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**Calculation of Neutron Cross Sections on
Isotopes of Yttrium and Zirconium**

University of California

LOS ALAMOS SCIENTIFIC LABORATORY

Post Office Box 1663 Los Alamos, New Mexico 87545

Calculation of Neutron Cross Sections on Isotopes of Yttrium and Zirconium

E. D. Arthur

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CALCULATION OF NEUTRON CROSS SECTIONS ON ISOTOPES OF YTTRIUM AND ZIRCONIUM

by

E. D. Arthur

ABSTRACT

Multistep Hauser-Feshbach calculations with preequilibrium corrections have been made for neutron-induced reactions on yttrium and zirconium isotopes between 0.001 and 20 MeV. Recently new neutron cross-section data have been measured for unstable isotopes of these elements. These data, along with results from charged-particle simulation of neutron reactions, provide unique opportunities under which to test nuclear-model techniques and parameters in this mass region. We have performed a complete and consistent analysis of varied neutron reaction types using input parameters determined independently from additional neutron and charged-particle data. The overall agreement between our calculations and a wide variety of experimental results available for these nuclei leads to increased confidence in calculated cross sections made where data are incomplete or lacking.

I. INTRODUCTION

Neutron-induced cross sections on yttrium and zirconium isotopes are of interest because of their use as dosimetry reactions for various practical applications. In addition to stable isotope data, there now exist experimental measurements for 14-15 MeV neutron reactions on certain unstable yttrium and zirconium isotopes. The comparison of these data and nuclear-model calculations can provide useful information regarding calculational techniques and input parameter values. Since there is an increasing trend to rely upon nuclear-model calculations to satisfy data needs for neutron-induced reactions in energy regions where measurements are incomplete or lacking, these types of comparisons become even more valuable. In addition, the proximity of these nuclei to the closed neutron shell at $N = 50$ leads to conditions arising from shell effects, separation energy differences, etc., which provide unique tests of nuclear models and which may allow information to be obtained that otherwise would be obscured.

In addition to direct measurements of neutron-induced reactions on unstable nuclei in this mass region, there are experimental data concerning proton-production cross sections that have recently become available through the use of charged-particle simulation reactions. Generally in medium-mass nuclei where competition between neutron and charged-particle reactions exists, neutron emission dominates, and there is a decreased sensitivity to the charged-particle parameters needed in a statistical calculation of the Hauser-Feshbach type. However for $^{89}\text{Y}(n,np)$ and $^{90}\text{Zr}(n,np)$ reactions, proton emission occurs from compound systems where the proton binding energy is considerably lower than that of the neutron. For example, in the ^{89}Y and ^{90}Zr compound systems, the proton binding energies are, respectively, 4.4 and 3.6 MeV less than those of the neutron. Thus, above the (n,np) threshold there is an energy region in which only proton and gamma rays compete with each other. In these cases, once parameters have been determined to describe gamma-ray emission, one has a unique situation in which to test proton optical parameters, especially their behavior at low-emission energies.

We therefore describe calculations of neutron-induced reactions on yttrium and zirconium isotopes made using multistep Hauser-Feshbach techniques¹ with corrections applied for nonstatistical effects through use of the exciton preequilibrium model.² Realistic optical parameters were used for neutron emission, and gamma-ray emission was described with gamma-ray strength functions derived from neutron capture data for $A = 80$ to 99 . Finally, proton optical parameters have been determined using, as a basis, recent results from sub-Coulomb barrier (p,n) data³ modified somewhat to reproduce in the best possible manner (n,np) data available for yttrium and zirconium isotopes. Calculations are given for capture, total inelastic, (n,p) , $(n,\alpha + n,\alpha n)$, (n,xn) , $(n,np + n,pn)$ and $(n,n\alpha)$ cross sections in the energy range from 0.001 to 20 MeV for the $^{86-92}\text{Y}$ and $^{88-90}\text{Zr}$ isotopes. In addition, cross sections for reactions leading to isomeric states having lifetimes greater than a millisecond were calculated. [Exceptions were isomeric cross sections resulting from (n,γ) , (n,α) , and $(n,n\alpha)$ reactions.]

II. MODEL CALCULATIONS AND PARAMETERS

The present calculations were made using the COMNUC⁴ and GNASH⁵ nuclear-model codes, both of which employ Hauser-Feshbach statistical model techniques to determine cross sections. The COMNUC code was used for incident energies up to 4 MeV since it includes width-fluctuation and correlation corrections important

at lower energies. The GNASH program was used between 4 and 20 MeV. It allows decay of up to ten compound nuclei, with each decaying system permitted to emit gamma rays and up to five additional particles. The program includes preequilibrium emission and a complete treatment of gamma-ray cascades. In order to use these codes properly, it is necessary to have the best information available concerning various input parameters. The remainder of this section deals with these model parameters and their determination in the most accurate manner possible.

A. Neutron Optical Parameters

Neutron-transmission coefficients were calculated using optical parameters based on values determined from fits to neutron total cross sections, elastic-scattering angular distributions, and resonance parameters for ^{89}Y by Lagrange.⁶ Two changes were made to the parameters of Ref. 6. The real and imaginary potential depths were modified to include an $(N-Z)/A$ dependence using values similar to those of Delaroche.⁷ Secondly, after preliminary Hauser-Feshbach calculations were made, it was felt that better agreement with experimental data [particularly $(n,2n)$ cross sections] could be obtained if the total reaction cross section was increased a small amount for neutron energies above 10 MeV. The imaginary potential depth was increased slightly to achieve this with no noticeable worsening of the agreement with the total cross section. For zirconium isotopes the real potential depth derived from fits to ^{89}Y data was modified to improve agreement with resonance parameter data while maintaining agreement with the $n + ^{90}\text{Zr}$ total cross section. The present parameters, given in Table I, provide reasonable transmission coefficients over the energy range from 0.010 to 20 MeV. Table II compares calculated and experimental resonance parameter data, while Fig. 1 illustrates the agreement between calculated and experimental ^{89}Y and ^{90}Zr total cross sections.

B. Proton Optical Parameters

The ability to accurately calculate (n,np) cross sections, especially near threshold, depends strongly on the proton transmission coefficients used, since most of the cross-section results from transitions to discrete levels in the residual nucleus and level-density effects are minimal. In cases where only gamma-ray emission competes, there is an additional sensitivity to the behavior of low-energy proton transmission coefficients. Recently results have been published

TABLE I

NEUTRON PARAMETERS USED IN THIS WORK

<u>Y Isotopes</u>	<u>r(fm)</u>	<u>a(fm)</u>
$V \text{ (MeV)} = 53.21 - 30 (N-Z)/A - 0.28E$	1.24	0.62
$W_{SD} \text{ (MeV)} = 8.96 - 35 (N-Z)/A + 0.3E$	1.26	0.58
$W_{SD} \text{ (Maximum)} = 7.0 - 7.5 \text{ MeV}$		
$V_{SO} = 6.2 \text{ MeV}$	1.12	0.47

Zr Isotopes

<u>$^{90}_{Zr}$</u>		
$V \text{ (MeV)} = 49.0 - 0.28E$	1.24	0.62
$W_{SD} \text{ (MeV)} = 3.4 + 0.3E$	1.26	0.58
$W_{SD} \text{ (Maximum)} = 7.0 \text{ MeV}$		
$V_{SO} = 6.2 \text{ MeV}$	1.12	0.47

 $^{88,89}_{Zr}$

Same as for $^{90}_{Zr}$ except $V = 47.5 - 0.28E$. (By making this change, the expected s- and p-wave strength values based on systematics were better reproduced.)

TABLE II

CALCULATED AND EXPERIMENTAL RESONANCE DATA

<u>$n + ^{89}_{Y}$</u>	<u>Calculation</u>	<u>Experimental</u>
S_0	0.47	0.28-0.32
S_1	3.4	2.6-4.4
R'	6.78	~ 6.7
<u>$n + ^{90}_{Zr}$</u>	<u>Calculation</u>	<u>Experimental</u>
S_0	0.466	0.56-0.62
S_1	3.8	~ 3.8
R'	6.71	~ 7.1

Fig. 1.
Comparison of total cross sections calculated with the
parameters of Table I with experimental results for
 ^{89}Y and ^{90}Zr .

by Johnson et al.³ dealing with optical parameters for sub-Coulomb barrier protons determined from the analysis of low-energy (p,n) reactions. In these analyses it was necessary to decrease the surface-derivative imaginary well depth to approximately one third of its usual value as obtained from conventional analyses of proton elastic-scattering data. This decrease qualitatively agreed with results of fits to other low-energy proton data.⁸ We therefore used the Johnson parameters as a starting point for the determination of proton parameters used in this paper.

The Johnson parameters were adjusted to produce agreement between calculated and experimental $^{89}\text{Y}(p,n)$ and $^{87}\text{Sr}(p,n)$ cross sections when the modified Lagrange parameters of Sec. II. A were employed for the outgoing neutron channel. This differed somewhat from the calculation of Ref. 4, since there the Wilmore-Hodgson neutron parameters⁹ were used. (We believe the modified Lagrange parameters to be superior to those of Wilmore-Hodgson, especially for the case of low-energy neutron emission.) Some adjustment was also made on the basis of preliminary Hauser-Feshbach calculations of the $^{89}\text{Y}(n,np)$ cross section. Table III lists the proton parameters of the present calculations. A main feature is the relatively small imaginary well depth. As noted before, Johnson and others have found it necessary to reduce the imaginary potential depth from about 13 MeV to about 4 MeV for low-energy protons. The strong energy dependence of the present imaginary potential ensures that for proton energies of 10-15 MeV, the imaginary potential well depth is around 12-14 MeV, in agreement with more conventional proton parameter sets.¹⁰ Figure 2 compares the reaction cross section calculated with the present parameters (solid curve) with values determined from several other proton parameter sets. The Johnson parameter results are indicated by the dashed line.

The reaction cross sections calculated with the present parameters (Table III) agree reasonably with the Johnson results at low energies. At energies around 10-12 MeV, the reaction cross section obtained with the Johnson set does not increase with energy but instead shows a slight decrease. This is probably due in part to the fact that these parameters were determined from low-energy data and do not have an imaginary potential energy dependence appropriate to describe higher-energy regions. The triangles and circles result from calculations using the Perey¹⁰ optical parameters and the set of Schulte et al.¹¹ The Perey parameters are a global set determined from the analysis of proton data in the mass range $30 \leq A \leq 100$ for energies < 20 MeV. The Schulte parameters were determined from fits to elastic scattering data on ^{88}Sr , ^{89}Y , ^{90}Zr , and ^{92}Mo in the

TABLE III
PROTON OPTICAL PARAMETERS

<u>p + Sr</u>	<u>$\bar{r}$ (fm)</u>	<u>a (fm)</u>
V (MeV) = $56.4 + 24 (N-Z)/A + 0.4Z/A^{1/3} - 0.32E$	1.2	0.68
W_{SD} (MeV) = $3.0 + 0.6E$	1.225	0.4
$V_{S0} = 6.4$ MeV	1.03	0.63
<u>p + Y</u>		
V (MeV) = $56.4 + 24 (N-Z)/A + 0.4Z/A^{1/3} - 0.32E$	1.2	0.73
W_{SD} (MeV) = $4.0 + 0.5E$	1.3	0.4
$V_{S0} = 6.4$ MeV	1.03	0.63

Fig. 2.
Calculated reaction cross sections for $p + {}^{88}\text{Sr}$. The solid curve results from the parameters of Table III, the dashed curve from the Johnson parameters,³ the triangles from the Perey set,¹⁰ and the circles are calculated with the Schulte parameters.¹¹

energy range 8-14 MeV. Figure 2 shows that the parameters of Table III agree with the Johnson results at low energies while also agreeing with the other more conventional sets at higher energies.

In Fig. 3 we compare (p,n) cross sections calculated using our proton parameters (Table III) and neutron parameters (Table I) to the $^{89}\text{Y}(p,n)^{89}\text{Zr}$ data of Johnson et al.³ (Resonances have been omitted to facilitate comparison with the present Hauser-Feshbach statistical calculation.) Also indicated by the squares are early (1951) measurements by Blaser et al.¹²

For the calculation of $^{88,89}\text{Y}(n,np)^{87,88}\text{Sr}$ cross sections, experimental information concerning $^{87,88}\text{Sr}(p,n)$ reactions is of interest to provide a further check on our parameter sets. To our knowledge, the only published data for $^{87,88}\text{Sr}(p,n)$ reactions are the 1951 measurements of Blaser.¹² Our calculation agrees well with these data as shown in Fig. 4. Even though these data are quite old, the fact that the Blaser measurement for $^{89}\text{Y}(p,n)$ agrees with the more recent Johnson results increases our confidence in its use for present proton-parameter determinations.

C. Gamma-Ray Emission Parameters

Certain portions of our calculated results are sensitive to the description of gamma-ray emission, and therefore an accurate knowledge of the parameters involved is a necessity. In most Hauser-Feshbach calculations, the integral of the product of level density and gamma-ray transmission coefficients is normalized to the experimental value of $2\pi\langle\Gamma_Y\rangle/\langle D\rangle$, where $\langle\Gamma_Y\rangle$ and $\langle D\rangle$ are the average gamma width and spacing for s-wave neutron resonances. This normalization directly influences the amount of gamma-ray emission occurring, either in the capture reaction or in competition to particle-emission reactions. Experimental data for $\langle\Gamma_Y\rangle$ and $\langle D\rangle$ are not always reliable (especially where resonance spacings are large), and for compound systems lacking such data, reliance must be placed upon determination of these quantities from systematics. Since the observed spacing $\langle D\rangle$ can vary drastically between nearby nuclei in closed shell regions, considerable uncertainty can exist concerning the amount of gamma-ray emission to be included in a calculation.

An alternate approach has been suggested by Gardner¹³ that eliminates many of these problems, leading in turn to more accurate capture cross sections where data is unavailable and to a better treatment of gamma-ray competition. This method is based upon determination of the gamma-ray strength function $f(\epsilon_Y)$ defined by

Fig. 3.

The calculated $^{89}\text{Y}(p,n)$ cross section is compared to the data of Johnson³ (circles) and Blasser¹² (squares).

Fig. 4.

Calculation of the $^{87}\text{Sr}(p,n)$ reaction is compared to the Blasser data.¹²

$$\frac{\langle \Gamma_Y \rangle}{\langle D \rangle} = \int_0^{S_n} f(\epsilon_Y) \epsilon_Y^3 \rho(S_n - \epsilon_Y) d\epsilon_Y, \quad (1)$$

where S_n is the neutron separation energy and ρ is the level density of the compound system. The electric dipole strength function is assumed to have a giant dipole resonance (GDR) form given by

$$f_{E1}(\epsilon_Y) = \frac{k \epsilon_Y \Gamma_{GDR}}{(\epsilon_Y \Gamma_{GDR})^2 + (\epsilon_Y^2 - E_{GDR}^2)^2}. \quad (2)$$

The strength function can be extracted from the analysis of neutron capture cross sections measured for stable nuclei or through the analysis of spectral data resulting from capture. Since the strength function is expected to vary smoothly between nearby nuclei, some of the problems mentioned earlier can be eliminated, and one can use it with increased confidence.

Prior to the present calculations, we explored the magnitude and behavior of these strength functions by fitting neutron capture cross sections to obtain values for the constant k in Eq. (2) for target nuclei from ^{80}Se to ^{99}Tc . We considered only E1 contributions and took the giant dipole resonance parameters Γ_{GDR} and E_{GDR} from photonuclear data.¹⁴ The E1 strength functions for several compound systems are shown in Fig. 5.

We concluded from the analysis of $^{85,87}\text{Rb}(n,\gamma)$ and $^{90-92}\text{Zr}(n,\gamma)$ data that the strength function was almost identical (within the accuracy of our fit) for isotopes of the same element. The strength functions for ^{89}Sr and $^{91,92}\text{Zr}$ compound systems lie very close to the values for ^{90}Y and, for clarity, have been omitted in Fig. 5. Since recent experimental results are available for the ^{88}Sr , ^{89}Y , and $^{90-92}\text{Zr}(n,\gamma)$ reactions,¹⁵⁻¹⁷ we believe the extracted strength functions to be particularly reliable for these cases.

D. Level Density Parameters

In the present calculations all nuclei are described using a combination of discrete levels and a continuum level-density expression at energies high enough where reliable experimental level data do not exist. We used the Gilbert-Cameron

level density expression¹⁸ along with the Cook values¹⁹ for the pairing terms and level-density parameter, a . The Gilbert-Cameron formalism consists of a Fermi-gas level-density expression along with a constant-temperature expression of the form

$$\rho(E, J) = \rho(J)_e \frac{(E-E_0)^{1/2}}{T}, \quad (3)$$

which represents the level density at lower-excitation energies. The Fermi-gas and constant-temperature expressions are then joined smoothly at a matching energy U_x . These expressions should also be joined smoothly to the cumulative number of discrete levels available from experimental data at lower energies. To do so, we adjusted E_0 and T in Eq. (3) and the matching energy U_x until these conditions were met. At times it was also necessary to adjust the pairing energy used in the Fermi-gas expression from the values given by Cook. For some nuclei we chose values for the level-density constant a , which agreed with results from a more recent and specialized analysis²⁰ of resonance spacings in this mass region. Table IV lists the level density parameters used in the present calculations.

Fig. 5.

Gamma-ray strength functions determined from fits to neutron capture data are presented for several compound nuclei.

TABLE IV
LEVEL DENSITY PARAMETERS OF THE PRESENT CALCULATIONS

Nucleus	a (MeV ⁻¹)	Δ (MeV)	E_0 (MeV)	T (MeV)	U_x (MeV)
Rb ⁸²	12.802	0.29	-0.436	0.629	3.162
Rb ⁸³	12.669	1.61	-0.921	0.836	7.694
Rb ⁸⁴	12.313	-0.12	-0.385	0.773	0.163
Rb ⁸⁵	11.591	1.50	-0.262	0.816	6.475
Rb ⁸⁶	10.761	0.04	-0.312	0.663	2.36
Rb ⁸⁷	9.689	0.97	-0.053	0.843	4.927
Rb ⁸⁸	10.083	0.05	-0.945	0.812	3.880
Rb ⁸⁹	10.671	0.66	-0.315	0.773	4.355
Sr ⁸⁴	12.675	2.81	1.09	0.758	7.544
Sr ⁸⁵	12.312	1.08	-0.435	0.753	5.51
Sr ⁸⁶	11.589	2.7	0.987	0.812	7.595
Sr ⁸⁷	10.734	1.24	0.767	0.688	3.854
Sr ⁸⁸	9.00	2.17	1.812	0.921	7.437
Sr ⁸⁹	10.043	1.25	1.095	0.687	3.547
Sr ⁹⁰	10.634	1.86	1.252	0.719	4.809
Sr ⁹¹	11.662	0.74	0.171	0.659	3.465
Sr ⁹²	11.756	2.66	0.975	0.802	7.511
Y ⁸⁵	12.452	1.86	-0.834	0.861	8.253
Y ⁸⁶	12.078	0.13	-0.854	0.699	3.618
Y ⁸⁷	11.341	1.75	0.643	0.753	5.584
Y ⁸⁸	10.00	0.29	-0.764	0.826	4.253
Y ⁸⁹	9.365	1.22	1.181	0.821	5.303
Y ⁹⁰	9.759	0.03	-0.262	0.766	3.291
Y ⁹¹	10.352	0.91	0.338	0.73	3.83
Y ⁹²	11.385	-0.21	0.142	0.804	0.088
Y ⁹³	11.475	1.71	-0.383	0.873	6.404
Zr ⁸⁷	12.585	0.93	0.763	0.539	2.575
Zr ⁸⁸	11.0	2.55	0.815	0.848	7.597
Zr ⁸⁹	10.965	1.09	0.133	0.753	4.701
Zr ⁹⁰	9.85	2.02	1.157	1.092	2.35
Zr ⁹¹	10.252	1.10	0.669	0.853	1.46

The quantities above are defined as follows:

a = Level density parameter appearing in the Fermi-gas level density expressions.

Δ = Pairing energy.

E_0 and T = Constant temperature expression parameters. See Eq. (3).

U_x = Matching energy at which constant temperature and Fermi-gas expressions are joined.

E. Discrete Levels

In some cases discrete-level information plays an important role regarding cross sections determined for $(n,2n)$ or (n,np) reactions. For example, the difference in spins populated in the initial compound system and that of the residual nucleus reached through decay via neutron or proton emission can lead to cross sections dominated by populations of one or a few levels. Near thresholds, the importance of accurate discrete-level information is increased because of the absence or lack of significant population of states in the continuum represented by a level-density expression. We made an effort to include as many levels as possible and to, of course, make the best judgment possible for spin and parity values where such information was incomplete. Information from the latest evaluations and compilations appearing in the Nuclear Data Tables²¹ formed the basis for the majority of the level schemes used. However, in some cases it was necessary to make judgments based on newer experimental data or from systematics. The level schemes used in this report appear in Appendix A.

F. Preequilibrium Formalism and Parameters

At higher neutron energies, effects other than those included in the standard Hauser-Feshbach statistical calculation become important. These semi-direct effects result from the reaction proceeding through a series of particle-hole configurations, starting from very simple ones and leading to more complex ones until equilibrium is reached. At each successive stage there exists a probability for particle emission, and the resultant spectra and cross sections can be quite different from those obtained from Hauser-Feshbach methods.

To describe the preequilibrium process, we have used the Kalbach exciton model of Ref. 2. Since the expressions used to calculate preequilibrium contributions are given in detail there, we will not repeat them. However in such calculations, state densities are used to classify the number of particle-hole degrees of freedom. Since the excitation energy of the system is redistributed through a series of two-body energy-conserving interactions, expressions describing the rates for creation or destruction of particle-hole pairs are needed. Such rates are directly proportional to the square of the average matrix element M^2 for the effective, residual two-body interaction. In our present calculations we have used a new empirical representation for M^2 developed by Kalbach²²

$$M^2(n, E) = \frac{k}{A^{3/2}} f(e) \quad , \quad (4)$$

where n is the exciton number ($n = p + h$) and e is the average excitation energy per exciton, E/n . The function $f(e)$ represents a different energy dependence for M^2 over several ranges of e and appears explicitly in Ref. 22. In Eq. (4) the value of the constant k was determined to be 135 MeV^3 when the state density constant for the composite system g_0 was equal to $A/13$, where A is the nuclear mass. We obtained better results with $k = 160 \text{ MeV}^3$ when $g_0 = A/13$. However, we chose to represent the state density constant for each residual nucleus g_1 as $g_1 = \frac{6}{\pi^2} a_1$ where a_1 is the level density constant of Sec. II. D. In this mass region, shell effects are important, and values of the level-density constant a deviate from values obtained from systematics in regions away from closed shells, namely, $a \sim A/8$. Since the excitation energies of the residual systems are relatively low, we concluded that shell effects may play some role in preequilibrium calculations. However, for the composite systems, the state density constant g_0 was retained equal to $A/13$ since at the higher-excitation energies involved, shell effects should be less noticeable. Attempts to calculate preequilibrium components when all state density constants (including that of the composite system) were set equal to $\frac{6}{\pi^2} a_1$ produced unusually high preequilibrium fractions for incident-neutron energies between 10 and 20 MeV. Over the same energy range, the preequilibrium fraction calculated using the state density constants described above ranged from 15-30%. We also included pairing effects in the determination of the energy at which the state density was to be evaluated.

To include nonstatistical effects occurring in the emission of complex particles (namely, alpha particles), we employed semiempirical expressions developed by Kalbach^{3,23} to describe knockout and inelastic processes as well as stripping and pickup. These expressions made it unnecessary to use quantities such as "alpha preformation" coefficients, and in general the method worked reasonably well. For alpha emission, the dominate contribution originates from pickup and knockout and not from statistical or purely preequilibrium processes.

Finally, since the exciton model used here does not include angular momentum effects, we assumed that the spin distribution of the preequilibrium components would be the same as those determined for the equilibrium components through the usual Hauser-Feshbach techniques.

III. CROSS SECTION RESULTS

In this section we compare cross sections calculated using the techniques and parameters of Sec. II with available experimental data. Trends in cross sections for different isotopes of yttrium and zirconium will also be illustrated. Table V lists the reactions calculated, their threshold, and the reaction type (MT) numbers as used in the ENDF/B system for evaluated neutron data. For all reactions [except capture and (n,α)], cross sections for production of isomeric levels having lifetimes roughly a millisecond or greater were calculated. In accordance with procedures for the ENDF/B system, we have provided cross sections from the reaction threshold up to 20 MeV. For reactions having positive Q values, cross sections begin at 10^{-5} eV and extend to 20 MeV. In these cases, we used the nuclear model calculations over the energy range generally from 1 keV to 20 MeV. From 10^{-5} eV to 1 keV, cross-section estimates were made based on knowledge of thermal values and expected resonance locations. The method used for estimating cross sections below the lower limit for statistical calculations and the complete cross-section sets appear in Appendices B and C.

A. Yttrium Results and Comparisons to Experimental Data

1. Elastic and (n,n') Cross Sections. Although these cross sections are not provided in Appendix C, the calculated results for the ^{89}Y elastic cross section and inelastic scattering to specific final states are compared to the data of Perey and Kinney²⁴ in Figs. 6 and 7. The generally good agreement between the calculations and data is indicative of the applicability of the neutron optical parameters used in the present calculations.

There also exist several measurements²⁵⁻²⁹ of the $^{89}\text{Y}(n,n')$ reaction leading to the 16 second isomer in ^{89}Y ($E_x = 0.909$ MeV, $J^\pi = 9/2^+$). These results span the region from 2-18 MeV and are compared to our calculated values in Fig. 8. These data, which cover a wide energy range, provide a useful test of our calculations, particularly with respect to the treatment of gamma-ray cascades instrumental in the population of this state at higher energies and in the preequilibrium corrections used. The preequilibrium contributions prevent the calculated cross sections from dropping to zero once thresholds for tertiary reactions occur. Reasonable agreement is obtained with the higher-energy data of Abboud²⁵ (circles).

Another test of preequilibrium cross sections occurs through the comparison shown in Fig. 9. Here the secondary neutron-energy spectrum measured by Luk'yanov³⁰ for an incident energy of 14.36 MeV is compared to our calculated

TABLE V
Q-VALUES AND THRESHOLDS FOR YTTRIUM AND ZIRCONIUM REACTIONS

<u>MAT</u>	<u>MT</u>	<u>Reaction</u>	<u>Final State</u> ^a	<u>Q (MeV)</u>	<u>E_{th} (MeV)</u>
3986	4	$^{86}\text{Y}(n, n')^{86}\text{Y}$	0	- 0.208	0.210
	16	$^{86}\text{Y}(n, 2n)^{85}\text{Y}$	0	- 9.473	9.584
	16	$^{86}\text{Y}(n, 2n)^{85m}\text{Y}$	1	- 9.493	9.604
	22	$^{86}\text{Y}(n, n\alpha)^{82}\text{Rb}$	0	- 5.43	5.494
	28	$^{86}\text{Y}(n, np + n, pn)^{85}\text{Sr}$	0	- 5.669	5.736
	52	$^{86}\text{Y}(n, n')^{86m}\text{Y}$	2	- 0.218	0.221
	102	$^{86}\text{Y}(n, \gamma)^{87}\text{Y}$	0	11.82	--
	103	$^{86}\text{Y}(n, p)^{86}\text{Sr}$	0	6.055	--
	107	$^{86}\text{Y}(n, \alpha + n, \alpha n)^{83, 82}\text{Rb}$	0	5.359	--
3987	4	$^{87}\text{Y}(n, n')^{87}\text{Y}$	0	- 3.81	0.386
	16	$^{87}\text{Y}(n, 2n)^{86}\text{Y}$	0	-11.82	11.96
	16	$^{87}\text{Y}(n, 2n)^{86m}\text{Y}$	2	-12.04	12.17
	22	$^{87}\text{Y}(n, n\alpha)^{83}\text{Rb}$	0	- 6.46	6.535
	28	$^{87}\text{Y}(n, np + n, pn)^{86}\text{Sr}$	0	- 5.764	5.831
	51	$^{87}\text{Y}(n, n')^{87m}\text{Y}$	1	- 3.81	0.386
	102	$^{87}\text{Y}(n, \gamma)^{88}\text{Y}$	0	9.377	--
	103	$^{87}\text{Y}(n, p)^{87}\text{Sr}$	0	2.665	--
	103	$^{87}\text{Y}(n, p)^{87m}\text{Sr}$	1	2.276	--
	107	$^{87}\text{Y}(n, \alpha + n, \alpha n)^{84, 83}\text{Rb}$	0	2.416	--
3988	4	$^{88}\text{Y}(n, n')^{88}\text{Y}$	0	- 0.232	0.235
	16	$^{88}\text{Y}(n, 2n)^{87}\text{Y}$	0	- 9.376	9.484
	16	$^{88}\text{Y}(n, 2n)^{87m}\text{Y}$	1	- 9.758	9.87
	22	$^{88}\text{Y}(n, n\alpha)^{84}\text{Rb}$	0	- 3.73	3.773
	28	$^{88}\text{Y}(n, np + n, pn)^{87}\text{Sr}$	0	- 6.712	6.789
	28	$^{88}\text{Y}(n, np + n, pn)^{87m}\text{Sr}$	1	- 7.1	7.182
	52	$^{88}\text{Y}(n, n')^{88m1}\text{Y}$	2	- 0.393	0.398
	53	$^{88}\text{Y}(n, n')^{88m2}\text{Y}$	3	- 0.675	0.683
	102	$^{88}\text{Y}(n, \gamma)^{89}\text{Y}$	0	11.468	--
	103	$^{88}\text{Y}(n, p)^{88}\text{Sr}$	0	4.401	--
	107	$^{88}\text{Y}(n, \alpha + n, \alpha n)^{85, 84}\text{Rb}$	0	3.517	--

3989	4	$^{89}\text{Y}(\text{n}, \text{n}') ^{89}\text{Y}$	0	- 0.908	0.918
	16	$^{89}\text{Y}(\text{n}, 2\text{n}) ^{88}\text{Y}$	0	-11.468	11.598
	16	$^{89}\text{Y}(\text{n}, 2\text{n}) ^{88\text{m}1}\text{Y}$	2	-11.86	11.96
	16	$^{89}\text{Y}(\text{n}, 2\text{n}) ^{88\text{m}2}\text{Y}$	3	-12.143	12.281
	22	$^{89}\text{Y}(\text{n}, \text{n}\alpha) ^{85}\text{Rb}$	0	- 7.95	8.04
	28	$^{89}\text{Y}(\text{n}, \text{np} + \text{n}, \text{pn}) ^{88}\text{Sr}$	0	- 7.07	7.147
	51	$^{89}\text{Y}(\text{n}, \text{n}') ^{89\text{m}}\text{Y}$	1	- 9.08	0.918
	102	$^{89}\text{Y}(\text{n}, \gamma) ^{90}\text{Y}$	0	6.86	--
	102	$^{89}\text{Y}(\text{n}, \gamma) ^{90\text{m}}\text{Y}$	2	6.178	--
	103	$^{89}\text{Y}(\text{n}, \text{p}) ^{89}\text{Sr}$	0	- 0.707	0.715
	107	$^{89}\text{Y}(\text{n}, \alpha + \text{n}, \alpha\text{n})$	0	0.699	--
3990	4	$^{90}\text{Y}(\text{n}, \text{n}') ^{90}\text{Y}$	0	- 0.203	0.205
	16	$^{90}\text{Y}(\text{n}, 2\text{n}) ^{89}\text{Y}$	0	- 6.86	6.937
	16	$^{90}\text{Y}(\text{n}, 2\text{n}) ^{89\text{m}}\text{Y}$	1	- 7.768	7.855
	17	$^{90}\text{Y}(\text{n}, 3\text{n}) ^{88}\text{Y}$	0	-18.33	18.53
	22	$^{90}\text{Y}(\text{n}, \text{n}\alpha) ^{86}\text{Rb}$	0	- 6.16	6.23
	28	$^{90}\text{Y}(\text{n}, \text{np} + \text{n}, \text{pn}) ^{89}\text{Sr}$	0	7.567	7.652
	52	$^{90}\text{Y}(\text{n}, \text{n}') ^{90\text{m}}\text{Y}$	2	- 0.685	0.693
	102	$^{90}\text{Y}(\text{n}, \gamma) ^{91}\text{Y}$	0	7.946	--
	103	$^{90}\text{Y}(\text{n}, \text{p}) ^{90}\text{Sr}$	0	0.237	--
	107	$^{90}\text{Y}(\text{n}, \alpha + \text{n}, \alpha\text{n}) ^{87, 86}\text{Rb}$	0	3.765	--
3991	4	$^{91}\text{Y}(\text{n}, \text{n}') ^{91}\text{Y}$	0	- 0.556	0.562
	16	$^{91}\text{Y}(\text{n}, 2\text{n}) ^{90}\text{Y}$	0	- 7.946	8.034
	16	$^{91}\text{Y}(\text{n}, 2\text{n}) ^{90\text{m}}\text{Y}$	2	- 8.63	8.727
	17	$^{91}\text{Y}(\text{n}, 3\text{n}) ^{89}\text{Y}$	0	-14.81	14.97
	17	$^{91}\text{Y}(\text{n}, 3\text{n}) ^{89\text{m}}\text{Y}$	1	-15.71	15.89
	22	$^{91}\text{Y}(\text{n}, \text{n}\alpha) ^{87}\text{Rb}$	0	- 4.18	4.23
	28	$^{91}\text{Y}(\text{n}, \text{np} + \text{n}, \text{pn}) ^{90}\text{Sr}$	0	- 7.709	7.759
	51	$^{91}\text{Y}(\text{n}, \text{n}') ^{91\text{m}}\text{Y}$	1	- 0.556	0.562
	102	$^{91}\text{Y}(\text{n}, \gamma) ^{92}\text{Y}$	0	6.557	--
	103	$^{91}\text{Y}(\text{n}, \text{p}) ^{91}\text{Sr}$	0	- 1.883	1.903
	107	$^{91}\text{Y}(\text{n}, \alpha + \text{n}, \alpha\text{n}) ^{88, 87}\text{Rb}$	0	1.902	--
3992	4	$^{92}\text{Y}(\text{n}, \text{n}') ^{92}\text{Y}$	0	- 0.28	0.283

3992	16	$^{92}\text{Y}(\text{n}, 2\text{n})^{91\text{m}}\text{Y}$	1	- 7.113	7.191
	17	$^{92}\text{Y}(\text{n}, 3\text{n})^{90}\text{Y}$	0	-14.5	14.66
	17	$^{92}\text{Y}(\text{n}, 3\text{n})^{90\text{m}}\text{Y}$	2	-15.19	15.35
	22	$^{92}\text{Y}(\text{n}, \text{n}\alpha)^{88}\text{Rb}$	0	- 4.655	4.706
	28	$^{92}\text{Y}(\text{n}, \text{np} + \text{n}, \text{pn})^{91}\text{Sr}$	0	- 8.44	8.532
	102	$^{92}\text{Y}(\text{n}, \gamma)^{93}\text{Y}$	0	7.49	--
	103	$^{92}\text{Y}(\text{n}, \text{p})^{92}\text{Sr}$	0	- 1.13	1.14
	107	$^{92}\text{Y}(\text{n}, \alpha + \text{n}, \alpha\text{n})^{89,88}\text{Rb}$	0	2.52	--
4088	4	$^{88}\text{Zr}(\text{n}, \text{n}')^{88}\text{Zr}$	0	- 1.058	1.07
	16	$^{88}\text{Zr}(\text{n}, 2\text{n})^{87}\text{Zr}$	0	-12.2	12.34
	16	$^{88}\text{Zr}(\text{n}, 2\text{n})^{87\text{m}}\text{Zr}$	2	-12.536	12.68
	22	$^{88}\text{Zr}(\text{n}, \text{n}\alpha)^{84}\text{Sr}$	0	- 5.397	5.449
	28	$^{88}\text{Zr}(\text{n}, \text{np} + \text{n}, \text{pn})^{87}\text{Y}$	0	- 7.917	8.01
	28	$^{88}\text{Zr}(\text{n}, \text{np} + \text{n}, \text{pn})^{87\text{m}}\text{Y}$	1	- 8.298	8.39
	102	$^{88}\text{Zr}(\text{n}, \gamma)^{89}\text{Zr}$	0	9.312	--
	103	$^{88}\text{Zr}(\text{n}, \text{p})^{88}\text{Y}$	0	1.462	--
	103	$^{88}\text{Zr}(\text{n}, \text{p})^{88\text{m}1}\text{Y}$	2	1.069	--
	103	$^{88}\text{Zr}(\text{n}, \text{p})^{88\text{m}2}\text{Y}$	3	0.787	-
	107	$^{88}\text{Zr}(\text{n}, \alpha + \text{n}, \alpha\text{n})^{85,84}\text{Sr}$	0	3.13	--
4089	4	$^{89}\text{Zr}(\text{n}, \text{n}')^{89}\text{Zr}$	0	- 0.587	0.594
	16	$^{89}\text{Zr}(\text{n}, 2\text{n})^{88}\text{Zr}$	0	- 9.311	9.417
	22	$^{89}\text{Zr}(\text{n}, \text{n}\alpha)^{85}\text{Sr}$	0	- 6.18	6.25
	28	$^{89}\text{Zr}(\text{n}, \text{np} + \text{n}, \text{pn})^{88}\text{Y}$	0	- 7.853	7.941
	28	$^{89}\text{Zr}(\text{n}, \text{np} + \text{n}, \text{pn})^{88\text{m}1}\text{Y}$	2	- 8.245	8.339
	28	$^{89}\text{Zr}(\text{n}, \text{np} + \text{n}, \text{pn})^{88\text{m}2}\text{Y}$	3	- 8.527	8.624
	51	$^{89}\text{Zr}(\text{n}, \text{n}')^{89\text{m}}\text{Zr}$	1	- 0.587	0.594
	102	$^{89}\text{Zr}(\text{n}, \gamma)^{90}\text{Zr}$	0	11.983	--
	103	$^{89}\text{Zr}(\text{n}, \text{p})^{89}\text{Y}$	0	3.616	--
	103	$^{89}\text{Zr}(\text{n}, \text{p})^{89\text{m}}\text{Y}$	1	2.708	--
	107	$^{89}\text{Zr}(\text{n}, \alpha + \text{n}, \alpha\text{n})^{86,85}\text{Sr}$	0	5.305	--
4090	4	$^{90}\text{Zr}(\text{n}, \text{n}')^{90}\text{Zr}$	0	- 1.76	1.78
	16	$^{90}\text{Zr}(\text{n}, 2\text{n})^{89}\text{Zr}$	0	-11.903	12.117
	16	$^{90}\text{Zr}(\text{n}, 2\text{n})^{89\text{m}}\text{Zr}$	1	-12.57	12.71

4090	22	$^{90}\text{Zr}(n,n)^{86}\text{Sr}$	0	- 6.678	6.753
	28	$^{90}\text{Zr}(n,np + n,pn)^{89}\text{Y}$	0	- 8.366	8.46
	28	$^{90}\text{Zr}(n,np + n,pn)^{89m}\text{Y}$	1	- 9.27	9.38
102		$^{90}\text{Zr}(n,)^{91}\text{Zr}$	0	7.203	--
103		$^{90}\text{Zr}(n,p)^{90}\text{Y}$	0	- 1.506	1.523
103		$^{90}\text{Zr}(n,p)^{90m}\text{Y}$	2	- 2.19	2.216
107		$^{90}\text{Zr}(n, + n, n)^{87,88}\text{Sr}$	0	1.75	--

^a The convention used here is that for a particular reaction a final state of 0 signifies that the cross section listed is the total cross section for that reaction, not just the amount leading to the ground state. If the final state is not equal to 0, then the cross section listed is that for population of the indicated isomeric state.

