3.70E-02	3.06E-02	2.49E-02	2.02E-02	1.66E-02
14.00	4.16E-02	4.07E-02	3.81E-02	3.42E-02	2.95E-02	2.46E-02	1.99E-02	1.58E-02	1.24E-02	9.76E-03
16.00	2.21E-02	2.15E-02	2.01E-02	1.79E-02	1.53E-02	1.26E-02	1.00E-02	7.80E-03	5.98E-03	4.58E-03

- EPS	100	110	120	130	140	150	160	170	180	TOTAL
1.00	3.03E-01	3.16E-01	3.36E-01	3.61E-01	3.89E-01	4.15E-01	4.37E-01	4.52E-01	4.57E-01	4.41E+00
2.00	7.68E-01	8.01E-01	8.55E-01	9.23E-01	9.97E-01	1.07E+00	1.13E+00	1.17E+00	1.18E+00	1.13E+01
3.00	5.80E-01	6.06E-01	6.49E-01	7.02E-01	7.62E-01	8.19E-01	8.66E-01	8.98E-01	9.09E-01	8.62E+00
4.00	3.99E-01	4.17E-01	4.48E-01	4.86E-01	5.29E-01	5.70E-01	6.05E-01	6.28E-01	6.36E-01	6.00E+00
5.00	2.71E-01	2.83E-01	3.04E-01	3.31E-01	3.61E-01	3.90E-01	4.15E-01	4.31E-01	4.37E-01	4.14E+00
6.00	1.78E-01	1.86E-01	1.99E-01	2.17E-01	2.37E-01	2.57E-01	2.73E-01	2.85E-01	2.88E-01	2.77E+00
7.00	1.13E-01	1.17E-01	1.25E-01	1.36E-01	1.49E-01	1.61E-01	1.72E-01	1.79E-01	1.81E-01	1.81E+00
8.00	7.10E-02	7.23E-02	7.64E-02	8.26E-02	8.99E-02	9.72E-02	1.04E-01	1.08E-01	1.09E-01	1.17E+00
9.00	4.46E-02	4.44E-02	4.60E-02	4.90E-02	5.29E-02	5.69E-02	6.04E-02	6.28E-02	6.37E-02	7.66E-01
10.00	2.89E-02	2.78E-02	2.79E-02	2.90E-02	3.08E-02	3.28E-02	3.45E-02	3.58E-02	3.62E-02	5.22E-01
12.00	1.41E-02	1.23E-02	1.13E-02	1.09E-02	1.08E-02	1.10E-02	1.12E-02	1.14E-02	1.15E-02	2.85E-01
14.00	7.77E-03	6.35E-03	5.36E-03	4.71E-03	4.29E-03	4.03E-03	3.89E-03	3.83E-03	3.81E-03	1.74E-01
16.00	3.53E-03	2.77E-03	2.23E-03	1.85E-03	1.59E-03	1.41E-03	1.29E-03	1.22E-03	1.20E-03	8.51E-02

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

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

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	2.68E-01	2.66E-01	2.61E-01	2.52E-01	2.41E-01	2.30E-01	2.19E-01	2.11E-01	2.05E-01	2.03E-01
3.00	2.28E+00	2.26E+00	2.21E+00	2.13E+00	2.03E+00	1.93E+00	1.84E+00	1.76E+00	1.71E+00	1.70E+00
4.00	6.46E+00	6.41E+00	6.25E+00	6.02E+00	5.73E+00	5.43E+00	5.15E+00	4.93E+00	4.79E+00	4.74E+00
5.00	1.05E+01	1.04E+01	1.01E+01	9.71E+00	9.23E+00	8.72E+00	8.25E+00	7.87E+00	7.63E+00	7.54E+00
6.00	1.20E+01	1.19E+01	1.16E+01	1.11E+01	1.05E+01	9.88E+00	9.32E+00	8.87E+00	8.58E+00	8.48E+00
7.00	1.09E+01	1.08E+01	1.05E+01	1.00E+01	9.48E+00	8.90E+00	8.37E+00	7.94E+00	7.66E+00	7.56E+00
8.00	8.64E+00	8.55E+00	8.29E+00	7.91E+00	7.45E+00	6.97E+00	6.53E+00	6.17E+00	5.94E+00	5.86E+00
9.00	6.35E+00	6.28E+00	6.09E+00	5.79E+00	5.44E+00	5.07E+00	4.72E+00	4.45E+00	4.28E+00	4.21E+00
10.00	4.45E+00	4.40E+00	4.26E+00	4.04E+00	3.78E+00	3.51E+00	3.26E+00	3.06E+00	2.93E+00	2.88E+00
12.00	1.99E+00	1.97E+00	1.90E+00	1.79E+00	1.66E+00	1.53E+00	1.41E+00	1.31E+00	1.24E+00	1.22E+00
14.00	8.20E-01	8.08E-01	7.76E-01	7.28E-01	6.69E-01	6.09E-01	5.53E-01	5.07E-01	4.77E-01	4.63E-01
16.00	3.38E-01	3.33E-01	3.18E-01	2.96E-01	2.69E-01	2.41E-01	2.14E-01	1.92E-01	1.77E-01	1.68E-01
20.00	1.00E-01	9.84E-02	9.28E-02	8.44E-02	7.42E-02	6.34E-02	5.30E-02	4.39E-02	3.64E-02	3.08E-02
24.00	6.13E-02	5.99E-02	5.59E-02	5.00E-02	4.30E-02	3.56E-02	2.86E-02	2.24E-02	1.73E-02	1.34E-02
26.00	5.84E-02	5.70E-02	5.30E-02	4.71E-02	4.00E-02	3.27E-02	2.58E-02	1.99E-02	1.51E-02	1.14E-02

