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**ATLAS OF PHOTONEUTRON CROSS SECTIONS OBTAINED
WITH MONOENERGETIC PHOTONS**

Bicentennial Edition

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ATLAS OF PHOTONEUTRON CROSS SECTIONS OBTAINED
WITH MONOENERGETIC PHOTONS

Bicentennial Edition

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Photoneutron cross-section data obtained with monoenergetic photons are presented in a uniform format. This compilation is current as of December, 1976.

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INTRODUCTION

Over the years, a considerable body of data on photoneutron cross sections obtained with monoenergetic photons has been acquired at the Livermore, Saclay, and several other laboratories. In view of the need for a comprehensive compilation of photoneutron cross-section data, these monoenergetic-photon data are gathered together here and presented in a uniform format. A more complete compilation and evaluation (which would include data obtained with continuous bremsstrahlung radiation sources as well), is being undertaken by the photonuclear group at the National Bureau of Standards.¹ Billow and Forkman² have prepared a selected compilation of photonuclear cross sections, which partly overlaps this one and which emphasizes those nuclei of particular importance for photoactivation analysis. A critique of monoenergetic-photon techniques and the data obtained therefrom is included in a recent review article.³ The data here made available in graphical form also are available upon request in digital form for purposes of theoretical analysis and for those associated with applications to other scientific disciplines and technical uses.

ANNIHILATION-PHOTON TECHNIQUE

The experimental methods for producing beams of monoenergetic photons which have been used for photonuclear-reaction studies include the annihilation in flight of fast positrons, tagged bremsstrahlung, and nuclear γ -rays from the capture of protons or neutrons. Since most of the work surveyed here has been done with annihilation photons, a brief description of this method is given.

The annihilation-photon method for obtaining a monoenergetic photon beam was first suggested by Tzara⁴ and has been developed or

studied at several laboratories since, principally at Saclay and at Livermore. The method consists in producing positrons by pair production, transporting a beam of fast positrons having the desired energy E_{e^+} to the experimental area, and allowing it to strike a thin, low-Z target, thus producing, in the forward direction, a monoenergetic beam of annihilation photons (where the photon energy $E_\gamma = E_{e^+} + 0.76$ MeV, the latter term being $3/4$ of the rest mass of the annihilating pair).

Figure A is a schematic experimental diagram illustrating the technique. Positrons are produced from the bremsstrahlung created when the intense beam of high-energy electrons from the first section of a high-current linac strikes a thick, high-Z converter. The emergent positrons are captured into the second section of the linac and, by operating the second accelerator section with the radio frequency 180° out of phase with that normally used for electrons, are accelerated to the desired energy. The positron beam is energy-analyzed to the desired momentum resolution with a bending magnet and slit, is transported to the experimental area, and is focused onto the annihilation target. Some of the positrons annihilate in flight, producing the monoenergetic photon beam; some produce bremsstrahlung, whose effects must be subtracted out by repeating the measurement with electrons instead of positrons; and the rest are swept away from the photon beam line and into a dump hole by a magnet. The collimated photon beam passes through a transmission ion chamber beam monitor and strikes the nuclear sample under study.

This photoneutron sample is located in the center of a highly efficient 4π neutron detector, whose electronic scaling circuitry is triggered after each accelerator beam burst. The number of neutrons

Fig. A. Schematic diagram of an annihilation-photon-induced photoneutron experiment (see text). The diagram is considerably simplified and is not to scale; shielding walls have been omitted for clarity. Inset: NaI spectra of positron- and electron-induced photon beams and their difference. The (poor) resolution is that of the NaI spectrometer.

detected for each beam burst is recorded, and this "multiplicity-counting" system, together with a knowledge of the neutron detector efficiency, allows one to obtain the single, double, triple, etc., photoneutron cross sections simultaneously and independently. This is essential if one is to obtain directly the total photoneutron cross section, which is nearly the same as the total photon absorption cross section for medium and heavy nuclei, where proton (and other charged-particle) emission at giant-resonance energies is inhibited by the Coulomb barrier.

The ion chamber photon beam monitor is calibrated against a NaI(Tl) photon spectrometer whose response functions and absolute efficiency are measured separately. The energy resolution of the photon beam is determined primarily by the momentum spread of the positron beam, together with the dE/dx losses suffered by the positrons before annihilation which result from the finite thickness of the annihilation target. The energy scale is set with reference to known nuclear energy levels and thresholds. Figure A also shows sample NaI photon spectra for incident positrons, incident electrons, and their difference.

DATA

The data are presented graphically, generally in order of increasing mass number. Figure B (p. 15), in the form of a chart of the stable nuclei, constitutes an index of the isotopes studied to date with monoenergetic photons. When two or more laboratories have measured the same nucleus, the data are presented in chronological order. The top (and sometimes only) data plot for each nucleus is the total photoneutron cross section $\sigma[(\gamma,n) + (\gamma,pn) + (\gamma,2n) + (\gamma,p2n) + (\gamma,3n) + \dots]$; below it, where appropriate, are the single photoneutron cross section $\sigma[(\gamma,n) + (\gamma,pn)]$, the double photoneutron cross section $\sigma[(\gamma,2n) +$

$(\gamma, p2n)$], and the triple photoneutron cross section $\sigma(\gamma, 3n)$. [Sometimes another cross section is substituted for $\sigma(\gamma, 3n)$ --see Explanation of the Graphs.] Most of the total photoneutron data plots for medium and heavy nuclei have Lorentz-curve fits superposed.

A table of properties of the giant resonance derived from measurements made with monoenergetic photon beams also is included. Integrated cross sections and their moments, derived directly from the data, constitute about half the table, and the parameters of Lorentz curves fitted to the giant-resonance data, the other half. Numerous quantities of physical interest can be derived from these integrated cross sections and Lorentz parameters; a detailed exposition of these is given in Ref. 3. The "Reference" and "Laboratory" columns constitute an index to the monoenergetic-photon-data references. The references to the tables follow the notation of Ref. 1.

In the semiclassical theory of the interaction of photons with nuclei, the shape of a fundamental resonance in the absorption cross section is that of the Lorentz curve^{5,6}

$$\sigma(E) = \frac{\sigma_m}{1 + [(E^2 - E_m^2)^2 / E^2 \Gamma^2]} \quad (1)$$

where the Lorentz parameters E_m , σ_m , and Γ are the resonance energy, peak cross section, and full width at half-maximum, respectively. In the hydrodynamic theory of photonuclear reactions, the giant dipole resonance consists of one such Lorentz line for spherical nuclei,^{5,7} corresponding to the absorption of photons which induce oscillations of the neutron and proton fluids in the nucleus against each other, and the superposition of two such lines for statically deformed spheroidal nuclei,^{6,8} corresponding to oscillations along each of the nondegenerate axes of the spheroid. (The lower-energy line corresponds to oscillations along the longer axis and the higher-energy line along

the shorter, since the absorption frequency decreases with increasing nuclear dimensions.)

$$\sigma(E) = \sum_{i=1}^2 \frac{\sigma_{mi}}{1 + [(E^2 - E_{mi}^2)^2 / E^2 \Gamma_i^2]} \quad (2)$$

where $i = 1, 2$ correspond to the lower- and higher-energy lines. Note that the two Lorentz lines are noninterfering and that the damping parameters Γ_i are not energy-dependent.