Fig. 6.
Calculated elastic and inelastic excitation functions for $n + ^{89}\text{Y}$ are compared to the data of Perey and Kinney.²⁴

Fig. 7.
Further comparison of the calculated yttrium inelastic scattering cross sections to the Perey results.²⁴

Fig. 8.
Calculated and experimental cross sections for the production of ^{89m}Y through neutron inelastic scattering (the data of Refs. 25-29 are $\circ$, ∇ , Δ , $\blacktriangle$, and $\square$, respectively).

Fig. 9.
The calculated secondary neutron emission spectra at 14.36 MeV is compared to the Luk'yanov data.³⁰

spectrum. The fact that reasonable agreement is obtained, especially for secondary energies greater than 6 or 7 MeV, indicates the use of a proper fraction in the preequilibrium correction.

2. (n,2n) Cross Sections. Various experimental measurements exist for the $^{89}\text{Y}(n,2n)^{88}\text{Y}$ reaction. In Fig. 10 we compare our calculations to three of the most recent. The closed circles are the scintillation tank measurements of Frehaut³¹ from threshold up to about 15 MeV, while the open circles are the Veaser results³² (also scintillation tank measurements). The triangles are data of Bayhurst et al.³³ measured using activation techniques. Good agreement is obtained between calculated and experimental results, even near the threshold. This indicates that a proper amount of gamma-ray competition has been included using the strength functions described in Sec. II. C. It also provides an indirect confirmation that the amount of competition from the $^{89}\text{Y}(n,np)$ reaction is reasonable for energies less than 13-14 MeV.

A few experimental results³⁴⁻³⁷ exist for population of the first and second isomeric states in ^{88}Y ($E_x = 0.393$ MeV, $J^\pi = 1^+$, and $E_x = 0.687$, $J^\pi = 8^+$) through the $^{89}\text{Y}(n,2n)$ reaction. Our results are shown in Fig. 11 with these data (closed symbols are experimental cross sections for production of the first isomeric state, while the open ones are results leading to the second). Our calculations for the first isomer do rather poorly in reproducing the data, while for the second, the scatter in the experimental data prevent a firm conclusion although perhaps the agreement is somewhat better.

Recently, experimental measurements³⁸ of the (n,2n) cross section for neutrons incident on the unstable ^{88}Y nucleus have been made. Although these data generally exist at only one energy around 14.7 MeV, they provide a unique test of nuclear-model calculations in regions where one has to rely increasingly on parameters determined from systematics. Figure 12 shows data for the $^{88}\text{Y}(n,2n)$ reaction, both for the total (n,2n) cross section (open circles) and that (closed circles) leading to the ^{87}Y isomeric state at $E_x = 0.381$ MeV ($J^\pi = 9/2^+$) along with our calculations. The $^{88}\text{Y}(n,2n)$ cross section is somewhat higher at 14 MeV than that for the $^{89}\text{Y}(n,2n)$ reaction as a result of a lower threshold and a decreased competition from charged-particle emission.

3. (n,p) and Proton Production Cross Sections. The proton optical model-parameters we have used represent a departure from values generally employed in Hauser-Feshbach calculations. In Sec. II. C we showed that (p,n) cross sections calculated with these parameters sets agreed with experimental data for ^{89}Y and

Fig. 10.
The calculated $^{89}\text{Y}(n,2n)^{88}\text{Y}$ cross section is compared to three recent experimental data sets (● Ref. 31, Δ Ref. 32, and ○ Ref. 33).

Fig. 11.
Isomeric state yields in ^{88}Y from the $^{89}\text{Y}(n,2n)$ reaction. The closed symbols are ^{88m1}Y results while the open symbols are ^{88m2}Y data (Δ▲Ref. 34, ▼▼Ref. 35, ■ Ref. 36, and ○●Ref. 37).

Fig. 12.
Calculated cross sections for the $^{88}\text{Y}(n,2n)$ reaction
are compared to the data of Ref. 38.

$^{87}\text{Sr}(p,n)$ reactions. Our main interest, however, is knowing to what extent these parameters (along with those developed for neutron and gamma-ray emission) produce cross sections that agree with data for proton production induced by neutrons on isotopes of yttrium. Until recently, the only available proton emission cross-section data available for yttrium were activation measurements of the $^{89}\text{Y}(n,p)^{89}\text{Sr}$ cross section. Since the $^{89}\text{Y}(n,np + n,pn)$ reactions lead to the stable ^{88}Sr nucleus, there have been no data pertaining to this cross section.

This situation has changed as a result of recent data³⁹ from charged-particle reactions that simulate proton production arising from neutron-induced reactions on yttrium isotopes. For example, proton emission resulting from $n + ^{89}\text{Y}$ is simulated through use of the $^{91}\text{Zr}(t,\alpha)$ reaction, which produces ^{90}Y in a series of excited, unbound states. By measuring the proton emission probability and normalizing it with a calculated compound-nucleus formation cross section, the total proton production cross section can be determined for an equivalent neutron energy.

Before comparisons are made to this type of data, Fig. 13 shows our calculated $^{89}\text{Y}(n,p)$ cross section along with available experimental data.⁴⁰⁻⁴⁴ With the proton parameters of Sec. II. C, reasonable agreement is obtained between the calculation and data, especially for energies greater than 14 MeV.

The total proton production cross section measured through charged-particle simulation of the $n + ^{89}\text{Y} \rightarrow p + X$ reactions is compared with our calculation [sum of contributions from $(n,p) + (n,np) + (n,pn)$] in Fig. 14. The experimental data show a rapid rise above 10 MeV, which corresponds to the excitation energy region in the ^{89}Y compound system where only proton and gamma-ray emission occur. Once neutron emission begins, the proton production cross section drops. In the equivalent $n + ^{89}\text{Y}$ calculations, the (n,np) reaction is the major contributor to the peak around 12.5 MeV. Competition from the $(n,2n)$ reaction causes the proton production to then drop at higher energies. Although all points in the measured data are not reproduced, the calculated values agree well with the main features.

Similar measurements exist for the $n + ^{88}\text{Y} \rightarrow p + X$ reactions and are shown in Fig. 15. Here the calculations fail to reproduce some of the features, particularly the measured rise around a neutron energy of 8 MeV. Even though the threshold for the (n,np) reaction is 6.79 MeV, Coulomb barrier effects prevent sizable contributions to the calculated cross section until 10 MeV. Using similar proton parameters as those used in the curve appearing in Fig. 14, the general magnitude of the cross section is reproduced however.

4. The (n,γ) Cross Section. Experimental data⁴⁵⁻⁵⁴ exist for the $^{89}\text{Y}(n,\gamma)$ cross section over a wide energy range extending from approximately 100 eV to 15 MeV. We fitted the $^{89}\text{Y}(n,\gamma)$ experimental data for energies between 0.01 and 0.5 MeV to extract the E1 gamma-ray strength function for yttrium isotopes, and our calculation is compared to the data in Fig. 16. (Below 7 keV the curve was simply hand-drawn through the data of Bergman⁴⁵ for the purpose of providing an evaluation of this cross section.) Above 7 keV and extending to approximately 10 MeV, the curve results from our Hauser-Feshbach calculation of the capture cross section. In the region from 10-20 MeV, we calculated the cross section using a semiempirical model to simulate the direct-semidirect processes through which the E1 giant dipole resonance influences the capture cross section. In this model, the cross section was calculated using a preequilibrium cascade process with gamma-ray emission probabilities computed at each stage. The calculations exhibit a giant dipole resonance effect, and for energies around 14 MeV the cross section is around 1-2 mb in agreement with measured values for a wide range of nuclei.⁵⁵

Fig. 13.
Calculated and experimental data for the $^{89}\text{Y}(n,p)^{89}\text{Sr}$ reaction (Δ Ref. 40, $\circ$ Ref. 41, $\square$ Ref. 43, ∇ Ref. 44, and $\bullet$ Ref. 45).

Fig. 14.
Calculated total proton production cross section for $n + ^{89}\text{Y}$ compared to the results from charged-particle simulation of this reaction.³⁹

Fig. 15.
Calculated total proton production cross section for $n + {}^{88}\text{Y}$ compared to the results from charged-particle simulation of this reaction.

Fig. 16.
Experimental data for the ${}^{89}\text{Y}(n, \gamma)$ reaction are compared with our calculated (evaluated) results. (Data from Refs. 45-54 are represented by $\circ$, $\blacksquare$, $\square$, $\triangle$, $\bullet$, ∇ , $\blacktriangledown$, $\blacktriangle$, $\diamond$, and $\star$, respectively.)

5. (n, α) and Alpha Production Cross Sections. Alpha production cross sections generally are lower in magnitude than most other cross sections calculated here and are, therefore, of less interest. We included (n, α) and other alpha-production cross sections in the calculations, but a thorough investigation of alpha-particle optical parameters was not made. In addition, a large contribution to alpha production arises from nonstatistical effects described in Sec. II. F, and there is a decreased sensitivity to the alpha-particle transmission coefficients used. We chose the parameters of Park⁵⁶ determined from 20 MeV alpha scattering on yttrium for use throughout these calculations.

Adequate agreement was obtained for the calculated $^{89}\text{Y}(n,\alpha)$ cross section compared to the experimental data⁴⁰⁻⁴³ as shown in Fig. 17. Since we did not separate the (n, α) and (n, αn) cross sections in the calculation, the solid curve represents the contribution estimated to be largely from the (n, α) reaction, while the dashed portion includes both (n, α) and (n, αn) contributions. Other comparisons made to the total alpha-production cross section as measured through charged-particle simulation of $n + ^{89}\text{Y} \rightarrow \alpha + X$ reactions also show good agreement.

B. Cross Section Trends for Yttrium Isotopes

Here we compare trends in the cross sections determined for selected neutron reactions on $^{86-92}\text{Y}$. Figure 18 illustrates the capture cross sections. All curves are calculated values except for the $^{89}\text{Y}(n,\gamma)$ reaction below 7 keV where experimental information indicates the presence of a resonance. For the other yttrium isotopes, resonance effects should occur at lower energies since their resonance spacing is expected to be less than that for the $n + ^{89}\text{Y}$ compound system (see Appendix B). Thus, Hauser-Feshbach calculations for these isotopes should be applicable for 1 kilovolt (and perhaps lower) incident-neutron energies. As we described in Sec. II. C, all capture calculations relied on use of the gamma-ray strength function determined from $^{89}\text{Y}(n,\gamma)$ data to provide a normalization for the gamma-ray transmission coefficients used. At low energies, the capture cross sections for $^{86-88}\text{Y}$ are the largest since their neutron separation energies are higher (9.4-11.8 MeV) than those for $^{89-92}\text{Y}$ (6.6-7.9 MeV). Thus, the integral over the product of the normalized gamma-ray transmission coefficients and the compound nucleus level density extends over a larger integration range resulting in a larger capture cross section. At higher energies, the presence of the E1 giant dipole resonance (GDR) was incorporated in the manner described in Sec. III. A. 4. All capture cross sections have approximately the same magnitude around 15 MeV in

Fig. 17.
Calculated and experimental data for the $^{89}\text{Y}(n, \alpha)$ reaction. The portion of the curve represented by a dashed line also includes the $(n, \alpha n)$ contributions. Data are from Ref. 40 Δ , 41 $\circ$, 42 $\bullet$, and 43 ∇ .

Fig. 18.
Trends in calculated neutron capture cross sections for $^{86-92}\text{Y}$.

agreement with expected trends arising from experimental data at this energy. In cases where the capture component resulting from compound-nucleus contributions is large ($^{86-88}\text{Y}$), the giant dipole resonance shape is distorted on the low-energy side. For the other cases with relatively small compound-nucleus contributions, such effects are minimal.

Figure 19 compares cross sections calculated for (n,2n) reactions on these isotopes. Several general characteristics are apparent. The neutron-rich isotopes $^{90-92}\text{Y}$ have larger peak (n,2n) values, partially because of lower (< 8 MeV) thresholds and less competition from charged-particle emission. For $^{91,92}\text{Y}$, the (n,3n) threshold occurs around 16 MeV, causing a decline in the (n,2n) cross section above this energy. The proton-rich $^{86,87}\text{Y}$ isotopes have more competition from the (n,np) process therefore lowering the (n,2n) cross section. For ^{86}Y , the effect is most apparent causing a substantial lowering of the cross section as well as influencing the shape of the excitation function.

The calculated (n,p) cross sections are illustrated in Fig. 20. The proton-rich isotopes have positive Q values for this reaction, leading to appreciable cross sections at low energies. The $^{86}\text{Y}(n,p)$ reaction has the most positive Q value (6.055 MeV) resulting in the largest (n,p) cross section at low energies and continuing up to 20 MeV. The structure in this cross section around 2-3 MeV occurs from a peaking in the calculated inelastic cross section resulting in a drop in the (n,p) cross section. At 3 MeV, the inelastic cross section begins to drop, causing the (n,p) cross section to rise again. The ^{89}Y and neutron-rich isotopes $^{90-92}\text{Y}$ have negative Q values resulting in a threshold for this reaction and a smaller peak magnitude.

Much of the behavior of the (n,np + n,pn) cross sections of Fig. 21 can be explained in terms of the difference in neutron and proton binding energies of the second compound nucleus involved. As noted earlier for $n + ^{89}\text{Y}$, the binding energy of the proton in the ^{89}Y compound system is 4.4 MeV less than that of the neutron leading to a peak around an incident energy of 12 MeV from the (n,np) contribution. This situation occurs for the ^{88}Y system but to a lesser extent. Here the difference in proton- and neutron-binding energies is approximately 2.7 MeV, and a shoulder occurs in the cross section. Again, the difference is large for $^{86,87}\text{Y}$, resulting in a peak. For the $^{90-92}\text{Y}$ isotopes, the binding energy of the neutron in the $^{90-92}\text{Y}$ compound systems is less than that of the proton and there is very little (n,np) contribution. In these cases most of the calculated cross section arises from the (n,pn) reaction.

Fig. 19.
Calculated (n,2n) cross sections for the $^{86-92}\text{Y}$ isotopes.

Fig. 20.
Calculated $^{86-92}\text{Y}(n,p)$ cross sections from 0.001 to 20 MeV.

Fig. 21.
Sum of calculated (n,np) and (n,pn) cross
sections for $^{86-92}\text{Y}$.

C. Cross Sections and Comparisons to Data for Zirconium Isotopes

In this section we compare calculated and experimental cross sections for selected neutron reactions on zirconium isotopes. As was the case for yttrium, there also exist unstable isotope measurements for zirconium. These data supplement the unstable yttrium isotope results and place further constraints on the techniques and parameter values used to calculate theoretical cross sections in this mass region.

1. Inelastic Scattering Cross Sections. In Fig. 22 we compare our calculated cross section for production of the isomeric state ($E_x = 2.319 \text{ MeV}$, $J^\pi = 5^-$) in ^{90}Zr through inelastic neutron scattering. The calculations lie slightly above the experimental data,^{57,58} but the agreement is reasonable. Unfortunately, the experimental data extend only to 6 MeV, preventing a test at higher energies as was the case for the $^{89}\text{Y}(n,n')^{89m}\text{Y}$ reaction. Similar information exists from measurements for production cross sections for discrete gamma-ray lines through ^{90}Zr inelastic neutron scattering. In Fig. 23 the data of Glickstein et al.⁵⁹ are shown along with our calculations. All these gamma rays result from

Fig. 22.
Calculated and experimental cross sections for the $^{90}\text{Zr}(n, n')^{90\text{m}}\text{Zr}$ reaction (▲ Ref. 57, and ● Ref. 58).

Fig. 23.
Calculated results for discrete gamma rays following inelastic neutron scattering on ^{90}Zr are compared with the data of Glickstein et al.⁵⁹

transition between discrete levels lying below the 2^+ level in ^{90}Zr at 3.309 MeV. Further detail concerning these transitions can be found in Ref. 59. This comparison not only tests the population of states directly by inelastic scattering but also the population of levels through gamma-ray cascade processes.

2. (n,2n) Cross Sections. For this reaction a unique situation exists, because in addition to $^{90}\text{Zr}(n,2n)$ results there are also experimental measurements on the unstable $^{88,89}\text{Zr}$ isotopes. Thus, neutron parameters that provide good results for the $^{90}\text{Zr}(n,2n)$ reaction can be tested to determine how well they reproduce the (n,2n) cross section on these unstable isotopes. The treatment of charged-particle competition and its influence on these cross sections can also be indirectly tested.

Many experimental measurements^{33,40,60-71} of the $^{90}\text{Zr}(n,2n)$ reaction exist, and six are shown with our calculated curve in Fig. 24. The calculations agree quite well with the data, especially compared to the recent Bayhurst³³ results (denoted by the $\blacktriangledown$ symbol). Also, a relative abundance of data^{34,61,65-68,71} for this reaction leading to the ^{89}Zr isomeric state ($E_x = 0.588$ MeV, $J^\pi = 1/2^-$) exist. As seen in Fig. 25, the calculations agree well with the experimental data from threshold up to 18 MeV.

Comparatively speaking, the unstable ^{89}Zr nucleus has a wealth of (n,2n) data in that measurements⁷² have been made for 3 neutron energies between 14-15 MeV, giving valuable information concerning the shape of the (n,2n) excitation curve. Our calculation agrees extremely well with these data, as seen in Fig. 26. Comparing Figs. 25 and 26, the $^{89}\text{Zr}(n,2n)$ cross section at 14 MeV is seen to be about 33% higher than that for ^{90}Zr . This results partially because the $^{89}\text{Zr}(n,2n)$ threshold is about 2.5 MeV lower. For energies around 18-20 MeV, increased charged-particle emission reduces the $^{89}\text{Zr}(n,2n)$ cross section relative to ^{90}Zr .

It should also be noted that according to our calculations, approximately 90% of the $^{89}\text{Zr}(n,2n)$ cross section for incident 14-15 MeV neutrons results from population of discrete final levels in the residual ^{88}Zr nucleus. This situation again indicates the necessity for accurate level scheme information and, because level-density effects are reduced, provides stringent tests on the neutron transmission coefficients used.

The calculated $^{88}\text{Zr}(n,2n)$ cross section is compared in Fig. 27 to the one available data point³⁸ around 15 MeV. The curve lies around 15% higher than the experimental value, leading to an underprediction in the charged-particle emission cross section calculated for ^{88}Zr . Considering, however, the difficulties

Fig. 24. $^{90}\text{Zr}(n,2n)^{89}\text{Zr}$ reaction (▼ Ref. 33, ○ Ref. 40, × Ref. 60, △ Ref. 61, □ Ref. 62, and ● Ref. 63).

Fig. 25. Experimental and calculated yields of the ^{89}Zr isomeric state resulting from the $^{90}\text{Zr}(n,2n)$ reaction (△ Ref. 34, ○ Ref. 60, ▲ Ref. 61, □ Ref. 65, ▽ Ref. 66, ■ Ref. 67, ○ Ref. 68, and * Ref. 71).

Fig. 26.
Calculated and experimental (Ref. 72)
values for the $^{89}\text{Zr}(n,2n)^{88}\text{Zr}$ reaction.

Fig. 27.
The present calculations are compared to
the data of Ref. 38 for the $^{88}\text{Zr}(n,2n)$
reaction.

involved in both the experiment and calculation, this agreement is still reasonable.

3. (n,p) and Proton-Production Cross Sections. While no total proton-production data exist for ^{90}Zr as was the case for ^{89}Y , there are data concerning the $^{90}\text{Zr}(n,p)$ reaction and one experimental measurement of the cross section resulting from $^{88}\text{Zr}(n,np + n,pn + n,d)$ reactions.

In Fig. 28 we compare our calculation to the $^{90}\text{Zr}(n,p)$ experimental results. Our curve lies lower than the excitation function data of Prestwood⁴⁰ (1961, closed triangles) and the 1966 data of Carroll.⁷³ However, at 14-15 MeV, the more recent measurements of Tikku,⁷⁴ Levkovsky,⁷⁵ and Qaim⁶⁴ (open triangle, closed circle, and open circle, respectively) agree better with our calculated value of approximately 31 millibarns. Also, as shown in Fig. 29, our calculations agree well with the measured values^{68,69,71,75} for the $^{90}\text{Zr}(n,p)$ reaction leading to the ($E_x = 0.682$ MeV, $J^\pi = 7^+$) isomeric state in ^{90}Y .

For the ^{88}Zr nucleus, there exist data³⁸ for the production of ^{87}Y through the $^{88}\text{Zr}(n,np + n,pn + n,d)$ reactions. Information is also available for the production of the isomeric state in ^{87}Y ($E_x = 0.381$ MeV, $J^\pi = 9/2^+$). Our calculations are compared to these data in Fig. 30. As noted in Sec. III. C. 2, our calculation overpredicts the $^{88}\text{Zr}(n,2n)$ cross section; this in turn leads to the slight underprediction shown in the figure.

D. Cross Section Trends for Zirconium Isotopes

In this section, as we did in Sec. III. B for yttrium, we compare calculated or evaluated cross sections for the zirconium isotopes studied here. By doing so, one can obtain an overall view of cross-section magnitudes and their behavior as a function of isotope and incident-neutron energy.

Figure 31 illustrates the behavior of capture cross sections for the $^{88-90}\text{Zr}$ isotopes. For ^{90}Zr , below 0.1 MeV we have included the average cross-section results of Boldeman¹⁷ since resonance effects are important here. These were joined to Hauser-Feshbach calculations for energies greater than 0.1 MeV. To our knowledge no experimental data exist for the $^{90}\text{Zr}(n,\gamma)$ reaction above several hundred kilovolts, and therefore one has to rely on calculational results. For all three isotopes, the effect of the E1 giant-dipole resonance is evident in the region between 10-20 MeV. With ^{88}Zr and ^{89}Zr , a large compound nucleus contribution results in a distortion of the resonance shape. As was the case for the yttrium calculations, all zirconium capture cross sections were calculated with

Fig. 28.
Calculated and experimental $^{90}\text{Zr}(n,p)$ cross-section values ($\blacktriangle$ Ref. 40, $\circ$ Ref. 64, $\square$ Ref. 73, $\triangle$ Ref. 74, and $\bullet$ Ref. 75).

Fig. 29.
Calculated and experimental yields for the ^{90}Y isomeric state resulting from the $^{90}\text{Zr}(n,p)$ reaction ($\triangle$ Ref. 68, $\bullet$ Ref. 69, $\square$ Ref. 71, and $\circ$ Ref. 75).

Fig. 30.
The calculated yields for ^{87}Y and $^{87\text{m}}\text{Y}$ from the $^{88}\text{Zr}(n,np + n,pn + n,d)$ reactions are compared to the data of Ref. 38.

Fig. 31
Trends in calculated capture cross sections for $^{88-90}\text{Zr}$. The $^{90}\text{Zr}(n,\gamma)$ cross section below 100 keV is based on the average capture data of Boldeman.¹⁷

the E1 strength function determined from a fit to $^{90-92}\text{Zr}(n,\gamma)$ data. The $^{89}\text{Zr}(n,\gamma)$ reaction has the highest cross section because its neutron-binding energy of 11.98 MeV is the greatest of the three isotopes, providing the largest integration range for calculation of this cross section.

In Fig. 32, $^{88-90}\text{Zr}(n,2n)$ cross-section trends are displayed. The ^{89}Zr and $^{90}\text{Zr}(n,2n)$ reactions have thresholds that differ by approximately 2 MeV, but at higher energies the difference in cross sections is less than 10%. On the other hand, for ^{88}Zr this cross section is quite different, being smaller by almost a factor of two. Here the (n,p) and (n,pn) cross sections are calculated to be quite large, which in turn lowers the fraction of the total reaction cross section available for the $(n,2n)$ reaction. Competition from the (n,np) reaction also plays a role in lowering this cross section in comparison to those values computed for ^{89}Zr and ^{90}Zr .

Cross-section characteristics for $^{88-90}\text{Zr}(n,p)$ reactions are shown in Fig. 33. The unstable $^{88,89}\text{Zr}$ isotopes have positive Q values for this reaction. The fact that the $^{89}\text{Zr}(n,p)$ reaction has the largest positive value (3.6 MeV) leads to a substantial contribution at low energies. The $^{88}\text{Zr}(n,p)$ Q value is less (1.46 MeV), leading to reduced cross sections for energies less than a few hundred keV. However, this situation changes above 1 MeV, where substantial cross-section values are predicted.

The $^{88-90}\text{Zr}(n,np) + (n,pn)$ reactions are shown in Fig. 34. The shape of the curve shown for ^{90}Zr is somewhat different than that in Fig. 20 for ^{89}Y since no bump occurs. This results because in the ^{90}Zr compound system, the proton neutron binding-energy difference is less than for ^{89}Y . Also, the proton binding energy in ^{90}Zr is about 1.3 MeV higher. In this case note that the thresholds for the $(n,np) + (n,pn)$ reactions are about the same (7-8 MeV) for all three isotopes. However, the calculated curves for $^{88,89}\text{Zr}$ lie above that for ^{90}Zr largely as a result of 30-40% contributions from the (n,pn) reaction.

IV. SUMMARY

We have described an extensive series of calculations of neutron-induced reactions on yttrium and zirconium isotopes performed using consistent sets of input parameters and calculational techniques. Calculations made in this mass region around the closed neutron shell lead to the ability to test model parameters in somewhat unusual circumstances not always occurring in other regions. These parameters were determined with a variety of techniques from the use of

Fig. 32.
The calculated (n,2n) cross sections
are compared for $^{88-90}\text{Zr}$.

Fig. 33.
Calculated $^{88-90}\text{Zr}(n,p)$ cross sections
in the energy range from 0.001 to 20 MeV.

Fig. 34.
The sum of (n,np + n,pn) cross sections as
calculated for the $^{88-90}\text{Zr}$ isotopes.

independent neutron data such as total cross-section results to the use of information from charged-particle reactions. The calculated results were tested rigorously against a large portion of the available experimental data for ^{89}Y and ^{90}Zr isotopes. This comparison was extended to data for unstable isotopes of these nuclei with satisfactory results. The degree of effort involved in these parameter determinations as well as the fact that most calculated results agree well with experimental data, leads to increased confidence in the ability of these calculations to provide reasonable cross-section results in nearby mass and energy regions lacking in experimental data.