- EPS	100	110	120	130	140	150	160	170	180	TOTAL
2.00	2.05E-01	2.11E-01	2.19E-01	2.30E-01	2.41E-01	2.52E-01	2.61E-01	2.66E-01	2.68E-01	2.82E+00
3.00	1.71E+00	1.76E+00	1.84E+00	1.93E+00	2.03E+00	2.13E+00	2.21E+00	2.26E+00	2.28E+00	2.37E+01
4.00	4.79E+00	4.93E+00	5.15E+00	5.43E+00	5.73E+00	6.01E+00	6.25E+00	6.41E+00	6.46E+00	6.66E+01
5.00	7.62E+00	7.87E+00	8.24E+00	8.71E+00	9.22E+00	9.70E+00	1.01E+01	1.04E+01	1.05E+01	1.07E+02
6.00	8.57E+00	8.86E+00	9.31E+00	9.87E+00	1.05E+01	1.11E+01	1.15E+01	1.19E+01	1.20E+01	1.21E+02
7.00	7.66E+00	7.93E+00	8.36E+00	8.89E+00	9.47E+00	1.00E+01	1.05E+01	1.08E+01	1.09E+01	1.09E+02
8.00	5.94E+00	6.16E+00	6.51E+00	6.95E+00	7.43E+00	7.89E+00	8.27E+00	8.52E+00	8.61E+00	8.49E+01
9.00	4.27E+00	4.44E+00	4.71E+00	5.04E+00	5.41E+00	5.76E+00	6.05E+00	6.24E+00	6.31E+00	6.16E+01
10.00	2.92E+00	3.04E+00	3.24E+00	3.48E+00	3.75E+00	4.00E+00	4.22E+00	4.36E+00	4.41E+00	4.25E+01
12.00	1.24E+00	1.29E+00	1.38E+00	1.50E+00	1.63E+00	1.75E+00	1.85E+00	1.92E+00	1.94E+00	1.84E+01
14.00	4.68E-01	4.89E-01	5.26E-01	5.73E-01	6.25E-01	6.76E-01	7.18E-01	7.47E-01	7.57E-01	7.14E+00
16.00	1.67E-01	1.73E-01	1.85E-01	2.01E-01	2.20E-01	2.38E-01	2.54E-01	2.64E-01	2.68E-01	2.66E+00
20.00	2.69E-02	2.45E-02	2.35E-02	2.34E-02	2.40E-02	2.49E-02	2.58E-02	2.65E-02	2.67E-02	5.18E-01
24.00	1.04E-02	8.26E-03	6.70E-03	5.61E-03	4.84E-03	4.32E-03	3.98E-03	3.80E-03	3.74E-03	2.43E-01
26.00	8.67E-03	6.69E-03	5.26E-03	4.24E-03	3.50E-03	2.99E-03	2.64E-03	2.44E-03	2.38E-03	2.17E-01

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

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

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

- EPS	0	10	20	30	40	50	60	70	80	90
5.00	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	8.16E+00
7.00	4.09E-01	3.61E-01	3.28E-01	3.09E-01	2.98E-01	2.94E-01	2.93E-01	2.94E-01	2.94E-01	7.53E+00
8.00	3.65E-01	3.15E-01	2.80E-01	2.58E-01	2.44E-01	2.36E-01	2.33E-01	2.31E-01	2.31E-01	6.94E+00
9.00	3.26E-01	2.76E-01	2.41E-01	2.17E-01	2.01E-01	1.92E-01	1.86E-01	1.83E-01	1.83E-01	6.39E+00
10.00	2.90E-01	2.42E-01	2.07E-01	1.83E-01	1.67E-01	1.56E-01	1.50E-01	1.47E-01	1.46E-01	5.85E+00
12.00	2.26E-01	1.84E-01	1.53E-01	1.31E-01	1.16E-01	1.06E-01	9.93E-02	9.57E-02	9.45E-02	4.83E+00
14.00	1.66E-01	1.32E-01	1.08E-01	9.01E-02	7.78E-02	6.94E-02	6.39E-02	6.08E-02	5.98E-02	3.77E+00
16.00	1.06E-01	8.28E-02	6.62E-02	5.44E-02	4.61E-02	4.04E-02	3.66E-02	3.44E-02	3.38E-02	2.56E+00

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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
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- 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+B.E.
CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
2.00	1.86E-01	1.85E-01	1.80E-01	1.74E-01	1.66E-01	1.58E-01	1.50E-01	1.44E-01	1.40E-01	1.38E-01
3.00	1.62E+00	1.61E+00	1.57E+00	1.51E+00	1.44E+00	1.36E+00	1.29E+00	1.23E+00	1.19E+00	1.17E+00
4.00	4.78E+00	4.74E+00	4.62E+00	4.44E+00	4.21E+00	3.97E+00	3.75E+00	3.56E+00	3.43E+00	3.36E+00
5.00	8.14E+00	8.06E+00	7.84E+00	7.51E+00	7.10E+00	6.67E+00	6.26E+00	5.91E+00	5.67E+00	5.53E+00
6.00	9.94E+00	9.84E+00	9.56E+00	9.12E+00	8.59E+00	8.02E+00	7.48E+00	7.03E+00	6.69E+00	6.50E+00
7.00	9.87E+00	9.77E+00	9.46E+00	9.00E+00	8.43E+00	7.83E+00	7.25E+00	6.76E+00	6.38E+00	6.16E+00
8.00	8.78E+00	8.68E+00	8.39E+00	7.95E+00	7.41E+00	6.83E+00	6.28E+00	5.79E+00	5.42E+00	5.17E+00
9.00	7.52E+00	7.43E+00	7.17E+00	6.76E+00	6.27E+00	5.73E+00	5.22E+00	4.76E+00	4.40E+00	4.15E+00
10.00	6.43E+00	6.34E+00	6.10E+00	5.73E+00	5.28E+00	4.79E+00	4.31E+00	3.88E+00	3.54E+00	3.29E+00
12.00	4.94E+00	4.87E+00	4.66E+00	4.34E+00	3.94E+00	3.51E+00	3.09E+00	2.71E+00	2.39E+00	2.14E+00
14.00	4.11E+00	4.05E+00	3.85E+00	3.56E+00	3.20E+00	2.81E+00	2.42E+00	2.07E+00	1.77E+00	1.52E+00
16.00	3.65E+00	3.59E+00	3.40E+00	3.12E+00	2.78E+00	2.41E+00	2.04E+00	1.71E+00	1.42E+00	1.19E+00
20.00	2.88E+00	2.82E+00	2.66E+00	2.41E+00	2.11E+00	1.78E+00	1.47E+00	1.19E+00	9.54E-01	7.62E-01
24.00	1.86E+00	1.82E+00	1.70E+00	1.52E+00	1.31E+00	1.08E+00	8.68E-01	6.80E-01	5.26E-01	4.06E-01
26.00	1.15E+00	1.13E+00	1.05E+00	9.30E-01	7.91E-01	6.46E-01	5.11E-01	3.94E-01	2.99E-01	2.27E-01

