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FAST-NEUTRON CROSS SECTIONS OF HAFNIUM, GADOLINIUM, AND SAMARIUM

by

G. L. Sherwood, A. B. Smith,
and J. F. Whalen

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Available from

Clearinghouse for Federal Scientific and Technical Information

National Bureau of Standards, U. S. Department of Commerce

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Reactor Physics Division

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FAST-NEUTRON CROSS SECTIONS OF HAFNIUM, GADOLINIUM, AND SAMARIUM*

by

G. L. Sherwood, A. B. Smith, and J. F. Whalen

ABSTRACT

Elastic and inelastic neutron-scattering cross sections of elemental hafnium, gadolinium, and samarium were measured at incident neutron energies of 0.3-1.5 MeV. The experimental resolution was sufficient to reasonably resolve elastic and inelastic processes and to define individual inelastic cross sections for the most appreciably excited states. The total neutron cross sections were determined up to 1.5 MeV with resolutions of ≥ 2.5 keV. Within the precisions of the measurements, all observed cross sections were relatively smooth functions of energy. The experimental results were compared with those obtained from calculations based upon both spherical and deformed optical potentials and statistical theory, inclusive of fluctuation corrections. The calculated results were descriptive of measured total, elastic scattering, and, to a lesser extent, inelastic scattering cross sections. Experimental and calculated results were compared with previously reported measured values and with the contents of several evaluated neutron data sets used in reactor design.

I. INTRODUCTION

The elements hafnium, gadolinium, and samarium are complex mixtures of even and odd isotopes. Some of the isotopes are fission products, and some have large thermal-capture cross sections. As a result, they are found in reactor systems and are often used as reactor poisons or control components. The isotopes of these elements are deformed, and their low-lying excited states are predominantly rotational and vibrational structures.^{1,2} Even at relatively low incident neutron energies, these collective states can be directly excited by inelastic neutron-scattering processes. The strength of these direct reactions (DR's) increases with incident energy and leads to inelastic neutron distributions differing significantly from those associated with compound nucleus (CN) processes.

* All numerical data contained here have been transmitted to the National Neutron Cross Section Center (NNCSC), Brookhaven National Laboratory.

Despite the applied importance and physical interest of hafnium, gadolinium, and samarium, relatively little is known of the interaction of fast neutrons with these elements. Studies of low-energy cross sections have provided values of the $\ell = 0$ strength function, but not always with good agreement between experiments or with calculation.³ At neutron energies above ~ 100 keV, measured total cross sections are not consistent, particularly with respect to the presence of intermediate structure.⁴⁻⁶ Elastic neutron-scattering cross sections have been reported at selected incident energies, primarily near 1.0 MeV.^{7,8} Often the experimental resolutions previously used did not clearly differentiate the elastic scattering from inelastic processes. Studies of inelastic neutron scattering from these elements have been largely confined to indirect observation of the $(n, n'\gamma)$ processes⁹ and to determinations of nonelastic scattering cross sections.¹⁰

The excited structure of a number of the isotopes of hafnium, gadolinium, and samarium has been extensively studied through coulomb excitation, charge particle, and neutron-capture gamma-ray measurements.^{2,11} In some cases, a reasonably detailed knowledge of the excited structure has resulted, particularly for the odd isotopes. However, general understanding of the structure is incomplete, and, coupled with uncertainties in reaction mechanisms and associated potentials, this makes the quantitative calculation of neutron cross sections difficult.

The objective of the present work is to provide fast-neutron cross sections of hafnium, gadolinium, and samarium for applied use in reactor design; to provide the experimental basis for developing reaction models of wide and quantitative usefulness; and to further the understanding of the structure of deformed nuclei.

II. EXPERIMENTAL METHODS

The fast-neutron time-of-flight method was used to determine scattered neutron-velocity distributions. Total neutron cross sections were derived from monoenergetic neutron transmissions. These techniques and associated apparatus have been described elsewhere and will not be detailed here.^{12,13} The time-of-flight method employed concurrently-determined scattered neutron-velocity distributions at eight scattering angles distributed over the interval 25-155°. The scattering angles varied during the studies, but were carefully determined for a given measurement. Throughout the work, the ${}^7\text{Li}(p,n){}^7\text{Be}$ reaction was used as a neutron source in such a manner as to provide the desired incident neutron spreads at the sample under study.¹⁴ All scattering samples were metallic right cylinders 2.0 cm high and 2.0 cm in diameter fabricated from the natural element. Their chemical purities were >98% per atom, and the sample densities those of the natural element. Neutrons were incident upon the base of the cylinders in the total cross-section measurements and upon the lateral cylindrical surfaces in the scattering studies. All scattering cross sections were determined relative to the differential elastic scattering cross sections of carbon.¹⁵ Using a Monte Carlo procedure,¹³ we corrected the scattering measurements for incident beam attenuation, for finite angular resolution of the apparatus, and for multiple scattering effects. All measured results were reduced to barns per atom of the natural element.

III. EXPERIMENTAL RESULTS

A. Total Neutron Cross Sections

The total neutron cross sections of hafnium, gadolinium, and samarium were measured from ~0.10 to 1.5 MeV. Incident neutron-energy resolutions were 2-3 keV, and measurements were made at energy intervals of ≈ 5 keV. The statistical errors associated with the measured data points were ~1%. "In-scattering" corrections were estimated, found to be small, and neglected. Figures 1-3 summarize the experimental results for hafnium,

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Fig. 1. Measured Total Neutron Cross Sections of Hafnium. The vertical bars indicate measured values and their uncertainties. The dashed line denotes the sum of measured elastic and inelastic scattering cross sections. The solid curve is the "eye guide" of BNL-325.⁴

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Fig. 2. Measured Total Neutron Cross Sections of Gadolinium. Format and notation are identical to those of Fig. 1.

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Fig. 3. Measured Total Neutron Cross Sections of Samarium. Format and notation are identical to those of Fig. 1.

gadolinium and samarium, respectively. Numerical values are given in the appendix. The present hafnium results are in good agreement with those obtained in a number of earlier measurements,⁴ but significantly higher than some of the recent values reported in Ref. 4. The present gadolinium values are in good agreement with those reported by Stupigia *et al.*⁴ and by Gilboy and Towle.⁸ However, they tend to be somewhat larger than the results of Seth⁵ and do not show the reported strong intermediate structure. The possible presence of such structure is discussed in Section IV.A of this report. Generally, the total cross sections of samarium obtained in the present work are similar to previously reported values obtained with less detailed energy resolution.⁴

B. Elastic Neutron Scattering

Elastic neutron scattering was measured at incident neutron-energy intervals of $\lesssim 50$ keV from 0.3 to 1.5 MeV. The incident neutron-energy spreads were ~ 20 keV, the scattered neutron-energy resolution ~ 1.5 nsec/m, and the scattered neutron sensitivity a few millibarns per steradian. The scattered-neutron resolution was usually sufficient to resolve the elastic neutron group from inelastic contributions, as is illustrated in Fig. 4. However, at incident neutron energies > 1.2 MeV, the resolution was less than definitive, particularly at forward scattering angles, and the observed elastic scattering was corrected for contributions from inelastic processes associated with small reaction Q values ($|Q| \leq 100$ keV). These corrections were based upon selected good-resolution measurements and theoretical extrapolation from measured values.

Fig. 4

Time-of-flight Distribution Obtained by Scattering 0.8-MeV Neutrons from Hafnium through an Angle of 115° . A small background has been subtracted. Vertical bars indicate statistical counting uncertainties. Neutrons due to elastic scattering and the observed inelastic excitation of states at 0.094 and 0.307 MeV are indicated. Neutrons corresponding to the excitation of a state at 0.190 MeV are attributed to double inelastic scattering to the 0.094-MeV state.

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The differential elastic scattering angular distributions were usually determined at eight scattering angles. These angles were similar, but not always identical, at various incident neutron energies. Typical values of these laboratory scattering angles were 28.5, 38.5, 53.5, 69.5, 84.5, 114.3, 129.5, 154.2° . The angular resolution of the measurements was $\lesssim 5^\circ$, largely determined by the source-sample configuration. All measured elastic scattering angular distributions were reduced to corrected cross sections

(relative to the carbon standard) and expressed as an expansion of Legendre polynomials of the form

$$\frac{d\sigma}{dn} = \frac{\sigma}{4\pi} \left[1 + \sum_{i=1}^n \omega_i P_i(\theta) \right], \quad (1)$$

where the scattering angle is given in the laboratory system. The parameters σ and ω_i were derived from a least-squares fit of Eq. 1 to the actual experimental values. The value n was chosen so that the fitting error on the n th coefficient did not generally exceed its value. This led to values of $n = 5$ at higher energies (~ 0.8 - 1.5 MeV) and $n = 4$ at energies of $\lesssim 0.8$ MeV. The experimental results expressed in the form of the above expansion were descriptive of the individual differential measurements as indicated by the solid curves and data points of Figs. 5-8. The use of this expansion permitted easy comparison of results obtained at slightly differing scattering angles and incident neutron energies. However, extrapolation of the measured results by means of Eq. 1 beyond the experimental angular interval of ~ 25 to $\sim 155^\circ$ may not necessarily be valid.

The measured differential elastic scattering cross sections of hafnium, gadolinium, and samarium, expressed in the form of Eq. 1, are summarized in Figs. 9-11 and expressed in tabular form in the appendix. These results are composites of a number of measurements made over several years. Where multiple values were available within an energy increment approximating the incident-energy resolution, they were averaged to obtain

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Fig. 5. Scattering of 1.0-MeV Neutrons from Hafnium. Solid data points are the present elastic and inelastic ($Q = -98$ keV) results. Open points are from Ref. 7. Curves are the result of calculation as discussed in the text.

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Fig. 6. Scattering of 0.5-MeV Neutrons from Gadolinium. Elastic and inelastic ($Q = -80$ keV) results are indicated. The curves are discussed in the text.

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Fig. 7. Scattering of 0.98-MeV Neutrons from Gadolinium. Solid data points are the results of the present elastic and inelastic ($Q = -80$ keV) measurements. Open points are from Ref. 8.

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Fig. 8. Scattering of 0.98-MeV Neutrons from Samarium. Results of present elastic and inelastic ($Q = -100$ keV) measurements are indicated by solid data points. Open circles indicate the values of Ref. 8. The curves are discussed in the text.

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Fig. 9. Differential Elastic Scattering Cross Sections of Hafnium, Expressed in the Form of Eq. 1. The curves indicate the results of model calculations described in the text.

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Fig. 10. Differential Elastic Scattering Cross Sections of Gadolinium, Expressed in the Form of Eq. 1. The curves are discussed in the text.

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Fig. 11. Differential Elastic Scattering Cross Sections of Samarium. The format is the same as that of Fig. 9.

Eq. 1 to the measured values and do not necessarily reflect the uncertainties in the individual points. Generally, the fit to the individual experimental points was well within the estimated experimental uncertainty. (See Figs. 5-8.)

The results of the present elastic scattering measurements are in reasonable agreement with previously reported elastic scattering angular distributions when cognizance is taken of the various experimental resolutions employed. The results of Gilboy and Towle⁸ obtained by scattering 0.98-MeV neutrons from gadolinium and from samarium compare well with the sum of the elastic and first inelastic group cross sections determined in the present work. (See Figs. 7 and 8.) When corrected for inelastic content, the results obtained by Walt and Barschall⁷ for the scattering of 1.0-MeV neutrons from hafnium are reasonably consistent with the results obtained in the present work, though there appears to be some discrepancy at very forward and back scattering angles. (See Fig. 5.) These differences are not outside of the experimental uncertainties.

C. Inelastic Neutron Scattering

The elements hafnium, gadolinium, and samarium each consist of five or more isotopes, of which at least 30% are of odd A .² All are deformed and, particularly the odd isotopes, are characterized by complex low-lying excited structure. If only isotopes of greater than 10% abundance are

the results shown. The uncertainties associated with individual differential cross-section determinations must be subjectively estimated, as they are complex functions of statistical effects, systematic uncertainties, and instrumental properties and are not necessarily constant from energy to energy or from measurement to measurement. Figures 5-8 indicate conservative estimates of these uncertainties. The influence of multiple scattering and other correction factors was generally small (10% in the worst configurations) and led to uncertainties in the measured values of only a few percent. It was judged that the integrated elastic cross section derived from Eq. 1 was known to $\pm 8\%$ inclusive of uncertainties in the carbon standard cross sections. This error was somewhat larger at incident energies above 1.2 MeV, because of the correction for partially resolved inelastic scattering contributions. The quoted errors associated with the ω_i values are representative of the "goodness" of the fit of

considered, the number of states per element below an excitation energy of ~ 1.0 MeV exceeds 40. This estimate is conservative, since the structure of many isotopes is only partially known. Thus the average spacing between states barely exceeded the optimum scattered-neutron resolution of the present experiments, and it was difficult to associate an observed neutron group with the excitation of a specific nuclear state. More correctly, a neutron-emission cross section was determined. This was associated with an average reaction $Q \pm dQ$ value, assuming inelastic neutron scattering processes were the contributing factors. The Q values were determined from measured neutron flight times and flight paths and were verified by comparison with the inelastic excitation of well-known states (850-keV (2+) state in ^{56}Fe , for example). The assigned uncertainties in Q values, dQ , were generally governed by the complexity of the nuclear structure and available resolution and indicated the energy interval associated with the specified cross-section determination. These dQ uncertainties usually exceeded the experimental scattered-neutron resolutions.

The observed structure of hafnium, gadolinium, and samarium is summarized in Table I and compared with known states in the individual isotopes in Figs. 12-14. The measured Q values and cross sections near excitation energies of 500 keV were distorted by elastically scattered neutrons originating in the second neutron group from the $^7\text{Li}(p,n)^7\text{Be}$ source reaction.¹³ The results were corrected for this elastic contamination using the known yield of the second source group¹⁵ and the measured elastic cross sections. This correction procedure did introduce uncertainties. Inelastic

TABLE I. Energies in keV of States in Hafnium, Gadolinium, and Samarium, as Observed in the Present Inelastic Neutron Scattering Measurements^a

Hafnium	Gadolinium	Samarium
98 ± 10	80 ± 20	100 ± 20
310 ± 50	260 ± 40	$200 (?)$
450 ± 50	350 ± 40	270 ± 30
525 ± 25^b	430 ± 30	350 ± 30
610 ± 50^b	$500 \pm 40(?)^b$	$520 \pm 50(?)^b$
800 ± 100	870 ± 50	690 ± 50
1050 ± 90	960	810 ± 50
1240 ± 90	1140	930 ± 40
	1230	1020 ± 30
		1090 ± 40

^aSee text for discussion of uncertainties.

^bContains contribution from elastic scattered neutrons originating in the second group from the $^7\text{Li}(p,n)^7\text{Be}$ source reaction.

scattering of second-group neutrons introduced further uncertainties, which were particularly evident in hafnium where the second-group excitation of the 98-keV state was estimated to account for $\approx 20\%$ of the observed cross section for the excitation of the 610-keV state. Similar second-group inelastic excitations were not explicitly observed in either gadolinium or samarium and were estimated to make relatively small ($\approx 10\%$) contributions to the observed cross sections in the worst cases. Throughout the measurements, no corrections were made for any second-source-group inelastic scattering.

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Fig. 12. Excited Structure of Hafnium. Left, reported values.² Right, model used in calculations. Center, experimental observation.

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Fig. 13. Excited Structure of Gadolinium. The format is the same as that of Fig. 12.

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Fig. 14. Excited Structure of Samarium. The format is the same as that of Fig. 13.

Many measured time spectra indicated that the observed "levels" were multiplets. (The 960-, 1140-, and 1230-keV states in gadolinium were acute examples.) "Unfolding" techniques could have been used to break these complex groups into individual components, particularly if the structure were known from other sources. However, such procedures could have led to deceptive results and were avoided, since the spirit of the investigation was the provision of cross sections for applied use. It was doubtful if extensive unfolding procedures would have contributed to this end. Therefore the resolutions given in Table I and the corresponding cross-section values are to be interpreted as observational quantities in the context of a more complex structure.

The inelastic scattering angular distributions were observed at eight or more laboratory scattering angles, usually concurrent with elastic scattering angular distributions. The observed angular distributions were essentially isotropic with, in some instances, slight tendencies toward forward scattering angles. (See Figs. 5-8.) The latter effect was most in evidence for reactions associated with small Q values (e.g., $\lesssim 100$ keV) and at higher incidence energies, where it was difficult to resolve the inelastic neutron group from an order of magnitude more intense elastically scattered component at forward angles. The angle-integrated inelastic cross sections were derived from the measured differential cross sections by constructing a simple average and multiplying by 4π . In the context of the above observed isotropy and small anisotropy, it was estimated that this procedure incurred no more than a 5% error. Scattered neutrons of $\ll 200$ keV were observed, but in this region detector sensitivity changed rapidly with energy, and cross-section determination was judged unreliable. Thus cross sections were only determined at incident energies > 200 keV above the respective inelastic scattering thresholds. Figures 15-17 show the resulting inelastic excitation cross sections of hafnium, gadolinium, and samarium, respectively.

