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Title: Improved Cross Sections From Group T-2 For 11B, 151Eu, 153Eu, and 165Ho

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memorandum

TO: Distribution
FROM: R. C. Little and R. E. Seamon, X-6
SYMBOL: X-6:RCL:RES-86-212
SUBJECT: IMPROVED CROSS SECTIONS FROM GROUP T-2 FOR ^{11}B , ^{151}Eu , ^{153}Eu , and ^{165}Ho

DATE: May 28, 1986
MAIL STOP/TELEPHONE: B226/7-4886

Group T-2 has recently completed neutron-induced cross-section evaluations for ^{11}B , ^{151}Eu , ^{153}Eu , and ^{165}Ho . Evaluations for the latter three isotopes are described in Ref. 1. We have prepared cross-section tables based on the new evaluations for use in X-Division deterministic and Monte Carlo codes.

Before describing how to access the new data for your calculations, we will compare some characteristics of the new data with previously-available data. Z Aid identifiers for the new and old data are listed in Table I, along with the source of the old data.

TABLE I
Z AID IDENTIFIERS

<u>Isotope</u>	<u>New Z AID</u>	<u>Previous Z AID</u>	<u>Source of Previous Data</u>
5-B-11	5011.56	5011.55	Group T-2 (Ref. 2)
63-Eu-151	63151.55	63151.50	ENDF/B-V
63-Eu-153	63153.55	63153.50	ENDF/B-V
67-Ho-165	67165.55	67165.35	ENDL85

In Figs. 1-4 we plot the total photon-production cross section for each isotope, both from new and previous evaluations. Except for certain energy ranges, the new photon-production cross sections are larger for all four isotopes. The most notable increase is for ^{11}B .

The ^{165}Ho photon-production cross section has been substantially increased below 0.2 and above 3.0 MeV. For both europium isotopes, the increases are generally small.

Figures 5-8 show the contributions to the total photon-production cross sections from the various neutron interactions. For ^{11}B , Fig. 5 shows that inelastic photons dominate up to ~ 16.5 MeV. Figures 6-8 show the radiative capture photons, inelastic photons, n,2n photons, and n,3n photons for the three rare-earth isotopes. In all cases, radiative capture photons dominate for neutron energies below ~ 0.5 MeV and inelastic photons dominate for neutron energies between ~ 0.5 and 10 MeV.

It is important to know not only how many photons are produced, but also at what energies they are produced. Table II indicates the average photon energy for a variety of incident neutron energies. The average photon energy from high-energy incident neutron interactions with ^{11}B is moderately higher in the new evaluation. However, for the three rare-earth isotopes, the average photon produced by neutrons at all incident energies of interest is much less energetic when data from the new evaluations are used (except for ^{165}Ho at 1 and 2 MeV).

Neutron reaction cross sections and secondary distributions have been updated as well. The largest changes in total cross sections are for ^{11}B at high energy ($E_n > 0.5$ MeV) and ^{165}Ho at low energy ($E_n < 0.1$ MeV). Modifications have been less severe for the Eu isotopes.

We will next describe how one uses the new evaluations in Monte Carlo and deterministic calculations.

I. MONTE CARLO

For the MCNP family of codes, one simply needs to specify (in the INP file) the ZAID identifiers found in Table I: 5011.56, 63151.55, 63153.55, and 67165.55. The public cross-section directory, XSDIR, contains the information necessary to fetch a special cross-section library from CFS. It IS NOT necessary for the user to fetch any special files. It IS necessary for the user to specify the ZAID identifiers exactly as indicated above.

If you want to use the new data in other Monte Carlo codes, please see us.

II. DETERMINISTIC

The latest versions of the public multigroup libraries MENDF5 and MENDF5G are described in Refs. 3 and 4. In Ref. 5 we describe additional data for ^{11}B (ZAID = 5011.55), Ag (47000.55), ^{151}Eu (63151.50), and ^{153}Eu (63153.50). Similarly, Ref. 6 describes additional data for Eu (63000.35), Gd (64000.35), and ^{165}Ho (67165.35). In both cases, the data were added to private versions of MENDF5 and MENDF5G (available from CFS as MENDF5X and MENDF5GX).

We have now updated and replaced MENDF5X and MENDF5GX using the latest data from Group T-2. It has been necessary to delete the old data for ^{11}B (5011.55), ^{151}Eu (63151.50), ^{153}Eu (63153.50), and ^{165}Ho (67165.35). We have added the new data, again using the ZAID identifiers of Table I: 5011.56, 63151.55, 63153.55, and 67165.55. The libraries are stored on CFS as /X6MGXS/CTSS/MENDF5X and /X6MGXS/CTSS/MENDF5GX. It is necessary to fetch both files and then change their names to MENDF5 and MENDF5G before calculations are performed.

An updated list of materials available on MENDF5X is given in Table III. An updated list of data available on MENDF5GX is given in Table IV.

The old versions of MENDF5X and MENDF5GX (as described in Ref. 6) have been archived on CFS as /X6MGXS/CTSS/MENDF5D/M5X1) and /X6MGXS/CTSS/MENDF5GD/M5GX1.