- EPS	100	110	120	130	140	150	160	170	180	TOTAL
2.00	1.38E-01	1.41E-01	1.46E-01	1.53E-01	1.60E-01	1.67E-01	1.72E-01	1.76E-01	1.77E-01	1.91E+00
3.00	1.18E+00	1.20E+00	1.25E+00	1.30E+00	1.37E+00	1.43E+00	1.48E+00	1.51E+00	1.52E+00	1.64E+01
4.00	3.37E+00	3.44E+00	3.57E+00	3.73E+00	3.92E+00	4.10E+00	4.25E+00	4.35E+00	4.39E+00	4.73E+01
5.00	5.53E+00	5.64E+00	5.84E+00	6.12E+00	6.44E+00	6.74E+00	7.00E+00	7.17E+00	7.22E+00	7.84E+01
6.00	6.46E+00	6.57E+00	6.81E+00	7.13E+00	7.50E+00	7.86E+00	8.17E+00	8.37E+00	8.44E+00	9.27E+01
7.00	6.09E+00	6.16E+00	6.36E+00	6.65E+00	7.00E+00	7.33E+00	7.62E+00	7.81E+00	7.88E+00	8.85E+01
8.00	5.07E+00	5.10E+00	5.24E+00	5.46E+00	5.73E+00	6.00E+00	6.23E+00	6.39E+00	6.44E+00	7.50E+01
9.00	4.02E+00	4.00E+00	4.08E+00	4.23E+00	4.42E+00	4.62E+00	4.79E+00	4.91E+00	4.95E+00	6.07E+01
10.00	3.13E+00	3.08E+00	3.10E+00	3.19E+00	3.31E+00	3.44E+00	3.56E+00	3.64E+00	3.67E+00	4.85E+01
12.00	1.96E+00	1.85E+00	1.81E+00	1.80E+00	1.83E+00	1.88E+00	1.92E+00	1.95E+00	1.96E+00	3.22E+01
14.00	1.34E+00	1.21E+00	1.12E+00	1.08E+00	1.06E+00	1.05E+00	1.06E+00	1.07E+00	1.07E+00	2.35E+01
16.00	1.00E+00	8.70E-01	7.75E-01	7.11E-01	6.71E-01	6.48E-01	6.36E-01	6.31E-01	6.29E-01	1.88E+01
20.00	6.14E-01	5.03E-01	4.21E-01	3.63E-01	3.22E-01	2.94E-01	2.76E-01	2.66E-01	2.63E-01	1.28E+01
24.00	3.15E-01	2.48E-01	2.00E-01	1.65E-01	1.41E-01	1.24E-01	1.13E-01	1.07E-01	1.05E-01	7.37E+00
26.00	1.73E-01	1.34E-01	1.06E-01	8.65E-02	7.26E-02	6.30E-02	5.67E-02	5.31E-02	5.19E-02	4.31E+00

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

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

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

- EPS	0	10	20	30	40	50	60	70	80	90
5.00	9.70E-03	9.60E-03	9.31E-03	8.87E-03	8.34E-03	7.78E-03	7.26E-03	6.84E-03	6.56E-03	6.45E-03
6.00	9.32E-02	9.21E-02	8.92E-02	8.47E-02	7.94E-02	7.37E-02	6.85E-02	6.42E-02	6.13E-02	6.01E-02
7.00	3.60E-01	3.55E-01	3.43E-01	3.25E-01	3.03E-01	2.80E-01	2.59E-01	2.41E-01	2.29E-01	2.24E-01
8.00	6.32E-01	6.24E-01	6.02E-01	5.68E-01	5.27E-01	4.85E-01	4.44E-01	4.11E-01	3.88E-01	3.77E-01
9.00	7.18E-01	7.08E-01	6.81E-01	6.41E-01	5.92E-01	5.40E-01	4.91E-01	4.51E-01	4.22E-01	4.06E-01
10.00	6.43E-01	6.34E-01	6.08E-01	5.70E-01	5.23E-01	4.73E-01	4.27E-01	3.87E-01	3.58E-01	3.41E-01
12.00	4.44E-01	4.37E-01	4.17E-01	3.87E-01	3.50E-01	3.11E-01	2.74E-01	2.42E-01	2.16E-01	1.99E-01
14.00	3.04E-01	2.99E-01	2.83E-01	2.60E-01	2.32E-01	2.02E-01	1.73E-01	1.48E-01	1.27E-01	1.11E-01
16.00	2.09E-01	2.05E-01	1.93E-01	1.76E-01	1.55E-01	1.33E-01	1.11E-01	9.18E-02	7.58E-02	6.33E-02
20.00	6.12E-02	5.98E-02	5.60E-02	5.02E-02	4.33E-02	3.61E-02	2.92E-02	2.31E-02	1.81E-02	1.42E-02
24.00	2.49E-05	2.44E-05	2.28E-05	2.04E-05	1.76E-05	1.48E-05	1.23E-05	1.04E-05	9.25E-06	8.85E-06

- EPS	100	110	120	130	140	150	160	170	180	TOTAL
5.00	6.51E-03	6.73E-03	7.10E-03	7.56E-03	8.07E-03	8.56E-03	8.97E-03	9.24E-03	9.33E-03	9.36E-02
6.00	6.06E-02	6.27E-02	6.62E-02	7.07E-02	7.57E-02	8.05E-02	8.45E-02	8.71E-02	8.80E-02	8.80E-01
7.00	2.25E-01	2.33E-01	2.46E-01	2.63E-01	2.83E-01	3.01E-01	3.17E-01	3.27E-01	3.31E-01	3.31E+00
8.00	3.77E-01	3.90E-01	4.12E-01	4.42E-01	4.75E-01	5.07E-01	5.34E-01	5.52E-01	5.58E-01	5.62E+00
9.00	4.04E-01	4.16E-01	4.39E-01	4.70E-01	5.06E-01	5.41E-01	5.70E-01	5.90E-01	5.97E-01	6.12E+00
10.00	3.36E-01	3.44E-01	3.61E-01	3.86E-01	4.15E-01	4.44E-01	4.68E-01	4.85E-01	4.90E-01	5.20E+00
12.00	1.90E-01	1.89E-01	1.94E-01	2.05E-01	2.18E-01	2.32E-01	2.44E-01	2.53E-01	2.56E-01	3.11E+00
14.00	1.01E-01	9.54E-02	9.40E-02	9.57E-02	9.94E-02	1.04E-01	1.08E-01	1.11E-01	1.12E-01	1.79E+00
16.00	5.42E-02	4.82E-02	4.46E-02	4.29E-02	4.26E-02	4.31E-02	4.39E-02	4.45E-02	4.48E-02	1.05E+00
20.00	1.12E-02	9.13E-03	7.65E-03	6.64E-03	5.98E-03	5.57E-03	5.33E-03	5.21E-03	5.17E-03	2.53E-01
24.00	9.25E-06	1.04E-05	1.23E-05	1.48E-05	1.76E-05	2.04E-05	2.28E-05	2.44E-05	2.49E-05	1.74E-04

1
-S= 10.28 MEV
-OCCUPATION PROBABILITIES PO= 2, HO= 1
TARGET Z= 26, N= 28 PROJ Z= 1, N= 0
G= 4.231, E=66.000
SCALE FACTOR= 1.350, FRAC PREEQ= 0.916

-	P	H	RHOU/RHO	STRU/STR	STRD/STR
	1	0	1.000E+00	0.	0.
	2	1	1.000E+00	1.000E+00	1.000E+00
	3	2	1.000E+00	1.000E+00	1.000E+00
	4	3	1.000E+00	1.000E+00	1.000E+00
	5	4	9.581E-01	9.387E-01	9.387E-01
	6	5	8.680E-01	8.558E-01	8.151E-01
	7	6	7.513E-01	7.499E-01	6.399E-01
	8	7	6.175E-01	6.154E-01	4.353E-01
	9	8	4.794E-01	4.751E-01	2.442E-01