APPENDIX A

DISCRETE LEVELS USED IN THE PRESENT CALCULATIONS

<u>Nucleus</u>	<u>Level Energy (MeV)</u>	<u>Spin Parity</u>
37082	0.000000	1.0 +
37083	0.000000	5.0 -
	0.000000	2.5 -
	.005000	1.5 -
	.042000	4.5 +
	.390000	1.5 -
37084	.424000	7.5 +
	0.000000	2.0 -
	.248300	3.0 +
	.463600	6.0 +
37085	0.000000	2.5 -
	.151300	1.5 -
	.514000	4.5 +
	.870000	3.5 -
37086	0.000000	2.0 -
	.488000	2.0 +
	.555900	6.0 -
	.557000	3.0 -
	.780000	5.0 -
	.873000	3.0 -
	.979000	4.0 -
37087	0.000000	4.5 +
	.388000	.5 -
	.873000	1.5 -

<u>Nucleus</u>	<u>Level Energy (MeV)</u>	<u>Spin Parity</u>
37088	0.000000	2.0 -
	.028000	3.0 -
	.196000	1.0 -
	.268000	4.0 -
	.363000	1.0 -
37089	0.000000	1.5 -
	.221000	2.5 -
38084	0.000000	0.0 +
	.793000	2.0 +
	1.454000	0.0 +
	1.768000	4.0 +
	2.056000	0.0 +
	2.448000	3.0 -
38085	0.000000	4.5 +
	.231700	3.5 +
	.238700	.5 -
	.742800	1.5 -
	.767000	2.5 +
	.786000	1.5 +
	.937000	2.5 -
	1.153000	1.5 -
	1.220000	3.5 +
	1.262000	4.5 +
	1.355000	1.5 +
	1.405000	2.5 +
	1.453000	2.5 +
	1.552000	2.5 +
38086	0.000000	0.0 +
	1.076630	2.0 +
	1.854200	2.0 +
	2.080000	0.0 +
	2.229700	4.0 +
	2.481900	3.0 -
	2.642000	6.0 +
	2.673000	5.0 -
	2.788000	2.0 +
	2.857000	6.0 +
	2.878000	4.0 +
	2.955000	8.0 +
	2.997000	3.0 -
	3.056000	4.0 -
	3.185000	3.0 -

<u>Nucleus</u>	<u>Level Energy (MeV)</u>	<u>Spin Parity</u>
38087	0.000000	4.5 +
	.388400	.5 -
	.873200	1.5 -
	1.232000	2.5 +
	1.554000	2.5 +
	1.767000	2.5 +
	1.918000	5.5 +
	2.108000	.5 -
	2.170000	5.5 +
	2.237000	4.5 +
	2.418000	2.5 -
38088	0.000000	0.0 +
	1.836000	2.0 +
	2.741000	3.0 -
	3.150000	0.0 +
	3.219500	2.0 +
	3.487000	1.0 +
	3.520000	2.0 +
	3.584000	4.0 -
	3.635000	3.0 +
	3.953000	4.0 +
	3.990000	3.0 -
	4.036000	2.0 +
39089	0.000000	2.5 +
	1.031000	.5 +
	1.460000	3.5 +
	1.931000	2.5 +
	2.007600	1.5 +
	2.057000	4.5 +
	2.079000	5.5 -
	2.280000	.5 -
	2.455000	1.5 +
	2.570000	1.5 -
	2.671000	3.5 +
	2.708000	3.5 +
39090	0.000000	0.0 +
	.832000	2.0 +
	1.660000	4.0 +
	1.892000	2.0 +
	2.207000	2.0 +
	2.407000	2.0 +
	2.528000	3.0 +
	2.571000	1.0 +
	2.928000	3.0 +
	2.971000	0.0 +
	3.032000	1.0 +
	3.039000	1.0 +

<u>Nucleus</u>	<u>Level Energy (MeV)</u>	<u>Spin Parity</u>
3A091	0.000000	2.5 +
	.093600	1.5 +
	.439000	1.5 +
	1.042000	2.5 +
	1.231000	.5 +
3A092	0.000000	0.0 +
	.815000	2.0 +
	1.385000	2.0 +
	1.778000	2.0 +
	2.088000	2.0 +
	2.141000	4.0 +
	2.527000	3.0 +
	2.624000	2.0 +
	2.783000	3.0 -
	2.821000	1.0 +
39085	0.000000	.5 -
	.020000	4.5 +
	.268000	2.5 -
	.417000	1.5 -
	.436000	1.5 +
	.639000	1.5 -
	.803000	1.5 +
	.883000	2.5 +
	.936000	.5 -
	.962000	1.5 -
	1.212000	1.5 -
	1.278000	2.5 +
	1.375000	.5 +
39086	0.000000	4.0 -
	.208000	5.0 -
	.218200	8.0 +
	.243000	2.0 -
	.271000	1.0 +
39087	0.000000	.5 -
	.381000	4.5 +
	.792000	2.5 -
	.986000	1.5 -
	1.155000	2.5 +
	1.180000	1.5 -
	1.605000	4.5 +
	1.848000	1.5 -
	2.000000	3.5 -
	2.085000	1.5 -
	2.150000	2.5 +
	2.203000	4.5 +
	2.278000	2.5 -
	2.407000	2.5 +
	2.510000	4.5 +
	2.730000	2.5 -

<u>Nucleus</u>	<u>Level Energy (MeV)</u>	<u>Spin Parity</u>
39088	0.000000	4.0 -
	.232000	5.0 -
	.393000	1.0 +
	.675000	8.0 +
	.707000	2.0 -
	.715000	7.0 +
	.767000	0.0 +
	.843000	5.0 +
	.985000	4.0 +
	1.088000	5.0 -
	1.129000	5.0 -
	1.221000	2.0 +
	1.284000	3.0 +
	1.320000	6.0 -
	1.462000	7.0 -
	1.476000	9.0 +
	1.576000	2.0 +
	1.596000	4.0 -
	1.703000	3.0 +
39089	0.000000	.5 -
	.908000	4.5 +
	1.507000	1.5 -
	1.745000	2.5 -
	2.220000	2.5 +
	2.529000	3.5 +
	2.568000	5.5 +
	2.622000	4.5 +
	2.871000	3.5 +
	2.884000	1.5 -
	3.069000	1.5 -
	3.106000	2.5 -
	3.138000	2.5 -
	3.246000	.5 +
	3.411000	3.5 +
	3.450000	2.5 +
	3.502000	3.5 +
	3.511000	1.5 -
	3.559000	.5 -
	3.625000	4.5 +
	3.716000	2.5 +
	3.748000	4.5 +
	3.852000	2.5 +
	3.864000	2.5 -
	3.990000	1.5 -
	4.000000	.5 +

<u>Nucleus</u>	<u>Level Energy (MeV)</u>	<u>Spin Parity</u>
39291	0.000000	2.0 -
	.203000	3.0 -
	.685000	7.0 +
	.777000	2.0 +
	.954000	3.0 +
	1.047000	5.0 +
	1.189300	4.0 +
	1.215000	0.0 -
	1.298000	6.0 +
	1.371000	1.0 -
	1.417000	1.0 -
	1.572000	3.0 -
	1.641000	1.0 -
	1.760000	3.0 -
	1.813000	3.0 -
39291	0.000000	.5 -
	.556000	4.5 +
	.653000	1.5 -
	.926000	2.5 -
	1.180000	3.5 -
	1.304000	2.5 +
	1.476000	1.5 -
	1.549000	3.5 -
	1.580000	3.5 +
	1.976000	2.5 +
	2.069000	2.5 +
	2.167000	1.5 -
	2.211000	2.5 -
39292	0.000000	2.0 -
	.280000	3.0 -
	.440000	4.0 -
	.820000	1.0 -
	.898000	2.0 -
	.953000	1.0 -
	1.050000	3.0 -
	1.320000	0.0 -
	1.384000	1.0 +
	1.480000	2.0 +
	1.711000	3.0 +
39293	0.000000	.5 -
	.590000	1.5 -
	.758400	4.5 +
	.875800	2.5 -
	1.130000	2.5 -
	1.290000	2.5 -
	1.540000	1.5 -
	1.700000	2.5 +
	1.870000	2.5 -
	2.000000	1.5 -
	2.070000	5.5 -

<u>Nucleus</u>	<u>Level Energy (MeV)</u>	<u>Spin Parity</u>
40087	0.000000	4.5 +
	.201000	3.5 +
	.336000	.5 -
	.470700	3.5 +
	.801000	3.5 +
	.818000	3.5 +
	1.087100	2.5 -
	1.884300	4.5 +
40088	0.000000	0.0 +
	1.058000	2.0 +
	1.520000	0.0 +
	1.827000	2.0 +
	2.140000	4.0 +
	2.225000	0.0 +
	2.445000	3.0 -
	2.540000	5.0 -
	2.570000	2.0 +
	2.600000	6.0 +
	2.800000	5.0 -
	2.887000	8.0 +
	2.990000	4.0 -
40089	0.000000	4.5 +
	.587000	.5 -
	1.095000	1.5 -
	1.451000	2.5 -
	1.512000	4.5 +
	1.628000	2.5 +
	1.746000	1.5 -
	1.834000	2.5 +
	1.865600	1.5 -
	1.943000	6.5 +
	2.087000	1.5 +
	2.100300	2.5 -
	2.101000	5.5 +
	2.122000	6.5 -

<u>Nucleus</u>	<u>Level Energy (MeV)</u>	<u>Spin Parity</u>
40090	0.000000	0.0 +
	1.761000	0.0 +
	2.186000	2.0 +
	2.319000	5.0 -
	2.739000	4.0 -
	2.748000	3.0 -
	3.077000	4.0 +
	3.309000	2.0 +
	3.448000	6.0 +
	3.589000	8.0 +
	3.843000	2.0 +
	3.970000	5.0 -
	4.040000	4.0 +
	4.120000	2.0 +
	4.130000	0.0 +
	4.232000	5.0 -
	4.238000	2.0 +
	4.280000	4.0 -
	4.330000	4.0 +
	4.428000	0.0 +
40091	0.000000	2.5 +
	1.205000	.5 +
	1.466000	2.5 +
	1.882000	3.5 +
	2.041400	1.5 +
40092		

APPENDIX B

DETERMINATION OF LOW ENERGY CROSS SECTIONS FOR REACTIONS WITH POSITIVE Q VALUES

In cases involving positive Q-value reactions, we have provided cross sections down to the lower energy limit used in ENDF/B of 10^{-5} eV. For the stable ^{89}Y and ^{90}Zr nuclei resonance parameter and thermal cross-section, information exist that allowed us to determine cross sections in energy regions where Hauser-Feshbach techniques are no longer applicable. For the other nuclei, estimates had to be made of the energy at which resonance effects should become important.

Since we used gamma-ray strength functions (Sec. II. C) to normalize our gamma-ray transmission coefficients, it was possible to obtain a calculated value of the ratio $2\pi\langle\Gamma_Y\rangle/\langle D\rangle$. When assumptions concerning the value of the average gamma-ray width $\langle\Gamma_Y\rangle$ were made, then the average s-wave resonance spacing $\langle D\rangle$

could be deduced. This in turn provided an estimate of the position of the first resonance occurring in a particular compound system.

For yttrium and zirconium isotopes we chose values for $\langle \Gamma_Y \rangle$ of 0.1 and 0.15 eV, respectively. Substituting this in the calculated $2\pi\langle \Gamma_Y \rangle / \langle D \rangle$ ratio resulted in the $\langle D \rangle$ values shown in Table B-I. We then used these $\langle D \rangle$ values to place the location of the first resonance and assumed a shape similar to that of the $^{89}\text{Y}(n,\gamma)$ reaction at low energies.⁴⁵ (We did not assume the interference dip appearing before the resonance peak in this data.) For the unstable isotopes this resonance peak cross section was joined smoothly to the Hauser-Feshbach results at energies around 1 keV. In some cases ($^{90,91}\text{Y}$), experimental thermal cross-section values were available that were then extrapolated using a $1/v$ dependence and then joined to the lower energy side of the resonance shape. In the other cases a similar procedure was followed, but estimates for thermal cross sections were made on the basis of systematics in this mass region.

TABLE B-I
RESONANCE SPACINGS DEDUCED FROM CALCULATED
 $2\pi\langle \Gamma_Y \rangle / \langle D \rangle$ RATIOS

<u>Target Nucleus</u>	<u>$\langle D \rangle$ (eV) (Deduced)</u>
^{86}Y	5.0
^{87}Y	75.0
^{88}Y	30.0
^{90}Y	353.0
^{91}Y	742.0
^{92}Y	67.0
^{88}Zr	349.0
^{89}Zr	27.0

APPENDIX C

ENDF/B REPRESENTATION OF THE YTTRIUM AND ZIRCONIUM CROSS SECTIONS
CALCULATED OR EVALUATED IN THE PRESENT WORK

3.9086 +04	8.5177 +01	0	0	0	13986	1451	1
0.	1.	0	0	0	03986	1451	2
0.	0.	0	0	53	113986	1451	3
39-Y = 86 LASL					3986	1451	4
LA-7301,7482PR					3986	1451	5
FVAL=DEC78 E.D. ARTHUR					3986	1451	6
DIST=DEC78 RFV0							
GENERAL DESCRIPTION							

-----	3986	1451	7
THE FOLLOWING CROSS SECTIONS RESULT FROM A NEW EVALUATION OF	3986	1451	8
YTTRIUM 86-92 ISOTOPES MADE USING GNASH AND COMNUC	3986	1451	9
STATISTICAL NUCLEAR MODEL CODES. THIS EVALUATION USES NEW MODEL	3986	1451	10
PARAMETERS AND SHOULD REPRESENT AN IMPROVEMENT OVER THE EARLIER	3986	1451	11
EVALUATION (6/17/77).	3986	1451	12
PRELIMINARY REPORTS OF THIS WORK APPEAR IN LA-7301-PR(1978) P.2	3986	1451	13
AND LA-7482-PR (1978) P.6, AND A DETAILED DESCRIPTION OF THE	3986	1451	14
CALCULATIONS WILL APPEAR IN AN UPCOMING LOS ALAMOS REPORT. A	3986	1451	15
BRIEF DESCRIPTION, HOWEVER, WILL BE GIVEN BELOW.	3986	1451	16
PRINCIPAL IMPROVEMENTS INCORPORATED IN THE PRESENT CALCULATIONS	3986	1451	17
RESULT FROM BETTER PROTON AND NEUTRON OPTICAL PARAMETERS AND	3986	1451	18
THE DETERMINATION AND USE OF GAMMA-RAY STRENGTH FUNCTIONS IN THIS	3986	1451	19
MASS REGION. NEW PROTON OPTICAL PARAMETERS WERE DETERMINED	3986	1451	20
FROM LOW ENERGY SR-87, Y-89 (P,N) DATA (REF.1) AND ARE SOMEWHAT	3986	1451	21
DIFFERENT FROM STANDARD PARAMETER SETS. NEUTRON PARAMETERS WERE	3986	1451	22
BASED ON A MODIFICATION OF THE LAGRANGE PARAMETERS (REF.2) WHICH	3986	1451	23
ARE APPLICABLE FROM 1 KEV TO 20 MEV.	3986	1451	24
TO DESCRIBE THE NEUTRON CAPTURE PROCESS AND GAMMA-RAY COMPETITION	3986	1451	25
A SYSTEMATIC STUDY WAS MADE OF GAMMA-RAY STRENGTH FUNCTIONS FOR	3986	1451	26
A=85-100 AS SUGGESTED IN REF.3. THESE GAMMA-RAY STRENGTH	3986	1451	27
FUNCTIONS CAN BE DETERMINED FROM CAPTURE DATA ON STABLE NUCLEI	3986	1451	28
AND THEN BE USED TO GIVE REALISTIC CAPTURE CROSS SECTIONS ON	3986	1451	29
UNSTABLE NUCLEI, AS WELL AS TO PROVIDE AN ACCURATE DESCRIPTION	3986	1451	30
OF GAMMA EMISSION WHERE IT IS AN IMPORTANT COMPETING REACTION.	3986	1451	31
FINALLY A NEW PREEQUILIBRIUM MODEL BASED ON THE KALBACH RESULTS	3986	1451	32

(REF. 4) WAS USED TO DESCRIBE NONSTATISTICAL EFFECTS IN THE RANGE 10-20 MFV. (OTHER PARAMETERS RELATING TO LEVEL DENSITIES AND THE FORM OF THE GAMMA-RAY EMISSION MODEL WERE SIMILAR TO THOSE USED IN THE 6/17/77 EVALUATION) THE NET RESULTS OF THESE IMPROVEMENTS WERE A CONSISTENT PARAMETER SETS WHICH REPRODUCED NEUTRON AND CHARGED PARTICLE DATA FOR Y AND ZR ISOTOPES.

A FEW MISCELLANEOUS REMARKS ABOUT THE PRESENT EVALUATION. ALL CROSS SECTIONS LEADING TO UNSTABLE RESIDUAL NUCLEI OR META-
STABLE STATES WERE CALCULATED FOR ALL REACTIONS. (METASTABLE STATES WERE NOT GENERALLY CALCULATED FOR (N,GAMMA) AND (N,ALPHA) REACTIONS). THE CONVENTION USED IS IF THE FINAL STATE FLAG (LFS) IS EQUAL TO ZERO THEN THE CROSS SECTION GIVEN REPRESENTS THE TOTAL CROSS SECTION FOR THAT REACTION. CROSS SECTIONS LEADING TO AN ISOMERIC STATE ARE DENOTED BY LFS EQUAL TO THE NUMBER OF THE STATE. FINALLY THE (N,ALPHA) AND (N,ALPHA,N) CROSS SECTIONS ARE INCLUDED TOGETHER.

REFERENCES

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1	451	53
3	4	18
3	16	11
3	16	11
3	22	11
3	28	13
3	28	13
3	53	16
3	102	22
3	103	22
3	107	18

3986	1451	33
3986	1451	34
3986	1451	35
3986	1451	36
3986	1451	37
3986	1451	38
3986	1451	39
3986	1451	40
3986	1451	41
3986	1451	42
3986	1451	43
3986	1451	44
3986	1451	45
3986	1451	46
3986	1451	47
3986	1451	48
3986	1451	49
3986	1451	50
3986	1451	51
3986	1451	52
3986	1451	53
3986	1451	54
3986	1451	55
3986	1451	56
3986	1451	57
3986	1451	58
3986	1451	59
3986	1451	60
3986	1451	61
3986	1451	62
3986	1451	63
3986	1451	64
3986	1451	65
3986	1451	66
3986	1451	67
3986	1451	68
3986	1451	69
3986	1	70
3986	0	71
03986	2151	72
03986	2151	73

3. 9286E+04 8.5177E+01
3. 9286E+04 0.

0	0	1
0	0	1

1.2500E+07	3.2009E-01	1.3000E+07	3.2000E-01	1.3500E+07	3.1439E-01	3986	3	16	6
1.4000E+07	3.1100E-01	1.4500E+07	3.1905E-01	1.5000E+07	3.4100E-01	3986	3	16	7
1.5500E+07	3.6907E-01	1.6000E+07	3.9700E-01	1.6500E+07	4.2269E-01	3986	3	16	8
1.7000E+07	4.4700E-01	1.7500E+07	4.6700E-01	1.8000E+07	4.8400E-01	3986	3	16	9
1.8500E+07	4.9604E-01	1.9000E+07	5.0500E-01	1.9500E+07	5.1197E-01	3986	3	16	10
2.0000E+07	5.1700E-01	0.	0.	0.	0.	3986	3	16	11
3.9000E+04	8.5177E+01	0.	0.	0.	0.	3986	3	0	0
0.	-5.4672E+06	0.	0.	0.	22	3986	3	22	1
22	2	0.	0.	0.	0.	3986	3	22	2
5.5310E+06	0.	1.0000E+07	1.0000E-09	1.0500E+07	2.2616E-08	3986	3	22	3
1.1000E+07	6.0000E-08	1.1500E+07	5.5176E-07	1.2000E+07	1.5000E+07	3986	3	22	4
1.2500E+07	5.7001E-06	1.3000E+07	1.5000E-05	1.3500E+07	3.3304E-05	3986	3	22	5
1.4000E+07	6.4000E-05	1.4500E+07	1.0426E-04	1.5000E+07	1.5000E-04	3986	3	22	6
1.5500E+07	2.0123E-04	1.6000E+07	2.6000E-04	1.6500E+07	3.4410E-04	3986	3	22	7
1.7000E+07	4.6000E-04	1.7500E+07	6.1056E-04	1.8000E+07	8.0000E-04	3986	3	22	8
1.8500E+07	1.0271E-03	1.9000E+07	1.3000E-03	1.9500E+07	1.6236E-03	3986	3	22	9
2.0000E+07	2.0000E-03	0.	0.	0.	0.	3986	3	22	10
3.9000E+04	8.5177E+01	0.	0.	0.	0.	3986	3	0	11
0.	-5.4299E+06	0.	0.	0.	0.	3986	3	0	0
20	2	0.	0.	0.	0.	3986	3	0	1
5.4940E+06	0.	7.0000E+06	2.3000E-04	7.5000E+06	3.8105E-03	3986	3	28	2
8.0000E+06	1.4900E-02	8.5000E+06	5.8652E-02	9.0000E+06	1.2900E-01	3986	3	28	3
9.5000E+06	2.3596E-01	1.0000E+07	3.1200E-01	1.0500E+07	3.1324E-01	3986	3	28	4
1.1000E+07	3.1200E-01	1.1500E+07	3.1295E-01	1.2000E+07	3.1800E-01	3986	3	28	5
1.2500E+07	3.3978E-01	1.3000E+07	3.7200E-01	1.3500E+07	4.0591E-01	3986	3	28	6
1.4000E+07	4.3900E-01	1.4500E+07	4.6500E-01	1.5000E+07	4.8400E-01	3986	3	28	7
1.5500E+07	4.9405E-01	1.6000E+07	5.0300E-01	1.6500E+07	5.1010E-01	3986	3	28	8
1.7000E+07	5.1600E-01	1.7500E+07	5.2050E-01	1.8000E+07	5.2500E-01	3986	3	28	9
1.8500E+07	5.2950E-01	1.9000E+07	5.3400E-01	1.9500E+07	5.3912E-01	3986	3	28	10
2.0000E+07	5.4500E-01	0.	0.	0.	0.	3986	3	28	11
3.9000E+04	8.5177E+01	0.	0.	0.	0.	3986	3	0	12
0.	-5.6600E+06	0.	0.	0.	0.	3986	3	0	13
20	2	0.	0.	0.	0.	3986	3	0	0
5.7360E+06	0.	7.0000E+06	5.2000E-06	7.5000E+06	2.9775E-04	3986	3	28	1
8.0000E+06	1.0000E-03	8.5000E+06	6.0632E-03	9.0000E+06	1.5500E-02	3986	3	28	2
9.5000E+06	3.3473E-02	1.0000E+07	4.7700E-02	1.0500E+07	4.5677E-02	3986	3	28	3
1.1000E+07	4.2600E-02	1.1500E+07	4.2243E-02	1.2000E+07	4.3400E-02	3986	3	28	4
1.2500E+07	4.6697E-02	1.3000E+07	5.0000E-02	1.3500E+07	5.2996E-02	3986	3	28	5

1.4000E+07	5.6000E-02	1.4500E+07	5.9800E-02	1.5300E+07	6.3000E-02	1986	3	28	9
1.5500E+07	6.4417E-02	1.6000E+07	6.5600E-02	1.6500E+07	6.6800E-02	1986	3	28	10
1.7000E+07	6.8000E-02	1.7500E+07	6.9200E-02	1.8000E+07	7.0400E-02	1986	3	28	11
1.8500E+07	7.1224E-02	1.9000E+07	7.1700E-02	1.9500E+07	7.2100E-02	1986	3	28	12
2.0000E+07	7.2600E-02	0.	0.	0.	0.	1986	3	28	13
3.9000E+04	8.5177E+01	0	0	0	0	1986	3	0	14
0.	-2.1820E+05	0	0	0	0	1986	3	53	1
	43	0	0	0	0	1986	3	53	2
2.2000E+05	0.	2.5000E+05	2.7300E-03	5.3000E+05	2.0300E-02	1986	3	53	3
7.5000E+05	4.0000E-02	1.0000E+06	5.9600E-02	1.5000E+06	7.3800E-02	1986	3	53	4
2.0000E+06	8.8000E-02	2.5000E+06	9.9000E-02	3.0000E+06	1.1000E-01	1986	3	53	5
3.5000E+06	1.3487E-01	4.0000E+06	1.6100E-01	4.5000E+06	1.7450E-01	1986	3	53	6
5.0000E+06	1.8800E-01	5.5000E+06	2.0150E-01	6.0000E+06	2.1500E-01	1986	3	53	7
6.5000E+06	2.2850E-01	7.0000E+06	2.4200E-01	7.5000E+06	2.5492E-01	1986	3	53	8
8.0000E+06	2.6700E-01	8.5000E+06	2.7582E-01	9.0000E+06	2.8100E-01	1986	3	53	9
9.5000E+06	2.8407E-01	1.0000E+07	2.8100E-01	1.0500E+07	2.7197E-01	1986	3	53	10
1.1000E+07	2.6100E-01	1.1500E+07	2.4880E-01	1.2000E+07	2.3700E-01	1986	3	53	11
1.2500E+07	2.2694E-01	1.3000E+07	2.1700E-01	1.3500E+07	2.0617E-01	1986	3	53	12
1.4000E+07	1.9400E-01	1.4500E+07	1.7992E-01	1.5000E+07	1.6500E-01	1986	3	53	13
1.5500E+07	1.4945E-01	1.6000E+07	1.3400E-01	1.6500E+07	1.2057E-01	1986	3	53	14
1.7000E+07	1.0950E-01	1.7500E+07	1.0013E-01	1.8000E+07	9.2000E-02	1986	3	53	15
1.8500E+07	8.4743E-02	1.9000E+07	7.8400E-02	1.9500E+07	7.3301E-02	1986	3	53	16
2.0000E+07	6.9400E-02	0.	0.	0.	0.	1986	3	53	17
3.9000E+04	8.5177E+01	0	0	0	0	1986	3	0	18
0.	1.1819E+07	0	0	0	0	1986	3	0	19
	9	56	2	0	0	1986	3	0	20
1.0000E-05	3.1400E+03	2.5300E-02	6.2230E+01	5.0000E-01	1.4000E+01	1986	3	0	1
1.0000E+00	1.4200E+01	3.0000E+00	1.4000E+01	5.0000E+00	1.4000E+02	1986	3	0	2
9.0000E+00	5.0000E+01	1.0000E+02	1.2690E+01	5.0000E+02	5.0270E+00	1986	3	0	3
1.0000E+03	3.3400E+00	1.0000E+04	1.0220E+00	2.5000E+04	7.3800E-01	1986	3	0	4
5.0000E+04	5.7000E-01	1.0000E+05	4.1600E-01	2.5000E+05	2.4600E-01	1986	3	0	5
5.0000E+05	1.3700E-01	7.5000E+05	1.0600E-01	1.0000E+06	9.0000E-02	1986	3	0	6
1.5000E+06	7.2500E-02	2.0000E+06	1.4060E-02	2.5000E+06	3.6500E-02	1986	3	0	7
3.0000E+06	2.3300E-02	3.5000E+06	1.4067E-02	4.0000E+06	9.5800E-03	1986	3	0	8
4.5000E+06	6.3090E-03	5.0000E+06	4.1600E-03	5.0000E+06	2.8932E-03	1986	3	0	9
6.0000E+06	2.0100E-03	6.5000E+06	1.4736E-03	7.0000E+06	1.3000E-03	1986	3	0	10
7.5000E+06	1.5526E-03	8.0000E+06	1.8000E-03	8.5000E+06	1.9827E-03	1986	3	0	11
9.0000E+06	2.1000E-03	9.5000E+06	2.1350E-03	1.0000E+07	2.1700E-03	1986	3	0	12
1.0500E+07	2.2050E-03	1.1000E+07	2.7400E-03	1.1500E+07	2.2844E-03	1986	3	0	13

1.2000E+07	2.3340E-03	1.2500E+07	2.3772E-03	1.3000E+07	2.4180E-03	3102	17
1.3500E+07	2.4596E-03	1.4000E+07	2.4500E-03	1.4500E+07	2.3857E-03	3102	18
1.5000E+07	2.3200E-03	1.5500E+07	2.2701E-03	1.6000E+07	2.1920E-03	3102	19
1.6500E+07	2.0057E-03	1.7000E+07	1.7970E-03	1.7500E+07	1.5922E-03	3102	20
1.8000E+07	1.4010E-03	1.8500E+07	1.2549E-03	1.9000E+07	1.1250E-03	3102	21
1.9500E+07	9.8636E-04	2.0000E+07	8.4780E-04	0.	0.	3102	22
3.9086E+04	8.5177E+01	0	0	0	0.	3986	0
0.	6.0550E+06	0	0	0	0	3986	1
	56	0	0	0	0	563986	2
1.0000E-05	2.5400E+03	2.5300E-02	5.0500E+01	5.0000E-01	1.1300E+01	3103	3
1.0000E+00	1.1300E+01	3.0000E+00	1.1300E+01	5.0000E+00	1.1300E+02	3103	4
9.0000E+00	4.3600E+01	1.0000E+02	1.1060E+01	5.0000E+02	4.6500E+00	3103	5
1.0000E+03	3.1900E+00	1.0000E+04	1.0900E+00	2.5000E+04	8.5800E-01	3103	6
5.0000E+04	7.4400E-01	1.0000E+05	6.2800E-01	2.5000E+05	4.5800E-01	3103	7
5.0000E+05	3.0100E-01	7.5000E+05	2.3400E-01	1.0000E+06	2.3100E-01	3103	8
1.5000E+06	1.9900E-01	2.0000E+06	1.6800E-01	2.5000E+06	1.3300E-01	3103	9
3.0000E+06	9.8000E-02	3.5000E+06	1.3403E-01	4.0000E+06	1.8000E-01	3103	10
4.5000E+06	1.6610E-01	5.0000E+06	1.5000E-01	5.5000E+06	1.4073E-01	3103	11
6.0000E+06	1.4100E-01	6.5000E+06	1.3875E-01	7.0000E+06	1.3800E-01	3103	12
7.5000E+06	1.3900E-01	8.0000E+06	1.4000E-01	8.5000E+06	1.4100E-01	3103	13
9.0000E+06	1.4200E-01	9.5000E+06	1.4031E-01	1.0000E+07	1.3600E-01	3103	14
1.0500E+07	1.3175E-01	1.1000E+07	1.2600E-01	1.1500E+07	1.1861E-01	3103	15
1.2000E+07	1.1100E-01	1.2500E+07	1.0323E-01	1.3000E+07	0.5500E-02	3103	16
1.3500E+07	8.8403E-02	1.4000E+07	8.2200E-02	1.4500E+07	7.6019E-02	3103	17
1.5000E+07	7.2100E-02	1.5500E+07	6.7745E-02	1.6000E+07	6.4000E-02	3103	18
1.6500E+07	6.0939E-02	1.7000E+07	5.8400E-02	1.7500E+07	5.6187E-02	3103	19
1.8000E+07	5.4000E-02	1.8500E+07	5.1841E-02	1.9000E+07	4.9700E-02	3103	20
1.9500E+07	4.7739E-02	2.0000E+07	4.6300E-02	0.	0.	3986	21
3.9086E+04	8.5177E+01	0	0	0	0	3986	22
0.	5.3590E+06	0	0	0	0	03986	0
	43	0	0	0	0	433986	1
1.0000E-05	0.	2.5300E-02	0.	5.0000E+02	0.	3986	2
1.0000E+03	0.	1.0000E+06	5.0000E-05	1.5000E+06	1.5000E-04	3107	3
2.0000E+06	3.0000E-04	2.5000E+06	4.8000E-04	3.0000E+06	7.0000E-04	3107	4
3.0000E+06	8.6235E-04	4.0000E+06	1.5000E-03	4.5000E+06	3.5156E-03	3107	5
5.0000E+06	6.0000E-03	5.5000E+06	7.9000E-03	6.0000E+06	1.0000E-02	3107	6
6.5000E+06	1.3375E-02	7.0000E+06	1.7000E-02	7.5000E+06	2.0000E-02	3107	7
8.0000E+06	2.3000E-02	8.5000E+06	2.6000E-02	9.0000E+06	2.9000E-02	3107	8
9.5000E+06	3.1735E-02	1.0000E+07	3.4200E-02	1.0500E+07	3.6555E-02	3107	9
1.1000E+07	3.8700E-02	1.1500E+07	4.0536E-02	1.2000E+07	4.2000E-02	3107	10
						3107	11
						3107	12

1.2500E+07	4.3011E+02	1.3000E+07	4.4000E+02	1.3500E+07	4.5554E+02	3986	13
1.4000E+07	4.7000E+02	1.4500E+07	4.7935E+02	1.5000E+07	4.8790E+02	3986	14
1.5500E+07	4.9395E+02	1.6000E+07	5.0000E+02	1.6500E+07	5.0481E+02	3986	15
1.7000E+07	5.0900E+02	1.7500E+07	5.1279E+02	1.8000E+07	5.1600E+02	3986	16
1.8500E+07	5.1804E+02	1.9000E+07	5.2000E+02	1.9500E+07	5.2277E+02	3986	17
2.0000E+07	5.2600E+02	0.	0.	0.	0.	3986	18
3.9087E+04	8.6164E+01	0	0	0	0	3986	0
0.	1.	0	0	0	0	3986	0
0.	0.	0	0	0	0	3986	0
39-Y = 87 LASL		EVAL=DEC78 E.D.ARMJR		53	115987	1451	1
LA-7301,7482		HIST=DEC78 RFV0			5987	1451	2
		GENERAL DESCRIPTION			5987	1451	3
					5987	1451	4
					5987	1451	5
					5987	1451	6

THE FOLLOWING CROSS SECTIONS RESULT FROM A NEW EVALUATION OF	5987	1451	7
YTTRIUM 86-92 ISOTOPES MADE USING GNASH AND COMNHC	5987	1451	8
STATISTICAL NUCLEAR MODEL CODES. THIS EVALUATION USES NEW MODEL	5987	1451	9
PARAMETERS AND SHOULD REPRESENT AN IMPROVEMENT OVER THE EARLIER	5987	1451	10
EVALUATION (6/17/77).	5987	1451	11
PRELIMINARY REPORTS OF THIS WORK APPEAR IN LA-7301-PR(1978) P.2	5987	1451	12
AND LA-7482-PR (1978) P.6, AND A DETAILED DESCRIPTION OF THE	5987	1451	13
CALCULATIONS WILL APPEAR IN AN UPCOMING LOS ALAMOS REPORT. A	5987	1451	14
BRIEF DESCRIPTION, HOWEVER, WILL BE GIVEN BELOW.	5987	1451	15
PRINCIPAL IMPROVEMENTS INCORPORATED IN THE PRESENT CALCULATIONS	5987	1451	16
RESULT FROM BETTER PROTON AND NEUTRON OPTICAL PARAMETERS AND	5987	1451	17
THE DETERMINATION AND USE OF GAMMA-RAY STRENGTH FUNCTIONS IN THIS	5987	1451	18
MASS REGION. NEW PROTON OPTICAL PARAMETERS WERE DETERMINED	5987	1451	19
FROM LOW ENERGY SR=87, Y=89 (P,N) DATA (REF.1) AND ARE SOMEWHAT	5987	1451	20
DIFFERENT FROM STANDARD PARAMETER SETS. NEUTRON PARAMETERS WERE	5987	1451	21
BASED ON A MODIFICATION OF THE LAGRANGE PARAMETERS (REF.2) WHICH	5987	1451	22
ARE APPLICABLE FROM 1 KEV TO 20 MEV.	5987	1451	23
TO DESCRIBE THE NEUTRON CAPTURE PROCESS AND GAMMA-RAY COMPETITIONS	5987	1451	24
A SYSTEMATIC STUDY WAS MADE OF GAMMA-RAY STRENGTH FUNCTIONS FOR	5987	1451	25
A=85-100 AS SUGGESTED IN REF.3. THESE GAMMA-RAY STRENGTH	5987	1451	26
FUNCTIONS CAN BE DETERMINED FROM CAPTURE DATA ON STABLE NUCLEI	5987	1451	27
AND THEN BE USED TO GIVE REALISTIC CAPTURE CROSS SECTIONS ON	5987	1451	28
	5987	1451	29

1.7000E+07	1.3200E-01	1.7500E+07	1.4100E-01	1.8000E+07	1.5000E-01	1.5987	3	16	7
1.9500E+07	1.5872E-01	1.9000E+07	1.6700E-01	1.9500E+07	1.7447E-01	1.5987	3	16	8
2.2000E+07	1.8100E-01	0.	0.	0.	0.	1.5987	3	16	9
3.9087E+04	8.6164E+01	0	0	0	0.	1.5987	3	0	0
0.	-6.4602E+06	0	0	0	0	0.5987	3	22	1
	20	0	0	0	0	20.5987	3	22	2
6.5350E+06	0.	1.1000E+07	1.2000E-08	1.1500E+07	2.9695E-07	0.5987	3	22	3
1.2000E+07	7.6000E-07	1.2500E+07	2.3125E-06	1.3000E+07	5.0000E-06	0.5987	3	22	4
1.3500E+07	1.4262E-05	1.4000E+07	3.5000E-05	1.4500E+07	7.5487E-05	0.5987	3	22	5
1.5000E+07	1.4000E-04	1.5500E+07	2.1784E-04	1.6000E+07	3.1000E-04	0.5987	3	22	6
1.6500E+07	4.1483E-04	1.7000E+07	5.2000E-04	1.7500E+07	6.2325E-04	0.5987	3	22	7
1.8000E+07	7.2000E-04	1.8500E+07	7.9687E-04	1.9000E+07	8.6000E-04	0.5987	3	22	8
1.9500E+07	9.2187E-04	2.0000E+07	9.8000E-04	0.	0.	1.5987	3	22	9
3.9087E+04	8.6164E+01	0	0	0	0	1.5987	3	0	10
0.	-5.7637E+06	0	0	0	0	0.5987	3	28	0
	28	0	0	0	0	28.5987	3	28	1
5.8310E+06	0.	7.0000E+06	8.4000E-06	7.5000E+06	1.5202E-03	0.5987	3	28	2
8.0000E+06	4.7000E-03	8.5000E+06	1.8326E-02	9.0000E+06	4.7500E-02	0.5987	3	28	3
9.5000E+06	9.3163E-02	1.0000E+07	1.5700E-01	1.0500E+07	2.3590E-01	0.5987	3	28	4
1.1000E+07	3.2400E-01	1.1500E+07	4.3631E-01	1.2000E+07	5.4200E-01	0.5987	3	28	5
1.2500E+07	5.8316E-01	1.3000E+07	5.7100E-01	1.3500E+07	5.3965E-01	0.5987	3	28	6
1.4000E+07	5.3400E-01	1.4500E+07	4.6343E-01	1.5000E+07	4.2400E-01	0.5987	3	28	7
1.5500E+07	3.8979E-01	1.6000E+07	3.6100E-01	1.6500E+07	3.3750E-01	0.5987	3	28	8
1.7000E+07	3.1900E-01	1.7500E+07	3.0400E-01	1.8000E+07	2.9200E-01	0.5987	3	28	9
1.8500E+07	2.8267E-01	1.9000E+07	2.7500E-01	1.9500E+07	2.6884E-01	0.5987	3	28	10
2.0000E+07	2.6400E-01	0.	0.	0.	0.	1.5987	3	28	11
3.9087E+04	8.6164E+01	0	1	0	0	1.5987	3	0	12
0.	-3.8130E+05	0	0	0	0	0.5987	3	51	0
	42	0	0	0	0	42.5987	3	51	1
3.8570E+05	0.	5.0000E+05	3.4300E-02	7.5000E+05	9.6000E-02	0.5987	3	51	2
1.0000E+06	1.3300E-01	1.5000E+06	1.7300E-01	2.0000E+06	2.1200E-01	0.5987	3	51	3
2.5000E+06	3.0100E-01	3.0000E+06	3.9400E-01	3.5000E+06	4.3603E-01	0.5987	3	51	4
4.0000E+06	4.5500E-01	4.5000E+06	4.8959E-01	5.0000E+06	5.2500E-01	0.5987	3	51	5
5.5000E+06	5.6205E-01	6.0000E+06	6.0100E-01	6.5000E+06	6.4176E-01	0.5987	3	51	6
7.0000E+06	6.8200E-01	7.5000E+06	7.1607E-01	8.0000E+06	7.4700E-01	0.5987	3	51	7
8.5000E+06	7.7682E-01	9.0000E+06	8.0300E-01	9.5000E+06	8.1476E-01	0.5987	3	51	8
1.0000E+07	8.1200E-01	1.0500E+07	8.4039E-01	1.1000E+07	7.7600E-01	0.5987	3	51	9
1.1500E+07	7.3730E-01	1.2000E+07	6.7500E-01	1.2500E+07	5.8917E-01	0.5987	3	51	10