REFERENCES

1. P. G. Young, E. D. Arthur, and R. E. MacFarlane, "n+ ^{151}Eu , ^{153}Eu , and ^{165}Ho Evaluated Cross Sections, "Los Alamos National Laboratory internal memorandum T-2-M-1713 to J. Gordon and J. Clow (April 29, 1986).
2. P. G. Young, "n + ^{11}B Gamma-ray Production Evaluation," Los Alamos National Laboratory internal memorandum T-2-M-1529 to R. C. Little and R. E. Seamon (August 31, 1984).
3. R. C. Little, "Multigroup Cross-Section Library Change #2," Los Alamos National Laboratory internal memorandum X-6:RCL-84-70 to Distribution (July 12, 1984).
4. R. C. Little and R. E. Seamon, "MENDFG: Multigroup Photon-Production and Photon-Interaction Library," Los Alamos National

May 28, 1986

Laboratory internal memorandum X-6:RCL-84-123 to J. G. Sanderson (Aug. 21, 1984).

5. R. C. Little and R. E. Seamon, "Additional Multigroup Data for MENDF5 and MENDF5G," Los Alamos National Laboratory internal memorandum X-6:RCL:RES-84-222 to J. W. Gordon (Oct. 25, 1984).
6. R. E. Seamon and R. C. Little, "Multigroup Cross Sections for Eu, Gd, and Ho-165 from ENDL85," Los Alamos National Laboratory internal memorandum X-6:RES:RCL-85-468 to Distribution (Sept. 20, 1985).

/sam

Distribution

T-2, MS B243

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TABLE II

AVERAGE PHOTON ENERGY (MeV) FOR VARIOUS INCIDENT NEUTRON ENERGIES

<u>Material</u>	<u>ZAID</u>	<u>0.1 MeV</u>	<u>1.0 MeV</u>	<u>2.0 MeV</u>	<u>10.0 MeV</u>	<u>14.0 MeV</u>
^{11}B	5011.56		(below threshold)		4.55	4.18
	5011.55		(below threshold)		4.47	3.71
^{151}Eu	63151.55	1.13	0.60	0.61	1.05	0.94
	63151.50	1.51	0.92	0.94	1.25	1.05
^{153}Eu	63153.55	1.19	0.43	0.50	1.08	0.70
	63153.50	1.58	0.86	0.99	1.30	1.10
^{165}Ho	67165.55	1.05	0.34	0.45	0.83	0.77
	67165.35	2.33	0.28	0.41	1.02	1.51

TABLE III
MATERIALS AVAILABLE ON MENDF5X

<u>Isotope</u>	<u>ZAID</u>	<u>Source</u>	<u>Isotope</u>	<u>ZAID</u>	<u>Source</u>
H-1	1001.50	ENDF/B-V	U-235 FP	45117.90	Group T-2
D	1002.55	Group T-2	Pu-239 FP	46119.90	Group T-2
T	1003.50	ENDF/B-V	Ag	47000.55	Group T-2
He-3	2003.50	ENDF/B-V	Ag-107	47107.50	ENDF/B-V
He-4	2004.50	ENDF/B-V	Ag-109	47109.50	ENDF/B-V
Li-6	3006.50	ENDF/B-V	Cd	48000.50	ENDF/B-V
Li-7	3007.55	Group T-2	FPP	50998.99	PERMFILE
Be-9	4009.50	ENDF/B-V	FPA	50999.99	PERMFILE
B-10	5010.50	ENDF/B-V	Ba-138	56138.50	ENDF/B-V
B-11	5011.56	Group T-2	Eu	63000.35	ENDL85
C	6000.50	ENDF/B-V	Eu-151	63151.55	Group T-2
C-12	6012.50	ENDF/B-V*	Eu-153	63153.55	Group T-2
N-14	7014.50	ENDF/B-V	Gd	64000.35	ENDL85
N-15	7015.55	Group T-2	Ho-165	67165.55	Group T-2
O-16	8016.50	ENDF/B-V	Ta-181	73181.50	ENDF/B-V
F-19	9019.50	ENDF/B-V	W	74000.55	Group T-2
Na-23	11023.50	ENDF/B-V	W-182	74182.55	Group T-2
Mg	12000.50	ENDF/B-V	W-183	74183.55	Group T-2
Al-27	13027.50	ENDF/B-V	W-184	74184.55	Group T-2
Si	14000.50	ENDF/B-V	W-186	74186.55	Group T-2
P-31	15031.50	ENDF/B-V	Re-185	75185.50	ENDF/B-V
S-32	16032.50	ENDF/B-V	Re-187	75187.50	ENDF/B-V
C1	17000.50	ENDF/B-V	Pt	78000.99	PERMFILE
Ar	18000.99	PERMFILE	Au-197	79197.50	ENDF/B-V
K	19000.50	ENDF/B-V	Pb	82000.50	ENDF/B-V
Ca	20000.50	ENDF/B-V	Bi-209	83209.50	ENDF/B-V
Ti	22000.50	ENDF/B-V	Th-232	90232.50	ENDF/B-V
V	23000.50	ENDF/B-V	Pa-233	91233.50	ENDF/B-V
Cr	24000.50	ENDF/B-V	U-233	92233.50	ENDF/B-V
Mn-55	25055.50	ENDF/B-V	U-234	92234.50	ENDF/B-V
Fe	26000.55	Group T-2	U-235	92235.50	ENDF/B-V
Co-59	27059.50	ENDF/B-V	U-236	92236.50	ENDF/B-V
Ni	28000.50	ENDF/B-V	U-237	92237.50	ENDF/B-V
Cu	29000.50	ENDF/B-V	U-238	92238.50	ENDF/B-V
Ga	31000.50	ENDF/B-V	U-239	92239.99	PERMFILE
As	33075.99	PERMFILE	Np-237	93237.55	Group T-2
Kr-78	36078.50	ENDF/B-V	Pu-238	94238.50	ENDF/B-V
Kr-80	36080.50	ENDF/B-V	Pu-239	94239.55	Group T-2
Kr-82	36082.50	ENDF/B-V	Pu-240	94240.50	ENDF/B-V
Kr-83	36083.50	ENDF/B-V	Pu-241	94241.50	ENDF/B-V
Kr-84	36084.50	ENDF/B-V	Pu-242	94242.50	ENDF/B-V
Kr-86	36086.50	ENDF/B-V	Am-241	95241.50	ENDF/B-V
Zr	40000.50	ENDF/B-V	Am-242m	95242.50	ENDF/B-V
Nb-93	41093.50	ENDF/B-V	Am-243	95243.50	ENDF/B-V
Mo	42000.50	ENDF/B-V	Cm-242	96242.50	ENDF/B-V
Rh-103	45103.50	ENDF/B-V	Cm-244	96244.50	ENDF/B-V

