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Proposal

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Proposal to Extend CSEWG Neutron and Photon Multigroup Structures for Wider Applications

by

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PROPOSAL TO EXTEND CSEWG NEUTRON AND PHOTON MULTIGROUP
STRUCTURES FOR WIMER APPLICATIONS

by

R. J. LaBauve and W. B. Wilson

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ABSTRACT

The 239-group neutron multigroup structure recommended by the Codes and Formats Subcommittee of the Cross Section Evaluation Working Group (CSEWG) for use in LMFBR design is not well suited for application in certain other areas, particularly thermal reactor design. This report describes a proposal for a neutron group structure consisting of 347 groups, which is an extension of the CSEWG group structure into the thermal range, and also includes more detail in other energy ranges important in LWR, HTGR, GCFR, and CTR design. Similarly, a proposed extension of the CSEWG 94-group photon multigroup structure to 103 groups is described. A subset of the neutron multigroup structure, consisting of 154 groups and for use in power reactor studies, is also presented.

I. INTRODUCTION

In 1973 the Codes and Formats Subcommittee of the Cross Section Evaluation Working Group (CSEWG) recommended a "fast" neutron multigroup structure consisting of 239 groups¹ and a "thermal" neutron group structure consisting of 460 groups.² The 239-group structure includes an energy range from 0.414 eV to 19.97 MeV, and the 460-group structure a range from 0.0 to 3.15 eV. Also, in 1973 the Shielding Subcommittee of CSEWG recommended a photon multigroup structure consisting of 94 groups³ with an energy range from 0.005 to 20.0 MeV.

Studies since 1973 have indicated some inadequacies in these multigroup structures. In particular, resonance structure in important fissile and fertile materials is not well treated. Also, some energy boundaries common in several multigroup sets now in use are not included in the 239-group structure and, finally, this set is not sufficiently dense in the eV range for thermal applications.

On the other hand, the 460-group thermal set seems too detailed for most applications. The structure is the union of all energy boundaries used in a total of nine thermal codes; it would seem that

it would be adequate to limit the set to include boundaries of the THERMOS,⁴ LASER,⁵ and GRANIT⁶ codes.

The 94-group photon multigroup structure has proven inadequate in the high energy range. Although the maximum energy for ENDF/B-IV was set at 20 MeV, energies of photons produced in capture reactions can go much higher in cases where the photon energy for primary gamma rays is given with the LP = 2 option, that is, by

$$E = EG_K + \frac{AWR}{AWR + 1} E_n$$

where EG_K is the energy of the K^{th} primary gamma ray for zero-energy incident neutrons, and E_n is the actual incident neutron energy. Consequently, the 94-photon group structure needs to be extended to a higher limit with detail above 20 MeV.

We are therefore proposing:

1. A neutron multigroup structure consisting of 347 groups in the energy range from 10^{-5} eV to 20 MeV.

2. A 154 neutron multigroup structure for a more limited use in power reactor studies.
3. A photon multigroup structure consisting of 103 groups in the energy range from 0 to 50 MeV.

II. THE 347-GROUP NEUTRON MULTIGROUP STRUCTURE

The multigroup energy boundaries of the 347 neutron group structure are shown in Table I. Also given are lethargy bounds, lethargy widths, and the group numbers for other multigroup sets which are subsets of the 347-group structure. Briefly, the 347-group set was constructed as follows.

For $78.893 \text{ eV} < E \leq 20 \text{ MeV}$:

Groups from CSEWG standard set.....	216
Group added to include 20-MeV point.....	1
Groups added to include RSIC 171-group set..	7
Total.....	224

For $0.414 \text{ eV} < E \leq 78.893 \text{ eV}$:

Groups from CSEWG standard set.....	23
Groups added to include THERMOS 30-group set.....	3
Groups added to include LASER 35-group set..	15
Groups added to include GRANIT 48-group set..	15
Groups added for ^{238}U resonances in eV range.....	5
Groups added for ^{232}Th in eV range.....	11
Total.....	72

For $1.0 \times 10^{-5} \text{ eV} \leq E \leq 0.414 \text{ eV}$:

Groups added to include THERMOS 30-group set.....	27
Groups added to include LASER 35-group set..	19
Groups added to include LASL 30-group set...	2
Group added to include RSIC 171-group set...	1
Group added at $7.6 \times 10^{-4} \text{ eV}$ to fill gap....	1
Group added to extend lower boundary to $1.0 \times 10^{-5} \text{ eV}$	1
Total.....	51
Grand Total....	347

Other group structures, such as MUFT⁹ and EPRI-4,¹⁰ are subsets of the proposed 347-group set. Also note that a number of boundaries, not common with any of the compared sets, were added to (a) extend the energy limits, (b) better treat the resonances of ^{238}U and ^{232}Th , and (c) fill in a gap in the low eV range. Point (b) is illustrated in Figs. 1 to 3.

Fig. 1. ^{238}U total cross section, $T = 950^\circ\text{K}$.

Fig. 2. ^{232}Th total cross section, $T = 950^\circ\text{K}$.

III. THE 154-GROUP PRS NEUTRON MULTIGROUP STRUCTURE

This 154-group structure is shown in Table II. It is a subset of the 347-group structure and is primarily intended to be used in power reactor studies (PRS). The 154-group structure extends from 10^{-5} eV to 20 MeV and includes all of the energy bounds of GAM-1, GRANIT, LASER, LASL-30, and EPRI-4 group

Fig. 3. ^{232}Th total cross section, $T = 950^\circ\text{K}$.

structures. In addition, groups were added to extend upper and lower energy limits; to better treat the resonances of several fuel, fission product, and structural materials; and to provide detail around the fission spectrum. Where practical, these group boundaries were selected from the CSEWG 239-group structure.

IV. THE 103-GROUP PHOTON MULTIGROUP STRUCTURE

The multigroup boundaries for the proposed group structure for photon production and photon interaction cross sections are an extension of that recommended by the Shielding Subcommittee of CSEWG in 1973. The CSEWG group structure extends from 0.005 to 20 MeV; the proposed group structure includes these groups plus one group from 0.0 to 0.005 MeV, three groups to include the RSIC 36-group set, one group from 17 to 20 MeV, and four groups from 20 to 50 MeV. The proposed photon multigroup structure is given in Table III. Note that the LASL 12-group structure is a subset of the proposed 103-group structure.

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8. T. J. Hiron, Los Alamos Scientific Laboratory, private communication.
9. H. Bahl, E. Gelbard, and G. Ryan, "MUFT-4 -- Fast Spectrum Code for the IBM-704," Westinghouse Corporation report WAPD-TM-72 (1957).
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TABLE I

