ORNL-TM-3859

REVIEW OF THE CROSS SECTIONS OF THE ISOTOPES ^{6}Li AND ^{7}Li AS TABULATED ON THE ENDF/B VERSION III FILES

Melvin Tobias

OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION • FOR THE U.S. ATOMIC ENERGY COMMISSION

ORNL-TM-3859

Contract No. W-7405-eng-26

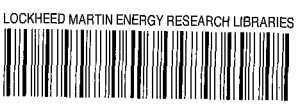
Reactor Division

REVIEW OF THE CROSS SECTIONS OF THE ISOTOPES ^{6}Li AND ^{7}Li AS TABULATED ON THE ENDF/B VERSION III FILES

Melvin Tobias

JULY 1972

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
U. S. ATOMIC ENERGY COMMISSION



CONTENTS

REVIEW OF THE CROSS SECTIONS OF THE ISOTOPES ^{6}Li AND ^{7}Li AS TABULATED ON THE ENDF/B VERSION III FILES

Melvin Tobias

Abstract

The following report reviews the cross section information contained in the ENDF/B files concerning the isotopes ^{6}Li and ^{7}Li. The purpose of this study is to seek out those areas of uncertainty which may be of concern to fusion reactor technology. Other nuclides will be similarly examined and the information obtained will be used in cross section sensitivity studies for fusion reactor design.

Keywords: lithium isotopes, fusion reactor technology, cross sections.

INTRODUCTION

The information contained in this report expands upon the information provided in File 1, Section 451 of the ENDF/B data on ^{6}Li and ^{7}Li, reproduced in Appendices 1 and 2. These data are saved as elements 1115 and 1116 on the ORENDF disk under the data set name ENDF.VERSION.THREE.DATA and on the NUCLIB disk as LMP.ENDFB3.

This report is part of a continuing effort to develop cross section information for use in a simultaneous program of sensitivity studies of various aspects of fusion reactor design. Other nuclides which will undergo similar examination are niobium, graphite, fluorine, vanadium, beryllium, molybdenum and iron.

LITHIUM 6

(Literature references for this section are those in Appendix 1.)

Resonance Parameters

No resonance data are given. A scattering radius of 0.23936×10^{-12} cm is reported, which corresponds to a potential scattering cross section of 0.72 barns shown later in File 3, Section 2. (There exists a broad resonance, however, at 250 keV which is given elsewhere in the files as pointwise cross sections.)

Smooth Cross Sections

Total Cross Section

Total cross section data are provided from 10^{-5} to 20 MeV (Fig. 2).

0.7-2 MeV. – Hibdon and Mooring[3] note that the 250 keV resonance may contain fine structure because the theoretical height computed for any possible J value disagrees with the measured peak. Measurements were made with both good (~1-3 keV) and poor (~8-9 keV) resolution near the peak and elsewhere the spread was ~2 keV. In the neighborhood of the peak, the statistical accuracy is ~0.2 barns; in other ranges, the dispersion is very small.

2-15 MeV. – Foster and Glasgow[4] give measurements of the total cross section for lithium, presumably the natural mixture. The standard deviation claimed is about 1% to 3% from 5 to 15 MeV; from 3 to 5 MeV, it falls from 10% to 2%. The ENDF cross section library, whether for ^{6}Li or ^{7}Li is about 10% higher than that given in Ref. 4.

15-20 MeV. – In this range, the total cross section appears to be a slowly varying function of energy, so that interpolation is justified over fairly wide energy ranges. The measurements were made at 18.1 and 20.4 eV with an uncertainty of ~2%.

0.7-2 MeV. – Calculated by difference between total and nonelastic. The total cross section is of high accuracy in this range, while the nonelastic cross section is the sum of Files 52 and 91, each of which is of about 20% uncertainty (see Figs. 4, 5, and 6).

4-10 MeV. – This is based on Hopkins' evaluation[6] which in turn depends on measurements by Foster and Glasgow. The standard deviations are about 5%. (The cross sections in the file differ slightly from

those cited by Hopkins.) Hopkins fits the data to a straight line in energy, and there is considerable scatter.

Total Inelastic

Sum of (n,n') and (n,n')α,d (Figs. 7 and 8).

(n,2n)α,p

The source of this data is Ref. 1. The evaluation is based on measurements at only two energies, (Fig. 10). The curve drawn by Pendlebury is based on an 8.3 MeV threshold and drawn to be consistent with the data of Ashby. (Phys. Rev. 129, 1771, 1963.) The extrapolation to 20 eV looks like a gently rising parabola.

(n,n')γ

These data are uncertain to about 20% up to about 7 MeV; from 7 to 20 MeV a constant value of 5 mb is used (Figs. 11 and 12). (Note: As given, File 3 indicated −3.56 eV instead of MeV for the Q value.)

(n,n')α,d

Up to 14 MeV, the measurements have about a 20% experimental uncertainty (Figs. 13, 14 and 15).

(n,γ)

This reaction is unimportant at high energies. Pendlebury[1] states that the only measured values are thermal. He recommends a 1/v extrapolation be used until the cross section falls to 10 μb and constant thereafter. The latter recommendation does not seem to have been followed by the ENDF evaluators (Fig. 16).

(n,p)

Up to 7 MeV, the data of Presser are used which have a ±10% uncertainty. From 7 to 15 MeV, the files are based on data for three

energies, likewise of ±10% experimental precision, which was extrapolated to 20 MeV (Figs. 17 and 18).

(n,α)

K. M. Diment and C. A. Uttley (AERE-PR-NP-15) recommend that the (n,α) cross section be obtained by subtracting the scattering cross section from the total cross section up to the threshold of the (n,d) reaction at 1.7 MeV. Between 2 and 15 MeV, the uncertainty in the data is about 10%, as may be seen from Fig. 11 from Pendlebury's report. The basis for the curve between 8 and 12 MeV is not made clear. The data of Kern and Kreger which are used from 15 MeV upwards are estimated to be of about 6% uncertainty (Fig. 5 from Kern and Kreger), (Figs. 19, 20 and 21).

Secondary Angular Distributions

Section 2, elastic scattering. The original data on which this section is based have quite small error. From 10 to 20 MeV calculations were used to infer the Legendre coefficients using 14 MeV given in BNL-400.

Section 24 (n,2n)α-p and Section 52 (n,n') gamma were tabulated as isotropic in the L and C systems respectively. Experimental data are lacking in both cases.

Section 91. Here the tabulations are smoothed from rough-looking histograms similar to those in Fig. 38.

Secondary Energy Distributions

Section 24 (n,2n)α-p. The distribution given has no experimental basis and is based on the assumption that on the average neutrons are emitted at right angles to the center of mass velocity.

Section 91 (n,n')α-d based on data between 4.4 and 14 MeV. The original data are rough-looking histograms.

LITHIUM-7 CROSS SECTIONS

The basic reference, AWRE Report O-61/64, has the following to say about the data accuracy.

Total Cross Section

Total cross section is no better than 10% uncertain over 1 keV and possibly more than that below due to lack of data.

Elastic Cross Section

Elastic cross section no better than 10%.

The $(n,n')\gamma$ and $(n,n')\alpha,t$ Reactions

For $(n,n')\gamma$, up to 4 MeV, 10% uncertain. From 4 to 14 MeV, no measurements exist, it is guessed that the accuracy is 25%. For $(n,n')\alpha,t$ 10 to 20% up to 15 MeV.

The (n,2n) and $(n,2n)\alpha$-d cross sections may be grossly in error.

The (n,γ) Reaction

Errors may be large in percent, but this cross section is quite small anyway.

The (n,d) Reaction

This is another small cross section of 10 to 15% uncertainty.

Secondary Energy and Angle Distributions

Secondary energy and angle distributions for the (n,2n) reactions are based only on "reasonable" models and there is no corroborative experimental data.

Elastic Secondary Angular Distributions

Elastic secondary angular distributions are about 10% accurate.

FINAL COMMENTS ON DATA UNCERTAINTIES

The quality of the data for the primary tritium breeding reaction cross sections $^{6}Li(n,\alpha)$ and $^{7}Li(n,n')\alpha,t$ as assessed in this report is much the same as that cited by Steiner* who gave estimates of 10% and 25% respectively. The inelastic and (n,2n) data for both elements, both for the cross sections and the secondary energy distribution, are not well known and are significant to nuclear heating calculations, as well as to breeding estimates. However, any cross section sensitivity studies must be constrained by the need to preserve the accuracy of the total cross section. That is, the total cross section above 10 MeV is known to within 0.1 to 0.2 barns, so that no individual deviations should be assumed outside of this range. (Even under this constraint there is ample leeway for the observation of the effects of assumed cross section errors.)

---

*D. Steiner, Proceedings of the Conference on Nuclear Cross Sections in Technology, March 1971.

APPENDICES

APPENDIX 1

File 1, Section 451 Reproduced from ENDF/B for Lithium-6

```
     LI-6       LASL        EVAL-AUG71 M.E.BATTAT AND R.J.LABAUVE
MATERIAL= 1115   ZA=  3006.    AWR =   5.9634       FILE=  1   SECTION= 451

                          DIST-JAN72
 *         *         *          *         *         *          *

 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 *                                                               *
 * CROSS SECTION STANDARD -- LI-6 %N,ALPHA<                      *
 *                                                               *
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 *                                                               *
 * THIS STANDARD CROSS SECTION WAS RECOMMENDED BY THE CSEWG      *
 *                                                               *
 * NORMALIZATION AND STANDARDS SUBCOMMITTEE FOR NEUTRON ENERGIES *
 *                                                               *
 * FROM THERMAL TO 2.0 MEV                                       *
 *                                                               *
 *         *         *          *         *         *          *
LI-6   MAT 1115   LASL   EVAL-AUG 71   M.E.BATTAT AND R.J.LABAUVE
 DATA GIVEN FOR MAT 1115 IS AN E.TENSIVE REVISION OF EARLIER DATA
 %MAT 1005< WHICH WAS BASED CN AN UKAEA EVALUATION %REF. 1<.  AS
 PER THE RECOMMENDATION OF THE CSEWG NORMALIZATION AND STANDARDS
 COMMITTEE, THE TOTAL, ELASTIC, AND N-ALPHA CROSS SECTIONS BELOW
 2 MEV REFLECT THE DATA OF DIMENI AND UTTLEY %REF. 2<.


MF # 2                    RESONANCE PARAMETERS

   MT # 151.  SCATTERING RADIUS ONLY.


MF # 3                    SMOOTH CROSS SECTIONS

   MT # 1, TOTAL. BELOW 0.7 MEV, DATA OF REF. 2.  BETWEEN 0.7 AND
   2 MEV, CROSS SECTIONS REFLECT HIBDON AND MOORING DATA %REF. 3<.
   FROM 2 TO 15 MEV, PRIMARY REFERENCE IS FOSTER AND GLASGOW DATA
   %REF. 4<. E.TRAPOLATION TO 20 MEV BASED ON DATA OF PETERSON
   %REF. 5<.

   MT # 2, ELASTIC.  BELOW 0.7 MEV, DATA OF REF. 2.       BETWEEN
   0.7 AND 2 MEV, DIFFERENCE BETWEEN TOTAL AND NONELASTIC. PRIMARY
   REFERENCE BETWEEN 4 AND 10 MEV WAS HOPKINS EVALUATION %REF. 6<.
   AT 14 MEV, A VALUE OF 0.880 INSTEAD OF 0.865 BARN %REF. 1< WAS
   USED.

   MT # 4, TOTAL INELASTIC.  SUM OF MT # 52 AND MT # 91.

   MT #24, %N,2N<ALPHA-P.  EVALUATION OF REF. 1 TO 15 MEV. E.TRAP-
   OLATED TO 20 MEV.

   MT #52, %N,N PRIME<GAMMA.  DATA OF PRESSER %REF. 7< TO 7 MEV.
```

LI-6 LASL EVAL-AUG71 M.E.BATTAT AND R.J.LABAUVE
MATERIAL= 1115 ZA= 3006. AWR = 5.9634 FILE= 1 SECTION= 451

CONSTANT CROSS SECTION OF 5 MILLIBARN ASSUMED ABOVE 7 MEV.

MT # 91, %N,N PRIME<ALPHA-D. REF. 1 UP TO ABOUT 3 MEV. HOPKINS EVALUATION %REF. 6< CONSIDERED BETWEEN 4 AND 10 MEV. A SOMEWHAT HIGHER VALUE - 433 VERSUS 403 MILLIBARN - THAN IN REF. 1 WAS USED AT 14 MEV. E.TRAPOLATION TO 20 MEV USING DIFFERENCE BETWEEN TOTAL AND OTHER PARTIAL CROSS SECTIONS.

MT # 102, %N,GAMMA<. EVALUATION OF REF. 1.

MT # 103, %N,P<. DATA OF PRESSER %REF. 7< TO 7 MEV. REF. 1 FROM 7 TO 15 MEV. E.TRAPOLATED TO 20 MEV.

MT # 107, %N,ALPHA<. DIMENT AND UTTLEY DATA %REF. 2< TO 2 MEV. REF. 1 BETWEEN 2 AND 15 MEV. E.TRAPOLATION TO 20 MEV BASED ON KERN AND KREGER DATA %REF. 8< BETWEEN 15 AND 18 MEV.

MT # 251, 252, 253 %MUBAR, .I, GAMMA<. CALCULATED USING ELASTIC ANGULAR DISTRIBUTIONS GIVEN IN FILE 4.

MF # 4 SECONDARY ANGULAR DISTRIBUTIONS

MT # 2, ELASTIC. LEGENDRE COEFFICIENTS DETERMINED AS FOLLOWS. FROM 0.12 TO 2.5 MEV, LANE DATA %REF. 9< WERE FITTED. BETWEEN 4.83 AND 7.5 MEV, FIT OF HOPKINS DATA %REF. 7< WAS USED. BASED ON 14-MEV ELASTIC SCATTERING DATA GIVEN IN BNL-400, OPTICAL MODEL CALCULATIONS %ABACUS CODE< WERE USED TO INFER LEGENDRE COEFFICIENTS BETWEEN 10 AND 20 MEV.

MT # 24, %N,2N<ALPHA-P. EVALUATION OF REF. 1. ISOTROPIC IN LAB SYSTEM.

MT # 52, %N,N PRIME<GAMMA. TABULATED DISTRIBUTION. ISOTROPIC IN CM SYSTEM.

MT # 91, %N,N PRIME<ALPHA-P. TABULATED DISTRIBUTION %L SYSTEM< OF REF. 1. E.TRAPOLATED TO 20 MEV.

MF # 5 SECONDARY ENERGY DISTRIBUTIONS

MT # 24, %N,2N<ALPHA-P. DISTRIBUTIONS GIVEN IN REF. 1 APPRO.-IMATED BY ENDF/B LAW 9 WITH THETA EQUAL 0.21 * SQRT%E<.

MT # 91, %N,N PRIME<ALPHA-D. DISTRIBUTIONS GIVEN IN REF. 1 APPRO.IMATED BY ENDF/B LAW 9. THETA VALUES OBTAINED BY LINEAR INTERPOLATION BETWEEN FOLLOWING POINTS - - -
E # 1.718 MEV, THETA # 0.05 MEV
E # 4.1 MEV, THETA # 0.75 MEV

LI-6 LASL EVAL-AUG71 M.E.BATTAT AND R.J.LABAUVE
MATERIAL= 1115 ZA= 3006. AWR = 5.9634 FILE= 1 SECTION= 451

E #20.0 MEV, THETA # 8.40 MEV

REFERENCES

1. PENDLEBURY, E.D., REPORT AWRE O-60/64.
2. DIMENT, K.M., AND UTTLEY, C.A., NUCLEAR PHYSICS DIVISION PROGRESS REPORTS AERE-PR/NP 15 AND AERE-PR/NP 16 %1969<. ALSO PRIVATE COMMUNICATION FROM C. A. UTTLEY TO LEONA STEWART.
3. HIBDON, C.T., AND MOORING, F.P., CONFERENCE ON NEUTRON C/S TECHNOLOGY, WASH., D.C., 1, 159 %1968<.
4. FOSTER, D.G.,JR., AND GLASGOW, D.W., HW-73116 AND HW-77311.
5. PETERSON, J.M., ET AL, PHYS REV 120, 521 %1960<.
6. HOPKINS, J.C., ET AL, LOS ALAMOS SCI LAB REPORT LA-3765 %1967<.
7. PRESSER, G., ET AL, NUCL PHYS A131, 679 %1969<.
8. KERN, B.D., AND KREGER, W.E., PHYS REV 112, 926 %1958<.
9. LANE, R.C., ET AL, ANN PHYS 12, 135 %1961<.

LI-6 LASL EVAL-AUG71 M.E.BATTAT AND R.J.LABAUVE
MATERIAL= 1115 ZA= 3006. AWR = 5.9634 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	DESCRIPTIVE	142
2	151	RESONANCE	4
3	1	TOTAL	62
3	2	ELASTIC	62
3	4	(N,N*) TOTAL	21
3	24	(N,2N) ALPHA	11
3	52	(N,N*) LEVEL	14
3	91	(N,N*) CONT	21
3	102	(N,GAMMA)	18
3	103	(N,P)	16
3	107	(N,ALPHA)	62
3	251	MU BAR	15
3	252	XI	15
3	253	GAMMA	15
4	2	ELASTIC	111
4	24	(N,2N) ALPHA	10
4	52	(N,N*) LEVEL	10
4	91	(N,N*) CONT	100
5	24	(N,2N) ALPHA	7
5	91	(N,N*) CONT	7

APPENDIX 2

File 1, Section 451 Reproduced from ENDF/B for Lithium-7

```
 LI-7      LASL       EVAL-SEP69 M.E.BATTAT AND R.J.LABAUVE
MATERIAL= 1116   ZA=  3007.   AWR =   6.9557      FILE=  1   SECTION= 451

                          DIST-JAN72 REV-MAR71
 *         *         *         *         *         *         *
LITHIUM-7 CROSS SECTIONS  MATERIAL 1006  ENDF/B  SEPTEMBER 1969

******  DATA MODIFIED FOR ENDF/B-II FORMAT, MARCH 1971.        **
DATA SUBMITTED BY M. E. BATTAT AND R. J. LABAUVE, LASL.

UNLESS OTHERWISE NOTED, THE LI-7 DATA - DATA FILE NUMBER %DFN<
 215, MARK LABEL A - IN THE UKAEA NUCLEAR DATA LIBRARY ARE
 TABULATED.   ENERGY RANGE IS 1.0E-5 EV TO 15 MEV.

BASIC REFERENCE FOR THIS NUCLIDE IS AWRE REPORT O-61/64 %JULY
 1964<, WHICH GIVES DATA FOR DFN-176.  AS PER AWRE REPORT O-55/65
 %APRIL 1965<, DFN 215 HAS SAME DATA AS DFN-176 BUT WITH SLIGHTLY
 LOWER ELASTIC CROSS SECTIONS BETWEEN 0.01 AND 0.2 MEV.  DATA
 BELOW 0.001 EV WERE ADDED AT AEE, WINFRITH, IN JANUARY 1967 AND
 NUCLIDE IDENTIFIED AS 215A %SEE AEEW-M 802, FEBRUARY 1968<.  IN
 AUGUST 1967, TEMPERATURE WAS REVISED TO ZERO DEGREES KELVIN AND
 NUCLIDE IDENTIFIED AS 215D.  AT THIS DATE, LISTING OF 215D WAS
 NOT AVAILABLE AT LASL.  IT HAS BEEN ASSUMED THAT THIS CHANGE IS
 A FLAG FOR THE UKAEA PROCESSING CODES AND NO CROSS SECTION
 CHANGES WERE MADE IN 215D.


DATA FOR THIS MATERIAL ARE SUMMARIZED BELOW - -

**MF # 1**  GENERAL INFORMATION AND COMMENT CARDS

**MF # 2**  SCATTERING RADIUS ONLY.

**MF # 3**  SMOOTH CROSS SECTIONS
            MT#  1  TOTAL
            MT#  2  ELASTIC
            MT#  4  %N,N PRIME<GAMMA & %N,N PRIME<ALPHA-T
            MT# 16  %N,2N<
            MT# 24  %N,2N<ALPHA-D
            MT# 51  %N,N PRIME<GAMMA
            MT# 91  %N,N PRIME<ALPHA-T
            MT#102  %N,GAMMA<
            MT#104  %N,D<
            MT#251  MU-BAR--AVERAGE COSINE OF SCATTERING ANGLE
            MT#252  .I-AVERAGE LOGARITHMIC ENERGY DECREMENT
            MT#253  GAMMA

**MF # 4**  SECONDARY ANGULAR DISTRIBUTIONS

            MT#  2  LEGENDRE/%C< SYSTEM/TRANSFORMATION MATRI.
                    GIVEN.  DATA FROM H. ALTER OF A-I.  %PRIVATE
                    COMMUNICATION<.
```

LI-7 LASL EVAL-SEP69 M.E.BATTAT AND R.J.LABAUVE
MATERIAL= 1116 ZA= 3007. AWR = 6.9557 FILE= 1 SECTION= 451

MT# 16 TABULAR/%L< SYSTEM. 8.300 TO 15 MEV.