The Thomas-Reiche-Kuhn (TRK) sum rule⁹ is an expression giving the total integrated cross section for electric-dipole photon absorption, in the absence of exchange forces, and is given by

$$\int_0^\infty \sigma(E) dE = \frac{2\pi^2 e^2 \hbar}{Mc} \frac{NZ}{A} = 60 \left(\frac{NZ}{A} \right) \text{ MeV-mb} \quad (3)$$

where M is the nucleon mass and the integration is over all energies for which dipole absorption can occur. It should be noted that the area under the Lorentz curve [from Eq. (1) or (2)] is given by

$$\int_0^\infty \sigma(E) dE = \frac{\pi}{2} \sigma_m \Gamma \quad (\text{or } \frac{\pi}{2} \sum_{i=1}^2 \sigma_{mi} \Gamma_i). \quad (4)$$

The first moment of the integrated cross section, also known as the "bremsstrahlung-weighted" cross section (since the energy dependence of the bremsstrahlung spectrum often is approximated by $1/E$), is given by

$$\sigma_{-1} = \int_0^\infty [\sigma(E)/E] dE = \frac{4\pi^2 e^2}{3 \hbar c} \frac{NZ}{A-1} \langle r^2 \rangle \quad (5)$$

for light nuclei,⁹ where $\langle r^2 \rangle$ is the mean-square radius of the nuclear charge distribution.

The second moment of the integrated cross section σ_{-2} is proportional

to the nuclear polarizability $p = (e^2 R^2 A / 40 K)$ and hence increases with the diffuseness of the nucleus. Here R is the radius of the equivalent spherical nucleus and K is the nuclear symmetry energy. Then the Migdal sum rule^{9,10} states that

$$\sigma_{-2} = \int_0^\infty [\sigma(E)/E^2] dE = \frac{2\pi^2}{hc} p = \frac{\pi^2}{20} \frac{e^2}{hc} \frac{R^2 A}{K} \quad (6)$$

A second table gives recent or relevant references to measurements of photoneutron cross sections for which the source of radiation was a continuous bremsstrahlung beam, together with general comments. Typically, the results of these measurements are somewhat larger in absolute magnitude than those of the monoenergetic-photon measurements, but there are a considerable number of exceptions. More important, many of the bremsstrahlung experiments have resulted in the reporting of such structure in the cross sections which agree neither with the monoenergetic-photon data nor with each other.

POLICY

No attempt is made here to evaluate the data; that is, to choose between two sets of data for the same nucleus measured at different laboratories or to compromise between them by presenting a set of recommended intermediate values. It should be noted, however, that the overall agreement and consistency between measurements made with monoenergetic photons are very good indeed, especially when viewed in the light of the enormous discrepancies frequently obtained in the past for bremsstrahlung-induced photonuclear measurements.

NOTE ON REFERENCES

When data from this Atlas are cited, reference should be made to the original publication as well.

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EXPLANATION OF THE TABLES

TABLE 1. Giant-Resonance Properties from Monoenergetic-
Photon Measurements

E_{ymax}	The upper-energy limit of the data
$\sigma_{\text{int}}(\gamma, \text{tot})$	The integrated total photoneutron cross section

$$\sigma_{\text{int}}(\gamma, \text{tot}) = \int_{E_{\text{thr}}(\gamma, n)}^{E_{\text{ymax}}} \sigma(\gamma, \text{tot}) dE_{\gamma}$$

where $E_{\text{thr}}(\gamma, n)$ is the photoneutron threshold energy,

$$\sigma(\gamma, \text{tot}) = \sigma[(\gamma, 1n) + (\gamma, 2n) + (\gamma, 3n)],$$

$$\sigma(\gamma, 1n) = \sigma f(\gamma, n) + (\gamma, pn), \text{ and}$$

$$\sigma(\gamma, 2n) = \sigma[(\gamma, 2n) + (\gamma, p2n)].$$

For the nuclei ^{16}O , ^{31}P , ^{32}S , and ^{39}K , $\sigma(\gamma, pn)$ is substituted for $\sigma(\gamma, 3n)$; for ^{18}O , $\sigma(\gamma, p)$ is substituted there; and for the actinide nuclei, the photofission cross section $\sigma(\gamma, f)$ is substituted, where $\sigma(\gamma, f)$ is the sum of the first- and second-chance photofission cross sections $\sigma(\gamma, f)$ and $\sigma(\gamma, nF)$, respectively, and the lower limit of integration is 5 MeV.

$\sigma_{\text{int}}(\gamma, 1n)$	The integrated single photoneutron cross section
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$$\sigma_{\text{int}}(\gamma, 1n) = \int_{E_{\text{thr}}(\gamma, n)}^{E_{\text{ymax}}} \sigma(\gamma, 1n) dE_{\gamma}$$

$\sigma_{\text{int}}(\gamma, 2n)$	The integrated double photoneutron cross section
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$$\sigma_{\text{int}}(\gamma, 2n) = \int_{E_{\text{thr}}(\gamma, 2n)}^{E_{\text{ymax}}} \sigma(\gamma, 2n) dE_{\gamma}$$

where $E_{\text{thr}}(\gamma, 2n)$ is the threshold energy for the photoejection of two neutrons

$\sigma_{\text{int}}(\gamma, 3n)$

The integrated triple photoneutron cross section

$$\sigma_{\text{int}}(\gamma, 3n) = \int_{E_{\text{thr}}(\gamma, 3n)}^{E_{\gamma\text{max}}} \sigma(\gamma, 3n) dE_{\gamma}$$

where $E_{\text{thr}}(\gamma, 3n)$ is the threshold energy for the photoejection of three neutrons. For ^{16}O , ^{31}P , ^{32}S , and ^{39}K , $\sigma_{\text{int}}(\gamma, pn)$ appears in this column; for ^{18}O , $\sigma_{\text{int}}(\gamma, p)$ appears there; and for the actinide nuclei

$$\sigma_{\text{int}}(\gamma, f) = \int_{5 \text{ MeV}}^{E_{\gamma\text{max}}} \sigma(\gamma, f) dE_{\gamma}.$$