1.3000E+07	5.0200E-01	1.3500E+07	4.2266E-01	1.4000E+07	3.5000E-01	3.51
1.4500E+07	2.9245E-01	1.5000E+07	2.5000E-01	1.5500E+07	2.1560E-01	3.51
1.6000E+07	1.9400E-01	1.6500E+07	1.7168E-01	1.7000E+07	1.5700E-01	3.51
1.7500E+07	1.4503E-01	1.8000E+07	1.3500E-01	1.8500E+07	1.2705E-01	3.51
1.9000E+07	1.2000E-01	1.9500E+07	1.1370E-01	2.0000E+07	1.0000E-01	3.51
3.9087E+04	8.6164E+01	0.	0.	0.	0.	0.
0.	9.3770E+06	0.	0.	0.	0.	0.
1.0000E-05	1.6100E+03	2.5300E-02	3.2000E+01	1.0000E+00	5.0000E+00	3.102
4.0000E+00	2.5000E+00	8.0000E+00	1.0000E+00	8.0000E+01	1.0000E+01	3.102
1.3000E+02	6.8000E+00	2.5000E+02	4.0000E+00	5.0000E+02	2.4200E+00	3.102
1.0000E+03	1.4960E+00	1.0000E+00	4.5200E-01	2.5000E+04	2.5000E+04	3.102
5.0000E+04	1.6100E-01	1.0000E+05	1.0200E-01	2.5000E+05	7.2000E-02	3.102
5.0000E+05	5.8300E-02	7.5000E+05	5.5200E-02	1.0000E+06	4.2500E-02	3.102
1.5000E+06	3.4400E-02	2.0000E+06	2.6300E-02	2.5000E+06	2.5000E-02	3.102
3.0000E+06	2.4400E-02	3.5000E+06	2.0978E-02	4.0000E+06	1.6500E-02	3.102
4.5000E+06	1.2804E-02	5.0000E+06	9.6800E-03	5.5000E+06	7.3270E-03	3.102
6.0000E+06	5.3900E-03	6.5000E+06	3.3816E-03	7.0000E+06	2.0900E-03	3.102
7.5000E+06	1.8195E-03	8.0000E+06	1.7800E-03	8.5000E+06	1.7451E-03	3.102
9.0000E+06	1.7500E-03	9.5000E+06	1.8137E-03	1.0000E+07	1.0000E-03	3.102
1.0500E+07	1.9867E-03	1.1000E+07	2.0800E-03	1.1500E+07	2.0920E-03	3.102
1.2000E+07	2.3714E-03	1.2500E+07	2.1929E-03	1.3000E+07	2.2900E-03	3.102
1.3500E+07	2.3714E-03	1.4000E+07	2.4000E-03	1.4500E+07	2.3631E-03	3.102
1.5000E+07	2.3200E-03	1.5500E+07	2.3145E-03	1.6000E+07	2.2340E-03	3.102
1.6500E+07	2.0300E-03	1.7000E+07	1.8300E-03	1.7500E+07	1.6231E-03	3.102
1.8000E+07	1.4300E-03	1.8500E+07	1.2781E-03	1.9000E+07	1.1400E-03	3.102
1.9500E+07	9.9500E-04	2.0000E+07	8.5000E-04	0.	0.	3.102
3.9087E+04	8.6164E+01	0.	0.	0.	0.	0.
0.	2.6646E+06	0.	0.	0.	0.	0.
1.0000E-05	2.1700E+02	2.5300E-02	4.3000E+00	1.0000E+00	6.7500E-01	3.103
4.0000E+00	3.8000E-01	8.0000E+00	2.4000E-01	8.0000E+01	2.4000E+00	3.103
1.3000E+02	9.2000E-01	2.5000E+02	5.4000E-01	5.0000E+02	3.2000E-01	3.103
1.0000E+03	1.8200E-01	1.0000E+04	2.8600E-02	2.5000E+04	1.4100E-02	3.103
5.0000E+04	8.6400E-03	1.0000E+05	5.9000E-03	2.5000E+05	6.2600E-03	3.103
1.5000E+05	9.9400E-03	7.5000E+05	1.6400E-02	1.0000E+06	1.9000E-02	3.103
1.5000E+06	2.7900E-02	2.0000E+06	3.6800E-02	2.5000E+06	4.8600E-02	3.103
3.0000E+06	6.0400E-02	3.5000E+06	6.7671E-02	4.0000E+06	6.9800E-02	3.103
4.5000E+06	7.1304E-02	5.0000E+06	7.2700E-02	5.5000E+06	7.4000E-02	3.103

6.0000E+06	7.5300E-02	6.5000E+06	7.6565E-02	7.0000E+06	7.8000E-02	3103	13
7.5000E+06	8.1003E-02	8.0000E+06	8.4800E-02	8.5000E+06	8.7985E-02	3103	14
9.0000E+06	9.1000E-02	9.5000E+06	9.3022E-02	1.0000E+07	9.4000E-02	3103	15
1.0500E+07	9.4326E-02	1.1000E+07	9.3000E-02	1.1500E+07	8.9964E-02	3103	16
1.2000E+07	8.6000E-02	1.2500E+07	8.1661E-02	1.3000E+07	7.7000E-02	3103	17
1.3500E+07	7.2000E-02	1.4000E+07	6.7000E-02	1.4500E+07	6.2000E-02	3103	18
1.5000E+07	5.7000E-02	1.5500E+07	5.2700E-02	1.6000E+07	4.9000E-02	3103	19
1.6500E+07	4.5101E-02	1.7000E+07	4.2000E-02	1.7500E+07	3.9812E-02	3103	20
1.8000E+07	3.8000E-02	1.8500E+07	3.6211E-02	1.9000E+07	3.4600E-02	3103	21
1.9500E+07	3.3542E-02	2.0000E+07	3.3000E-02	0.	5987	3103	22
3.9087E+04	8.6164E+01	0	1	0	5987	3	0
0.	2.2762E+06	0	0	1	05987	3103	1
	56	0	0	0	05987	3103	2
1.0000E+05	1.6200E+02	2.5300E+02	3.2000E+00	1.0000E+00	5.0000E-01	3103	3
4.0000E+00	2.8000E-01	8.0000E+00	1.8000E-01	8.9000E+01	1.8000E+00	3103	4
1.3000E+02	6.9000E-01	2.5000E+02	4.0000E-01	5.0000E+02	2.4000E-01	3103	5
1.0000E+03	1.3600E-01	1.0000E+04	2.1000E-02	2.5000E+04	1.0500E-02	3103	6
5.0000E+04	6.4600E-03	1.0000E+05	4.4000E-03	2.5000E+05	4.7000E-03	3103	7
5.0000E+05	7.4000E-03	7.5000E+05	1.2300E-02	1.0000E+06	1.4200E-02	3103	8
1.5000E+06	1.7400E-02	2.0000E+06	2.0500E-02	2.5000E+06	2.9000E-02	3103	9
3.0000E+06	3.7500E-02	5.0000E+06	4.0000E-02	4.0000E+06	4.3800E-02	3103	10
4.5000E+06	4.4305E-02	6.5000E+06	4.1000E-02	5.5000E+06	4.3000E-02	3103	11
6.0000E+06	4.0019E-02	8.0000E+06	4.0000E-02	7.0000E+06	4.0000E-02	3103	12
7.5000E+06	4.1300E-02	9.5000E+06	4.0845E-02	1.0000E+07	3.9600E-02	3103	13
9.0000E+06	3.8125E-02	1.1000E+07	3.6000E-02	1.1500E+07	3.3000E-02	3103	14
1.0500E+07	3.0200E-02	1.2500E+07	2.7500E-02	1.3000E+07	2.5000E-02	3103	15
1.2000E+07	2.2439E-02	1.4000E+07	2.0000E-02	1.4500E+07	1.8000E-02	3103	16
1.3500E+07	1.6400E-02	1.5500E+07	1.4700E-02	1.6000E+07	1.3400E-02	3103	17
1.5000E+07	1.2349E-02	1.7000E+07	1.1600E-02	1.7500E+07	1.1000E-02	3103	18
1.6500E+07	1.0500E-02	1.8500E+07	1.0000E-02	1.9000E+07	0.7000E-02	3103	19
1.8000E+07	9.3267E-03	2.0000E+07	0.0000E-03	0.	5987	3103	20
1.9500E+07	8.6164E+01	0	0	0	5987	3	21
0.	2.4163E+06	0	0	1	05987	3107	22
	41	0	0	0	05987	3107	23
1.0000E-05	0.	2.5300E-02	0.	5.0000E+02	0.	3107	24
1.0000E+03	0.	2.0000E+06	1.0000E-09	2.5000E+06	1.0000E-08	3107	25
3.0000E+06	1.0000E-07	3.5000E+06	9.3854E-07	4.0000E+06	2.5000E-06	3107	26
4.5000E+06	1.0841E-05	5.0000E+06	2.5000E-05	5.5000E+06	5.5128E-05	3107	27

6.4000E+06	1.1000E-04	6.5000E+06	2.5465E-04	7.0000E+06	5.0000E-04	3987	3107	8
7.5000E+06	8.3832E-04	8.0000E+06	1.3000E-03	8.5000E+06	1.9123E-03	3987	3107	9
9.0000E+06	2.7000E-03	9.5000E+06	3.6706E-03	1.0000E+07	4.8000E-03	3987	3107	10
1.0500E+07	6.1809E-03	1.1000E+07	7.6000E-03	1.1500E+07	8.2938E-03	3987	3107	11
1.2000E+07	9.2000E-03	1.2500E+07	1.1271E-02	1.3000E+07	1.3000E-02	3987	3107	12
1.3500E+07	1.4715E-02	1.4000E+07	1.6500E-02	1.4500E+07	1.8709E-02	3987	3107	13
1.5000E+07	2.1000E-02	1.5500E+07	2.2938E-02	1.6000E+07	2.5000E-02	3987	3107	14
1.6500E+07	2.7350E-02	1.7000E+07	2.9700E-02	1.7500E+07	3.2050E-02	3987	3107	15
1.8000E+07	3.4400E-02	1.8500E+07	3.6750E-02	1.9000E+07	3.9100E-02	3987	3107	16
1.9500E+07	4.1512E-02	2.0000E+07	4.4000E-02	0.	0.	3987	3107	17
						3987	3	0
						3987	0	0
						0	0	0
3.9088E+04	8.7154E+01	0	0	0		13988	1451	1
0.	1.	0	0	0		03988	1451	2
0.	0.	0	0	53		123988	1451	3
39-Y = 88 LASL		EVAL=DEC78	E.D. ARTHJR			3988	1451	4
LA-7301,7482PR		DIST=DEC78	REFV0			3988	1451	5
		GENERAL DESCRIPTION				3988	1451	6

THE FOLLOWING CROSS SECTIONS RESULT FROM A NEW EVALUATION OF
 YTTRIUM 86 -92 ISOTOPES MADE USING GNASH AND COMNOC
 STATISTICAL NUCLEAR MODEL CODES. THIS EVALUATION USES NEW MODEL
 PARAMETERS AND SHOULD REPRESENT AN IMPROVEMENT OVER THE EARLIER
 EVALUATION (6/17/77).
 PRELIMINARY REPORTS OF THIS WORK APPEAR IN LA-7301-PR(1978) P.2
 AND LA-7482-PR (1978) P.6, AND A DETAILED DESCRIPTION OF THE
 CALCULATIONS WILL APPEAR IN AN UPCOMING LOS ALAMOS REPORT. A
 BRIEF DESCRIPTION, HOWEVER, WILL BE GIVEN BELOW.
 PRINCIPAL IMPROVEMENTS INCORPORATED IN THE PRESENT CALCULATIONS
 RESULT FROM BETTER PROTON AND NEUTRON OPTICAL PARAMETERS AND
 THE DETERMINATION AND USE OF GAMMA-RAY STRENGTH FUNCTIONS IN THIS
 MASS REGION. NEW PROTON OPTICAL PARAMETERS WERE DETERMINED
 FROM LOW ENERGY SR-87, Y-89 (P,N) DATA (REF.1) AND ARE SOMEWHAT
 DIFFERENT FROM STANDARD PARAMETER SETS. NEUTRON PARAMETERS WERE
 BASED ON A MODIFICATION OF THE LAGRANGE PARAMETERS (REF.2) WHICH
 ARE APPLICABLE FROM 1 KEV TO 20 MEV.
 TO DESCRIBE THE NEUTRON CAPTURE PROCESS AND GAMMA-RAY COMPETITION
 A SYSTEMATIC STUDY WAS MADE OF GAMMA-RAY STRENGTH FUNCTIONS FOR

3988	1451	7
3988	1451	8
3988	1451	9
3988	1451	10
3988	1451	11
3988	1451	12
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3988	1451	14
3988	1451	15
3988	1451	16
3988	1451	17
3988	1451	18
3988	1451	19
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3988	1451	21
3988	1451	22
3988	1451	23
3988	1451	24
3988	1451	25
3988	1451	26

A=85-100 AS SUGGESTED IN REF. 3. THESE GAMMA-RAY STRENGTH FUNCTIONS CAN BE DETERMINED FROM CAPTURE DATA ON STABLE NUCLEI AND THEN BE USED TO GIVE REALISTIC CAPTURE CROSS SECTIONS ON UNSTABLE NUCLEI, AS WELL AS TO PROVIDE AN ACCURATE DESCRIPTION OF GAMMA EMISSION WHERE IT IS AN IMPORTANT COMPETING REACTION. FINALLY A NEW PREEQUILIBRIUM MODEL BASED ON THE KALRACH RESULTS (REF. 4) WAS USED TO DESCRIBE NONSTATISTICAL EFFECTS IN THE RANGE 10-20 MEV. (OTHER PARAMETERS RELATING TO LEVEL DENSITIES AND THE FORM OF THE GAMMA-RAY EMISSION MODEL WERE SIMILAR TO THOSE USED IN THE 6/17/77 EVALUATION) THE NET RESULTS OF THESE IMPROVEMENTS WERE A CONSISTENT PARAMETER SETS WHICH REPRODUCED NEUTRON AND CHARGED PARTICLE DATA FOR Y AND ZR ISOTOPIES. A FEW MISCELLANEOUS REMARKS ABOUT THE PRESENT EVALUATION. ALL CROSS SECTIONS LEADING TO UNSTABLE RESIDUAL NUCLEI OR META-STABLE STATES WERE CALCULATED FOR ALL REACTIONS. (METASTABLE STATES WERE NOT GENERALLY CALCULATED FOR (N,GAMMA) AND (N,ALPHA) REACTIONS). THE CONVENTION USED IS IF THE FINAL STATE FLAG (LFS) IS EQUAL TO ZERO THEN THE CROSS SECTION GIVEN REPRESENTS THE TOTAL CROSS SECTION FOR THAT REACTION. CROSS SECTIONS LEADING TO AN ISOMERIC STATE ARE DENOTED BY LFS EQUAL TO THE NUMBER OF THE STATE. FINALLY THE (N,ALPHA) AND (N,ALPHA,N) CROSS SECTIONS ARE INCLUDED TOGETHER.

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1	451	53
3	4	18
3	16	11
3	16	11
3	22	7
3	28	12
3	28	10
3	52	17
3	53	17

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3.9088E+04	8.7154E+01	0	0	1	0	3988	3.0	0
0.	-9.7580E+06	0	0	0	1	03988	3 16	1
22		0	0	0	0	223988	3 16	2
9.8700E+06	0.	1.0000E+07	6.8000E-03	1.0500E+07	1.0500E+07	03988	3 16	3
1.1000E+07	3.1500E-01	1.1500E+07	4.4177E-01	1.2000E+07	5.5200E-01	013988	3 16	4
1.2500E+07	6.3762E-01	1.3000E+07	6.9100E-01	1.3500E+07	7.2143E-01	013988	3 16	5
1.4000E+07	7.5100E-01	1.4500E+07	7.7991E-01	1.5000E+07	8.0900E-01	013988	3 16	6
1.5500E+07	8.4025E-01	1.6000E+07	8.7200E-01	1.6500E+07	9.0025E-01	013988	3 16	7
1.7000E+07	9.2500E-01	1.7500E+07	9.4433E-01	1.8000E+07	9.6000E-01	013988	3 16	8
1.8500E+07	9.6802E-01	1.9000E+07	9.7600E-01	1.9500E+07	1.0179E+00	03988	3 16	9
2.0000E+07	1.0940E+00	0.	0.	0.	0.	3988	3 16	10
						3988	3 16	11
3.9098E+04	8.7154E+01	0	0	0	0	3988	3 0	0
0.	-3.7300E+06	0	0	0	1	03988	3 22	1
12		0	0	0	0	123988	3 22	2
3.7730E+06	0.	1.5000E+07	7.0000E-06	1.5500E+07	1.5107E-05	03988	3 22	3
1.6000E+07	2.8000E-05	1.6500E+07	4.8502E-05	1.7000E+07	7.8100E-05	053988	3 22	4
1.7500E+07	1.2044E-04	1.8000E+07	1.9000E-04	1.8500E+07	2.7892E-04	053988	3 22	5
1.9000E+07	4.0000E-04	1.9500E+07	5.5928E-04	2.0000E+07	7.6000E-04	053988	3 22	6
						3988	3 22	7
3.9088E+04	8.7154E+01	0	0	0	0	3988	3 0	0
0.	-6.7122E+06	0	0	0	1	03988	3 28	1
26		0	0	0	0	263988	3 28	2
6.7892E+06	0.	8.0000E+06	1.0000E-06	8.5000E+06	1.8033E-04	03988	3 28	3
9.0000E+06	8.2000E-04	9.5000E+06	9.8667E-03	1.0000E+07	2.0000E-02	053988	3 28	4
1.0500E+07	2.3020E-02	1.1000E+07	2.5800E-02	1.1500E+07	2.8400E-02	053988	3 28	5
1.2000E+07	3.1000E-02	1.2500E+07	3.3934E-02	1.3000E+07	3.7700E-02	053988	3 28	6
1.3500E+07	4.8000E-02	1.4000E+07	5.9600E-02	1.4500E+07	6.6071E-02	053988	3 28	7
1.5000E+07	7.0900E-02	1.5500E+07	7.4400E-02	1.6000E+07	7.7700E-02	053988	3 28	8
1.6500E+07	8.0567E-02	1.7000E+07	8.3600E-02	1.7500E+07	8.6950E-02	053988	3 28	9
1.8000E+07	9.0300E-02	1.8500E+07	9.3650E-02	1.9000E+07	9.7000E-02	053988	3 28	10
1.9500E+07	1.0076E-01	2.0000E+07	1.0500E-01	0.	0.	3988	3 28	11
						3988	3 28	12
3.9088E+04	8.7154E+01	0	0	0	0	3988	3 0	0
0.	-7.1000E+06	0	0	0	1	03988	3 28	1
22		0	0	0	1	223988	3 28	2
7.1820E+06	0.	1.0000E+07	1.0000E-04	1.0500E+07	5.9451E-04	053988	3 28	3
1.1000E+07	1.1000E-03	1.1500E+07	1.5507E-03	1.2000E+07	2.0000E-03	053988	3 28	4
1.2500E+07	2.6668E-03	1.3000E+07	4.0000E-03	1.3500E+07	6.0633E-03	053988	3 28	5
1.4000E+07	8.2000E-03	1.4500E+07	1.0150E-02	1.5000E+07	1.2000E-02	053988	3 28	6
						3988	3 28	7

1.55200E+07	1.3614E-02	1.6000E+07	1.5000E-02	1.6500E+07	1.6240E-02	3 28	8
1.70200E+07	1.7320E-02	1.7500E+07	1.8210E-02	1.8000E+07	1.9000E-02	3 28	9
1.85200E+07	1.9700E-02	1.9000E+07	2.0400E-02	1.9500E+07	2.1100E-02	3 28	10
2.00200E+07	2.1800E-02	2.0000E+07	0.	0.	0.	3 28	11
3.9088E+04	8.7154E+01	0	0	0	0	3 0	12
0.	-3.9300E+05	0	0	0	0	3 52	13
3.9750E+05	0.	5.0000E+05	1.0000E-02	7.5000E+05	1.5600E-01	3 52	14
1.0000E+06	2.1500E-01	1.5000E+06	2.3700E-01	2.0000E+06	2.5900E-01	3 52	15
2.5020E+06	2.9200E-01	3.0000E+06	3.2400E-01	3.5000E+06	3.3270E-01	3 52	16
4.0020E+06	3.2300E-01	4.5000E+06	3.1373E-01	5.0000E+06	3.0500E-01	3 52	17
5.5020E+06	2.9747E-01	6.0000E+06	2.9200E-01	6.5000E+06	2.8940E-01	3 52	18
7.0020E+06	2.8700E-01	7.5000E+06	2.8402E-01	8.0000E+06	2.8100E-01	3 52	19
8.5020E+06	2.7767E-01	9.0000E+06	2.7400E-01	9.5000E+06	2.6670E-01	3 52	20
1.0000E+07	2.4700E-01	1.0500E+07	2.1074E-01	1.1000E+07	1.7200E-01	3 52	21
1.1520E+07	1.3890E-01	1.2000E+07	1.0900E-01	1.2500E+07	8.5583E-02	3 52	22
1.3020E+07	6.9020E-02	1.3500E+07	5.6830E-02	1.4000E+07	4.8000E-02	3 52	23
1.4520E+07	4.1499E-02	1.5000E+07	3.7000E-02	1.5500E+07	3.4379E-02	3 52	24
1.6020E+07	3.2000E-02	1.6500E+07	2.9759E-02	1.7000E+07	2.7700E-02	3 52	25
1.7520E+07	2.6048E-02	1.8000E+07	2.4700E-02	1.8500E+07	2.3612E-02	3 52	26
1.9020E+07	2.2500E-02	1.9500E+07	2.1135E-02	2.0000E+07	1.9600E-02	3 52	27
3.9088E+04	8.7154E+01	0	3	0	0	3 0	28
0.	-6.7500E+05	0	0	0	0	3 53	29
6.8320E+05	0.	7.5000E+05	0	0	0	3 53	30
1.5000E+06	2.4300E-01	2.0000E+06	8.0000E-02	1.0000E+06	1.5800E-01	3 53	31
3.0000E+06	3.7300E-01	3.5000E+06	3.2700E-01	2.5000E+06	3.5000E-01	3 53	32
4.5000E+06	3.8626E-01	5.0000E+06	3.8402E-01	4.0000E+06	3.8600E-01	3 53	33
6.0000E+06	4.1100E-01	6.5000E+06	3.8900E-01	5.5000E+06	3.9805E-01	3 53	34
7.5000E+06	4.4964E-01	8.0000E+06	4.2402E-01	7.0000E+06	4.3700E-01	3 53	35
9.0000E+06	4.8100E-01	9.5000E+06	4.6200E-01	8.5000E+06	4.7230E-01	3 53	36
1.0500E+07	4.7517E-01	1.1000E+07	4.8826E-01	1.0000E+07	4.9000E-01	3 53	37
1.2000E+07	3.6600E-01	1.2500E+07	3.3575E-01	1.1500E+07	4.0400E-01	3 53	38
1.3500E+07	2.8663E-01	1.4000E+07	2.6600E-01	1.3000E+07	3.0800E-01	3 53	39
1.5000E+07	1.4900E-01	1.5500E+07	1.4342E-01	1.4500E+07	2.0285E-01	3 53	40
1.6500E+07	1.3836E-01	1.7000E+07	1.4342E-01	1.6000E+07	1.4000E-01	3 53	41
1.8000E+07	1.0300E-01	1.8500E+07	1.3500E-01	1.7500E+07	1.2045E-01	3 53	42
1.9500E+07	7.3056E-02	2.0000E+07	9.1159E-02	1.9000E+07	8.1000E-02	3 53	43
			6.7000E-02	0.	0.	3 53	44

0	3.9088E+04	8.7154E+01	0	0	0	5988	3	0
1	0.	1.1468E+07	0	0	0	03988	3102	03988
2	9	5	56	0	0	563988	3102	563988
3	1.0000E+05	2.3700E+03	2.5300E+02	4.7050E+01	1.0000E+00	03988	3102	03988
4	4.0000E+00	4.0000E+00	2.0000E+01	5.0000E+00	3.5000E+01	7.5000E+00	3102	7.5000E+00
5	6.0000E+01	2.0000E+01	1.0000E+02	1.0670E+01	5.0000E+02	4.0000E+01	3102	4.0000E+01
6	1.0000E+03	2.1100E+00	1.0000E+00	5.7700E-01	2.5000E+00	3.4100E+00	3102	3.4100E+00
7	5.0000E+04	2.0600E-01	1.0000E+05	1.2600E-01	2.5000E+04	3.3200E-01	3102	3.3200E-01
8	5.0000E+05	3.9900E-02	7.5000E+05	3.0500E-02	1.0000E+05	6.8400E-02	3102	6.8400E-02
9	1.5000E+06	1.6200E-02	2.0000E+06	1.1400E-02	2.5000E+06	2.1000E-02	3102	2.1000E-02
10	3.0000E+06	4.6400E-03	3.5000E+06	3.3620E-03	4.0000E+06	9.6000E-03	3102	9.6000E-03
11	4.5000E+06	1.9175E-03	5.0000E+06	1.4400E-03	5.5000E+06	1.2198E-03	3102	1.2198E-03
12	6.0000E+06	1.2000E-03	6.5000E+06	1.3340E-03	7.0000E+06	1.5000E-03	3102	1.5000E-03
13	7.5000E+06	1.7133E-03	8.0000E+06	1.9000E-03	8.5000E+06	2.0146E-03	3102	2.0146E-03
14	9.0000E+06	2.1300E-03	9.5000E+06	2.1750E-03	1.0000E+07	2.2500E-03	3102	2.2500E-03
15	1.0500E+07	2.3250E-03	1.1000E+07	2.4000E-03	1.1500E+07	2.4458E-03	3102	2.4458E-03
16	1.2000E+07	2.4500E-03	1.2500E+07	2.4350E-03	1.3000E+07	2.4000E-03	3102	2.4000E-03
17	1.3500E+07	2.5500E-03	1.4000E+07	2.3000E-03	1.4500E+07	2.2500E-03	3102	2.2500E-03
18	1.5000E+07	2.2000E-03	1.5500E+07	2.0375E-03	1.6000E+07	1.8000E-03	3102	1.8000E-03
19	1.6500E+07	1.5900E-03	1.7000E+07	1.4000E-03	1.7500E+07	1.2471E-03	3102	1.2471E-03
20	1.8000E+07	1.1000E-03	1.8500E+07	9.5000E-04	1.9000E+07	8.0000E-04	3102	8.0000E-04
21	1.9500E+07	4.0076E-04	2.0000E+07	0.	0.	0.	3102	0.
22	3.9088E+04	8.7154E+01	0	0	0	5988	3	0
0	0.	4.0010E+06	0	0	0	03988	3103	03988
1	56	2	0	0	0	563988	3103	563988
2	1.0000E+05	2.3700E+02	2.5300E+02	4.7000E+00	1.0000E+00	7.5000E-01	3103	7.5000E-01
3	4.0000E+00	4.0000E-01	2.0000E+01	5.0000E-01	3.5000E+01	4.0000E+00	3103	4.0000E+00
4	6.0000E+01	2.0000E+00	1.0000E+02	1.1300E+00	5.0000E+02	3.7900E-01	3103	3.7900E-01
5	1.0000E+03	2.3400E-01	1.0000E+04	5.8600E-02	2.5000E+04	3.6800E-02	3103	3.6800E-02
6	5.0000E+04	2.5300E-02	7.5000E+05	1.7400E-02	2.5000E+05	1.2600E-02	3103	1.2600E-02
7	5.0000E+05	1.1600E-02	7.5000E+05	1.2100E-02	1.0000E+06	1.1000E-02	3103	1.1000E-02
8	1.5000E+06	1.1800E-02	2.0000E+06	1.2500E-02	2.5000E+06	1.1900E-02	3103	1.1900E-02
9	3.0000E+06	1.1200E-02	3.5000E+06	1.1450E-02	4.0000E+06	1.1700E-02	3103	1.1700E-02
10	4.5000E+06	1.1950E-02	5.0000E+06	1.2200E-02	5.5000E+06	1.2519E-02	3103	1.2519E-02
11	6.0000E+06	1.3000E-02	6.5000E+06	1.4131E-02	7.0000E+06	1.6000E-02	3103	1.6000E-02
12	7.5000E+06	1.8300E-02	8.0000E+06	2.0600E-02	8.5000E+06	2.2400E-02	3103	2.2400E-02
13	9.0000E+06	2.4200E-02	9.5000E+06	2.6112E-02	1.0000E+07	2.8100E-02	3103	2.8100E-02
14	1.0500E+07	3.0865E-02	1.1000E+07	3.3600E-02	1.1500E+07	3.4900E-02	3103	3.4900E-02
15	1.2000E+07	3.5400E-02	1.2500E+07	3.5519E-02	1.3000E+07	3.5100E-02	3103	3.5100E-02

1.3510E+07	3.4158E-02	1.4000E+07	3.3100E-02	1.4500E+07	3.1943E-02	3988	3103	18
1.5000E+07	3.0800E-02	1.5500E+07	2.9719E-02	1.6000E+07	2.8800E-02	3988	3103	19
1.6500E+07	2.8172E-02	1.7000E+07	2.7400E-02	1.7500E+07	2.6745E-02	3988	3103	20
1.8000E+07	2.6100E-02	1.8500E+07	2.5539E-02	1.9000E+07	2.5000E-02	3988	3103	21
1.9500E+07	2.3971E-02	2.0000E+07	2.2800E-02	0.	0.	3988	3103	22
						3988	3	0
3.9088E+04	8.7154E+01	0	0	0	0	3988	3107	1
0.	3.5170E+06	0	0	1	433988	3107	2	
	43	2	0	0	0	3988	3107	3
1.0000E-05	0.	2.5300E-02	0.	5.0000E+02	0.	3988	3107	4
1.0000E+03	0.	1.0000E+06	3.4000E-09	1.5000E+06	2.8000E-08	3988	3107	5
2.0000E+06	1.9000E-07	2.5000E+06	9.3000E-07	3.0000E+06	3.1000E-06	3988	3107	6
3.5000E+06	1.2322E-05	4.0000E+06	2.7000E-05	4.5000E+06	5.0613E-05	3988	3107	7
5.0000E+06	8.5000E-05	5.5000E+06	1.5794E-04	6.0000E+06	3.0000E-04	3988	3107	8
6.5000E+06	5.3864E-04	7.0000E+06	9.0000E-04	7.5000E+06	1.3460E-03	3988	3107	9
8.0000E+06	1.8000E-03	8.5000E+06	2.2057E-03	9.0000E+06	2.6000E-03	3988	3107	10
9.5000E+06	3.1713E-03	1.0000E+07	4.1000E-03	1.0500E+07	6.2159E-03	3988	3107	11
1.1000E+07	8.4000E-03	1.1500E+07	9.6348E-03	1.2000E+07	1.0000E-02	3988	3107	12
1.2500E+07	1.1856E-02	1.3000E+07	1.3000E-02	1.3500E+07	1.4382E-02	3988	3107	13
1.4000E+07	1.5800E-02	1.4500E+07	1.7142E-02	1.5000E+07	1.8500E-02	3988	3107	14
1.5500E+07	1.9997E-02	1.6000E+07	2.1600E-02	1.6500E+07	2.3202E-02	3988	3107	15
1.7000E+07	2.5000E-02	1.7500E+07	2.7000E-02	1.8000E+07	2.9000E-02	3988	3107	16
1.8500E+07	3.1000E-02	1.9000E+07	3.3000E-02	1.9500E+07	3.4687E-02	3988	3107	17
2.0000E+07	3.6000E-02	0.	0.	0.	0.	3988	3107	18
						3988	3	0
						3988	0	0
						0	0	0
						0	0	0
3.9089E+04	8.8142E+01	0	0	0	0	13989	1451	1
0.	1.	0	0	0	0	3989	1451	2
0.	0.	0	0	53	113989	1451	3	
39-Y = 89 LASL		EVAL=DEC78	E.D. ARTHJR			3989	1451	4
LA=7301,7482PR		DIST=DEC78	REVN			3989	1451	5
		GENERAL DESCRIPTION				3989	1451	6
-----						3989	1451	7
THE FOLLOWING CROSS SECTIONS RESULT FROM A NEW EVALUATION OF						3989	1451	8
YTTRIUM 86 -92 ISOTOPES MADE USING GNASH AND COMNUC						3989	1451	9
STATISTICAL NUCLEAR MODEL CODES. THIS EVALUATION USES NEW MODEL						3989	1451	10
PARAMETERS AND SHOULD REPRESENT AN IMPROVEMENT OVER THE EARLIER						3989	1451	11
EVALUATION (6/17/77).						3989	1451	12

PRELIMINARY REPORTS OF THIS WORK APPEAR IN LA-7301-PR(1978) P.2	3989	1451	13
AND LA-7482-PR (1978) P.6, AND A DETAILED DESCRIPTION OF THE	3989	1451	14
CALCULATIONS WILL APPEAR IN AN UPCOMING LOS ALAMOS REPORT. A	3989	1451	15
BRIEF DESCRIPTION, HOWEVER, WILL BE GIVEN BELOW.	3989	1451	16
PRINCIPAL IMPROVEMENTS INCORPORATED IN THE PRESENT CALCULATIONS	3989	1451	17
RESULT FROM BETTER PROTON AND NEUTRON OPTICAL PARAMETERS AND	3989	1451	18
THE DETERMINATION AND USE OF GAMMA-RAY STRENGTH FUNCTIONS IN THIS	3989	1451	19
MASS REGION. NEW PROTON OPTICAL PARAMETERS WERE DETERMINED	3989	1451	20
FROM LOW ENERGY SR-87, Y-89 (P,N) DATA (REF.1) AND ARE SOMEWHAT	3989	1451	21
DIFFERENT FROM STANDARD PARAMETER SETS. NEUTRON PARAMETERS WERE	3989	1451	22
BASED ON A MODIFICATION OF THE LAGRANGE PARAMETERS (REF.2) WHICH	3989	1451	23
ARE APPLICABLE FROM 1 KEV TO 20 MEV.	3989	1451	24
TO DESCRIBE THE NEUTRON CAPTURE PROCESS AND GAMMA-RAY COMPETITION	3989	1451	25
A SYSTEMATIC STUDY WAS MADE OF GAMMA-RAY STRENGTH FUNCTIONS FOR	3989	1451	26
A=85-100 AS SUGGESTED IN REF.3. THESE GAMMA-RAY STRENGTH	3989	1451	27
FUNCTIONS CAN BE DETERMINED FROM CAPTURE DATA ON STABLE NUCLEI	3989	1451	28
AND THEN BE USED TO GIVE REALISTIC CAPTURE CROSS SECTIONS ON	3989	1451	29
UNSTABLE NUCLEI, AS WELL AS TO PROVIDE AN ACCURATE DESCRIPTION	3989	1451	30
OF GAMMA EMISSION WHERE IT IS AN IMPORTANT COMPETING REACTION.	3989	1451	31
FINALLY A NEW PREEQUILIBRIUM MODEL BASED ON THE KALRACH RESULTS	3989	1451	32
(REF.4) WAS USED TO DESCRIBE NONSTATISTICAL EFFECTS IN THE RANGE	3989	1451	33
10-20 MEV. (OTHER PARAMETERS RELATING TO LEVEL DENSITIES AND THE	3989	1451	34
FORM OF THE GAMMA-RAY EMISSION MODEL WERE SIMILAR TO THOSE USED	3989	1451	35
IN THE 6/17/77 EVALUATION) THE NET RESULTS OF THESE IMPROVEMENTS	3989	1451	36
WERE A CONSISTENT PARAMETER SETS WHICH REPRODUCED NEUTRON AND	3989	1451	37
CHARGED PARTICLE DATA FOR Y AND ZR ISOTOPES.	3989	1451	38
A FEW MISCELLANEOUS REMARKS ABOUT THE PRESENT EVALUATION.	3989	1451	39
ALL CROSS SECTIONS LEADING TO UNSTABLE RESIDUAL NUCLEI OR META-	3989	1451	40
STABLE STATES WERE CALCULATED FOR ALL REACTIONS. (METASTABLE	3989	1451	41
STATES WERE NOT GENERALLY CALCULATED FOR (N,GAMMA) AND (N,ALPHA)	3989	1451	42
REACTIONS). THE CONVENTION USED IS IF THE FINAL STATE FLAG (LFS)	3989	1451	43
IS EQUAL TO ZERO THEN THE CROSS SECTION GIVEN REPRESENTS THE	3989	1451	44
TOTAL CROSS SECTION FOR THAT REACTION. CROSS SECTIONS LEADING TO	3989	1451	45
AN ISOMERIC STATE ARE DENOTED BY LFS EQUAL TO THE NUMBER OF THE	3989	1451	46
STATE. FINALLY THE (N,ALPHA) AND (N,ALPHA,N) CROSS SECTIONS ARE	3989	1451	47
INCLUDED TOGETHER.	3989	1451	48
	3989	1451	49
	3989	1451	50
	3989	1451	51
	3989	1451	52
	3989	1451	53
REFERENCES			
1. C.H. JOHNSON ET AL. NUCL. PHYS. A187,21(1968), AND			
PHYS. REV. LETT. 39,1624(1977)			

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4. C. KALHACH, Z. PHYS. A283, 401 (1977).