THE 347-GROUP NEUTRON MULTIGROUP STRUCTURE

GROUP NO.	UPPER ENERGY BOUND, (EV)	GROUP ENERGY WIDTH, (EV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING									
					CSEWG	RSIC	PRS	GAMI	GRANIT	LASER	THERMOS	LASL	EPRI	
					239	171	154	68	48	35	30	30	4	
1	2.00000000E+07	2.9588370E+04	-6.931472E-01	1.480514E-03										
2	1.997041163E+07	3.3008187E+05	-6.916667E-01	1.666667E-02	1									
3	1.964032976E+07	4.8492147E+05	-6.750000E-01	2.500000E-02	2									
4	1.915540829E+07	4.7294872E+05	-6.500000E-01	2.500000E-02	3									
5	1.868245957E+07	4.6127157E+05	-6.250000E-01	2.500000E-02	4									
6	1.822118800E+07	4.4988273E+05	-6.000000E-01	2.500000E-02	5									
7	1.777130527E+07	4.3877509E+05	-5.750000E-01	2.500000E-02	6									
8	1.733253018E+07	4.2794170E+05	-5.500000E-01	2.500000E-02	7	1								
9	1.690458848E+07	4.1737577E+05	-5.250000E-01	2.500000E-02	8									
10	1.648721271E+07	4.0707074E+05	-5.000000E-01	2.500000E-02	9	2							1	
11	1.608014197E+07	3.9702012E+05	-4.750000E-01	2.500000E-02	10									
12	1.568312185E+07	3.8721765E+05	-4.500000E-01	2.500000E-02	11	3								
13	1.529590420E+07	3.7765722E+05	-4.250000E-01	2.500000E-02	12									
14	1.491824698E+07	3.6833283E+05	-4.000000E-01	2.500000E-02	13	4							2	
15	1.454991415E+07	3.5923866E+05	-3.750000E-01	2.500000E-02	14	5								
16	1.419067549E+07	3.5036903E+05	-3.500000E-01	2.500000E-02	15	6								
17	1.384030646E+07	3.4171838E+05	-3.250000E-01	2.500000E-02	16	7								
18	1.349858808E+07	3.3328133E+05	-3.000000E-01	2.500000E-02	17	8								
19	1.316530675E+07	3.2505258E+05	-2.750000E-01	2.500000E-02	18									
20	1.284025417E+07	3.1702701E+05	-2.500000E-01	2.500000E-02	19	9								
21	1.252322716E+07	3.0919958E+05	-2.250000E-01	2.500000E-02	20									
22	1.221402758E+07	3.0156541E+05	-2.000000E-01	2.500000E-02	21	10								
23	1.191246217E+07	2.9411974E+05	-1.750000E-01	2.500000E-02	22									
24	1.161834243E+07	2.8685790E+05	-1.500000E-01	2.500000E-02	23	11								
25	1.133148453E+07	2.7977535E+05	-1.250000E-01	2.500000E-02	24									
26	1.105170918E+07	2.7286767E+05	-1.000000E-01	2.500000E-02	25	12								
27	1.077884151E+07	2.6613055E+05	-7.500000E-02	2.500000E-02	26									
28	1.051271396E+07	2.5955975E+05	-5.000000E-02	2.500000E-02	27	13								
29	1.025315121E+07	2.5315121E+05	-2.500000E-02	2.500000E-02	28									
30	1.000000000E+07	2.4690000E+05	0.	2.500000E-02	29	14	7	1				5	1	
31	9.753099120E+06	2.4080000E+05	2.500000E-02	2.500000E-02	30									
32	9.512294245E+06	2.3485438E+05	5.000000E-02	2.500000E-02	31	15								
33	9.277434803E+06	2.2906068E+05	7.500000E-02	2.500000E-02	32									
34	9.048374180E+06	2.2340515E+05	1.000000E-01	2.500000E-02	33	16								
35	8.824969026E+06	2.1788926E+05	1.250000E-01	2.500000E-02	34									
36	8.607079764E+06	2.1250456E+05	1.500000E-01	2.500000E-02	35	17								
37	8.394570208E+06	2.0726268E+05	1.750000E-01	2.500000E-02	36									
38	8.187307531E+06	2.0214534E+05	2.000000E-01	2.500000E-02	37	18								
39	7.985162188E+06	1.9715436E+05	2.250000E-01	2.500000E-02	38									
40	7.788007831E+06	1.9228000E+05	2.500000E-01	2.500000E-02	39	19	8	2				6		

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING									
					CSEWG 239	ASIC 171	PRS 154	GAMI 6H	GRANIT 4H	LASER 35	THERMOS 30	LASL 30	EPRI 4	
41	7.595721232E+06	1.8753903E+05	2.750000E-01	2.500000E-02	40									
42	7.408182207E+06	1.8290867E+05	3.000000E-01	2.500000E-02	41	24								
43	7.225273536E+06	1.7839264E+05	3.250000E-01	2.500000E-02	42									
44	7.046800897E+06	1.7398811E+05	3.500000E-01	2.500000E-02	43	21								
45	6.872892788E+06	1.6969233E+05	3.750000E-01	2.500000E-02	44									
46	6.703200460E+06	5.5627899E+04	4.000000E-01	8.333333E-03	45	22								
47	6.647572501E+06	5.5106259E+04	4.083333E-01	8.333333E-03	46									
48	6.592400302E+06	5.4708451E+04	4.166667E-01	8.333333E-03	47	23								
49	6.537697851E+06	1.6141634E+05	4.250000E-01	2.500000E-02	48									
50	6.376281516E+06	1.5743095E+05	4.500000E-01	2.500000E-02	49	24								
51	6.218850565E+06	1.5354397E+05	4.750000E-01	2.500000E-02	50									
52	6.065306597E+06	1.4975295E+05	5.000000E-01	2.500000E-02	51	25	9	3					7	
53	5.915553644E+06	1.4605554E+05	5.250000E-01	2.500000E-02	52									
54	5.769498104E+06	2.8138174E+05	5.500000E-01	5.000000E-02	53	26								
55	5.488116361E+06	2.6705852E+05	6.000000E-01	5.000000E-02	54	27								
56	5.220457768E+06	2.5460473E+05	6.500000E-01	5.000000E-02	55	28								
57	4.965853038E+06	1.2260735E+05	7.000000E-01	2.500000E-02	56	29								
58	4.843245690E+06	1.1958016E+05	7.250000E-01	2.500000E-02	57									
59	4.723665527E+06	1.1662772E+05	7.500000E-01	2.500000E-02	58	30	10	4						
60	4.607037810E+06	1.1374817E+05	7.750000E-01	2.500000E-02	59									
61	4.493289641E+06	2.1914032E+05	8.000000E-01	5.000000E-02	60	31								
62	4.271149319E+06	2.0845272E+05	8.500000E-01	5.000000E-02	61									
63	4.065696597E+06	1.9828636E+05	9.000000E-01	5.000000E-02	62	32								
64	3.867410234E+06	1.8861582E+05	9.500000E-01	5.000000E-02	63									
65	3.678794412E+06	1.7941692E+05	1.000000E+00	5.000000E-02	64	33	11	5					8	
66	3.499377491E+06	1.7066665E+05	1.050000E+00	5.000000E-02	65									
67	3.328710837E+06	8.2186163E+04	1.100000E+00	2.500000E-02	66	34								
68	3.246524674E+06	8.0156980E+04	1.125000E+00	2.500000E-02	67									
69	3.166367644E+06	7.8177897E+04	1.150000E+00	2.500000E-02	68	35								
70	3.088189747E+06	7.6247678E+04	1.175000E+00	2.500000E-02	69									
71	3.011942119E+06	1.4689415E+05	1.200000E+00	5.000000E-02	70	36								
72	2.965047969E+06	1.3973004E+05	1.250000E+00	5.000000E-02	71	37	12	6					9	
73	2.725317930E+06	1.3291532E+05	1.300000E+00	5.000000E-02	72	38								
74	2.592402606E+06	1.2643297E+05	1.350000E+00	5.000000E-02	73	39								
75	2.465969639E+06	4.0758893E+04	1.400000E+00	1.666667E-02	74	40								
76	2.425210746E+06	4.0085207E+04	1.416667E+00	1.666667E-02	75									
77	2.385125539E+06	1.9793459E+04	1.433333E+00	8.333333E-03	76	41								
78	2.365332080E+06	1.9629199E+04	1.441667E+00	8.333333E-03	77	42								
79	2.345702881E+06	3.8771058E+04	1.450000E+00	1.666667E-02	78	43								
80	2.306931823E+06	3.8130230E+04	1.466667E+00	1.666667E-02	79	44								
81	2.268801593E+06	3.7499992E+04	1.483333E+00	1.666667E-02	80									
82	2.231301601E+06	1.0882186E+05	1.500000E+00	5.000000E-02	81	45	13	7					10	
83	2.122479738E+06	1.0351456E+05	1.550000E+00	5.000000E-02	82	46								
84	2.018965180E+06	4.9848428E+04	1.600000E+00	2.500000E-02	83	47								
85	1.969116752E+06	4.8617666E+04	1.625000E+00	2.500000E-02	84									