Fig. 15

Observed Inelastic-excitation Cross Sections of Hafnium. Crosses indicate measured cross sections and associated cross-section error. Observed reaction Q values in MeV are indicated. Curves are the results of calculations as described in the text.

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Fig. 16. Observed Inelastic-excitation Cross Sections of Gadolinium. The notation is the same as that in Fig. 14.

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Fig. 17. Observed Inelastic-excitation Cross Sections of Samarium. The notation is the same as that in Fig. 14.

The corresponding numerical values are listed in the appendix. The indicated uncertainties are subjective and conservative estimates due to a number of sources, including errors in the carbon reference standard.

The lack of previous experimental results made it difficult to make quantitative comparisons with the present measured inelastic values. The nonelastic cross section of hafnium reported by Walt and Barschall⁷ was ~10% less than that derived from the present work. There was little correlation between the reported cross sections for inelastic gamma-ray emission from hafnium and the directly measured cross sections for inelastic scattering of the present experiment.⁹ A search of the literature did not reveal any previous direct determinations of inelastic neutron scattering cross sections of either gadolinium or samarium in an energy range comparable to that of the present work.

It is of interest to examine the present elastic scattering, inelastic scattering, and total cross-section results for internal consistency. The total scattering cross sections were estimated by extrapolating the measured inelastic cross sections to threshold and combining with the observed elastic scattering cross sections. Figures 1-3 compare these results with the directly measured total cross sections. The total and the total scattering cross sections of gadolinium are in good agreement; the total scattering cross section of hafnium and of samarium deviate from the total cross section by as much as 5-6% at higher energies. These discrepancies can be

partly attributed to uncertainties associated with the second source group, discussed above. In all three elements, there are some differences between total and total scattering cross sections near the lowest measured energies. These differences are not systematic nor due to capture effects. They are believed due to uncertainties in the extrapolation of the first and relatively intense inelastic group to threshold. The low-energy discrepancies are $\lesssim 10\%$, within the respective experimental accuracies.

IV. PHYSICAL INTERPRETATION

A. Total Neutron Cross Sections and Intermediate Resonance Structure

Intermediate resonance structure has been reported in the total neutron cross sections of heavy deformed nuclei.³ This structure has been attributed to collective "doorway" states and should be evident at low incident neutron energies where the number of available exit channels is limited.^{16,17} Such structure has been particularly reported in the total cross sections of gadolinium over the energy range 0.1-0.6 MeV and was characterized by a magnitude 10-20% that of the entire total cross section and an average periodicity of ~20 keV. Such structure was not qualitatively evident in the present work, as illustrated by Figs. 1-3, though the statistical precisions and energy resolutions used here generally were superior to those used in past measurements.

Close inspection of the present total cross-section results indicated a possible tendency toward an intermediate structure of small magnitude (a few percent). The possible existence of such structure was quantitatively assayed using the correlation function¹⁸

$$C(\delta) = \frac{\langle \sigma(E+\delta) \cdot \sigma(E) \rangle}{\langle \sigma(E+\delta) \rangle \cdot \langle \sigma(E) \rangle} - 1. \quad (2)$$

$C(\delta)$ was evaluated as a function of δ over the entire measured energy interval and several subintervals thereof for the total cross sections of hafnium, gadolinium, and samarium. The measured total cross sections consisted of compound nucleus (CN) and direct reaction (DR) components. The latter were assumed to vary slowly with energy and were estimated by least-squares fitting the measured values with a cubic power series in energy. The DR cross section obtained in this manner was subtracted from the measured values, leaving a fluctuating CN contribution. This latter fluctuating cross section was assayed using Eq. 2.

Figure 18 shows representative results of the above correlation analysis of hafnium, samarium, and gadolinium. In each case, $C(\delta)$ rapidly decreases with increasing δ in a manner expected from the theoretical Lorentzian form.¹⁸ Superimposed on this Lorentzian shape is a general oscillatory behavior, characteristic of the finite range of the experimental sample and of the predicted rms magnitude. For hafnium, there seems to be an additional component slowly decreasing with increasing values of δ . This is believed due to a residual direct reaction not fully corrected for in the above fitting procedures. Fitting with higher-order power series greatly reduced the effect. In all instances, these correlation functions indicated an apparent resonance width of 2-4 keV. This width was essentially equivalent to the experimental resolution and much larger than the characteristic CN

resonance widths. It was judged that these correlation distributions gave no quantitative evidence for resonance structure with average widths appreciably larger than that associated with the experimental resolution of 2-3 keV.

Fig. 18

Correlation Function, $C(\delta)$, Distributions of the Form of Eq. 2 Determined from the Measured Total Neutron Cross Sections of Gadolinium, Samarium, and Hafnium

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B. Calculations Using the Optical Model and Statistical Theory

The experimental results were compared with values calculated from the optical model and statistical theory.¹⁹⁻²² The initial calculations used a spherical potential and established the qualitative basis for subsequent use of a deformed potential. Individual calculations for each isotope of these complex elements would have been unduly tedious. As an alternative, even and odd "models" of each element were used. (See Figs. 12-14.) The even models were reasonably consistent with the structure observed in this and other work and with the known systematics of nuclear structure.²³ The structure of the odd models was more speculative, but they were of minority natural abundance. Calculations were carried out for each element using the pair of model isotopes. The results were combined in accordance with the respective model isotopic abundance and averaged over energy intervals equivalent to the experimental resolutions for comparison with measured values. (The averaging increments are indicated by the brackets of Figs. 12-14.)

The optical potentials were adjusted to provide a subjectively judged "best" description of the total and the differential elastic neutron scattering cross sections determined in the present study. Throughout, the statistical methods of Hauser-Feshbach were used to determine compound elastic and inelastic neutron scattering cross sections.²¹ When deformed potentials were used, attention was given to direct inelastic excitation processes associated with the coupling of the ground (0+) and first excited (2+) states of the even nuclei.

The spherical surface-absorption potential of Moldauer was taken as a point of departure.²⁴ This potential has been shown descriptive of low-energy neutron-scattering processes and strength functions. The potential has the form

$$\left. \begin{aligned} -Vq - iWp + V_{so} \left(\frac{\hbar}{m_{\pi}c} \right)^2 \sigma \cdot \frac{\ell}{r} \frac{dq}{dr}, \\ q(r) = \left[1 + \exp\left(\frac{r-R}{a}\right) \right]^{-1}, \\ \text{and} \\ p(r) = \exp\left[-\left(\frac{r-R-c}{b}\right)^2\right], \end{aligned} \right\} \quad (3)$$

where

$$R = 1.16 A^{1/3} + 0.6 F,$$

$$a = 0.62 F,$$

$$c = 0.5 F,$$

and

$$V_{so} \text{ (spin-orbit term)} = 7.0 \text{ MeV.}$$

Calculations were carried out using the ABACUS-NEARREX computer program.²⁵ V , W , and the absorption width, b , were varied to obtain the best agreement with measured elastic scattering. Table II lists the resulting "selected" parameter values. Total cross sections calculated from these parameters are reasonably descriptive of the experimental values for hafnium, gadolinium, and samarium, as indicated by the ABACUS curve of Figs. 19 and 20, for example. Further, the calculated elastic scattering is in qualitative agreement with experiment (see Figs. 9-11), though detailed comparisons with measured angular distributions reveal appreciable discrepancies, particularly at scattering angles greater than 90° . (See Figs. 5,

6, and 8.) Inelastic excitation cross sections calculated with the above spherical potentials are in fair agreement with the experimental results, as indicated in Fig. 15 (ABACUS). Detailed agreement is probably not significant other than for the excitation of the first few states, since the relation of the measured values to the model structures used in

TABLE II. "Best" Optical-model Parameters

Quantity	Samarium	Gadolinium	Hafnium
$\bar{A}$	150	156	178
V_R , MeV	42.0	43.0	44.1
W_{IM} , MeV	8.0	12.0	12.0
b , F	1.37	1.25	1.0
V_{DIR} , MeV	-	43.0	44.1
β	0.35	0.36	0.27

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Fig. 19. Measured Total Neutron Cross Sections (crosses) of Hafnium, Compared with Results of Spherical (ABACUS) and Deformed (2-PLUS) Optical-model Calculations. Square data points are the results of check measurements using a different (time-of-flight) technique.

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Fig. 20. Comparison of Measured and Calculated Total Cross Sections of Gadolinium. The notation is the same as in Fig. 19.

the calculations is uncertain. However, the nonelastic cross sections derived from the calculations, from the present measurements, and as reported from previous experiments, are similar.⁷ The above calculated inelastic angular distributions are symmetric about 90° and, in the present cases, nearly isotropic. (See Fig. 5, for example.) This is in agreement with the measured results, though there appears to be a systematic tendency for the largest experimental values to occur toward forward scattering angles.

Differences between measured and calculated inelastic scattering can be attributed to incorrect excited structures used in the calculations. In simple cases, it is reasonable to compare experimental results with values calculated from alternate structure assignments and thereby obtain some insight into the nuclear structure. In the context of the isotopic and structural complexity of the elements of this study, such a procedure was judged unrewarding and not attempted. Moreover, in the present work there can be little doubt that inelastic processes associated with small Q values are predominantly due to the excitation of the levels of the well-known ground-state rotational bands of the even isotopes.

Compound nuclear processes are influenced by resonance-width fluctuations and correlations.²⁶ These concepts can be incorporated in the Hauser-Feshbach formulation as corrected transmission coefficients, $\langle \theta \rangle$, where

$$\langle \theta_\alpha \rangle = T_\alpha + \frac{1}{Q} \left[1 - \sqrt{1 - QT_\alpha} \right]^2. \quad (4)$$

Q can vary between zero (strongly overlapping compound nuclear levels) and one (isolated levels), and in the present cases, Q would be expected to approach the former limit. The above spherical calculations were extended to include both limiting values of Q --zero and one--using the ABACUS-NEARREX computational program. The use of the above "corrections" did not significantly alter the calculated elastic scattering cross sections. However, the calculated cross sections for the excitations of the first (2+) state of the even isotopes were (for either choice of Q) 15% or more lower than the uncorrected Hauser-Feshbach result and in poorer agreement with experiment. This does not imply that the concepts of Eq. 4 and Ref. 26 are incorrect, but rather may indicate the deficiency of the model in other areas.

The calculations were extended to include the effects of the known static deformations of the even isotopes of hafnium and gadolinium. A deformed potential and the 2-PLUS computer program were used to calculate total, elastic, and inelastic scattering cross sections of the even model isotopes.²⁷ The direct excitation of the first (2+) state was explicitly considered. The excitations of higher levels in the even isotopes and all inelastic scattering from the odd isotopes were calculated with the conventional Hauser-Feshbach formula. The nuclear deformation parameter, β , was taken from the literature,¹⁰ and the direct well was assumed equivalent to the real well. Initial attempts to determine "best" deformed potential values indicated that the parameters would be similar to those obtained for the spherical potential, and the latter were accepted for further detailed deformed calculations. (See Table II.) The calculated total cross sections were, particularly for gadolinium, in somewhat poorer agreement with experiment than those derived from the spherical potential. (See Fig. 20.) The deformed calculations did result in better agreement with experimental elastic angular distributions than those obtained from the spherical potential. (See Figs. 5, 6, 9, and 10.) This was particularly true of angular distributions at scattering angles greater than 90°. For hafnium, there were very small differences between the energy-dependent shapes and the magnitudes of the excitation cross sections of the first (2+) states as calculated using the two methods. (See Fig. 16.) For gadolinium, the two results were essentially indistinguishable, and only the 2-PLUS result is shown in Fig. 16. Generally, the calculated direct excitation of this first (2+) state was small ($\lesssim 5\%$ of the compound nucleus contribution) at the energies of the present experiment. Thus, though the direct contribution was peaked forward, it should not have led to large asymmetries in the observable cross sections. (See Figs. 5 and 6.) Small asymmetries in the inelastic cross sections were possibly supported by the measured distributions. But, as pointed out above, it was not clear to what extent the small experimental asymmetries were due to instrumental effects. No attempt was made to incorporate the

"corrections" of Eq. 4 into the deformed potential calculations. It is reasonable to expect their effect to be similar to that of the spherical case discussed above.

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Fig. 21

Comparison of Calculated Elastic and Inelastic (2+) Scattering of 6.0-MeV Neutrons from Hafnium Using Spherical (ABACUS) and Deformed (2-PLUS) Potentials

results and reported experimental values. Unfortunately, the uncertainties associated with the experimental values are large, often exceeding the difference between the two calculated results. In this mass region, the strength function is known to follow a "double humped" behavior,^{3,23,28} and hafnium and gadolinium are approximately symmetrically placed on either

At the energies of the present experiments, the contribution of the direct excitation of the first (2+) state is small. This is not true at higher incident neutron energies. Figure 21 compares elastic and inelastic (2+) scattering of 6.0-MeV neutrons from hafnium as calculated with the spherical (ABACUS) and the deformed (2-PLUS) potential. At these energies, the effect of the DR component is pronounced in the minima of the elastic cross section and in the angular distribution of the inelastic scattered neutrons. Experimental resolution of such effects would require measured scattered-neutron velocity resolutions more than an order of magnitude better than that used in the present experiments.

The spherical and the deformed optical potentials selected above were used to calculate the $\ell = 0$ strength functions of hafnium and gadolinium. Table III compares the calculated

TABLE III. $\ell = 0$ Strength Functions of Even Isotopes of Hafnium and Gadolinium

Isotope	Experimental	Calculated
¹⁵⁶ Gd	$(1.9 \pm 0.3) \times 10^{-4}$ $(1.9 \pm 0.4) \times 10^{-4a}$	$(1.9 \pm 0.9) \times 10^{-4b}$ 2.08×10^{-4} (ABACUS)
¹⁵⁸ Gd	$(2.2 \pm 1.2) \times 10^{-4c}$	
Gd		$(1.5 \pm 0.3) \times 10^{-4b}$ 1.58×10^{-4} (2-PLUS)
¹⁷⁴ Hf	$(2.8 \pm 1.3) \times 10^{-4d}$	
¹⁷⁶ Hf	$(1.44 \pm 0.5) \times 10^{-4d}$	$(1.44 \pm 0.5) \times 10^{-4b}$ 2.47×10^{-4} (ABACUS)
¹⁷⁸ Hf	$(2.1 \pm 0.7) \times 10^{-4d}$	$(2.1 \pm 0.7) \times 10^{-4b}$
¹⁸⁰ Hf	$(0.3 \pm 0.26) \times 10^{-4d}$	1.73×10^{-4} (2-PLUS)
Hf		$(2.5 \pm 0.5) \times 10^{-4b}$

^aR. Chrien and S. Mughabghab, Proc. of Antwerp Conf., p. 21 (1965).

^bRecommend. value.³

^cR. Chrien, private communication as quoted in Ref. 3.

^dT. Fuketa and J. Harvey, private communication as quoted in Ref. 3.

side of the intermediate valley. This characteristic behavior of the strength function can be interpreted in terms of nuclear deformation, and, indeed, the above deformed potential does lead to such a dependence of strength function on mass. However, comparison of calculated strength functions with the present experimental values of hafnium and of gadolinium, as in Table III, does not alone indicate any clear preference for the spherical (ABACUS) or deformed (2-PLUS) potentials.

The potential parameters derived from the present experiments differ somewhat from those found generally applicable in the lighter-mass region.²⁴ Both real and imaginary potential parameters tend to be several MeV smaller, and the absorption width, b , tends to be larger, though the width of the surface absorption cannot be entirely divorced from its magnitude. The tendency toward increased surface-absorption widths in the deformed nuclear region has been noted before in studies of tantalum, rhenium, platinum, and tungsten.^{28,33} Very qualitatively, the absorption width appears related to the deformation parameter, β . Values of $b \approx 0.5 F$ tend to be suitable for $\beta \approx 0.15$. The width increases from this value in a relatively linear manner as β increases beyond 0.15, reaching a value of $\sim 1.4 F$ at $\beta = 0.35$.

V. COMPARISON WITH EVALUATED NUCLEAR DATA FILE-B (ENDF-B)

Since a primary motivation of the present work is the provision of cross-section data for reactor design, it is of interest to compare the present experimental results with the contents of the Evaluated Nuclear Data File-B, ENDF-B.²⁹⁻³¹ This file contains a relatively complete set of evaluated cross sections for hafnium and gadolinium, but only material pertinent to a single isotope of samarium (¹⁴⁸Sm). Therefore evaluated samarium data of Ref. 32 were used in the comparison with experimental results.

Figures 22-24 compare measured and evaluated total cross sections of samarium, gadolinium, and hafnium. Each figure uses the total cross section values given in BNL-325⁴ to extend the present measurements from 1.5 to 10.0 MeV. The hafnium ENDF-B total cross sections tend to follow the BNL-325 values and deviate from the present results by $\lesssim 10\%$, particularly in the energy range 1.0-1.5 MeV. The hafnium evaluation of Ref. 32 differs somewhat from that of ENDF-B, but is in no better agreement with the present experimental results. The evaluated total cross sections of gadolinium are in better agreement with experiment than those of hafnium,

Fig. 22

Comparison of Measured and Evaluated Total Cross Sections of Samarium. Present experimental results are noted by bars. Boxes are from Ref. 4. The line labeled KFK is from the evaluated data of Ref. 32.