*Data for C-12 are identical to data for C.

TABLE IV
DATA AVAILABLE ON MENDF5GX

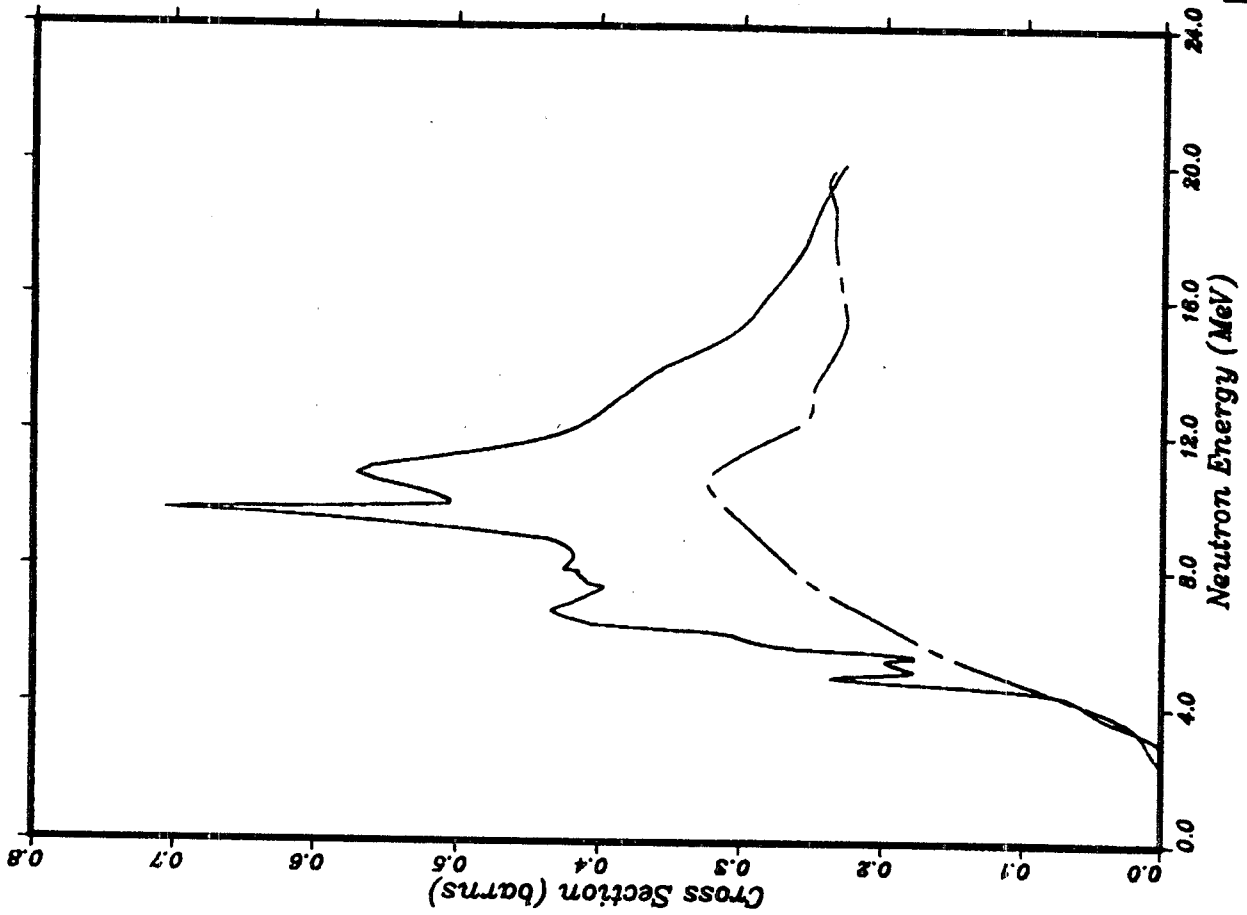
<u>Isotope</u>	<u>ZAID</u>	<u>Photon Production</u>	<u>Photon Transport</u>	<u>Isotope</u>	<u>ZAID</u>	<u>Photon Production</u>	<u>Photon Transport</u>
H-1	1001.50	Yes	Yes	U-235 FP	45117.90	Yes	Yes
D	1002.55	Yes	Yes	Pu-239 FP	46119.90	Yes	Yes
T	1003.50	No	Yes	Ag	47000.55	Yes	Yes
He-3	2003.50	No	Yes	Ag-107	47107.50	No	Yes
He-4	2004.50	No	Yes	Ag-109	47109.50	No	Yes
Li-6	3006.50	Yes	Yes	Cd	48000.50	No	Yes
Li-7	3007.55	Yes	Yes	FPP	50998.99	No	Yes
Be-9	4009.50	Yes	Yes	FPA	50999.99	No	Yes
B-10	5010.50	Yes	Yes	Ba-138	56138.50	Yes	Yes
B-11	5011.56	Yes	Yes	Eu	63000.35	Yes	Yes
C	6000.50	Yes	Yes	Eu-151	63151.55	Yes	Yes
C-12	6012.50	Yes	Yes	Eu-153	63153.55	Yes	Yes
N-14	7014.50	Yes	Yes	Gd	64000.35	Yes	Yes
N-15	7015.55	Yes	Yes	Ho-165	67165.55	Yes	Yes
O-16	8016.50	Yes	Yes	Ta-181	73181.50	Yes	Yes
F-19	9019.50	Yes	Yes	W	74000.55	Yes	Yes
Na-23	11023.50	Yes	Yes	W-182	74182.55	Yes	Yes
	12000.50	Yes	Yes	W-183	74183.55	Yes	Yes
-27	13027.50	Yes	Yes	W-184	74184.55	Yes	Yes
Si	14000.50	Yes	Yes	W-186	74186.55	Yes	Yes
P-31	15031.50	Yes	Yes	Re-185	75185.50	No	Yes
S-32	16032.50	Yes	Yes	Re-187	75187.50	No	Yes
Cl	17000.50	Yes	Yes	Pt	78000.99	No	Yes
Ar	18000.99	No	Yes	Au-197	79197.50	No	Yes
K	19000.50	Yes	Yes	Pb	82000.50	Yes	Yes
Ca	20000.50	Yes	Yes	Bi-209	83209.50	Yes	Yes
Ti	22000.50	Yes	Yes	Th-232	90232.50	Yes	Yes
V	23000.50	Yes	Yes	Pa-233	91233.50	No	Yes
Cr	24000.50	Yes	Yes	U-233	92233.50	No	Yes
Mn-55	25055.50	Yes	Yes	U-234	92234.50	No	Yes
Fe	26000.55	Yes	Yes	U-235	92235.50	Yes	Yes
Co-59	27059.50	Yes	Yes	U-236	92236.50	No	Yes
Ni	28000.50	Yes	Yes	U-237	92237.50	Yes	Yes
Cu	29000.50	Yes	Yes	U-238	92238.50	Yes	Yes
Ga	31000.50	Yes	Yes	U-239	92239.99	No	Yes
As	33075.99	No	Yes	Np-237	93237.55	No	Yes
Kr-78	36078.50	No	Yes	Pu-238	94238.50	No	Yes
Kr-80	36080.50	No	Yes	Pu-239	94239.55	Yes	Yes
Kr-82	36082.50	No	Yes	Pu-240	94240.50	Yes	Yes
Kr-83	36083.50	No	Yes	Pu-241	94241.50	Yes	Yes
Kr-84	36084.50	No	Yes	Pu-242	94242.50	Yes	Yes
Kr-86	36086.50	No	Yes	Am-241	95241.50	No	No
Zr	40000.50	No	Yes	Am-242m	95242.50	No	No
-93	41093.50	Yes	Yes	Am-243	95243.50	No	No
	42000.50	Yes	Yes	Cm-242	96242.50	No	No
Rh-103	45103.50	No	Yes	Cm-244	96244.50	No	No