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING								
					CSEW	RSIC	PRS	GANI	GRANII	LASER	THERMOS	LASL	EPRI
					239	171	154	6H	4H	35	30	30	4
131	3.096183382E+05	7.6045000E+03	3.475000E+02	2.500000E-02	130								
132	3.019738342E+05	3.4738342E+03	3.500000E+02	1.157044E-02	131	80	26	15				15	
133	2.985000000E+05	1.3000000E+03	3.511570E+02	4.304620E-03		81							
134	2.972000000E+05	2.6819263E+03	3.515935E+02	9.064941E-03		82							
135	2.945180737E+05	7.2716772E+03	3.525000E+02	2.500000E-02	132	83							
136	2.872463965E+05	7.0921388E+03	3.550000E+02	2.500000E-02	133	84							
137	2.801542577E+05	6.9170332E+03	3.575000E+02	2.500000E-02	134								
138	2.732572245E+05	1.3325937E+04	3.600000E+02	5.000000E-02	135	85	27						
139	2.599112878E+05	1.2676023E+04	3.650000E+02	5.000000E-02	136								
140	2.472352647E+05	1.2057006E+04	3.700000E+02	5.000000E-02	137	86							
141	2.351774586E+05	1.1369740E+04	3.750000E+02	5.000000E-02	138	87	28	16					
142	2.237077186E+05	1.0910354E+04	3.800000E+02	5.000000E-02	139	88							
143	2.127973644E+05	1.0378250E+04	3.850000E+02	5.000000E-02	140	89	29						
144	2.024191145E+05	9.8720967E+03	3.900000E+02	5.000000E-02	141	90							
145	1.925470178E+05	9.3006289E+03	3.950000E+02	5.000000E-02	142	91							
146	1.831563889E+05	8.9326425E+03	4.000000E+02	5.000000E-02	143	92	30	17				16	
147	1.742237004E+05	4.3015996E+03	4.050000E+02	2.500000E-02	144	93							
148	1.649221468E+05	4.1953928E+03	4.107500E+02	2.500000E-02	145								
149	1.657267540E+05	4.0918001E+03	4.100000E+02	2.500000E-02	146	94							
150	1.616349459E+05	3.9907811E+03	4.125000E+02	2.500000E-02	147								
151	1.576441648E+05	7.6883966E+03	4.150000E+02	5.000000E-02	148	95							
152	1.499557682E+05	7.3134291E+03	4.200000E+02	5.000000E-02	149	96							
153	1.426423391E+05	6.9567490E+03	4.250000E+02	5.000000E-02	150	97	31	18					
154	1.356855901E+05	6.6174643E+03	4.300000E+02	5.000000E-02	151	98							
155	1.290081258E+05	6.2947268E+03	4.350000E+02	5.000000E-02	152	99							
156	1.227733990E+05	5.9817293E+03	4.400000E+02	5.000000E-02	153	100							
157	1.167856697E+05	5.6957043E+03	4.450000E+02	5.000000E-02	154	101							
158	1.110899654E+05	1.3053415E+04	4.500000E+02	1.250000E-01	155	102	32	19					
159	9.803659036E+04	1.1519598E+04	4.625000E+02	1.250000E-01	156	103							
160	8.651695203E+04	4.00169520E+03	4.750000E+02	4.754200E-02	157	104	33	20					
161	8.250000000E+04	3.0000000E+03	4.797422E+02	3.704127E-02	105								
162	7.950000000E+04	3.1490578E+03	4.834583E+02	4.001665E-02	106								
163	7.635094219E+04	4.3509222E+03	4.875000E+02	5.867425E-02	158								
164	7.200000000E+04	4.6205300E+03	4.933674E+02	6.632575E-02	107								
165	6.737946999E+04	4.8686056E+03	5.000000E+02	7.500000E-02	159	108	34	21				17	
166	6.251086440E+04	3.0486900E+03	5.075000E+02	5.000000E-02	160								
167	5.946217356E+04	2.9000004E+03	5.125000E+02	5.000000E-02	161								
168	5.656216914E+04	4.0869851E+03	5.175000E+02	7.500000E-02	162	109							
169	5.247518399E+04	6.1659467E+03	5.250000E+02	1.250000E-01	163	110	35	22					
170	4.630918734E+04	5.4014730E+03	5.375000E+02	1.250000E-01	164	111							
171	4.086771438E+04	4.8020830E+03	5.500000E+02	1.250000E-01	165	112	36	23					
172	3.606563136E+04	8.9046361E+02	5.625000E+02	2.500000E-02	166								
173	3.517516775E+04	8.6847794E+02	5.650000E+02	2.500000E-02	167								
174	3.430668974E+04	2.4788818E+03	5.675000E+02	7.500000E-02	168	113							
175	3.182780797E+04	3.3278080E+03	5.750000E+02	1.104363E-01	169	114	37	24					

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING								
					CSEWG 239	RSIC 171	PRS 154	GAMI 68	GRANIT 48	LASER 35	THERMOS 30	LASL 30	EPRI 4
176	2.850000000E+04	4.12050005E+02	5.860430E+00	1.456372E-02		115							
177	2.808794195E+04	1.0879420E+03	5.875000E+00	3.950351E-02	170		38						
178	2.740000000E+04	9.4159482E+02	5.914504E+00	3.549649E-02		116							
179	2.605040518E+04	1.2700834E+03	5.950000E+00	5.000000E-02	171	117	39						
180	2.478752177E+04	6.1200610E+02	6.000000E+00	2.500000E-02	172	118	40	25				18	
181	2.417551567E+04	5.9689561E+02	6.025000E+00	2.500000E-02	173	119							
182	2.357862000E+04	1.7037089E+03	6.050000E+00	7.500000E-02	174	120	41						
183	2.187491118E+04	5.4009348E+02	6.125000E+00	2.500000E-02	175	121							
184	2.133481770E+04	2.0302763E+03	6.150000E+00	1.000000E-01	176								
185	1.930454136E+04	2.2683434E+03	6.250000E+00	1.250000E-01	177	122	42	26					
186	1.703619796E+04	2.0018060E+03	6.375000E+00	1.250000E-01	178								
187	1.503439193E+04	1.7665876E+03	6.500000E+00	1.250000E-01	179	123	43	27					
188	1.326780451E+04	1.5590081E+03	6.625000E+00	1.250000E-01	180								
189	1.170879621E+04	1.3758148E+03	6.750000E+00	1.250000E-01	181	124	44	28					
190	1.033297639E+04	1.2141567E+03	6.875000E+00	1.250000E-01	182								
191	9.118819656E+03	1.0714896E+03	7.000000E+00	1.250000E-01	183	125	45	29				19	
192	8.047330101E+03	9.4558621E+02	7.125000E+00	1.250000E-01	184								
193	7.101743888E+03	8.3447690E+02	7.250000E+00	1.250000E-01	185	126	46	30					
194	6.267266984E+03	7.3642328E+02	7.375000E+00	1.250000E-01	186								
195	5.530843701E+03	5.2632937E+02	7.500000E+00	1.000000E-01	187	127	47	31					3
196	5.004514334E+03	4.7624251E+02	7.600000E+00	1.000000E-01	188								
197	4.528271829E+03	2.2084642E+02	7.700000E+00	5.000000E-02	189								
198	4.307425406E+03	2.1007562E+02	7.750000E+00	5.000000E-02	190	128	48	32					
199	4.097349790E+03	3.8991439E+02	7.800000E+00	1.000000E-01	191								
200	3.707435405E+03	3.5280913E+02	7.900000E+00	1.000000E-01	192	129							
201	3.354626279E+03	3.1923490E+02	8.000000E+00	1.000000E-01	193	130	49	33				20	
202	3.035391381E+03	1.7199409E+02	8.100000E+00	5.833333E-02	194	131							
203	2.863392294E+03	1.1685659E+02	8.158333E+00	4.166667E-02	195								
204	2.746535700E+03	1.3395013E+02	8.200000E+00	5.000000E-02	196	132							
205	2.612585573E+03	1.2741730E+02	8.250000E+00	5.000000E-02	197	133	50	34					
206	2.485168271E+03	2.3649503E+02	8.300000E+00	1.000000E-01	198	134							
207	2.248673242E+03	2.1398955E+02	8.400000E+00	1.000000E-01	199	135							
208	2.034683690E+03	1.9362575E+02	8.500000E+00	1.000000E-01	200	136	51	35					
209	1.841057937E+03	1.7519983E+02	8.600000E+00	1.000000E-01	201								
210	1.665850110E+03	8.1244854E+01	8.700000E+00	5.000000E-02	202								
211	1.584613251E+03	7.7282500E+01	8.750000E+00	5.000000E-02	203	137	52	36					
212	1.507330751E+03	1.4344149E+02	8.800000E+00	1.000000E-01	204								
213	1.363889265E+03	1.2979122E+02	8.900000E+00	1.000000E-01	205								
214	1.234098041E+03	2.7298152E+02	9.000000E+00	2.500000E-01	206	138	53	37				21	
215	9.611165206E+02	2.1259822E+02	9.250000E+00	2.500000E-01	207	139	54	38					
216	7.485182989E+02	1.6557166E+02	9.500000E+00	2.500000E-01	208	140	55	39					
217	5.829466373E+02	1.2894734E+02	9.750000E+00	2.500000E-01	209	141	56	40					
218	4.539992976E+02	1.0042429E+02	1.000000E+01	2.500000E-01	210	142	57	41				22	
219	3.535750085E+02	7.8210515E+01	1.025000E+01	2.500000E-01	211	143	58	42					
220	2.753644935E+02	6.091410E+01	1.050000E+01	2.500000E-01	212	144	59	43					