σ_{-1}

The first moment of the integrated total photoneutron cross section

$$\sigma_{-1} = \int_{E_{\text{thr}}(\gamma, n)}^{E_{\gamma\text{max}}} [\sigma(\gamma, \text{tot})/E_{\gamma}] dE_{\gamma}$$

σ_{-2}

The second moment of the integrated total photoneutron cross section

$$\sigma_{-2} = \int_{E_{\text{thr}}(\gamma, n)}^{E_{\gamma\text{max}}} [\sigma(\gamma, \text{tot})/E_{\gamma}^2] dE_{\gamma}$$

Fitting
Interval

The photon energy interval over which the Lorentz-curve fits to the data were made

$E_{\text{mi}}, \sigma_{\text{mi}}, \Gamma_i$

The parameters of the Lorentz curves fitted to the data within the fitting interval given in the preceding column. The Lorentz curves are of the form

$$\sigma(E_{\gamma}) = \sum_i \sigma_{\text{mi}} / \{1 + [(E_{\gamma} - E_{\text{mi}})^2 / E_{\gamma}^2 \Gamma_i^2]\}.$$

For spherical nuclei, $i = 1$; for deformed nuclei $i = 1, 2$. Here "spherical" merely indicates that a one-component Lorentz curve gives a better fit to the data than a two-component one, and "deformed" indicates the opposite. The fitting procedure used is the standard best-least-squares method, wherein the squares of the residuals are weighted with the inverse squares of the statistical uncertainties.

Reference	The data references follow the Table. References which end with the letter P indicate preliminary data.
Laboratory	The laboratory at which the data were obtained: L Livermore S Saclay G Giessen GA General Atomic I Illinois P Pennsylvania

TABLE II. Selected Bremsstrahlung Results for Comparison

Comments	The words "same" or "x% higher (lower)" refer to the absolute magnitude of the cross section at or near the peak of the giant dipole resonance.
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EXPLANATION OF THE GRAPHS
OF
PHOTONEUTRON CROSS SECTIONS

The graphs presented are listed in Table I with relevant figure numbers.

Figure B, on the following page, shows in diagrammatic style the stable nuclei for which giant-resonance cross-section measurements have been made with monoenergetic photons.

The following designations are used on the graphs:

- (a) Total photoneutron cross section
 $\sigma(\gamma, \text{tot}) = \sigma[(\gamma, 1n) + (\gamma, 2n) + (\gamma, 3n)]$.
- (b) Single photoneutron cross section
 $\sigma(\gamma, 1n) = \sigma[(\gamma, n) + (\gamma, pn)]$.
- (c) Double photoneutron cross section
 $\sigma(\gamma, 2n) = \sigma[(\gamma, 2n) + (\gamma, p2n)]$.
- (d) Triple photoneutron cross section $\sigma(\gamma, 3n)$. For the nuclei ^{16}O , ^{31}P , ^{32}S , and ^{39}K , part (d) is $\sigma(\gamma, pn)$; for ^{18}O , it is $\sigma(\gamma, p)$; and for the actinide nuclei it is $\sigma(\gamma, f)$.

Threshold Energies Indicated on the graphs by arrows; values are taken from A. H. Wapstra and N. B. Gove, Nuclear Data Tables 9, 303 (1971).

References for the data and the laboratories where the measurements were made are listed in Table I.

The solid curves, drawn on the graphs of the total photoneutron cross sections for most medium and heavy nuclei, are Lorentz curves fitted to the giant-resonance data, whose parameters are given in Table I.

Fig. B. Chart of the stable nuclei, showing those for which giant-resonance cross-section measurements have been performed with monoenergetic photons.

Table I. Giant-Resonance Properties from Monoenergetic-Photon Measurements

Nucleus	$E_{\gamma \text{ max}}$ (MeV)	$\sigma_{\text{int}}(\gamma, \text{tot})$		$\sigma_{\text{int}}(\gamma, 1n)$		$\sigma_{\text{int}}(\gamma, 2n)$		$\sigma_{\text{int}}(\gamma, 3n)$		σ_{-1} (mb)	σ_{-2} (mb-MeV ⁻¹)	Fitting Interval (MeV)	Lorentz Parameters						Reference	Laboratory	Figure Number
		(MeV-mb)		(MeV-mb)		(MeV-mb)		(MeV-mb)					E_{m1} (MeV)	σ_{m1} (mb)	Γ_1 (MeV)	E_{m2} (MeV)	σ_{m2} (mb)	Γ_2 (MeV)			
³ He	30.2	13.0		13.0						0.77	0.030								74Be8	L	1
⁴ He	31.4	7.94		7.94		0				0.30	0.012								71Be3	L	2
⁶ Li	32.0	27.7		27.3		0.4				1.87	0.15								653e1	L	3
⁷ Li	30.5	20.1		10.0		10.1				1.15	0.071								73Br11	L	4
⁹ Be	37.0	58.1		32.5		25.6				2.52	0.132								75Kn5	G	5
¹⁰ B	35.1	82.3		80.4		1.9				3.69	0.183								76Kn3	G	6
¹¹ B	35.1	69.2		54.3		14.9				2.93	0.132								76Kn3	G	7
¹² C	26.7	34.5		34.5						1.47	0.063								62De1/66Lo1	P	8
	25.5	29.4		29.4															66Mi2	S	
	37.4	46.8		46.8		0				1.83	0.073								66Fu1	L	9
	32.1	>1.6 ^a								2.08	0.085								75Kn8	G	10
¹³ C	42.2	133		127		6				5.95	0.305								76McP	L	11
¹⁴ N	29.5	97.6		97.6						4.36	0.20								70Be8	L	12
¹⁶ O	26.3	41.5		41.5						1.76	0.075								66Mi2	S	
	28.0	41.5		41.5						3.06	0.12								64Br1/65Ca1	L	13
	37.1	80		79		0.6		13 ^P		2.40	0.094								74Ve1	S	14
	37.0	62.9		62.9		0													75Kn8	G	15
¹⁷ O	30.7	94								4.7	0.26								76McP	L	
¹⁸ O	30.6	151		100		51		30 ^S		7.6	0.42								76FaP/76Be4	L	16
	33.0	142		93		49				6.90	0.38								76Kn4	G	17
¹⁹ F	27.8	104		99		5.2				4.95	0.23								74Ve1	S	18
^{Ne} _{Nat}	25.9	43		40		3.1				1.98	0.09								74Ve1	S	19
²² Ne	25.9					34													74Ve1	S	
²³ Na	27.1	119		118		0.6				5.74	0.29								71Al1	L	20
	30.1	136		133		2.7				6.18	0.29								74Ve1	S	21
^{Na} _{Nat}	26.0	58 ^a																	66Mi2	S	
	28.0	75.6																	71Pu2	L	
²⁴ Mg	28.3	51.9		51.9						2.37	0.11								71Fu2	L	22
²⁵ Mg	28.9	247		245		1.5				11.5	0.56								71Al1	L	23
²⁶ Mg	28.6	236		164		72				11.5	0.59								71Fu2	L	24
²⁷ Al	36.7	167		159		7.6				7.17	0.32								44Fu1	L	25
	30.3	151		150		0.6				6.77	0.31								74Ve1	S	26