*Data for C-12 are identical to data for C.

05/22/86
B-11
MT-302
GAMMA PRODUCTION

ZAID = 5011.56C
From File NEWXS3

ZAID = 5011.55C
From File RMCCSA



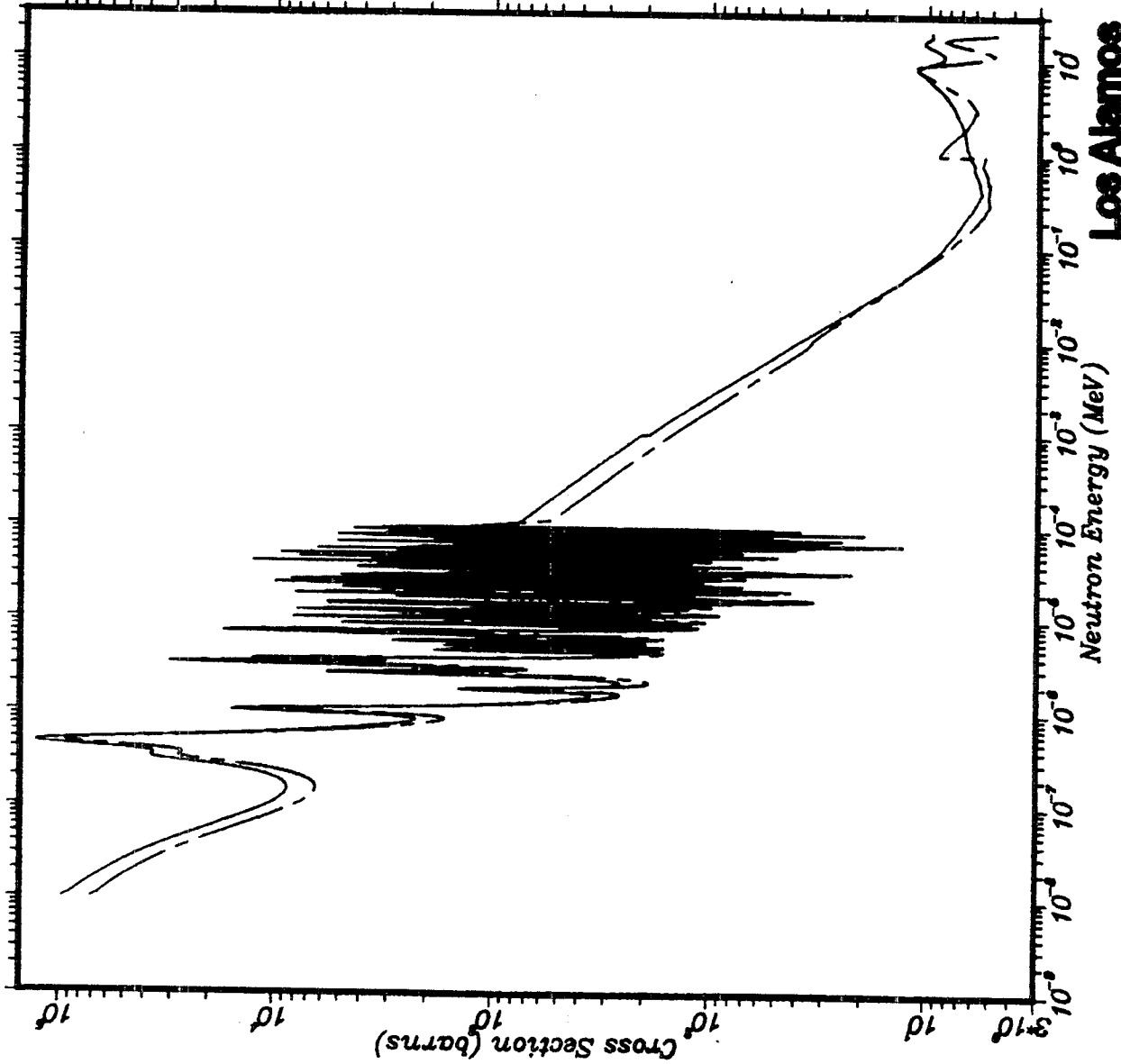
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Figure 1