1	451	53	59A9	1451	54
3	4	17	59A9	1451	55
3	16	9	59A9	1451	56
3	16	9	59A9	1451	57
3	22	9	59A9	1451	58
3	24	12	59A9	1451	59
3	51	17	59A9	1451	60
3	102	27	59A9	1451	61
3	102	27	59A9	1451	62
3	103	16	59A9	1451	63
3	107	16	59A9	1451	64
3			59A9	1451	65
3			59A9	1451	66
3			59A9	1451	67
3			59A9	1451	68
3			59A9	1451	69
3			59A9	1451	70
3			59A9	1451	71
3			59A9	1451	72
3			59A9	1451	73
3			59A9	1451	74
3			59A9	1451	75
3			59A9	1451	76
3			59A9	1451	77
3			59A9	1451	78
3			59A9	1451	79
3			59A9	1451	80
3			59A9	1451	81
3			59A9	1451	82
3			59A9	1451	83
3			59A9	1451	84
3			59A9	1451	85
3			59A9	1451	86
3			59A9	1451	87
3			59A9	1451	88
3			59A9	1451	89
3			59A9	1451	90
3			59A9	1451	91
3			59A9	1451	92
3			59A9	1451	93
3			59A9	1451	94
3			59A9	1451	95
3			59A9	1451	96
3			59A9	1451	97
3			59A9	1451	98
3			59A9	1451	99
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3			59A9	1451	101
3			59A9	1451	102
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3			59A9	1451	105
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3			59A9	1451	107
3			59A9	1451	108
3			59A9	1451	109
3			59A9	1451	110
3			59A9	1451	111
3			59A9	1451	112
3			59A9	1451	113
3			59A9	1451	114
3			59A9	1451	115
3			59A9	1451	116
3			59A9	1451	117

3.9089E+04	8.8142E+01	0	7.2500E+02	1.2500E+07	2.7400E+01	5989	3	0
0.	-1.1468E+07	0	0	0	0	05989	3	16
	18	2	0	0	1	185989	3	16
1.1598E+07	0.	0	0	0	0	05989	3	16
1.13000E+07	4.9200E+01	0	7.2500E+02	1.2500E+07	2.7400E+01	015989	3	16
1.14500E+07	9.7233E+01	0	6.7850E+01	1.4000E+07	8.3600E+01	015989	3	16
1.16000E+07	1.2150E+00	0	1.0790E+00	1.5500E+07	1.1586E+00	005989	3	16
1.17500E+07	1.3043E+00	0	1.2548E+00	1.7000E+07	1.2840E+00	005989	3	16
1.19200E+07	1.3290E+00	0	1.3180E+00	1.8500E+07	1.3252E+00	005989	3	16
3.9089E+04	8.8142E+01	0	1.3290E+00	2.0000E+07	1.3280E+00	005989	3	16
0.	-1.1860E+07	0	2	0	0	5989	3	0
	18	2	0	0	1	05989	3	16
1.1960E+07	0.	0	0	0	0	185989	3	16
1.13000E+07	6.8700E+02	0	2.9000E+04	1.2500E+07	2.2300E+00	025989	3	16
1.14500E+07	1.6574E+01	0	1.0694E+01	1.4000E+07	1.4000E+07	015989	3	16
1.16200E+07	2.1700E+01	0	1.8700E+01	1.5500E+07	2.0489E+01	015989	3	16
1.17500E+07	2.2627E+01	0	2.1615E+01	1.7000E+07	2.1400E+01	015989	3	16
1.19200E+07	2.3400E+01	0	2.3600E+01	1.8500E+07	2.3584E+01	015989	3	16
3.9089E+04	8.8142E+01	0	2.3132E+01	2.0000E+07	2.2800E+01	015989	3	16
0.	-1.2143E+07	0	3	0	0	5989	3	0
	17	2	0	0	1	05989	3	16
1.12281E+07	0.	0	0	0	0	175989	3	16
1.13500E+07	8.3486E+02	0	1.6000E+03	1.3000E+07	3.5000E+00	025989	3	16
1.15000E+07	2.1840E+01	0	1.3200E+01	1.4500E+07	1.7811E+01	015989	3	16
1.16500E+07	2.7826E+01	0	2.4435E+01	1.6000E+07	2.6200E+01	015989	3	16
1.18200E+07	3.1200E+01	0	2.9200E+01	1.7500E+07	3.0285E+01	015989	3	16
1.19500E+07	3.3370E+01	0	3.1978E+01	1.9000E+07	3.2700E+01	015989	3	16
3.9089E+04	8.8142E+01	0	3.4000E+01	2.0000E+07	0.	5989	3	16
0.	-7.9514E+06	0	0	0	0	05989	3	0
	17	2	0	0	1	05989	3	22
8.4414E+06	0.	0	0	0	0	175989	3	22
1.13500E+07	1.8627E+08	0	2.0000E+10	1.3000E+07	1.0000E+00	005989	3	22
1.15000E+07	7.0000E+07	0	5.0000E+08	1.4500E+07	2.7422E+07	075989	3	22
1.16500E+07	1.0284E+05	0	2.2061E+06	1.6000E+07	5.0000E+06	065989	3	22
1.18200E+07	5.0000E+05	0	1.0000E+05	1.7500E+07	3.1598E+05	055989	3	22
1.19500E+07	1.2894E+04	0	7.3301E+05	1.9000E+07	1.0000E+07	045989	3	22
			1.6000E+04	2.0000E+07	0.	5989	3	22

1	1.0000E+05	9.0000E-03	1.2500E+05	8.1150E-03	1.5000E+05	7.0000E-03	3102
2	2.0000E+05	7.9000E-03	3.0000E+05	7.1000E-03	4.0000E+05	6.6000E-03	3102
3	3.0000E+05	6.0000E-03	6.0000E+05	6.3200E-03	7.0000E+05	6.3200E-03	3102
4	4.0000E+05	6.0000E-03	9.0000E+05	6.6500E-03	1.0000E+06	6.0000E-03	3102
5	5.0000E+05	6.0000E-03	1.2000E+06	6.8400E-03	1.3000E+06	6.0000E-03	3102
6	6.0000E+05	6.0000E-03	1.5000E+06	5.0000E-03	1.6000E+06	6.0000E-03	3102
7	7.0000E+05	6.0000E-03	1.8000E+06	3.7300E-03	2.0000E+06	6.0000E-03	3102
8	8.0000E+05	6.0000E-03	3.0000E+06	3.2700E-03	3.5000E+06	6.0000E-03	3102
9	9.0000E+05	6.0000E-03	4.5000E+06	2.2200E-03	5.0000E+06	6.0000E-03	3102
10	1.0000E+06	6.0000E-03	6.0000E+06	6.5400E-04	6.5000E+06	6.0000E-03	3102
11	1.1000E+06	6.0000E-03	7.5000E+06	6.7200E-04	8.0000E+06	6.0000E-03	3102
12	1.2000E+06	6.0000E-03	9.0000E+06	8.2600E-04	9.5000E+06	6.0000E-03	3102
13	1.3000E+06	6.0000E-03	1.0500E+07	1.0100E-03	1.1000E+07	6.0000E-03	3102
14	1.4000E+06	6.0000E-03	1.2000E+07	1.5300E-03	1.2500E+07	6.0000E-03	3102
15	1.5000E+06	6.0000E-03	1.3500E+07	1.9800E-03	1.4000E+07	6.0000E-03	3102
16	1.6000E+06	6.0000E-03	1.5000E+07	2.2600E-03	1.5500E+07	6.0000E-03	3102
17	1.7000E+06	6.0000E-03	1.7000E+07	1.8100E-03	1.8000E+07	6.0000E-03	3102
18	1.8000E+06	6.0000E-03	2.0000E+07	1.0000E-03	2.0000E+07	6.0000E-03	3102
19	1.9000E+06	6.0000E-03	2.5000E+07	1.0000E-03	2.5000E+07	6.0000E-03	3102
20	2.0000E+06	6.0000E-03	3.0000E+07	1.0000E-03	3.0000E+07	6.0000E-03	3102
21	2.1000E+06	6.0000E-03	3.5000E+07	1.0000E-03	3.5000E+07	6.0000E-03	3102
22	2.2000E+06	6.0000E-03	4.0000E+07	1.0000E-03	4.0000E+07	6.0000E-03	3102
23	2.3000E+06	6.0000E-03	4.5000E+07	1.0000E-03	4.5000E+07	6.0000E-03	3102
24	2.4000E+06	6.0000E-03	5.0000E+07	1.0000E-03	5.0000E+07	6.0000E-03	3102
25	2.5000E+06	6.0000E-03	5.5000E+07	1.0000E-03	5.5000E+07	6.0000E-03	3102
26	2.6000E+06	6.0000E-03	6.0000E+07	1.0000E-03	6.0000E+07	6.0000E-03	3102
27	2.7000E+06	6.0000E-03	6.5000E+07	1.0000E-03	6.5000E+07	6.0000E-03	3102
28	2.8000E+06	6.0000E-03	7.0000E+07	1.0000E-03	7.0000E+07	6.0000E-03	3102
29	2.9000E+06	6.0000E-03	7.5000E+07	1.0000E-03	7.5000E+07	6.0000E-03	3102
30	3.0000E+06	6.0000E-03	8.0000E+07	1.0000E-03	8.0000E+07	6.0000E-03	3102
31	3.1000E+06	6.0000E-03	8.5000E+07	1.0000E-03	8.5000E+07	6.0000E-03	3102
32	3.2000E+06	6.0000E-03	9.0000E+07	1.0000E-03	9.0000E+07	6.0000E-03	3102
33	3.3000E+06	6.0000E-03	9.5000E+07	1.0000E-03	9.5000E+07	6.0000E-03	3102
34	3.4000E+06	6.0000E-03	1.0000E+08	1.0000E-03	1.0000E+08	6.0000E-03	3102
35	3.5000E+06	6.0000E-03	1.0500E+08	1.0000E-03	1.0500E+08	6.0000E-03	3102
36	3.6000E+06	6.0000E-03	1.1000E+08	1.0000E-03	1.1000E+08	6.0000E-03	3102
37	3.7000E+06	6.0000E-03	1.1500E+08	1.0000E-03	1.1500E+08	6.0000E-03	31

1.1500E+07	3.5000E-04	1.2000E+07	4.1900E-04	1.2500E+07	4.8000E-04	3989	3102	23
1.3000E+07	5.5000E-04	1.3500E+07	7.6000E-04	1.4000E+07	7.6000E-04	3989	3102	24
1.4500E+07	8.0000E-04	1.5000E+07	9.0000E-04	1.5500E+07	9.8000E-04	3989	3102	25
1.6000E+07	8.5000E-04	1.7000E+07	7.5000E-04	1.8000E+07	6.6000E-04	3989	3102	26
1.9000E+07	5.5000E-04	2.0000E+07	4.0960E-04	-0.	-0.	3989	3102	27
3.9000E+04	8.8142E+01	0.	0.	0.	0.	3989	3102	0
0.	-7.0730E+05	0.	0.	1	0	3989	3103	1
38	2	0.	0.	0.	0.	3989	3103	2
7.1530E+05	0.	2.0000E+06	7.7000E-04	2.5000E+06	1.0000E-05	3989	3103	3
3.0000E+06	6.5000E-05	3.5000E+06	2.2909E-04	4.0000E+06	5.0000E-04	3989	3103	4
4.5000E+06	8.5284E-04	5.0000E+06	1.2000E-03	5.5000E+06	1.4702E-03	3989	3103	5
6.0000E+06	1.7000E-03	6.5000E+06	2.0560E-03	7.0000E+06	2.4000E-03	3989	3103	6
7.5000E+06	2.7626E-03	8.0000E+06	3.3000E-03	8.5000E+06	4.0703E-03	3989	3103	7
9.0000E+06	4.9000E-03	9.5000E+06	5.7000E-03	1.0000E+07	6.6000E-03	3989	3103	8
1.0500E+07	8.0105E-03	1.1000E+07	9.8000E-03	1.1500E+07	1.1623E-02	3989	3103	9
1.2000E+07	1.3400E-02	1.2500E+07	1.5000E-02	1.3000E+07	1.6500E-02	3989	3103	10
1.3500E+07	1.8468E-02	1.4000E+07	2.0000E-02	1.4500E+07	2.0201E-02	3989	3103	11
1.5000E+07	2.0400E-02	1.5500E+07	2.0735E-02	1.6000E+07	2.1000E-02	3989	3103	12
1.6500E+07	2.0985E-02	1.7000E+07	2.0800E-02	1.7500E+07	2.0612E-02	3989	3103	13
1.8000E+07	2.0300E-02	1.8500E+07	1.9850E-02	1.9000E+07	1.9400E-02	3989	3103	14
1.9500E+07	1.8950E-02	2.0000E+07	1.8500E-02	0.	0.	3989	3103	15
3.9000E+04	8.8142E+01	0.	0.	0.	0.	3989	3103	16
0.	6.9950E+05	0.	0.	1	0	3989	3107	0
37	2	0.	0.	0.	0.	373989	3107	1
1.0000E-05	0.	2.5300E-02	0.	5.0000E+02	0.	3989	3107	2
1.0000E+03	0.	4.0000E+06	1.6000E-09	4.5000E+06	2.9884E-08	3989	3107	3
5.0000E+06	8.0000E-08	5.5000E+06	5.3709E-07	6.0000E+06	1.4000E-06	3989	3107	4
6.5000E+06	5.5218E-06	7.0000E+06	1.3000E-05	7.5000E+06	2.8866E-05	3989	3107	5
8.0000E+06	5.6000E-05	8.5000E+06	1.0600E-04	9.0000E+06	1.8000E-04	3989	3107	6
9.5000E+06	2.8185E-04	1.0000E+07	4.2000E-04	1.0500E+07	6.1113E-04	3989	3107	7
1.1000E+07	8.7000E-04	1.1500E+07	1.1956E-03	1.2000E+07	1.6000E-03	3989	3107	8
1.2500E+07	2.1000E-03	1.3000E+07	2.7000E-03	1.3500E+07	3.3926E-03	3989	3107	9
1.4000E+07	4.1800E-03	1.4500E+07	5.0950E-03	1.5000E+07	6.1500E-03	3989	3107	10
1.5500E+07	7.3213E-03	1.6000E+07	8.6000E-03	1.6500E+07	9.9832E-03	3989	3107	11
1.7000E+07	1.1500E-02	1.7500E+07	1.3148E-02	1.8000E+07	1.5000E-02	3989	3107	12
1.8500E+07	1.7000E-02	1.9000E+07	1.9000E-02	1.9500E+07	2.1000E-02	3989	3107	13
2.0000E+07	2.3000E-02	0.	0.	0.	0.	3989	3107	14
						3989	3107	15
						3989	3107	16
						3989	3107	0
						3989	3107	0

A FEW MISCELLANEOUS REMARKS ABOUT THE PRESENT EVALUATION. ALL CROSS SECTIONS LEADING TO UNSTABLE RESIDUAL NUCLEI OR META-
STABLE STATES WERE CALCULATED FOR ALL REACTIONS. (METASTABLE
STATES WERE NOT GENERALLY CALCULATED FOR (N,GAMMA) AND (N,ALPHA)
REACTIONS). THE CONVENTION USED IS IF THE FINAL STATE FLAG (LFS)
IS EQUAL TO ZERO THEN THE CROSS SECTION GIVEN REPRESENTS THE
TOTAL CROSS SECTION FOR THAT REACTION. CROSS SECTIONS LEADING TO
AN ISOMERIC STATE ARE DENOTED BY LFS EQUAL TO THE NUMBER OF THE
STATE. FINALLY THE (N,ALPHA) AND (N,ALPHA,N) CROSS SECTIONS ARE
INCLUDED TOGETHER.

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			3990	1451	39
			3990	1451	40
			3990	1451	41
			3990	1451	42
			3990	1451	43
			3990	1451	44
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			3990	1451	66
			3990	1451	67
			3990	1451	68
			3990	1451	69
			3990	1	70
			3990	2	71
3.9090E+04	8.9135E+01	0	0	1	72
3.9090E+04	0.	0	0	1	73
1. E=05	2. F=07	0	0	0	74
0.	1.	0	0	0	75
			3990	2	76
			3990	0	77
3.9090E+04	8.9135E+01	0	0	0	1
0.	-2.0300E+05	0	0	1	2

2.2530E+05	0.	2	2.5000E+05	2	2.0000E+05	0	5.0000E+05	0	6.8400E-01	3	4	3
7.5000E+05	7.2700E-01		1.0000E+06		8.4300E-01		1.5000E+06		1.1330E-01	3	4	4
2.0000E+06	1.5200E+00		2.5000E+06		1.7320E+00		3.0000E+06		1.8110E-01	3	4	5
3.0000E+06	1.8100E+00		4.0000E+06		1.7960E+00		4.5000E+06		1.7200E-01	3	4	6
5.0000E+06	1.6580E+00		5.5000E+06		1.6480E+00		6.0000E+06		1.6420E-01	3	4	7
6.5000E+06	1.6462E+00		7.0000E+06		1.6480E+00		7.5000E+06		1.5695E-01	3	4	8
8.0000E+06	1.3950E+00		8.5000E+06		1.1635E+00		9.0000E+06		9.3200E-01	3	4	9
9.5000E+06	7.3737E-01		1.0000E+07		5.7300E-01		1.0500E+07		4.5116E-01	3	4	10
1.1000E+07	3.6700E-01		1.1500E+07		3.0500E-01		1.2000E+07		2.6390E-01	3	4	11
1.2500E+07	2.3512E-01		1.3000E+07		2.1200E-01		1.3500E+07		1.9263E-01	3	4	12
1.4000E+07	1.7600E-01		1.4500E+07		1.6200E-01		1.5000E+07		1.5200E-01	3	4	13
1.5500E+07	1.4200E-01		1.6000E+07		1.3500E-01		1.6500E+07		1.2800E-01	3	4	14
1.7000E+07	1.2200E-01		1.7500E+07		1.1315E-01		1.8000E+07		1.0500E-01	3	4	15
1.8500E+07	9.9863E-02		1.9000E+07		9.5600E-02		1.9500E+07		9.1565E-02	3	4	16
2.0000E+07	8.7800E-02		0.		0.		0.		0.	3	4	17
3.0000E+07	8.9135E-01		0.		0.		0.		0.	3	4	18
0.	-6.8600E+06		0.		0.		0.		0.	3	4	19
6.9370E+06	0.	2	7.0000E+06	0.	1.9800E-02	0.	7.5000E+06	0.	1.5418E-01	3	4	20
8.0000E+06	2.9200E-01		8.5000E+06		5.1470E-01		9.0000E+06		7.5600E-01	3	4	21
9.5000E+06	9.4325E-01		1.0000E+07		1.0950E+00		1.0500E+07		1.2058E-01	3	4	22
1.1000E+07	1.2820E+00		1.1500E+07		1.3350E+00		1.2000E+07		1.3750E-01	3	4	23
1.2500E+07	1.4051E+00		1.3000E+07		1.4250E+00		1.3500E+07		1.4340E-01	3	4	24
1.4000E+07	1.4410E+00		1.4500E+07		1.4550E+00		1.5000E+07		1.4500E-01	3	4	25
1.5500E+07	1.4529E+00		1.6000E+07		1.4550E+00		1.6500E+07		1.4557E-01	3	4	26
1.7000E+07	1.4560E+00		1.7500E+07		1.4501E+00		1.8000E+07		1.4630E-01	3	4	27
1.8500E+07	1.4609E+00		1.9000E+07		1.4510E+00		1.9500E+07		1.4260E-01	3	4	28
2.0000E+07	1.3840E+00		0.		0.		0.		0.	3	4	29
3.0000E+07	8.9135E+01		0.		1		0.		0.	3	4	30
0.	-7.7681E+06		0.		0.		0.		0.	3	4	31
7.8550E+06	0.	2	8.0000E+06	0.	3.5000E-02	0.	8.5000E+06	0.	1.9750E-01	3	4	32
9.0000E+06	3.6200E-01		9.5000E+06		5.0347E-01		1.0000E+07		6.2500E-01	3	4	33
1.0500E+07	7.2072E-01		1.1000E+07		7.8200E-01		1.1500E+07		8.1947E-01	3	4	34
1.2000E+07	8.5000E-01		1.2500E+07		8.7725E-01		1.3000E+07		9.0000E-01	3	4	35
1.3500E+07	9.1646E-01		1.4000E+07		9.3100E-01		1.4500E+07		9.4454E-01	3	4	36
1.5000E+07	9.5700E-01		1.5500E+07		9.6754E-01		1.6000E+07		9.7500E-01	3	4	37
1.6500E+07	9.7963E-01		1.7000E+07		9.8400E-01		1.7500E+07		9.8940E-01	3	4	38
1.8000E+07	9.9500E-01		1.8500E+07		9.9586E-01		1.9000E+07		9.9100E-01	3	4	39

1.9500E+07	9.8068E-01	2.0000E+07	9.6400E-01	0.	3990	3	16	12
3.9000E+04	8.9135E+01				3990	3	0	0
0.	-1.8330E+07				03900	3	17	1
	4				43900	3	17	2
1.8530E+07	2				03900	3	17	3
2.0000E+07	5.0000E-02	1.9000E+07	2.6000E-02	1.9500E+07	0.1915E-02	3990	3	4
					0.	3990	3	5
3.9000E+04	8.9135E+01				3990	3	0	7
0.	-6.1610E+06				03900	3	22	1
	1A				183990	3	22	2
6.2300E+06	0.				03900	3	22	3
1.3000E+07	7.0000E-08	1.2000E+07	6.0000E-09	1.2500E+07	2.9559E-08	3990	3	4
1.4500E+07	1.6749E-06	1.3500E+07	2.5872E-07	1.4000E+07	6.0000E-07	3990	3	5
1.6000E+07	1.3000E-05	1.5000E+07	3.5000E-06	1.5500E+07	7.0186E-06	3990	3	6
1.7500E+07	6.1415E-05	1.6500E+07	2.4000E-05	1.7000E+07	4.0000E-05	3990	3	7
1.9000E+07	1.8000E-04	1.8000E+07	8.9000E-05	1.8500E+07	1.2697E-04	3990	3	8
					3.5000E-04	3990	3	9
3.9000E+04	8.9135E+01				3990	3	0	0
0.	-7.5670E+06				03900	3	2A	1
	22				223990	3	2A	2
7.6520E+06	0.				03900	3	2A	3
1.1000E+07	7.0000E-05	1.0000E+07	2.4000E-06	1.0500E+07	2.5903E-05	3990	3	4
1.2500E+07	9.6635E-04	1.1500E+07	2.2000E-04	1.2000E+07	4.9000E-04	3990	3	5
1.4000E+07	4.6000E-03	1.3000E+07	1.7330E-03	1.3500E+07	2.8852E-03	3990	3	6
1.5500E+07	1.2228E-02	1.4500E+07	6.8017E-03	1.5000E+07	9.4000E-03	3990	3	7
1.7000E+07	2.2500E-02	1.6000E+07	1.5400E-02	1.6500E+07	1.8914E-02	3990	3	8
1.8500E+07	3.3680E-02	1.7500E+07	2.6111E-02	1.8000E+07	2.9800E-02	3990	3	9
2.0000E+07	4.5900E-02	1.9000E+07	3.7700E-02	1.9500E+07	4.1769E-02	3990	3	10
					0.	3990	3	11
3.9000E+04	8.9135E+01				3990	3	0	0
0.	-6.8500E+05				03900	3	52	1
	40				403990	3	52	2
6.9270E+05	0.				03900	3	52	3
2.0000E+06	1.6700E-01	1.0000E+06	5.0000E-03	1.5000E+06	8.6000E-02	3990	3	4
3.5000E+06	2.8901E-01	2.5000E+06	2.1300E-01	3.0000E+06	2.5900E-01	3990	3	5
5.0000E+06	3.4100E-01	4.0000E+06	3.0600E-01	4.5000E+06	3.2217E-01	3990	3	6
6.5000E+06	4.3508E-01	5.5000E+06	3.7280E-01	6.0000E+06	4.0700E-01	3990	3	7
8.0000E+06	4.8300E-01	7.0000E+06	4.6100E-01	7.5000E+06	4.9180E-01	3990	3	8
9.5000E+06	3.0269E-01	8.5000E+06	4.2530E-01	9.0000E+06	3.6400E-01	3990	3	9
1.1000E+07	1.6100E-01	1.0000E+07	2.4200E-01	1.0500E+07	1.9379E-01	3990	3	10
					1.1600E-01	3990	3	11

1.2500E+07	1.0275E-01	1.3000E+07	9.2000E-02	1.3500E+07	8.3200E-02	3 52	12
1.4000E+07	7.6000E-02	1.4500E+07	7.0615E-02	1.5000E+07	6.6200E-02	3 52	13
1.5500E+07	6.2539E-02	1.6000E+07	5.9400E-02	1.6500E+07	5.7134E-02	3 52	14
1.7000E+07	5.0900E-02	1.7500E+07	5.1205E-02	1.8000E+07	4.8000E-02	3 52	15
1.8500E+07	4.6481E-02	1.9000E+07	4.5000E-02	1.9500E+07	4.3371E-02	3 52	16
2.0000E+07	4.1700E-02	2.	0.	0.	0.	3 52	17
3.9000E+00	8.9135E+01	0	0	0	0	3 0	0
0.	7.9463E+06	0	0	2	535990	3102	1
15	5	53	2	0	0	3102	2
1.0000E-05	2.8000E+02	2.5300E-02	5.6000E+00	4.0000E+01	1.4000E-01	3102	3
2.5000E+02	1.4000E-01	4.2000E+02	1.4000E+00	6.0000E+02	6.5000E-01	3102	4
1.0000E+03	4.5800E-01	1.0000E+04	1.0000E-01	2.5000E+04	4.7300E-02	3102	5
5.0000E+04	2.7600E-02	1.0000E+05	1.7200E-02	2.5000E+05	8.3000E-03	3102	6
5.0000E+05	5.2000E-03	7.5000E+05	4.4000E-03	1.0000E+06	3.3000E-03	3102	7
1.5000E+06	2.8000E-03	2.0000E+06	2.2900E-03	2.5000E+06	1.8400E-03	3102	8
3.0000E+06	1.3800E-03	3.5000E+06	1.0119E-03	4.0000E+06	7.6000E-04	3102	9
4.5000E+06	5.6999E-04	5.0000E+06	4.2800E-04	5.5000E+06	3.2156E-04	3102	10
6.0000E+06	2.6500E-04	6.5000E+06	2.7317E-04	7.0000E+06	3.6500E-04	3102	11
7.5000E+06	5.1376E-04	8.0000E+06	6.7000E-04	8.5000E+06	8.3466E-04	3102	12
9.0000E+06	9.9500E-04	9.5000E+06	1.1290E-03	1.0000E+07	1.2600E-03	3102	13
1.0500E+07	1.4102E-03	1.1000E+07	1.5600E-03	1.1500E+07	1.7021E-03	3102	14
1.2000E+07	1.8400E-03	1.2500E+07	1.9678E-03	1.3000E+07	2.0860E-03	3102	15
1.3500E+07	2.2036E-03	1.4000E+07	2.2500E-03	1.4500E+07	2.2250E-03	3102	16
1.5000E+07	2.2000E-03	1.5500E+07	2.1750E-03	1.6000E+07	2.1500E-03	3102	17
1.6500E+07	1.9819E-03	1.7000E+07	1.7180E-03	1.7500E+07	1.4871E-03	3102	18
1.8000E+07	1.2840E-03	1.8500E+07	1.1441E-03	1.9000E+07	1.0180E-03	3102	19
1.9500E+07	8.8456E-04	2.0000E+07	7.5100E-04	2.	0.	3102	20
3.9000E+00	8.9135E+01	0	0	0	0	3 0	21
0.	2.3700E+05	0	0	0	0	3 0	0
43	2	0	0	0	0	3 0	1
1.0000E-05	0.	2.5300E-02	7.	5.0000E+02	0.	3103	2
1.0000E+03	0.	1.0000E+06	1.2000E-08	1.5000E+06	3.0000E-07	3103	3
2.0000E+06	4.0000E-06	2.5000E+06	1.5000E-05	3.0000E+06	4.0000E-05	3103	4
3.5000E+06	8.1259E-05	4.0000E+06	1.3000E-04	4.5000E+06	1.8730E-04	3103	5
5.0000E+06	2.6000E-04	5.5000E+06	3.9600E-04	6.0000E+06	6.0000E-04	3103	6
6.5000E+06	8.6515E-04	7.0000E+06	1.2000E-03	7.5000E+06	1.6344E-03	3103	7
8.0000E+06	2.2000E-03	8.5000E+06	2.9528E-03	9.0000E+06	3.9000E-03	3103	8
9.5000E+06	4.9889E-03	1.0000E+07	6.4000E-03	1.0500E+07	8.1900E-03	3103	9
1.1000E+07	1.0000E-02	1.1500E+07	1.1052E-02	1.2000E+07	1.3300E-02	3103	10

1.2500E+07	1.5150E-02	1.3000E+07	1.7000E-02	1.3500E+07	1.8320E-02	3103	13
1.4000E+07	1.9200E-02	1.4500E+07	1.9903E-02	1.5000E+07	2.0300E-02	3103	14
1.5500E+07	2.0300E-02	1.6000E+07	2.0400E-02	1.6500E+07	2.0360E-02	3103	15
1.7000E+07	2.0200E-02	1.7500E+07	1.9150E-02	1.8000E+07	1.8100E-02	3103	16
1.8500E+07	1.7901E-02	1.9000E+07	1.7700E-02	1.9500E+07	1.7457E-02	3103	17
2.0000E+07	1.7200E-02	0.	0.	0.	0.	3103	18
3.9090E+04	8.9135E+01	0	0	0	0.	3107	0
0.	3.7650E+06	0	0	0	0	3107	1
43	2	0	0	0	0	3107	2
1.0000E-05	0.	2.5300E-02	0.	5.0000E+02	0.	3107	3
1.0000E+03	0.	1.0000E+06	3.5000E-08	1.5000E+06	2.5000E-07	3107	4
2.0000E+06	1.2000E-06	2.5000E+06	4.5000E-06	3.0000E+06	1.2000E-05	3107	5
3.5000E+06	3.4827E-05	4.0000E+06	6.9000E-05	4.5000E+06	1.1285E-04	3107	6
5.0000E+06	1.8000E-04	5.5000E+06	3.1363E-04	6.0000E+06	5.0000E-04	3107	7
6.5000E+06	6.7303E-04	7.0000E+06	1.0000E-04	7.5000E+06	1.5113E-03	3107	8
8.0000E+06	2.0400E-03	8.5000E+06	2.5666E-03	9.0000E+06	3.1000E-03	3107	9
9.5000E+06	3.6781E-03	1.0000E+07	4.3000E-03	1.0500E+07	4.9323E-03	3107	10
1.1000E+07	5.6000E-03	1.1500E+07	6.3000E-03	1.2000E+07	7.0000E-03	3107	11
1.2500E+07	7.7000E-03	1.3000E+07	8.4000E-03	1.3500E+07	9.0625E-03	3107	12
1.4000E+07	9.7000E-03	1.4500E+07	1.0350E-02	1.5000E+07	1.1000E-02	3107	13
1.5500E+07	1.1993E-02	1.6000E+07	1.3000E-02	1.6500E+07	1.3505E-02	3107	14
1.7000E+07	1.3800E-02	1.7500E+07	1.3831E-02	1.8000E+07	1.4000E-02	3107	15
1.8500E+07	1.4726E-02	1.9000E+07	1.5500E-02	1.9500E+07	1.6126E-02	3107	16
2.0000E+07	1.6700E-02	0.	0.	0.	0.	3107	17
3.9091E+04	9.0126E+01	0	0	0	0	3107	18
0.	1.	0	0	0	0	3107	0
0.	0.	0	0	0	0	3107	0
39-Y = 91 LASL	EVAL=DFC78 F.D. ARTHJR	0	0	0	0	1451	1
LA=7301.7482PR	DIST=DFC78 REVM	0	0	0	0	1451	2
	GENERAL DESCRIPTION	53				1451	3
						1451	4
						1451	5
						1451	6
						1451	7
						1451	8
						1451	9
						1451	10
						1451	11