Nucleus	E_{γ} max (MeV)	$C_{int}(v, tot)$		$C_{int}(v, 1n)$		$C_{int}(v, 2n)$		$C_{int}(v, 3n)$		C_{-1} (mb)	C_{-2} (mb-MeV ⁻¹)	Fitting Interval (MeV)	Lorentz Parameters					Reference	Laboratory	Figure Number		
		(MeV-mb)	(MeV-mb)	(MeV-mb)	(MeV-mb)	(MeV-mb)	(MeV-mb)	E_{m1} (MeV)	C_{m1} (mb)				E_{m2} (MeV)	C_{m2} (mb)	E_{m3} (MeV)							
NatS ₁	31.0 30.0	68.5 95	68.5 95	0				3.05 4.25	0.14 0.19									63Cal 70Ve1	L S	27 28		
31P	28.6	179	178	0.4		4.2 ^a		8.34	0.40									70Ve1	S	29		
32S	32.2	98	98	0.1		14.7 ^a		4.24	0.19									70Ve1	S	30		
NatCl	17.6	273	254	19				13.3	0.67									70Ve1	S	31		
37Cl	24.0					48												70Ve1	S			
NatK	31.6	217	217	0.3		39 ^a		9.7	0.45									70Ve1	S	32		
40Ar	26.5	390	342	148				21.0	1.18									70Ve1	S	33		
40Ca	28.0 29.5	73 101	73 100					4.55	0.21									68M12 70Ve1	S S			
45Sc	28.1	382	365	17				19.6	1.05									70Ve1	S	35		
51V	27.8	552	650	102				28.9	1.36			14-23	17.86	58.8	4.42	21.22	28.8	5.10		62Fu1	L	36
	27.8	610	531	79				31.2	1.65			14-23	17.93	53.3	3.62	20.95	40.7	7.15		70Ve1	S	37
55Mn	36.5	798	629	166			3.4	18.8	2.02			14-21	16.62	47.4	4.24	19.91	44.9	4.16		73Al16	L	38
58Ni	33.5	286	270	7.7				13.8	0.70											70Fu3	L	39
59Co	36.5	884	741	139			4.2	43.5	2.28			14-21	16.37	26.3	2.56	18.90	64.5	7.61		73Al17	L	40
60Ni	33.2	700	628	72			0	35.4	1.89			14-21	16.30	34.1	2.44	18.51	55.2	6.37		70Fu3	L	41
NatCu	39.6	450 ^a																		67M13	S	
	27.8	604	498	106				33.8	1.97											64Fu1	L	42
63Cu	27.8	604	528	76								14-21	16.24	60.8	4.65	19.65	26.8	4.59		60Fu1	L	43
	25.1		498 ^b	43				33.4	1.92			15-21	16.72	66.1	4.19	19.10	30.1	3.56		68Su1	GA	44
64Zn	29.5	747	703	44				38.1	2.03			14-21	16.23	61.4	3.27	19.19	56.1	5.98		70Ca1	S	45
65Cu	27.8	619	421	198				36.0	2.18			14-20	16.70	75.2	6.89					60Fu1	L	46
NatGa	26.5	912	716	196				52.0	3.09			13-21	16.69	107	6.91					70Ca1	S	47
70Ge	26.5	771	687	84				43.2	2.31			13-21	16.79	89.4	7.66					70Ca1	S	48
72Ge	26.5	935	737	198				53.5	3.10			13-21	16.67	107	7.68					70Ca1	S	49
74Ge	24.5	1013	704	309				58.8	3.56			13-21	14.52	23.9	1.92	17.02	102.3	6.18		70Ca1	S	50
75As	29.5	909	688	221			0	51.4	3.05			13-21	14.98	41.1	3.64	17.61	76.9	7.26		69Be1	L	51
	26.2	1089	872	217				62.7	3.76			13-21	15.23	69.2	4.52	18.24	74.6	7.75		70Ca1	S	52
76Ge	26.5	1110	733	377			0	63.8	3.86			13-21	15.51	59.4	4.36	18.63	73.0	11.44		70Ca1	S	53
76Se	26.5	996	815	181				77.0	3.39			13-21	14.95	68.2	3.84	18.40	81.8	6.47		70Ca1	S	54