05/22/86
EU-151
MT-302
GAMMA PRODUCTION

ZAID = 63151.55C
From File NEWXS3

ZAID = 63151.50C
From File RMCCS



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Figure 2

05/22/86
EU-153
MT=302

GAMMA PRODUCTION

ZAID = 63153.55C
From File NEWXS3

ZAID = 63153.50C
From File RMCCS

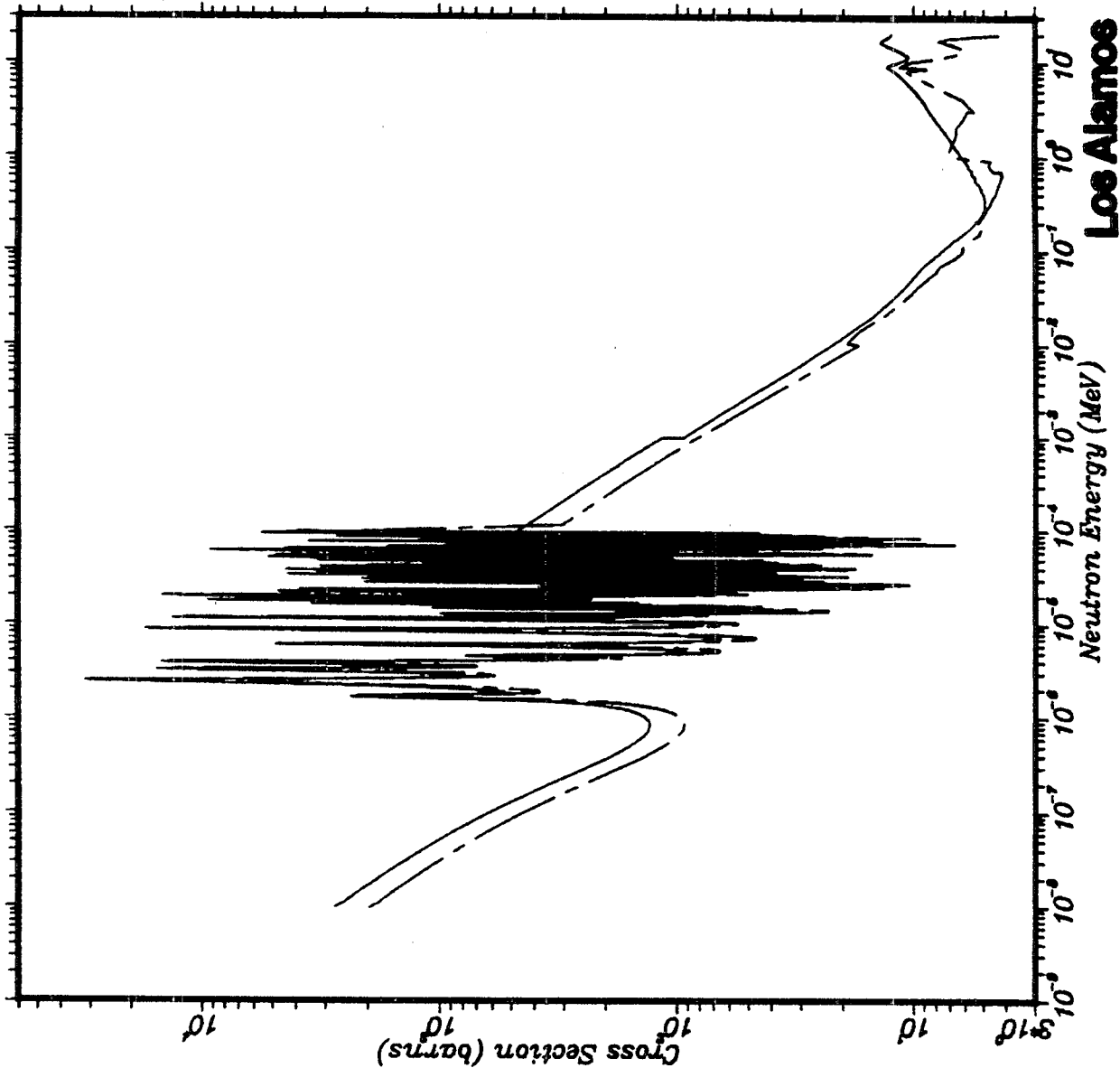