MT# 24 TABULAR/%L< SYSTEM. 10.00 TO 15 MEV.

MT# 51 TABULAR/%C< SYSTEM. 0.550 TO 15 MEV.

MT# 91 TABULAR/%L< SYSTEM. 2.821 TO 15 MEV.

MF # 5 SECONDARY ENERGY DISTRIBUTIONS

MT# 16 %N,2N<. ENERGY RANGE IS 8.3 TO 15 MEV. DISTRIBUTION APPRO.IMATED BY ENDF/B LAW 9, WITH THETA %MEV< EQUAL
0.21 * SQRT%E<
THIS CORRESPONDS TO AN AVERAGE THETA OF 0.7 MEV IN THE 8.3 TO 15 MEV ENERGY INTERVAL.

MT# 24 %N, 2N<ALPHA-1. ENERGY RANGE IS 10 TO 15 MEV. DISTRIBUTION APPRO.IMATED BY ENDF/B LAW 9, WITH THETA %MEV< EQUAL
0.1133 * SQRT%E<.
THIS CORRESPONDS TO AN AVERAGE THETA OF 0.4 MEV IN THE 10 TO 15 MEV ENERGY INTERVAL.

MT# 91 %N, N PRIME<ALPHA-T. DISTRIBUTIONS APPRO.-IMATED USING LAW 9. THETA VALUES OBTAINED BY LINEAR INTERPOLATION BETWEEN FOLLOWING POINTS - - -
E # 2.821 MEV, THETA #0.10 MEV
E # 5.8 MEV, THETA #0.70 MEV
E # 8.0 MEV, THETA #2.80 MEV
E #15.0 MEV, THETA #5.35 MEV

LI-7 LASL EVAL-SEP69 M.E.BATTAT AND P.J.LABAUVE
MATERIAL= 1116 ZA= 3007. AWF = 6.9557 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	DESCRIPTIVE	109
2	151	RESONANCE	4
3	1	TOTAL	39
3	2	ELASTIC	39
3	4	(N,N*) TOTAL	23
3	16	(N,2N)	8
3	24	(N,2N)ALPHA	7
3	51	(N,N*) LEVEL	23
3	91	(N,N*) CONT	16
3	102	(N,GAMMA)	11
3	104	(N,D)	8
3	251	MU BAR	95
3	252	XI	95
3	253	GAMMA	9
4	2	ELASTIC	81
4	16	(N,2N)	10
4	24	(N,2N)ALPHA	10
4	51	(N,N*) LEVEL	10
4	91	(N,N*) CONT	73
5	16	(N,2N)	7
5	24	(N,2N)ALPHA	7
5	91	(N,N*) CONT	8

LIST OF FIGURES

[a] The * denotes the ENDF/B Version III files.

Fig. No.	Title	Source
30	$^{7}Li(n,2n)^{6}Li$ and $^{7}Li(n,2n)\alpha,d$ below 15 MeV	AWRE O-61/64
31	$^{7}Li(n,2n)$ alpha	*
32	$^{7}Li(n,n^{*})$ 1-st excited state	*
33	$^{7}Li(n,n')^{7}Li^{*}(\gamma)^{7}Li$ gs	AWRE O-61/64
34	$^{7}Li(n,n^{*})$ continuum	*
35	$^{7}Li(n,n')\alpha,t$	AWRE O-61/64
36	$^{7}Li(n,\gamma)$	*
37	$^{7}Li(n,d)$	*
38	Some angular distribution data for the $^{7}Li(n,n')\alpha,t$ reaction	AWRE O-61/64

ORNL DWG 72-6581

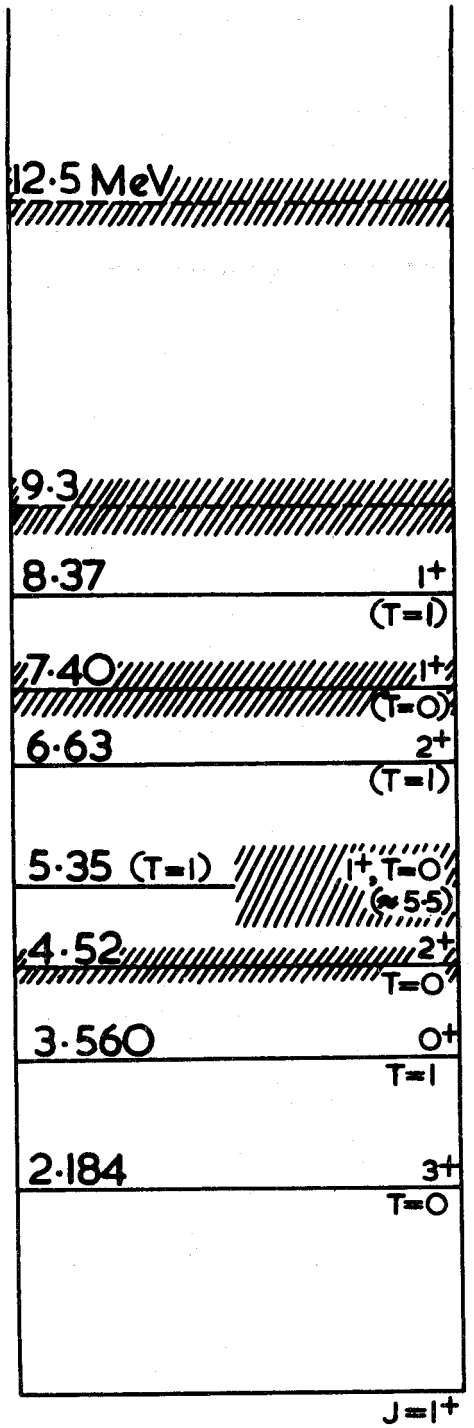


Fig. 1. Energy levels of ^{6}Li.

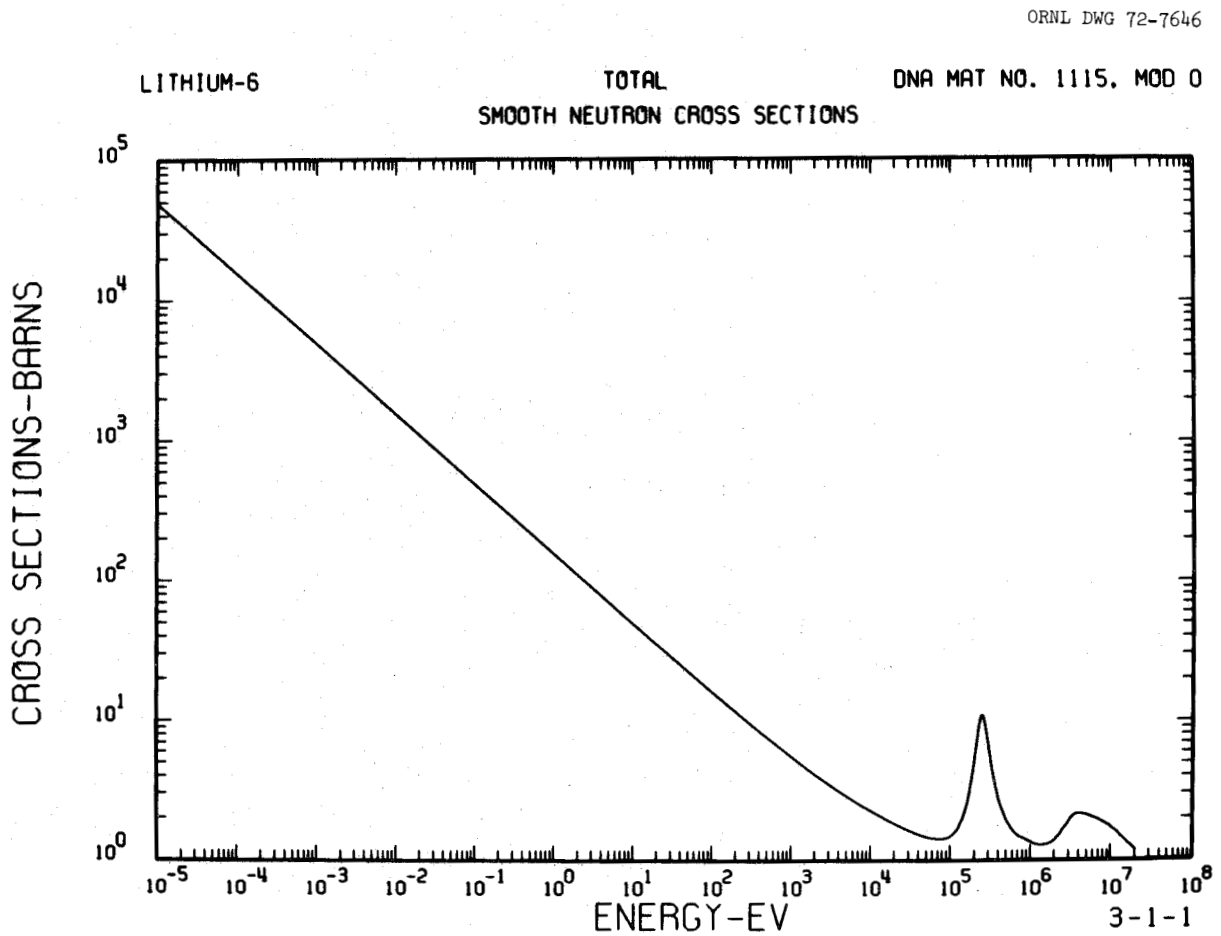


Fig. 2. Total cross section, ^{6}Li.

ORNL DWG 72-6587

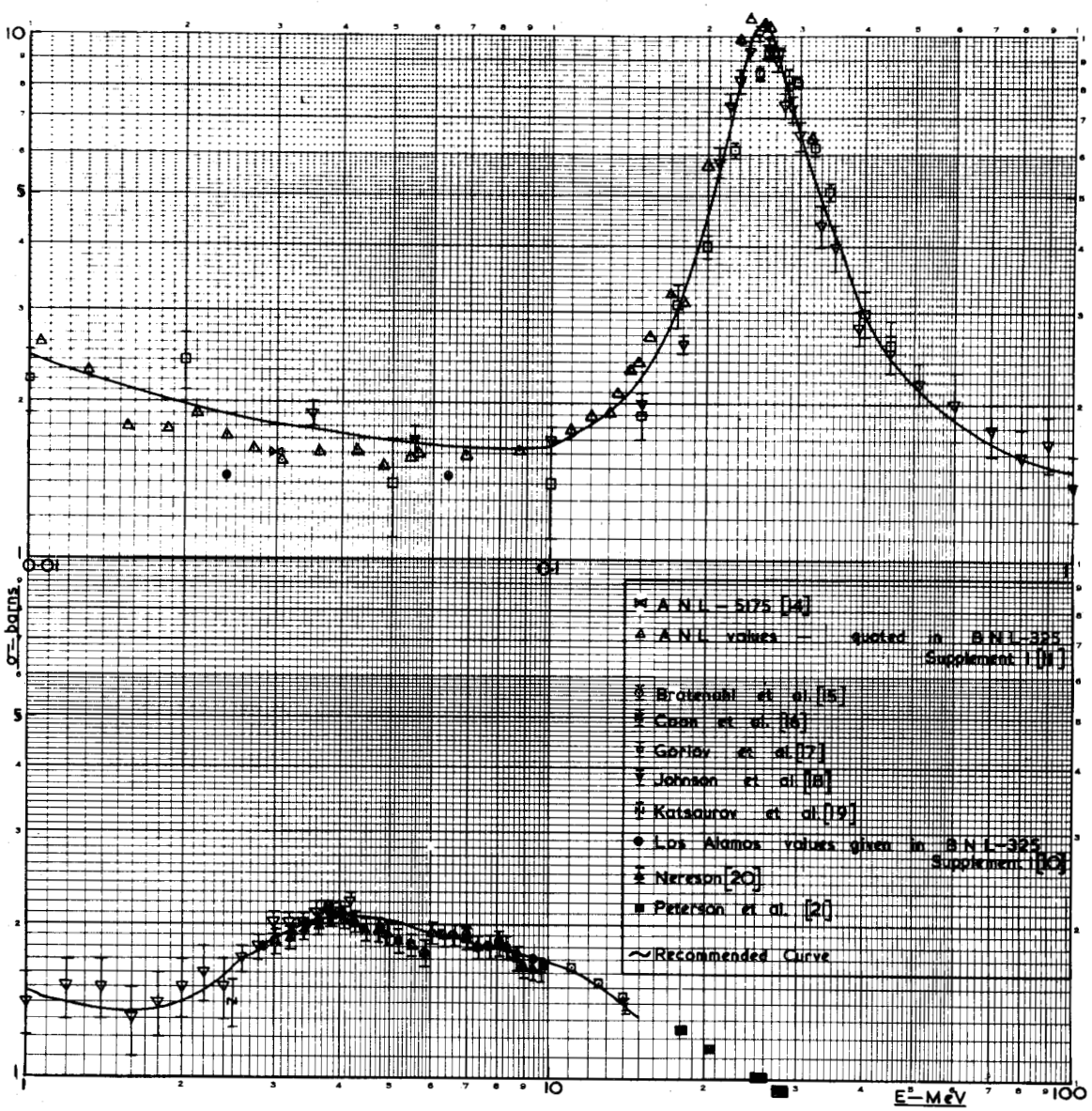


Fig. 3. Total cross section of ^{6}Li in the energy range 0.01 - 28 MeV.

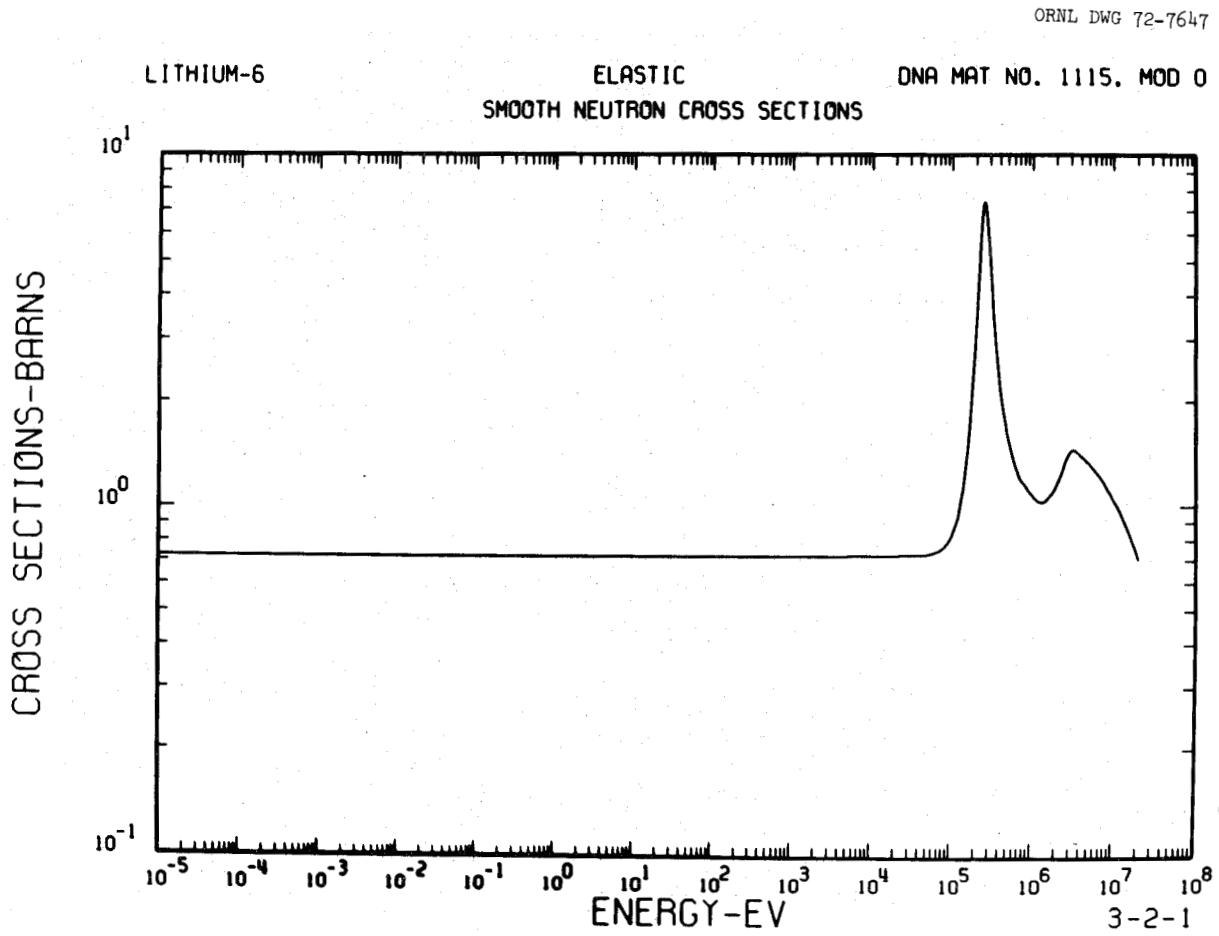


Fig. 4. Elastic cross section, ^{6}Li.