1PARTICLE SPECTRA Z= 0, N= 1
FIRST EMISSION AT P= 2
TARGET Z= 26, N= 28 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	2.670E-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+B.E.
CROSS SECTIONS IN MB/STR-MEV

- EPS	0	10	20	30	40	50	60	70	80	90
2.00	6.42E-01	6.32E-01	6.05E-01	5.64E-01	5.13E-01	4.58E-01	4.03E-01	3.52E-01	3.09E-01	2.73E-01
4.00	9.83E-01	9.67E-01	9.23E-01	8.54E-01	7.70E-01	6.79E-01	5.88E-01	5.05E-01	4.34E-01	3.75E-01
6.00	1.16E+00	1.14E+00	1.08E+00	9.98E-01	8.92E-01	7.77E-01	6.64E-01	5.60E-01	4.71E-01	3.98E-01
8.00	1.27E+00	1.25E+00	1.18E+00	1.08E+00	9.59E-01	8.26E-01	6.96E-01	5.77E-01	4.76E-01	3.93E-01
10.00	1.36E+00	1.33E+00	1.26E+00	1.14E+00	1.00E+00	8.54E-01	7.09E-01	5.79E-01	4.68E-01	3.79E-01
12.00	1.43E+00	1.40E+00	1.32E+00	1.19E+00	1.04E+00	8.72E-01	7.15E-01	5.74E-01	4.56E-01	3.62E-01
14.00	1.50E+00	1.47E+00	1.37E+00	1.23E+00	1.06E+00	8.86E-01	7.16E-01	5.66E-01	4.42E-01	3.44E-01
16.00	1.53E+00	1.50E+00	1.40E+00	1.24E+00	1.06E+00	8.74E-01	6.96E-01	5.41E-01	4.15E-01	3.17E-01
18.00	1.56E+00	1.52E+00	1.41E+00	1.25E+00	1.05E+00	8.56E-01	6.71E-01	5.13E-01	3.86E-01	2.89E-01
20.00	1.57E+00	1.53E+00	1.42E+00	1.24E+00	1.04E+00	8.32E-01	6.42E-01	4.81E-01	3.55E-01	2.61E-01
22.00	1.59E+00	1.54E+00	1.42E+00	1.23E+00	1.02E+00	8.03E-01	6.08E-01	4.47E-01	3.23E-01	2.32E-01
24.00	1.59E+00	1.54E+00	1.41E+00	1.22E+00	9.92E-01	7.69E-01	5.71E-01	4.11E-01	2.90E-01	2.05E-01
26.00	1.59E+00	1.54E+00	1.40E+00	1.19E+00	9.59E-01	7.30E-01	5.31E-01	3.73E-01	2.57E-01	1.77E-01
28.00	1.58E+00	1.53E+00	1.38E+00	1.16E+00	9.21E-01	6.88E-01	4.88E-01	3.34E-01	2.25E-01	1.52E-01
30.00	1.56E+00	1.51E+00	1.35E+00	1.13E+00	8.77E-01	6.41E-01	4.43E-01	2.95E-01	1.93E-01	1.27E-01
32.00	1.54E+00	1.48E+00	1.31E+00	1.08E+00	8.26E-01	5.89E-01	3.96E-01	2.55E-01	1.62E-01	1.05E-01
34.00	1.50E+00	1.44E+00	1.27E+00	1.03E+00	7.70E-01	5.34E-01	3.48E-01	2.17E-01	1.33E-01	8.44E-02
36.00	1.45E+00	1.38E+00	1.21E+00	9.66E-01	7.06E-01	4.76E-01	2.99E-01	1.79E-01	1.07E-01	6.66E-02
38.00	1.38E+00	1.32E+00	1.14E+00	8.93E-01	6.36E-01	4.14E-01	2.49E-01	1.43E-01	8.25E-02	5.13E-02
40.00	1.30E+00	1.23E+00	1.05E+00	8.08E-01	5.60E-01	3.50E-01	2.01E-01	1.10E-01	6.16E-02	3.86E-02
42.00	1.19E+00	1.12E+00	9.46E-01	7.11E-01	4.76E-01	2.85E-01	1.55E-01	8.02E-02	4.40E-02	2.85E-02
44.00	1.04E+00	9.83E-01	8.18E-01	6.00E-01	3.86E-01	2.19E-01	1.12E-01	5.47E-02	2.99E-02	2.06E-02
46.00	8.66E-01	8.11E-01	6.64E-01	4.73E-01	2.92E-01	1.55E-01	7.29E-02	3.38E-02	1.92E-02	1.45E-02
48.00	6.39E-01	5.95E-01	4.78E-01	3.30E-01	1.93E-01	9.49E-02	4.05E-02	1.79E-02	1.13E-02	9.53E-03
50.00	3.51E-01	3.24E-01	2.56E-01	1.70E-01	9.32E-02	4.15E-02	1.56E-02	6.92E-03	5.32E-03	4.89E-03