Nucleus	E_{γ} (MeV)	$\sigma_{\text{int}}(\gamma, \text{tot})$ (MeV-mb)	$\sigma_{\text{int}}(\gamma, 1s)$ (MeV-mb)	$\sigma_{\text{int}}(\gamma, 2s)$ (MeV-mb)	$\sigma_{\text{int}}(\gamma, 3s)$ (MeV-mb)	σ_{-1} (mb)	σ_{-2} (mb-MeV ⁻¹)	Fitting interval (MeV)	Lorentz Parameters						Reference	Laboratory	Figure Number
									Γ_1 m1 (MeV)	Γ_1 m1 (mb)	Γ_1 1 (MeV)	Γ_2 m2 (MeV)	Γ_2 m2 (mb)	Γ_2 2 (MeV)			
⁷⁸ Se	26.5	1050	778	272		61.4	3.74	13-21	15.23	35.8	2.58	17.18	101.8	5.55	76Ca1	S	55
⁸⁰ Se	28.1	1138	749	389	0	65.9	3.39	13-21	16.53	136	5.90				76Ca1	S	56
⁸² Se	26.5	1124	727	397	0	66.4	4.11	13-21	16.65	148	5.91				76Ca1	S	57
Nat Nb	24.3	1147	1052	95		67.1	4.04	14-19	16.60	190	4.47				71Le1	S	58
Nat Sr	27.0	1432	1311	121		80.3	4.68	14-19	16.84	206	4.50				71Le1	S	59
⁸⁹ Y	28.0	1059	960	99		59.8	3.48	14-19	16.79	185	3.95				67Be2	L	60
	27.0	1353	1279	74		76.5	4.46	14-19	16.74	226	4.25				71Le1	S	61
	18.1	641				40.0	2.52	14-19 ^{ak}	16.83	205	3.69				72Yo	1	62
⁹⁰ Zr	27.6	1060	962	98		59.1	3.38	14-19	16.85	185	4.02				67Be2	L	63
	25.9	1260	1211	49		70.8	4.08	14-19	16.74	211	4.16				71Le1	S	64
⁹¹ Zr	30.0	1103	903	200	0	65.4	4.07	14-19	16.58	184	4.20				67Be2	L	65
⁹² Zr	27.8	1091	639	452	0	64.2	3.92	14-19	16.26	166	4.68				67Be2	L	66
⁹² Mo	29.5	1079	1049	30		57.4	3.16	14-19	16.82	162	4.14				74Be3	S	67
⁹³ Nb	24.3	1331	1052	279		78.5	4.80	14-19	16.59	200	5.05				71Le1	S	68
⁹⁴ Zr	31.1	1121	508	580	33	68.5	4.40	14-19	16.22	161	5.29				67Be2	L	69
⁹⁴ Mo	28.4	1352	1039	313		78.3	4.73	14-19	16.36	185	5.50				74Be3	S	70
⁹⁶ Mo	27.8	1483	1045	438	5	87.6	5.44	13-19	16.20	185	6.01				74Be3	S	71
⁹⁸ Mo	26.8	1518	940	574	4 ^u	92.1	5.89	13-19	15.80	189	5.94				74Be3	S	72
¹⁰⁰ Mo	27.0	1528	811	692	25 ^v	93.6	6.06	12-20	15.74	171	7.81				74Be3	S	73
¹⁰³ Rh	25.8	1568 ^b	1188	380		94.7	5.97	13-19	16.16	191	7.26				74Le1	S	74
Nat Pd	21.3	1381	1111	270		88.5	5.88	13-19	15.92	199	7.18				74Le1	S	75
¹⁰⁷ Ag	29.5	1356	1093	263	0	78.7	4.82	13-19	15.90	150	6.71				69Be1	L	76
Nat Ag	24.9	1643 ^c	1364	279		98.8	6.20	13-19	16.07	199	7.38				74Le1	S	77
Nat Cd	24.6	1685 ^d	1224	361	0	106	6.96	13-19	15.81	227	6.22				74Le1	S	78
¹¹⁵ In	31.1	1875	1354	508	13	113	7.13	13-18	15.63	266	5.24				69Fu1	L	79
	24.1	1748 ^e	1470	278		108	6.91	13-18	15.72	247	5.60				74Le1	S	80
¹¹⁶ Sn	29.6	1669	1255	414	0	99	6.13	13-18	15.68	266	4.19				69Fu1	L	81
	22.1	1630 ^e	1437	193		104	6.78	13-18	15.56	271	5.08				74Le1	S	82
¹¹⁷ Sn	31.1	1894	1480	416	28	114	7.30	13-18	15.66	254	4.02				69Fu1	L	83
	21.1	1554	1334	220		102	7.09	13-18	15.64	257	5.04				74Le1	S	84

Nucleus	E_{γ} (MeV)	$\sigma_{\text{int}}(\gamma, \text{tot})$ (MeV-mb)	$\sigma_{\text{int}}(\gamma, \text{in})$ (MeV-mb)	$\sigma_{\text{int}}(\gamma, 2n)$ (MeV-mb)	$\sigma_{\text{int}}(\gamma, 3n)$ (MeV-mb)	σ_{-1} (mb)	σ_{-2} (mb-MeV ⁻¹)	Fitting Interval (MeV)	Lorentz Parameters						Reference	Laboratory	Figure Number
									Γ_{m1} (MeV)	Γ_{m1} (mb)	Γ_{m1} (MeV)	Γ_{m2} (MeV)	Γ_{m2} (mb)	Γ_{m2} (MeV)			
118Sn	30.8 21.6	1853 1635	1302 1377	531 258	20	110	6.83 7.07	13-18 13-18	15.59 15.44	256 279	4.77 4.56				69Ful 74Le1	L S	85 86
119Sn	31.1	1993	1326	597	69	118	7.55	13-18	15.53	253	4.81				69Ful	L	87
120Sn	29.9 22.4	2074 1770 ^c	1389 1371	673 399	12	124 113	7.79 7.49	13-18 13-18	15.40 15.37	270 285	4.69 5.10				69Ful 74Le1	L S	88 89
124Sn	31.1 21.6	2010 1558 ^c	1285 1056	670 502	55	123 101	8.02 6.74	13-18 13-18	15.19 15.38	283 276	4.81 4.80				69Ful 74Le1	L S	90 91
NatSb	25.7	1927 ^c	1539	388	0	119	7.69	13-18	15.48	277	5.05				74Le1	S	92
124Te	26.5	2022	1546	476	0	127	6.29	12-19	15.24	281	5.56				76Le2	S	93
126Te	24.8	2023	1513	510		129	8.56	12-19	15.17	296	5.44				76Le2	S	94
127I	29.5 24.9	1729 1991	1286 1601	443 390 ^h	<20 w	105 128	6.70 8.55	12-20 12-20	14.24 14.57	118 239	3.24 4.08	16.27 16.69	159 118	5.27 4.92	66Br1 69Be6	L S	95 96
128Te	26.2	2093	1454	639	0	134	8.92	12-19	15.13	305	5.36				76Le2	S	97
130Te	25.9	2180	1467	713	0	139	9.27	12-19	15.12	320	5.03				76Le2	S	98
NatTe	25.7	2112	1588	524	0	134	9.05	12-19	15.46	297	5.32				74Le1	S	99
137Ba	29.5 24.2	1986 2156	1475 1828	503 328	8	126 137	8.09 9.09	12-19 12-19	15.25 15.34	287 317	5.01 5.31				69Be1 74Le1	L S	100 101
NatBa	24.3	2248	1877	371	0	146	9.94	12-19	15.29	356	4.89				71Be4	S	102
138Ba	27.1	2040	1547	490	3 ^x	130	8.71	12-19	15.26	327	4.61				70Be8	L	103
139La	21.2 24.3	1910 ^h 1978	1687	291 ⁱ	y	128	8.54	12-19	15.24	336	4.47				62Ni3 68Be5/71Be4	S S	104
NatCe	21.2 25.2	1880 ^h 2165	1764	400 ^j	1 ^x	143	9.83	12-19	14.95	351	4.64				62Ni3 69Be6/71Be4	S S	105
140Ce	26.5	2398	1961	457	0	153	10.3	12-19	15.04	383	4.41				76Le2	S	106
141Pr	29.8 23.7 16.9 18.1	2062 1717 1714 ^h 1422 1395 ^h	1717 1714 ^h 1422	340	5 ^{aa}	129	8.37 7.31 6.61 ^a	12-19 12-19 ^{kh} 12-19 ^{kh}	15.15 15.23 15.04	324 341 347	4.42 4.00 4.69				66Br1 70Su1 71Be4 72Yo	L GA S I	107 108 109 110
142Ce	23.5	2208	1022	1186	0	150	10.7	12-19	14.86	332	5.10				76Le2	S	111
NatNd	18.0	1559	1236	323		112	8.46	12-19 ^{kh}	14.92	315	4.70				71Be4	S	112
142Nd	20.2	1873	1828	45		126	8.66	12-19	14.94	359	4.44				71Ca1	F	113
143Nd	19.8	1875	1696	179		130	9.39	12-19	15.01	349	4.75				71Ca1	S	114