ORNL DWG 72-6589

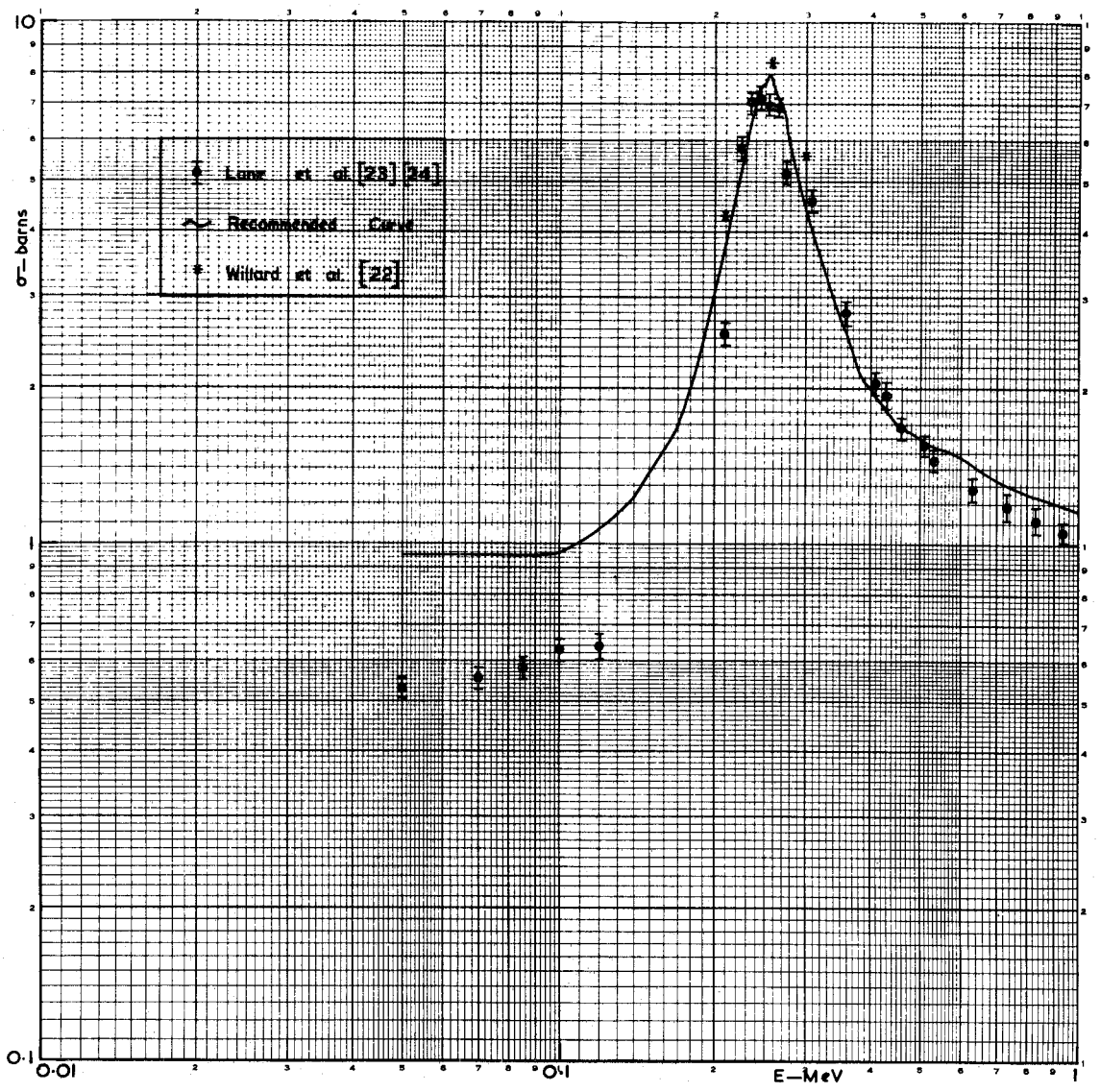


Fig. 5. Elastic cross section of ^{6}Li in the energy range 50 keV - 1 MeV.

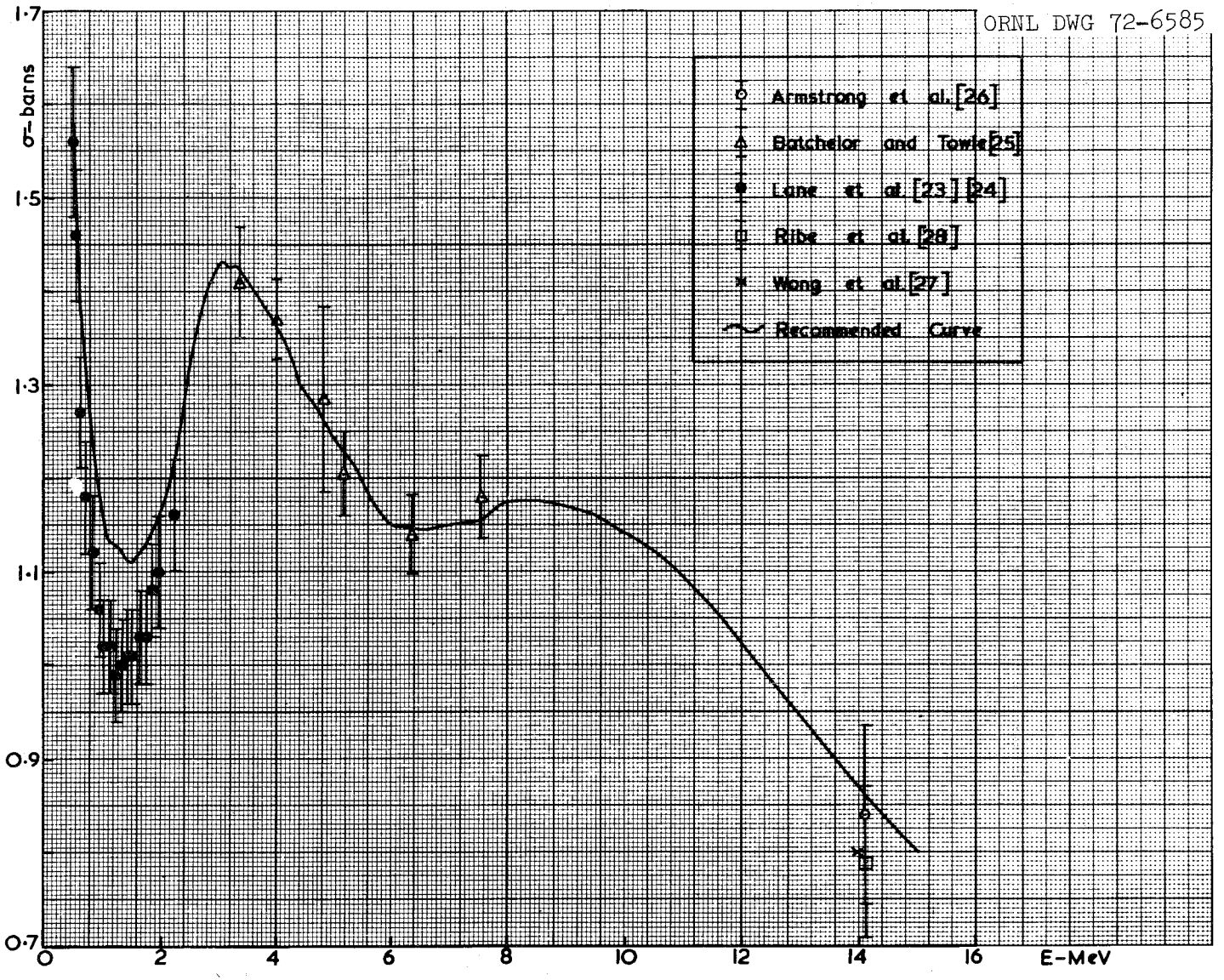


Fig. 6. Elastic cross section of ^{6}Li in the energy range 0.5 - 15 MeV.

ORNL DWG 72-7648

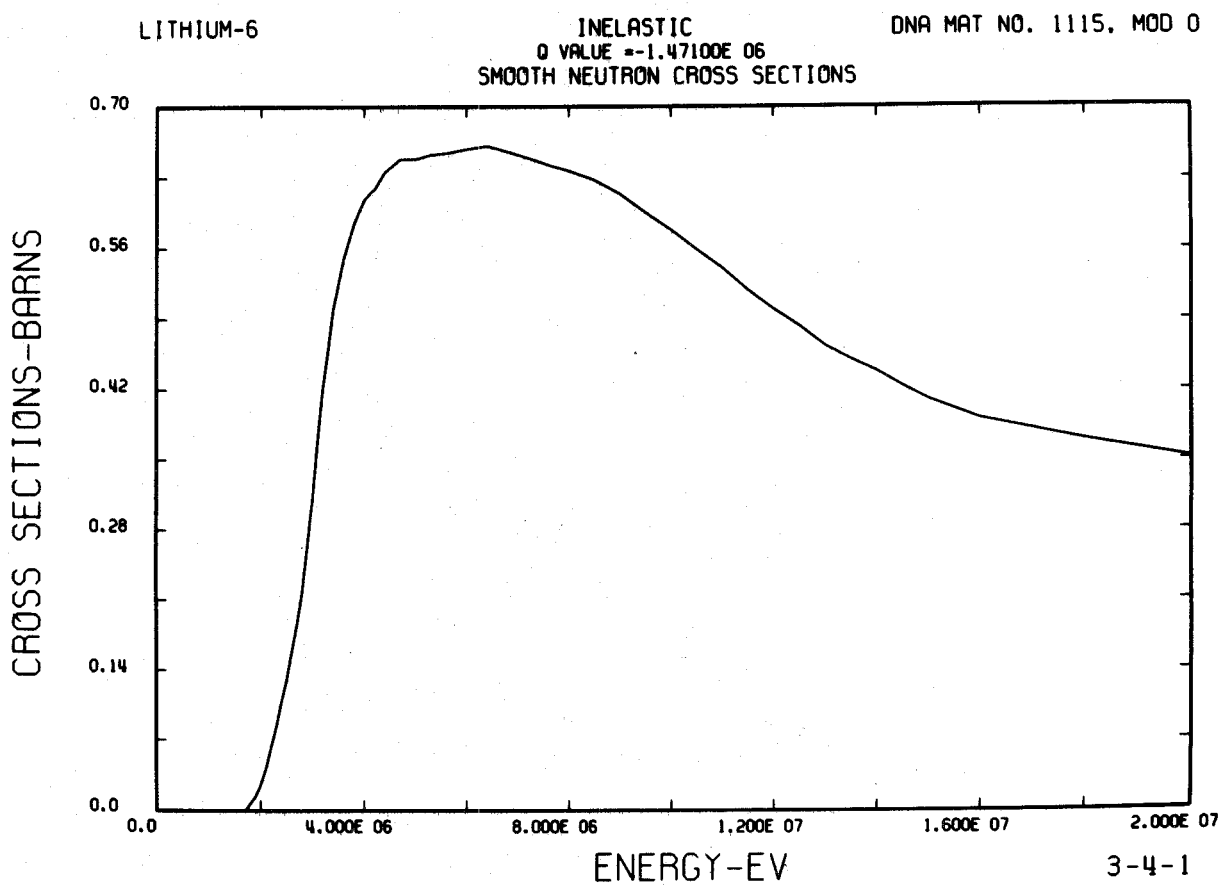


Fig. 7. Inelastic cross section, ^{6}Li.

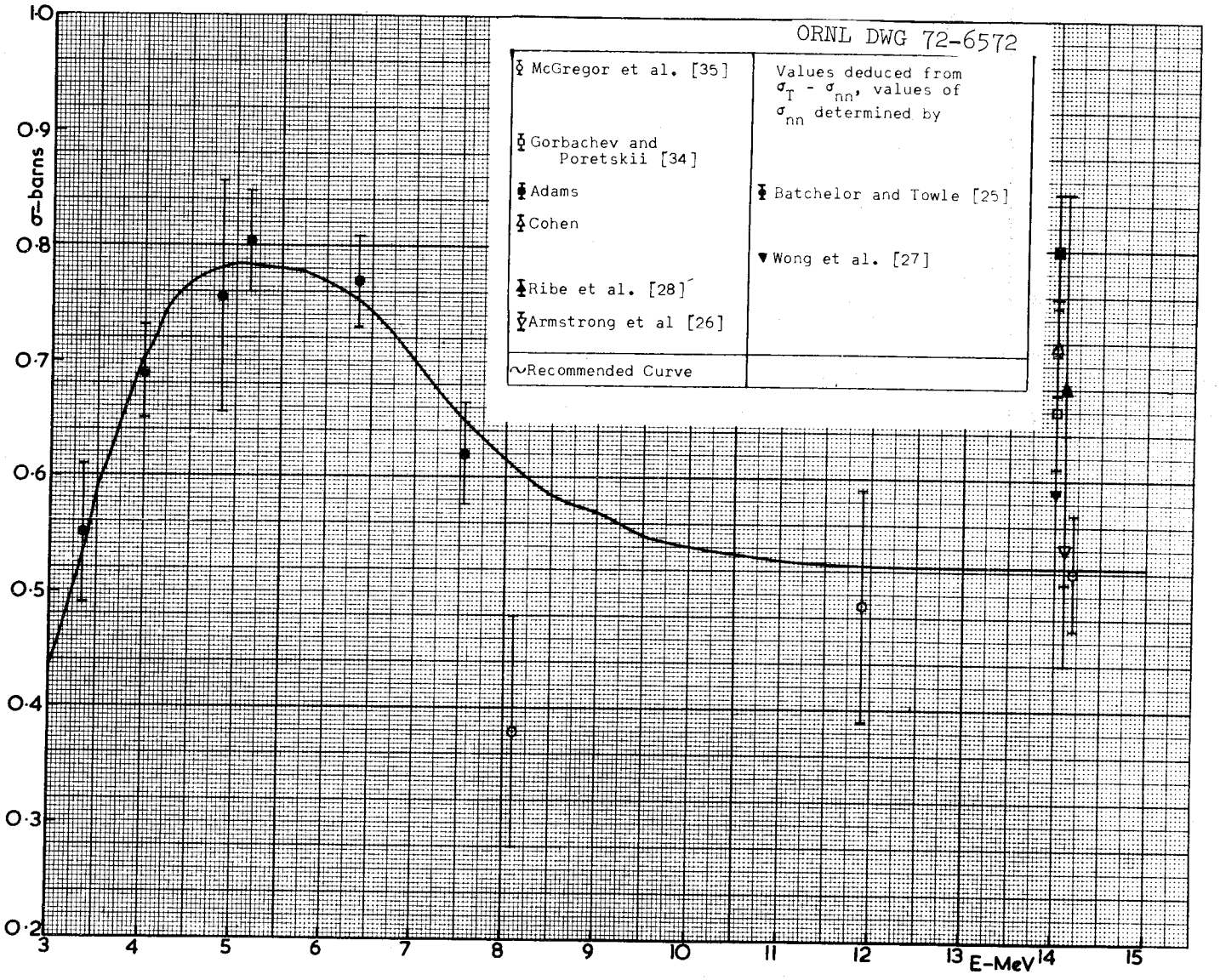


Fig. 8. Non-elastic cross section of ^{6}Li in the energy range 3 - 15 MeV.

ORNL DWG 72-7649

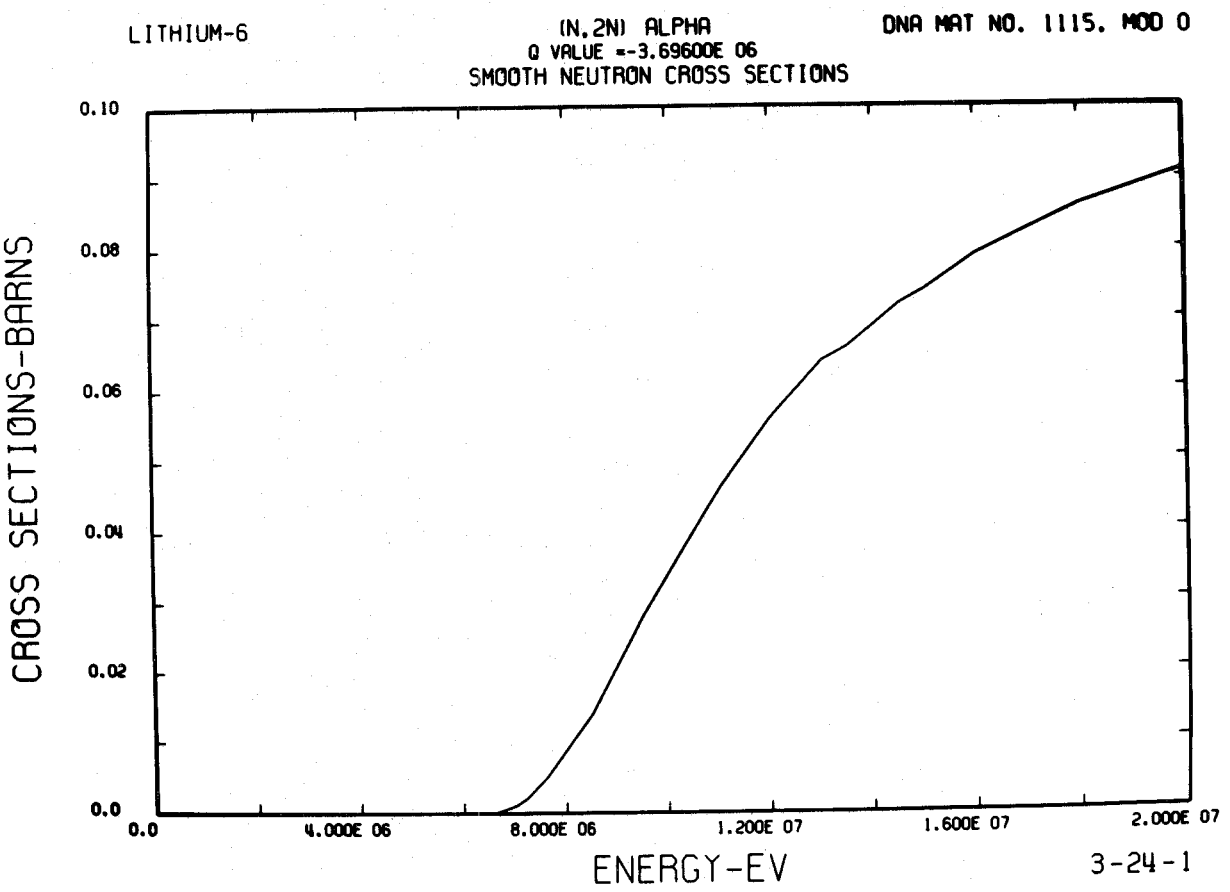


Fig. 9. (n,2n) alpha, ^{6}Li.

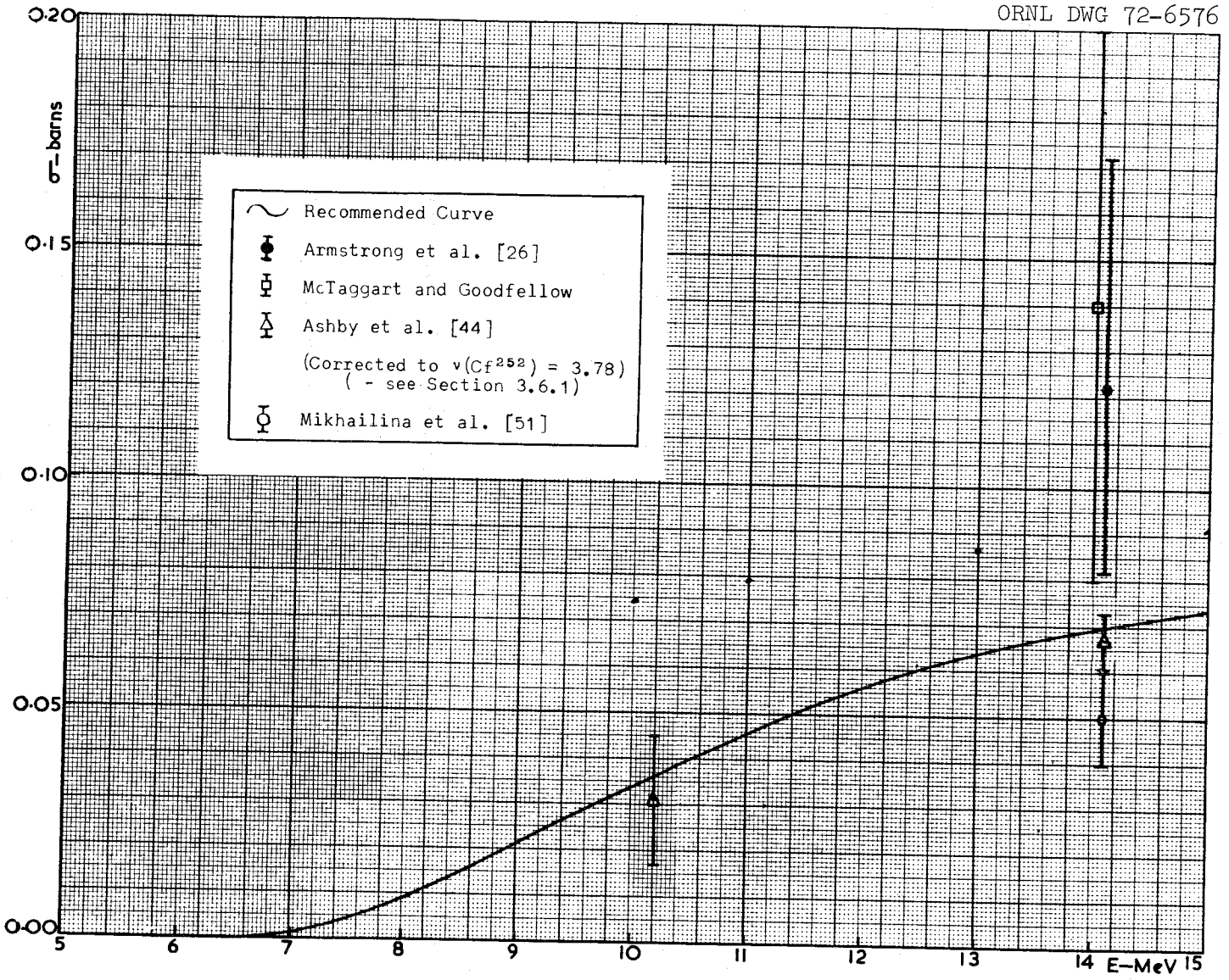


Fig. 10. $^{6}Li(n,2n)\alpha,p$ cross section in the energy range below 15 MeV.