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING									
					CSEW	RSIC	PRS	GAMI	GRANIT	LASER	THERMOS	LASL	EPRI	
					239	171	154	6H	4H	35	30	30	4	
221	2.144544832E+02	4.7437075E+01	1.075000E+01	2.500000E-01	213	145	60	44						
222	1.670170079E+02	3.6944431E+01	1.100000E+01	2.500000E-01	214	146	61	45				23		
223	1.300729765E+02	2.8772040E+01	1.125000E+01	2.500000E-01	215	147	62	46						
224	1.013009360E+02	2.240768E+01	1.150000E+01	2.500000E-01	216	148	63	47						
225	7.889324827E+01	5.2932483E+00	1.175000E+01	6.945003E-02	217	149	64	48						
226	7.360000000E+01	5.8500000E+00	1.181445E+01	5.372761E-02			65							
227	6.975000000E+01	1.2000000E+00	1.187318E+01	1.735401E-02			66							
228	6.855100000E+01	1.5510000E+00	1.189053E+01	2.287079E-02			67							
229	6.700000000E+01	5.5578765E+00	1.191340E+01	8.059697E-02			68							
230	6.144212353E+01	1.0421235E+00	1.200000E+01	2.501915E-02	218	150	69	49				24		
231	5.990000000E+01	8.5000000E-01	1.202542E+01	1.029196E-02			70							
232	5.905000000E+01	6.5000000E-01	1.203971E+01	1.106865E-02			71							
233	5.840000000E+01	1.0548826E+01	1.205078E+01	1.992202E-01			72							
234	4.785117392E+01	7.8511739E+00	1.225000E+01	1.792162E-01	219	151	73	50						
235	4.000000000E+01	2.7334683E+00	1.242922E+01	7.078300E-02			74							
236	3.726653172E+01	1.2165317E+00	1.250000E+01	3.318879E-02	220	152	75	51						
237	3.605000000E+01	1.0500000E+00	1.253319E+01	2.955880E-02			76							
238	3.500000000E+01	5.9767959E+00	1.256275E+01	1.872524E-01			77							
239	2.902320409E+01	5.3132041E+00	1.275000E+01	2.021988E-01	221	153	78	52						
240	2.371000000E+01	5.1000000E-01	1.295220E+01	2.174462E-02			79							
241	2.320000000E+01	5.9670593E-01	1.297394E+01	2.005663E-02			80							
242	2.200329407E+01	5.0329407E-01	1.300000E+01	2.251804E-02	222	154	81	53				25		
243	2.210000000E+01	6.0000000E-01	1.302252E+01	2.752467E-02			82							
244	2.150000000E+01	1.2000000E+00	1.305004E+01	5.743205E-02			83							
245	2.030000000E+01	2.6965369E+00	1.310747E+01	1.425252E-01			84							
246	1.760346312E+01	3.8938723E+00	1.325000E+01	2.500000E-01	223	155	85	54						
247	1.370959086E+01	3.0325500E+00	1.350000E+01	2.500000E-01	224	156	86	55						
248	1.067704010E+01	2.3617529E+00	1.375000E+01	2.500000E-01	225	157	87	56						
249	8.315287191E+00	1.3152872E+00	1.400000E+01	1.721855E-01	226	158	88	57				26		
250	7.000000000E+00	5.2004782E-01	1.417219E+01	7.781450E-02			89							
251	6.475952176E+00	1.4324755E+00	1.425000E+01	2.500000E-01	227	159	90	58						
252	5.043476626E+00	1.1156131E+00	1.450000E+01	2.500000E-01	228	160	91	59						
253	3.927863545E+00	8.6884034E-01	1.475000E+01	2.500000E-01	229	161	92	60						
254	3.059023205E+00	4.9817846E-01	1.500000E+01	1.777585E-01	230	162	93	61	48			27		
255	2.560844746E+00	1.7847508E-01	1.517776E+01	7.224153E-02			94					47		
256	2.382369666E+00	6.6344444E-02	1.525000E+01	2.824320E-02	231	163	95	62				46		
257	2.316025224E+00	2.1734124E-02	1.527824E+01	9.428544E-03			96					45		
258	2.294291100E+00	2.1631664E-02	1.528767E+01	9.473203E-03			97					44		
259	2.272659436E+00	2.1529203E-02	1.529714E+01	9.518288E-03			98					43		
260	2.251130233E+00	7.9001585E-02	1.530666E+01	3.572479E-02			99					42		
261	2.172128648E+00	7.8050829E-02	1.534239E+01	3.659436E-02			100					41		
262	2.094077819E+00	7.6176895E-02	1.537898E+01	3.705248E-02			101					40		
263	2.017906924E+00	8.2290918E-02	1.541603E+01	4.163517E-02			102					39		
264	1.935616006E+00	8.0224643E-02	1.545767E+01	4.232997E-02			103					38		
★265	1.855391363E+00	4.6423297E-02	1.550000E+01	2.533910E-02	232	164	104	63	37	35				