Nucleus	E _γ max (MeV)	σ _{int} (γ,tot) (MeV-mb)	σ _{int} (γ,1n) (MeV-mb)	σ _{int} (γ,2n) (MeV-mb)	σ _{int} (γ,3n) (MeV-mb)	σ ₋₁ (mb)	σ ₋₂ (mb-MeV ⁻¹)	Fitting Interval (MeV)	Lorentz Parameters						Reference	Laboratory	Figure Number
									E _{m1} (MeV)	σ _{m1} (mb)	Γ ₁ (MeV)	E _{m2} (MeV)	σ _{m2} (mb)	Γ ₂ (MeV)			
¹⁴⁴ Nd	20.2	1882	1319	563		128	9.01	12-19	15.05	317	5.28				71Ca1	S	115
¹⁴⁴ Sm	20.8	1935	1900	35		126	8.41	12-19	15.32	383	4.45				74Ca5	S	116
¹⁴⁵ Nd	20.2	2037	1380	657	0	147	11.3	12-19	14.95	296	6.31				71Ca1	S	117
¹⁴⁶ Nd	20.2	1920	1253	667		133	9.60	12-19	14.74	310	5.78				71Ca1	S	118
¹⁴⁶ Nd	18.8	1702	867	835		122	9.02	10.8-18.8	12.76	107	3.97	15.48	220	5.36	71Ca1	S	119
¹⁴⁸ Sm	20.0	1942	1386	556		134	9.51	12-19	14.82	339	5.09				74Ca5	S	120
¹⁵⁰ Nd	20.2	2011	1174	837	0	142	10.4	10.8-18.8	12.30	175	3.38	16.04	223	5.17	71Ca1	S	121
¹⁵⁰ Sm	19.8	1991	1295	696		141	10.3	12-19	14.61	312	5.97				74Ca5	S	122
¹⁵² Sm	20.0	2076	1345	681		143	10.5	10.8-18.8	12.38	176	2.97	15.74	234	5.22	74Ca5	S	123
¹⁵³ Eu	28.9	2273	1566	670	37	148	10.2	10.8-18.8	12.33	155	2.75	15.79	222	5.83	69Be8	L	124
¹⁵⁴ Sm	21.1	2059	1277	782		144	10.6	10.8-18.8	12.27	181	2.95	15.94	215	5.70	74Ca5	S	125
¹⁵⁴ Sm	25.2	2425	1628	772	25 ^{bb}	164	11.7								69Be6	S	126
¹⁵⁹ Tb	28.0	2300	1413	887 ^k		151	10.5	10.8-18.8	12.22	181	2.64	15.67	220	4.97	64Br1	L	127
	27.4	2557	1936	605	16 ^{cc}	170	12.0	10.8-18.8	12.07	196	2.98	15.88	248	5.10	68Be5	S	128
¹⁶⁰ Gd	29.5	2533	1398	1055	80	169	12.1	10.8-18.8	12.23	215	2.77	15.96	233	5.28	69Be8	L	129
¹⁶⁵ Ho	19.6	2540 ^f							12.02	238	2.35	15.59	308	4.85	66Ca1	S	
	28.9	2523	1735	744	44 ^{dd}	166	11.6	10.8-18.8	12.28	214	2.57	15.78	246	5.00	69Be8	L	130
	26.6	2871	2090	766	15 ^{dd}	194	13.9	10.8-18.8	12.01	239	2.52	15.59	291	5.12	68Be5	S	131
¹⁶⁵ Ho	21.1	2387	1801	586 ⁱ	ee	172	12.9	10.8-18.8	12.12	242	2.76	15.58	259	4.74	69Be6	S	132
¹⁷⁵ Lu	23.0	2507	1872	635 ^m	ff	173	12.5	10.8-18.8	12.32	217	2.57	15.47	287	4.70	69Be6	S	133
¹⁸¹ Ta	22.0	2970 ⁿ													62M13	S	
	24.6	2181	1306	881 ^k		149	10.7	10.8-18.8	12.54	154	1.67	14.95	273	5.23	63Br1	L	134
	25.2	2983	2180	790	13 ^{ee}	205	14.8	10.8-18.8	12.30	259	2.43	15.23	341	4.48	68Be5	S	135
¹⁸¹ Ta	21.3	2854	1860	994	0	203	15.0	10.8-18.8	12.56	268	2.66	15.17	328	4.69	75Ve5	S	136
¹⁸⁶ W	28.6	3004	1655	1200	149	203	14.5	10.8-18.8	12.59	211	2.29	14.68	334	5.18	69Be8	L	137
¹⁸⁶ W	21.6	3226	2461	765	0	227	16.6	10.8-18.8	12.63	279	2.77	15.24	375	4.69	75Ve5	S	138
¹⁸⁶ Os	19.7	2501	2019	482		179	13.2	10.8-18.8	14.10	433	5.60				76BeP	L	139
¹⁸⁸ Os	30.4	3435	2438	890	107	228	16.0	10.8-18.8	14.22	480	5.56				76BeP	L	140
¹⁸⁹ Os	29.9	3341	2205	979	157	227	16.4	10.8-18.8	13.89	502	4.78				76BeP	L	141
¹⁹⁰ Os	29.4	3344	2215	1018	111	224	15.8	10.8-18.8	14.19	467	5.65				76BeP	L	142