ORNL DWG 72-7650

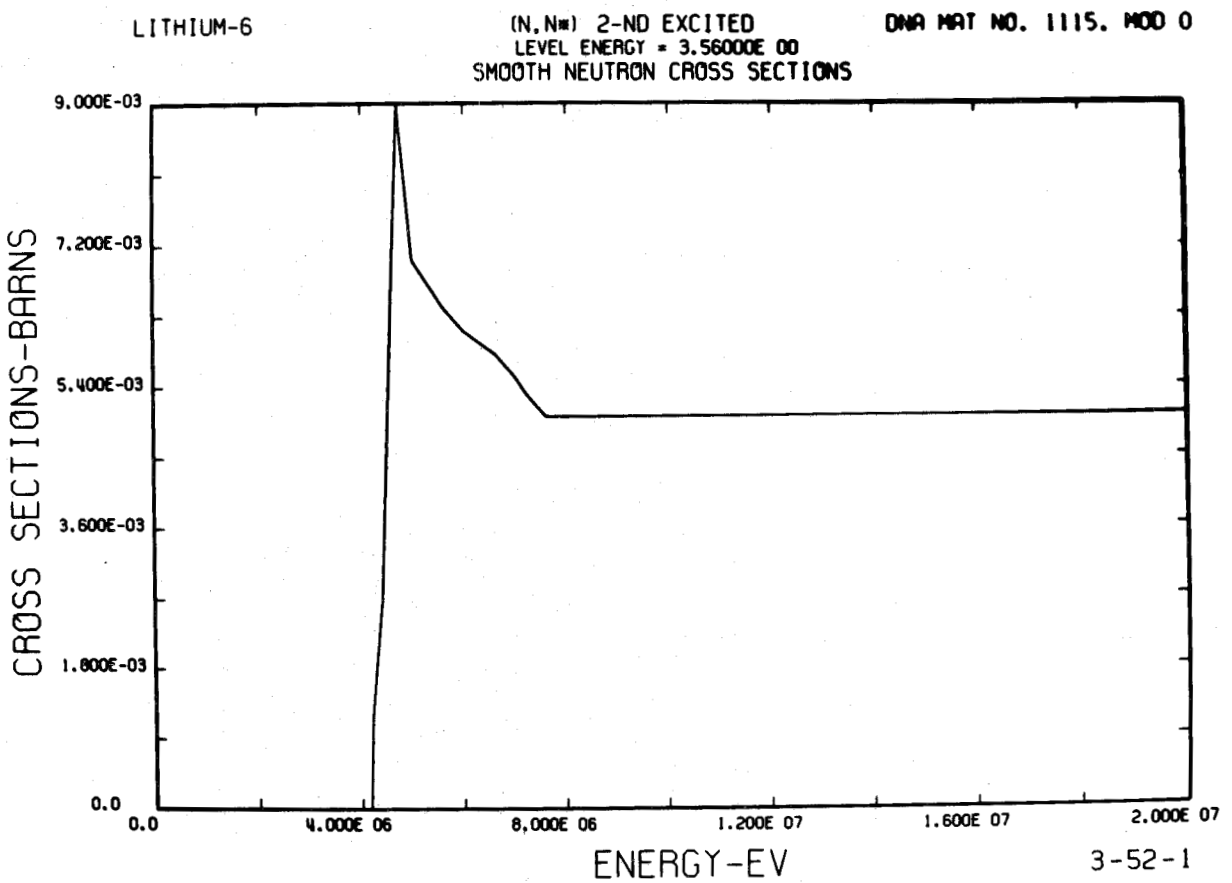


Fig. 11. $^{6}Li(n,n^{*})$ 2-nd excited state (level energy 3.56 MeV).

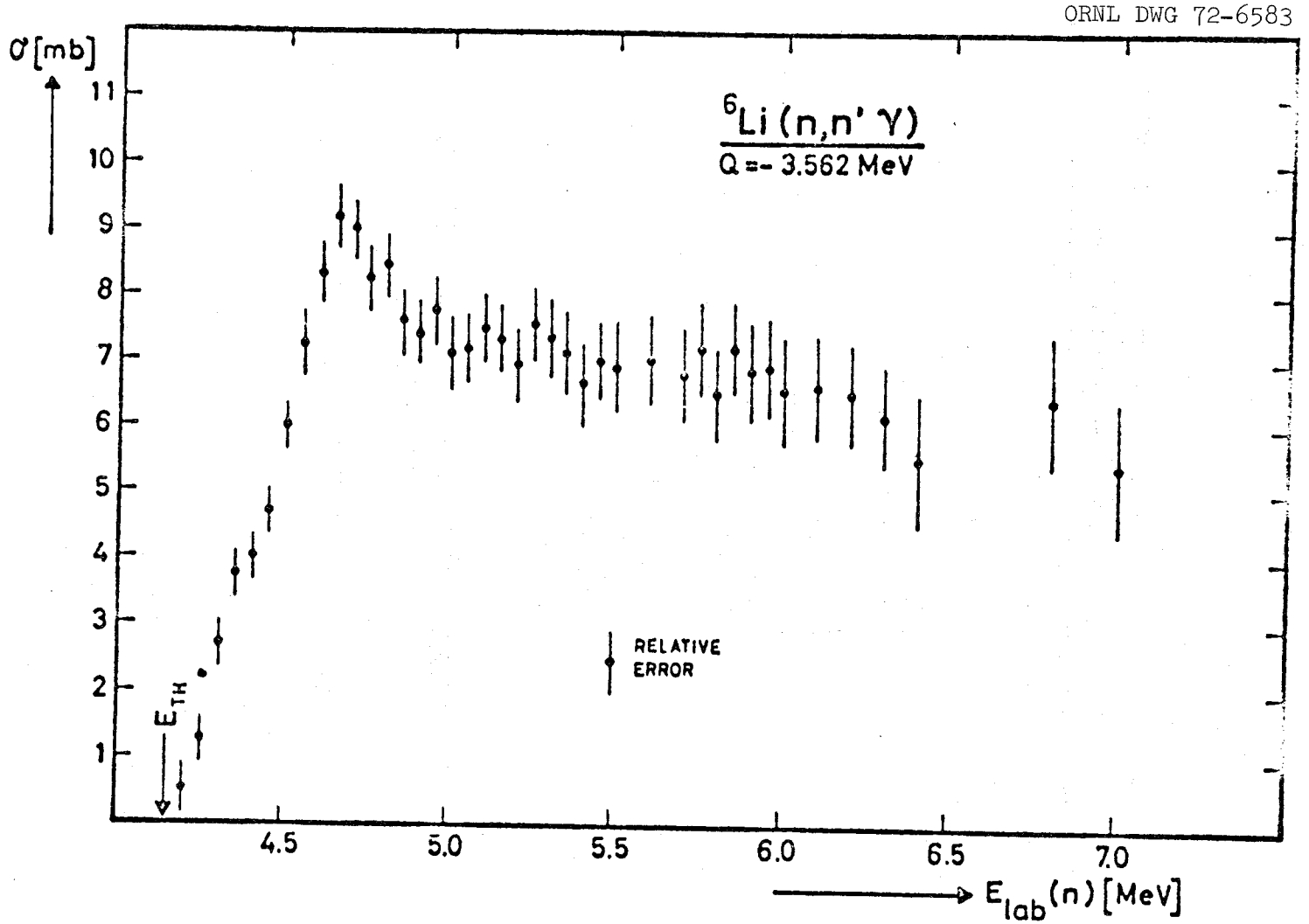


Fig. 12. Excitation function of the reaction ^{6}Li(n,n')^{6}Li(3.56).

ORNL DWG 72-7651

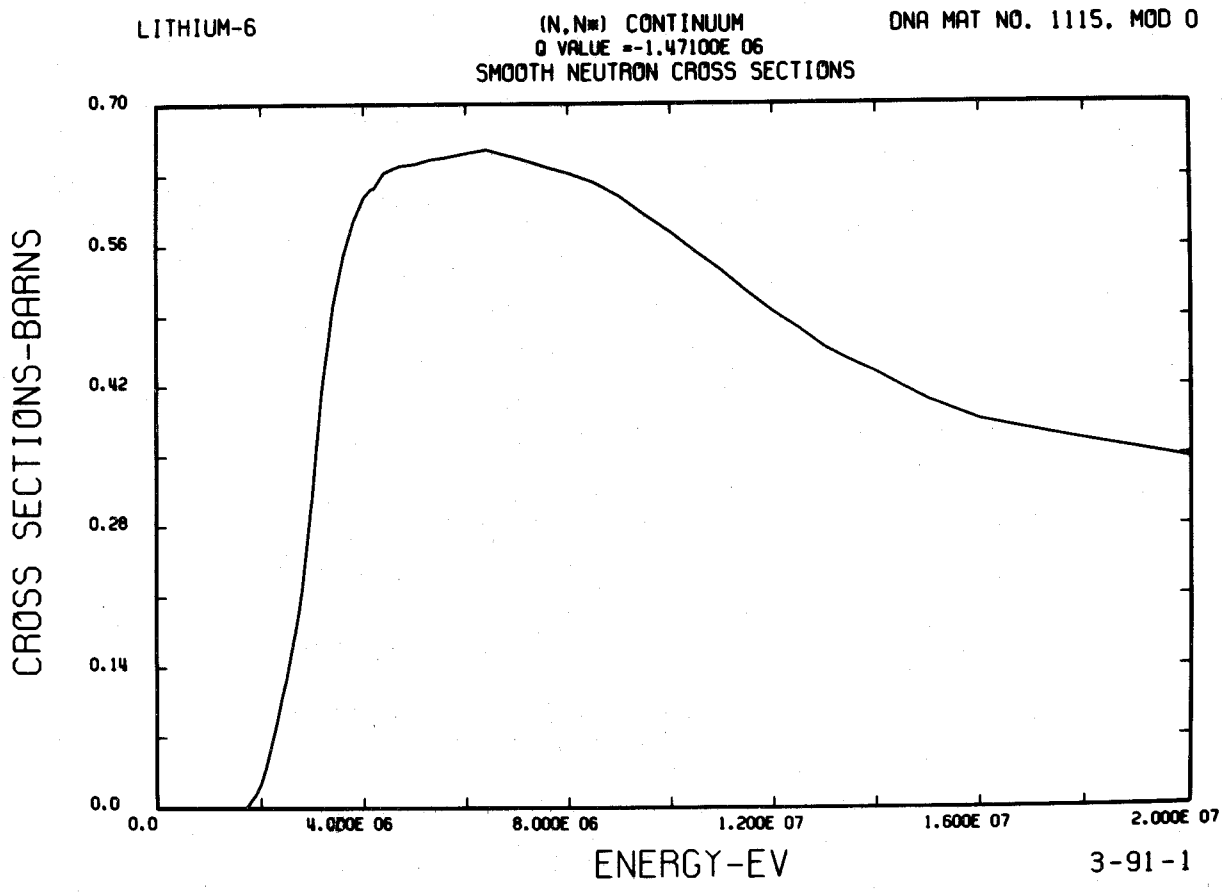


Fig. 13. $^{6}Li(n,n^{*})$ continuum.

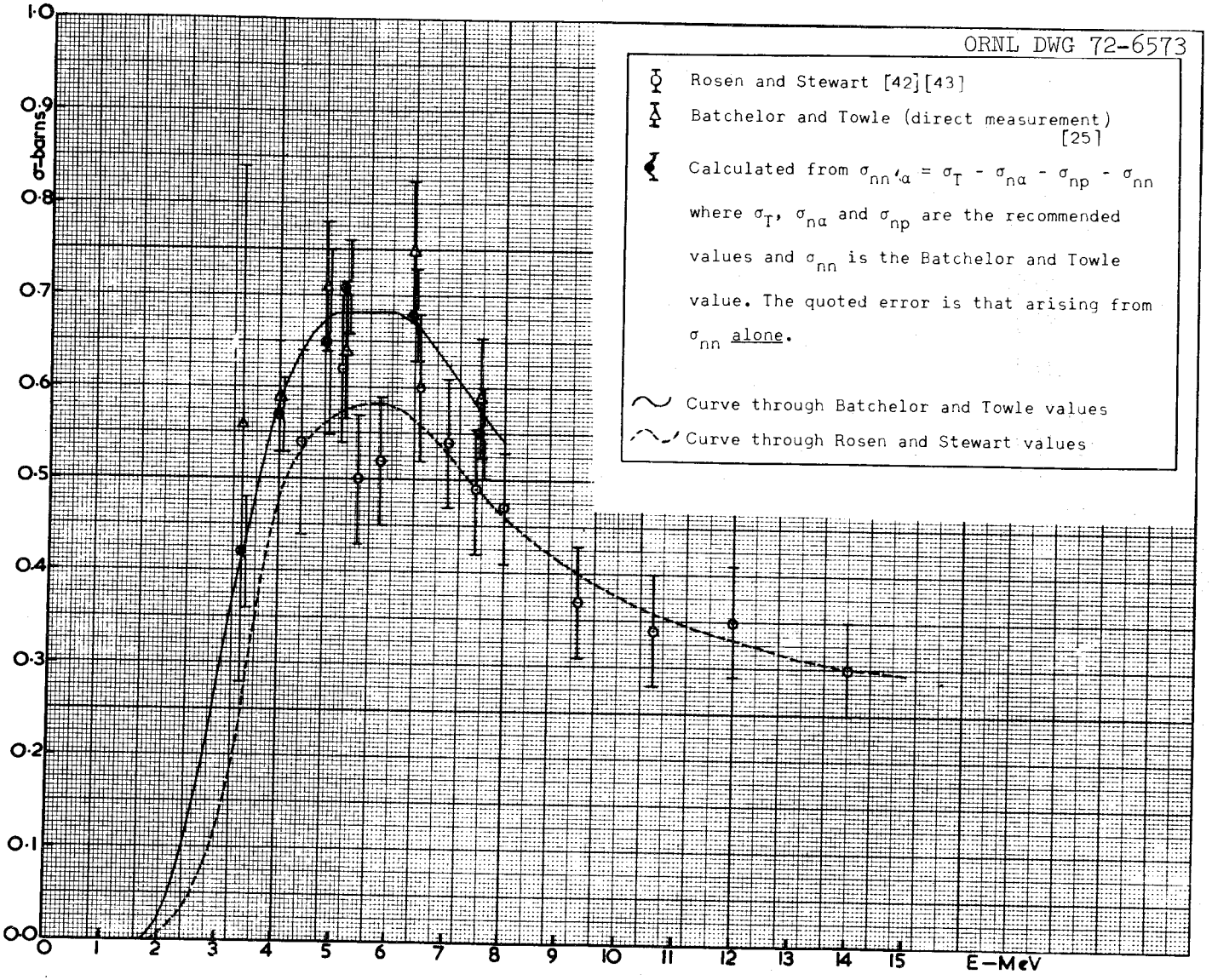


Fig. 14. Experimental values for the $^6Li(n,n')\alpha d$ cross section ($\sigma_{nn'\alpha}$).

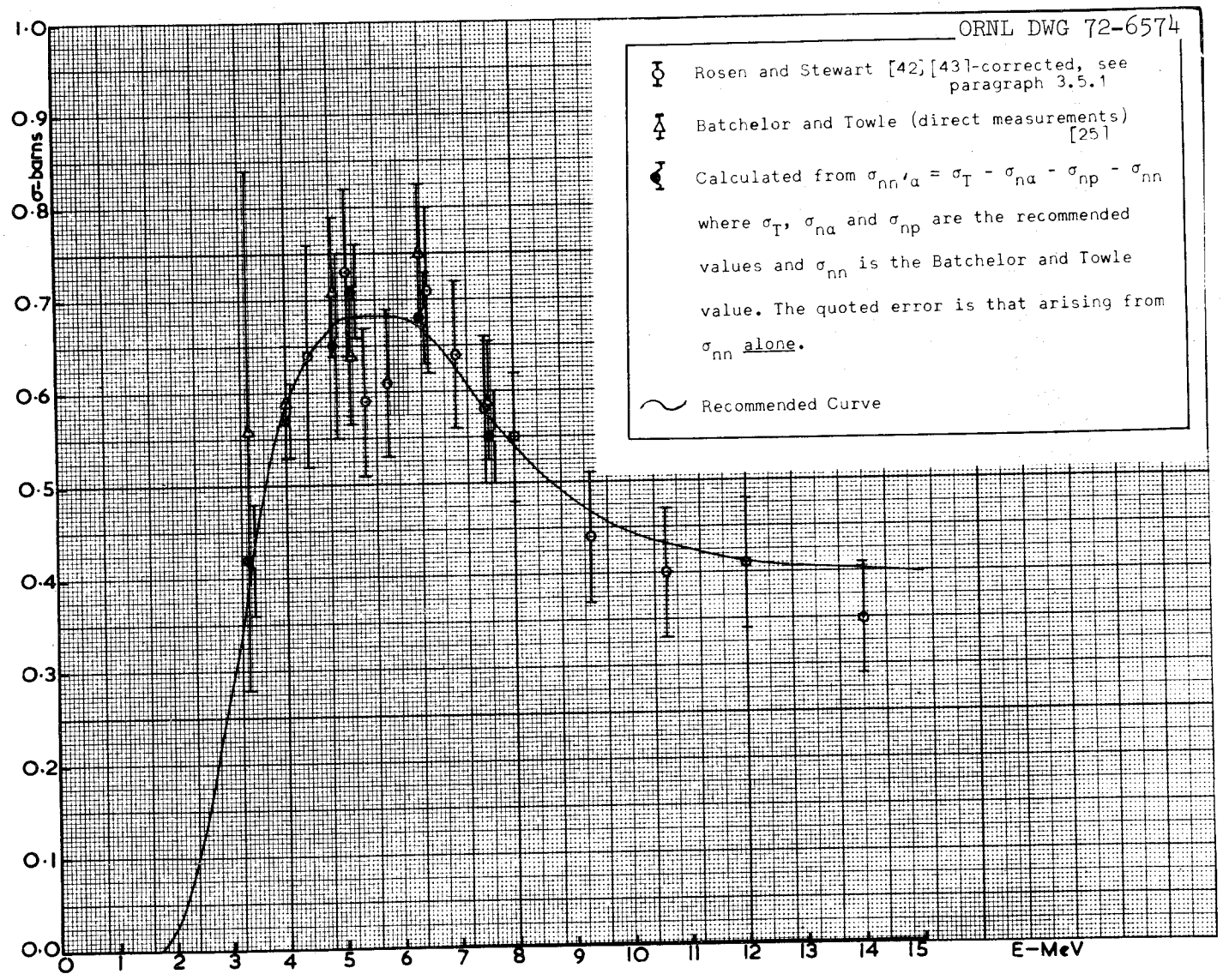


Fig. 15. $^{6}Li(n,n')\alpha d$ cross section ($\sigma_{nn'\alpha}$) in the energy range below 15 MeV.