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Fig. 23
Comparison of Measured and Evaluated Total Cross Sections of Gadolinium. Bars denote the present experimental results, boxes the data of Ref. 4. The ENDF-B evaluation is indicated by the curve.²⁹

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Fig. 24. Comparison of Measured and Evaluated Total Cross Sections of Hafnium. Bars denote the present experimental results, boxes the data of Ref. 4. The solid curve shows the evaluated results of Ref. 29, and the dashed curve Ref. 32.

deviating slightly from measurement only at the lower energies. The experimental total cross sections of samarium are a little larger than the values given in Ref. 32, which follows the BNL-325 compilation.

The hafnium evaluated elastic scattering cross sections given in ENDF-B are in reasonable agreement with experiment above ~ 400 keV, as indicated in Fig. 25. The agreement with experiment is less satisfactory for gadolinium, as shown in Fig. 26. The evaluated total elastic scattering cross sections of gadolinium are appreciably below the measured values. Since the ENDF-B file is internally consistent, the evaluated total cross sections of gadolinium agree with the presently measured results, and the measured elastic and inelastic cross sections are reasonably consistent with the total cross sections. The discrepancy between measured and evaluated elastic scattering cross sections would be expected to persist in the inelastic scattering cross sections, as it does (see below).

113-807 Rev. 1

Fig. 25

Comparison of Measured (crosses) and Evaluated (curve from Ref. 29) Elastic Scattering Cross Sections of Hafnium

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Fig. 26

Comparison of Measured (crosses) and Evaluated (solid curve from Ref. 29) Elastic Scattering Cross Sections of Gadolinium. The dashed curve denotes the results of spherical calculations described in the text.

Figure 27 compares the observed inelastic scattering cross sections of hafnium with the ENDF-B evaluated quantities. In making this comparison, we averaged the reaction Q-values of the evaluated data to make possible a comparison with the observed quantities. The evaluated data did not contain a cross section that could be reasonably associated with the excitation of the 1.05-MeV state. Generally, the evaluated and experimental

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Fig. 27. Comparison of Measured (crosses) and Evaluated (curve from Ref. 29) Inelastic Excitation Cross Sections of Hafnium

inelastic scattering cross sections of hafnium are in reasonable agreement, but for the excitation of the first state ($Q = -0.098$ MeV). The evaluated excitation cross sections for this first state were based upon optical-model and statistical calculations and led to results appreciably below the experimental quantities, particularly at higher incident energies. A similar tendency of calculated results was noted in Section IV. No detailed experimental inelastic-excitation cross sections of gadolinium were available when the ENDF-B evaluation was carried out. As a result, the gadolinium evaluation gives only total inelastic cross sections and temperature distributions. Figure 28 compares the total inelastic scattering cross sections of gadolinium derived from the present measurements and as given in ENDF-B. The evaluated result tends to be appreciably larger than the measured values at incident neutron energies above 0.6 MeV. This discrepancy compensates for the discrepancy in the elastic scattering cross sections and leads to a total cross section rather in good agreement with experiment.

Generally, the results of the present experiments provide a far more definitive experimental basis for a sound evaluation. If used for this purpose, they would lead to modification of the evaluated cross sections of ENDF-B, particularly for the

elastic and inelastic scattering cross sections of gadolinium.

Fig. 28
Total Inelastic Scattering Cross Section of Gadolinium Derived from Measurements (dashed curve), and Corresponding Values of Refs. 29 and 31

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VI. CONCLUDING REMARK

The observed total cross sections of hafnium, gadolinium, and samarium tend to be a little larger than some of the previously reported values and do not show measurable evidence of intermediate structure. Elastic and inelastic differential neutron-scattering cross sections of the three elements were determined in detail throughout the energy range 0.3-1.5 MeV. The results are suitable for meeting most applied needs. The experimental resolution and the complexity of these elements precluded extensive interpretations leading to appreciably improved knowledge of nuclear structure. Results of optical-model and statistical calculations were quantitatively descriptive of total, elastic, and, to a lesser extent, inelastic cross sections. At the energies of the present experiments, the contributions of direct-reaction processes were not pronounced. The evaluated total neutron cross sections contained in ENDF-B were reasonably descriptive of the experimental results. The agreement between the ENDF-B data and the measured elastic and inelastic scattering cross sections was less satisfactory, particularly for gadolinium. The present experimental results should make possible an appreciable improvement in the evaluated elastic and inelastic neutron-scattering data sets.

APPENDIX

Tabular Results

The experimental numerical data forming the basis for this paper are tabulated here. These data have been forwarded to the National Neutron Cross Section Center (NNCSC), Brookhaven National Laboratory.

```

C HAFNIUM DATA BLOCK
C   G, SHERWOOD, A, SMITH, J. WHALEN---TO BE PUBLISHED
C
C
C
C
C ELASTIC SCATTERING FROM NATURAL HAFNIUM      DATE 11-68
C   FINAL VALUES
C   TIME-OF-FLIGHT METHOD
C   INCIDENT RESOLUTION ABOUT 20 KEV
C   SCATTERED RESOLUTION 1.5 NSEC/M
C   ESTIMATED ERROR IN INTEGRATED X-SEC 8 PERCENT INCLUDING STD.
C   ERROR IN OMEGA COEF, ESTIMATED FROM LEAST SQ. FITTING.
C   FORMAT
C       D X=SEC= (X*SEC/ 4*PI)*(1.+ SUM OMEGA*P)      EQ(1)
C       SUM FROM 1-9
C       P=LEGENDRE POLYNOMIAL IN LAB. SYSTEM
C   MEASURED ANGULAR INTERVAL 25-155 DEG. AT EIGHT ANGLES
C   ALL DATA CORRECTED FOR MULTIPLE SCATTERING
C   ALL RESULTS RELATIVE TO DIF. CARBON X*SEC OF ANL-5567(REV)
C   FOLLOWING CARD FORMAT 6X, 214, 5(15,14) , BCD
C       WHERE RESPECTIVE VALUES ARE,
C       E=N IN KEV
C       X*SEC*100
C       OMEGA=1 *1000
C       D=OMEGA=1*1000
C       -----
C       OMEGA=5 *1000
C       D=OMEGA=5*1000
C   FOLLOWING EQ(1) ABOVE,
C
300 839 621 120 470 100 100 80 80 30 100
315 820 728 120 342 100 115 100 80 100
330 705 692 120 401 80 80 60 10 80
346 753 673 100 637 100 100 100 0 100
373 695 821 100 553 100 100 80 10 80
390 675 922 100 750 80 216 100 60 80
406 653 927 100 678 80 244 80 100 80
425 635 963 100 691 60 230 60 78 80
435 608 909 100 788 60 186 60 50 80
450 605 932 100 740 60 280 60 100 80
466 594 936 100 786 50 262 50 60 60
476 602 941 80 829 50 235 50 60 60
490 591 935 60 785 50 232 50 46 60
506 562 924 60 783 50 227 50 25 60
526 570 950 50 900 50 337 50 203 80
543 555 998 50 947 50 373 50 125 80
570 525 977 50 963 50 368 50 144 60
585 500 950 50 940 50 360 50 120 60
606 522 989 50 997 50 439 60 172 70

```


[illegible]

.6100E 00	.1000E-01-.9800E-01	.1000F-01	.1370F 01	.2050E 00	.2050E 00	114
.6200E 00	.1000E-01-.9800E-01	.1000F-01	.1393E 01	.1481E 00	.1481E 00	115
.6300E 00	.1000E-01-.9800E-01	.1000F-01	.1430E 01	.2150E 00	.2150E 00	116
.6400E 00	.1000E-01-.9800E-01	.1000F-01	.1517E 01	.1611E 00	.1611E 00	117
.6500E 00	.1000E-01-.9800E-01	.1000F-01	.1360F 01	.2040E 00	.2040E 00	118
.6600E 00	.1000E-01-.9800E-01	.1000F-01	.1429E 01	.1519E 00	.1519E 00	119
.6800E 00	.1000E-01-.9800E-01	.1000F-01	.1472E 01	.1557E 00	.1557E 00	120
.6900E 00	.1000E-01-.9800E-01	.1000F-01	.1430F 01	.2140E 00	.2140E 00	121
.7000E 00	.1000E-01-.9800E-01	.1000E-01	.1547E 01	.1643E 00	.1643E 00	122
.7100E 00	.1000E-01-.9800E-01	.1000E-01	.1440F 01	.2160E 00	.2160E 00	123
.7200E 00	.1000E-01-.9800E-01	.1000F-01	.1549E 01	.1643E 00	.1643E 00	124
.7300E 00	.1000E-01-.9800E-01	.1000E-01	.1450F 01	.2170E 00	.2170E 00	125
.7400E 00	.1000E-01-.9800E-01	.1000E-01	.1626E 01	.2439E 00	.2439E 00	126
.7500E 00	.1000E-01-.9800E-01	.1000E-01	.1520E 01	.2280E 00	.2280E 00	127
.7600E 00	.1000E-01-.9800E-01	.1000E-01	.1499E 01	.1592E 00	.1592E 00	128
.7700E 00	.1000E-01-.9800E-01	.1000F-01	.1520E 01	.2290E 00	.2290E 00	129
.7800E 00	.1000E-01-.9800E-01	.1000E-01	.1552E 01	.1650E 00	.1650E 00	130
.7900E 00	.1000E-01-.9800E-01	.1000F-01	.1480F 01	.2220E 00	.2220E 00	131
.8000E 00	.1000E-01-.9800E-01	.1000E-01	.1465E 01	.1554E 00	.1554E 00	132
.8100E 00	.1000E-01-.9800E-01	.1000E-01	.1530E 01	.2300E 00	.2300E 00	133
.8200E 00	.1000E-01-.9800E-01	.1000E-01	.1600E 01	.1695E 00	.1695E 00	134
.8300E 00	.1000E-01-.9800E-01	.1000E-01	.1560E 01	.2340E 00	.2340E 00	135
.8400E 00	.1000E-01-.9800E-01	.1000E-01	.1700E 01	.2540E 00	.2540E 00	136
.8600E 00	.1000E-01-.9800E-01	.1000E-01	.1608E 01	.2413E 00	.2413E 00	137
.8800E 00	.1000E-01-.9800E-01	.1000E-01	.1545E 01	.2319E 00	.2319E 00	138
.9000E 00	.1000E-01-.9800E-01	.1000E-01	.1679E 01	.2519E 00	.2519E 00	139
.9200E 00	.1000E-01-.9800E-01	.1000E-01	.1554E 01	.2331E 00	.2331E 00	140
.9400E 00	.1000E-01-.9800E-01	.1000E-01	.1589E 01	.2383E 00	.2383E 00	141
.9800E 00	.1000E-01-.9800E-01	.1000E-01	.1803E 01	.2705E 00	.2705E 00	142
.1000E 01	.1000E-01-.9800E-01	.1000E-01	.1879E 01	.2818E 00	.2818E 00	143
.1020E 01	.1000E-01-.9800E-01	.1000E-01	.1611E 01	.2416E 00	.2416E 00	144
.1040E 01	.1000E-01-.9800E-01	.1000E-01	.1737E 01	.1844E 00	.1844E 00	145
.1050E 01	.1000E-01-.9800E-01	.1000E-01	.1740E 01	.2610E 00	.2610E 00	146
.1060E 01	.1000E-01-.9800E-01	.1000E-01	.1809E 01	.1919E 00	.1919E 00	147
.1080E 01	.1000E-01-.9800E-01	.1000E-01	.1835E 01	.1946E 00	.1946E 00	148
.1100E 01	.1000E-01-.9800E-01	.1000E-01	.1840E 01	.1952E 00	.1952E 00	149
.1120E 01	.1000E-01-.9800E-01	.1000E-01	.1864E 01	.1977E 00	.1977E 00	150
.1140E 01	.1000E-01-.9800E-01	.1000E-01	.1757E 01	.2636E 00	.2636E 00	151
.1160E 01	.1000E-01-.9800E-01	.1000E-01	.1828E 01	.1938E 00	.1938E 00	152
.1180E 01	.1000E-01-.9800E-01	.1000E-01	.1716E 01	.1820E 00	.1820E 00	153
.1200E 01	.1000E-01-.9800E-01	.1000E-01	.1735E 01	.1503E 00	.1503E 00	154
.1220E 01	.1000E-01-.9800E-01	.1000E-01	.1528E 01	.2292E 00	.2292E 00	155
.1240E 01	.1000E-01-.9800E-01	.1000E-01	.1610E 01	.1708E 00	.1708E 00	156
.1250E 01	.1000E-01-.9800E-01	.1000E-01	.1601E 01	.2401E 00	.2401E 00	157
.1260E 01	.1000E-01-.9800E-01	.1000E-01	.1506E 01	.1598E 00	.1598E 00	158
.1270E 01	.1000E-01-.9800E-01	.1000E-01	.1533E 01	.2299E 00	.2299E 00	159
.1280E 01	.1000E-01-.9800E-01	.1000E-01	.1499E 01	.1592E 00	.1592E 00	160
.1290E 01	.1000E-01-.9800E-01	.1000E-01	.1609E 01	.2413E 00	.2413E 00	161
.1300E 01	.1000E-01-.9800E-01	.1000E-01	.1378E 01	.2068E 00	.2068E 00	162
.1310E 01	.1000E-01-.9800E-01	.1000E-01	.1470E 01	.2205E 00	.2205E 00	163
.1320E 01	.1000E-01-.9800E-01	.1000E-01	.1418E 01	.2127E 00	.2127E 00	164
.1330E 01	.1000E-01-.9800E-01	.1000E-01	.1557E 01	.2336E 00	.2336E 00	165
.1340E 01	.1000E-01-.9800E-01	.1000E-01	.1640E 01	.2460E 00	.2460E 00	166
.1360E 01	.1000E-01-.9800E-01	.1000E-01	.1432E 01	.2025E 00	.2025E 00	167
.1380E 01	.1000E-01-.9800E-01	.1000E-01	.1236E 01	.2481E 00	.2481E 00	168
.1400E 01	.1000E-01-.9800E-01	.1000E-01	.1344E 01	.2469E 00	.2469E 00	169
						170
HF Q=310 KEV						171
.8000E 00	.1000E-01-.3100E 00	.5000E-01	.6943E 00	.2041E 00	.2041E 00	172
.8800E 00	.1000E-01-.3100E 00	.5000E-01	.4500E 00	.1749E 00	.1749E 00	173
.9000E 00	.1000E-01-.3100E 00	.5000E-01	.6163E 00	.1547E 00	.1547E 00	174
.1000E 01	.1000E-01-.3100E 00	.5000E-01	.3410E 00	.1520E 00	.1520E 00	175
.1040E 01	.1000E-01-.3100E 00	.5000E-01	.5914E 00	.9871E-01	.9871E-01	176