Nucleus	E _γ max (MeV)	σ _{int} (γ,tot) (MeV-mb)	σ _{int} (γ,1n) (MeV-mb)	σ _{int} (γ,2n) (MeV-mb)	σ _{int} (r,3n) (MeV-mb)	σ _{int} (r,4n) (mb)	σ _{int} (r,5n) (mb-MeV ⁻¹)	Fitting Interval (MeV)	Lorentz Parameters						Reference	Laboratory	Figure Number
									E _{m1} (MeV)	σ _{m1} (mb)	Γ _{m1} (MeV)	E _{m2} (MeV)	σ _{m2} (mb)	Γ _{m2} (MeV)			
¹⁹² Os	29.4	3126	2041	1182	103	221	15.6	10.5-18.8	14.03	462	5.31			78bEP	1	143	
¹⁹² Ir	21.9	2905	2334	631		211	15.6	11-17	13.80	487	5.08			75Ve5	S	144	
¹⁹² Pt	20.3	3055	2537	519		228	17.8	11-17	13.72	512	4.99			75Ve5	S	145	
¹⁹⁷ Au	22.0	3000 ^a												62M13	S		
	24.7	2967	2190	777 ^k		205	14.7	11-17	13.82	560	3.84			62Fu2	L	146	
	21.7	3067	2588	479 ⁿ	hh	217	15.9	11-17	13.72	541	4.61			70Ve1	S	147	
¹⁹⁸ Hg	21.1	3133	2588	545	0	227	17.2	11-17	13.72	582	4.39			75Ve5	S	148	
²⁰⁶ Pb	26.4	2909	2377	532 ^k		203	15.0	10-17	13.59	514	3.85			64Ha2	L	149	
²⁰⁷ Pb	26.4	2718	2169	569 ^k		191	14.2	10-17	13.36	481	3.96			64Ha2	L	150	
²⁰⁸ Pb	26.4	2636	1776	860 ^k		139	14.2	10-17	13.46	491	3.90			64Ha2	L	151	
	18.9	3059	2731	328 ^o	ff	229	17.6	10-17	13.43	639	4.07			70Ve1	S	152	
	14.9	2090 ^a				165 ^a	13.3 ^a	10-17 ^{kk}	13.63	645	3.94			72Vo	L	153	
²⁰⁸ Pb	22.0	4100 ^a												62M13	S		
²⁰⁹ Bi	22.0	3730 ^a												62M13	S		
	26.4	3058	2344	714 ^k		214	15.8	10-17	13.45	521	3.97			64Ha2	L	154	
	14.8	2129 ^a				170 ^a	13.8 ^a	10-17 ^{kk}	13.56	648	3.72			72Vo	L	155	
²³² Th	16.3	2807	1828	787		192 ^{jj}		9-16.5 ^{kk}	11.26	283	4.32	14.18	304	4.48	73Ve1 ¹¹	S	156
	18.3	3552	1675	1540		337 ^{jj}	284	9-18	10.83	303	2.55	13.74	449	5.14	76Ca ¹¹	L	157
²³⁵ U	18.3	3714	1066	1588		1060 ^{jj}	24.1	9-16.5	10.50	380	1.77	13.84	531	4.55	64Bo3 ¹¹	L	
	18.3	3579	1193	376		2010 ^{jj}	23.5	9-18	10.91	297	2.28	13.83	475	5.05	76Ca ¹¹	L	158
²³⁶ U	18.3	3179	1194	512		1473 ^{jj}	21.1	9-18	11.04	306	2.95	13.95	381	4.70	76Ca ¹¹	L	159
²³⁷ Np	16.6	2864	1061	121		1683 ^{jj}	21.8	9-16.5	11.00	250	2.58	14.10	394	4.85	76Ve1 ¹¹	S	160
	18.3	3971	1381	604		1986 ^{jj}	25.2	9-18	11.01	250	1.82	14.03	537	6.13	76Ca ¹¹	L	161
²³⁸ U	18.3	3061	1236	899		926 ^{jj}	21.2	9-16.5	10.92	291	2.60	13.98	383	4.72	73Ve1 ¹¹	S	162
	18.3	3579	1360	1133		1086	286	9-18	10.80	320	2.44	13.85	454	5.12	76Ca ¹¹	L	163

Footnotes to Table 1

- ^a Not corrected for $(\gamma, 2n)$ events; the figures given are for the photoneutron yield cross section $\sigma[(\gamma, n) + (\gamma, pn) + 2(\gamma, 2n)]$.
- ^b Some (γ, tot) data up to 30.1 MeV.
- ^c Some (γ, tot) data up to 29.5 MeV.
- ^d Some (γ, tot) data up to 26.2 MeV.
- ^e Some (γ, tot) data up to 22.7 MeV.
- ^f Extrapolated to 23 MeV.
- ^g Does not include (γ, pn) events.
- ^h 508 MeV-mb up to 31.2 MeV.
- ⁱ Some $(\gamma, 2n)$ data up to 29 MeV.
- ^j 473 MeV-mb up to 29.6 MeV.
- ^k Includes $(3/2) \sigma_{int}(\gamma, 3n)$.
- ^l 768 MeV-mb up to 27.4 MeV.
- ^m 742 MeV-mb up to 28.5 MeV.
- ⁿ 671 MeV-mb up to 27.1 MeV.
- ^o 614 MeV-mb up to 26.3 MeV.
- ^p $\sigma_{int}(\gamma, pn)$.
- ^q $\sigma_{int}(\gamma, p)$.
- ^r $\sigma_{int}(\gamma, pn)$ up to 30.0 MeV.
- ^s $\sigma_{int}(\gamma, pn)$ up to 27.8 MeV.
- ^t 3.4 MeV-mb up to 29.2 MeV.
- ^u 22 MeV-mb up to 28.9 MeV.
- ^v 49 MeV-mb up to 28.4 MeV.
- ^w 31 MeV-mb up to 31.2 MeV.
- ^x 13 MeV-mb up to 28.6 MeV.
- ^y Some $(\gamma, 3n)$ data up to 30 MeV.
- ^z 19 MeV-mb up to 29.6 MeV.
- ^{aa} 36 MeV-mb up to 33.0 MeV.
- ^{bb} 59 MeV-mb up to 27.4 MeV.
- ^{cc} 46 MeV-mb up to 29.3 MeV.
- ^{dd} 45 MeV-mb up to 28.5 MeV.
- ^{ee} 52 MeV-mb up to 27.7 MeV.
- ^{ff} 65 MeV-mb up to 28.5 MeV.
- ^{gg} 137 MeV-mb up to 36.4 MeV; some $(\gamma, 4n)$ data up to 36.4 MeV.
- ^{hh} 24 MeV-mb up to 27.1 MeV.
- ⁱⁱ 197 MeV-mb up to 37.8 MeV; some $(\gamma, 4n)$ data up to 37.8 MeV.
- ^{jj} $\sigma_{int}(\gamma, f)$.
- ^{kk} Data do not extend to upper limit of fitting interval.
- ^{ll} $\bar{v}(E_\gamma)$ estimated.
- ^{mm} $\bar{v}(E_\gamma)$ measured.