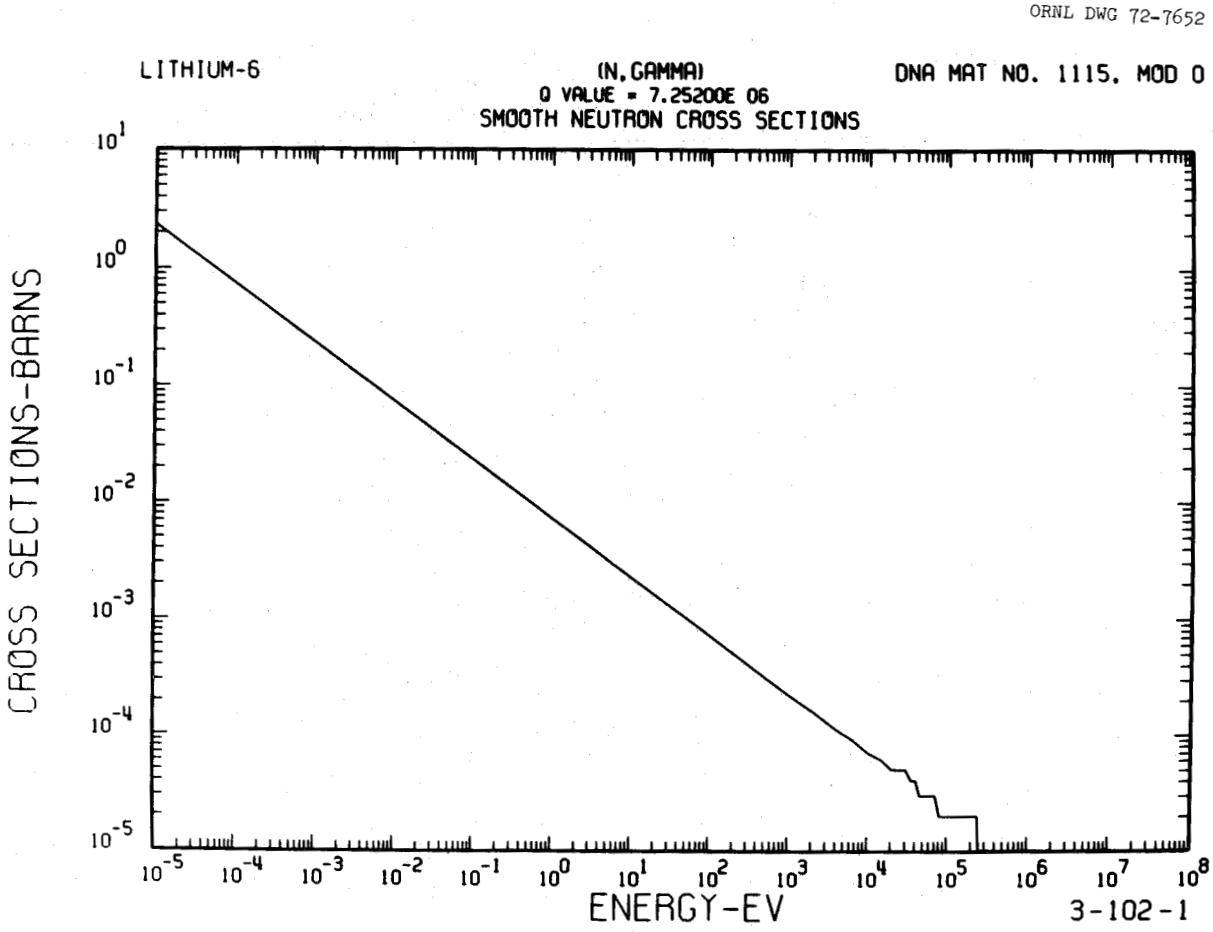


Fig. 16. ^{6}Li(n,gamma).

ORNL DWG 72-7653

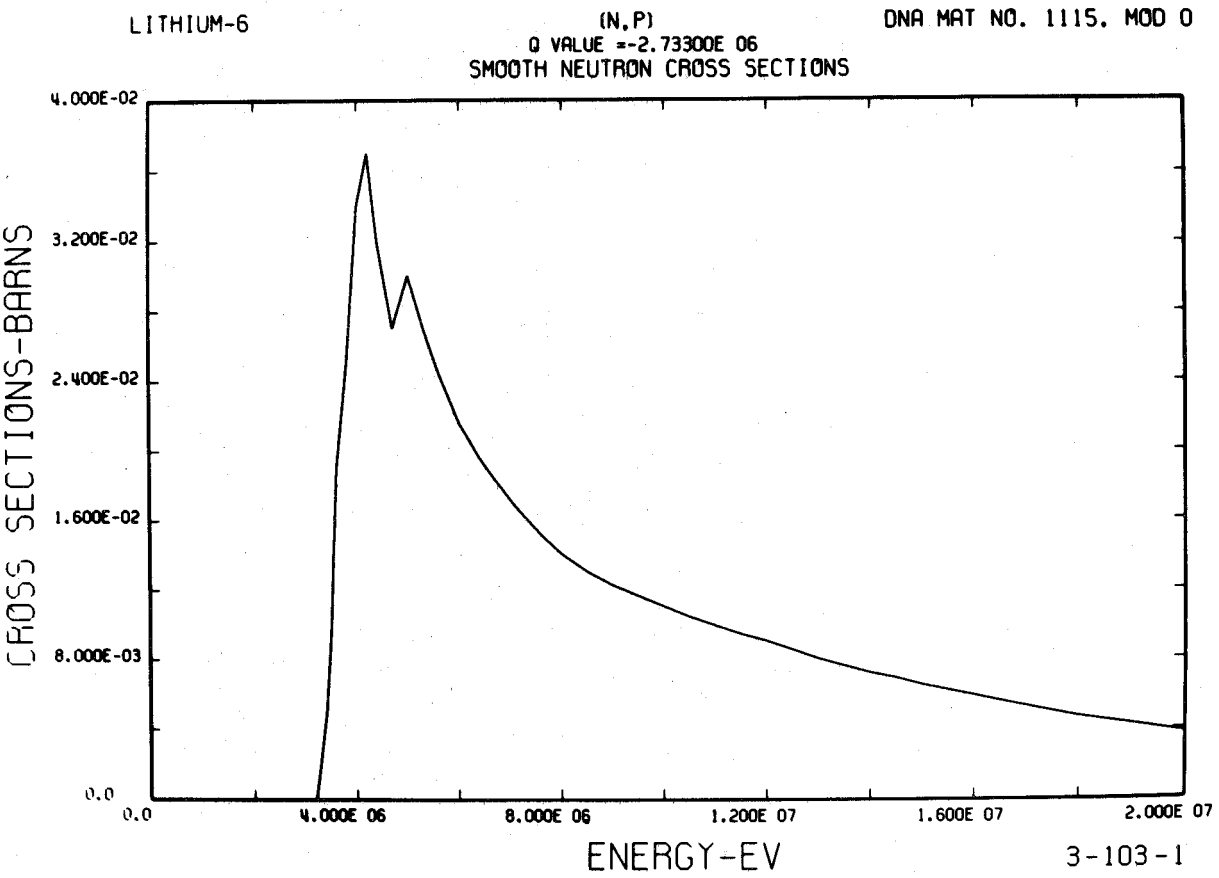


Fig. 17. $^{6}Li(n,p)$.

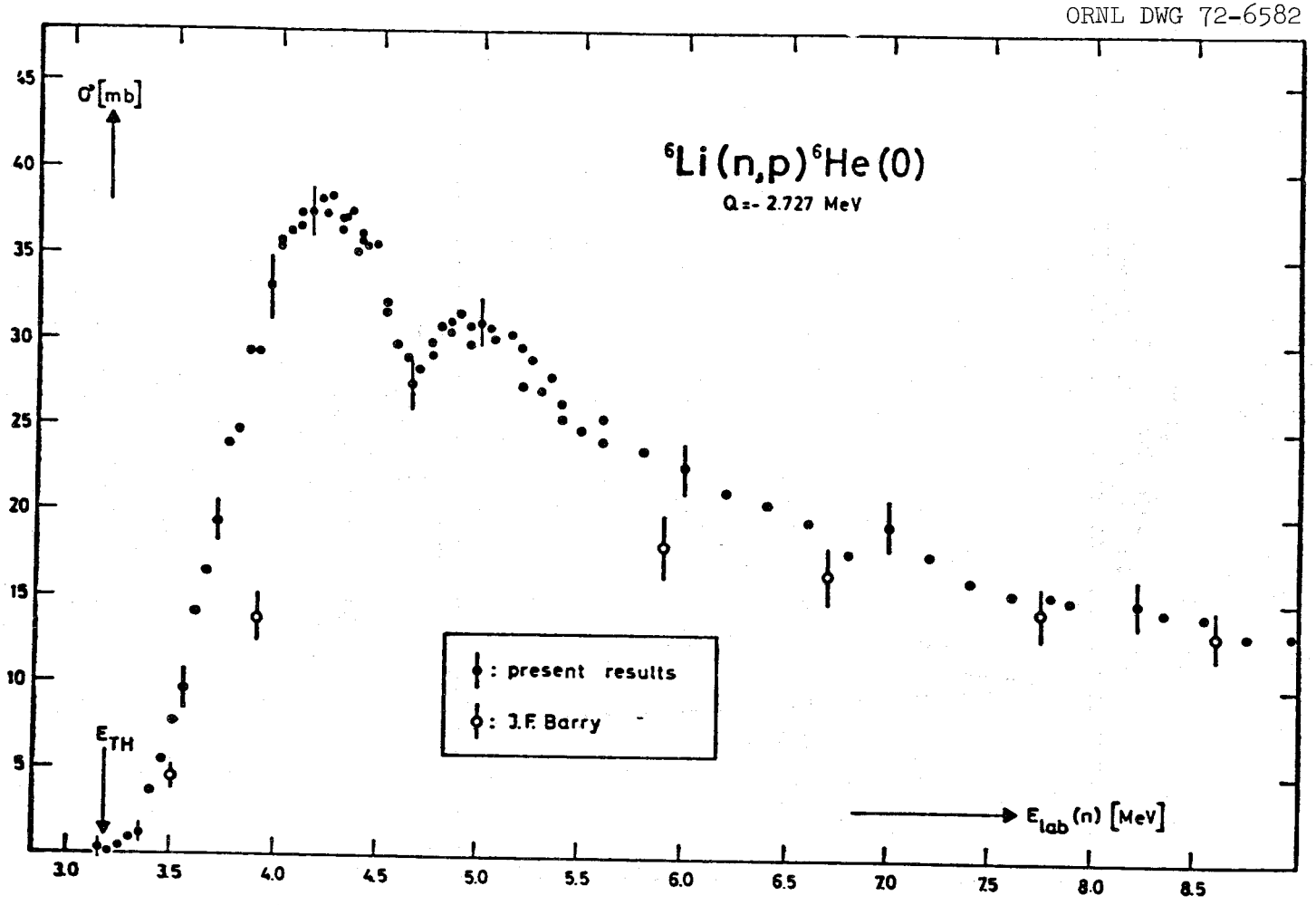


Fig. 18. Excitation function of the reaction ^{6}Li(n,p)^{6}He(0).

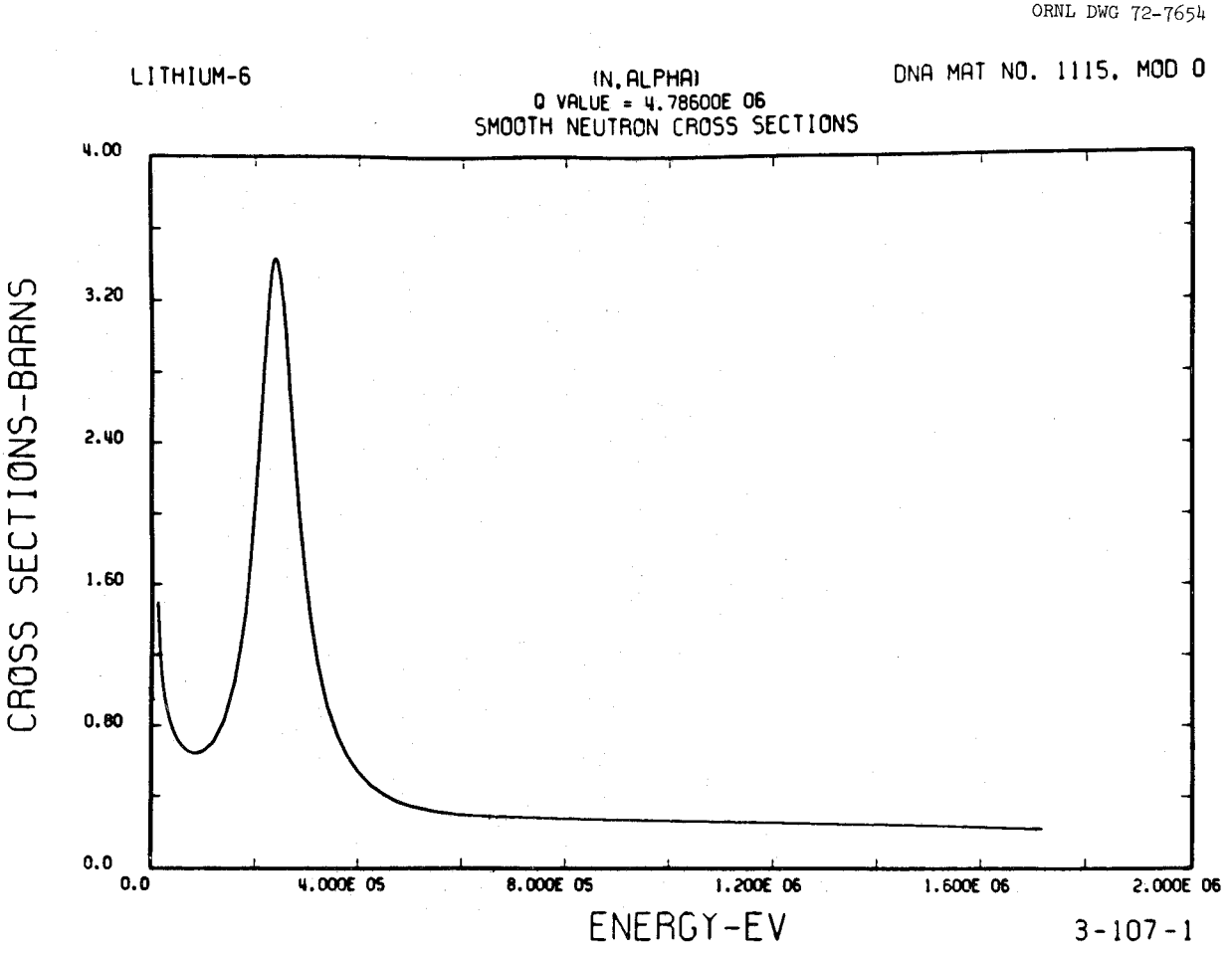


Fig. 19. ^{6}Li(n,alpha).

ORNL DWG 72-6571

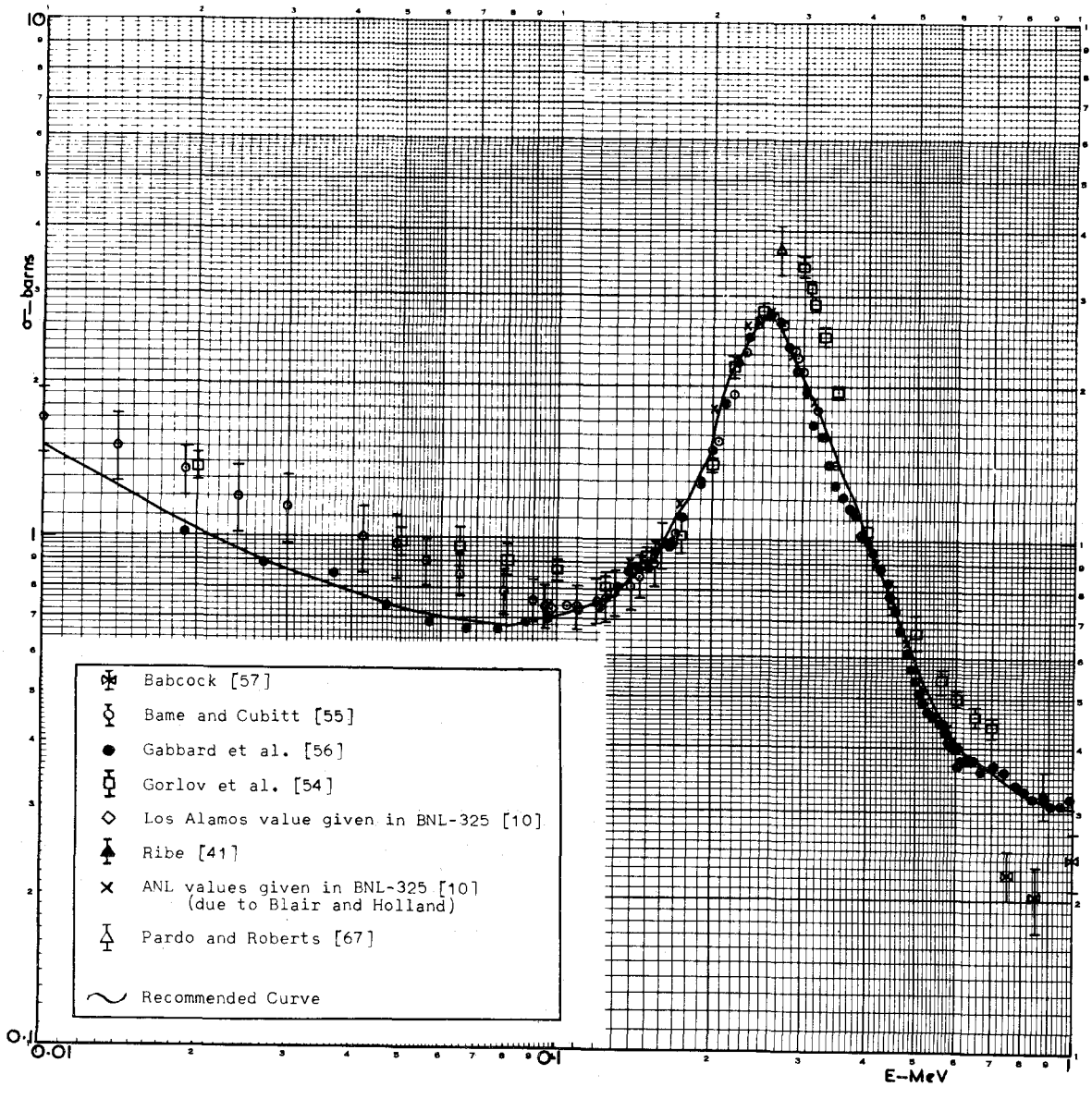


Fig. 20. $^{6}Li(n,\alpha)t$ cross section ($\sigma_{n\alpha}$) in the energy range 0.01 - 1.0 MeV.