.1060E	01	.1000E+01-.3100E	00	.5000E+01	.5870E	00	.6931E+01	.6931E+01	177
.1100E	01	.1000E+01-.3100E	00	.5000E+01	.4800E	00	.6827E+01	.6827E+01	178
.1120E	01	.1000E+01-.3100E	00	.5000E+01	.4844E	00	.6740E+01	.6740E+01	179
.1140E	01	.1000E+01-.3100E	00	.5000E+01	.5158E	00	.7109E+01	.7109E+01	180
.1160E	01	.1000E+01-.3100E	00	.5000E+01	.5872E	00	.8085E+01	.8085E+01	181
.1180E	01	.1000E+01-.3100E	00	.5000E+01	.5578E	00	.6876E+01	.6876E+01	182
.1200E	01	.1000E+01-.3100E	00	.5000E+01	.5917E	00	.1168E	.1168E	183
.1220E	01	.1000E+01-.3100E	00	.5000E+01	.5527E	00	.1290E	.1290E	184
.1240E	01	.1000E+01-.3100E	00	.5000E+01	.5154E	00	.9246E+01	.9246E+01	185
.1250E	01	.1000E+01-.3100E	00	.5000E+01	.6660E	00	.1990E	.1990E	186
.1260E	01	.1000E+01-.3100E	00	.5000E+01	.5811E	00	.1717E	.1717E	187
.1270E	01	.1000E+01-.3100E	00	.5000E+01	.6395E	00	.1592E	.1592E	188
.1280E	01	.1000E+01-.3100E	00	.5000E+01	.4743E	00	.1031E	.1031E	189
.1290E	01	.1000E+01-.3100E	00	.5000E+01	.6376E	00	.1564E	.1564E	190
.1300E	01	.1000E+01-.3100E	00	.5000E+01	.5245E	00	.1868E	.1868E	191
.1310E	01	.1000E+01-.3100E	00	.5000E+01	.5891E	00	.1837E	.1837E	192
.1320E	01	.1000E+01-.3100E	00	.5000E+01	.4644E	00	.8206E+01	.8206E+01	193
.1330E	01	.1000E+01-.3100E	00	.5000E+01	.5472E	00	.1208E	.1208E	194
.1340E	01	.1000E+01-.3100E	00	.5000E+01	.6667E	00	.1000E	.1000E	195
.1360E	01	.1000E+01-.3100E	00	.5000E+01	.5475E	00	.8777E+01	.8777E+01	196
.1380E	01	.1000E+01-.3100E	00	.5000E+01	.4696E	00	.8112E+01	.8112E+01	197
.1400E	01	.1000E+01-.3100E	00	.5000E+01	.5016E	00	.8345E+01	.8345E+01	198
.1410E	01	.1000E+01-.3100E	00	.5000E+01	.5625E	00	.1437E	.1437E	199
.1420E	01	.1000E+01-.3100E	00	.5000E+01	.5318E	00	.1090E	.1090E	200
.1430E	01	.1000E+01-.3100E	00	.5000E+01	.4908E	00	.1361E	.1361E	201
.1450E	01	.1000E+01-.3100E	00	.5000E+01	.5260E	00	.1890E	.1890E	202
.1470E	01	.1000E+01-.3100E	00	.5000E+01	.4921E	00	.1382E	.1382E	203
.1480E	01	.1000E+01-.3100E	00	.5000E+01	.4442E	00	.9408E+01	.9408E+01	204
.1500E	01	.1000E+01-.3100E	00	.5000E+01	.4883E	00	.1257E	.1257E	205
.1510E	01	.1000E+01-.3100E	00	.5000E+01	.3391E	00	.2086E	.2086E	206
HF Q=450 KEV									207
.1000E	01	.1000E+01-.4500E	00	.5000E+01	.1850E	00	.4770E+01	.4770E+01	208
.1040E	01	.1000E+01-.4500E	00	.5000E+01	.1780E	00	.4670E+01	.4670E+01	209
.1100E	01	.1000E+01-.4500E	00	.5000E+01	.1600E	00	.4390E+01	.4390E+01	210
.1120E	01	.1000E+01-.4500E	00	.5000E+01	.2640E	00	.5960E+01	.5960E+01	211
.1160E	01	.1000E+01-.4500E	00	.5000E+01	.1720E	00	.4270E+01	.4270E+01	212
.1360E	01	.1000E+01-.4500E	00	.5000E+01	.3150E	00	.8730E+01	.8730E+01	213
.1380E	01	.1000E+01-.4500E	00	.5000E+01	.2930E	00	.8390E+01	.8390E+01	214
HF SECOND GROUP CORRECTED, Q= ABOUT 525 KEV									215
.1000E	01	.1000E+01-.5250E	00	.2500E+01	.4049E	00	.2336E	.2336E	216
.1040E	01	.1000E+01-.5250E	00	.2500E+01	.3032E	00	.1000E	.1000E	217
.1060E	01	.1000E+01-.5250E	00	.2500E+01	.3257E	00	.1074E	.1074E	218
.1080E	01	.1000E+01-.5250E	00	.2500E+01	.2168E	00	.7154E+01	.7154E+01	219
.1100E	01	.1000E+01-.5250E	00	.2500E+01	.2363E	00	.7797E+01	.7797E+01	220
.1120E	01	.1000E+01-.5250E	00	.2500E+01	.2553E	00	.8424E+01	.8424E+01	221
.1160E	01	.1000E+01-.5250E	00	.2500E+01	.2628E	00	.8672E+01	.8672E+01	222
.1180E	01	.1000E+01-.5250E	00	.2500E+01	.2258E	00	.7451E+01	.7451E+01	223
.1200E	01	.1000E+01-.5250E	00	.2500E+01	.2450E	00	.8084E+01	.8084E+01	224
.1220E	01	.1000E+01-.5250E	00	.2500E+01	.1240E	00	.8092E+01	.8092E+01	225
.1320E	01	.1000E+01-.5250E	00	.2500E+01	.1710E	00	.5643E+01	.5643E+01	226
.1400E	01	.1000E+01-.5250E	00	.2500E+01	.2868E	00	.9464E+01	.9464E+01	227
.1500E	01	.1000E+01-.5250E	00	.2500E+01	.1675E	00	.5527E+01	.5527E+01	228
.1500E	01	.1000E+01-.5250E	00	.2500E+01	.1454E	00	.4798E+01	.4798E+01	229
HF Q=610 KEV									230
.1160E	01	.1000E+01-.6100E	00	.5000E+01	.2790E	00	.9206E+01	.9206E+01	231
.1180E	01	.1000E+01-.6100E	00	.5000E+01	.2940E	00	.9702E+01	.9702E+01	232
.1240E	01	.1000E+01-.6100E	00	.5000E+01	.3070E	00	.1013E	.1013E	233
.1320E	01	.1000E+01-.6100E	00	.5000E+01	.2600E	00	.8580E+01	.8580E+01	234
.1500E	01	.1000E+01-.6100E	00	.5000E+01	.1982E	00	.4897E+01	.4897E+01	235
									236
									237
									238
									239

HF Q# 800 KEV		240
.1400E 01 .1000E-01-.8000E 00 .1000E 00 .4022E 00 .1327E 00 .1327E 00		241
.1500E 01 .1000E-01-.8000E 00 .1000E 00 .2858E 00 .9431E-01 .9431E-01		242
		243
HF Q# 1050 KEV		244
.1400E 01 .1000E-01-.1050E 01 .9000E-01 .1262E 00 .3155E-01 .3155E-01		245
.1500E 01 .1000E-01-.1050E 01 .9000E-01 .1961E 00 .4902E-01 .4902E-01		246
		247
HF Q# 1240 KEV		248
.1490E 01 .2000E-01-.1240E 01 .9000E-01 .4790E 00 .1580E 00 .1580E 00		249
.1500E 01 .2000E-01-.1240E 01 .9000E-01 .2000E 00 .6600E-01 .6600E-01		250
.1510E 01 .2000E-01-.1240E 01 .9000E-01 .5030E 00 .1659E 00 .1659E 00		251
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C MONOENERGETIC SOURCE METHOD		256
C RESOLUTION 2=3 KEV		257
C FORMAT(3E12,6)		258
C ENERGY IN KEV		259
C XSEC IN BARNS		260
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.104499E 03 .918000E 01 .230000E 00		263
.106600E 03 .942000E 01 .130000E 00		264
.108600E 03 .952000E 01 .130000E 00		265
.110600E 03 .920000E 01 .130000E 00		266
.112700E 03 .918000E 01 .130000E 00		267
.114700E 03 .921000E 01 .230000E 00		268
.116700E 03 .941000E 01 .130000E 00		269
.118700E 03 .899000E 01 .220000E 00		270
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.130900E 03 .910000E 01 .130000E 00		273
.132900E 03 .909000E 01 .130000E 00		274
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.590800E 03	.724999E 01	.130000E 00	502
.592800E 03	.732000E 01	.130000E 00	503
.594800E 03	.744000E 01	.130000E 00	504
.596800E 03	.740000E 01	.130000E 00	505
.598800E 03	.736000E 01	.130000E 00	506
.600800E 03	.708000E 01	.130000E 00	507
.602800E 03	.730000E 01	.130000E 00	508
.604800E 03	.707000E 01	.130000E 00	509
.606800E 03	.723000E 01	.130000E 00	510
.608800E 03	.726000E 01	.130000E 00	511
.610800E 03	.730000E 01	.130000E 00	512
.612800E 03	.717000E 01	.130000E 00	513
.614800E 03	.744000E 01	.130000E 00	514
.616800E 03	.719000E 01	.130000E 00	515
.618800E 03	.734000E 01	.130000E 00	516
.620800E 03	.711000E 01	.130000E 00	517
.622800E 03	.736000E 01	.130000E 00	518
.624800E 03	.716000E 01	.130000E 00	519
.626800E 03	.722000E 01	.130000E 00	520
.628800E 03	.719000E 01	.130000E 00	521
.630800E 03	.744000E 01	.130000E 00	522
.632800E 03	.747000E 01	.130000E 00	523
.634800E 03	.735000E 01	.130000E 00	524
.636800E 03	.716000E 01	.130000E 00	525
.638800E 03	.717000E 01	.130000E 00	526
.640800E 03	.709000E 01	.130000E 00	527
.642800E 03	.703000E 01	.130000E 00	528
.644800E 03	.740000E 01	.130000E 00	529
.646800E 03	.747000E 01	.130000E 00	530
.648800E 03	.747000E 01	.160000E 00	531
.648999E 03	.694982E 01	.899150E=01	532
.651823E 03	.654032E 01	.155446E 00	533
.654001E 03	.753805E 01	.109925E 00	534
.656831E 03	.705875E 01	.896910E=01	535
.661839E 03	.695828E 01	.898200E=01	536
.666846E 03	.705560E 01	.898100E=01	537
.671854E 03	.709253E 01	.898740E=01	538
.676862E 03	.702908E 01	.897510E=01	539
.681869E 03	.709467E 01	.899520E=01	540
.686877E 03	.732818E 01	.900630E=01	541
.691884E 03	.714669E 01	.898170E=01	542
.696892E 03	.734269E 01	.899190E=01	543
.701899E 03	.725200E 01	.899740E=01	544
.706906E 03	.731727E 01	.900760E=01	545
.711914E 03	.711649E 01	.902270E=01	546
.716921E 03	.741816E 01	.898750E=01	547
.721928E 03	.709487E 01	.901210E=01	548
.726935E 03	.684662E 01	.899570E=01	549
.731942E 03	.732749E 01	.897840E=01	550
.736949E 03	.730807E 01	.899460E=01	551
.741956E 03	.702897E 01	.901030E=01	552
.746963E 03	.713477E 01	.899620E=01	553
.751970E 03	.711347E 01	.900730E=01	554
.756977E 03	.706628E 01	.900660E=01	555
.761984E 03	.706394E 01	.901300E=01	556
.766991E 03	.704603E 01	.901400E=01	557
.771997E 03	.718717E 01	.902810E=01	558
.777004E 03	.737753E 01	.901650E=01	559
.782011E 03	.747053E 01	.900600E=01	560
.787018E 03	.703525E 01	.903930E=01	561

.792024E 03	.728098E 01	.902450E=01	562
.797031E 03	.728754E 01	.901340E=01	563
.802037E 03	.712023E 01	.899280E=01	564
.807044E 03	.754799E 01	.901270E=01	565
.812050E 03	.713618E 01	.902430E=01	566
.817057E 03	.744250E 01	.901020E=01	567
.822063E 03	.739001E 01	.900380E=01	568
.827070E 03	.753925E 01	.901030E=01	569
.832076E 03	.729323E 01	.903860E=01	570
.837081E 03	.724584E 01	.900760E=01	571
.842089E 03	.722921E 01	.899160E=01	572
.847095E 03	.728205E 01	.900900E=01	573
.852101E 03	.747113E 01	.903220E=01	574
.857107E 03	.735119E 01	.110344E 00	575
.862113E 03	.722975E 01	.901000E=01	576
.867120E 03	.716567E 01	.900610E=01	577
.872126E 03	.730712E 01	.900150E=01	578
.877132E 03	.716638E 01	.902280E=01	579
.882138E 03	.716261E 01	.901180E=01	580
.887144E 03	.728691E 01	.900270E=01	581
.892150E 03	.726903E 01	.900340E=01	582
.897156E 03	.728582E 01	.900900E=01	583
.902162E 03	.697261E 01	.899490E=01	584
.907168E 03	.728893E 01	.898770E=01	585
.912173E 03	.742379E 01	.899850E=01	586
.917179E 03	.715211E 01	.898110E=01	587
.922185E 03	.741539E 01	.897140E=01	588
.927191E 03	.674303E 01	.897960E=01	589
.932197E 03	.730995E 01	.897370E=01	590
.937202E 03	.714265E 01	.898130E=01	591
.942207E 03	.728442E 01	.898870E=01	592
.947214E 03	.723500E 01	.897700E=01	593
.952219E 03	.731464E 01	.898610E=01	594
.957225E 03	.731504E 01	.899140E=01	595
.962231E 03	.706243E 01	.898680E=01	596
.967236E 03	.745660E 01	.895480E=01	597
.972242E 03	.710181E 01	.897350E=01	598
.977247E 03	.735570E 01	.897660E=01	599
.982253E 03	.744756E 01	.895360E=01	600
.987259E 03	.743486E 01	.897070E=01	601
.992264E 03	.757189E 01	.895010E=01	602
.997269E 03	.744623E 01	.894870E=01	603
.100227E 04	.732933E 01	.894910E=01	604
.100727E 04	.715691E 01	.894290E=01	605
.101228E 04	.734630E 01	.894550E=01	606
.101729E 04	.734732E 01	.894260E=01	607
.102229E 04	.734143E 01	.893550E=01	608
.102730E 04	.729935E 01	.893990E=01	609
.103230E 04	.719575E 01	.892140E=01	610
.103731E 04	.727823E 01	.892450E=01	611
.104231E 04	.725820E 01	.892680E=01	612
.104732E 04	.722059E 01	.893270E=01	613
.105232E 04	.737430E 01	.891990E=01	614
.105733E 04	.721150E 01	.890410E=01	615
.106233E 04	.702294E 01	.890530E=01	616
.106734E 04	.736983E 01	.891550E=01	617
.107234E 04	.718837E 01	.109058E 00	618
.107735E 04	.700849E 01	.889370E=01	619
.108235E 04	.724466E 01	.890050E=01	620
.108736E 04	.749781E 01	.890470E=01	621
.109236E 04	.732922E 01	.889600E=01	622
.109737E 04	.714996E 01	.888520E=01	623
.110237E 04	.742123E 01	.890060E=01	624
.110738E 04	.761385E 01	.889880E=01	625

.111238E 04 .736650E 01 .888380E-01
.111739E 04 .722521E 01 .889010E-01
.112239E 04 .725909E 01 .888220E-01
.112740E 04 .721019E 01 .888220E-01
.113240E 04 .728435E 01 .888250E-01
.113741E 04 .752160E 01 .887400E-01
.114241E 04 .743165E 01 .887490E-01
.114742E 04 .718761E 01 .885710E-01
.115242E 04 .745850E 01 .885180E-01
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.116243E 04 .723879E 01 .885790E-01
.116744E 04 .756777E 01 .887190E-01
.117745E 04 .719637E 01 .886320E-01
.118245E 04 .726402E 01 .886880E-01
.118746E 04 .714181E 01 .885950E-01
.119246E 04 .740259E 01 .886490E-01
.119747E 04 .723217E 01 .886020E-01
.120247E 04 .734614E 01 .886800E-01
.120748E 04 .750865E 01 .886360E-01
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.123750E 04 .732414E 01 .885410E-01
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.125252E 04 .714842E 01 .884850E-01
.125752E 04 .721149E 01 .886120E-01
.126253E 04 .732546E 01 .886920E-01
.126753E 04 .723443E 01 .885730E-01
.127254E 04 .728259E 01 .885820E-01
.127754E 04 .743983E 01 .885720E-01
.128254E 04 .721070E 01 .884690E-01
.128755E 04 .726209E 01 .108464E 00
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.129756E 04 .739665E 01 .883330E-01
.130256E 04 .727772E 01 .883810E-01
.130757E 04 .721180E 01 .883260E-01
.131257E 04 .729639E 01 .882910E-01
.131757E 04 .742597E 01 .883360E-01
.132258E 04 .710082E 01 .882730E-01
.132758E 04 .725633E 01 .881670E-01
.133259E 04 .743281E 01 .880840E-01
.133759E 04 .722748E 01 .880850E-01
.134260E 04 .770738E 01 .880620E-01
.134760E 04 .715568E 01 .880520E-01
.135260E 04 .748566E 01 .880750E-01
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.136261E 04 .725300E 01 .880940E-01
.136762E 04 .742656E 01 .881280E-01
.137763E 04 .727073E 01 .881160E-01
.138763E 04 .733560E 01 .880320E-01
.139264E 04 .727200E 01 .879270E-01
.139764E 04 .717381E 01 .880210E-01
.140265E 04 .736978E 01 .879780E-01
.140765E 04 .741296E 01 .879920E-01
.141265E 04 .712914E 01 .879910E-01
.141766E 04 .722802E 01 .879080E-01
.142266E 04 .724666E 01 .879030E-01
.142767E 04 .763760E 01 .880200E-01
.143267E 04 .727289E 01 .878980E-01
.143768E 04 .720623E 01 .879470E-01

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.144268E 04	.731065E 01	.879720E=01	690
.144768E 04	.716394E 01	.879040E=01	691
.145269E 04	.749786E 01	.879950E=01	692
.145769E 04	.725036E 01	.878340E=01	693
.146270E 04	.716412E 01	.878060E=01	694
.146770E 04	.723387E 01	.878560E=01	695
.147270E 04	.737580E 01	.879340E=01	696
.147771E 04	.768428E 01	.879370E=01	697
.148271E 04	.736958E 01	.878670E=01	698
.148771E 04	.700501E 01	.879320E=01	699
.149272E 04	.734804E 01	.879240E=01	700
.149772E 04	.722816E 01	.107579E 00	701

C		702		
C		703		
C	TOTAL CROSS SECTIONS OF HAFNIUM	704		
C	CHECK POINTS USING TIME-OF-FLIGHT TECHNIQUE	705		
C	FORMAT(AS PER ABOVE)	706		
C		707		
C		708		
C	.606667E 03	.731600E 01	.126000E 00	709
C	.805737E 03	.680960E 01	.137000E 00	710
C	.100482E 04	.721900E 01	.157000E 00	711
C	.120405E 04	.774150E 01	.173000E 00	712
C	.140321E 04	.720747E 01	.199000E 00	713