- EPS	100	110	120	130	140	150	160	170	180	TOTAL
2.00	2.47E-01	2.29E-01	2.19E-01	2.14E-01	2.13E-01	2.14E-01	2.17E-01	2.19E-01	2.20E-01	4.08E+00
4.00	3.31E-01	2.99E-01	2.78E-01	2.66E-01	2.60E-01	2.58E-01	2.59E-01	2.60E-01	2.60E-01	5.71E+00
6.00	3.41E-01	3.00E-01	2.71E-01	2.53E-01	2.42E-01	2.36E-01	2.34E-01	2.33E-01	2.33E-01	6.21E+00
8.00	3.29E-01	2.81E-01	2.47E-01	2.24E-01	2.09E-01	2.00E-01	1.95E-01	1.93E-01	1.92E-01	6.30E+00
10.00	3.10E-01	2.58E-01	2.21E-01	1.95E-01	1.77E-01	1.65E-01	1.58E-01	1.55E-01	1.54E-01	6.27E+00
12.00	2.89E-01	2.36E-01	1.96E-01	1.69E-01	1.49E-01	1.36E-01	1.28E-01	1.24E-01	1.22E-01	6.20E+00
14.00	2.69E-01	2.15E-01	1.75E-01	1.47E-01	1.27E-01	1.13E-01	1.04E-01	9.94E-02	9.78E-02	6.12E+00
16.00	2.44E-01	1.90E-01	1.52E-01	1.25E-01	1.06E-01	9.24E-02	8.36E-02	7.87E-02	7.71E-02	5.89E+00
18.00	2.18E-01	1.67E-01	1.31E-01	1.06E-01	8.79E-02	7.53E-02	6.69E-02	6.21E-02	6.06E-02	5.65E+00
20.00	1.93E-01	1.46E-01	1.13E-01	8.93E-02	7.27E-02	6.11E-02	5.34E-02	4.89E-02	4.74E-02	5.39E+00
22.00	1.69E-01	1.26E-01	9.57E-02	7.48E-02	5.99E-02	4.94E-02	4.23E-02	3.82E-02	3.68E-02	5.12E+00
24.00	1.46E-01	1.07E-01	8.06E-02	6.22E-02	4.90E-02	3.96E-02	3.32E-02	2.95E-02	2.83E-02	4.83E+00
26.00	1.25E-01	9.02E-02	6.73E-02	5.14E-02	3.99E-02	3.16E-02	2.59E-02	2.25E-02	2.14E-02	4.54E+00
28.00	1.05E-01	7.52E-02	5.58E-02	4.23E-02	3.24E-02	2.50E-02	1.99E-02	1.69E-02	1.59E-02	4.24E+00
30.00	8.69E-02	6.21E-02	4.60E-02	3.47E-02	2.62E-02	1.97E-02	1.51E-02	1.23E-02	1.14E-02	3.93E+00
32.00	7.09E-02	5.08E-02	3.79E-02	2.85E-02	2.11E-02	1.53E-02	1.12E-02	8.74E-03	7.93E-03	3.62E+00
34.00	5.71E-02	4.14E-02	3.12E-02	2.34E-02	1.70E-02	1.18E-02	8.05E-03	5.88E-03	5.17E-03	3.29E+00
36.00	4.54E-02	3.36E-02	2.58E-02	1.93E-02	1.36E-02	8.87E-03	5.53E-03	3.65E-03	3.06E-03	2.97E+00
38.00	3.58E-02	2.74E-02	2.14E-02	1.59E-02	1.08E-02	6.45E-03	3.51E-03	1.98E-03	1.53E-03	2.63E+00
40.00	2.81E-02	2.23E-02	1.77E-02	1.30E-02	8.32E-03	4.42E-03	1.93E-03	8.11E-04	5.37E-04	2.28E+00
42.00	2.19E-02	1.81E-02	1.45E-02	1.04E-02	6.18E-03	2.71E-03	7.55E-04	1.31E-04	6.57E-05	1.93E+00
44.00	1.69E-02	1.44E-02	1.16E-02	8.10E-03	4.29E-03	1.32E-03	-3.81E-05	-9.93E-05	7.20E-05	1.57E+00
46.00	1.25E-02	1.09E-02	8.78E-03	5.90E-03	2.65E-03	2.49E-04	-4.68E-04	3.68E-05	4.42E-04	1.19E+00
48.00	8.42E-03	7.29E-03	5.91E-03	3.82E-03	1.32E-03	-4.23E-04	-5.67E-04	3.60E-04	9.25E-04	8.05E-01
50.00	4.19E-03	3.57E-03	2.95E-03	1.86E-03	3.97E-04	-5.75E-04	-3.89E-04	5.30E-04	1.04E-03	4.02E-01

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

- EPS --	DIRECT	--	PREEQUILIBRIUM	--	EQUIL --	TOTAL (MB/MEV)		
	-- NUTRA	KNOCK --	MSD	MSC --	WEISS --	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	4.01E-01	3.91E-01	3.87E-01	1.58E+01
20.00	7.20E-01	5.89E-01	4.92E-01	4.23E-01	3.73E-01	3.40E-01	3.18E-01	3.06E-01	3.03E-01	1.51E+01
22.00	6.57E-01	5.26E-01	4.31E-01	3.62E-01	3.13E-01	2.79E-01	2.57E-01	2.44E-01	2.40E-01	1.45E+01
24.00	5.92E-01	4.65E-01	3.74E-01	3.08E-01	2.61E-01	2.28E-01	2.07E-01	1.94E-01	1.90E-01	1.39E+01
26.00	5.23E-01	4.04E-01	3.19E-01	2.58E-01	2.15E-01	1.85E-01	1.64E-01	1.53E-01	1.49E-01	1.31E+01
28.00	4.59E-01	3.48E-01	2.71E-01	2.16E-01	1.76E-01	1.49E-01	1.30E-01	1.20E-01	1.16E-01	1.23E+01
30.00	3.98E-01	2.98E-01	2.28E-01	1.79E-01	1.44E-01	1.19E-01	1.03E-01	9.33E-02	9.01E-02	1.15E+01
32.00	3.41E-01	2.51E-01	1.90E-01	1.47E-01	1.17E-01	9.52E-02	8.05E-02	7.19E-02	6.90E-02	1.08E+01
34.00	2.89E-01	2.10E-01	1.57E-01	1.21E-01	9.43E-02	7.53E-02	6.23E-02	5.47E-02	5.21E-02	1.00E+01
36.00	2.41E-01	1.74E-01	1.29E-01	9.81E-02	7.56E-02	5.91E-02	4.77E-02	4.09E-02	3.86E-02	9.23E+00
38.00	1.98E-01	1.42E-01	1.05E-01	7.95E-02	6.04E-02	4.60E-02	3.59E-02	2.99E-02	2.79E-02	8.46E+00
40.00	1.61E-01	1.15E-01	8.53E-02	6.42E-02	4.80E-02	3.55E-02	2.66E-02	2.13E-02	1.95E-02	7.70E+00
42.00	1.28E-01	9.22E-02	6.90E-02	5.19E-02	3.81E-02	2.71E-02	1.92E-02	1.45E-02	1.30E-02	6.93E+00
44.00	1.01E-01	7.37E-02	5.59E-02	4.20E-02	3.00E-02	2.03E-02	1.33E-02	9.29E-03	8.01E-03	6.17E+00
46.00	7.83E-02	5.88E-02	4.54E-02	3.40E-02	2.35E-02	1.48E-02	8.68E-03	5.35E-03	4.34E-03	5.42E+00
48.00	6.15E-02	4.79E-02	3.77E-02	2.79E-02	1.84E-02	1.05E-02	5.20E-03	2.60E-03	1.89E-03	4.76E+00
50.00	4.84E-02	3.92E-02	3.13E-02	2.28E-02	1.41E-02	6.90E-03	2.55E-03	8.20E-04	4.75E-04	4.11E+00
52.00	3.78E-02	3.18E-02	2.56E-02	1.82E-02	1.02E-02	3.90E-03	6.33E-04	-6.53E-05	2.70E-05	3.43E+00
54.00	2.89E-02	2.49E-02	2.02E-02	1.38E-02	6.82E-03	1.48E-03	-5.71E-04	-1.39E-04	4.27E-04	2.73E+00
56.00	2.09E-02	1.81E-02	1.46E-02	9.66E-03	3.89E-03	-2.61E-04	-1.10E-03	3.69E-04	1.36E-03	1.99E+00
58.00	1.27E-02	1.10E-02	8.94E-03	5.70E-03	1.63E-03	-1.14E-03	-1.02E-03	9.79E-04	2.13E-03	1.22E+00
60.00	4.16E-03	3.50E-03	2.98E-03	1.87E-03	2.57E-04	-7.92E-04	-4.36E-04	7.91E-04	1.46E-03	4.04E-01