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING									
					CSEWG HIST PRS	GAMI	GRANIT	LASER	THERMOS	LASL	EPRI			
					239	171	154	68	48	35	30	30	4	
266	1.808968066E+00	4.5913180E-02	1.552534F+01	2.570852E-02						105		36		
267	1.763054886E+00	3.6974385E-02	1.555105E+01	2.119480E-02						106		35		
268	1.726080501E+00	8.3486240E-03	1.557224E+01	4.848487E-03						107			34	
269	1.717731877E+00	7.0146149E-02	1.557709E+01	4.169372E-02						108		34		
270	1.647585728E+00	5.2654518E-02	1.561878E+01	3.248804E-02						109		33		
271	1.594931210E+00	1.6429054E-02	1.565127E+01	1.035421E-02						110			33	
272	1.578502156E+00	1.2148290E-01	1.566162E+01	7.980041E-02						111		32		
273	1.457419257E+00	1.2439011E-02	1.574143E+01	8.571589E-03						112			32	
274	1.444980246E+00	1.3712785E-01	1.575000E+01	9.970925E-02	233	165		113	64	31				
275	1.307852396E+00	9.9160537E-02	1.584971E+01	7.886428E-02						114			31	
276	1.208671859E+00	4.2290688E-02	1.592857E+01	3.561618E-02						115		30		
277	1.166381171E+00	4.1029424E-02	1.596419E+01	3.5811029E-02						116			30	
278	1.125351747E+00	2.6670325E-02	1.603000E+01	2.398490E-02	234	166		117	65				28	
279	1.098681422E+00	2.6513205E-02	1.602398E+01	2.442778E-02						118		29	29	
280	1.072168217E+00	9.8589660E-03	1.604841E+01	9.237892E-03						119		28	28	
281	1.062309251E+00	9.8134280E-03	1.605765E+01	9.280759E-03						120		27	27	
282	1.052495823E+00	9.7678900E-03	1.606693E+01	9.324026E-03						121		26	26	
283	1.042727953E+00	2.9030442E-02	1.607626E+01	2.823576E-02						122		25	25	
284	1.013697491E+00	6.3040759E-02	1.610449E+01	6.421097E-02						123		24	24	
285	9.536527323E-01	7.4227910E-02	1.616870E+01	8.129791E-02						124		23	23	
286	8.764248219E-01	4.2743743E-02	1.625000E+01	5.880000E-02	235	167		125	66					
287	8.336810790E-01	4.8786477E-02	1.630000E+01	6.034149E-02	236									
288	7.848946816E-01	2.8157631E-03	1.636030E+01	3.593891E-03								30		
289	7.820788385E-01	9.9518501E-02	1.636390E+01	1.361046E-01				126		22	22			
290	6.825603376E-01	5.0088838E-02	1.650000E+01	7.021577E-02	237	168		127	67					
291	6.324715000E-01	7.4115000E-03	1.657622E-02	1.178752E-02								29		
★292	6.250600000E-01	9.3481475E-02	1.658800E+01	1.019967E-01	238			128		21	21		4	
293	5.315785254E-01	2.0041447E-02	1.675000E+01	3.916026E-02	239	169		129	68					
294	5.111640988E-01	7.9292952E-03	1.678916E+01	1.563380E-02								28		
295	5.032348036E-01	8.6218515E-02	1.680479E+01	1.879316E-01				130		20	20			
296	4.170162887E-01	3.0225168E-03	1.699273E+01	7.274353E-03				131		19	19			
★297	4.139937719E-01	5.6328609E-02	1.708000E+01	1.402537E-01	207	170		132	801			27	29	
298	3.576651631E-01	1.8771754E-02	1.714625E+01	5.391162E-02				133		18	18			
299	3.388934090E-01	1.8265777E-02	1.720017E+01	5.500521E-02								26		
300	3.206276321E-01	1.9507951E-02	1.725557E+01	6.277263E-02				134		17	17			
301	3.011196812E-01	1.3082652E-02	1.731834E+01	3.508862E-02				135		16	16			
302	2.907370290E-01	1.1882887E-02	1.735343E+01	4.173028E-02				136		15	15			
303	2.788541545E-01	8.3359744E-03	1.739516E+01	3.803496E-02								25		
304	2.705181801E-01	1.9490242E-02	1.742551E+01	7.477506E-02				137		14	14			
305	2.510279384E-01	1.9524558E-02	1.750029E+01	8.096976E-02				138		13	13			
306	2.315033808E-01	3.8136408E-03	1.758126E+01	1.661056E-02								24		
307	2.276897400E-01	3.3574117E-02	1.759787E+01	1.595299E-01				139		12	12			
308	1.901156229E-01	9.6869335E-03	1.775740E+01	5.119109E-02								23		
309	1.904286894E-01	1.9922852E-02	1.780859E+01	1.143168E-01				140		11	11			
310	1.645058372E-01	1.2206640E-02	1.792290E+01	7.709512E-02								22		

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING								
					CSEWG	NSIC	PRS	GAMI	GRANIT	LASER	THERMOS	LASER	EPRI
					239	171	154	68	48	35	30	30	4
311	1.522997974E-01	6.5783638E-03	1.800000E+01	4.415412E-02			141					30	
312	1.457214336E-01	4.8169029E-03	1.804415E+01	3.361424E-02			142		10	10			
313	1.409045307E-01	1.9013991E-02	1.807777E+01	1.449591E-01							21		
314	1.218905400E-01	1.0322567E-02	1.822273E+01	8.848940E-02							20		
315	1.115679726E-01	5.2495134E-03	1.831122E+01	4.819510E-02			143		9	9			
316	1.063184592E-01	6.3184592E-03	1.835941E+01	6.126874E-02							19		
317	1.000000000E-01	7.7072289E-03	1.842068E+01	8.020437E-02	171								
318	9.229277110E-02	1.0320445E-02	1.850089E+01	1.186332E-01							18		
319	8.196830649E-02	1.8113984E-03	1.861952E+01	2.234660E-02			144		8	8			
320	8.015002800E-02	1.0043369E-02	1.864186E+01	1.395915E-01							17		
321	7.971353860E-02	8.9330275E-03	1.878146E+01	1.371253E-01							16		
322	6.078051110E-02	3.8580761E-03	1.891358E+01	6.557964E-02							15		
323	5.692243500E-02	3.7315819E-03	1.898410E+01	6.780310E-02			145		7	7			
324	5.319085310E-02	7.0836808E-03	1.905196E+01	1.429179E-01							14		
325	4.610717230E-02	3.3520989E-03	1.919488E+01	7.548065E-02							13		
326	4.275507340E-02	3.2256047E-03	1.927036E+01	7.804143E-02			146		6	6			
327	3.952946870E-02	6.0717264E-03	1.934880E+01	1.115763E-01							12		
328	3.345774230E-02	2.8461217E-03	1.951557E+01	8.890352E-02							11		
329	3.061162060E-02	2.7196275E-03	1.960447E+01	9.304003E-02			147		5	5			
330	2.789199310E-02	5.0597720E-03	1.969751E+01	2.001669E-01							10		
331	2.283222110E-02	2.3401445E-03	1.989768E+01	1.081344E-01							9		
332	2.049207660E-02	2.2136503E-03	2.000581E+01	1.143168E-01			148		4	4			
333	1.827842630E-02	4.0478176E-03	2.012013E+01	2.503263E-01							8		
334	1.423060870E-02	1.8341673E-03	2.0337046E+01	1.379857E-01							7		
335	1.239644140E-02	1.7076731E-03	2.050844E+01	1.482159E-01			149		3	3			
336	1.068876830E-02	3.0358631E-03	2.065666E+01	3.341082E-01							6		
337	7.652905150E-03	1.3281901E-03	2.099077E+01	1.906204E-01							5		
338	6.324715000E-03	1.2016959E-03	2.118139E+01	2.107210E-01			150		2	2			
339	5.123019150E-03	2.0239088E-03	2.139211E+01	5.026289E-01							4		
340	3.099110350E-03	8.2221295E-04	2.189474E+01	3.083014E-01							3		
341	2.276697400E-03	6.9571865E-04	2.220304E+01	3.646431E-01			151		1	1			
342	1.581178750E-03	8.2096001E-04	2.256768E+01	7.323197E-01							2		
343	7.602187410E-04	1.9099439E-04	2.330000E+01	2.893316E-01			152						
344	5.692243500E-04	3.1623575E-04	2.358933E+01	8.109302E-01							1		
345	2.529886600E-04	1.1410916E-04	2.440026E+01	5.997382E-01			153		801	801			
346	1.388794386E-04	7.5632269E-05	2.500000E+01	7.865561E-01			154					801	
347	6.324715000E-05	5.3247150E-05	2.578650E+01	1.844405E+00							801		
LOWER ROUND	1.000000000E-05		2.763102E+01				801	801					801

★ The upper energy boundaries of groups 265, 292, and 297 correspond to lethargy values of 15.5, 16.588, and 17.0 of the CSEWG 239-group structure. These energies differ slightly from the velocity-specified boundaries of group structures used with GRANIT, LASER, and THERMOS.