C		714
C	END HAFNIUM DATA BLOCK	715

C		716
C		717
C		718
C		719
C		720
C		721

C	GADOLINIUM DATA BLOCK	722
C	G, SHERWOOD, A. SMITH, J. WHALEN---TO BE PUBLISHED	723

C		724
C		725

C		726
C		727

C	ELASTIC SCATTERING FROM NATURAL GADOLINIUM	DATE 11-68	728
C	FINAL VALUES		729

C	TIME-OF-FLIGHT METHOD	730
C	INCIDENT RESOLUTION ABOUT 20 KEV	731

C	SCATTERED RESOLUTION 1.5 NSEC/M	732
C	ESTIMATED ERROR IN INTEGRATED X*SEC 8 PERCENT INCLUDING STD.	733

C	ERROR IN OMEGA COEF, ESTIMATED FROM LEAST SQ. FITTING.	734
C	FORMAT	735

C	D X*SEC= (X*SEC/ 4*PI)*(1.+ SUM OMEGA*P)	EQ(1)	736
C	SUM FROM 1-5		737

C	P=LEGENDRE POLYNOMIAL IN LAB. SYSTEM	738
C	MEASURED ANGULAR INTERVAL 25-155 DEG. AT EIGHT ANGLES	739

C	ALL DATA CORRECTED FOR MULTIPLE SCATTERING	740
C	ALL RESULTS RELATIVE TO DIF. CARBON X*SEC OF ANL-5567(REV)	741

C		742
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C	FOLLOWING CARD FORMAT 6X, 2I4, 5(I5,I4) , BCD	743
C	WHERE RESPECTIVE VALUES ARE,	744

C	E=N IN KEV	745
C	X*SEC*100	746

C	OMEGA=1 *1000	747
C	D=OMEGA=1*1000	748

C	-----	749
C	OMEGA=5 *1000	750

C	D=OMEGA-5*1000	751
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C INELASTIC SCATTERING FROM GADOLINIUM DATE 11-68 819
C FORMAT( 7E10.4) 820
C RESPECTIVELY== 821
C 1) INCIDENT ENERGY IN MEV 822
C 2) UNCERTAINTY (+-) IN INCIDENT ENERGY 823
C 3) REACTION Q IN MEV 824
C 4) TOTAL UNCERTAINTY IN Q VALUE, USUALLY INTERVAL 825
C OVER WHICH CROSS SECTION IS INTEGRATED, 826
C 5) RESPECTIVE INELASTIC CROSS SECTION, 827
C 6) + ERROR IN CROSS SECTION 828
C 7) - ERROR IN CROSS SECTION 829
C ALL DATA ASSOCIATED WITH ABOVE ELASTIC MEASUREMENTS 830
C ALL DATA RELATIVE TO THE DIFFERENTIAL ELASTIC SCATTERING 831
C CROSS SECTION OF CARBON== ANL=5567(REV) 832
C 833
GD Q=0.080 834
.3200E 00 .1000E=01-.8000E=01 .2000E=01 .8728E 00 .3309E 00 .3309E 00 835
.3300E 00 .1000E=01-.8000E=01 .2000E=01 .1343E 01 .3014E 00 .3014E 00 836
.3400E 00 .1000E=01-.8000E=01 .2000E=01 .1350E 01 .3025E 00 .3025E 00 837
.3500E 00 .1000E=01-.8000E=01 .2000E=01 .1021E 01 .3121E 00 .3121E 00 838
.4000E 00 .1000E=01-.8000E=01 .2000E=01 .9700E 00 .3000E 00 .3000E 00 839
.4400E 00 .1000E=01-.8000E=01 .2000E=01 .1312E 01 .1942E 00 .1942E 00 840
.4500E 00 .1000E=01-.8000E=01 .2000E=01 .9338E 00 .3121E 00 .3121E 00 841
.4600E 00 .1000E=01-.8000E=01 .2000E=01 .1445E 01 .1448E 00 .1448E 00 842
.4700E 00 .1000E=01-.8000E=01 .2000E=01 .1345E 01 .1426E 00 .1426E 00 843
.4800E 00 .1000E=01-.8000E=01 .2000E=01 .1176E 01 .1764E 00 .1764E 00 844
.4900E 00 .1000E=01-.8000E=01 .2000E=01 .1244E 01 .1866E 00 .1866E 00 845
.5000E 00 .1000E=01-.8000E=01 .2000E=01 .1130E 01 .1734E 00 .1734E 00 846
.5100E 00 .1000E=01-.8000E=01 .2000E=01 .1345E 01 .2017E 00 .2017E 00 847
.5200E 00 .1000E=01-.8000E=01 .2000E=01 .1155E 01 .1733E 00 .1733E 00 848
.5300E 00 .1000E=01-.8000E=01 .2000E=01 .1421E 01 .2131E 00 .2131E 00 849
.5400E 00 .1000E=01-.8000E=01 .2000E=01 .1410E 01 .1049E 00 .1049E 00 850
.5500E 00 .1000E=01-.8000E=01 .2000E=01 .1341E 01 .1422E 00 .1422E 00 851
.5600E 00 .1000E=01-.8000E=01 .2000E=01 .1457E 01 .1093E 00 .1093E 00 852
.5700E 00 .1000E=01-.8000E=01 .2000E=01 .1405E 01 .2108E 00 .2108E 00 853
.5800E 00 .1000E=01-.8000E=01 .2000E=01 .1413E 01 .1335E 00 .1335E 00 854
.5900E 00 .1000E=01-.8000E=01 .2000E=01 .1532E 01 .2299E 00 .2299E 00 855
.6000E 00 .1000E=01-.8000E=01 .2000E=01 .1498E 01 .1018E 00 .1018E 00 856
.6200E 00 .1000E=01-.8000E=01 .2000E=01 .1380E 01 .1171E 00 .1171E 00 857
.6400E 00 .1000E=01-.8000E=01 .2000E=01 .1303E 01 .1105E 00 .1105E 00 858
.6600E 00 .1000E=01-.8000E=01 .2000E=01 .1354E 01 .1148E 00 .1148E 00 859
.6800E 00 .1000E=01-.8000E=01 .2000E=01 .1471E 01 .1250E 00 .1250E 00 860
.7000E 00 .1000E=01-.8000E=01 .2000E=01 .1398E 01 .1257E 00 .1257E 00 861
.7500E 00 .1000E=01-.8000E=01 .2000E=01 .1450E 01 .3000E 00 .3000E 00 862
.7999E 00 .1000E=01-.8000E=01 .2000E=01 .1453E 01 .1437E 00 .1437E 00 863
.8200E 00 .1000E=01-.8000E=01 .2000E=01 .1345E 01 .1427E 00 .1427E 00 864
.8400E 00 .1000E=01-.8000E=01 .2000E=01 .1561E 01 .1656E 00 .1656E 00 865
.8499E 00 .1000E=01-.8000E=01 .2000E=01 .1410E 01 .3000E 00 .3000E 00 866
.8600E 00 .1000E=01-.8000E=01 .2000E=01 .1499E 01 .1590E 00 .1590E 00 867
.8800E 00 .1000E=01-.8000E=01 .2000E=01 .1383E 01 .1468E 00 .1468E 00 868
.8999E 00 .1000E=01-.8000E=01 .2000E=01 .1389E 01 .1397E 00 .1397E 00 869
.9200E 00 .1000E=01-.8000E=01 .2000E=01 .1482E 01 .1571E 00 .1571E 00 870
.9566E 00 .1000E=01-.8000E=01 .2000E=01 .1383E 01 .1392E 00 .1392E 00 871
.9800E 00 .1000E=01-.8000E=01 .2000E=01 .1431E 01 .1518E 00 .1518E 00 872
.1000E 01 .1000E=01-.8000E=01 .2000E=01 .1422E 01 .1508E 00 .1508E 00 873
.1020E 01 .1000E=01-.8000E=01 .2000E=01 .1421E 01 .1507E 00 .1507E 00 874
.1040E 01 .1000E=01-.8000E=01 .2000E=01 .1371E 01 .1454E 00 .1454E 00 875
.1060E 01 .1000E=01-.8000E=01 .2000E=01 .1302E 01 .1249E 00 .1249E 00 876
.1080E 01 .1000E=01-.8000E=01 .2000E=01 .1463E 01 .1551E 00 .1551E 00 877
.1100E 01 .1000E=01-.8000E=01 .2000E=01 .1392E 01 .1477E 00 .1477E 00 878
.1140E 01 .1000E=01-.8000E=01 .2000E=01 .1412E 01 .1498E 00 .1498E 00 879
.1160E 01 .1000E=01-.8000E=01 .2000E=01 .1406E 01 .2091E 00 .2091E 00 880
.1200E 01 .1000E=01-.8000E=01 .2000E=01 .1246E 01 .3322E 00 .3322E 00 881
.1220E 01 .1000E=01-.8000E=01 .2000E=01 .1188E 01 .2560E 00 .2560E 00 882

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.1240E 01	.1000E=01	.8000E=01	.2000E=01	.1132E 01	.2702E 00	.2702E 00	883
.1260E 01	.1000E=01	.8000E=01	.2000E=01	.1169E 01	.2526E 00	.2526E 00	884
.1280E 01	.1000E=01	.8000E=01	.2000E=01	.1155E 01	.2826E 00	.2826E 00	885
.1300E 01	.1000E=01	.8000E=01	.2000E=01	.1095E 01	.3010E 00	.3010E 00	886
.1320E 01	.1000E=01	.8000E=01	.2000E=01	.1043E 01	.3602E=00	.3602E=00	887
							888
GD Q=-260+-40 KEV,							889
.7000E 00	.1000E=01	.2600E 00	.4000E=01	.4315E 00	.9470E=01	.9470E=01	890
.8000E 00	.1000E=01	.2600E 00	.4000E=01	.2346E 00	.9519E=01	.9519E=01	891
.1020E 01	.1000E=01	.2600E 00	.4000E=01	.5215E 00	.9532E=01	.9532E=01	892
.1040E 01	.1000E=01	.2600E 00	.4000E=01	.4691E 00	.9979E=01	.9979E=01	893
.1050E 01	.1000E=01	.2600E 00	.4000E=01	.4350E 00	.2000E 00	.2000E 00	894
.1060E 01	.1000E=01	.2600E 00	.4000E=01	.5064E 00	.9595E=01	.9595E=01	895
.1100E 01	.1000E=01	.2600E 00	.4000E=01	.5616E 00	.9963E=01	.9963E=01	896
.1140E 01	.1000E=01	.2600E 00	.4000E=01	.4037E 00	.9281E=01	.9281E=01	897
.1160E 01	.1000E=01	.2600E 00	.4000E=01	.4220E 00	.9476E=01	.9476E=01	898
.1180E 01	.1000E=01	.2600E 00	.4000E=01	.3826E 00	.9059E=01	.9059E=01	899
.1199E 01	.1000E=01	.2600E 00	.4000E=01	.3948E 00	.9661E=01	.9661E=01	900
.1220E 01	.1000E=01	.2600E 00	.4000E=01	.4212E 00	.9468E=01	.9468E=01	901
.1240E 01	.1000E=01	.2600E 00	.4000E=01	.4180E 00	.9434E=01	.9434E=01	902
.1260E 01	.1000E=01	.2600E 00	.4000E=01	.4077E 00	.9621E=01	.9621E=01	903
.1280E 01	.1000E=01	.2600E 00	.4000E=01	.4407E 00	.9034E=01	.9034E=01	904
.1300E 01	.1000E=01	.2600E 00	.4000E=01	.4265E 00	.9202E=01	.9202E=01	905
.1320E 01	.1000E=01	.2600E 00	.4000E=01	.3877E 00	.9113E=01	.9113E=01	906
.1340E 01	.1000E=01	.2600E 00	.4000E=01	.4366E 00	.9633E=01	.9633E=01	907
.1400E 01	.1000E=01	.2600E 00	.4000E=01	.4182E 00	.9249E=01	.9249E=01	908
.1420E 01	.1000E=01	.2600E 00	.4000E=01	.3836E 00	.9069E=01	.9069E=01	909
.1450E 01	.1000E=01	.2600E 00	.4000E=01	.3472E 00	.9683E=01	.9683E=01	910
.1480E 01	.1000E=01	.2600E 00	.4000E=01	.4683E 00	.9161E=01	.9161E=01	911
.1500E 01	.1000E=01	.2600E 00	.4000E=01	.3968E 00	.9726E=01	.9726E=01	912
							913
GD Q=-350 +- 40 KEV WEAK							914
.8000E 00	.1000E=01	.3500E 00	.4000E=01	.1361E 00	.8042E=01	.8042E=01	915
.1100E 01	.1000E=01	.3500E 00	.4000E=01	.1584E 00	.8480E=01	.8480E=01	916
.1200E 01	.1000E=01	.3500E 00	.4000E=01	.4686E=01	.3900E=01	.3900E=01	917
.1450E 01	.1000E=01	.3500E 00	.4000E=01	.3472E=01	.3683E=01	.3683E=01	918
							919
GD Q=-430 +- 30 KEV WEAK							920
.1100E 01	.1000E=01	.4300E 00	.3000E=01	.1483E 00	.5990E=01	.5990E=01	921
.1200E 01	.1000E=01	.4300E 00	.3000E=01	.9128E=01	.5047E=01	.5047E=01	922
.1300E 01	.1000E=01	.4300E 00	.3000E=01	.1210E 00	.5628E=01	.5628E=01	923
							924
GD Q=-500+-30, VERY DOUBTFUL 2ND GROUP CORR.							925
.1400E 01	.2000E=01	.5000E 00	.4000E=01	.8704E=01	.1575E 00	.1575E 00	926
.1500E 01	.2000E=01	.5000E 00	.4000E=01	.1430E 00	.1514E 00	.1514E 00	927
.1400E 01	.2000E=01	.5000E 00	.4000E=01	.1419E 00	.1571E 00	.1571E 00	928
							929
GD Q=-870+-50 KEV							930
.1300E 01	.1000E=01	.8700E 00	.5000E=01	.1154E 00	.5886E=01	.5886E=01	931
.1400E 01	.1000E=01	.8700E 00	.5000E=01	.1437E 00	.5096E=01	.5096E=01	932
.1450E 01	.1000E=01	.8700E 00	.5000E=01	.5255E=01	.4162E=01	.4162E=01	933
.1500E 01	.1000E=01	.8700E 00	.5000E=01	.6740E=01	.4348E=01	.4348E=01	934
							935
GD Q= COMPOSITE OF STATES NEAR 1.10+-0.1 MEV							936
1.500+000	2.000-002	-1.100+000	2.000-002	4.700-001	1.535-001	1.535-001	937
							938
							939
							940

C	TOTAL CROSS SECTIONS OF GADOLINIUM				941
C	MONOENERGETIC SOURCE METHOD				942
C	RESOLUTION 2-3 KEV				943
C	FORMAT(3E12.6)				944
C	ENERGY IN KEV				945
C	XSEC IN BARNS				946
C	ERROR IN XSEC IN BARNS				947
C					948
	.999999E	02	.863000E	01 .150000E 00	949
	.101100E	03	.869000E	01 .150000E 00	950
	.102100E	03	.866000E	01 .150000E 00	951
	.103100E	03	.840000E	01 .150000E 00	952
	.104100E	03	.858000E	01 .150000E 00	953
	.105100E	03	.868000E	01 .150000E 00	954
	.106200E	03	.831000E	01 .140000E 00	955
	.107200E	03	.831000E	01 .150000E 00	956
	.108200E	03	.811000E	01 .140000E 00	957
	.109200E	03	.836000E	01 .140000E 00	958
	.110200E	03	.824000E	01 .140000E 00	959
	.111200E	03	.809000E	01 .140000E 00	960
	.112300E	03	.835000E	01 .140000E 00	961
	.114300E	03	.818000E	01 .140000E 00	962
	.115300E	03	.863000E	01 .140000E 00	963
	.116300E	03	.842000E	01 .140000E 00	964
	.117300E	03	.844000E	01 .140000E 00	965
	.118300E	03	.815000E	01 .140000E 00	966
	.119300E	03	.870000E	01 .140000E 00	967
	.120300E	03	.811000E	01 .140000E 00	968
	.121300E	03	.824000E	01 .140000E 00	969
	.122400E	03	.832000E	01 .140000E 00	970
	.123400E	03	.799999E	01 .140000E 00	971
	.124400E	03	.819000E	01 .140000E 00	972
	.125400E	03	.785000E	01 .140000E 00	973
	.126400E	03	.789000E	01 .140000E 00	974
	.127400E	03	.864000E	01 .140000E 00	975
	.128400E	03	.813000E	01 .140000E 00	976
	.129400E	03	.823000E	01 .140000E 00	977
	.130400E	03	.845000E	01 .140000E 00	978
	.131400E	03	.819000E	01 .140000E 00	979
	.132400E	03	.820000E	01 .140000E 00	980
	.133400E	03	.846000E	01 .140000E 00	981
	.134400E	03	.812000E	01 .140000E 00	982
	.135400E	03	.793000E	01 .140000E 00	983
	.136400E	03	.809000E	01 .140000E 00	984
	.137499E	03	.809000E	01 .140000E 00	985
	.138499E	03	.797000E	01 .140000E 00	986
	.139499E	03	.821000E	01 .140000E 00	987
	.140499E	03	.829000E	01 .140000E 00	988
	.141499E	03	.807000E	01 .140000E 00	989
	.142499E	03	.839000E	01 .140000E 00	990
	.143499E	03	.816000E	01 .140000E 00	991
	.144499E	03	.819000E	01 .140000E 00	992
	.145499E	03	.790000E	01 .140000E 00	993
	.146499E	03	.781000E	01 .140000E 00	994
	.147499E	03	.796000E	01 .140000E 00	995
	.148499E	03	.801000E	01 .140000E 00	996
	.149499E	03	.780000E	01 .140000E 00	997
	.150499E	03	.786000E	01 .140000E 00	998
	.151499E	03	.817000E	01 .140000E 00	999
	.152499E	03	.804000E	01 .140000E 00	1000
	.153499E	03	.801000E	01 .140000E 00	1001
	.154499E	03	.790000E	01 .140000E 00	1002
	.155499E	03	.767000E	01 .140000E 00	1003
	.156600E	03	.765000E	01 .249999E 00	1004