THE FOLLOWING CROSS SECTIONS RESULT FROM A NEW EVALUATION OF
 YTTRIUM 86-92 ISOTOPIES MADE USING GNASH AND COMNOC
 STATISTICAL NUCLEAR MODEL CODES. THIS EVALUATION USES NEW MODEL
 PARAMETERS AND SHOULD REPRESENT AN IMPROVEMENT OVER THE EARLIER

EVALUATION (6/17/77).	3991	1451	12
PRELIMINARY REPORTS OF THIS WORK APPEAR IN LA-7301-PR(1978) P.2	3991	1451	13
AND LA-7482-PR (1978) P.6, AND A DETAILED DESCRIPTION OF THE	3991	1451	14
CALCULATIONS WILL APPEAR IN AN UPCOMING LOS ALAMOS REPORT. A	3991	1451	15
BRIEF DESCRIPTION, HOWEVER, WILL BE GIVEN BELOW.	3991	1451	16
PRINCIPAL IMPROVEMENTS INCORPORATED IN THE PRESENT CALCULATIONS	3991	1451	17
RESULT FROM BETTER PROTON AND NEUTRON OPTICAL PARAMETERS AND	3991	1451	18
THE DETERMINATION AND USE OF GAMMA-RAY STRENGTH FUNCTIONS IN THIS	3991	1451	19
MASS REGION. NEW PROTON OPTICAL PARAMETERS WERE DETERMINED	3991	1451	20
FROM LOW ENERGY SR-87, Y-89 (P,N) DATA (REF.1) AND ARE SOMEWHAT	3991	1451	21
DIFFERENT FROM STANDARD PARAMETER SETS. NEUTRON PARAMETERS WERE	3991	1451	22
BASED ON A MODIFICATION OF THE LAGRANGE PARAMETERS (REF.2) WHICH	3991	1451	23
ARE APPLICABLE FROM 1 KEV TO 20 MEV.	3991	1451	24
TO DESCRIBE THE NEUTRON CAPTURE PROCESS AND GAMMA-RAY COMPETITION	3991	1451	25
A SYSTEMATIC STUDY WAS MADE OF GAMMA-RAY STRENGTH FUNCTIONS FOR	3991	1451	26
A=85-100 AS SUGGESTED IN REF.3. THESE GAMMA-RAY STRENGTH	3991	1451	27
FUNCTIONS CAN BE DETERMINED FROM CAPTURE DATA ON STABLE NUCLEI	3991	1451	28
AND THEN BE USED TO GIVE REALISTIC CAPTURE CROSS SECTIONS ON	3991	1451	29
UNSTABLE NUCLEI, AS WELL AS TO PROVIDE AN ACCURATE DESCRIPTION	3991	1451	30
OF GAMMA EMISSION WHERE IT IS AN IMPORTANT COMPETING REACTION.	3991	1451	31
FINALLY A NEW PREEQUILIBRIUM MODEL BASED ON THE KALBACH RESULTS	3991	1451	32
(REF.4) WAS USED TO DESCRIBE NONSTATISTICAL EFFECTS IN THE RANGE	3991	1451	33
10-20 MEV. (OTHER PARAMETERS RELATING TO LEVEL DENSITIES AND THE	3991	1451	34
FORM OF THE GAMMA-RAY EMISSION MODEL WERE SIMILAR TO THOSE USED	3991	1451	35
IN THE 6/17/77 EVALUATION) THE NET RESULTS OF THESE IMPROVEMENTS	3991	1451	36
WERE A CONSISTENT PARAMETER SETS WHICH REPRODUCED NEUTRON AND	3991	1451	37
CHARGED PARTICLE DATA FOR Y AND ZR ISOTOPES.	3991	1451	38
A FEW MISCELLANEOUS REMARKS ABOUT THE PRESENT EVALUATION.	3991	1451	39
ALL CROSS SECTIONS LEADING TO UNSTABLE RESIDUAL NUCLEI OR META-	3991	1451	40
STABLE STATES WERE CALCULATED FOR ALL REACTIONS. (METASTABLE	3991	1451	41
STATES WERE NOT GENERALLY CALCULATED FOR (N,GAMMA) AND (N,ALPHA)	3991	1451	42
REACTIONS). THE CONVENTION USED IS IF THE FINAL STATE FLAG (LFS)	3991	1451	43
IS EQUAL TO ZERO THEN THE CROSS SECTION GIVEN REPRESENTS THE	3991	1451	44
TOTAL CROSS SECTION FOR THAT REACTION. CROSS SECTIONS LEADING TO	3991	1451	45
AN ISOMERIC STATE ARE DENOTED BY LFS EQUAL TO THE NUMBER OF THE	3991	1451	46
STATE. FINALLY THE (N,ALPHA) AND (N,ALPHA,N) CROSS SECTIONS ARE	3991	1451	47
INCLUDED TOGETHER.	3991	1451	48
REFERENCES	3991	1451	49
	3991	1451	50
	3991	1451	51
1. C.H. JOHNSON ET AL. NUCL. PHYS. A107,21(1968),AND	3991	1451	52

PHYS. REV. LETT. 39,1600(1977)

2. CH. LAGRANGE, NATIONAL SOVIET CONFERENCE ON NEUTRON PHYSICS (1975)

3. D.G. GARDNER AND M. A. GARDNER, HAPS22,2903 (1977)

4. C. KALBACH, Z. PHYS. A283,401(1977).

3.90091E+04	9.0126E+01	0	451	53	53
3.90091E+04	0.	0	4	17	54
1. E=05	2. E+07	0	16	11	55
0.	1.	0	16	11	56
		0	17	7	57
		0	17	7	58
		0	22	11	59
		0	28	11	60
		0	51	17	61
		0	102	21	62
		0	103	15	63
		0	107	16	64
		0			65
		0			66
		0			67
		0			68
		0			69
		0			70
		0			71
		0			72
		0			73
		0			74
		0			75
		0			76
		0			77
		0			78
		0			79
		0			80
		0			81
		0			82
		0			83
		0			84
		0			85
		0			86
		0			87
		0			88
		0			89
		0			90
		0			91
		0			92
		0			93
		0			94
		0			95
		0			96
		0			97
		0			98
		0			99
		0			100
		0			101
		0			102
		0			103
		0			104
		0			105
		0			106
		0			107
		0			108
		0			109
		0			110
		0			111
		0			112
		0			113
		0			114
		0			115

1.8000E+07	1.1900E+01	1.8500E+07	1.1325E+01	1.9000E+07	1.0000E+01	3	4	16
1.9500E+07	1.0325E+01	2.0000E+07	9.0000E+02	0.	0.	3	4	17
3.90091E+04	9.0126E+01	0	0	0	0	3	0	0
0.	-7.9463E+06	0	0	0	0	3	16	1
	24	0	0	0	0	3	16	2
8.0340E+06	0.	9.0000E+06	3.7100E+01	9.5000E+06	6.1397E+01	3	16	3
1.0000E+07	8.5500E+01	1.0500E+07	1.0347E+00	1.0000E+07	1.1630E+00	3	16	4
1.1500E+07	1.2568E+00	1.2000E+07	1.3250E+00	1.2500E+07	1.3750E+00	3	16	5
1.3000E+07	1.4080E+00	1.3500E+07	1.4245E+00	1.4000E+07	1.4360E+00	3	16	6
1.4500E+07	1.4433E+00	1.5000E+07	1.4490E+00	1.5500E+07	1.4507E+00	3	16	7
1.6000E+07	1.4460E+00	1.6500E+07	1.4206E+00	1.7000E+07	1.3680E+00	3	16	8
1.7500E+07	1.2989E+00	1.8000E+07	1.2780E+00	1.8500E+07	1.0987E+00	3	16	9
1.9000E+07	9.9000E+01	1.9500E+07	8.8519E+01	2.0000E+07	7.8200E+01	3	16	10
3.90091E+04	9.0126E+01	0	2	0	0	3	0	11
0.	-8.6310E+06	0	0	0	0	3	16	1
	24	0	0	0	0	3	16	2
8.7270E+06	0.	9.0000E+06	9.3000E+03	9.5000E+06	6.9150E+02	3	16	3
1.0000E+07	1.3300E+01	1.0500E+07	2.0076E+01	1.1000E+07	2.6700E+01	3	16	4
1.1500E+07	3.2254E+01	1.2000E+07	3.6800E+01	1.2500E+07	4.0820E+01	3	16	5
1.3000E+07	4.4100E+01	1.3500E+07	4.6710E+01	1.4000E+07	4.9000E+01	3	16	6
1.4500E+07	5.1351E+01	1.5000E+07	5.3200E+01	1.5500E+07	5.4700E+01	3	16	7
1.6000E+07	5.6300E+01	1.6500E+07	5.7312E+01	1.7000E+07	5.7400E+01	3	16	8
1.7500E+07	5.6342E+01	1.8000E+07	5.3600E+01	1.8500E+07	5.0362E+01	3	16	9
1.9000E+07	4.6600E+01	1.9500E+07	4.2629E+01	2.0000E+07	3.8500E+01	3	16	10
3.90091E+04	9.0126E+01	0	0	0	0	3	0	11
0.	-1.4806E+07	0	0	0	0	3	17	1
	12	0	0	0	0	3	17	2
1.4971E+07	0.	1.5000E+07	2.0000E+03	1.5500E+07	6.3000E+03	3	17	3
1.6000E+07	1.0500E+02	1.6500E+07	4.0328E+02	1.7000E+07	9.2000E+02	3	17	4
1.7500E+07	1.6253E+01	1.8000E+07	2.5100E+01	1.8500E+07	3.5500E+01	3	17	5
1.9000E+07	4.5900E+01	1.9500E+07	5.5649E+01	2.0000E+07	6.5100E+01	3	17	6
3.90091E+04	9.0126E+01	0	1	0	0	3	17	7
0.	-1.5710E+07	0	0	0	0	3	17	8
	10	0	0	0	0	3	17	9
1.5890E+07	0.	1.6000E+07	5.0000E+03	1.6500E+07	1.6517E+02	3	17	10
1.7000E+07	3.1000E+02	1.7500E+07	7.3927E+02	1.8000E+07	1.4000E+01	3	17	11
1.8500E+07	2.1423E+01	1.9000E+07	2.8000E+01	1.9500E+07	3.6030E+01	3	17	12

2.2000E+07	4.3200E+01	0.	0.	0.	0.	0.	0.	3 17	3991	0.	7
3.9091E+04	9.0126E+01	0	0	0	0	0	0	3 0	3991	0	0
0.	-4.1810E+06	0	0	0	0	0	0	3 22	23991	0	1
	24	0	0	0	0	0	0	3 22	243991	0	2
4.2300E+06	0.	0	0	0	0	0	0	3 22	03991	0	3
1.0000E+07	1.3000E+07	9.5000E+06	4.6000E+06	5.9666E+07	1.0500E+07	1.1000E+07	1.5000E+06	3 22	7.7757E+08	3991	4
1.1500E+07	4.7935E+06	1.2000E+07	1.2000E+07	1.1000E+05	1.2000E+07	1.2500E+07	1.5000E+06	3 22	1.5000E+06	3991	5
1.3000E+07	3.9000E+05	1.3500E+07	6.2103E+05	6.2103E+05	1.3500E+07	1.4000E+07	9.6000E+05	3 22	2.1906E+05	3991	6
1.4500E+07	1.4006E+04	1.5000E+07	1.9000E+04	1.9000E+04	1.5000E+07	1.5500E+07	2.4180E+04	3 22	9.6000E+05	3991	7
1.6000E+07	3.0000E+04	1.6500E+07	3.6500E+04	3.6500E+04	1.6500E+07	1.7000E+07	4.3000E+04	3 22	2.4180E+04	3991	8
1.7500E+07	4.9500E+04	1.8000E+07	5.6000E+04	5.6000E+04	1.8000E+07	1.8500E+07	6.4687E+04	3 22	4.3000E+04	3991	9
1.9000E+07	7.6000E+04	1.9500E+07	8.6225E+04	8.6225E+04	1.9500E+07	2.0000E+07	1.0300E+07	3 22	6.4687E+04	3991	10
3.9091E+04	9.0126E+01	0	0	0	0	0	0	3 0	3991	0	11
0.	-7.7090E+06	0	0	0	0	0	0	3 29	03991	0	12
	24	0	0	0	0	0	0	3 29	243991	0	13
7.7500E+06	0.	0	0	0	0	0	0	3 29	03991	0	14
1.0000E+07	5.0000E+07	1.0500E+07	7.0000E+06	6.5610E+06	1.0500E+07	1.1000E+07	1.8057E+07	3 29	1.8057E+07	3991	15
1.1500E+07	6.4876E+05	1.2000E+07	1.5000E+07	1.5000E+07	1.2000E+07	1.2500E+07	3.4062E+04	3 29	3.4062E+04	3991	16
1.3000E+07	6.9000E+04	1.3500E+07	1.2789E+03	1.2789E+03	1.3500E+07	1.4000E+07	2.0000E+07	3 29	2.0000E+07	3991	17
1.4500E+07	3.4971E+03	1.5000E+07	5.3000E+03	5.3000E+03	1.5000E+07	1.5500E+07	7.5000E+03	3 29	7.5000E+03	3991	18
1.6000E+07	1.0200E+02	1.6500E+07	1.3179E+02	1.3179E+02	1.6500E+07	1.7000E+07	1.6000E+02	3 29	1.6000E+02	3991	19
1.7500E+07	1.9820E+02	1.8000E+07	2.3500E+02	2.3500E+02	1.8000E+07	1.8500E+07	2.7000E+02	3 29	2.7000E+02	3991	20
1.9000E+07	3.1500E+02	1.9500E+07	3.5622E+02	3.5622E+02	1.9500E+07	2.0000E+07	3.0000E+02	3 29	3.0000E+02	3991	21
3.9091E+04	9.0126E+01	0	0	0	0	0	0	3 0	3991	0	22
0.	-5.5600E+05	0	0	0	0	0	0	3 51	03991	0	23
	41	0	0	0	0	0	0	3 51	413991	0	24
5.6220E+05	0.	0	0	0	0	0	0	3 51	03991	0	25
1.5000E+06	1.4000E+01	2.0000E+06	7.0000E+02	1.5900E+01	2.0000E+06	2.5000E+06	1.1000E+01	3 51	1.1000E+01	3991	26
3.0000E+06	2.6000E+01	3.5000E+06	3.2831E+01	3.2831E+01	3.5000E+06	4.0000E+06	3.8000E+01	3 51	3.8000E+01	3991	27
4.5000E+06	4.1554E+01	5.0000E+06	4.3900E+01	4.3900E+01	5.0000E+06	5.5000E+06	4.6000E+01	3 51	4.6000E+01	3991	28
6.0000E+06	4.9900E+01	6.5000E+06	5.1900E+01	5.1900E+01	6.5000E+06	7.0000E+06	5.3000E+01	3 51	5.3000E+01	3991	29
7.5000E+06	5.6522E+01	8.0000E+06	5.9100E+01	5.9100E+01	8.0000E+06	8.5000E+06	5.7231E+01	3 51	5.7231E+01	3991	30
9.0000E+06	5.0700E+01	9.5000E+06	4.1761E+01	4.1761E+01	9.5000E+06	1.0000E+07	3.3000E+01	3 51	3.3000E+01	3991	31
1.0500E+07	2.6102E+01	1.1000E+07	2.0500E+01	2.0500E+01	1.1000E+07	1.1500E+07	1.6370E+01	3 51	1.6370E+01	3991	32
1.2000E+07	1.3500E+01	1.2500E+07	1.1535E+01	1.1535E+01	1.2500E+07	1.3000E+07	1.0100E+01	3 51	1.0100E+01	3991	33
1.3500E+07	9.0836E+02	1.4000E+07	8.3400E+02	8.3400E+02	1.4000E+07	1.4500E+07	7.7356E+02	3 51	7.7356E+02	3991	34
1.5000E+07	7.3000E+02	1.5500E+07	6.9819E+02	6.9819E+02	1.5500E+07	1.6000E+07	6.7000E+02	3 51	6.7000E+02	3991	35
1.6500E+07	6.4500E+02	1.7000E+07	6.2000E+02	6.2000E+02	1.7000E+07	1.7500E+07	5.0500E+02	3 51	5.0500E+02	3991	36

1.8000E+07	5.7000E+02	1.8500E+07	5.4500E+02	1.9000E+07	5.2000E+02	3	51	16
1.9500E+07	4.9512E+02	2.0000E+07	4.8000E+02	2.0	0.	3	51	17
3.9001E+04	9.0126E+01	0	0	0	0	3	0	1
0.	6.5570E+06	0	0	0	0	3	0	1
1.0000E+05	2.0120E+02	2.5300E+02	4.0000E+00	8.0000E+01	7.0000E+02	3	0	2
5.0000E+02	7.0000E+02	8.0000E+02	7.6000E+01	9.0000E+02	5.0000E+01	3	0	3
1.0000E+03	3.3700E+01	1.0000E+04	7.6500E+02	2.5000E+02	3.6100E+02	3	0	4
5.0000E+04	2.2500E+02	1.0000E+05	1.5000E+02	2.5000E+05	1.3300E+02	3	0	5
5.0000E+05	1.3000E+02	7.5000E+05	6.7000E+03	1.0000E+06	4.0000E+03	3	0	6
1.5000E+06	3.6000E+03	2.0000E+06	2.0200E+03	2.5000E+06	2.0000E+03	3	0	7
3.0000E+06	2.6000E+03	3.5000E+06	2.1000E+03	4.0000E+06	1.6000E+03	3	0	8
4.5000E+06	1.2763E+03	5.0000E+06	9.5000E+04	5.5000E+06	6.0700E+04	3	0	9
6.0000E+06	5.6000E+04	6.5000E+06	5.1033E+04	7.0000E+06	5.1000E+04	3	0	10
7.5000E+06	5.1716E+04	8.0000E+06	5.3000E+04	8.5000E+06	5.5000E+04	3	0	11
9.0000E+06	5.0000E+04	9.5000E+06	6.2512E+04	1.0000E+07	6.0000E+04	3	0	12
1.0500E+07	7.4768E+04	1.1000E+07	8.2300E+04	1.1500E+07	9.0000E+04	3	0	13
1.2000E+07	1.0000E+03	1.2500E+07	1.0900E+03	1.3000E+07	1.1000E+03	3	0	14
1.3500E+07	1.2803E+03	1.4000E+07	1.3300E+03	1.4500E+07	1.3300E+03	3	0	15
1.5000E+07	1.3300E+03	1.5500E+07	1.3400E+03	1.6000E+07	1.3200E+03	3	0	16
1.6500E+07	1.2046E+03	1.7000E+07	1.0800E+03	1.7500E+07	9.5300E+04	3	0	17
1.8000E+07	8.4200E+04	1.8500E+07	7.5300E+04	1.9000E+07	6.6400E+04	3	0	18
1.9500E+07	5.7500E+04	2.0000E+07	4.0600E+04	0.	0.	3	0	19
3.9001E+04	9.0126E+01	0	0	0	0	3	0	20
0.	-1.8826E+06	0	0	0	0	3	0	21
1.9030E+06	0.	4.0000E+06	1.7200E+06	4.5000E+06	1.0600E+06	3	0	22
5.0000E+06	2.5000E+05	5.5000E+06	5.1302E+05	6.0000E+06	9.0000E+05	3	0	23
6.5000E+06	1.6001E+04	7.0000E+06	2.7000E+04	7.5000E+06	4.6300E+04	3	0	24
8.0000E+06	7.5000E+04	8.5000E+06	1.1400E+03	9.0000E+06	1.7000E+03	3	0	25
9.5000E+06	2.4354E+03	1.0000E+07	3.4000E+03	1.0500E+07	4.5700E+03	3	0	26
1.1000E+07	5.9000E+03	1.1500E+07	7.3722E+03	1.2000E+07	9.0000E+03	3	0	27
1.2500E+07	1.1203E+02	1.3000E+07	1.3200E+02	1.3500E+07	1.4027E+02	3	0	28
1.4000E+07	1.5600E+02	1.4500E+07	1.6772E+02	1.5000E+07	1.7000E+02	3	0	29
1.5500E+07	1.8600E+02	1.6000E+07	1.0100E+02	1.6500E+07	1.9426E+02	3	0	30
1.7000E+07	1.9600E+02	1.7500E+07	1.9632E+02	1.8000E+07	1.9600E+02	3	0	31
1.8500E+07	1.9520E+02	1.9000E+07	1.9400E+02	1.9500E+07	1.9225E+02	3	0	32
2.0000E+07	1.9000E+02	0.	0.	0.	0.	3	0	33

3.9091E+04	9.0126E+01	0	0	0	03991	3107	1
0.	1.9021E+06	0	0	1	373991	3107	2
37	2	0	0	0	03991	3107	3
1.0000E-05	0.	2.5300E-02	0.	5.0000E+02	0.	3991	3107
1.0000E+03	0.	4.0000E+06	4.5000E-07	4.5000E+06	1.9002E-06	3991	3107
5.0000E+06	5.0000E-06	5.5000E+06	1.5248E-05	6.0000E+06	3.4000E-05	3991	3107
6.5000E+06	6.4815E-05	7.0000E+06	1.1000E-04	7.5000E+06	1.7267E-04	3991	3107
8.0000E+06	2.6000E-04	8.5000E+06	3.7701E-04	9.0000E+06	5.2000E-04	3991	3107
9.5000E+06	6.8148E-04	1.0000E+07	8.8000E-04	1.0500E+07	1.1250E-03	3991	3107
1.1000E+07	1.4000E-03	1.1500E+07	1.6906E-03	1.2000E+07	2.0000E-03	3991	3107
1.2500E+07	2.3368E-03	1.3000E+07	2.7000E-03	1.3500E+07	3.0812E-03	3991	3107
1.4000E+07	3.5000E-03	1.4500E+07	3.9500E-03	1.5000E+07	4.4000E-03	3991	3107
1.5500E+07	4.8500E-03	1.6000E+07	5.3000E-03	1.6500E+07	5.7500E-03	3991	3107
1.7000E+07	6.2000E-03	1.7500E+07	6.6500E-03	1.8000E+07	7.1000E-03	3991	3107
1.8500E+07	7.5500E-03	1.9000E+07	8.0000E-03	1.9500E+07	8.3875E-03	3991	3107
2.0000E+07	8.7000E-03	0.	0.	0.	0.	3991	3107
						3991	3
						3991	7
						0	0
3.9092E+04	9.1120E+04	0	0	0	13992	1451	1
0.	1.	0	0	0	03992	1451	2
0.	0.	0	0	53	113992	1451	3
39-Y - 92 LASL	EVAL-DEC78	E.D. ARTHUR			3992	1451	4
LA-7301,7482PR	DIST-DEC78	REV0			3992	1451	5
	GENERAL DESCRIPTION				3992	1451	6

THE FOLLOWING CROSS SECTIONS RESULT FROM A NEW EVALUATION OF
 YTTRIUM 86 -92 ISOTOPES MADE USING GNASH AND COMNUC
 STATISTICAL NUCLEAR MODEL CODES. THIS EVALUATION USES NEW MODEL
 PARAMETERS AND SHOULD REPRESENT AN IMPROVEMENT OVER THE EARLIER
 EVALUATION (6/17/77).
 PRELIMINARY REPORTS OF THIS WORK APPEAR IN LA-7301-PR(1978) P.2
 AND LA-7482-PR (1978) P.6, AND A DETAILED DESCRIPTION OF THE
 CALCULATIONS WILL APPEAR IN AN UPCOMING LOS ALAMOS REPORT. A
 BRIEF DESCRIPTION, HOWEVER, WILL BE GIVEN BELOW.
 PRINCIPAL IMPROVEMENTS INCORPORATED IN THE PRESENT CALCULATIONS
 RESULT FROM BETTER PROTON AND NEUTRON OPTICAL PARAMETERS AND
 THE DETERMINATION AND USE OF GAMMA-RAY STRENGTH FUNCTIONS IN THIS
 MASS REGION. NEW PROTON OPTICAL PARAMETERS WERE DETERMINED

3992	1451	7
3992	1451	8
3992	1451	9
3992	1451	10
3992	1451	11
3992	1451	12
3992	1451	13
3992	1451	14
3992	1451	15
3992	1451	16
3992	1451	17
3992	1451	18
3992	1451	19
3992	1451	20

FROM LOW ENERGY SR-A7, Y-89 (P,N) DATA (REF.1) AND ARE SOMEWHAT DIFFERENT FROM STANDARD PARAMETER SETS. NEUTRON PARAMETERS WERE BASED ON A MODIFICATION OF THE LAGRANGE PARAMETERS (REF.2) WHICH ARE APPLICABLE FROM 1 KEV TO 20 MEV.

TO DESCRIBE THE NEUTRON CAPTURE PROCESS AND GAMMA-RAY COMPETITION A SYSTEMATIC STUDY WAS MADE OF GAMMA-RAY STRENGTH FUNCTIONS FOR A-85-100 AS SUGGESTED IN REF.3. THESE GAMMA-RAY STRENGTH FUNCTIONS CAN BE DETERMINED FROM CAPTURE DATA ON STABLE NUCLEI AND THEN BE USED TO GIVE REALISTIC CAPTURE CROSS SECTIONS ON UNSTABLE NUCLEI, AS WELL AS TO PROVIDE AN ACCURATE DESCRIPTION OF GAMMA EMISSION WHERE IT IS AN IMPORTANT COMPETING REACTION.

FINALLY A NEW PREEQUILIBRIUM MODEL BASED ON THE KALHACH RESULTS (REF.4) WAS USED TO DESCRIBE NONSTATISTICAL EFFECTS IN THE RANGE 10-20 MEV. (OTHER PARAMETERS RELATING TO LEVEL DENSITIES AND THE FORM OF THE GAMMA-RAY EMISSION MODEL WERE SIMILAR TO THOSE USED IN THE 6/17/77 EVALUATION) THE NET RESULTS OF THESE IMPROVEMENTS WERE A CONSISTENT PARAMETER SETS WHICH REPRODUCED NEUTRON AND CHARGED PARTICLE DATA FOR Y AND ZR ISOTOPES.

A FEW MISCELLANEOUS REMARKS ABOUT THE PRESENT EVALUATION.

ALL CROSS SECTIONS LEADING TO UNSTABLE RESIDUAL NUCLEI OR META-STABLE STATES WERE CALCULATED FOR ALL REACTIONS. (METASTABLE STATES WERE NOT GENERALLY CALCULATED FOR (N,GAMMA) AND (N,ALPHA) REACTIONS). THE CONVENTION USED IS IF THE FINAL STATE FLAG (LFS) IS EQUAL TO ZERO THEN THE CROSS SECTION GIVEN REPRESENTS THE TOTAL CROSS SECTION FOR THAT REACTION. CROSS SECTIONS LEADING TO AN ISOMERIC STATE ARE DENOTED BY LFS EQUAL TO THE NUMBER OF THE STATE. FINALLY THE (N,ALPHA) AND (N,ALPHA,N) CROSS SECTIONS ARE INCLUDED TOGETHER.

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1	451	53
3	4	17

3992	1451	21
3992	1451	22
3992	1451	23
3992	1451	24
3992	1451	25
3992	1451	26
3992	1451	27
3992	1451	28
3992	1451	29
3992	1451	30
3992	1451	31
3992	1451	32
3992	1451	33
3992	1451	34
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3992	1451	40
3992	1451	41
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3992	1451	43
3992	1451	44
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3992	1451	46
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3992	1451	48
3992	1451	49
3992	1451	50
3992	1451	51
3992	1451	52
3992	1451	53
3992	1451	54
3992	1451	55
3992	1451	56
3992	1451	57
3992	1451	58
3992	1451	59
3992	1451	60

3	16	13	5992	1451	61
3	16	12	5992	1451	62
3	17	7	5992	1451	63
3	17	7	5992	1451	64
3	22	9	5992	1451	65
3	28	9	5992	1451	66
3	102	22	5992	1451	67
3	103	15	5992	1451	68
3	107	16	5992	1451	69
			5992	1	70
			5992	2	71
3	0	1	5992	2151	72
3	0	1	5992	2151	73
3	0	0	5992	2151	74
3	0	0	5992	2151	75
			5992	2	76
			5992	3	77
3	0	0	5992	3	1
3	0	1	425992	3	2
3	0	0	5992	3	3
5	7.3500E+01	7.5000E+05	9.8300E+01	5992	4
1	1.5000E+06	1.5300E+00	2.0000E+06	5992	5
3	3.0000E+06	1.9300E+00	1.7040E+00	5992	6
4	4.5000E+06	1.7353E+00	1.8843E+00	5992	7
6	6.0000E+06	1.6330E+00	1.6650E+00	5992	8
7	7.5000E+06	1.4370E+00	1.6280E+00	5992	9
9	9.0000E+06	7.9600E+01	1.2100E+00	5992	10
1	1.0000E+07	4.4817E+01	6.3543E+01	5992	11
1	1.0500E+07	3.0900E+01	3.8700E+01	5992	12
1	1.1500E+07	3.4336E+01	2.8250E+01	5992	13
1	1.3000E+07	2.6000E+01	2.2500E+01	5992	14
1	1.4500E+07	2.1053E+01	1.8747E+01	5992	15
1	1.6000E+07	1.7800E+01	1.6100E+01	5992	16
1	1.7500E+07	1.5335E+01	1.3800E+01	5992	17
1	1.9000E+07	1.3200E+01	1.1900E+01	5992	18
3	0	0	5992	3	19
3	0	0	5992	3	20
3	0	1	5992	3	21
3	0	0	5992	3	22
3	0	0	5992	3	23
7	7.0000E+06	4.3700E+02	2.5022E+01	5992	24
8	8.0000E+06	4.8688E+01	8.0100E+01	5992	25
9	9.0000E+06	1.1400E+00	1.2153E+00	5992	26
3	0	0	5992	3	27
3	0	0	5992	3	28
3	0	0	5992	3	29
3	0	0	5992	3	30
3	0	0	5992	3	31
3	0	0	5992	3	32
3	0	0	5992	3	33
3	0	0	5992	3	34
3	0	0	5992	3	35
3	0	0	5992	3	36
3	0	0	5992	3	37
3	0	0	5992	3	38
3	0	0	5992	3	39
3	0	0	5992	3	40
3	0	0	5992	3	41
3	0	0	5992	3	42
3	0	0	5992	3	43
3	0	0	5992	3	44
3	0	0	5992	3	45
3	0	0	5992	3	46
3	0	0	5992	3	47
3	0	0	5992	3	48
3	0	0	5992	3	49
3	0	0	5992	3	50
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3	0	0	5992	3	83
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3	0	0	5992	3	94
3	0	0	5992	3	95
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3	0	0	5992	3	97
3	0	0	5992	3	98
3	0	0	5992	3	99
3	0	0	5992	3	100

1.1000E+07	1.2700E+00	1.1500E+07	1.3079E+00	1.2000E+07	1.3010E+00	3	16	7
1.2500E+07	1.3731E+00	1.3000E+07	1.3930E+00	1.3500E+07	1.3977E+00	3	16	8
1.4000E+07	1.4000E+00	1.4500E+07	1.4070E+00	1.5000E+07	1.4120E+00	3	16	9
1.5500E+07	1.4221E+00	1.6000E+07	1.4280E+00	1.6500E+07	1.4375E+00	3	16	10
1.7000E+07	1.2770E+00	1.7500E+07	1.1835E+00	1.8000E+07	1.0000E+00	3	16	11
1.8500E+07	9.8812E-01	1.9000E+07	8.8900E-01	1.9500E+07	8.0013E-01	3	16	12
2.0000E+07	7.2100E-01	0.	0.	0.	0.	3	16	13
3.0000E+07	9.1120E+00	0.	1	0	0	3	0	0
0.	-7.1130E+06	0	0	1	0	3	16	1
26		0	0	0	0	3	16	2
7.1910E+06	0.	8.3000E+06	2.0300E-01	8.5000E+06	3.2317E-01	3	16	3
9.0000E+06	4.1900E-01	9.5000E+06	4.7031E-01	1.0000E+07	4.9600E-01	3	16	4
1.0500E+07	5.1620E-01	1.1000E+07	5.3800E-01	1.1500E+07	5.6335E-01	3	16	5
1.2000E+07	5.8900E-01	1.2500E+07	6.1572E-01	1.3000E+07	6.4200E-01	3	16	6
1.3500E+07	6.6227E-01	1.4000E+07	6.7800E-01	1.4500E+07	6.9200E-01	3	16	7
1.5000E+07	7.0500E-01	1.5500E+07	7.1334E-01	1.6000E+07	7.1300E-01	3	16	8
1.6500E+07	6.9761E-01	1.7000E+07	6.6500E-01	1.7500E+07	6.2376E-01	3	16	9
1.8000E+07	5.7800E-01	1.8500E+07	5.2700E-01	1.9000E+07	4.7700E-01	3	16	10
1.9500E+07	4.3175E-01	2.0000E+07	3.9000E-01	0.	0.	3	16	11
3.0000E+07	9.1120E+00	0.	0	0	0	3	0	12
0.	-1.4500E+07	0	0	0	0	3	17	0
12		0	0	1	0	3	17	1
1.4660E+07	0.	1.5000E+07	1.0000E-02	1.5500E+07	2.4063E-02	3	17	2
1.6000E+07	3.9000E-02	1.6500E+07	8.5338E-02	1.7000E+07	1.7300E-01	3	17	3
1.7500E+07	2.7050E-01	1.8000E+07	3.6800E-01	1.8500E+07	4.6550E-01	3	17	4
1.9000E+07	5.6300E-01	1.9500E+07	6.4956E-01	2.0000E+07	7.2300E-01	3	17	5
3.0000E+07	9.1120E+00	0	2	0	0	3	0	6
0.	-1.5190E+07	0	0	0	0	3	17	7
10		0	0	1	0	3	17	0
1.5350E+07	0.	1.6000E+07	3.2000E-02	1.6500E+07	3.5270E-02	3	17	1
1.7000E+07	4.5000E-02	1.7500E+07	8.2907E-02	1.8000E+07	1.3000E-01	3	17	2
1.8500E+07	1.8103E-01	1.9000E+07	2.3100E-01	1.9500E+07	2.7761E-01	3	17	3
2.0000E+07	3.2200E-01	0.	0.	0.	0.	3	17	4
3.0000E+07	9.1120E+00	0	0	0	0	3	0	5
0.	-4.6550E+06	0	0	1	0	3	22	6
18		0	0	0	0	3	22	7
4.7000E+06	0.	1.2000E+07	8.3000E-07	1.2500E+07	2.5119E-06	3	22	0
0.		0	0	0	0	3	22	1
0.		0	0	0	0	3	22	2
0.		0	0	0	0	3	22	3
0.		0	0	0	0	3	22	4