ORNL DWG 72-6590

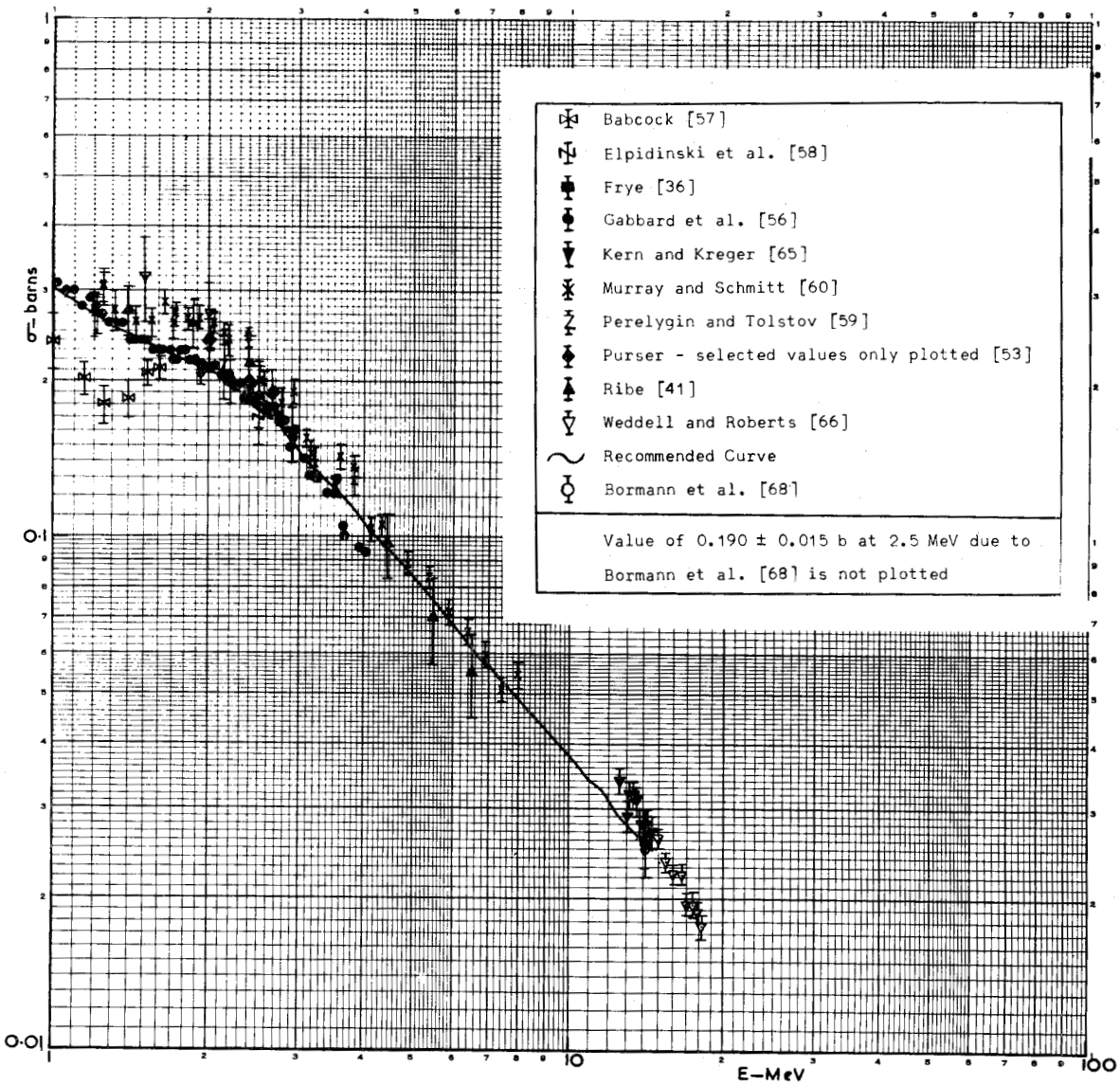


Fig. 21. $^{6}Li(n,\alpha)t$ cross section ($\sigma_{n\alpha}$) in the energy range 1.0 - 15.0 MeV.

ORNL DWG 72-6584

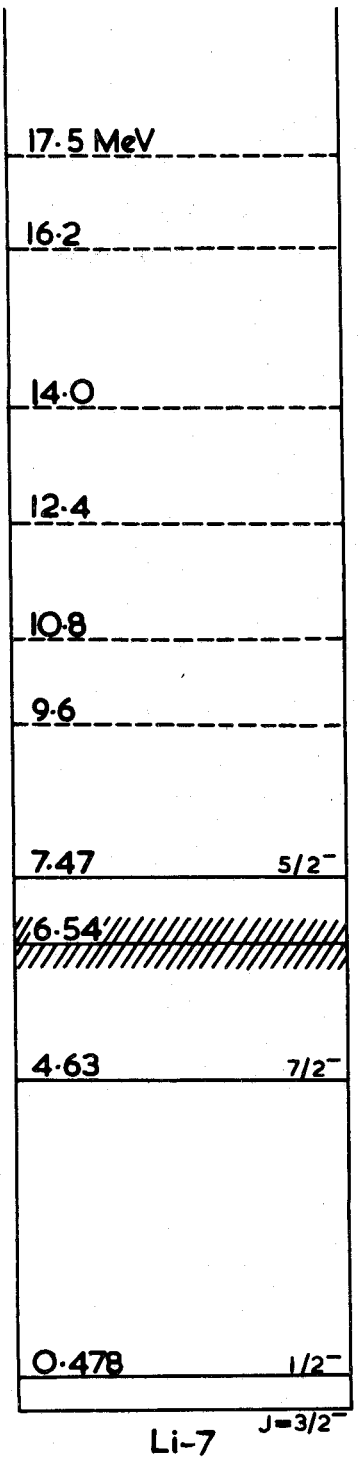


Fig. 22. Energy levels of ^{7}Li.

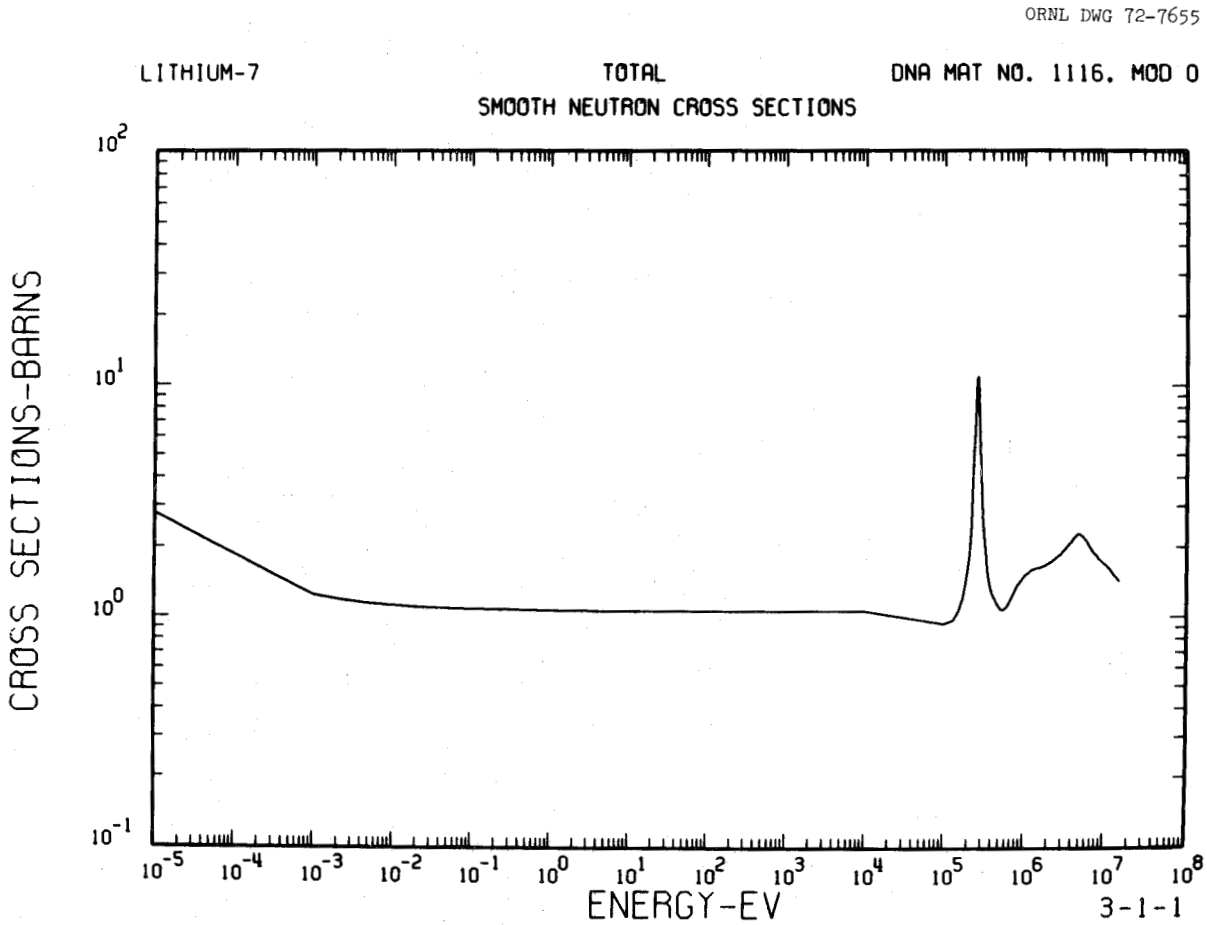


Fig. 23. Total cross section, ^{7}Li.

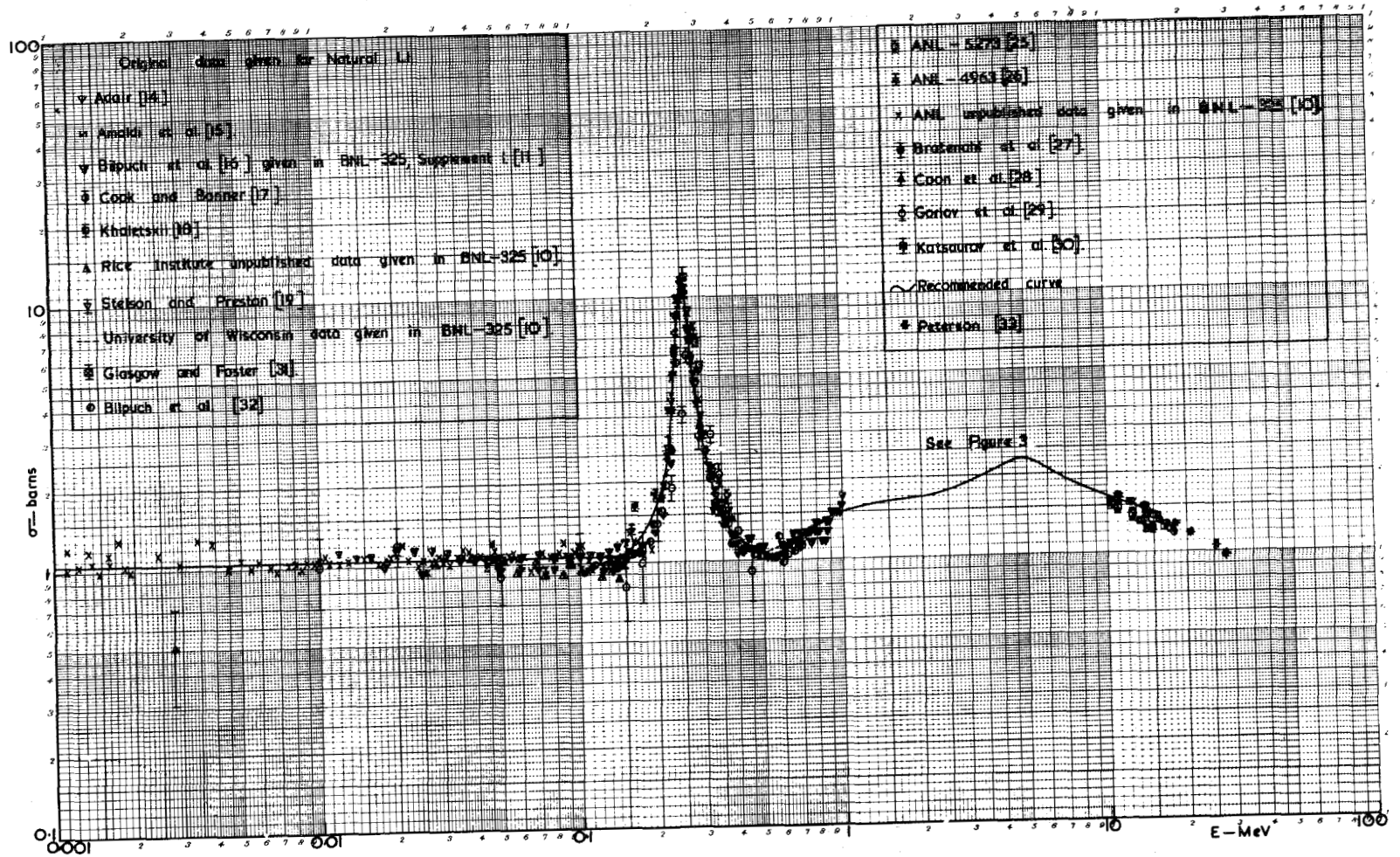


Fig. 24. Total cross section of ^{7}Li in the energy range 1 keV - 28 MeV.

ORNL DWG 72-6588

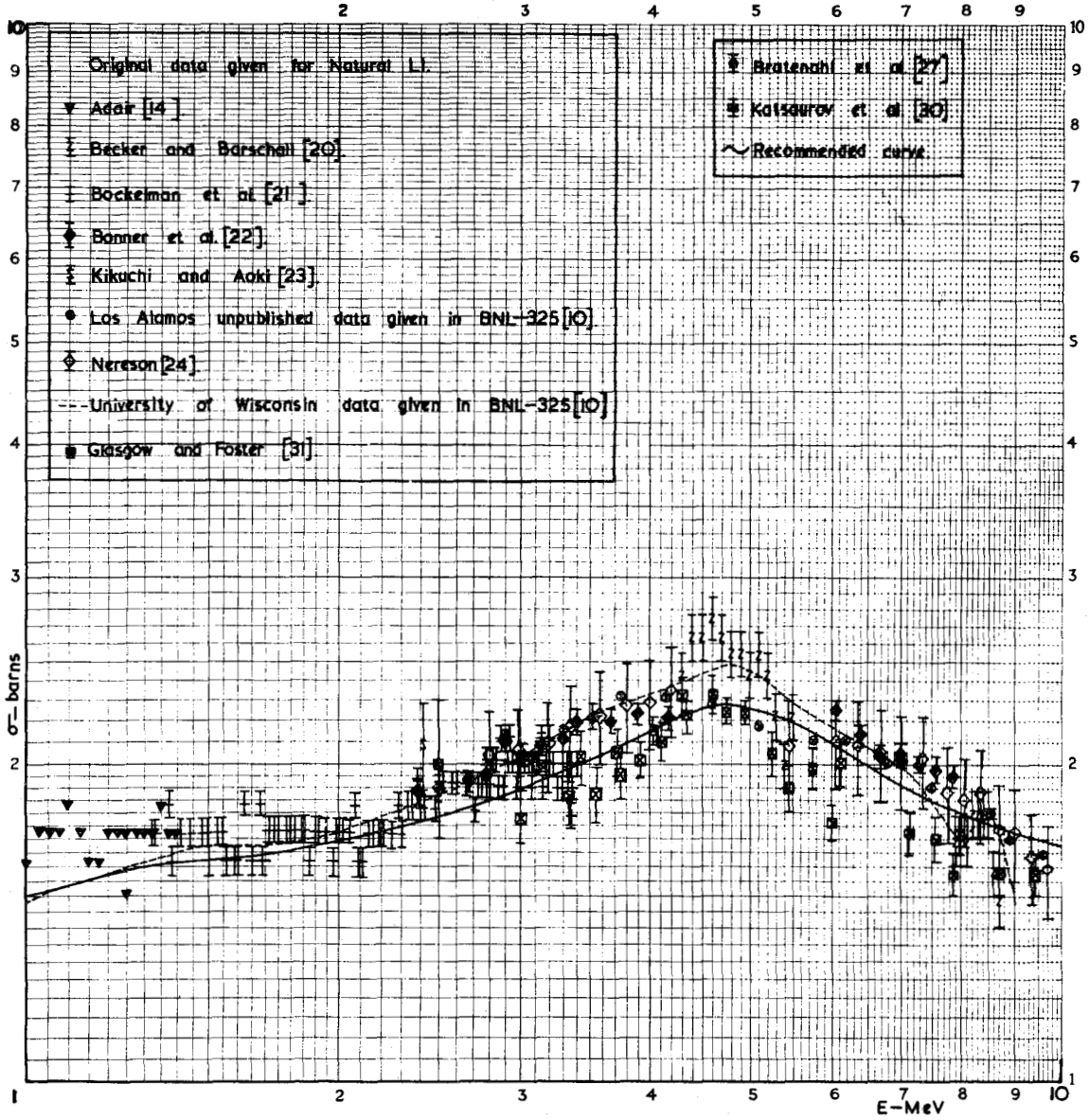


Fig. 25. Total cross section of ^{7}Li in the energy range 1 MeV - 10 MeV.

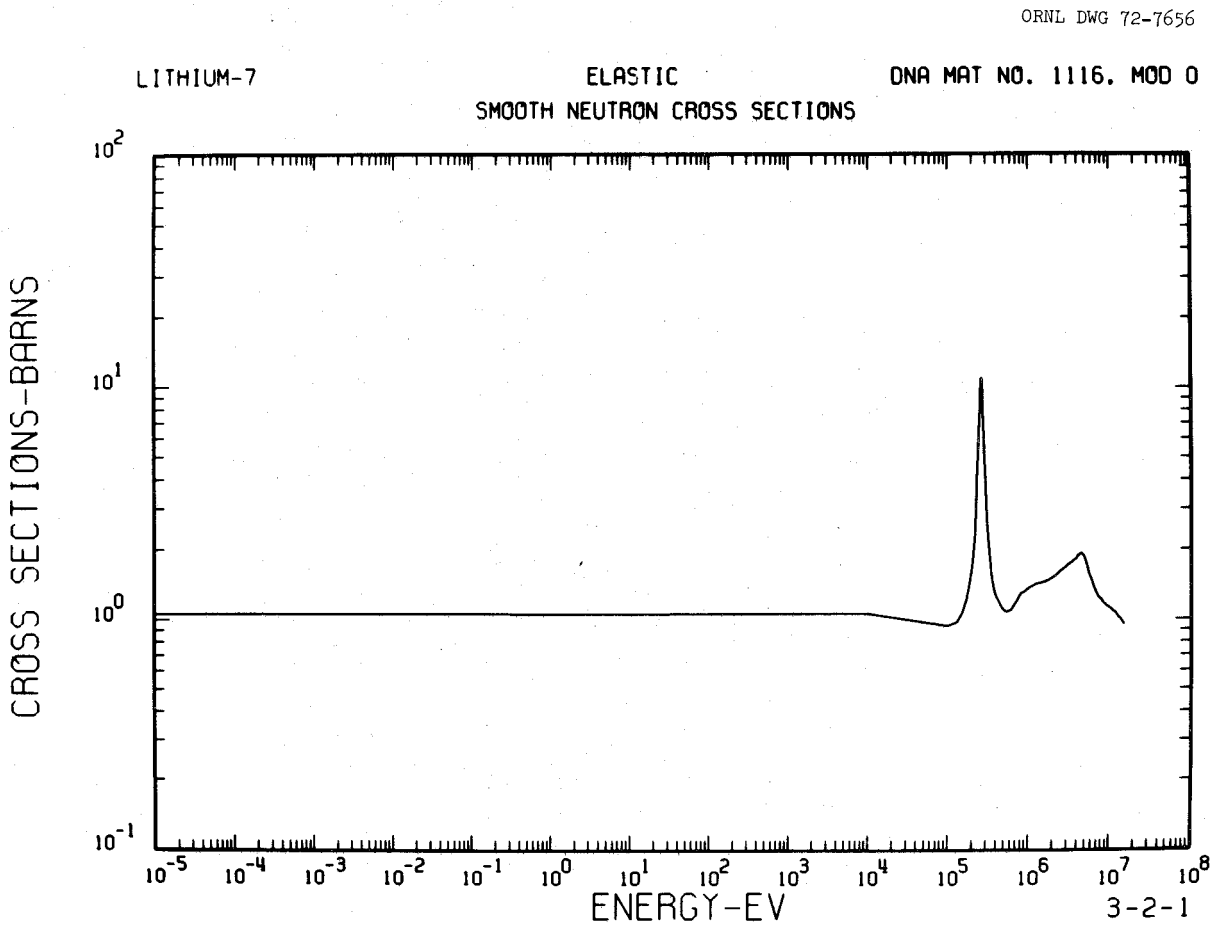


Fig. 26. Elastic cross section for ^{7}Li.