.157600E 03	.779000E 01	.140000E 00	1005
.158600E 03	.808000E 01	.140000E 00	1006
.159600E 03	.771000E 01	.140000E 00	1007
.160600E 03	.797000E 01	.140000E 00	1008
.161600E 03	.777000E 01	.140000E 00	1009
.162600E 03	.779000E 01	.140000E 00	1010
.163600E 03	.802000E 01	.140000E 00	1011
.164600E 03	.804000E 01	.140000E 00	1012
.165600E 03	.784000E 01	.140000E 00	1013
.166600E 03	.799999E 01	.140000E 00	1014
.167600E 03	.778000E 01	.140000E 00	1015
.168600E 03	.789000E 01	.140000E 00	1016
.169600E 03	.809000E 01	.140000E 00	1017
.170600E 03	.811000E 01	.140000E 00	1018
.171600E 03	.789000E 01	.140000E 00	1019
.172600E 03	.807000E 01	.140000E 00	1020
.173600E 03	.777000E 01	.140000E 00	1021
.174600E 03	.799000E 01	.140000E 00	1022
.175600E 03	.808000E 01	.140000E 00	1023
.176600E 03	.782000E 01	.140000E 00	1024
.177600E 03	.785000E 01	.140000E 00	1025
.178600E 03	.779000E 01	.140000E 00	1026
.179600E 03	.782000E 01	.140000E 00	1027
.180600E 03	.776000E 01	.140000E 00	1028
.181600E 03	.789000E 01	.140000E 00	1029
.182600E 03	.793000E 01	.140000E 00	1030
.183700E 03	.764000E 01	.140000E 00	1031
.184700E 03	.779000E 01	.140000E 00	1032
.185700E 03	.787000E 01	.140000E 00	1033
.186700E 03	.771000E 01	.140000E 00	1034
.187700E 03	.772000E 01	.140000E 00	1035
.188700E 03	.759000E 01	.140000E 00	1036
.189700E 03	.804000E 01	.140000E 00	1037
.190700E 03	.778000E 01	.140000E 00	1038
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.192700E 03	.792000E 01	.140000E 00	1040
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.194700E 03	.766000E 01	.140000E 00	1042
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.199700E 03	.780000E 01	.140000E 00	1047
.200700E 03	.772000E 01	.140000E 00	1048
.201700E 03	.803000E 01	.140000E 00	1049
.202700E 03	.762000E 01	.140000E 00	1050
.203700E 03	.780000E 01	.140000E 00	1051
.204700E 03	.799999E 01	.140000E 00	1052
.205700E 03	.752000E 01	.140000E 00	1053
.206700E 03	.756000E 01	.140000E 00	1054
.207700E 03	.760000E 01	.140000E 00	1055
.208700E 03	.751000E 01	.140000E 00	1056
.209700E 03	.766000E 01	.140000E 00	1057
.210700E 03	.765000E 01	.140000E 00	1058
.211700E 03	.758000E 01	.140000E 00	1059
.212700E 03	.794000E 01	.140000E 00	1060
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.214700E 03	.760000E 01	.140000E 00	1062
.215700E 03	.780000E 01	.140000E 00	1063
.216700E 03	.754000E 01	.140000E 00	1064
.217700E 03	.761000E 01	.140000E 00	1065
.218800E 03	.746000E 01	.140000E 00	1066
.219800E 03	.756000E 01	.140000E 00	1067
.220800E 03	.770000E 01	.140000E 00	1068

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.222800E 03	.754000E 01	.140000E 00	1070
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.224800E 03	.759000E 01	.140000E 00	1072
.225800E 03	.746000E 01	.140000E 00	1073
.226800E 03	.767000E 01	.140000E 00	1074
.227800E 03	.745000E 01	.140000E 00	1075
.228800E 03	.755000E 01	.140000E 00	1076
.229800E 03	.769000E 01	.140000E 00	1077
.230800E 03	.757000E 01	.140000E 00	1078
.231800E 03	.767000E 01	.140000E 00	1079
.232800E 03	.784000E 01	.140000E 00	1080
.233800E 03	.785000E 01	.140000E 00	1081
.234800E 03	.778000E 01	.140000E 00	1082
.235800E 03	.750000E 01	.140000E 00	1083
.236800E 03	.756000E 01	.140000E 00	1084
.237800E 03	.755000E 01	.140000E 00	1085
.238800E 03	.758000E 01	.140000E 00	1086
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.241800E 03	.719000E 01	.140000E 00	1089
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.244800E 03	.743000E 01	.140000E 00	1092
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.248800E 03	.729000E 01	.140000E 00	1096
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.250800E 03	.709000E 01	.240000E 00	1098
.251800E 03	.742000E 01	.170000E 00	1099
.252800E 03	.750000E 01	.140000E 00	1100
.253800E 03	.752000E 01	.140000E 00	1101
.254800E 03	.728000E 01	.140000E 00	1102
.255800E 03	.722000E 01	.140000E 00	1103
.256800E 03	.757000E 01	.140000E 00	1104
.257800E 03	.740000E 01	.140000E 00	1105
.258800E 03	.747000E 01	.140000E 00	1106
.259800E 03	.755000E 01	.140000E 00	1107
.260800E 03	.748000E 01	.140000E 00	1108
.261800E 03	.742000E 01	.140000E 00	1109
.262800E 03	.755000E 01	.140000E 00	1110
.263900E 03	.761000E 01	.140000E 00	1111
.264900E 03	.741000E 01	.140000E 00	1112
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.268900E 03	.757000E 01	.140000E 00	1116
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.270900E 03	.729000E 01	.140000E 00	1118
.271900E 03	.724999E 01	.140000E 00	1119
.272900E 03	.758000E 01	.140000E 00	1120
.273900E 03	.763000E 01	.140000E 00	1121
.274900E 03	.735000E 01	.140000E 00	1122
.275900E 03	.743000E 01	.130000E 00	1123
.276900E 03	.752000E 01	.140000E 00	1124
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.278900E 03	.766000E 01	.140000E 00	1126
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.280900E 03	.727000E 01	.119999E 00	1128
.281900E 03	.747000E 01	.140000E 00	1129
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.284900E 03	.752000E 01	.170000E 00	1132

.284900E 03	.739000E 01	.140000E 00	1133
.285900E 03	.737000E 01	.170000E 00	1134
.286900E 03	.736000E 01	.130000E 00	1135
.287900E 03	.769000E 01	.140000E 00	1136
.288900E 03	.759000E 01	.240000E 00	1137
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.302100E 03	.750000E 01	.130000E 00	1151
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.306200E 03	.740000E 01	.130000E 00	1154
.307200E 03	.722000E 01	.130000E 00	1155
.308200E 03	.736000E 01	.130000E 00	1156
.309200E 03	.757000E 01	.130000E 00	1157
.313200E 03	.743000E 01	.170000E 00	1158
.314200E 03	.745000E 01	.130000E 00	1159
.315200E 03	.770000E 01	.130000E 00	1160
.316200E 03	.746000E 01	.130000E 00	1161
.317200E 03	.732000E 01	.130000E 00	1162
.318200E 03	.716000E 01	.130000E 00	1163
.319200E 03	.735000E 01	.130000E 00	1164
.320200E 03	.739000E 01	.130000E 00	1165
.321200E 03	.724000E 01	.130000E 00	1166
.322200E 03	.720000E 01	.130000E 00	1167
.323200E 03	.747000E 01	.130000E 00	1168
.324200E 03	.750000E 01	.130000E 00	1169
.325200E 03	.741000E 01	.130000E 00	1170
.326200E 03	.724999E 01	.130000E 00	1171
.327200E 03	.749000E 01	.130000E 00	1172
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.330200E 03	.722000E 01	.130000E 00	1175
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.333200E 03	.736000E 01	.130000E 00	1177
.334200E 03	.747000E 01	.130000E 00	1178
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.336200E 03	.749000E 01	.130000E 00	1180
.337200E 03	.740000E 01	.130000E 00	1181
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.339200E 03	.719000E 01	.130000E 00	1183
.340200E 03	.751000E 01	.130000E 00	1184
.341200E 03	.721000E 01	.130000E 00	1185
.342200E 03	.745000E 01	.130000E 00	1186
.343200E 03	.761000E 01	.130000E 00	1187
.344200E 03	.744000E 01	.130000E 00	1188
.345200E 03	.749000E 01	.130000E 00	1189
.346200E 03	.750000E 01	.130000E 00	1190
.348200E 03	.724999E 01	.130000E 00	1191
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.353200E 03	.735000E 01	.130000E 00	1196

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.358200E 03	.761000E 01	.130000E 00	1201
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.360200E 03	.741000E 01	.130000E 00	1203
.361200E 03	.734000E 01	.130000E 00	1204
.362200E 03	.744000E 01	.130000E 00	1205
.363200E 03	.748000E 01	.130000E 00	1206
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.366200E 03	.702000E 01	.130000E 00	1209
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.369200E 03	.707000E 01	.130000E 00	1212
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.371200E 03	.710000E 01	.130000E 00	1214
.372200E 03	.745000E 01	.130000E 00	1215
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.377200E 03	.714000E 01	.130000E 00	1220
.378200E 03	.711000E 01	.240000E 00	1221
.381400E 03	.692000E 01	.240000E 00	1222
.382400E 03	.731000E 01	.130000E 00	1223
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.113815E	04	,733392E	01	,960870E=01	1583
.114314E	04	,739010E	01	,166071E 00	1584
.114815E	04	,748225E	01	,959400E=01	1585
.115316E	04	,711231E	01	,958590E=01	1586
.115816E	04	,739912E	01	,958080E=01	1587
.116317E	04	,727540E	01	,958310E=01	1588
.116817E	04	,729543E	01	,959260E=01	1589
.117317E	04	,728060E	01	,958930E=01	1590
.117818E	04	,700178E	01	,958080E=01	1591
.118318E	04	,714699E	01	,958130E=01	1592
.118818E	04	,710161E	01	,957840E=01	1593
.119319E	04	,723603E	01	,956420E=01	1594
.119819E	04	,737541E	01	,957700E=01	1595
.120319E	04	,717613E	01	,957710E=01	1596
.120820E	04	,714792E	01	,957420E=01	1597
.121320E	04	,713218E	01	,956290E=01	1598
.121820E	04	,722683E	01	,956630E=01	1599
.122321E	04	,705381E	01	,956570E=01	1600
.122821E	04	,753832E	01	,955800E=01	1601
.123321E	04	,747583E	01	,955510E=01	1602
.123822E	04	,725218E	01	,956570E=01	1603
.124322E	04	,707586E	01	,955450E=01	1604
.124822E	04	,716190E	01	,955340E=01	1605
.125323E	04	,740697E	01	,955240E=01	1606
.125823E	04	,732030E	01	,956610E=01	1607
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.126823E	04	,713012E	01	,955190E=01	1609
.127324E	04	,699505E	01	,954480E=01	1610
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.128825E	04	,698637E	01	,116792E 00	1613
.129325E	04	,708485E	01	,953510E=01	1614
.129825E	04	,737917E	01	,954040E=01	1615
.131326E	04	,722395E	01	,952170E=01	1616
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.132827E	04	,695821E	01	,950740E=01	1618
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.133828E	04	,715149E	01	,951510E=01	1620
.134328E	04	,735174E	01	,951970E=01	1621
.134828E	04	,729360E	01	,951390E=01	1622
.135329E	04	,689829E	01	,950180E=01	1623
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.136830E	04	,702430E	01	,949150E=01	1625
.137330E	04	,749941E	01	,948320E=01	1626
.137830E	04	,727333E	01	,948180E=01	1627
.138331E	04	,724650E	01	,948670E=01	1628
.138831E	04	,729588E	01	,947440E=01	1629
.139331E	04	,711872E	01	,947200E=01	1630
.139831E	04	,712930E	01	,947520E=01	1631
.140332E	04	,718138E	01	,948000E=01	1632
.140832E	04	,721233E	01	,948120E=01	1633
.141332E	04	,718534E	01	,948560E=01	1634
.141833E	04	,728114E	01	,948550E=01	1635
.142333E	04	,728399E	01	,947960E=01	1636
.142832E	04	,731648E	01	,164305E 00	1637
.142833E	04	,738978E	01	,116106E 00	1638
.143334E	04	,705716E	01	,949450E=01	1639
.143834E	04	,736933E	01	,948370E=01	1640
.144334E	04	,713873E	01	,948510E=01	1641
.144834E	04	,702031E	01	,949470E=01	1642
.145335E	04	,696754E	01	,949600E=01	1643
.145835E	04	,731914E	01	,949730E=01	1644
.146335E	04	,719318E	01	,949850E=01	1645
.146836E	04	,701062E	01	,949640E=01	1646

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.147836E 04 ,679127E 01 ,950090E-01      1648
.148336E 04 ,692856E 01 ,948670E-01      1649
.148837E 04 ,741597E 01 ,948520E-01      1650
.149337E 04 ,749825E 01 ,948070E-01      1651
.149837E 04 ,725394E 01 ,948080E-01      1652
C                                           1653
C                                           1654
C                                           1655
C      TOTAL CROSS SECTIONS OF GADOLINIUM      1656
C      CHECK POINTS USING TIME-OF-FLIGHT TECHNIQUE 1657
C      FORMAT( AS PER ABOVE )                  1658
C                                           1659
.606667E 03 ,697800E 01 ,135000E 00      1660
.805737E 03 ,696000E 01 ,146000E 00      1661
+.100482E+04+.747100E+01+.167000E+00      1662
.120405E 04 ,671800E 01 ,183000E 00      1663
.140321E 04 ,694400E 01 ,212000E 00      1664
C                                           1665
C                                           1666
C      END GADOLINIUM DATA BLOCK              1667
C                                           1668
C                                           1669
C                                           1670
C                                           1671
C                                           1672

C      SAMARIUM DATA BLOCK                    1673
C      G, SHERWOOD, A, SMITH, J, WHALEN---TO BE PUBLISHED 1674
C                                           1675
C                                           1676
C                                           1677
C                                           1678
C                                           1679
C      ELASTIC SCATTERING FROM NATURAL SAMARIUM      DATE 11-68 1680
C      FINAL VALUES                              1681
C      TIME-OF-FLIGHT METHOD                        1682
C      INCIDENT RESOLUTION ABOUT 20 KEV             1683
C      SCATTERED RESOLUTION 1.5 NSEC/M              1684
C      ESTIMATED ERROR IN INTEGRATED X-SEC A PERCENT INCLUDING STD. 1685
C      ERROR IN OMEGA COEF. ESTIMATED FROM LEAST SQ. FITTING. 1686
C      FORMAT                                         1687
C      D X=SEC= (X-SEC/ 4*PI)*(1,+ SUM OMEGA*P)      EQ(1) 1688
C      SUM FROM 1-5                                  1689
C      P=LEGENDRE POLYNOMIAL IN LAB. SYSTEM          1690
C      MEASURED ANGULAR INTERVAL 25-155 DEG. AT EIGHT ANGLES 1691
C      ALL DATA CORRECTED FOR MULTIPLE SCATTERING    1692
C      ALL RESULTS RELATIVE TO DIF, CARBON X-SEC OF ANL-5567(REV) 1693
C      FOLLOWING CARD FORMAT 6X, 214, 5(15,14) , BCD 1694
C      WHERE RESPECTIVE VALUES ARE,                 1695
C      E=N IN KEV                                     1696
C      X=SEC*100                                       1697
C      OMEGA=1 *1000                                  1698
C      D=OMEGA=1*1000                                1699
C      -----                                         1700
C      OMEGA=5 *1000                                  1701
C      D=OMEGA=5*1000                                1702
C      FOLLOWING EQ(1) ABOVE.                          1703
C                                           1704
303 618 887 88 381 57 105 69 -30 90      1705
325 657 934 93 471 86 194 105 21 141      1706
345 616 914 91 697 69 114 55 213 74      1707
365 645 824 82 734 73 -57 63 108 84      1708