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1PARTICLE SPECTRA  Z= 2, N= 2
 FIRST EMISSION AT P= 4
 TARGET  Z= 26, N= 28    PROJ  Z=  1, N=  0
 PO= 2, HO= 1, G= 4.231, E=66.000
 PAIR EXCIT. ACCORDING TO 2 COMP. ST. DENSITIES
 REACTION CROSS SECTION =  840.8
 SCALE FACTOR=    1.350, FRAC PREEQ= 0.916
 MSD POSSIBLE= 1.000, USED= 0.882
 CLOSED FORM SUM STARTS AT P= 4
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- EPS --	DIRECT		-- PREEQUILIBRIUM		-- EQUIL --	TOTAL (MB/MEV)		
--	NUTRA	KNOCK	-- MSD	MSC	-- WEISS --	MSD	MSC	MSD+MSC
6.00	3.860E-03	2.125E-04	9.239E-03	1.035E-02	8.395E-02	1.331E-02	9.430E-02	1.076E-01
8.00	3.047E-02	1.743E-03	5.062E-02	5.212E-02	3.665E-01	8.283E-02	4.187E-01	5.015E-01
10.00	8.499E-02	5.057E-03	9.770E-02	9.127E-02	5.601E-01	1.878E-01	6.513E-01	8.391E-01
12.00	1.453E-01	9.007E-03	1.154E-01	9.639E-02	5.192E-01	2.697E-01	6.156E-01	8.853E-01
14.00	1.927E-01	1.247E-02	1.059E-01	7.779E-02	3.698E-01	3.111E-01	4.476E-01	7.587E-01
16.00	2.284E-01	1.546E-02	8.714E-02	5.525E-02	2.328E-01	3.310E-01	2.880E-01	6.190E-01
18.00	2.536E-01	1.799E-02	6.747E-02	3.624E-02	1.356E-01	3.391E-01	1.719E-01	5.109E-01
20.00	2.693E-01	2.007E-02	5.035E-02	2.247E-02	7.468E-02	3.397E-01	9.714E-02	4.369E-01
22.00	2.767E-01	2.171E-02	3.670E-02	1.335E-02	3.926E-02	3.351E-01	5.261E-02	3.877E-01
24.00	2.767E-01	2.293E-02	2.634E-02	7.672E-03	1.982E-02	3.260E-01	2.749E-02	3.534E-01
26.00	2.704E-01	2.373E-02	1.873E-02	4.299E-03	9.634E-03	3.129E-01	1.393E-02	3.268E-01
28.00	2.588E-01	2.414E-02	1.323E-02	2.363E-03	4.515E-03	2.961E-01	6.877E-03	3.030E-01
30.00	2.428E-01	2.416E-02	9.309E-03	1.279E-03	2.040E-03	2.762E-01	3.318E-03	2.796E-01
32.00	2.233E-01	2.380E-02	6.530E-03	6.825E-04	8.872E-04	2.536E-01	1.570E-03	2.552E-01
34.00	2.012E-01	2.309E-02	4.566E-03	3.592E-04	3.709E-04	2.288E-01	7.301E-04	2.295E-01
36.00	1.773E-01	2.203E-02	3.182E-03	1.858E-04	1.486E-04	2.025E-01	3.344E-04	2.028E-01
38.00	1.524E-01	2.063E-02	2.205E-03	9.393E-05	5.679E-05	1.753E-01	1.507E-04	1.754E-01
40.00	1.273E-01	1.891E-02	1.515E-03	4.601E-05	2.060E-05	1.478E-01	6.662E-05	1.478E-01
42.00	1.028E-01	1.688E-02	1.028E-03	2.157E-05	7.046E-06	1.207E-01	2.862E-05	1.207E-01
44.00	7.949E-02	1.456E-02	6.830E-04	9.488E-06	2.250E-06	9.473E-02	1.174E-05	9.475E-02
46.00	5.807E-02	1.195E-02	4.390E-04	3.790E-06	6.618E-07	7.045E-02	4.452E-06	7.046E-02
48.00	3.916E-02	9.068E-03	2.671E-04	1.295E-06	1.761E-07	4.849E-02	1.471E-06	4.849E-02
50.00	2.336E-02	5.929E-03	1.475E-04	3.331E-07	4.125E-08	2.944E-02	3.743E-07	2.944E-02
52.00	1.123E-02	0.	6.745E-05	4.612E-08	8.129E-09	1.130E-02	5.425E-08	1.130E-02
54.00	3.302E-03	0.	1.926E-05	0.	1.243E-09	3.321E-03	1.243E-09	3.321E-03
56.00	0.	0.	0.	0.	1.232E-10	0.	1.232E-10	1.232E-10
OSUMS	7.466E+00	7.311E-01	1.418E+00	9.445E-01	4.839E+00			

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	4.02E-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	9.82E-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	2.167E-01	0.	8.757E-01	5.589E-02	1.353E-01	1.092E+00	1.912E-01	1.284E+00
14.00	2.678E-01	0.	8.531E-01	3.689E-02	7.518E-02	1.121E+00	1.121E-01	1.233E+00
16.00	3.182E-01	0.	8.119E-01	2.328E-02	3.931E-02	1.130E+00	6.259E-02	1.193E+00
18.00	3.678E-01	0.	7.636E-01	1.421E-02	1.955E-02	1.131E+00	3.375E-02	1.165E+00
20.00	4.167E-01	0.	7.140E-01	8.432E-03	9.290E-03	1.131E+00	1.772E-02	1.148E+00
22.00	4.648E-01	0.	6.665E-01	4.873E-03	4.230E-03	1.131E+00	9.104E-03	1.140E+00
24.00	5.121E-01	0.	6.225E-01	2.738E-03	1.846E-03	1.135E+00	4.584E-03	1.139E+00
26.00	5.587E-01	0.	5.829E-01	1.489E-03	7.714E-04	1.142E+00	2.260E-03	1.144E+00
28.00	6.046E-01	0.	5.479E-01	7.783E-04	3.079E-04	1.152E+00	1.086E-03	1.154E+00
30.00	6.497E-01	0.	5.174E-01	3.871E-04	1.169E-04	1.167E+00	5.040E-04	1.168E+00
32.00	6.940E-01	0.	4.915E-01	1.806E-04	4.205E-05	1.185E+00	2.226E-04	1.186E+00
34.00	7.376E-01	0.	4.699E-01	7.746E-05	1.422E-05	1.208E+00	9.168E-05	1.208E+00
36.00	7.804E-01	0.	4.526E-01	2.965E-05	4.476E-06	1.233E+00	3.413E-05	1.233E+00
38.00	8.225E-01	0.	4.396E-01	9.665E-06	1.295E-06	1.262E+00	1.096E-05	1.262E+00
40.00	8.638E-01	0.	4.307E-01	2.478E-06	3.379E-07	1.294E+00	2.816E-06	1.294E+00
42.00	9.044E-01	0.	4.261E-01	4.295E-07	7.728E-08	1.330E+00	5.068E-07	1.330E+00
44.00	9.442E-01	0.	4.259E-01	3.545E-08	1.479E-08	1.370E+00	5.025E-08	1.370E+00
46.00	9.832E-01	0.	4.304E-01	0.	2.179E-09	1.414E+00	2.179E-09	1.414E+00
48.00	1.022E+00	0.	4.400E-01	0.	2.046E-10	1.462E+00	2.046E-10	1.462E+00
OSUMS	2.444E+01	0.	2.605E+01	9.227E-01	2.730E+00			