VELOCITY-BASED GROUP STRUCTURE PARAMETERS

Group No.	Structure	Group No.	Velocity (x2200m/s)	Energy (eV)
265	LASER	35	8.5627	1.854908147
292	GRA 'IT	21	4.97	0.624904611
	LASER	21		
297	THERMOS	27	4.05	0.4149645512

TABLE II

THE 154-GROUP PRS NEUTRON MULTIGROUP STRUCTURE

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING				
					GAMT 4R	GRAMIT 4R	LASFH 35	LASL 30	EPRI 4
1	2.00000000E+07	1.7788120E+06	-6.951472E-01	9.314718E-02					
2	1.62211800E+07	1.3165995E+06	-6.000000E-01	7.500000E-02					
3	1.60045884E+07	1.9863415E+06	-5.250000E-01	1.250000E-01				1	
4	1.49182469E+07	1.4196589E+06	-4.000000E-01	1.000000E-01				2	
5	1.34985888E+07	1.5861259E+06	-3.000000E-01	1.250000E-01				3	
6	1.19124621E+07	1.9124622E+06	-1.752000E-01	1.750000E-01				4	
7	1.00000000E+07	2.2119922E+06	0.	2.500000E-01	1			5	1
8	7.78800781E+06	1.7227012E+06	2.500000E-01	2.500000E-01	2			6	
9	6.06530659E+06	1.3416411E+06	5.000000E-01	2.500000E-01	3			7	
10	4.72366552E+06	1.0448711E+06	7.500000E-01	2.500000E-01	4				
11	3.67879441E+06	8.1374644E+05	1.000000E+00	2.500000E-01	5			8	
12	2.86504790E+06	6.3374637E+05	1.250000E+00	2.500000E-01	6			9	
13	2.23130160E+06	4.9356217E+05	1.500000E+00	2.500000E-01	7			10	
14	1.73773945E+06	3.8138660E+05	1.750000E+00	2.500000E-01	8			11	
15	1.35335283E+06	2.9936059E+05	2.000000E+00	2.500000E-01	9			12	
16	1.05399224E+06	1.0830062E+05	2.250000E+00	1.000000E-01	10				
17	9.53691622E+05	1.3284164E+05	2.350000E+00	1.500000E-01					
18	8.20849986E+05	7.8114204E+04	2.500000E+00	1.000000E-01	11			13	2
19	7.42735782E+05	1.0345717E+05	2.600000E+00	1.500000E-01					
20	6.39278612E+05	6.0835403E+04	2.750000E+00	1.000000E-01	12				
21	5.78443208E+05	8.0572525E+04	2.850000E+00	1.500000E-01					
22	4.97870683E+05	4.7372660E+04	3.000000E+00	1.000000E-01	13			14	
23	4.50492023E+05	6.2749946E+04	3.100000E+00	1.500000E-01					
24	3.87742078E+05	3.6998537E+04	3.250000E+00	1.000000E-01	14				
25	3.50884354E+05	4.8869707E+04	3.350000E+00	1.500000E-01					
26	3.01973834E+05	2.8736610E+04	3.500000E+00	1.000000E-01	15			15	
27	2.73237224E+05	3.8059766E+04	3.600000E+00	1.500000E-01					
28	2.35177458E+05	2.2380094E+04	3.750000E+00	1.000000E-01	16				
29	2.12797364E+05	2.9640976E+04	3.850000E+00	1.500000E-01					
30	1.83156388E+05	4.0514050E+04	4.000000E+00	2.500000E-01	17			16	
31	1.42642339E+05	3.1552374E+04	4.250000E+00	2.500000E-01	18				
32	1.11089965E+05	2.4573013E+04	4.500000E+00	2.500000E-01	19				
33	8.65169520E+04	1.9137482E+04	4.750000E+00	2.500000E-01	20				
34	6.73794699E+04	1.4904286E+04	5.000000E+00	2.500000E-01	21			17	
35	5.24751839E+04	1.1607470E+04	5.250000E+00	2.500000E-01	22				
36	4.08677143E+04	9.0399064E+03	5.500000E+00	2.500000E-01	23				
37	3.18278079E+04	3.7398660E+03	5.750000E+00	1.250000E-01	24				
38	2.80879419E+04	2.0295368E+03	5.875000E+00	7.500000E-02					
39	2.60564051E+04	1.2708834E+03	5.950000E+00	5.000000E-02					
40	2.47875217E+04	1.2089017E+03	6.000000E+00	5.000000E-02	25			18	

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING				
					GAM 6A	GRANIT 4A	LASER 3A	LASL 3A	EPRI 4
41	2.357862006E+04	4.2740787E+03	6.4500000E+00	2.0000000E-01					
42	1.930454136E+04	4.2701494E+03	6.2500000E+00	2.5000000E-01	26				
43	1.503439193E+04	3.3255957E+03	6.5000000E+00	2.5000000E-01	27				
44	1.170879621E+04	2.5899766E+03	6.7500000E+00	2.5000000E-01	28				
45	9.118819656E+03	2.0170758E+03	7.0000000E+00	2.5000000E-01	29				
46	7.101143888E+03	1.5740000E+03	7.2500000E+00	2.5000000E-01	30			19	
47	5.530843701E+03	1.2734183E+03	7.5000000E+00	2.5000000E-01	31				5
48	4.307425406E+03	9.5279413E+02	7.7500000E+00	2.5000000E-01	32				
49	3.354626279E+03	7.4204071E+02	8.0000000E+00	2.5000000E-01	33			20	
50	2.612585573E+03	5.1790188E+02	8.2500000E+00	2.5000000E-01	34				
51	2.034683690E+03	4.5007044E+02	8.5000000E+00	2.5000000E-01	35				
52	1.584613251E+03	3.5051521E+02	8.7500000E+00	2.5000000E-01	36				
53	1.234008041E+03	2.7298132E+02	9.0000000E+00	2.5000000E-01	37			21	
54	9.611165206E+02	2.1259022E+02	9.2500000E+00	2.5000000E-01	38				
55	7.405182909E+02	1.6557166E+02	9.5000000E+00	2.5000000E-01	39				
56	5.829466373E+02	1.2894734E+02	9.7500000E+00	2.5000000E-01	40				
57	4.539992978E+02	1.0042429E+02	1.0000000E+01	2.5000000E-01	41			22	
58	3.535750085E+02	7.8210515E+01	1.0250000E+01	2.5000000E-01	42				
59	2.753644935E+02	6.0910410E+01	1.0500000E+01	2.5000000E-01	43				
60	2.144546832E+02	4.7137075E+01	1.0750000E+01	2.5000000E-01	44				
61	1.670170079E+02	3.6944031E+01	1.1000000E+01	2.5000000E-01	45			23	
62	1.300724765E+02	2.8772040E+01	1.1250000E+01	2.5000000E-01	46				
63	1.013009360E+02	2.2407688E+01	1.1500000E+01	2.5000000E-01	47				
64	7.889320827E+01	5.2932483E+00	1.1750000E+01	6.945063E-02	48				
65	7.360000000E+01	3.8500000E+00	1.181945E+01	5.372761E-02					
66	6.975000000E+01	1.2000000E+00	1.187318E+01	1.735001E-02					
67	6.855000000E+01	1.5500000E+00	1.189053E+01	2.287079E-02					
68	6.700000000E+01	5.5578765E+00	1.191340E+01	8.659697E-02					
69	6.144212353E+01	1.5021235E+00	1.2000000E+01	2.541915E-02	49			24	
70	5.990000000E+01	8.5000000E-01	1.202542E+01	1.429196E-02					
71	5.905000000E+01	6.5000000E-01	1.203971E+01	1.106865E-02					
72	5.840000000E+01	1.0548826E+01	1.205070E+01	1.092202E-01					
73	4.785117392E+01	1.8511739E+00	1.2250000E+01	1.702162E-01	50				
74	4.000000000E+01	2.7334683E+00	1.242422E+01	7.078380E-02					
75	3.726653172E+01	1.2165317E+00	1.2500000E+01	3.318879E-02	51				
76	3.645000000E+01	1.0500000E+00	1.253319E+01	2.955880E-02					
77	3.500000000E+01	5.9767959E+00	1.256275E+01	1.872524E-01					
78	2.907320409E+01	5.3132041E+00	1.2750000E+01	2.021988E-01	52				
79	2.371000000E+01	5.1000000E-01	1.295220E+01	2.174462E-02					
80	2.320000000E+01	5.9670593E-01	1.297394E+01	2.605663E-02					
81	2.260329407E+01	5.0329407E-01	1.3000000E+01	2.251804E-02	53			25	
82	2.210000000E+01	6.0000000E-01	1.302252E+01	2.752467E-02					
83	2.150000000E+01	1.2000000E+00	1.305000E+01	5.743205E-02					
84	2.030000000E+01	2.6965369E+00	1.310747E+01	1.425257E-01					
85	1.760346312E+01	3.8938723E+00	1.325000E+01	2.500000E-01	54				