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385	628	838	83	717	72	115	88	180	118	0	0	1709
405	607	980	98	759	75	222	70	169	94	0	0	1710
425	593	887	88	771	77	84	72	-39	96	0	0	1711
446	623	940	94	790	79	159	83	7	102	0	0	1712
465	590	1011	101	874	87	155	50	25	50	0	0	1713
485	643	933	93	821	82	184	60	82	80	0	0	1714
505	615	931	93	883	88	175	74	-25	99	0	0	1715
525	618	905	90	874	87	214	50	-1	50	0	0	1716
545	620	972	97	945	94	226	60	90	80	0	0	1717
565	631	1033	103	1004	100	265	50	97	54	0	0	1718
585	607	1014	101	1039	103	232	50	24	50	0	0	1719
605	624	1019	101	1019	101	207	100	125	67	0	0	1720
620	659	1004	100	1123	112	236	100	171	55	0	0	1721
646	622	1057	105	1090	109	328	100	110	51	0	0	1722
665	607	1026	102	1112	111	302	100	157	50	0	0	1723
685	609	1055	105	1177	117	332	106	80	88	0	0	1724
705	597	1083	108	1168	116	314	100	63	50	0	0	1725
725	592	1061	106	1178	117	241	103	87	72	0	0	1726
755	601	1093	109	1224	122	406	103	148	70	0	0	1727
775	558	1078	197	1270	127	357	135	-16	87	0	0	1728
795	570	1125	192	1350	135	470	133	109	97	0	0	1729
815	565	1177	197	1344	134	506	150	208	120	0	0	1730
860	567	1355	195	1506	150	687	126	391	169	0	0	1731
880	573	1345	194	1542	154	636	76	277	102	0	0	1732
900	578	1412	191	1664	166	729	122	271	52	0	0	1733
920	555	1419	191	1707	170	825	115	478	154	0	0	1734
940	530	1438	193	1721	172	825	158	494	211	0	0	1735
980	576	1408	190	1764	176	875	152	467	150	0	0	1736
1000	564	1335	193	1755	175	858	128	491	171	0	0	1737
1020	521	1332	193	1767	176	933	93	527	157	0	0	1738
1040	561	1387	198	1866	186	975	97	587	162			1739
1080	565	1348	194	1733	173	811	161	414	105			1740
1100	597	1448	194	1811	181	950	95	466	153	0	0	1741
1120	557	1425	142	1771	177	979	97	547	153			1742
1140	576	1478	147	1782	178	930	93	434	100			1743
1160	540	1448	144	1853	185	1016	151	495	158			1744
1180	539	1438	143	1779	177	870	157	288	145			1745
1200	556	1495	149	1880	188	995	99	441	142			1746
1220	568	1515	151	1819	181	945	144	367	150	0	0	1747
1240	586	1470	147	1853	185	866	146	357	150			1748
1260	550	1500	150	1950	195	950	165	360	200	0	0	1749
1300	547	1594	159	1817	181	926	172	397	165	18	167	1750
1320	551	1643	164	1973	197	1190	169	647	150	0	0	1751
1340	558	1674	167	2081	208	1285	128	562	150	130	162	1752
1360	560	1731	173	2122	212	1379	149	723	192	350	263	1753
1400	546	1703	170	2173	217	1364	136	749	150	158	159	1754
1420	517	1896	189	2316	231	1464	146	777	133	421	185	1755
1440	518	1695	169	2253	225	1435	143	853	185	211	170	1756
1460	564	1698	169	2210	221	1399	139	683	168	306	186	1757
1480	532	1737	173	2133	213	1540	154	696	150	150	150	1758
1500	538	1821	182	2281	228	1538	153	682	150	470	120	1759

C INELASTIC SCATTERING FROM SAMARIUM DATE 11-68
 C FORMAT(7E10.4)
 C RESPECTIVELY---
 C 1) INCIDENT ENERGY IN MEV
 C 2) UNCERTAINTY (+-) IN INCIDENT ENERGY
 C 3) REACTION Q IN MEV
 C 4) TOTAL UNCERTAINTY IN Q VALUE, USUALLY INTERVAL
 C OVER WHICH CROSS SECTION IS INTEGRATED.
 C 5) RESPECTIVE INELASTIC CROSS SECTION.
 C 6) + ERROR IN CROSS SECTION
 C 7) - ERROR IN CROSS SECTION
 C ALL DATA ASSOCIATED WITH ABOVE ELASTIC MEASUREMENTS

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C	ALL DATA RELATIVE TO THE DIFFERENTIAL ELASTIC SCATTERING													1773	
C	CROSS SECTION OF CARBON== ANL-5567(REV)													1774	
C														1775	
C	SM Q=100 KEV													1776	
	.5200E	00	.2000E	01	-.1000E	00	.2000E	01	.8848E	00	.1806E	00	.1806E	00	1777
	.5400E	00	.2000E	01	-.1000E	00	.2000E	01	.8339E	00	.1251E	00	.1251E	00	1778
	.5450E	00	.2000E	01	-.1000E	00	.2000E	01	.7948E	00	.1192E	00	.1192E	00	1779
	.5500E	00	.2000E	01	-.1000E	00	.2000E	01	.8785E	00	.1098E	00	.1098E	00	1780
	.5550E	00	.2000E	01	-.1000E	00	.2000E	01	.8630E	00	.1294E	00	.1294E	00	1781
	.5600E	00	.2000E	01	-.1000E	00	.2000E	01	.8303E	00	.1245E	00	.1245E	00	1782
	.5650E	00	.2000E	01	-.1000E	00	.2000E	01	.8220E	00	.1233E	00	.1233E	00	1783
	.5700E	00	.2000E	01	-.1000E	00	.2000E	01	.8165E	00	.1224E	00	.1224E	00	1784
	.5750E	00	.2000E	01	-.1000E	00	.2000E	01	.8605E	00	.1290E	00	.1290E	00	1785
	.5800E	00	.2000E	01	-.1000E	00	.2000E	01	.8918E	00	.1337E	00	.1337E	00	1786
	.5850E	00	.2000E	01	-.1000E	00	.2000E	01	.8857E	00	.1328E	00	.1328E	00	1787
	.5900E	00	.2000E	01	-.1000E	00	.2000E	01	.8761E	00	.1314E	00	.1314E	00	1788
	.5950E	00	.2000E	01	-.1000E	00	.2000E	01	.9292E	00	.1393E	00	.1393E	00	1789
	.6000E	00	.2000E	01	-.1000E	00	.2000E	01	.8459E	00	.1175E	00	.1175E	00	1790
	.6050E	00	.2000E	01	-.1000E	00	.2000E	01	.7658E	00	.1148E	00	.1148E	00	1791
	.6100E	00	.2000E	01	-.1000E	00	.2000E	01	.7719E	00	.1157E	00	.1157E	00	1792
	.6150E	00	.2000E	01	-.1000E	00	.2000E	01	.9535E	00	.1430E	00	.1430E	00	1793
	.6200E	00	.2000E	01	-.1000E	00	.2000E	01	.8075E	00	.1211E	00	.1211E	00	1794
	.6249E	00	.2000E	01	-.1000E	00	.2000E	01	.8332E	00	.1249E	00	.1249E	00	1795
	.6300E	00	.2000E	01	-.1000E	00	.2000E	01	.9639E	00	.1445E	00	.1445E	00	1796
	.6350E	00	.2000E	01	-.1000E	00	.2000E	01	.9543E	00	.1431E	00	.1431E	00	1797
	.6400E	00	.2000E	01	-.1000E	00	.2000E	01	.8224E	00	.1233E	00	.1233E	00	1798
	.6450E	00	.2000E	01	-.1000E	00	.2000E	01	.9941E	00	.1491E	00	.1491E	00	1799
	.6500E	00	.2000E	01	-.1000E	00	.2000E	01	.8776E	00	.1097E	00	.1097E	00	1800
	.6550E	00	.2000E	01	-.1000E	00	.2000E	01	.8197E	00	.1229E	00	.1229E	00	1801
	.6600E	00	.2000E	01	-.1000E	00	.2000E	01	.8346E	00	.1252E	00	.1252E	00	1802
	.6650E	00	.2000E	01	-.1000E	00	.2000E	01	.8782E	00	.1317E	00	.1317E	00	1803
	.6700E	00	.2000E	01	-.1000E	00	.2000E	01	.8410E	00	.1261E	00	.1261E	00	1804
	.6750E	00	.2000E	01	-.1000E	00	.2000E	01	.1042E	01	.1562E	00	.1562E	00	1805
	.6800E	00	.2000E	01	-.1000E	00	.2000E	01	.9347E	00	.1402E	00	.1402E	00	1806
	.6850E	00	.2000E	01	-.1000E	00	.2000E	01	.8866E	00	.1329E	00	.1329E	00	1807
	.6900E	00	.2000E	01	-.1000E	00	.2000E	01	.8959E	00	.1344E	00	.1344E	00	1808
	.7050E	00	.2000E	01	-.1000E	00	.2000E	01	.8776E	00	.7761E-01	.7761E-01			1809
	.7200E	00	.2000E	01	-.1000E	00	.2000E	01	.1018E	01	.1272E	00	.1272E	00	1810
	.7300E	00	.2000E	01	-.1000E	00	.2000E	01	.8749E	00	.1093E	00	.1093E	00	1811
	.7500E	00	.2000E	01	-.1000E	00	.2000E	01	.9083E	00	.1135E	00	.1135E	00	1812
	.7700E	00	.2000E	01	-.1000E	00	.2000E	01	.1123E	01	.1403E	00	.1403E	00	1813
	.7800E	00	.2000E	01	-.1000E	00	.2000E	01	.1049E	01	.1311E	00	.1311E	00	1814
	.7900E	00	.2000E	01	-.1000E	00	.2000E	01	.9915E	00	.1239E	00	.1239E	00	1815
	.7999E	00	.2000E	01	-.1000E	00	.2000E	01	.9543E	00	.1192E	00	.1192E	00	1816
	.8100E	00	.2000E	01	-.1000E	00	.2000E	01	.1109E	01	.1386E	00	.1386E	00	1817
	.8199E	00	.2000E	01	-.1000E	00	.2000E	01	.9117E	00	.1139E	00	.1139E	00	1818
	.8300E	00	.2000E	01	-.1000E	00	.2000E	01	.1035E	01	.1293E	00	.1293E	00	1819
	.8399E	00	.2000E	01	-.1000E	00	.2000E	01	.1013E	01	.1266E	00	.1266E	00	1820
	.8499E	00	.2000E	01	-.1000E	00	.2000E	01	.1024E	01	.1280E	00	.1280E	00	1821
	.8600E	00	.2000E	01	-.1000E	00	.2000E	01	.8997E	00	.1124E	00	.1124E	00	1822
	.8800E	00	.2000E	01	-.1000E	00	.2000E	01	.9142E	00	.1142E	00	.1142E	00	1823
	.8999E	00	.2000E	01	-.1000E	00	.2000E	01	.9269E	00	.1158E	00	.1158E	00	1824
	.9200E	00	.2000E	01	-.1000E	00	.2000E	01	.8780E	00	.1097E	00	.1097E	00	1825
	.9400E	00	.2000E	01	-.1000E	00	.2000E	01	.9351E	00	.1168E	00	.1168E	00	1826
	.9498E	00	.2000E	01	-.1000E	00	.2000E	01	.8640E	00	.1500E	00	.1500E	00	1827
	.9800E	00	.2000E	01	-.1000E	00	.2000E	01	.9594E	00	.1199E	00	.1199E	00	1828
	.1000E	01	.2000E	01	-.1000E	00	.2000E	01	.9458E	00	.1182E	00	.1182E	00	1829
	.1040E	01	.2000E	01	-.1000E	00	.2000E	01	.8832E	00	.1104E	00	.1104E	00	1830
	.1050E	01	.2000E	01	-.1000E	00	.2000E	01	.8850E	00	.2000E	00	.2000E	00	1831
	.1060E	01	.2000E	01	-.1000E	00	.2000E	01	.8936E	00	.1117E	00	.1117E	00	1832
	.1080E	01	.2000E	01	-.1000E	00	.2000E	01	.8147E	00	.2000E	00	.2000E	00	1833
	.1100E	01	.2000E	01	-.1000E	00	.2000E	01	.8946E	00	.2000E	00	.2000E	00	1834
	.1120E	01	.2000E	01	-.1000E	00	.2000E	01	.8827E	00	.2000E	00	.2000E	00	1835
	.1140E	01	.2000E	01	-.1000E	00	.2000E	01	.7841E	00	.2000E	00	.2000E	00	1836

.1150E	01	.2000E=01-.1000E	00	.2000E=01	.8110E	00	.2000E	00	.2000E	00	1837
.1160E	01	.2000E=01-.1000E	00	.2000E=01	.8869E	00	.2000E	00	.2000E	00	1838
.1180E	01	.2000E=01-.1000E	00	.2000E=01	.7116E	00	.2000E	00	.2000E	00	1839
.1200E	01	.2000E=01-.1000E	00	.2000E=01	.6818E	00	.2000E	00	.2000E	00	1840
.1240E	01	.2000E=01-.1000E	00	.2000E=01	.7342E	00	.2000E	00	.2000E	00	1841
.1250E	01	.2000E=01-.1000E	00	.2000E=01	.6390E	00	.2000E	00	.2000E	00	1842
.1280E	01	.2000E=01-.1000E	00	.2000E=01	.6330E	00	.2000E	00	.2000E	00	1843
.1300E	01	.2000E=01-.1000E	00	.2000E=01	.7145E	00	.2000E	00	.2000E	00	1844
.1320E	01	.2000E=01-.1000E	00	.2000E=01	.6277E	00	.2000E	00	.2000E	00	1845
.1340E	01	.2000E=01-.1000E	00	.2000E=01	.8069E	00	.2000E	00	.2000E	00	1846
.1400E	01	.2000E=01-.1000E	00	.2000E=01	.6321E	00	.2000E	00	.2000E	00	1847
.1420E	01	.2000E=01-.1000E	00	.2000E=01	.7447E	00	.2000E	00	.2000E	00	1848
											1849
C	SM	Q=-270 KEV									1850
.8000E	00	.2000E=01-.2700E	00	.3000E=01	.1477E	00	.5216E=01	.5216E=01			1851
.8499E	00	.2000E=01-.2700E	00	.3000E=01	.2110E	00	.4194E=01	.4194E=01			1852
.1100E	01	.2000E=01-.2700E	00	.3000E=01	.4100E	00	.1000E	00	.1000E	00	1853
.1200E	01	.2000E=01-.2700E	00	.3000E=01	.2830E	00	.5456E=01	.5456E=01			1854
.1220E	01	.2000E=01-.2700E	00	.3000E=01	.3627E	00	.8441E=01	.8441E=01			1855
.1300E	01	.2000E=01-.2700E	00	.3000E=01	.2810E	00	.5000E=01	.5000E=01			1856
.1350E	01	.2000E=01-.2700E	00	.3000E=01	.4510E	00	.2500E	00	.2500E	00	1857
.1400E	01	.2000E=01-.2700E	00	.3000E=01	.3050E	00	.1500E	00	.1500E	00	1858
.1450E	01	.2000E=01-.2700E	00	.3000E=01	.4000E	00	.1000E	00	.1000E	00	1859
.1500E	01	.2000E=01-.2700E	00	.3000E=01	.2960E	00	.1000E	00	.1000E	00	1860
											1861
C	SM	Q=-350 KEV									1862
.8000E	00	.2000E=01-.3500E	00	.3000E=01	.1385E	00	.6078E=01	.6078E=01			1863
.1100E	01	.2000E=01-.3500E	00	.3000E=01	.3601E	00	.7493E=01	.7493E=01			1864
.1200E	01	.2000E=01-.3500E	00	.3000E=01	.2000E	00	.7538E=01	.7538E=01			1865
.1300E	01	.2000E=01-.3500E	00	.3000E=01	.2600E	00	.5000E=01	.5000E=01			1866
.1400E	01	.2000E=01-.3500E	00	.3000E=01	.2260E	00	.9000E=01	.9000E=01			1867
.1500E	01	.2000E=01-.3500E	00	.3000E=01	.4060E	00	.9930E=01	.9930E=01			1868
											1869
C	SM	Q=-520 KEV, QUESTIONABLE									1870
.1100E	01	.2000E=01-.5200E	00	.5000E=01	.6661E	00	.2058E	00	.2058E	00	1871
.1200E	01	.2000E=01-.5200E	00	.5000E=01	.4133E	00	.2000E	00	.2000E	00	1872
.1300E	01	.2000E=01-.5200E	00	.5000E=01	.4430E	00	.2000E	00	.2000E	00	1873
.1400E	01	.2000E=01-.5200E	00	.5000E=01	.3619E	00	.2000E	00	.2000E	00	1874
.1450E	01	.2000E=01-.5200E	00	.5000E=01	.4297E	00	.2000E	00	.2000E	00	1875
.1500E	01	.2000E=01-.5200E	00	.5000E=01	.3824E	00	.2000E	00	.2000E	00	1876
											1877
C	SM	Q=-690 KEV									1878
.1100E	01	.2000E=01-.6900E	00	.5000E=01	.2867E	00	.1545E	00	.1545E	00	1879
.1200E	01	.2000E=01-.6900E	00	.5000E=01	.2367E	00	.1045E	00	.1045E	00	1880
.1300E	01	.2000E=01-.6900E	00	.5000E=01	.2709E	00	.1500E	00	.1500E	00	1881
.1400E	01	.2000E=01-.6900E	00	.5000E=01	.2675E	00	.1500E	00	.1500E	00	1882
.1450E	01	.2000E=01-.6900E	00	.5000E=01	.2253E	00	.1500E	00	.1500E	00	1883
.1500E	01	.2000E=01-.6900E	00	.5000E=01	.3119E	00	.1500E	00	.1500E	00	1884
											1885
	SM	Q=-810 KEV									1886
.1200E	01	.2000E=01-.8100E	00	.5000E=01	.3676E	00	.1200E	00	.1200E	00	1887
.1300E	01	.2000E=01-.8100E	00	.5000E=01	.2900E	00	.1200E	00	.1200E	00	1888
.1400E	01	.2000E=01-.8100E	00	.5000E=01	.3100E	00	.1200E	00	.1200E	00	1889
.1450E	01	.2000E=01-.8100E	00	.5000E=01	.2800E	00	.1200E	00	.1200E	00	1890
.1500E	01	.2000E=01-.8100E	00	.5000E=01	.2710E	00	.1200E	00	.1200E	00	1891
											1892
C	SM	Q= 930 KEV									1893
.1450E	01	.2000E=01-.9300E	00	.4000E=01	.2982E	00	.9789E=01	.9789E=01			1894
.1500E	01	.2000E=01-.9300E	00	.4000E=01	.2751E	00	.9914E=01	.9914E=01			1895
											1896
C	SM	Q=-1020 KEV									1897
.1400E	01	.2000E=01-.1020E	01	.3000E=01	.2663E	00	.9257E=01	.9257E=01			1898
.1450E	01	.2000E=01-.1020E	01	.3000E=01	.2527E	00	.9011E=01	.9011E=01			1899
.1500E	01	.2000E=01-.1020E	01	.3000E=01	.3190E	00	.9336E=01	.9336E=01			1900
											1901