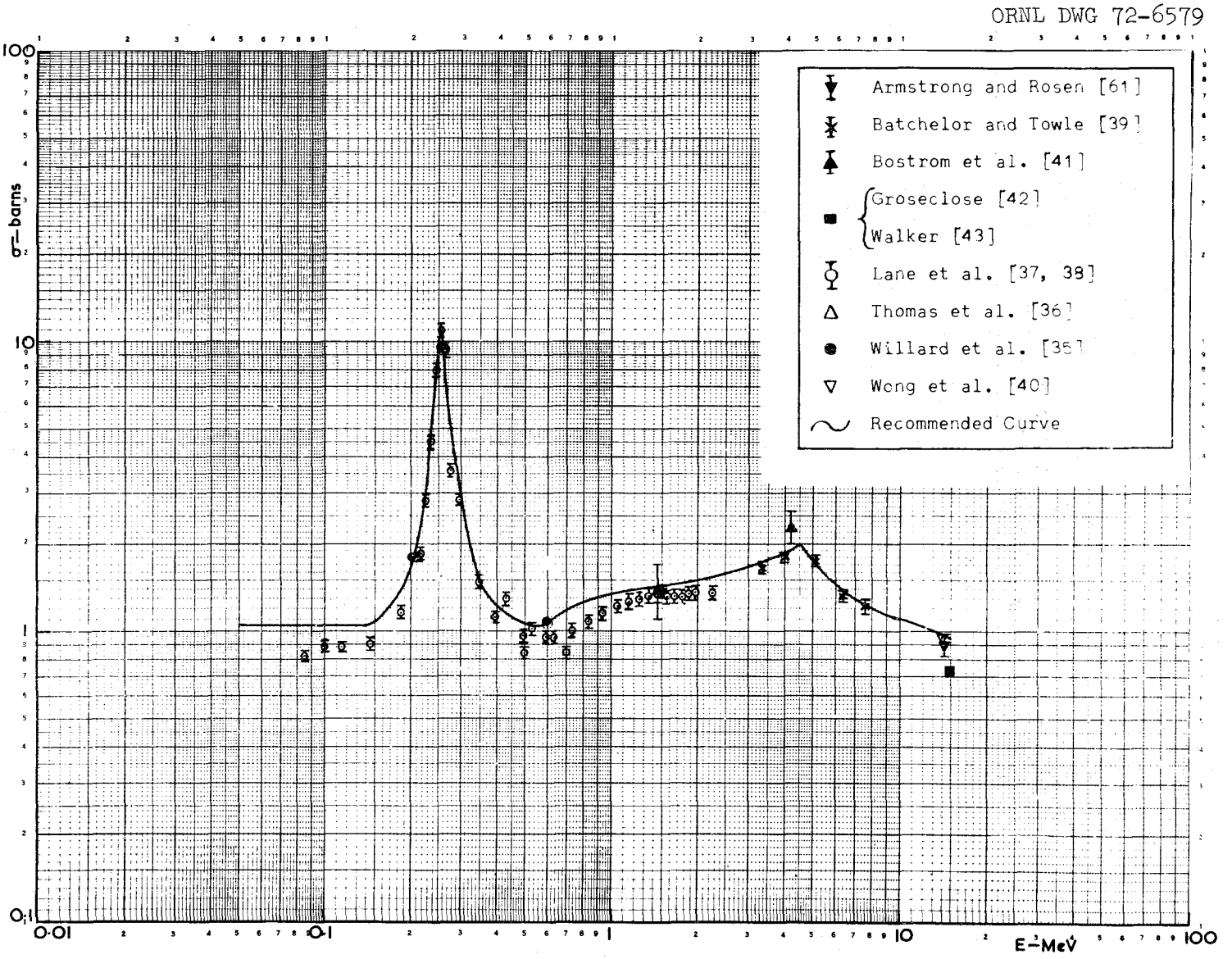


Fig. 27. Elastic cross section for ^{7}Li in the energy range 0.05 - 15 Mev.

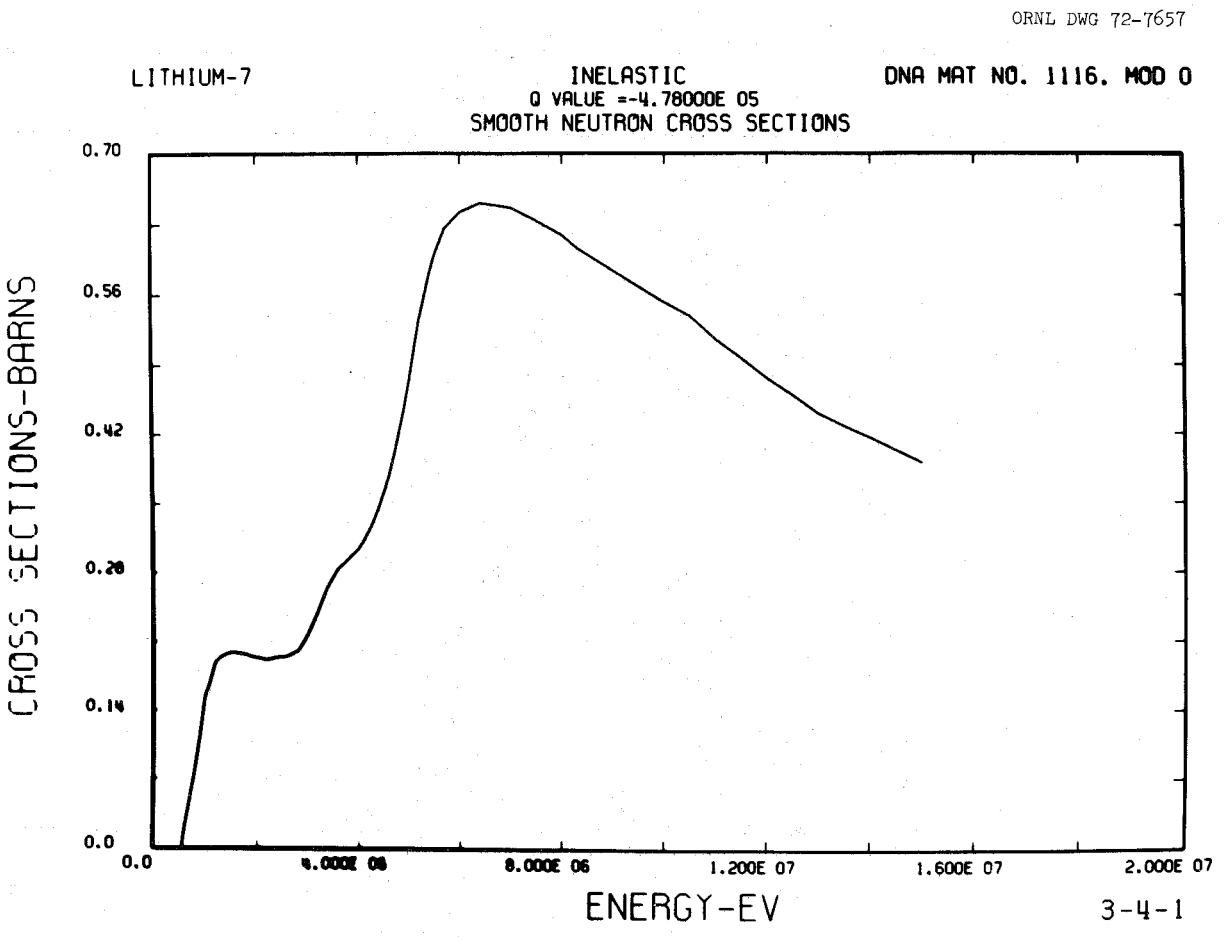


Fig. 28. Inelastic cross section of ^{7}Li.

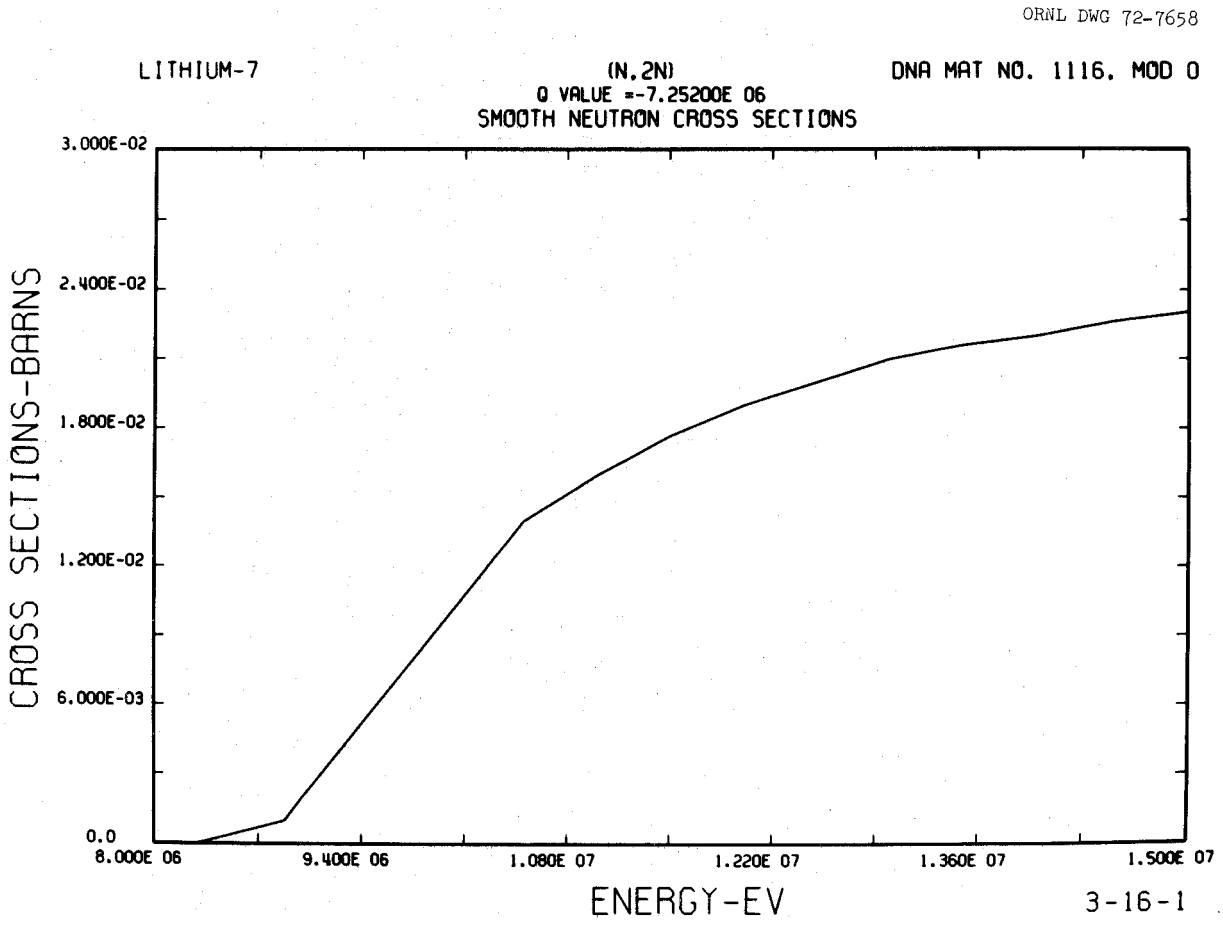


Fig. 29. $^{7}Li(n,2n)$.

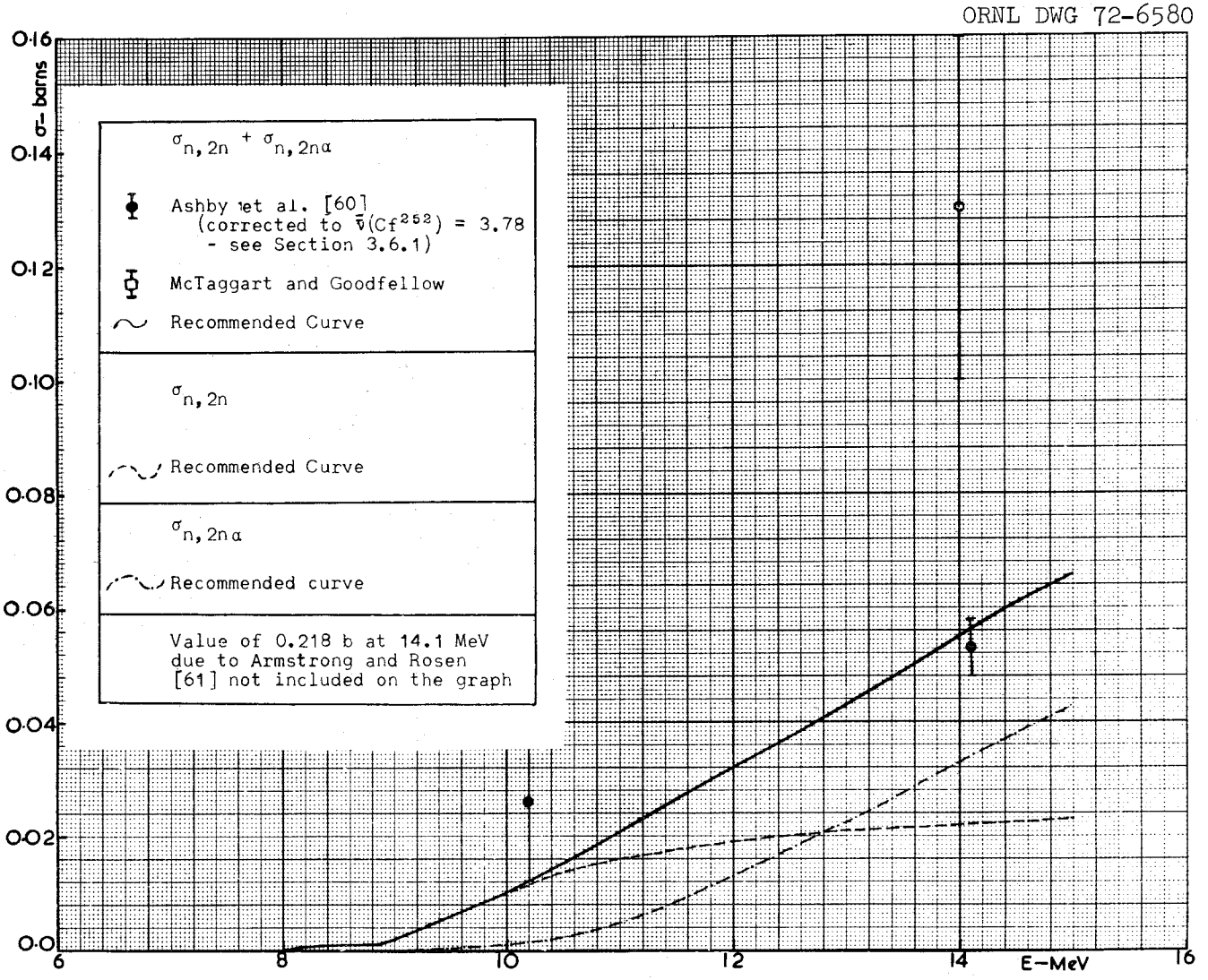


Fig. 30. $^{7}Li(n,2n)^{6}Li$ and $^{7}Li(n,2n)\alpha d$ cross sections in the energy range below 15 MeV.

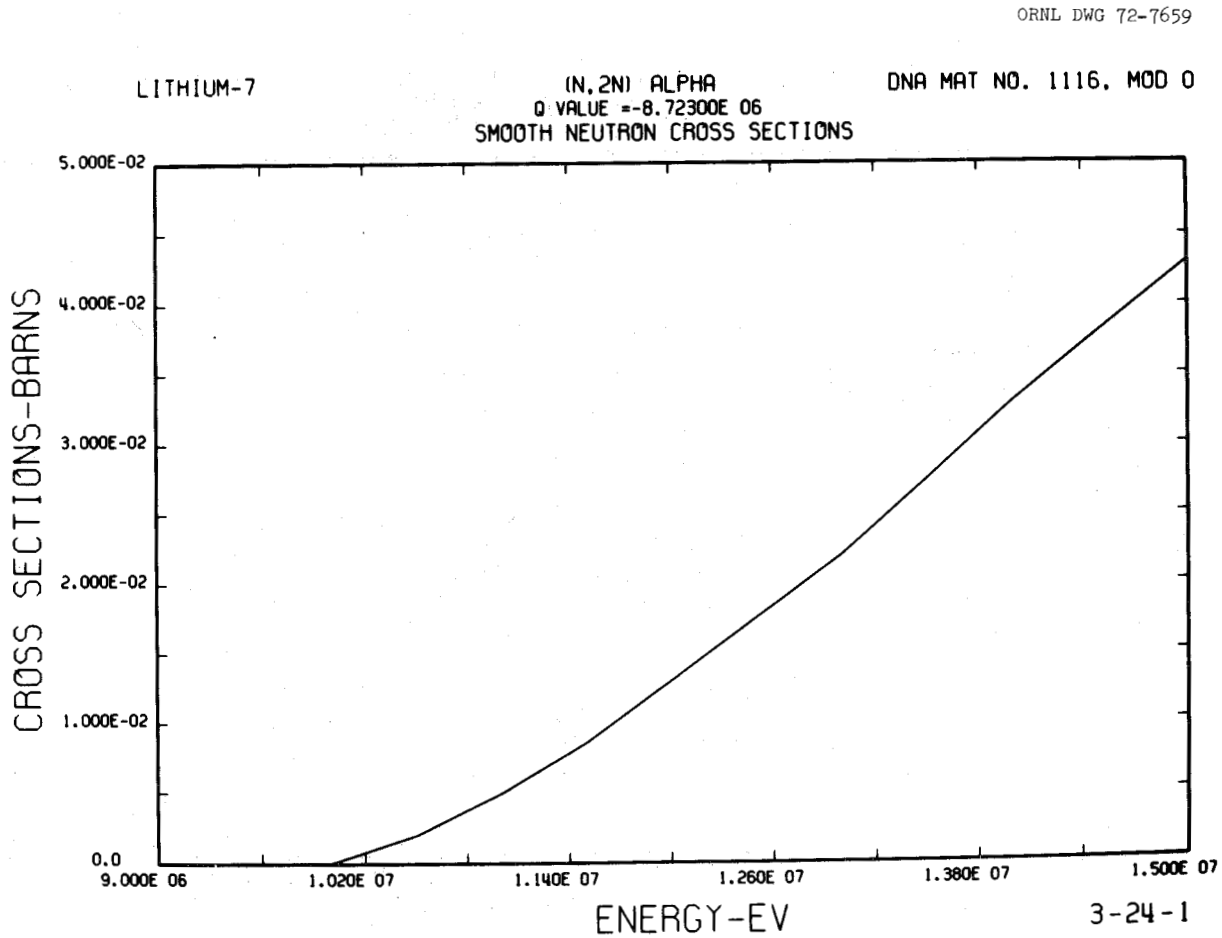


Fig. 31. $^{7}Li(n,2n)$ alpha.