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	6.86E-03	3.60E-03	1.07E-03	-6.61E-05	-8.63E-05	7.49E-05	1.33E+00
44.00	1.44E-02	1.25E-02	1.01E-02	6.76E-03	3.00E-03	2.26E-04	-5.67E-04	6.43E-05	5.55E-04	1.37E+00
46.00	1.48E-02	1.28E-02	1.04E-02	6.70E-03	2.27E-03	-8.17E-04	-1.02E-03	6.90E-04	1.72E-03	1.41E+00
48.00	1.52E-02	1.29E-02	1.07E-02	6.76E-03	1.38E-03	-2.19E-03	-1.43E-03	2.04E-03	3.96E-03	1.46E+00

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-C3	5.869E-07	1.049E-07	6.599E-02	6.918E-07	6.599E-02
39.00	4.683E-02	0.	2.957E-03	7.914E-08	2.181E-08	4.979E-02	1.009E-07	4.979E-02
41.00	2.992E-02	0.	1.926E-03	2.564E-09	3.606E-09	3.184E-02	6.170E-09	3.184E-02
43.00	1.122E-02	0.	9.170E-04	0.	4.115E-10	1.214E-02	4.115E-10	1.214E-02
45.00	0.	0.	0.	0.	2.313E-11	0.	2.313E-11	2.313E-11
OSUMS	3.024E+00	0.	1.006E+00	1.211E-01	4.083E-01			

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	7.62E-03
15.00	4.41E-02	4.29E-02	3.94E-02	3.44E-02	2.85E-02	2.26E-02	1.72E-02	1.28E-02	9.35E-03	6.88E-03
17.00	4.61E-02	4.48E-02	4.10E-02	3.54E-02	2.90E-02	2.26E-02	1.69E-02	1.22E-02	8.71E-03	6.23E-03
19.00	4.83E-02	4.68E-02	4.25E-02	3.64E-02	2.94E-02	2.25E-02	1.64E-02	1.16E-02	8.07E-03	5.62E-03
21.00	5.03E-02	4.86E-02	4.40E-02	3.72E-02	2.96E-02	2.22E-02	1.58E-02	1.09E-02	7.39E-03	5.02E-03
23.00	5.22E-02	5.03E-02	4.51E-02	3.78E-02	2.95E-02	2.17E-02	1.51E-02	1.01E-02	6.66E-03	4.42E-03
25.00	5.36E-02	5.16E-02	4.59E-02	3.79E-02	2.91E-02	2.09E-02	1.41E-02	9.18E-03	5.87E-03	3.81E-03
27.00	5.45E-02	5.23E-02	4.62E-02	3.76E-02	2.83E-02	1.98E-02	1.30E-02	8.14E-03	5.04E-03	3.21E-03
29.00	5.47E-02	5.24E-02	4.58E-02	3.67E-02	2.70E-02	1.83E-02	1.16E-02	7.01E-03	4.21E-03	2.64E-03
31.00	5.40E-02	5.15E-02	4.46E-02	3.51E-02	2.52E-02	1.65E-02	1.00E-02	5.82E-03	3.38E-03	2.10E-03
33.00	5.20E-02	4.94E-02	4.23E-02	3.27E-02	2.28E-02	1.44E-02	8.36E-03	4.62E-03	2.61E-03	1.63E-03
35.00	4.85E-02	4.59E-02	3.89E-02	2.94E-02	1.98E-02	1.20E-02	6.60E-03	3.47E-03	1.91E-03	1.22E-03
37.00	4.32E-02	4.07E-02	3.39E-02	2.50E-02	1.63E-02	9.35E-03	4.83E-03	2.40E-03	1.31E-03	8.88E-04
39.00	3.55E-02	3.32E-02	2.73E-02	1.96E-02	1.22E-02	6.59E-03	3.16E-03	1.48E-03	8.31E-04	6.14E-04
41.00	2.48E-02	2.31E-02	1.86E-02	1.30E-02	7.67E-03	3.85E-03	1.68E-03	7.51E-04	4.58E-04	3.78E-04
43.00	1.04E-02	9.59E-03	7.60E-03	5.09E-03	2.84E-03	1.29E-03	5.03E-04	2.21E-04	1.61E-04	1.46E-04
45.00	1.09E-11	1.00E-11	7.73E-12	4.95E-12	2.58E-12	1.09E-12	4.29E-13	2.63E-13	2.75E-13	2.94E-13