C	SM Q=-1090 KEV	1902
	.1450E 01 .2000E-01-.1090E 01 .4000E-01 .4996E 00 .9000E-01 .9000E-01	1903
	.1500E 01 .2000E-01-.1090E 01 .4000E-01 .4416E 00 .9496E-01 .9496E-01	1904
		1905
C		1906
C		1907
C	TOTAL CROSS SECTIONS OF SAMARIUM	1908
C	MONOENERGETIC SOURCE METHOD	1909
C	RESOLUTION 2=3 KEV	1910
C	FORMAT(3E12.6)	1911
C	ENERGY IN KEV	1912
C	XSEC IN BARNS	1913
C	ERROR IN XSEC IN BARNS	1914
C		1915
	.301499E 03 .795000E 01 .130000E 00	1916
	.303499E 03 .785000E 01 .130000E 00	1917
	.305499E 03 .768000E 01 .230000E 00	1918
	.307499E 03 .764000E 01 .130000E 00	1919
	.309499E 03 .767000E 01 .130000E 00	1920
	.311499E 03 .773000E 01 .130000E 00	1921
	.313499E 03 .784000E 01 .130000E 00	1922
	.315499E 03 .770000E 01 .130000E 00	1923
	.317499E 03 .770000E 01 .130000E 00	1924
	.319499E 03 .765000E 01 .130000E 00	1925
	.321499E 03 .773000E 01 .130000E 00	1926
	.323499E 03 .773000E 01 .130000E 00	1927
	.325499E 03 .762000E 01 .130000E 00	1928
	.327499E 03 .770000E 01 .130000E 00	1929
	.329499E 03 .765000E 01 .130000E 00	1930
	.331499E 03 .750000E 01 .130000E 00	1931
	.333499E 03 .749000E 01 .130000E 00	1932
	.335499E 03 .782000E 01 .130000E 00	1933
	.337499E 03 .769000E 01 .130000E 00	1934
	.339499E 03 .771000E 01 .160000E 00	1935
	.341499E 03 .794000E 01 .130000E 00	1936
	.343600E 03 .772000E 01 .130000E 00	1937
	.345600E 03 .774000E 01 .130000E 00	1938
	.347600E 03 .799000E 01 .130000E 00	1939
	.349600E 03 .771000E 01 .130000E 00	1940
	.351600E 03 .781000E 01 .130000E 00	1941
	.353600E 03 .774999E 01 .130000E 00	1942
	.355600E 03 .763000E 01 .130000E 00	1943
	.357600E 03 .768000E 01 .130000E 00	1944
	.359600E 03 .768000E 01 .130000E 00	1945
	.361600E 03 .761000E 01 .130000E 00	1946
	.363600E 03 .763000E 01 .130000E 00	1947
	.365600E 03 .766000E 01 .130000E 00	1948
	.369600E 03 .763000E 01 .130000E 00	1949
	.371600E 03 .784000E 01 .130000E 00	1950
	.373600E 03 .786000E 01 .130000E 00	1951
	.375600E 03 .762000E 01 .130000E 00	1952
	.377600E 03 .786000E 01 .130000E 00	1953
	.379600E 03 .774999E 01 .130000E 00	1954
	.381600E 03 .759000E 01 .130000E 00	1955
	.383600E 03 .769000E 01 .130000E 00	1956
	.385600E 03 .807000E 01 .130000E 00	1957
	.387600E 03 .765000E 01 .130000E 00	1958
	.389600E 03 .769000E 01 .130000E 00	1959
	.391600E 03 .764000E 01 .160000E 00	1960
	.393600E 03 .766000E 01 .130000E 00	1961
	.395600E 03 .750000E 01 .130000E 00	1962
	.397600E 03 .752000E 01 .130000E 00	1963
	.399600E 03 .764000E 01 .130000E 00	1964
	.401600E 03 .770000E 01 .130000E 00	1965

.403700E 03	.759000E 01	.130000E 00	1966
.405700E 03	.786000E 01	.130000E 00	1967
.407700E 03	.764000E 01	.130000E 00	1968
.409700E 03	.755000E 01	.130000E 00	1969
.411700E 03	.766000E 01	.130000E 00	1970
.413700E 03	.770000E 01	.130000E 00	1971
.415700E 03	.780000E 01	.130000E 00	1972
.417700E 03	.757000E 01	.130000E 00	1973
.419700E 03	.768000E 01	.130000E 00	1974
.421700E 03	.778000E 01	.130000E 00	1975
.423700E 03	.787000E 01	.130000E 00	1976
.425700E 03	.798000E 01	.130000E 00	1977
.427700E 03	.777000E 01	.130000E 00	1978
.429700E 03	.794000E 01	.130000E 00	1979
.431700E 03	.793000E 01	.130000E 00	1980
.433700E 03	.774999E 01	.130000E 00	1981
.435700E 03	.807000E 01	.130000E 00	1982
.437700E 03	.802000E 01	.130000E 00	1983
.439700E 03	.757000E 01	.130000E 00	1984
.441700E 03	.779000E 01	.130000E 00	1985
.443700E 03	.801000E 01	.130000E 00	1986
.445700E 03	.809000E 01	.130000E 00	1987
.447700E 03	.774000E 01	.130000E 00	1988
.449700E 03	.776000E 01	.130000E 00	1989
.451700E 03	.793000E 01	.130000E 00	1990
.453700E 03	.803000E 01	.170000E 00	1991
.455800E 03	.776000E 01	.140000E 00	1992
.457800E 03	.770000E 01	.140000E 00	1993
.459800E 03	.763000E 01	.140000E 00	1994
.461800E 03	.773000E 01	.140000E 00	1995
.463800E 03	.778000E 01	.140000E 00	1996
.465800E 03	.778000E 01	.140000E 00	1997
.467700E 03	.783000E 01	.240000E 00	1998
.469700E 03	.785000E 01	.170000E 00	1999
.471700E 03	.772000E 01	.240000E 00	2000
.473800E 03	.758000E 01	.240000E 00	2001
.475800E 03	.771000E 01	.140000E 00	2002
.477800E 03	.753000E 01	.140000E 00	2003
.479800E 03	.792000E 01	.140000E 00	2004
.481800E 03	.752000E 01	.140000E 00	2005
.483800E 03	.768000E 01	.170000E 00	2006
.485800E 03	.763000E 01	.130000E 00	2007
.487800E 03	.747000E 01	.140000E 00	2008
.489800E 03	.741000E 01	.140000E 00	2009
.491800E 03	.768000E 01	.140000E 00	2010
.493800E 03	.761000E 01	.140000E 00	2011
.495800E 03	.770000E 01	.140000E 00	2012
.497800E 03	.769000E 01	.140000E 00	2013
.499800E 03	.762000E 01	.140000E 00	2014
.501800E 03	.752000E 01	.140000E 00	2015
.503800E 03	.754000E 01	.140000E 00	2016
.505800E 03	.758000E 01	.140000E 00	2017
.507800E 03	.755000E 01	.140000E 00	2018
.509800E 03	.743000E 01	.140000E 00	2019
.511800E 03	.774999E 01	.140000E 00	2020
.513800E 03	.740000E 01	.140000E 00	2021
.515800E 03	.758000E 01	.140000E 00	2022
.517800E 03	.762000E 01	.140000E 00	2023
.519800E 03	.768000E 01	.140000E 00	2024
.521800E 03	.754000E 01	.140000E 00	2025
.523800E 03	.774000E 01	.140000E 00	2026
.525800E 03	.787000E 01	.140000E 00	2027
.527800E 03	.752000E 01	.140000E 00	2028
.529800E 03	.758000E 01	.140000E 00	2029

.531800E 03	.772000E 01	.140000E 00	2030
.533800E 03	.745000E 01	.140000E 00	2031
.535800E 03	.748000E 01	.170000E 00	2032
.537800E 03	.755000E 01	.140000E 00	2033
.539800E 03	.759000E 01	.140000E 00	2034
.541800E 03	.761000E 01	.140000E 00	2035
.543800E 03	.769000E 01	.140000E 00	2036
.545800E 03	.767000E 01	.140000E 00	2037
.547800E 03	.766000E 01	.140000E 00	2038
.549800E 03	.788000E 01	.140000E 00	2039
.551800E 03	.749000E 01	.140000E 00	2040
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.555900E 03	.724999E 01	.140000E 00	2042
.557900E 03	.759000E 01	.140000E 00	2043
.559900E 03	.744000E 01	.140000E 00	2044
.561900E 03	.757000E 01	.240000E 00	2045
.563900E 03	.748000E 01	.140000E 00	2046
.565900E 03	.762000E 01	.140000E 00	2047
.567900E 03	.754000E 01	.140000E 00	2048
.569900E 03	.736000E 01	.140000E 00	2049
.571900E 03	.742000E 01	.140000E 00	2050
.573900E 03	.759000E 01	.140000E 00	2051
.575900E 03	.746000E 01	.140000E 00	2052
.577900E 03	.774000E 01	.140000E 00	2053
.579900E 03	.755000E 01	.140000E 00	2054
.581900E 03	.740000E 01	.140000E 00	2055
.583900E 03	.754000E 01	.140000E 00	2056
.585900E 03	.747000E 01	.140000E 00	2057
.587900E 03	.768000E 01	.140000E 00	2058
.589900E 03	.772000E 01	.140000E 00	2059
.591900E 03	.745000E 01	.140000E 00	2060
.593900E 03	.763000E 01	.140000E 00	2061
.595900E 03	.786000E 01	.140000E 00	2062
.597900E 03	.737000E 01	.140000E 00	2063
.599900E 03	.755000E 01	.140000E 00	2064
.601900E 03	.765000E 01	.140000E 00	2065
.603900E 03	.740000E 01	.140000E 00	2066
.605900E 03	.746000E 01	.140000E 00	2067
.607900E 03	.776000E 01	.140000E 00	2068
.609900E 03	.731000E 01	.140000E 00	2069
.611900E 03	.755000E 01	.140000E 00	2070
.613900E 03	.761000E 01	.140000E 00	2071
.615900E 03	.737000E 01	.140000E 00	2072
.617900E 03	.803000E 01	.140000E 00	2073
.619900E 03	.757000E 01	.140000E 00	2074
.621900E 03	.767000E 01	.140000E 00	2075
.623900E 03	.781000E 01	.140000E 00	2076
.625900E 03	.756000E 01	.900000E=01	2077
.627900E 03	.761000E 01	.140000E 00	2078
.629900E 03	.754000E 01	.170000E 00	2079
.631900E 03	.748000E 01	.140000E 00	2080
.633900E 03	.709000E 01	.140000E 00	2081
.635900E 03	.767000E 01	.140000E 00	2082
.637900E 03	.749000E 01	.170000E 00	2083
.637900E 03	.749000E 01	.240000E 00	2084
.639900E 03	.769000E 01	.140000E 00	2085
.641900E 03	.762000E 01	.140000E 00	2086
.643900E 03	.768000E 01	.100000E 00	2087
.645900E 03	.780000E 01	.140000E 00	2088
.647900E 03	.741000E 01	.240000E 00	2089
.652186E 03	.777653E 01	.971800E=01	2090
.657193E 03	.774647E 01	.972040E=01	2091
.662200E 03	.735638E 01	.972410E=01	2092
.667207E 03	.747267E 01	.974110E=01	2093

.672214E 03	.738532E 01	.971150E=01	2094
.677220E 03	.744658E 01	.973670E=01	2095
.682227E 03	.753632E 01	.973140E=01	2096
.687234E 03	.773252E 01	.972750E=01	2097
.692240E 03	.745101E 01	.973920E=01	2098
.697247E 03	.720809E 01	.975030E=01	2099
.702253E 03	.767736E 01	.973030E=01	2100
.707260E 03	.740354E 01	.973980E=01	2101
.712266E 03	.747030E 01	.974890E=01	2102
.717273E 03	.757746E 01	.973540E=01	2103
.722279E 03	.771038E 01	.971690E=01	2104
.727285E 03	.763070E 01	.971730E=01	2105
.732292E 03	.755725E 01	.972240E=01	2106
.737298E 03	.701419E 01	.971970E=01	2107
.742304E 03	.739162E 01	.974480E=01	2108
.747310E 03	.739510E 01	.978400E=01	2109
.752316E 03	.791700E 01	.970680E=01	2110
.757322E 03	.740820E 01	.971940E=01	2111
.762328E 03	.768019E 01	.972960E=01	2112
.767335E 03	.744042E 01	.972590E=01	2113
.772341E 03	.752847E 01	.975560E=01	2114
.777347E 03	.773135E 01	.972880E=01	2115
.782352E 03	.776004E 01	.973930E=01	2116
.787358E 03	.783000E 01	.973650E=01	2117
.792364E 03	.767592E 01	.972200E=01	2118
.797370E 03	.740389E 01	.971920E=01	2119
.802376E 03	.760819E 01	.973620E=01	2120
.807382E 03	.773463E 01	.973150E=01	2121
.812387E 03	.788835E 01	.972150E=01	2122
.817393E 03	.758306E 01	.971740E=01	2123
.822399E 03	.765376E 01	.971920E=01	2124
.827404E 03	.731779E 01	.168474E 00	2125
.827404E 03	.775232E 01	.168396E 00	2126
.832410E 03	.779983E 01	.971730E=01	2127
.837416E 03	.764044E 01	.973940E=01	2128
.842421E 03	.736663E 01	.973100E=01	2129
.847427E 03	.760873E 01	.971240E=01	2130
.852432E 03	.728576E 01	.975300E=01	2131
.857438E 03	.775264E 01	.973660E=01	2132
.862443E 03	.776338E 01	.971780E=01	2133
.867449E 03	.761372E 01	.973570E=01	2134
.872454E 03	.775774E 01	.971740E=01	2135
.877459E 03	.774377E 01	.970690E=01	2136
.882465E 03	.774143E 01	.970930E=01	2137
.887470E 03	.759044E 01	.971180E=01	2138
.892475E 03	.782795E 01	.971880E=01	2139
.897480E 03	.762169E 01	.971250E=01	2140
.902486E 03	.743255E 01	.969600E=01	2141
.907491E 03	.761433E 01	.969070E=01	2142
.912496E 03	.767167E 01	.969490E=01	2143
.917502E 03	.759155E 01	.967500E=01	2144
.922506E 03	.800839E 01	.968220E=01	2145
.927512E 03	.766478E 01	.968870E=01	2146
.932517E 03	.749532E 01	.968080E=01	2147
.937522E 03	.767797E 01	.969210E=01	2148
.942527E 03	.773647E 01	.968210E=01	2149
.947532E 03	.782698E 01	.967680E=01	2150
.952537E 03	.772851E 01	.968200E=01	2151
.957542E 03	.763246E 01	.968160E=01	2152
.962547E 03	.766654E 01	.966890E=01	2153
.967552E 03	.791719E 01	.967630E=01	2154
.972557E 03	.783947E 01	.966430E=01	2155
.977562E 03	.794067E 01	.966820E=01	2156
.982567E 03	.786419E 01	.965960E=01	2157

.987572E 03	.784079E 01	.966320E=01	2158
.992577E 03	.790310E 01	.965640E=01	2159
.997581E 03	.784008E 01	.964610E=01	2160
.100258E 04	.774526E 01	.963560E=01	2161
.100759E 04	.744136E 01	.967160E=01	2162
.101259E 04	.799067E 01	.964100E=01	2163
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ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of a number of the members of the staff of the Applied Nuclear Physics Section of the Reactor Physics Division.

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