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING				
					GAMMA 6A	GRANITE 4A	LASER 3A	LASL 3A	EPRT 4
86	1.370959086E+01	3.0325508E+00	1.3500000E+01	2.5000000E-01	55				
87	1.067704010E+01	2.3617529E+00	1.3750000E+01	2.5000000E-01	56				
88	8.315287191E+00	1.3152872E+00	1.4000000E+01	1.721855E-01	57			26	
89	7.000000000E+00	5.2404782E-01	1.417219E+01	7.781450E-02					
90	6.475952176E+00	1.4324755E+00	1.4250000E+01	2.5000000E-01	58				
91	5.043476626E+00	1.1156131E+00	1.4500000E+01	2.5000000E-01	59				
92	3.927063545E+00	8.6884634E-01	1.4750000E+01	2.5000000E-01	60				
93	3.059023205E+00	4.9817846E-01	1.5000000E+01	1.777585E-01	61	48		27	
94	2.560844746E+00	1.7847508E-01	1.517776E+01	7.224153E-02		47			
95	2.382369660E+00	6.6344444E-02	1.5250000E+01	2.824320E-02	62	46			
96	2.316025224E+00	2.1734124E-02	1.527824E+01	9.428544E-03		45			
97	2.244291100E+00	2.1631664E-02	1.528767E+01	9.473203E-03		44			
98	2.272659436E+00	2.1529203E-02	1.529714E+01	9.518288E-03		43			
99	2.251130233E+00	7.9001585E-02	1.530666E+01	3.572479E-02		42			
100	2.172128648E+00	7.8050829E-02	1.534239E+01	3.659436E-02		41			
101	2.094077819E+00	7.6170895E-02	1.537898E+01	3.705244E-02		40			
102	2.017906924E+00	8.2290918E-02	1.541603E+01	4.163517E-02		39			
103	1.935616006E+00	8.0224643E-02	1.545767E+01	4.232997E-02		38			
★ 104	1.855391363E+00	4.6423297E-02	1.5500000E+01	2.533910E-02	63		35		
105	1.800968066E+00	4.5913180E-02	1.552534E+01	2.570852E-02		36			
106	1.763054886E+00	3.6974385E-02	1.555105E+01	2.119480E-02		35			
107	1.726080501E+00	8.3386240E-03	1.557224E+01	4.848487E-03			34		
108	1.717731877E+00	7.0146140E-02	1.557709E+01	4.169372E-02		34			
109	1.647505728E+00	5.2654518E-02	1.561878E+01	3.248041E-02		33			
110	1.594931210E+00	1.6429054E-02	1.565127E+01	1.035421E-02			33		
111	1.578502156E+00	1.2108290E-01	1.566162E+01	7.980916E-02		32			
112	1.457419257E+00	1.2439011E-02	1.574143E+01	8.571589E-03			32		
113	1.444980246E+00	1.3712785E-01	1.575000E+01	9.970925E-02	64	31			
114	1.307852396E+00	9.9180537E-02	1.584971E+01	7.886428E-02			31		
115	1.208671859E+00	4.2290688E-02	1.592857E+01	3.561618E-02		30			
116	1.166381171E+00	4.1029424E-02	1.596419E+01	3.581029E-02			30		
117	1.125351747E+00	2.6670325E-02	1.600000E+01	2.398490E-02	65			28	
118	1.098681422E+00	2.6513205E-02	1.602398E+01	2.442778E-02		29			
119	1.072168217E+00	9.8589660E-03	1.604841E+01	9.237892E-03		28			
120	1.062309251E+00	9.8134280E-03	1.605765E+01	9.280759E-03		27			
121	1.052495823E+00	9.7678900E-03	1.606693E+01	9.324026E-03		26			
122	1.042727933E+00	2.9030442E-02	1.607626E+01	2.823576E-02		25			
123	1.013697491E+00	6.3044759E-02	1.610449E+01	6.421097E-02		24			
124	9.506527323E-01	7.4227910E-02	1.616870E+01	8.129791E-02		23			
125	8.764248219E-01	9.4345983E-02	1.625000E+01	1.138954E-01	66				
126	7.820788385E-01	9.9518501E-02	1.636390E+01	1.361046E-01		22			
127	6.825603376E-01	5.7500338E-02	1.650000E+01	8.800328E-02	67				
★ 128	6.250600000E-01	9.3281475E-02	1.658800E+01	1.619967E-01		21			4
129	5.315785254E-01	2.8343722E-02	1.675000E+01	5.479406E-02	68				
130	5.032348036E-01	8.6218515E-02	1.680479E+01	1.879316E-01		20			

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPONDS WITH UPPER BOUND OF GROUPS IN THE FOLLOWING				
					GAMI 6A	GRANIT 4A	LASER 35	LASL 34	EPRI 4
131	4.170162887E-01	3.0225168F-03	1.699273F+01	7.274353F-03		19	19		
★ 132	4.139937719F-01	5.6328609E-02	1.700000E+01	1.462537F-01	ROT			29	
133	3.576651631F-01	3.7037531E-02	1.714625F+01	1.093168F-01		18	18		
134	3.206276321E-01	1.9507951E-02	1.725557E+01	6.277263F-02		17	17		
135	3.311196812E-01	1.0382652E-02	1.731634E+01	3.508862F-02		16	16		
136	2.967370290E-01	2.0218849F-02	1.735343E+01	7.207987F-02		15	15		
137	2.745181801E-01	1.9490242F-02	1.742551F+01	7.477506F-02		14	14		
138	2.519279384E-01	2.3338198E-02	1.750029F+01	9.758033F-02		13	13		
139	2.276697400E-01	4.3261651F-02	1.759787E+01	2.107214F-01		12	12		
140	1.844286894E-01	3.2128892E-02	1.780859F+01	1.914120E-01		11	11		
141	1.522997974E-01	6.5783638E-03	1.800000E+01	4.415412F-02				30	
142	1.457214336E-01	3.4153461F-02	1.804415E+01	2.670628F-01		10	10		
143	1.115679726E-01	2.9599666E-02	1.831122F+01	3.083014E-01		9	9		
144	8.196830640E-02	2.5045871E-02	1.861452F+01	3.646431F-01		8	8		
145	5.692243500E-02	1.4167362E-02	1.848416E+01	2.862017F-01		7	7		
146	4.275507340E-02	1.2143453F-02	1.927036E+01	3.341082F-01		6	6		
147	3.361162069E-02	1.0119544F-02	1.960447F+01	4.613414F-01		5	5		
148	2.249207600E-02	8.0956352F-03	2.000581E+01	5.026289F-01		4	4		
149	1.239644148E-02	6.0717264F-03	2.050844E+01	6.729445F-01		3	3		
150	6.324715000F-03	4.00478176E-03	2.118139E+01	1.021651F+00		2	2		
151	2.276897400E-03	1.5166787E-03	2.220304F+01	1.096963F+00		1	1		
152	7.602187410E-04	5.0723014E-04	2.350000F+01	1.100262F+00					
153	2.529886000E-04	1.1410916F-04	2.400026E+01	5.997382F-01	ROT	ROT			
154	1.388794386E-04	1.2887404E-04	2.500000E+01	2.631021F+00				ROT	
LOWER ROUND	1.000000000E-05		2.763102F+01						ROT