Figure 3

05/22/86
HO-165
MT-302
GAMMA PRODUCTION

ZAID = 67165.55C
From File NEWXS3

ZAID = 67165.35C
From File RMCCSA



Figure 4

05/22/86
ZAID = 5011.56C
B -11
From File B11LA2

MT=4001
TOTAL INELASTIC

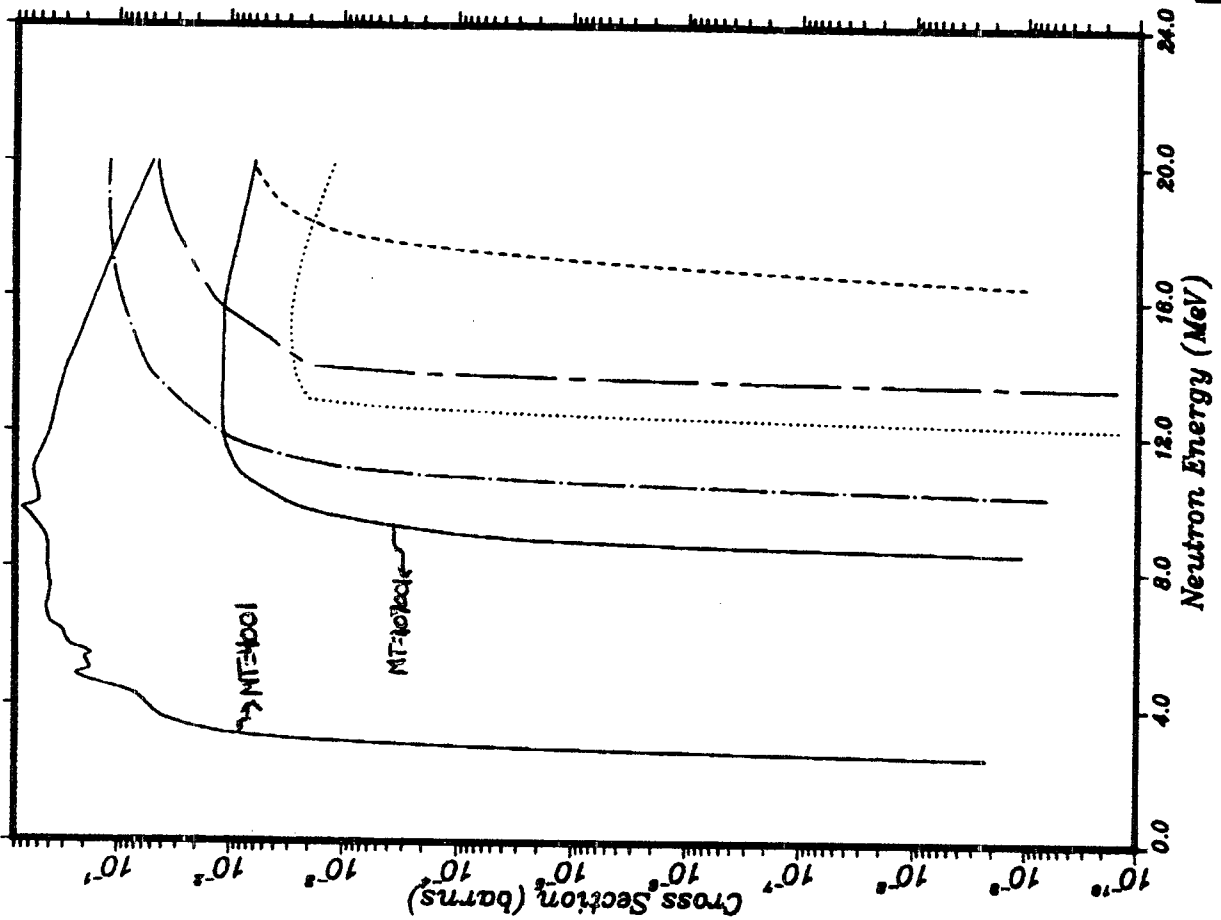
MT=16001
(N,2N)

MT=22001
(N,N')ALPHA

MT=28001
(N,NP)

MT=103001
(N,P)