1.3000E+07	5.4000E-06	1.3500E+07	1.0601E-05	1.4000E+07	1.9000E-05	3002	3	2
1.4500E+07	3.1921E-05	1.5000E+07	5.0000E-05	1.5500E+07	7.2512E-05	10002	3	2
1.6000E+07	1.0000E-04	1.6500E+07	1.3000E-04	1.7000E+07	1.7000E-04	10002	3	2
1.7500E+07	2.0600E-04	1.8000E+07	2.6000E-04	1.8500E+07	3.3000E-04	10002	3	2
1.9000E+07	4.0000E-04	1.9500E+07	4.7000E-04	2.0000E+07	5.4000E-04	10002	3	2
3.9002E+04	9.1120E+04	0.	0.	0.	0.	10002	3	2
0.	-8.4396E+06	0.	0.	0.	0.	10002	3	2
8.5320E+06	0.	1.2000E+07	8.0000E-06	1.2500E+07	2.9722E-05	10002	3	2
1.3000E+07	7.0000E-05	1.3500E+07	1.9072E-04	1.4000E+07	4.0000E-04	10002	3	2
1.4500E+07	7.3939E-04	1.5000E+07	1.3000E-03	1.5500E+07	2.1530E-03	10002	3	2
1.6000E+07	3.3000E-03	1.6500E+07	4.6150E-03	1.7000E+07	6.2000E-03	10002	3	2
1.7500E+07	8.0412E-03	1.8000E+07	1.0000E-02	1.8500E+07	1.2000E-02	10002	3	2
1.9000E+07	1.4100E-02	1.9500E+07	1.6227E-02	2.0000E+07	1.8000E-02	10002	3	2
3.9002E+04	9.1120E+04	0.	0.	0.	0.	10002	3	2
0.	7.4910E+06	0.	0.	0.	0.	10002	3	2
1.0000E-05	1.3420E+03	2.5300E-02	2.6700E+01	8.0000E+04	1.5000E+02	10002	3	2
2.5000E+01	1.5000E+00	4.5000E+01	1.5000E+00	8.0000E+01	1.5000E+01	10002	3	2
1.2000E+02	5.8000E+00	2.5000E+02	3.5000E+01	5.0000E+02	2.1100E+01	10002	3	2
1.0000E+03	3.0600E-01	1.0000E+03	5.4600E-02	2.5000E+03	2.0300E+02	10002	3	2
5.0000E+04	1.4300E-02	1.0000E+05	8.0000E-03	2.5000E+05	5.7000E-03	10002	3	2
5.0000E+05	2.0000E-03	7.5000E+05	1.5000E-03	1.0000E+06	1.2000E-03	10002	3	2
1.5000E+06	1.1600E-03	2.0000E+06	1.0300E-03	2.5000E+06	6.5000E-04	10002	3	2
3.0000E+06	2.7000E-04	3.5000E+06	1.0000E-04	4.0000E+06	1.1000E-04	10002	3	2
4.5000E+06	6.4001E-05	5.0000E+06	5.0000E-05	5.5000E+06	3.6005E-05	10002	3	2
6.0000E+06	2.9000E-05	6.5000E+06	3.3698E-05	7.0000E+06	5.1000E-05	10002	3	2
7.5000E+06	8.8074E-05	8.0000E+06	1.0000E-04	8.5000E+06	2.0741E-04	10002	3	2
9.0000E+06	3.1000E-04	9.5000E+06	5.0000E+06	1.0000E+07	7.6000E-04	10002	3	2
1.0500E+07	8.0002E-04	1.1000E+07	9.0000E+07	1.1500E+07	1.0000E-03	10002	3	2
1.2000E+07	1.1000E-03	1.2500E+07	1.2500E+07	1.3000E+07	1.4000E-03	10002	3	2
1.3500E+07	1.5197E-03	1.4000E+07	1.4000E+07	1.4500E+07	1.5500E-03	10002	3	2
1.5000E+07	1.5000E-03	1.5500E+07	1.5500E+07	1.6000E+07	1.6000E-03	10002	3	2
1.6500E+07	1.4172E-03	1.7000E+07	1.7000E+07	1.7500E+07	1.8000E-03	10002	3	2
1.8000E+07	9.7000E-04	1.8500E+07	1.8500E+07	1.9000E+07	2.0000E-04	10002	3	2
1.9500E+07	6.7714E-04	2.0000E+07	2.0000E+07	2.0500E+07	2.1000E-04	10002	3	2
3.9002E+04	9.1120E+04	0.	0.	0.	0.	10002	3	2
0.	-1.1290E+06	0.	0.	0.	0.	10002	3	2

34	2	0.	4.3200E+06	9.0200E-07	0.	4.5200E+06	0	03902	3103	3
1.1410E+06	4.0000E-06	0.	5.5200E+06	3.0740E-05	0.	6.0000E+06	0	03902	3103	4
5.0000E+06	1.1417E-04	0.	7.0000E+06	1.4200E-04	0.	7.5000E+06	0	03902	3103	5
6.5000E+06	3.8000E-04	0.	9.5000E+06	5.6347E-04	0.	9.7200E+06	0	03902	3103	6
8.0000E+06	1.1147E-03	0.	1.0000E+07	1.5200E-03	0.	1.0500E+07	0	03902	3103	7
9.5000E+06	2.5000E-03	0.	1.1500E+07	3.1762E-03	0.	1.2200E+07	0	03902	3103	8
1.1000E+07	4.0530E-03	0.	1.3200E+07	6.0200E-03	0.	1.3500E+07	0	03902	3103	9
1.2500E+07	8.4000E-03	0.	1.4500E+07	9.3145E-03	0.	1.5200E+07	0	03902	3103	10
1.4000E+07	1.0541E-02	0.	1.6000E+07	1.1200E-02	0.	1.6500E+07	0	03902	3103	11
1.5500E+07	1.1700E-02	0.	1.7500E+07	1.1846E-02	0.	1.8200E+07	0	03902	3103	12
1.7000E+07	1.1912E-02	0.	1.9000E+07	1.1900E-02	0.	1.9500E+07	0.	03902	3103	13
1.8500E+07	1.1800E-02	0.	2.0000E+07	2.	0.	2.	0.	03902	3103	14
2.0000E+07	9.1120E+04	0.	3.9202E+04	0.	0.	3.9202	0.	03902	3103	15
0.	2.5220E+06	0.	0.	0.	0.	0.	0.	03902	3107	16
37	2	0.	2.5300E-02	0.	0.	5.2200E+02	0.	373002	3107	17
1.0000E-05	0.	0.	4.2000E+06	4.0200E-07	0.	4.5200E+06	0.	43002	3107	18
1.0000E+03	0.	0.	5.5200E+06	7.0641E-06	0.	6.0200E+06	0.	43002	3107	19
5.0000E+06	3.0000E-06	0.	7.0000E+06	8.5200E-05	0.	7.5000E+06	0.	43002	3107	20
6.5000E+06	4.0506E-05	0.	8.5000E+06	3.4606E-04	0.	9.0000E+06	0.	43002	3107	21
8.0000E+06	2.3200E-04	0.	1.0000E+07	9.0200E-04	0.	1.0500E+07	0.	43002	3107	22
9.5000E+06	6.8571E-04	0.	1.1500E+07	1.7200E-03	0.	1.2200E+07	0.	43002	3107	23
1.1000E+07	1.4000E-03	0.	1.3000E+07	2.6200E-03	0.	1.3500E+07	0.	43002	3107	24
1.2500E+07	2.3200E-03	0.	1.4500E+07	3.4500E-03	0.	1.5200E+07	0.	43002	3107	25
1.4000E+07	3.2000E-03	0.	1.6000E+07	4.2000E-03	0.	1.6500E+07	0.	43002	3107	26
1.5500E+07	3.9500E-03	0.	1.7500E+07	4.9250E-03	0.	1.8200E+07	0.	43002	3107	27
1.7000E+07	4.7000E-03	0.	1.9000E+07	5.4200E-03	0.	1.9500E+07	0.	43002	3107	28
1.8500E+07	5.2500E-03	0.	2.0000E+07	2.	0.	2.	0.	43002	3107	29
2.0000E+07	5.7200E-03	0.	0.	0.	0.	0.	0.	43002	3107	30
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0.	0.	0.	0.	0.	0.	0.	0.	43002	3107	100

4.2088 +24 8.7155 +01	2	2	2	14088	1451	1
0.	0	0	0	04088	1451	2
0.	0	0	53	124088	1451	3
40-22- 88 LASL	EVAL-DEC78	F.D. ARTHUR		4088	1451	4
LA-7301,7482	DIST-DEC78	RFV		4088	1451	5
	GENERAL DESCRIPTION			4088	1451	6

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THE FOLLOWING CROSS SECTIONS RESULT FROM A NEW EVALUATION OF	4088	1451	8
ZR 89 - 90 ISOTOPES MADE USING GNASH AND COMNOC	4088	1451	9
STATISTICAL NUCLEAR MODEL CODES. THIS EVALUATION USES NEW MODEL	4088	1451	10
PARAMETERS AND SHOULD REPRESENT AN IMPROVEMENT OVER THE EARLIER	4088	1451	11
EVALUATION (6/17/77).	4088	1451	12
PRELIMINARY REPORTS OF THIS WORK APPEAR IN LA-7301-PR(1978) P.2	4088	1451	13
AND LA-7482-PR (1978) P.6, AND A DETAILED DESCRIPTION OF THE	4088	1451	14
CALCULATIONS WILL APPEAR IN AN UPCOMING LOS ALAMOS REPORT. A	4088	1451	15
BRIEF DESCRIPTION, HOWEVER, WILL BE GIVEN BELOW.	4088	1451	16
PRINCIPAL IMPROVEMENTS INCORPORATED IN THE PRESENT CALCULATIONS	4088	1451	17
RESULT FROM BETTER PROTON AND NEUTRON OPTICAL PARAMETERS AND	4088	1451	18
THE DETERMINATION AND USE OF GAMMA-RAY STRENGTH FUNCTIONS IN THIS	4088	1451	19
MASS REGION. NEW PROTON OPTICAL PARAMETERS WERE DETERMINED	4088	1451	20
FROM LOW ENERGY SR-87, Y-89 (P,N) DATA (REF.1) AND ARE SOMEWHAT	4088	1451	21
DIFFERENT FROM STANDARD PARAMETER SETS. NEUTRON PARAMETERS WERE	4088	1451	22
BASED ON A MODIFICATION OF THE LAGRANGE PARAMETERS (REF.2) WHICH	4088	1451	23
ARE APPLICABLE FROM 1 KEV TO 20 MEV.	4088	1451	24
TO DESCRIBE THE NEUTRON CAPTURE PROCESS AND GAMMA-RAY COMPETITION	4088	1451	25
A SYSTEMATIC STUDY WAS MADE OF GAMMA-RAY STRENGTH FUNCTIONS FOR	4088	1451	26
A=85-100 AS SUGGESTED IN REF.3. THESE GAMMA-RAY STRENGTH	4088	1451	27
FUNCTIONS CAN BE DETERMINED FROM CAPTURE DATA ON STABLE NUCLEI	4088	1451	28
AND THEN BE USED TO GIVE REALISTIC CAPTURE CROSS SECTIONS ON	4088	1451	29
UNSTABLE NUCLEI, AS WELL AS TO PROVIDE AN ACCURATE DESCRIPTION	4088	1451	30
OF GAMMA EMISSION WHERE IT IS AN IMPORTANT COMPETING REACTION.	4088	1451	31
FINALLY A NEW PREEQUILIBRIUM MODEL BASED ON THE KALBACH RESULTS	4088	1451	32
(REF.4) WAS USED TO DESCRIBE NONSTATISTICAL EFFECTS IN THE RANGE	4088	1451	33
10-20 MEV. (OTHER PARAMETERS RELATING TO LEVEL DENSITIES AND THE	4088	1451	34
FORM OF THE GAMMA-RAY EMISSION MODEL WERE SIMILAR TO THOSE USED	4088	1451	35
IN THE 6/17/77 EVALUATION) THE NET RESULTS OF THESE IMPROVEMENTS	4088	1451	36
WERE A CONSISTENT PARAMETER SETS WHICH REPRODUCED NEUTRON AND	4088	1451	37
CHARGED PARTICLE DATA FOR Y AND ZR ISOTOPES.	4088	1451	38
A FEW MISCELLANEOUS REMARKS ABOUT THE PRESENT EVALUATION.	4088	1451	39

ALL CROSS SECTIONS LEADING TO UNSTABLE RESIDUAL NUCLEI OR META-
STABLE STATES WERE CALCULATED FOR ALL REACTIONS. (METASTABLE
STATES WERE NOT GENERALLY CALCULATED FOR (N,GAMMA) AND (N,ALPHA)
REACTIONS). THE CONVENTION USED IS IF THE FINAL STATE FLAG (LFS)
IS EQUAL TO ZERO THEN THE CROSS SECTION GIVEN REPRESENTS THE
TOTAL CROSS SECTION FOR THAT REACTION. CROSS SECTIONS LEADING TO
AN ISOMERIC STATE ARE DENOTED BY LFS EQUAL TO THE NUMBER OF THE
STATE. FINALLY THE (N,ALPHA) AND (N,ALPHA,N) CROSS SECTIONS ARE
INCLUDED TOGETHER.

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4.00000 +04 8.7155 +01	0	451	53	4000 1451	40
4.00000 +04 0.	0	4	16	4000 1451	41
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0. 1.	0	16	9	4000 1451	43
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22	2	0	0	0	224000	3	28	2
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1.1000E+07	1.3200E-02	1.1500E+07	4.0683E-02	1.2000E+07	8.7000E-024000	3	28	4
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1.5500E+07	3.4102E-01	1.6000E+07	3.6800E-01	1.6500E+07	3.9416E-014000	3	28	7
1.7000E+07	4.1900E-01	1.7500E+07	4.4209E-01	1.8000E+07	4.6500E-014000	3	28	8
1.8500E+07	4.8854E-01	1.9000E+07	5.1200E-01	1.9500E+07	5.3383E-014000	3	28	9
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4.0000E+04	8.7155E+01	0	1	0	0	3	0	11
0.	-8.2980E+06	0	0	1	0	3	28	1
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1.2500E+07	8.2876E-02	1.3000E+07	1.1200E-01	1.3500E+07	1.3774E-014000	3	28	5
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1.5500E+07	2.1611E-01	1.6000E+07	2.3700E-01	1.6500E+07	2.5004E-014000	3	28	7
1.7000E+07	2.8100E-01	1.7500E+07	3.0193E-01	1.8000E+07	3.2300E-014000	3	28	8
1.8500E+07	3.4083E-01	1.9000E+07	3.6700E-01	1.9500E+07	3.8940E-014000	3	28	9
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1A	5	56	2	0	0	3	0	2
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1.5000E+01	9.2000E-01	7.6000E+01	9.2000E-01	1.5000E+02	9.2000E+004000	3	102	2
2.0000E+02	6.0000E+00	2.5000E+02	3.0000E+00	5.0000E+02	1.7250E+004000	3	102	3
1.0000E+03	1.0000E+00	1.0000E+04	2.0000E-01	2.5000E+04	1.7300E-014000	3	102	4
5.0000E+04	1.1600E-01	1.0000E+05	8.1000E-02	2.5000E+05	6.2800E-024000	3	102	5
5.0000E+05	6.3700E-02	7.5000E+05	7.1100E-02	1.0000E+06	8.0000E-024000	3	102	6
1.5000E+06	6.6900E-02	2.0000E+06	5.2900E-02	2.5000E+06	4.9900E-024000	3	102	7
3.0000E+06	4.6900E-02	3.5000E+06	4.1346E-02	4.0000E+06	3.4000E-024000	3	102	8

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6.0000E+06	1.3000E-02	6.5000E+06	8.3216E-03	7.0000E+06	4.0000E-03	4000	3102	13
7.5000E+06	1.8000E-03	8.0000E+06	1.5000E-03	8.5000E+06	1.6637E-03	4000	3102	14
9.0000E+06	1.8000E-03	9.5000E+06	1.8025E-03	1.0000E+07	1.0000E-03	4000	3102	15
1.0500E+07	2.0000E-03	1.1000E+07	2.1000E-03	1.1500E+07	2.1500E-03	4000	3102	16
1.2000E+07	2.2000E-03	1.2500E+07	2.2500E-03	1.3000E+07	2.3000E-03	4000	3102	17
1.3500E+07	2.3500E-03	1.4000E+07	2.4000E-03	1.4500E+07	2.4500E-03	4000	3102	18
1.5000E+07	2.5000E-03	1.5500E+07	2.5900E-03	1.6000E+07	2.6000E-03	4000	3102	19
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2.0000E+02	3.0000E-03	2.5000E+02	2.0000E-03	5.0000E+02	1.1300E-03	0	3103	4
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6.0000E+06	1.4200E-01	6.5000E+06	1.6137E-01	7.0000E+06	1.8100E-01	0	3103	11
7.5000E+06	1.9902E-01	8.0000E+06	2.1800E-01	8.5000E+06	2.3317E-01	0	3103	12
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1.0500E+07	2.6501E-01	1.1000E+07	2.7000E-01	1.1500E+07	2.7186E-01	0	3103	14
1.2000E+07	2.6900E-01	1.2500E+07	2.6128E-01	1.3000E+07	2.4800E-01	0	3103	15
1.3500E+07	2.3118E-01	1.4000E+07	2.1200E-01	1.4500E+07	1.9049E-01	0	3103	16
1.5000E+07	1.6900E-01	1.5500E+07	1.4800E-01	1.6000E+07	1.3000E-01	0	3103	17
1.6500E+07	1.1409E-01	1.7000E+07	1.0200E-01	1.7500E+07	9.2349E-02	0	3103	18
1.8000E+07	8.4000E-02	1.8500E+07	7.6601E-02	1.9000E+07	6.9800E-02	0	3103	19
1.9500E+07	6.3506E-02	2.0000E+07	6.0000E-02	0.	0.	4000	3103	20
4.0000E+04	8.7155E+01	0	0	0	0	4000	3103	21
0.	1.0690E+06	0	0	0	0	5600	3103	22
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1.5000E+01	8.0000E-05	7.6000E+01	8.0000E-05	1.5000E+02	8.0000E-05	0	3103	1
2.0000E+02	3.0000E-04	2.5000E+02	2.7000E-04	5.0000E+02	1.5000E-02	0	3103	2
1.0000E+03	6.6000E-04	1.0000E+04	1.7000E-04	2.5000E+04	1.1000E-04	0	3103	3
5.0000E+04	6.7000E-05	1.0000E+05	4.7000E-05	2.5000E+05	4.5000E-05	0	3103	4
5.0000E+05	2.1000E-04	7.5000E+05	9.1000E-04	1.0000E+06	2.5000E-04	0	3103	5
1.5000E+06	7.3000E-03	2.0000E+06	1.4000E-02	2.5000E+06	2.9600E-02	0	3103	6
3.0000E+06	4.0800E-02	3.5000E+06	6.2747E-02	4.0000E+06	8.2300E-02	0	3103	7
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6.0000E+06	1.4200E-01	6.5000E+06	1.6137E-01	7.0000E+06	1.8100E-01	0	3103	9
7.5000E+06	1.9902E-01	8.0000E+06	2.1800E-01	8.5000E+06	2.3317E-01	0	3103	10
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1.0500E+07	2.6501E-01	1.1000E+07	2.7000E-01	1.1500E+07	2.7186E-01	0	3103	12
1.2000E+07	2.6900E-01	1.2500E+07	2.6128E-01	1.3000E+07	2.4800E-01	0	3103	13
1.3500E+07	2.3118E-01	1.4000E+07	2.1200E-01	1.4500E+07	1.9049E-01	0	3103	14
1.5000E+07	1.6900E-01	1.5500E+07	1.4800E-01	1.6000E+07	1.3000E-01	0	3103	15
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1.9500E+07	6.3506E-02	2.0000E+07	6.0000E-02	0.	0.	4000	3103	18
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2.0000E+02	3.0000E-04	2.5000E+02	2.7000E-04	5.0000E+02	1.5000E-02	0	3103	23

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1.5000E+06	2.4000E-03	2.0000E+06	4.5000E-03	2.5000E+06	1.1000E-024000	3103	10
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1.9500E+07	1.0390E-02	2.0000E+07	9.8000E-03	0.	0.	3103	22
4.0000E+04	8.7155E+01	0	3	0	4000	3	0
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			0	0	560000	3103	2
			0	0	04000	3103	3
1.0000E+05	5.0000E-04	2.5300E+02	1.0000E-05	1.0000E+01	6.0000E-074000	3103	4
1.5000E+01	5.0000E-07	7.6000E+01	5.0000E-07	1.5000E+02	5.0000E-064000	3103	5
2.0000E+02	3.0000E-06	2.5000E+02	2.0000E-06	5.0000E+02	9.0000E-074000	3103	6
1.0000E+03	5.0000E-07	1.0000E+04	1.0000E-07	2.5000E+04	9.0000E-084000	3103	7
5.0000E+04	5.0000E-08	1.0000E+05	4.0000E-08	2.5000E+05	3.6000E-084000	3103	8
5.0000E+05	1.7000E-07	7.5000E+05	7.0000E-07	1.0000E+06	2.0000E-064000	3103	9
1.5000E+06	2.0000E-05	2.0000E+06	1.7000E-04	2.5000E+06	7.0000E-044000	3103	10
3.0000E+06	1.1000E-03	3.5000E+06	2.3587E-03	4.0000E+06	4.1000E-034000	3103	11
4.5000E+06	5.8434E-03	5.0000E+06	7.7000E-03	5.5000E+06	9.7060E-034000	3103	12
6.0000E+06	1.1800E-02	6.5000E+06	1.3971E-02	7.0000E+06	1.6300E-024000	3103	13
7.5000E+06	1.8041E-02	8.0000E+06	2.1500E-02	8.5000E+06	2.4261E-024000	3103	14
9.0000E+06	2.7000E-02	9.5000E+06	2.9550E-02	1.0000E+07	3.2000E-024000	3103	15
1.0500E+07	3.4361E-02	1.1000E+07	3.6600E-02	1.1500E+07	3.8460E-024000	3103	16
1.2000E+07	3.9900E-02	1.2500E+07	4.0913E-02	1.3000E+07	4.1000E-024000	3103	17
1.3500E+07	4.0129E-02	1.4000E+07	4.8500E-02	1.4500E+07	3.6478E-024000	3103	18
1.5000E+07	3.4400E-02	1.5500E+07	3.2200E-02	1.6000E+07	3.0100E-024000	3103	19
1.6500E+07	2.8152E-02	1.7000E+07	2.6500E-02	1.7500E+07	2.5096E-024000	3103	20
1.8000E+07	2.3700E-02	1.8500E+07	2.2204E-02	1.9000E+07	2.0700E-024000	3103	21
1.9500E+07	1.9273E-02	2.0000E+07	1.8000E-02	0.	0.	3103	22
				0.	4000	3	0
					4000	3	0

4.0088E+04	8.7155E+01	0	0	0	04088	3107	1	
0.	3.1312E+06	0	0	1	034088	3107	2	
43	2	0	0	0	04088	3107	3	
1.0000E+05	0.	2.5300E+02	0.	5.0000E+02	0.	4088	3107	4
1.0000E+03	0.	1.0000E+06	7.0000E-10	1.5000E+06	8.0000E-09	4088	3107	5
2.0000E+06	8.0000E-08	2.5000E+06	7.0000E-07	3.0000E+06	3.0000E-06	4088	3107	6
3.5000E+06	1.5585E+05	4.0000E+06	4.0000E-05	4.5000E+06	1.1249E-04	4088	3107	7
5.0000E+06	2.6000E-04	5.5000E+06	5.0291E-04	6.0000E+06	8.3000E-04	4088	3107	8
6.5000E+06	1.2093E-03	7.0000E+06	1.7000E-03	7.5000E+06	2.3507E-03	4088	3107	9
8.0000E+06	3.1000E-03	8.5000E+06	3.8912E-03	9.0000E+06	4.8000E-03	4088	3107	10
9.5000E+06	5.9341E-03	1.0000E+07	7.2000E-03	1.0500E+07	8.4000E-03	4088	3107	11
1.1000E+07	1.0000E-02	1.1500E+07	1.2070E-02	1.2000E+07	1.4300E-02	4088	3107	12
1.2500E+07	1.6513E-02	1.3000E+07	1.8800E-02	1.3500E+07	2.1310E-02	4088	3107	13
1.4000E+07	2.4000E-02	1.4500E+07	2.6762E-02	1.5000E+07	2.9600E-02	4088	3107	14
1.5500E+07	3.2520E-02	1.6000E+07	3.5600E-02	1.6500E+07	3.8856E-02	4088	3107	15
1.7000E+07	4.2200E-02	1.7500E+07	4.5590E-02	1.8000E+07	4.9000E-02	4088	3107	16
1.8500E+07	5.2458E-02	1.9000E+07	5.6000E-02	1.9500E+07	5.9833E-02	4088	3107	17
2.0000E+07	6.4000E-02	0.	0.	0.	0.	4088	3107	18
						4088	3	0
						4088	0	0
						0	0	0
4.0089 +04	8.8145 +01	0	0	0		14089	1451	1
0.	1.	0	0	0		04089	1451	2
0.	0.	0	0	53		124089	1451	3
40-ZR- 89 LASL	FVAL=DEC78	E.D. ARTHJR				4089	1451	4
LA-7301,7482	DIST=DEC78	RFVN				4089	1451	5
	GENERAL DESCRIPTION					4089	1451	6

THE FOLLOWING CROSS SECTIONS RESULT FROM A NEW EVALUATION OF
 ZR 89 - 90 ISOTOPES MADE USING GNASH AND COMNHC
 STATISTICAL NUCLEAR MODEL CODES. THIS EVALUATION USES NEW MODEL
 PARAMETERS AND SHOULD REPRESENT AN IMPROVEMENT OVER THE EARLIER
 EVALUATION (6/17/77).
 PRELIMINARY REPORTS OF THIS WORK APPEAR IN LA-7301-PR(1978) P.2
 AND LA-7482-PR (1978) P.6, AND A DETAILED DESCRIPTION OF THE
 CALCULATIONS WILL APPEAR IN AN UPCOMING LOS ALAMOS REPORT. A
 BRIEF DESCRIPTION, HOWEVER, WILL BE GIVEN BELOW.
 PRINCIPAL IMPROVEMENTS INCORPORATED IN THE PRESENT CALCULATIONS
 RESULT FROM BETTER PROTON AND NEUTRON OPTICAL PARAMETERS AND

4089	1451	7
4089	1451	8
4089	1451	9
4089	1451	10
4089	1451	11
4089	1451	12
4089	1451	13
4089	1451	14
4089	1451	15
4089	1451	16
4089	1451	17
4089	1451	18

THE DETERMINATION AND USE OF GAMMA-RAY STRENGTH FUNCTIONS IN THIS MASS REGION. NEW PROTON OPTICAL PARAMETERS WERE DETERMINED FROM LOW ENERGY SR-87, Y-89 (P,N) DATA (REF.1) AND ARE SOMEWHAT DIFFERENT FROM STANDARD PARAMETER SETS. NEUTRON PARAMETERS WERE BASED ON A MODIFICATION OF THE LAGRANGE PARAMETERS (REF.2) WHICH ARE APPLICABLE FROM 1 KEV TO 20 MEV. TO DESCRIBE THE NEUTRON CAPTURE PROCESS AND GAMMA-RAY COMPETITION A SYSTEMATIC STUDY WAS MADE OF GAMMA-RAY STRENGTH FUNCTIONS FOR $A=85-100$ AS SUGGESTED IN REF.3. THESE GAMMA-RAY STRENGTH FUNCTIONS CAN BE DETERMINED FROM CAPTURE DATA ON STABLE NUCLEI AND THEN BE USED TO GIVE REALISTIC CAPTURE CROSS SECTIONS ON UNSTABLE NUCLEI, AS WELL AS TO PROVIDE AN ACCURATE DESCRIPTION OF GAMMA EMISSION WHERE IT IS AN IMPORTANT COMPETING REACTION. FINALLY A NEW PREEQUILIBRIUM MODEL BASED ON THE KALBACH RESULTS (REF.4) WAS USED TO DESCRIBE NONSTATISTICAL EFFECTS IN THE RANGE 10-20 MEV. (OTHER PARAMETERS RELATING TO LEVEL DENSITIES AND THE FORM OF THE GAMMA-RAY EMISSION MODEL WERE SIMILAR TO THOSE USED IN THE 6/17/77 EVALUATION) THE NET RESULTS OF THESE IMPROVEMENTS WERE A CONSISTENT PARAMETER SETS WHICH REPRODUCED NEUTRON AND CHARGED PARTICLE DATA FOR Y AND ZR ISOTOPES. A FEW MISCELLANEOUS REMARKS ABOUT THE PRESENT EVALUATION. ALL CROSS SECTIONS LEADING TO UNSTABLE RESIDUAL NUCLEI OR META- STABLE STATES WERE CALCULATED FOR ALL REACTIONS. (METASTABLE STATES WERE NOT GENERALLY CALCULATED FOR (N,GAMMA) AND (N,ALPHA) REACTIONS). THE CONVENTION USED IS IF THE FINAL STATE FLAG (LFS) IS EQUAL TO ZERO THEN THE CROSS SECTION GIVEN REPRESENTS THE TOTAL CROSS SECTION FOR THAT REACTION. CROSS SECTIONS LEADING TO AN ISOMERIC STATE ARE DENOTED BY LFS EQUAL TO THE NUMBER OF THE STATE. FINALLY THE (N,ALPHA) AND (N,ALPHA,N) CROSS SECTIONS ARE INCLUDED TOGETHER.

REFERENCES

1. C.H. JOHNSON ET AL. NUCL. PHYS. A107, 21 (1968), AND PHYS. REV. LETT. 39, 1604 (1977)
2. CH. LAGRANGE, NATIONAL SOVIET CONFERENCE ON NEUTRON PHYSICS (1975)
3. D.G. GARDNER AND M. A. GARDNER, RAPS22, 2993 (1977)
4. C. KALBACH, Z. PHYS. A283, 401 (1977).