- EPS	100	110	120	130	140	150	160	170	180	TOTAL
3.00	4.64E-04	4.62E-04	4.80E-04	5.14E-04	5.56E-04	6.00E-04	6.38E-04	6.64E-04	6.73E-04	8.05E-03
5.00	5.92E-03	5.76E-03	5.90E-03	6.25E-03	6.74E-03	7.27E-03	7.74E-03	8.06E-03	8.18E-03	1.09E-01
7.00	8.37E-03	7.89E-03	7.87E-03	8.21E-03	8.77E-03	9.41E-03	1.00E-02	1.04E-02	1.06E-02	1.66E-01
9.00	7.94E-03	7.17E-03	6.90E-03	7.00E-03	7.34E-03	7.79E-03	8.22E-03	8.54E-03	8.65E-03	1.71E-01
11.00	6.91E-03	5.95E-03	5.46E-03	5.32E-03	5.41E-03	5.63E-03	5.88E-03	6.06E-03	6.13E-03	1.64E-01
13.00	5.95E-03	4.88E-03	4.26E-03	3.95E-03	3.85E-03	3.89E-03	3.97E-03	4.05E-03	4.09E-03	1.55E-01
15.00	5.18E-03	4.07E-03	3.38E-03	2.97E-03	2.76E-03	2.68E-03	2.66E-03	2.66E-03	2.67E-03	1.49E-01
17.00	4.55E-03	3.45E-03	2.75E-03	2.31E-03	2.04E-03	1.88E-03	1.80E-03	1.76E-03	1.75E-03	1.45E-01
19.00	4.00E-03	2.96E-03	2.29E-03	1.85E-03	1.55E-03	1.36E-03	1.24E-03	1.18E-03	1.16E-03	1.41E-01
21.00	3.51E-03	2.55E-03	1.93E-03	1.51E-03	1.22E-03	1.02E-03	8.86E-04	8.10E-04	7.85E-04	1.38E-01
23.00	3.03E-03	2.18E-03	1.64E-03	1.26E-03	9.85E-04	7.82E-04	6.43E-04	5.62E-04	5.36E-04	1.33E-01
25.00	2.59E-03	1.86E-03	1.39E-03	1.06E-03	8.04E-04	6.08E-04	4.70E-04	3.89E-04	3.63E-04	1.28E-01
27.00	2.17E-03	1.57E-03	1.19E-03	8.96E-04	6.61E-04	4.74E-04	3.40E-04	2.63E-04	2.38E-04	1.22E-01
29.00	1.79E-03	1.32E-03	1.01E-03	7.60E-04	5.43E-04	3.65E-04	2.38E-04	1.67E-04	1.45E-04	1.14E-01
31.00	1.46E-03	1.11E-03	8.60E-04	6.43E-04	4.41E-04	2.73E-04	1.57E-04	9.50E-05	7.67E-05	1.04E-01
33.00	1.17E-03	9.22E-04	7.29E-04	5.38E-04	3.50E-04	1.93E-04	9.09E-05	4.30E-05	3.07E-05	9.33E-02
35.00	9.26E-04	7.59E-04	6.09E-04	4.41E-04	2.66E-04	1.23E-04	4.01E-05	1.05E-05	5.96E-06	8.05E-02
37.00	7.16E-04	6.07E-04	4.90E-04	3.45E-04	1.88E-04	6.42E-05	4.49E-06	-3.13E-06	1.55E-06	6.60E-02
39.00	5.24E-04	4.54E-04	3.67E-04	2.49E-04	1.17E-04	1.79E-05	-1.56E-05	-6.88E-07	1.32E-05	4.98E-02
41.00	3.33E-04	2.89E-04	2.34E-04	1.52E-04	5.68E-05	-1.11E-05	-2.04E-05	1.02E-05	2.95E-05	3.18E-02
43.00	1.27E-04	1.08E-04	8.90E-05	5.64E-05	1.39E-05	-1.46E-05	-1.11E-05	1.30E-05	2.66E-05	1.21E-02
45.00	2.75E-13	2.63E-13	4.28E-13	1.09E-12	2.58E-12	4.94E-12	7.72E-12	1.00E-11	1.09E-11	2.31E-11

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

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

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

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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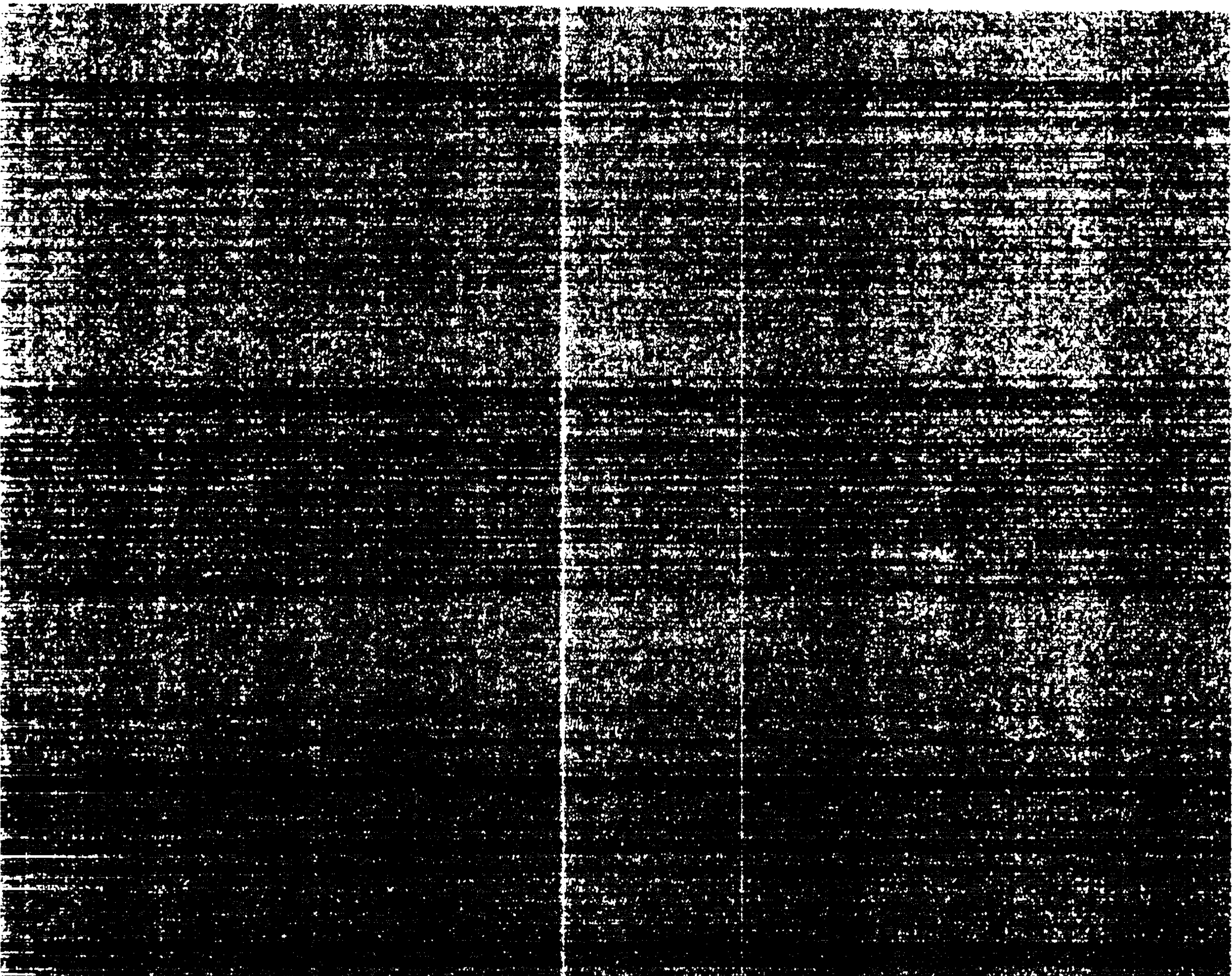

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