MT=107001
N,ALPHA



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Figure 5

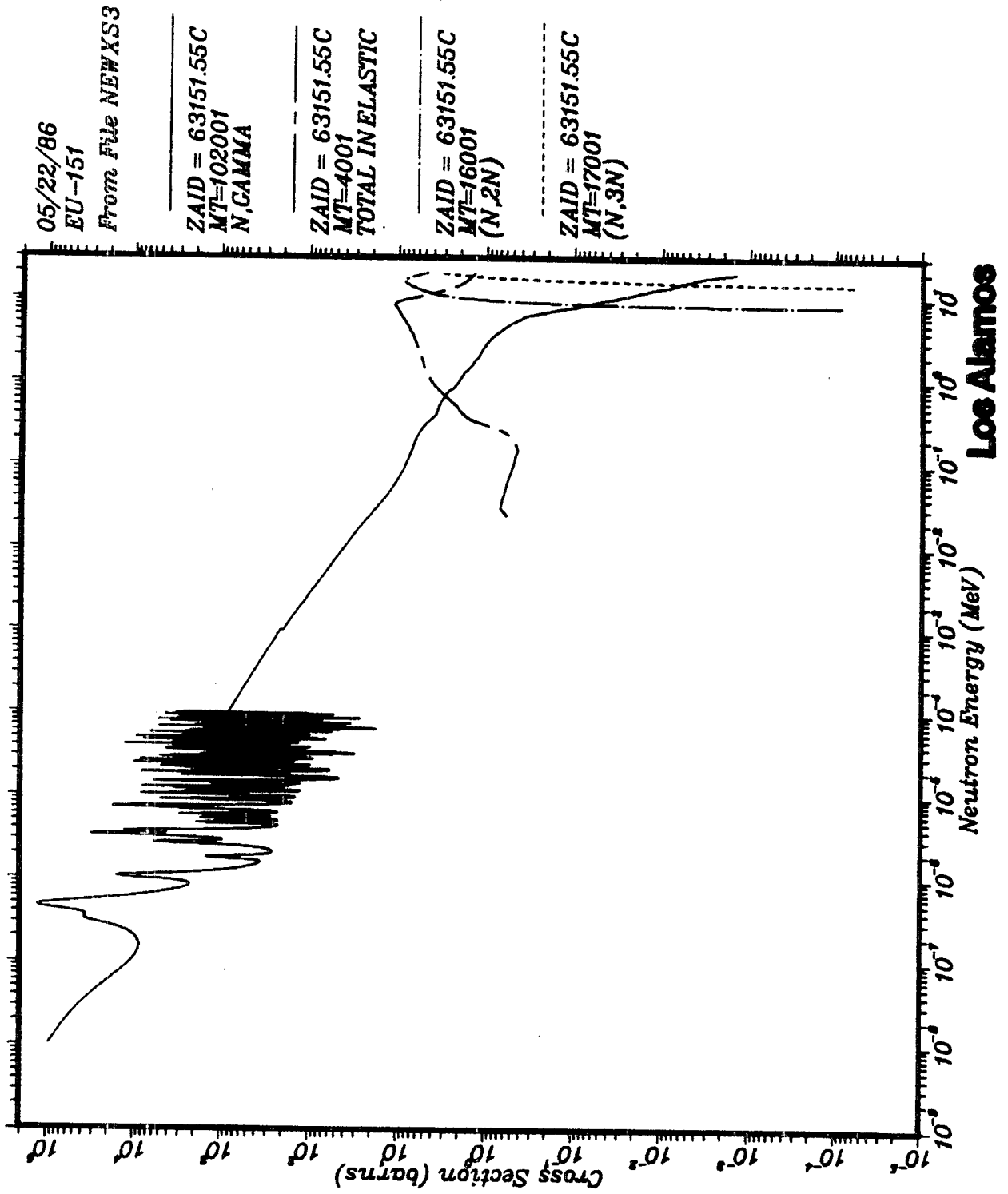


Figure 6

05/22/86
EU-153
From File NEWXS3

ZAID = 63153.55C
MT=102001
N,GAMMA

ZAID = 63153.55C
MT=4001
TOTAL INELASTIC

ZAID = 63153.55C
MT=16001
(N,2N)

ZAID = 63153.55C
MT=17001
(N,3N)