1.1000E+07	8.6300E-02	1.1500E+07	1.3704E-01	1.2000E+07	2.1900E-014009	3	16
1.2500E+07	3.3500E-01	1.3000E+07	4.5700E-01	1.3500E+07	5.8660E-014009	3	16
1.4000E+07	7.1400E-01	1.4500E+07	8.1300E-01	1.5000E+07	8.8700E-014009	3	16
1.5500E+07	9.4200E-01	1.6000E+07	9.8700E-01	1.6500E+07	1.0220E-014009	3	16
1.7000E+07	1.0550E+03	1.7500E+07	1.0847E+00	1.8000E+07	1.1100E-014009	3	16
1.8500E+07	1.1286E+00	1.9000E+07	1.1430E+00	1.9500E+07	1.1555E-014009	3	16
2.0000E+07	1.1660E+00	0.	0.	0.	0.	3	16
4.0000E+04	8.8145E+01	0	0	0	0	0	0
0.	-6.1810E+06	0	0	0	0	0	0
6.2510E+06	0.	1.0000E+07	4.0000E-11	1.0500E+07	3.4200E-014009	3	22
1.1000E+07	1.0000E-08	1.1500E+07	1.5300E-07	1.2000E+07	4.0000E-074009	3	22
1.2500E+07	9.8784E-07	1.3000E+07	2.0000E-06	1.3500E+07	6.0062E-064009	3	22
1.4000E+07	1.5000E-05	1.4500E+07	3.4000E-05	1.5000E+07	6.3000E-054009	3	22
1.5500E+07	1.0655E-04	1.6000E+07	1.7000E-04	1.6500E+07	2.4816E-044009	3	22
1.7000E+07	3.3000E-04	1.7500E+07	4.1521E-04	1.8000E+07	5.0000E-044009	3	22
1.8500E+07	5.9911E-04	1.9000E+07	7.1000E-04	1.9500E+07	8.2652E-044009	3	22
2.0000E+07	9.5000E-04	0.	0.	0.	0.	3	22
4.0000E+04	8.8145E+01	0	0	0	0	0	0
0.	-7.8520E+06	0	0	0	0	0	0
7.9410E+06	0.	1.0000E+07	2.6000E-04	1.0500E+07	2.0000E-034009	3	28
1.1000E+07	9.8800E-03	1.1500E+07	3.6873E-02	1.2000E+07	6.5000E-024009	3	28
1.2500E+07	9.2115E-02	1.3000E+07	1.1800E-01	1.3500E+07	1.3473E-014009	3	28
1.4000E+07	1.4400E-01	1.4500E+07	1.5100E-01	1.5000E+07	1.6800E-014009	3	28
1.5500E+07	1.7912E-01	1.6000E+07	1.8700E-01	1.6500E+07	1.9205E-014009	3	28
1.7000E+07	1.9200E-01	1.7500E+07	1.8650E-01	1.8000E+07	1.8100E-014009	3	28
1.8500E+07	1.7688E-01	1.9000E+07	1.7300E-01	1.9500E+07	1.6941E-014009	3	28
2.0000E+07	1.6600E-01	0.	0.	0.	0.	3	28
4.0000E+04	8.8145E+01	0	0	0	0	0	0
0.	-8.2450E+06	0	0	0	0	0	0
8.3390E+06	0.	1.0000E+07	1.0000E-06	1.0500E+07	2.6207E-054009	3	28
1.1000E+07	7.6000E-05	1.1500E+07	2.4864E-04	1.2000E+07	5.8000E-044009	3	28
1.2500E+07	1.0648E-03	1.3000E+07	1.9400E-03	1.3500E+07	3.1332E-034009	3	28
1.4000E+07	4.4000E-03	1.4500E+07	5.7000E-03	1.5000E+07	7.0000E-034009	3	28
1.5500E+07	8.4609E-03	1.6000E+07	1.0000E-02	1.6500E+07	1.1401E-024009	3	28
1.7000E+07	1.2500E-02	1.7500E+07	1.2866E-02	1.8000E+07	1.3100E-024009	3	28
1.8500E+07	1.3767E-02	1.9000E+07	1.4400E-02	1.9500E+07	1.4893E-024009	3	28

1.5000E+06	1.0500E-01	2.0000E+06	1.0600E-01	2.5000E+06	8.5000E-02	4089	3102	10
3.0000E+06	6.4300E-02	3.5000E+06	4.0618E-02	4.0000E+06	3.7200E-02	4089	3102	11
4.5000E+06	2.5885E-02	5.0000E+06	1.7000E-02	5.5000E+06	1.1442E-02	4089	3102	12
6.0000E+06	7.8000E-03	6.5000E+06	4.9895E-03	7.0000E+06	3.0000E-03	4089	3102	13
7.5000E+06	1.8981E-03	8.0000E+06	1.5000E-03	8.5000E+06	1.7706E-03	4089	3102	14
9.0000E+06	2.0000E-03	9.5000E+06	2.0424E-03	1.0000E+07	2.1000E-03	4089	3102	15
1.0500E+07	2.2100E-03	1.1000E+07	2.3000E-03	1.1500E+07	2.3500E-03	4089	3102	16
1.2000E+07	2.4000E-03	1.2500E+07	2.4000E-03	1.3000E+07	2.5000E-03	4089	3102	17
1.3500E+07	2.4750E-03	1.4000E+07	2.4000E-03	1.4500E+07	2.3500E-03	4089	3102	18
1.5000E+07	2.3000E-03	1.5500E+07	2.2648E-03	1.6000E+07	2.2000E-03	4089	3102	19
1.6500E+07	2.0227E-03	1.7000E+07	1.8000E-03	1.7500E+07	1.6000E-03	4089	3102	20
1.8000E+07	1.4000E-03	1.8500E+07	1.2281E-03	1.9000E+07	1.1000E-03	4089	3102	21
1.9500E+07	9.5937E-04	2.0000E+07	8.0000E-04	0.	0.	4089	3102	22
4.0089E+04	8.8145E+01	0	0	0	0	4089	3103	0
0.	3.6160E+06	0	0	1	564089	3103	3103	1
56	2	0	0	0	0	0	3103	2
1.0000E-05	1.5500E+03	2.5300E-02	3.2700E+01	1.1700E+00	1.6000E+00	0	3103	3
4.2000E+00	1.6000E+00	1.1000E+01	1.5700E+01	2.0000E+01	5.6000E+00	0	3103	4
1.0000E+02	1.9400E+00	2.5000E+02	1.1800E+00	5.0000E+02	6.6400E-01	0	3103	5
1.0000E+03	4.0700E-01	1.0000E+04	7.7000E-02	2.5000E+04	4.2000E-02	0	3103	6
5.0000E+04	2.6800E-02	1.0000E+05	1.8300E-02	2.5000E+05	1.4400E-02	0	3103	7
5.0000E+05	1.7200E-02	7.5000E+05	2.2400E-02	1.0000E+06	3.0000E-02	0	3103	8
1.5000E+06	4.9500E-02	2.0000E+06	6.0200E-02	2.5000E+06	6.3200E-02	0	3103	9
3.0000E+06	6.4400E-02	3.5000E+06	6.7400E-02	4.0000E+06	7.0000E-02	0	3103	10
4.5000E+06	6.6722E-02	5.0000E+06	6.2500E-02	5.5000E+06	6.1633E-02	0	3103	11
6.0000E+06	6.2000E-02	6.5000E+06	6.3572E-02	7.0000E+06	6.6000E-02	0	3103	12
7.5000E+06	6.9510E-02	8.0000E+06	7.3000E-02	8.5000E+06	7.5859E-02	0	3103	13
9.0000E+06	7.8000E-02	9.5000E+06	7.9232E-02	1.0000E+07	8.0000E-02	0	3103	14
1.0500E+07	8.0518E-02	1.1000E+07	8.0800E-02	1.1500E+07	8.0606E-02	0	3103	15
1.2000E+07	7.9700E-02	1.2500E+07	7.7864E-02	1.3000E+07	7.5000E-02	0	3103	16
1.3500E+07	7.1507E-02	1.4000E+07	6.7400E-02	1.4500E+07	6.2700E-02	0	3103	17
1.5000E+07	5.7700E-02	1.5500E+07	5.2948E-02	1.6000E+07	4.8500E-02	0	3103	18
1.6500E+07	4.4639E-02	1.7000E+07	4.1500E-02	1.7500E+07	3.8003E-02	0	3103	19
1.8000E+07	3.6700E-02	1.8500E+07	3.4735E-02	1.9000E+07	3.3500E-02	0	3103	20
1.9500E+07	3.2389E-02	2.0000E+07	3.1400E-02	0.	0.	4089	3103	21
4.0089E+04	8.8145E+01	0	0	0	0	4089	3103	22
0.	2.7080E+06	0	0	1	0	4089	3103	0
56	2	0	0	0	0	0	3103	1
1.0000E-05	1.1500E+03	2.5300E-02	2.4200E+01	1.1000E+00	1.2000E+00	0	3103	2
56	2	0	0	0	0	0	3103	3
1.0000E-05	1.1500E+03	2.5300E-02	2.4200E+01	1.1000E+00	1.2000E+00	0	3103	4

4.2000E+00	1.2000E+00	1.1000E+01	T.1600F+01	2.0000E+01	4.1000E+00	3103	5
1.0000E+02	1.4000E+00	2.5000E+02	0.7000E-01	5.0000E+02	4.9000E-01	3103	6
1.0000E+03	3.0100E-01	1.0000E+04	5.7000E-02	2.5000E+04	3.1000E-02	3103	7
5.0000E+04	2.0000E-02	1.0000E+05	1.3600E-02	2.5000E+05	1.0700E-02	3103	8
5.0000E+05	1.2800E-02	7.5000E+05	1.6600E-02	1.0000E+06	2.2200E-02	3103	9
1.5000E+06	3.4000E-02	2.0000E+06	4.6000E-02	2.5000E+06	4.7000E-02	3103	10
3.0000E+06	4.9000E-02	3.5000E+06	5.2743F-02	4.0000E+06	5.6000E-02	3103	11
4.5000E+06	5.2524E-02	5.0000E+06	4.8000E-02	5.5000E+06	4.7215E-02	3103	12
6.0000E+06	4.6800E-02	6.5000E+06	4.6591E-02	7.0000E+06	4.7000E-02	3103	13
7.5000E+06	4.8892E-02	8.0000E+06	5.1000E-02	8.5000E+06	5.2479E-02	3103	14
9.0000E+06	5.3700E-02	9.5000E+06	5.4543E-02	1.0000E+07	5.5100E-02	3103	15
1.0500E+07	5.5370E-02	1.1000E+07	5.5400E-02	1.1500E+07	5.5111E-02	3103	16
1.2000E+07	5.4400E-02	1.2500E+07	5.3160E-02	1.3000E+07	5.1000E-02	3103	17
1.3500E+07	4.8130E-02	1.4000E+07	4.5000E-02	1.4500E+07	4.1700E-02	3103	18
1.5000E+07	3.8200E-02	1.5500E+07	3.4852E-02	1.6000E+07	3.1700E-02	3103	19
1.6500E+07	2.8983E-02	1.7000E+07	2.6800E-02	1.7500E+07	2.4999E-02	3103	20
1.8000E+07	2.3500E-02	1.8500E+07	2.2199E-02	1.9000E+07	2.1400E-02	3103	21
1.9500E+07	2.0669E-02	2.0000E+07	2.0000E-02	0.	0.	3103	22
4.0000E+04	6.8145E+01	0	0	0	4000	3	0
0.	5.3050E+06	0	0	1	04000	3107	1
43	2	0	0	0	454000	3107	2
1.0000E-05	0.	2.5300E-02	0.	5.0000E+02	0.	3107	3
1.0000E+03	0.	1.0000E+06	2.0000E-06	1.5000E+06	2.2000E-06	3107	4
2.0000E+06	2.4000E-06	2.5000E+06	2.0000E-05	3.0000E+06	8.6000E-05	3107	5
3.5000E+06	1.4446E-04	4.0000E+06	2.0000E-04	4.5000E+06	3.4598E-04	3107	6
5.0000E+06	8.0000E-04	5.5000E+06	2.0294E-03	6.0000E+06	4.0000E-03	3107	7
6.5000E+06	6.2143F-03	7.0000E+06	8.0000E-03	7.5000E+06	1.0500E-02	3107	8
8.0000E+06	1.2600E-02	8.5000E+06	1.4700E-02	9.0000E+06	1.6800E-02	3107	9
9.5000E+06	1.8975E-02	1.0000E+07	2.1000E-02	1.0500E+07	2.2575F-02	3107	10
1.0000E+07	2.4000E-02	1.1500E+07	2.5500E-02	1.2000E+07	2.7000E-02	3107	11
1.2500E+07	2.8143F-02	1.3000E+07	2.9000E-02	1.3500E+07	2.9737E-02	3107	12
1.4000E+07	3.0500E-02	1.4500E+07	3.2500E-02	1.5000E+07	3.3400E-02	3107	13
1.5500E+07	3.4154E-02	1.6000E+07	3.5000E-02	1.6500E+07	3.6000E-02	3107	14
1.7000E+07	3.7000E-02	1.7500E+07	3.8000E-02	1.8000E+07	3.9000E-02	3107	15
1.8500E+07	4.0000E-02	1.9000E+07	4.1000E-02	1.9500E+07	4.2000E-02	3107	16
2.0000E+07	4.3000E-02	0.	0.	0.	4000	3107	17
					4000	3107	18
					4000	3	0
					4000	0	0
					4000	0	0
					4000	0	0
4.0000 +04	8.9132F+01	0	0	0	14000	1451	1

0.	1.	0	0	0	04090	1451	2
0.	0.	0	0	53	114090	1451	3
40-22- 90 LASL		FVAL-DEC78	E.D. ARTHUR		4090	1451	4
LA-7301,7482		DIST-DEC78	RFV0		4090	1451	5
		GENERAL DESCRIPTION			4090	1451	6
-----					4090	1451	7
THE FOLLOWING CROSS SECTIONS RESULT FROM A NEW EVALUATION OF					4090	1451	8
ZR 89 - 90 ISOTOPES MADE USING GNASH AND COMMUC					4090	1451	9
STATISTICAL NUCLEAR MODEL CODES. THIS EVALUATION USES NEW MODEL					4090	1451	10
PARAMETERS AND SHOULD REPRESENT AN IMPROVEMENT OVER THE EARLIER					4090	1451	11
EVALUATION (6/17/77).					4090	1451	12
PRELIMINARY REPORTS OF THIS WORK APPEAR IN LA-7301-PR(1978) P.2					4090	1451	13
AND LA-7482-PR (1978) P.6, AND A DETAILED DESCRIPTION OF THE					4090	1451	14
CALCULATIONS WILL APPEAR IN AN UPCOMING LOS ALAMOS REPORT. A					4090	1451	15
BRIEF DESCRIPTION, HOWEVER, WILL BE GIVEN BELOW.					4090	1451	16
PRINCIPAL IMPROVEMENTS INCORPORATED IN THE PRESENT CALCULATIONS					4090	1451	17
RESULT FROM BETTER PROTON AND NEUTRON OPTICAL PARAMETERS AND					4090	1451	18
THE DETERMINATION AND USE OF GAMMA-RAY STRENGTH FUNCTIONS IN THIS					4090	1451	19
MASS REGION. NEW PROTON OPTICAL PARAMETERS WERE DETERMINED					4090	1451	20
FROM LOW ENERGY SR-A7, Y-B9 (P,N) DATA (REF.1) AND ARE SOMEWHAT					4090	1451	21
DIFFERENT FROM STANDARD PARAMETER SETS. NEUTRON PARAMETERS WERE					4090	1451	22
BASED ON A MODIFICATION OF THE LAGRANGE PARAMETERS (REF.2) WHICH					4090	1451	23
ARE APPLICABLE FROM 1 KEV TO 20 MEV.					4090	1451	24
TO DESCRIBE THE NEUTRON CAPTURE PROCESS AND GAMMA-RAY COMPETITION					4090	1451	25
A SYSTEMATIC STUDY WAS MADE OF GAMMA-RAY STRENGTH FUNCTIONS FOR					4090	1451	26
A=85-100 AS SUGGESTED IN REF.3. THESE GAMMA-RAY STRENGTH					4090	1451	27
FUNCTIONS CAN BE DETERMINED FROM CAPTURE DATA ON STABLE NUCLEI					4090	1451	28
AND THEN BE USED TO GIVE REALISTIC CAPTURE CROSS SECTIONS ON					4090	1451	29
UNSTABLE NUCLEI, AS WELL AS TO PROVIDE AN ACCURATE DESCRIPTION					4090	1451	30
OF GAMMA EMISSION WHERE IT IS AN IMPORTANT COMPETING REACTION.					4090	1451	31
FINALLY A NEW PREEQUILIBRIUM MODEL BASED ON THE KALBACH RESULTS					4090	1451	32
(REF.4) WAS USED TO DESCRIBE NONSTATISTICAL EFFECTS IN THE RANGE					4090	1451	33
10-20 MEV. (OTHER PARAMETERS RELATING TO LEVEL DENSITIES AND THE					4090	1451	34
FORM OF THE GAMMA-RAY EMISSION MODEL WERE SIMILAR TO THOSE USED					4090	1451	35
IN THE 6/17/77 EVALUATION) THE NET RESULTS OF THESE IMPROVEMENTS					4090	1451	36
WERE A CONSISTENT PARAMETER SETS WHICH REPRODUCED NEUTRON AND					4090	1451	37
CHARGED PARTICLE DATA FOR Y AND ZR ISOTOPES.					4090	1451	38
A FEW MISCELLANEOUS REMARKS ABOUT THE PRESENT EVALUATION.					4090	1451	39
ALL CROSS SECTIONS LEADING TO UNSTABLE RESIDUAL NUCLEI OR META-					4090	1451	40
STABLE STATES WERE CALCULATED FOR ALL REACTIONS. (METASTABLE					4090	1451	41
STATES WERE NOT GENERALLY CALCULATED FOR (N,GAMMA) AND (N,ALPHA)					4090	1451	42

REACTIONS). THE CONVENTION USED IS IF THE FINAL STATE FLAG (LFS) IS EQUAL TO ZERO THEN THE CROSS SECTION GIVEN REPRESENTS THE TOTAL CROSS SECTION FOR THAT REACTION. CROSS SECTIONS LEADING TO AN ISOMERIC STATE ARE DENOTED BY LFS EQUAL TO THE NUMBER OF THE STATE. FINALLY THE (N,ALPHA) AND (N,ALPHA,N) CROSS SECTIONS ARE INCLUDED TOGETHER.

SENFABER

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1	451	53	4000	1451	58
3	4	16	4000	1451	59
3	16	9	4000	1451	60
3	16	9	4000	1451	61
3	22	11	4000	1451	62
3	28	11	4000	1451	63
3	28	11	4000	1451	64
3	102	24	4000	1451	65
3	103	15	4000	1451	66
3	103	15	4000	1451	67
3	103	15	4000	1451	68
3	107	15	4000	1451	69
			4000	1	70
			4000	0	71
0	0	1	4000	2151	72
0	0	1	4000	2151	73
0	0	0	4000	2151	74
0	0	0	4000	2151	75
			4000	2	76
			4000	0	77
0	0	0	4000	3	1
0	0	1	4000	3	2
0	0	0	4000	3	3
0	0	0	4000	3	4
0	0	0	4000	3	5
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0	0	0	4000	3	94
0	0	0	4000	3	95
0	0	0	4000	3	96
0	0	0	4000	3	97
0	0	0	4000	3	98
0	0	0	4000	3	99
0	0	0	4000	3	100

6.2020E+06	1.6810E+00	6.5000E+06	1.6921E+00	7.0000E+06	1.7030E+00	4090	3	7
7.5000E+06	1.7131E+00	8.0000E+06	1.7220E+00	8.5000E+06	1.7257E+00	4090	3	8
9.0000E+06	1.7230E+00	9.5000E+06	1.7170E+00	1.0000E+07	1.7090E+00	4090	3	9
1.0500E+07	1.6986E+00	1.1000E+07	1.6870E+00	1.1500E+07	1.6733E+00	4090	3	10
1.2000E+07	1.6480E+00	1.2500E+07	1.5459E+00	1.3000E+07	1.3670E+00	4090	3	11
1.3500E+07	1.1660E+00	1.4000E+07	9.8600E-01	1.4500E+07	8.3000E-01	4090	3	12
1.5000E+07	6.9800E-01	1.5500E+07	5.9662E-01	1.6000E+07	5.1800E-01	4090	3	13
1.6500E+07	4.5369E-01	1.7000E+07	4.0200E-01	1.7500E+07	3.6073E-01	4090	3	14
1.8000E+07	3.2700E-01	1.8500E+07	3.0008E-01	1.9000E+07	2.7700E-01	4090	3	15
1.9500E+07	2.5750E-01	2.0000E+07	2.4100E-01	0.	0.	4090	3	16
4.0090E+04	8.9132E+01	0.	0.	0.	0.	4090	3	0
0.	-1.1903E+07	0.	0.	0.	0.	4090	3	1
16	2	0.	0.	0.	164090	16	3	2
1.2117E+07	0.	1.3000E+07	2.2100E-01	1.3500E+07	4.0400E-01	4090	3	3
1.4000E+07	5.7000E-01	1.4500E+07	7.1500E-01	1.5000E+07	8.3900E-01	4090	3	4
1.5500E+07	9.3222E-01	1.6000E+07	1.0000E+00	1.6500E+07	1.0637E+00	4090	3	5
1.7000E+07	1.1110E+00	1.7500E+07	1.1467E+00	1.8000E+07	1.1730E+00	4090	3	6
1.8500E+07	1.1911E+00	1.9000E+07	1.2000E+00	1.9500E+07	1.2121E+00	4090	3	7
2.0000E+07	1.2160E+00	0.	0.	0.	0.	4090	3	8
4.0090E+04	8.9132E+01	0.	0.	0.	0.	4090	3	9
0.	-1.2570E+07	0.	0.	0.	0.	4090	3	0
16	2	0.	0.	0.	164090	16	3	1
1.2710E+07	0.	1.3000E+07	8.6000E-03	1.3500E+07	3.3000E-02	4090	3	2
1.4000E+07	7.1000E-02	1.4500E+07	1.1100E-01	1.5000E+07	1.5200E-01	4090	3	3
1.5500E+07	1.9150E-01	1.6000E+07	2.2700E-01	1.6500E+07	2.5050E-01	4090	3	4
1.7000E+07	2.6200E-01	1.7500E+07	2.7000E-01	1.8000E+07	2.7400E-01	4090	3	5
1.8500E+07	2.7420E-01	1.9000E+07	2.7300E-01	1.9500E+07	2.7000E-01	4090	3	6
2.0000E+07	2.6700E-01	0.	0.	0.	0.	4090	3	7
4.0090E+04	8.9132E+01	0.	0.	0.	0.	4090	3	8
0.	-6.6780E+06	0.	0.	0.	0.	4090	3	9
24	2	0.	0.	0.	0.	4090	3	0
6.7530E+06	0.	9.0000E+06	1.0000E-08	9.5000E+06	1.3489E-07	4090	3	1
1.0000E+07	3.0000E-07	1.0500E+07	4.9300E-07	1.1000E+07	7.0000E-07	4090	3	2
1.1500E+07	9.3335E-07	1.2000E+07	1.2000E-06	1.2500E+07	1.5800E-06	4090	3	3
1.3000E+07	2.0000E-06	1.3500E+07	2.2000E-06	1.4000E+07	3.0000E-06	4090	3	4
1.4500E+07	5.0000E-06	1.5000E+07	9.0000E-06	1.5500E+07	1.6794E-05	4090	3	5
1.6000E+07	2.8000E-05	1.6500E+07	4.1065E-05	1.7000E+07	5.7000E-05	4090	3	6

1.7520E+07	7.5492E-05	1.8220E+07	9.4000E-05	1.8500E+07	1.1194E-04	3	22	10
1.9020E+07	1.3200E-04	1.9500E+07	1.4935E-04	2.0000E+07	1.7000E-04	3	22	11
4.2090E+04	8.9132E+01	0.	0.	0.	4090	3	0	0
0.	-8.3660E+06	2	0	0	04090	3	28	1
8.4620E+06	0.	0	0	0	224090	3	28	2
1.1020E+07	2.8200E-03	1.1500E+07	1.2676E-02	1.2700E+07	04090	3	28	3
1.2520E+07	4.5222E-02	1.3200E+07	5.9700E-02	1.3520E+07	3.8917E-04	3	28	4
1.4020E+07	6.8200E-02	1.4500E+07	7.1200E-02	1.5700E+07	2.7500E-04	3	28	5
1.5520E+07	7.4814E-02	1.6000E+07	7.7500E-02	1.6500E+07	6.4500E-04	3	28	6
1.7020E+07	8.3000E-02	1.7500E+07	8.6177E-02	1.8000E+07	7.2200E-04	3	28	7
1.8520E+07	9.4072E-02	1.9000E+07	9.8700E-02	1.9500E+07	8.0225E-04	3	28	8
2.2020E+07	1.0900E-01	0.	0.	0.	8.9900E-04	3	28	9
4.2090E+04	8.9132E+01	0.	0	0	1.0367E-01	3	28	10
0.	-9.2740E+06	2	0	0	0.	3	28	11
9.3820E+06	0.	1.2000E+07	1.0000E-05	1.0500E+07	4090	3	0	0
1.1020E+07	1.0000E-03	1.1500E+07	5.1101E-03	1.2000E+07	4090	3	0	0
1.2520E+07	1.7882E-02	1.3000E+07	2.3000E-02	1.3500E+07	04090	3	28	1
1.4020E+07	2.7000E-02	1.4500E+07	2.8000E-02	1.5000E+07	224090	3	28	2
1.5520E+07	2.9495E-02	1.6000E+07	3.0600E-02	1.6500E+07	04090	3	28	3
1.7020E+07	3.2700E-02	1.7500E+07	3.3935E-02	1.8000E+07	2.6321E-05	3	28	4
1.8520E+07	3.7057E-02	1.9000E+07	3.8900E-02	1.9500E+07	1.1000E-04	3	28	5
2.2020E+07	4.3200E-02	0.	0.	0.	2.5000E-04	3	28	6
4.2090E+04	8.9132E+01	0.	0	0	2.8400E-04	3	28	7
0.	7.2030E+06	0.	0	0	3.1645E-04	3	28	8
1.0020E-05	5.0000E+00	2.5300E-02	1.0000E-01	2.5000E+02	3.1645E-04	3	28	9
3.0020E+03	1.0000E-03	3.0000E+03	7.2000E-02	4.0000E+03	3.5400E-04	3	28	10
5.0020E+03	2.0000E-04	6.0000E+03	1.0800E-01	8.0000E+03	4.0880E-04	3	28	11
1.0020E+04	1.0600E-02	1.5000E+04	3.0000E-02	2.0000E+04	0.	3	0	0
3.0020E+04	1.1000E-02	4.0000E+04	2.0000E-02	5.0000E+04	1.0000E-03	3	0	0
6.0020E+04	1.0000E-02	8.0000E+04	8.0000E-03	1.0000E+05	1.0000E-03	3	0	0
1.5020E+05	6.0000E-03	2.0000E+05	7.0000E-03	2.0000E+05	7.0000E-03	3	0	0
2.5020E+05	6.6400E-03	5.0000E+05	6.3800E-03	7.5000E+05	7.0000E-03	3	0	0
1.0020E+06	7.6000E-03	1.5000E+06	8.0000E-03	2.0000E+06	6.7000E-03	3	0	0
2.5020E+06	8.0000E-03	3.0000E+06	6.2600E-03	3.5000E+06	1.0000E-02	3	0	0
4.2090E+04	8.9132E+01	0.	0	0	5.5569E-03	3	0	0
0.	7.2030E+06	0.	0	0	04090	3	0	0
1.0020E-05	5.0000E+00	2.5300E-02	1.0000E-01	2.5000E+02	04090	3	0	0
3.0020E+03	1.0000E-03	3.0000E+03	7.2000E-02	4.0000E+03	04090	3	0	0
5.0020E+03	2.0000E-04	6.0000E+03	1.0800E-01	8.0000E+03	634090	3	0	0
1.0020E+04	1.0600E-02	1.5000E+04	3.0000E-02	2.0000E+04	24090	3	0	0
3.0020E+04	1.1000E-02	4.0000E+04	2.0000E-02	5.0000E+04	1.0000E-03	3	0	0
6.0020E+04	1.0000E-02	8.0000E+04	8.0000E-03	1.0000E+05	1.0000E-03	3	0	0
1.5020E+05	6.0000E-03	2.0000E+05	7.0000E-03	2.0000E+05	7.0000E-03	3	0	0
2.5020E+05	6.6400E-03	5.0000E+05	6.3800E-03	7.5000E+05	7.0000E-03	3	0	0
1.0020E+06	7.6000E-03	1.5000E+06	8.0000E-03	2.0000E+06	6.7000E-03	3	0	0
2.5020E+06	8.0000E-03	3.0000E+06	6.2600E-03	3.5000E+06	1.0000E-02	3	0	0

4.0000E+06	5.0000E-03	4.5000E+06	4.0500E-03	5.0000E+06	3.1000E-03	4090	3	0	14
5.5000E+06	2.1500E-03	6.0000E+06	1.2000E-03	6.5000E+06	5.5371E-04	4090	3	0	15
7.0000E+06	3.4000E-04	7.5000E+06	2.7042E-04	8.0000E+06	2.5000E-04	4090	3	0	16
8.5000E+06	2.6286E-04	9.0000E+06	2.8000E-04	9.5000E+06	3.0288E-04	4090	3	0	17
1.0000E+07	3.3000E-04	1.0500E+07	3.7020E-04	1.1000E+07	4.0300E-04	4090	3	0	18
1.1500E+07	5.0761E-04	1.2000E+07	6.0000E-04	1.2500E+07	7.0243E-04	4090	3	0	19
1.3000E+07	8.1000E-04	1.3500E+07	9.3000E-04	1.4000E+07	1.1000E-03	4090	3	0	20
1.4500E+07	1.2000E-03	1.5000E+07	1.2000E-03	1.5500E+07	1.1833E-03	4090	3	0	21
1.6000E+07	1.1500E-03	1.6500E+07	1.0750E-03	1.7000E+07	1.0000E-03	4090	3	0	22
1.7500E+07	9.5000E-04	1.8000E+07	9.0000E-04	1.8500E+07	8.5000E-04	4090	3	0	23
1.9000E+07	8.0000E-04	1.9500E+07	7.5000E-04	2.0000E+07	7.0000E-04	4090	3	0	24
4.0000E+04	8.9132E+01	0	0	0	0	4090	3	0	0
0.	-1.5060E+06	0	0	0	0	04090	3	0	1
1.5230E+06	0.	3.0000E+06	1.4000E-06	3.5000E+06	3.7117E-06	04090	3	0	2
4.0000E+06	1.5000E-05	4.5000E+06	4.1963E-04	5.0000E+06	9.5000E-04	04090	3	0	3
5.5000E+06	1.1753E-03	6.0000E+06	1.4000E-03	6.5000E+06	1.6994E-03	04090	3	0	4
7.0000E+06	2.0600E-03	7.5000E+06	2.6298E-03	8.0000E+06	3.4000E-03	04090	3	0	5
8.5000E+06	4.3159E-03	9.0000E+06	5.7000E-03	9.5000E+06	7.6862E-03	04090	3	0	6
1.0000E+07	1.0000E-02	1.0500E+07	1.2438E-02	1.1000E+07	1.5000E-02	04090	3	0	7
1.1500E+07	1.7991E-02	1.2000E+07	2.1000E-02	1.2500E+07	2.3042E-02	04090	3	0	8
1.3000E+07	2.5000E-02	1.3500E+07	2.8000E-02	1.4000E+07	3.0000E-02	04090	3	0	9
1.4500E+07	3.1100E-02	1.5000E+07	3.2000E-02	1.5500E+07	3.3159E-02	04090	3	0	10
1.6000E+07	3.4000E-02	1.6500E+07	3.3751E-02	1.7000E+07	3.3100E-02	04090	3	0	11
1.7500E+07	3.2575E-02	1.8000E+07	3.2000E-02	1.8500E+07	3.1080E-02	04090	3	0	12
1.9000E+07	3.0100E-02	1.9500E+07	2.9450E-02	2.0000E+07	2.9000E-02	04090	3	0	13
4.0000E+04	8.9132E+01	0	0	0	0	4090	3	0	14
0.	-2.1910E+06	0	0	0	0	04090	3	0	15
2.2160E+06	0.	4.0000E+06	6.0000E-06	4.5000E+06	3.4969E-06	04090	3	0	0
5.0000E+06	1.2000E-05	5.5000E+06	3.8754E-05	6.0000E+06	8.0000E-05	04090	3	0	1
6.5000E+06	1.3040E-04	7.0000E+06	2.0000E-04	7.5000E+06	5.2553E-04	04090	3	0	2
8.0000E+06	5.0000E-04	8.5000E+06	7.0037E-04	9.0000E+06	1.0000E-03	04090	3	0	3
9.5000E+06	1.4500E-03	1.0000E+07	2.0000E-03	1.0500E+07	2.5271E-03	04090	3	0	4
1.1000E+07	3.2000E-03	1.1500E+07	4.1083E-03	1.2000E+07	5.1000E-03	04090	3	0	5
1.2500E+07	6.1000E-03	1.3000E+07	7.1000E-03	1.3500E+07	8.1000E-03	04090	3	0	6
1.4000E+07	9.2000E-03	1.4500E+07	1.0000E-02	1.5000E+07	1.1000E-02	04090	3	0	7
1.5500E+07	1.1856E-02	1.6000E+07	1.2400E-02	1.6500E+07	1.2500E-02	04090	3	0	8

1.7000E+07	1.2600E-02	1.7500E+07	1.2500E-02	1.0000E+07	1.2500E-024000	3103
1.8500E+07	1.2300E-02	1.9000E+07	1.2100E-02	1.0500E+07	1.1977E-024000	3103
2.0000E+07	1.1900E-02	2.0000E+07	1.1900E-02	1.0000E+07	1.1900E-024000	3103
4.0000E+07	8.9132E+01	4.0000E+07	8.9132E+01	4.0000E+07	8.9132E+01	3103
6.0000E+07	1.7500E+06	6.0000E+07	1.7500E+06	6.0000E+07	1.7500E+06	3103
8.0000E+07	3.6000E+06	8.0000E+07	3.6000E+06	8.0000E+07	3.6000E+06	3103
1.0000E+08	0.0000E+00	1.0000E+08	0.0000E+00	1.0000E+08	0.0000E+00	3103
1.2000E+08	1.4000E-06	1.2000E+08	1.4000E-06	1.2000E+08	1.4000E-06	3103
1.4000E+08	2.8501E-05	1.4000E+08	2.8501E-05	1.4000E+08	2.8501E-05	3103
1.6000E+08	1.5000E-04	1.6000E+08	1.5000E-04	1.6000E+08	1.5000E-04	3103
1.8000E+08	4.3578E-04	1.8000E+08	4.3578E-04	1.8000E+08	4.3578E-04	3103
2.0000E+08	1.0000E-03	2.0000E+08	1.0000E-03	2.0000E+08	1.0000E-03	3103
2.2000E+08	2.6469E-03	2.2000E+08	2.6469E-03	2.2000E+08	2.6469E-03	3103
2.4000E+08	4.4000E-03	2.4000E+08	4.4000E-03	2.4000E+08	4.4000E-03	3103
2.6000E+08	8.1000E-03	2.6000E+08	8.1000E-03	2.6000E+08	8.1000E-03	3103
2.8000E+08	1.4000E-02	2.8000E+08	1.4000E-02	2.8000E+08	1.4000E-02	3103
3.0000E+08	1.9740E-02	3.0000E+08	1.9740E-02	3.0000E+08	1.9740E-02	3103
3.2000E+08	2.6000E-02	3.2000E+08	2.6000E-02	3.2000E+08	2.6000E-02	3103
3.4000E+08	3.3000E-02	3.4000E+08	3.3000E-02	3.4000E+08	3.3000E-02	3103
3.6000E+08	4.1000E-02	3.6000E+08	4.1000E-02	3.6000E+08	4.1000E-02	3103
3.8000E+08	5.0000E-02	3.8000E+08	5.0000E-02	3.8000E+08	5.0000E-02	3103
4.0000E+08	6.0000E-02	4.0000E+08	6.0000E-02	4.0000E+08	6.0000E-02	3103
4.2000E+08	7.1000E-02	4.2000E+08	7.1000E-02	4.2000E+08	7.1000E-02	3103
4.4000E+08	8.3000E-02	4.4000E+08	8.3000E-02	4.4000E+08	8.3000E-02	3103
4.6000E+08	9.7000E-02	4.6000E+08	9.7000E-02	4.6000E+08	9.7000E-02	3103
4.8000E+08	1.1000E-01	4.8000E+08	1.1000E-01	4.8000E+08	1.1000E-01	3103
5.0000E+08	1.3000E-01	5.0000E+08	1.3000E-01	5.0000E+08	1.3000E-01	3103
5.2000E+08	1.5000E-01	5.2000E+08	1.5000E-01	5.2000E+08	1.5000E-01	3103
5.4000E+08	1.7000E-01	5.4000E+08	1.7000E-01	5.4000E+08	1.7000E-01	3103
5.6000E+08	1.9000E-01	5.6000E+08	1.9000E-01	5.6000E+08	1.9000E-01	3103
5.8000E+08	2.1000E-01	5.8000E+08	2.1000E-01	5.8000E+08	2.1000E-01	3103
6.0000E+08	2.3000E-01	6.0000E+08	2.3000E-01	6.0000E+08	2.3000E-01	3103
6.2000E+08	2.5000E-01	6.2000E+08	2.5000E-01	6.2000E+08	2.5000E-01	3103
6.4000E+08	2.7000E-01	6.4000E+08	2.7000E-01	6.4000E+08	2.7000E-01	3103
6.6000E+08	2.9000E-01	6.6000E+08	2.9000E-01	6.6000E+08	2.9000E-01	3103
6.8000E+08	3.1000E-01	6.8000E+08	3.1000E-01	6.8000E+08	3.1000E-01	3103
7.0000E+08	3.3000E-01	7.0000E+08	3.3000E-01	7.0000E+08	3.3000E-01	3103
7.2000E+08	3.5000E-01	7.2000E+08	3.5000E-01	7.2000E+08	3.5000E-01	3103
7.4000E+08	3.7000E-01	7.4000E+08	3.7000E-01	7.4000E+08	3.7000E-01	3103
7.6000E+08	3.9					

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