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TABLE II. Selected Bremsstrahlung Results for Comparison

Nucleus	Reference	Comments
^3He	65Fe1	10% higher; gas sample
	66Ge1	10% lower; liquid sample
^4He	72Be2	Same; liquid sample, high beam
	72Do1	Factor of two higher; gas sample
	73Ir4	Same; liquid sample, high beam
	73Ma11	Factor of two higher; gas sample Factor of two higher; liquid sample, low beam
^6Li	65Ba2	Same
	65Ha1	20% higher
	66Co5	20% higher
^7Li	65Ha1	20% higher
	67Ba2	10% higher
^9Be	66Co4	Same
	72Th2	Same; unconfirmed structure
	75Hu1	40% lower; unconfirmed structure
^{10}B	65Ha1	10% higher
	73Hu14	Same
^{11}B	65Ha1	10% higher
	73Hu14	Same
$^{12}\text{C}^a$	65Mi1	10% higher
	65Ve1	Same; (γ, n_0)
	66Ba4	Same
	66Co2	10% higher; unconfirmed structure
	68Wu1	Same; (γ, n_0)
	69Ba1	Same; unconfirmed structure
	71Is3	10% higher; unconfirmed structure
$^{16}\text{O}^b$	72Va2	30% higher
	65Ha1	30% higher
	65Ve1	Same; (γ, n_0)
	66Co1	60% higher
	68Wu1	15 to 20% higher; (γ, n_0)
	69Kh1	15 to 20% higher; (γ, n_0)
	70Is5	30% higher; unconfirmed structure
^{19}F	70Ju1	15 to 20% higher; (γ, n_0)
	73Ca5	50% higher; unconfirmed structure
^{23}Na	63Sa1	Same
	64Fi	10% lower
^{24}Mg	70We1	Same
	72Is1	20% higher

TABLE II. Selected Bremsstrahlung Results for Comparison

Nucleus	Reference	Comments
^{26}Mg	72Is1	Same
^{27}Al	69Co2 69Is3	20% higher; unconfirmed structure 40% higher; unconfirmed structure
$^{28}\text{Si}^c$	68Go6 69Co1 70We1	Same 15% lower 15% lower
^{31}P	69Is3 72An12 74De10	Same Same Same
^{32}S	67We1 68Go6 70An3	Factor of two higher 20% higher 50% higher
^{39}K	65Co1	10% lower
^{40}Ca	64Ba1 68Go6 71Is1	Same 10% lower Same; unconfirmed structure
^{45}Sc	73Sa5	Factor of two lower
^{51}V	69Go3	Same; unconfirmed structure
^{55}Mn	70Is7 74Ca6	10% higher; unconfirmed structure 30% higher
^{59}Co	64Ba2 65Ba3 69Go3 71Ba1	Same Same Same; unconfirmed structure 40% higher; unconfirmed structure
$^{58,60}\text{Ni}$	68Mi1 69Go2 70W1	Same Same; unconfirmed structure 10% higher; unconfirmed structure
$^{63}\text{Cu}^d$	72Dr2	10% higher
$^{\text{Nat}}\text{Cu}$	65Ba3 68To1 70Is6	Same Same 10% higher; unconfirmed structure
^{64}Zn	74Is3 75Go	20% higher; unconfirmed structure 30% lower
$^{\text{Nat}}\text{Ga}$	65Ba3	Same
$^{70,72,74,76}\text{Ge}$	75Go 75Mc1	Same to 15% lower 10 to 70% higher

TABLE II. Selected Bremsstrahlung Results for Comparison

<u>Nucleus</u>	<u>Reference</u>	<u>Comments</u>
$^{75}_{\text{As}}\text{e}$	65Fil 70Ba	Same; unconfirmed structure Same
$^{76,78,80,82}_{\text{Se}}$	75Go	Same
$^{\text{Nat}}_{\text{Sr}}$	70Hil	20% lower
$^{89}_{\text{Y}}\text{f}$	70Is8	15% higher
$^{90}_{\text{Zr}}\text{g}$	65Col 71Is2 73As2	Same Same; unconfirmed structure 10% higher
$^{92,98}_{\text{Mo}}$	70Is1	Same to 30% higher; unconfirmed structure
$^{107}_{\text{Ag}}$	69Is2	10% higher; unconfirmed structure
$^{116,117,119,124}_{\text{Sn}}$ $^{118,120}_{\text{Sn}}$	$\left. \begin{array}{l} 72\text{Sol1} \\ 74\text{SolG} \end{array} \right\}$	$\left. \begin{array}{l} 10\% \text{ lower to } 10\% \text{ higher} \end{array} \right\}$
$^{139}_{\text{La}}$	64Ril 72De3	15% lower 10% higher
$^{141}_{\text{Pr}}$	64Ril 66Co3 68Cal 72De3 72Dr2	15% lower 10 to 15% higher; unconfirmed structure Unconfirmed structure 10 to 15% higher 10 to 15% higher
$^{146}_{\text{Nd}}$	71Va2	10% higher
$^{148,150}_{\text{Nd}}$	69Va3	30% higher; unconfirmed structure
$^{148}_{\text{Sm}}$	71Va2	Same
$^{150,152,154}_{\text{Sm}}$	69Va3	20 to 60% higher; unconfirmed structure
$^{153}_{\text{Eu}}$	71Va2	Same
$^{160}_{\text{Gd}}$	72Dr5	10% lower
$^{165}_{\text{Ho}}\text{h}$	74Ca7	Same
$^{181}_{\text{Ta}}\text{i}$	69Is1 73Hi6	10% lower; unconfirmed structure 10% lower
$^{186}_{\text{W}}$	73Go6	Same
$^{\text{Nat}}_{\text{Re}}$	73Go6	10% lower
$^{190}_{\text{Os}}$	73Go6	10% lower

TABLE II. Selected Bremsstrahlung Results for Comparison

<u>Nucleus</u>	<u>Reference</u>	<u>Comments</u>
^{197}Au	73So19	10% higher
^{206}Pb	73So	15% lower
$^{208}\text{Pb}^j$	68Go3	15% higher; unconfirmed structure
	70Is3	Same; unconfirmed structure
	73So	30% lower
$^{209}\text{Bi}^k$	73Ko3	15% lower
	73So19	Same

Footnotes to Table II

^aReferred to L; P is 10% higher, G is 20% higher

^bReferred to L or G; S is 10% higher

^cReferred to S; L is 30% lower

^dReferred to GA; L is 10% lower

^eReferred to L; S is 15% higher

^fReferred to L; S and I are 15% higher

^gReferred to L; S is 15% higher

^hReferred to S; L is 10% lower

ⁱReferred to S; L is 25% lower

^jReferred to S or I; L is 20% lower

^kReferred to I; L is 15% lower

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