★ See footnote to Table I

TABLE III

THE 103-GROUP PHOTON MULTIGROUP STRUCTURE

GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LETHARGY	LETHARGY DIFFERENCE	CORRESPOND WITH UPPER BOUND OF GROUPS IN THE FOLLOWING		
					CSFAG 94	RSIC 36	LASL 12
1	5.00000000E+07	1.00000000E+07	-1.609438E+00	2.231436E-01			
2	4.00000000E+07	1.00000000E+07	-1.386294E+00	2.876821E-01			
3	3.00000000E+07	5.00000000E+06	-1.098612E+00	1.823216E-01			1
4	2.50000000E+07	5.00000000E+06	-9.162907E-01	2.231436E-01			
5	2.00000000E+07	5.00000000E+06	-8.931472E-01	1.625189E-01	1		
6	1.70000000E+07	3.00000000E+06	-5.306283E-01	1.941560E-01			
7	1.40000000E+07	2.00000000E+06	-3.364722E-01	1.501507E-01	2	1	
8	1.20000000E+07	1.00000000E+06	-1.823216E-01	8.701138E-02	3	2	
9	1.00000000E+07	4.00000000E+05	-9.531018E-02	3.704127E-02	4		
10	1.00000000E+07	6.00000000E+05	-5.826891E-02	5.826891E-02	5		
11	1.00000000E+07	5.00000000E+05	0.	5.129329E-02	6	3	
12	9.50000000E+06	5.00000000E+05	5.129329E-02	5.406722E-02	7		
13	9.00000000E+06	5.00000000E+05	1.053605E-01	5.715841E-02	8		2
14	8.50000000E+06	5.00000000E+05	1.625189E-01	6.002462E-02	9		
15	8.00000000E+06	2.50000000E+05	2.231436E-01	3.174870E-02	10	4	3
16	7.75000000E+06	2.50000000E+05	2.548422E-01	3.278982E-02	11		
17	7.50000000E+06	2.50000000E+05	2.876821E-01	3.340155E-02	12	5	
18	7.25000000E+06	2.50000000E+05	3.215836E-01	3.509132E-02	13		
19	7.00000000E+06	2.50000000E+05	3.566744E-01	3.636764E-02	14	6	4
20	6.75000000E+06	2.50000000E+05	3.930426E-01	3.774033E-02	15		
21	6.50000000E+06	2.50000000E+05	4.307829E-01	3.922071E-02	16	7	
22	6.25000000E+06	2.50000000E+05	4.700036E-01	4.082199E-02	17		
23	6.00000000E+06	2.50000000E+05	5.108250E-01	4.255901E-02	18	8	5
24	5.75000000E+06	2.50000000E+05	5.533852E-01	4.445176E-02	19		
25	5.50000000E+06	1.00000000E+05	5.978370E-01	1.834914E-02	20	9	
26	5.40000000E+06	2.00000000E+05	6.161861E-01	3.774033E-02	21		
27	5.20000000E+06	2.00000000E+05	6.539265E-01	3.922071E-02	22		
28	5.00000000E+06	3.00000000E+05	6.931472E-01	6.187540E-02	23	10	6
29	4.70000000E+06	2.00000000E+05	7.550226E-01	4.348511E-02	24		
30	4.50000000E+06	1.00000000E+05	7.985077E-01	2.247286E-02	25	11	
31	4.40000000E+06	2.00000000E+05	8.209806E-01	4.052002E-02	26		
32	4.20000000E+06	2.00000000E+05	8.675006E-01	4.879016E-02	27		
33	4.00000000E+06	1.00000000E+05	9.162907E-01	2.531781E-02	28	12	7
34	3.90000000E+06	1.00000000E+05	9.416085E-01	2.507544E-02	29		
35	3.80000000E+06	1.50000000E+05	9.675840E-01	4.027390E-02	30		
36	3.65000000E+06	1.50000000E+05	1.007858E+00	4.196420E-02	31		
37	3.50000000E+06	1.70000000E+05	1.049822E+00	4.979066E-02	32	13	
38	3.30000000E+06	1.60000000E+05	1.099613E+00	5.050334E-02	33		
39	3.16000000E+06	1.66000000E+05	1.150116E+00	5.385667E-02	34		
40	3.00000000E+06	1.67000000E+05	1.203973E+00	5.727607E-02	35	14	8

					CORRESPONDENCE WITH UPPER BOUND OF GROUPS IN THE FOLLOWING		
GROUP NO.	UPPER ENERGY BOUND, (eV)	GROUP ENERGY WIDTH, (eV)	LITHARGY	LITHARGY DIFFERENCE	CSFAG 94	RSIC 36	LASL 12
41	2.83300000E+06	1.67200000E+05	1.261244E+02	6.075700E-02	36		
42	2.66600000E+06	1.66000000E+05	1.322000E+02	6.428649E-02	37		
43	2.50000000E+06	1.67000000E+05	1.386294E+02	6.913574E-02	38	15	
44	2.33300000E+06	1.67000000E+05	1.455430E+02	7.427284E-02	39		
45	2.16600000E+06	1.66000000E+05	1.529703E+02	7.973497E-02	40		
46	2.00000000E+06	1.25000000E+05	1.609435E+02	6.453852E-02	41	16	9
47	1.87500000E+06	1.25000000E+05	1.673470E+02	6.844287E-02	42		
48	1.75000000E+06	9.00000000E+04	1.742464E+02	5.270819E-02	43		
49	1.66000000E+06	6.00000000E+04	1.795767E+02	3.681497E-02	44	17	
50	1.60000000E+06	1.00000000E+05	1.832581E+02	6.453852E-02	45		
51	1.50000000E+06	6.00000000E+04	1.897120E+02	5.488824E-02	46	18	
52	1.42000000E+06	9.00000000E+04	1.951928E+02	6.547793E-02	47		
53	1.33000000E+06	8.00000000E+04	2.017406E+02	6.203539E-02	48	19	
54	1.25000000E+06	5.00000000E+04	2.079442E+02	4.082199E-02	49		
55	1.20000000E+06	7.50000000E+04	2.120264E+02	6.453852E-02	50		
56	1.12500000E+06	1.25000000E+05	2.164802E+02	1.177830E-01	51		
57	1.00000000E+06	1.00000000E+05	2.302585E+02	1.053605E-01	52	20	10
58	9.20000000E+05	3.50000000E+04	2.407446E+02	3.966526E-02	53		
59	8.65000000E+05	4.00000000E+04	2.447611E+02	4.734612E-02	54		
60	8.25000000E+05	2.50000000E+04	2.494957E+02	3.077160E-02	55		
61	8.30000000E+05	5.00000000E+04	2.525724E+02	6.453852E-02	56	21	
62	7.50000000E+05	5.00000000E+04	2.590267E+02	6.899287E-02	57		
63	7.00000000E+05	2.50000000E+04	2.659264E+02	3.636764E-02	58	22	
64	6.75000000E+05	2.50000000E+04	2.695628E+02	3.774033E-02	59		
65	6.50000000E+05	2.50000000E+04	2.733368E+02	3.922671E-02	60		
66	6.25000000E+05	2.50000000E+04	2.772584E+02	4.082199E-02	61		
67	6.00000000E+05	2.50000000E+04	2.813411E+02	4.255961E-02	62	23	
68	5.75000000E+05	2.50000000E+04	2.855970E+02	4.445176E-02	63		
69	5.50000000E+05	2.50000000E+04	2.900422E+02	4.652002E-02	64		
70	5.25000000E+05	1.30000000E+04	2.946942E+02	2.507364E-02	65		
71	5.12000000E+05	2.00000000E+03	2.972616E+02	3.913899E-03		24	
72	5.10000000E+05	1.00000000E+04	2.975430E+02	1.980263E-02		25	
73	5.00000000E+05	5.00000000E+04	2.995732E+02	1.053605E-01	66		11
74	4.50000000E+05	2.50000000E+04	3.101933E+02	5.715841E-02	67	26	
75	4.25000000E+05	2.50000000E+04	3.158251E+02	6.062462E-02	68		
76	4.00000000E+05	2.50000000E+04	3.218876E+02	6.453852E-02	69	27	
77	3.75000000E+05	2.50000000E+04	3.283414E+02	6.899287E-02	70		
78	3.50000000E+05	2.50000000E+04	3.352407E+02	7.410797E-02	71		
79	3.25000000E+05	2.50000000E+04	3.426515E+02	8.004271E-02	72		
80	3.00000000E+05	4.00000000E+04	3.506558E+02	1.431008E-01	73	28	
81	2.60000000E+05	4.00000000E+04	3.649659E+02	1.670541E-01	74		
82	2.20000000E+05	2.00000000E+04	3.816713E+02	9.531018E-02	75		
83	2.00000000E+05	1.00000000E+04	3.912023E+02	5.129324E-02		29	
84	1.90000000E+05	3.00000000E+04	3.963316E+02	1.718503E-01	76		
85	1.60000000E+05	1.00000000E+04	4.135167E+02	6.453852E-02	77		

LOWER
POUND 0.