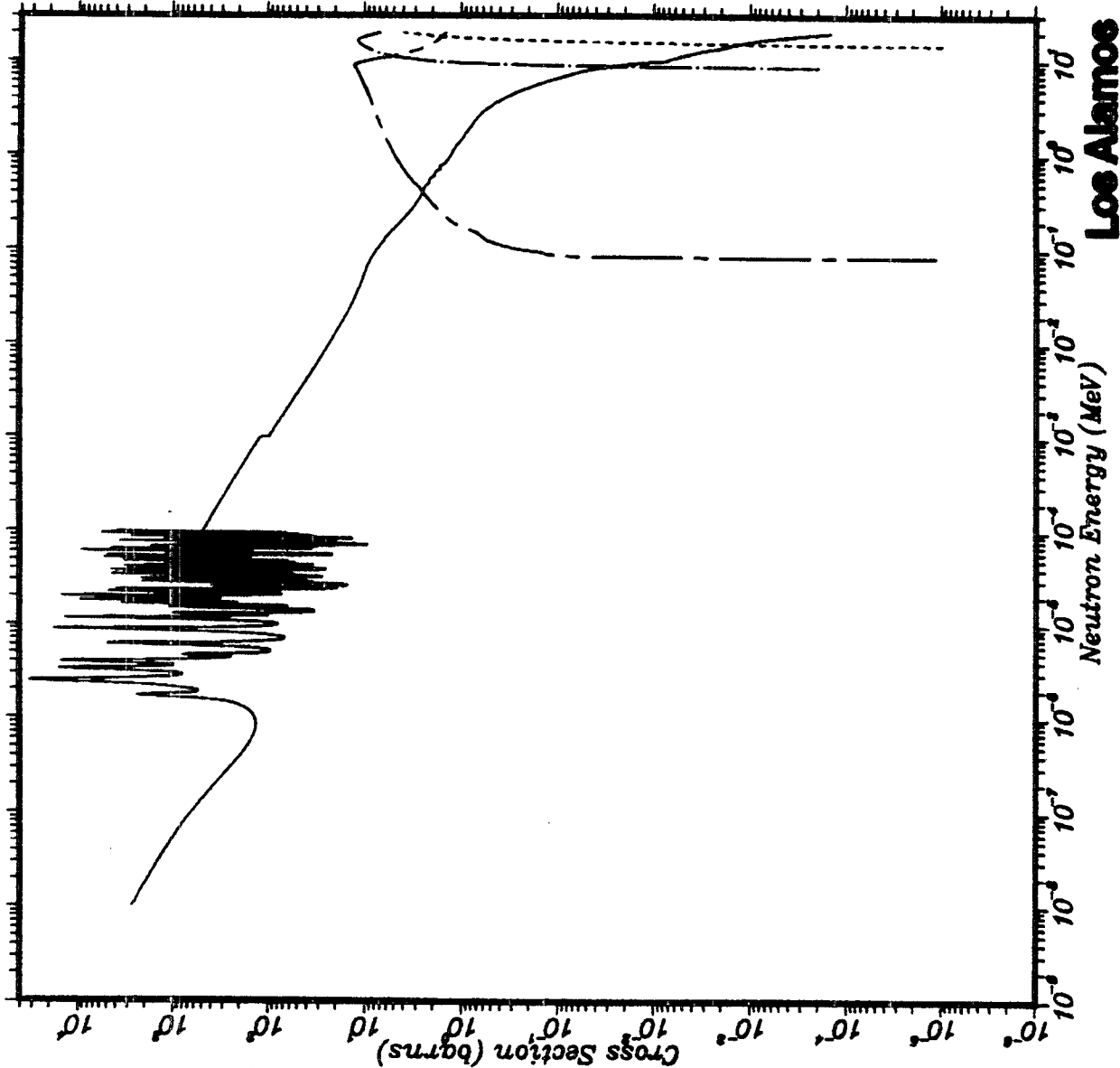


Figure 7

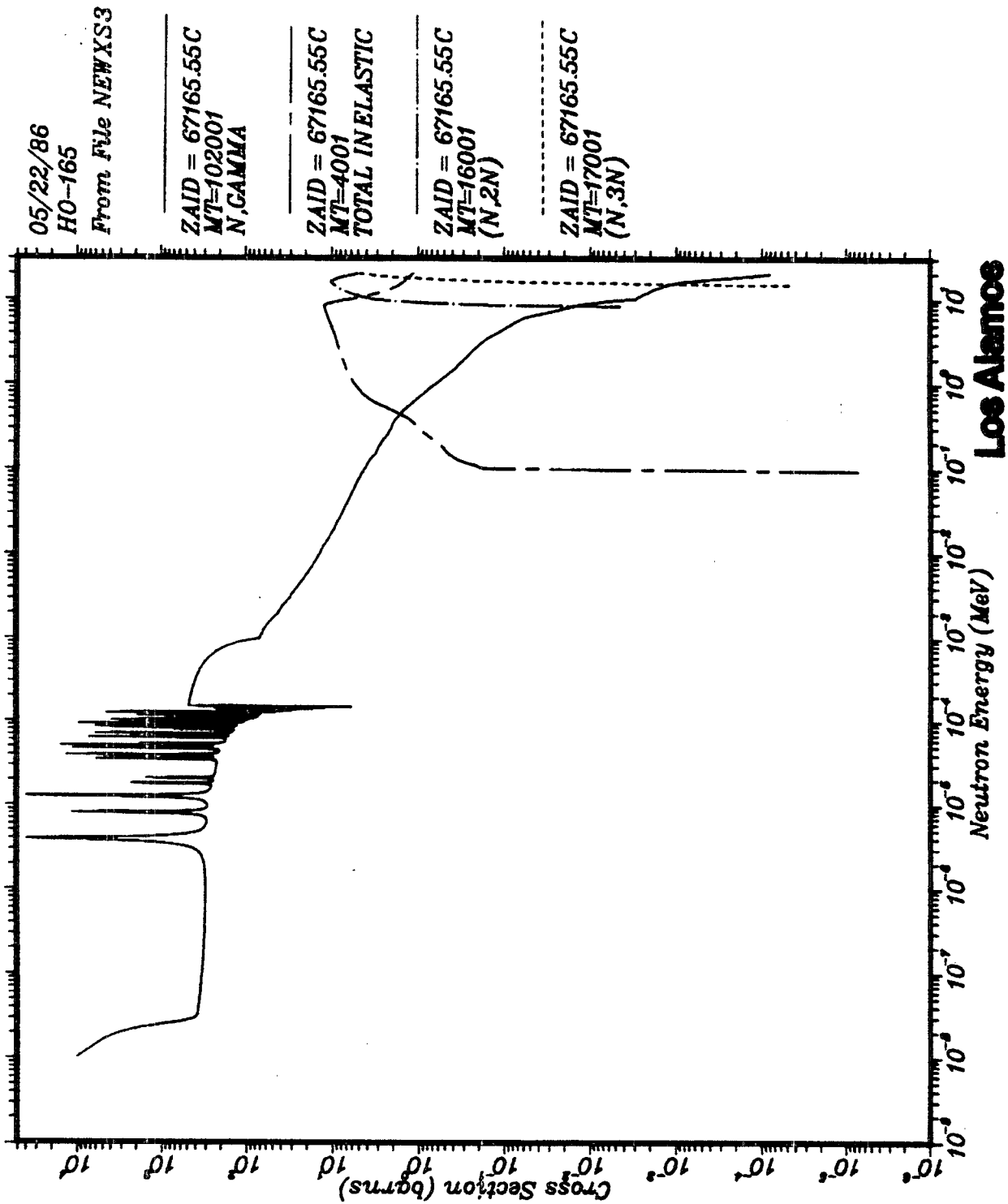


Figure 8