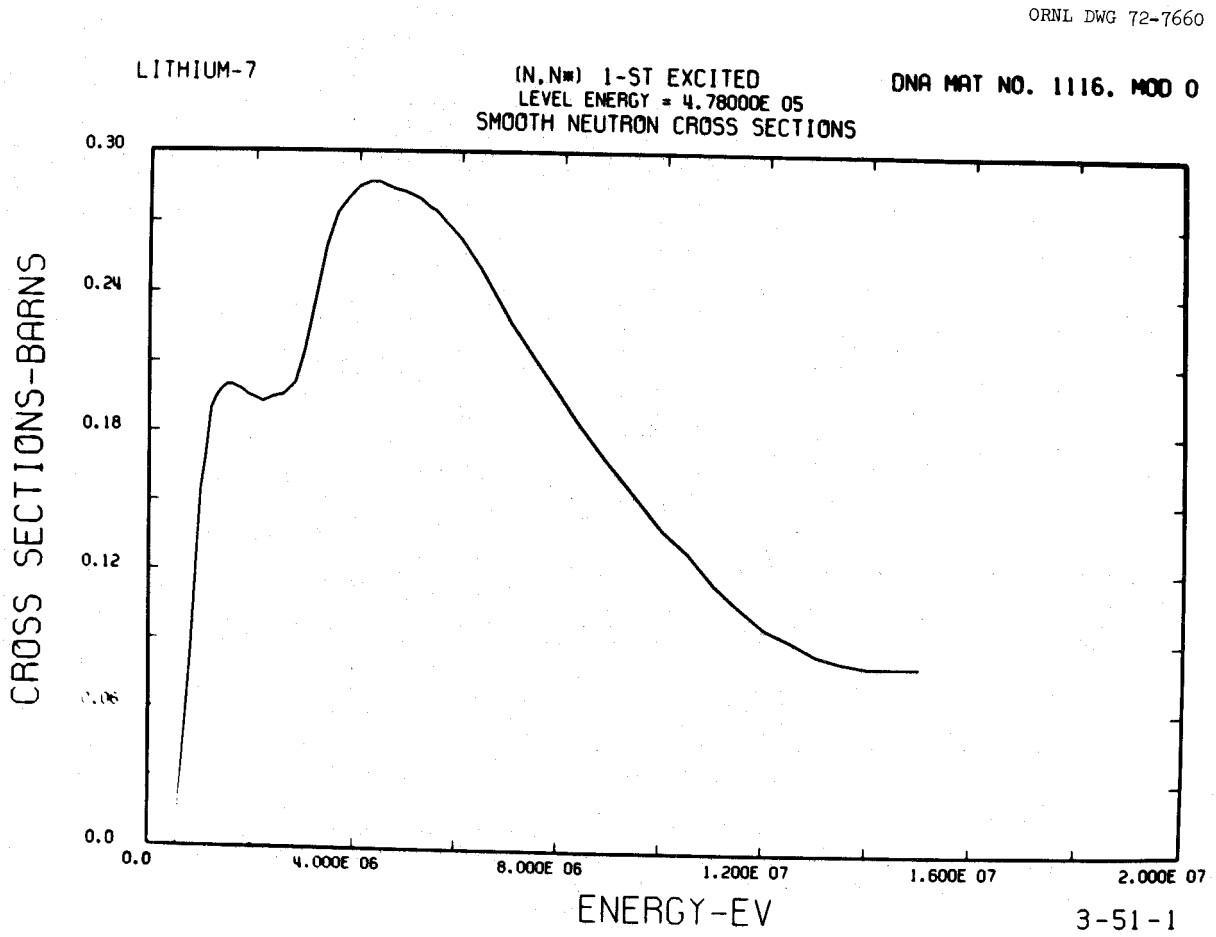


Fig. 32. $^{7}Li(n,n^{*})$ 1-st excited state.

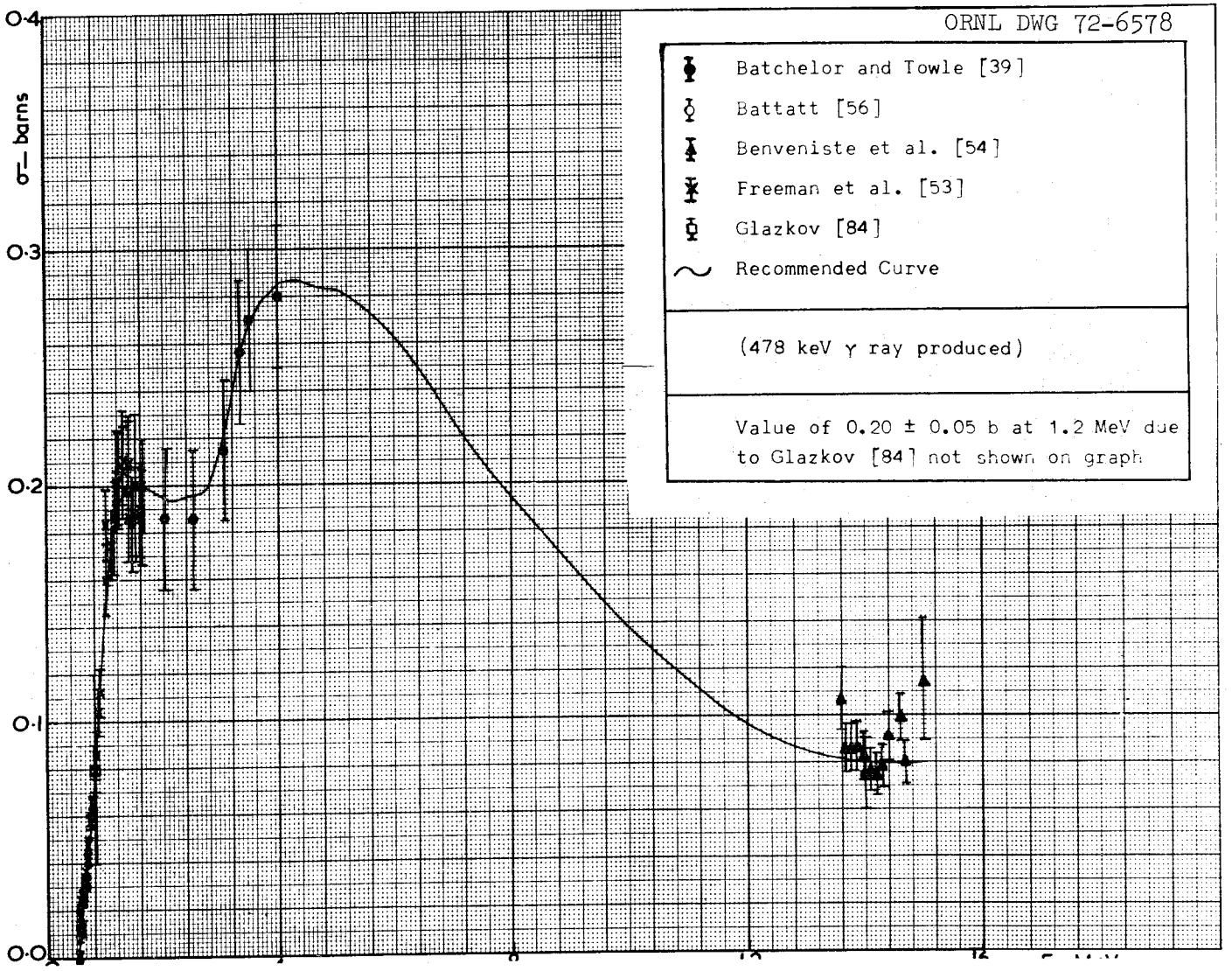


Fig. 33. $^{7}Li(n,n')^{7}Li^{*}(\gamma)^{7}Li$ gs cross section in the energy range below 15 MeV.

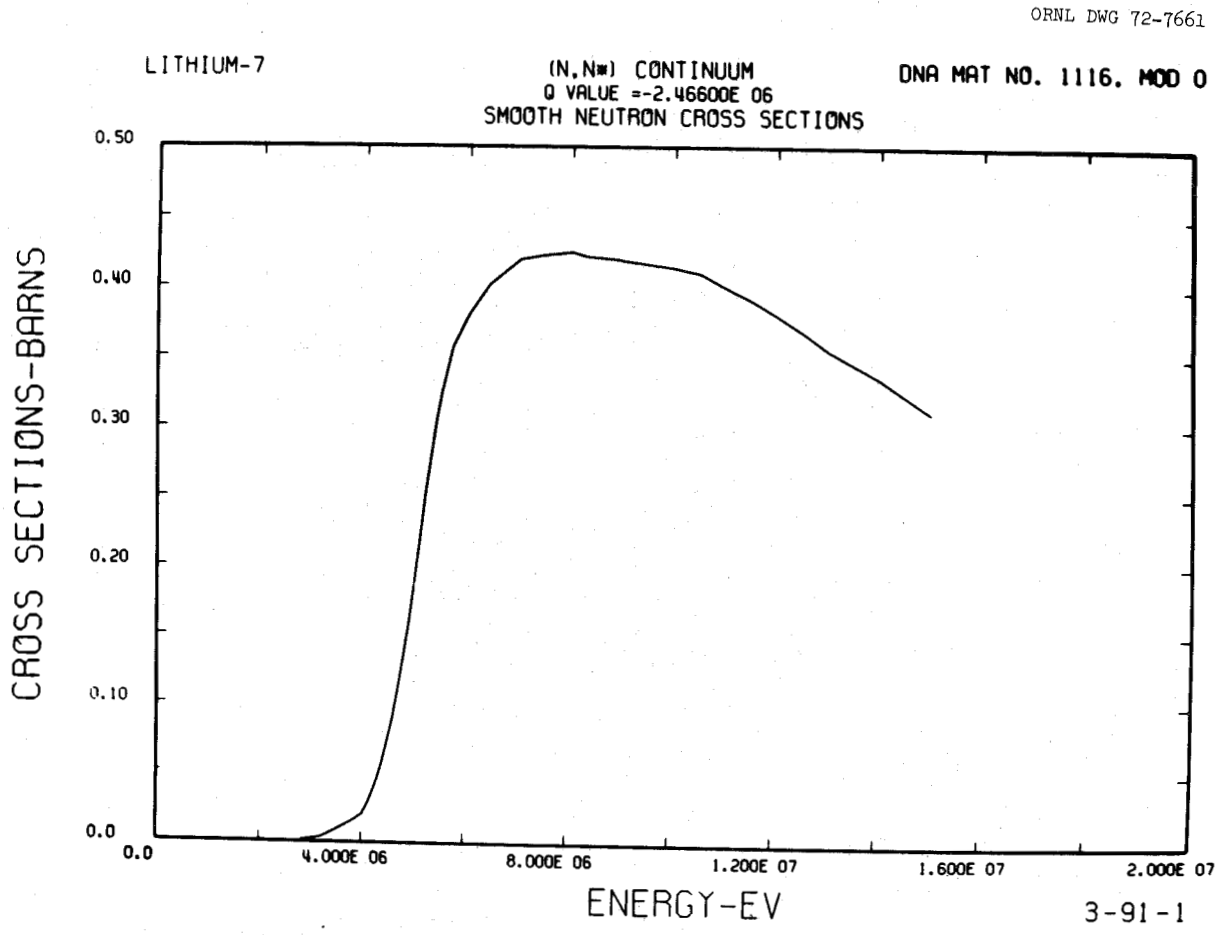


Fig. 34. $^{7}Li(n,n^{*})$ continuum.

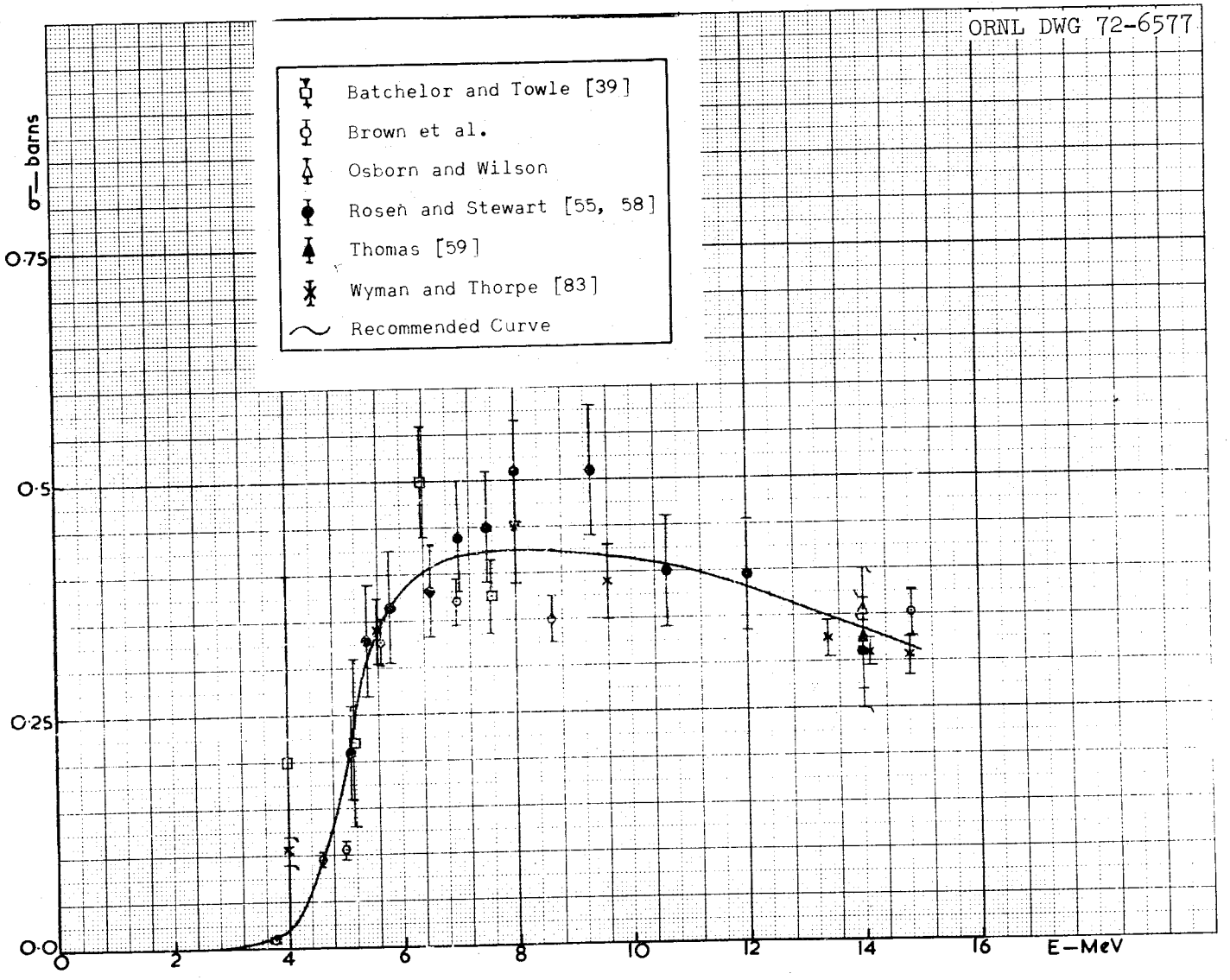


Fig. 35. $^{7}Li(n,n'\alpha)t$ cross section in the energy range below 15 MeV.

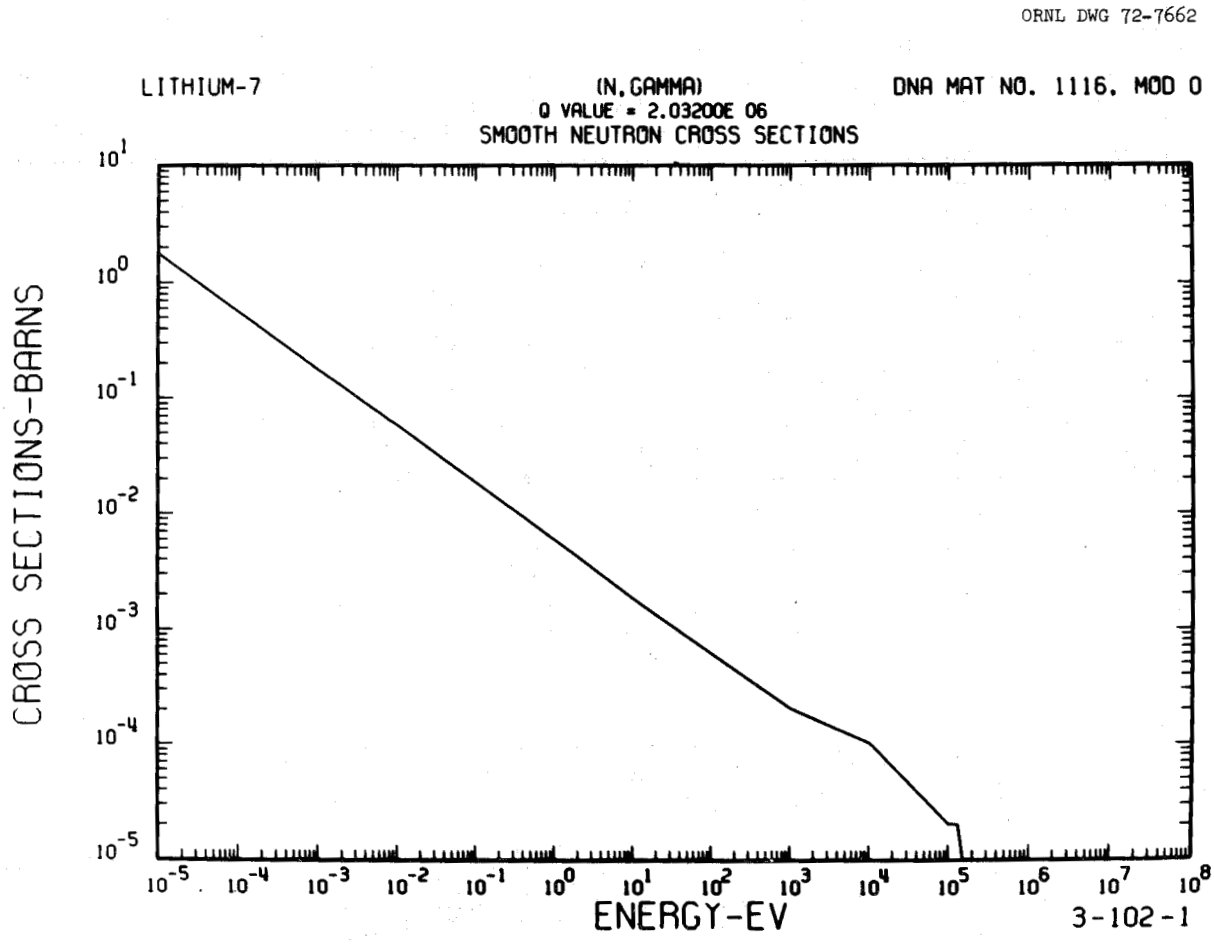


Fig. 36. ^{7}Li(n,gamma).

ORNL DWG 72-7663

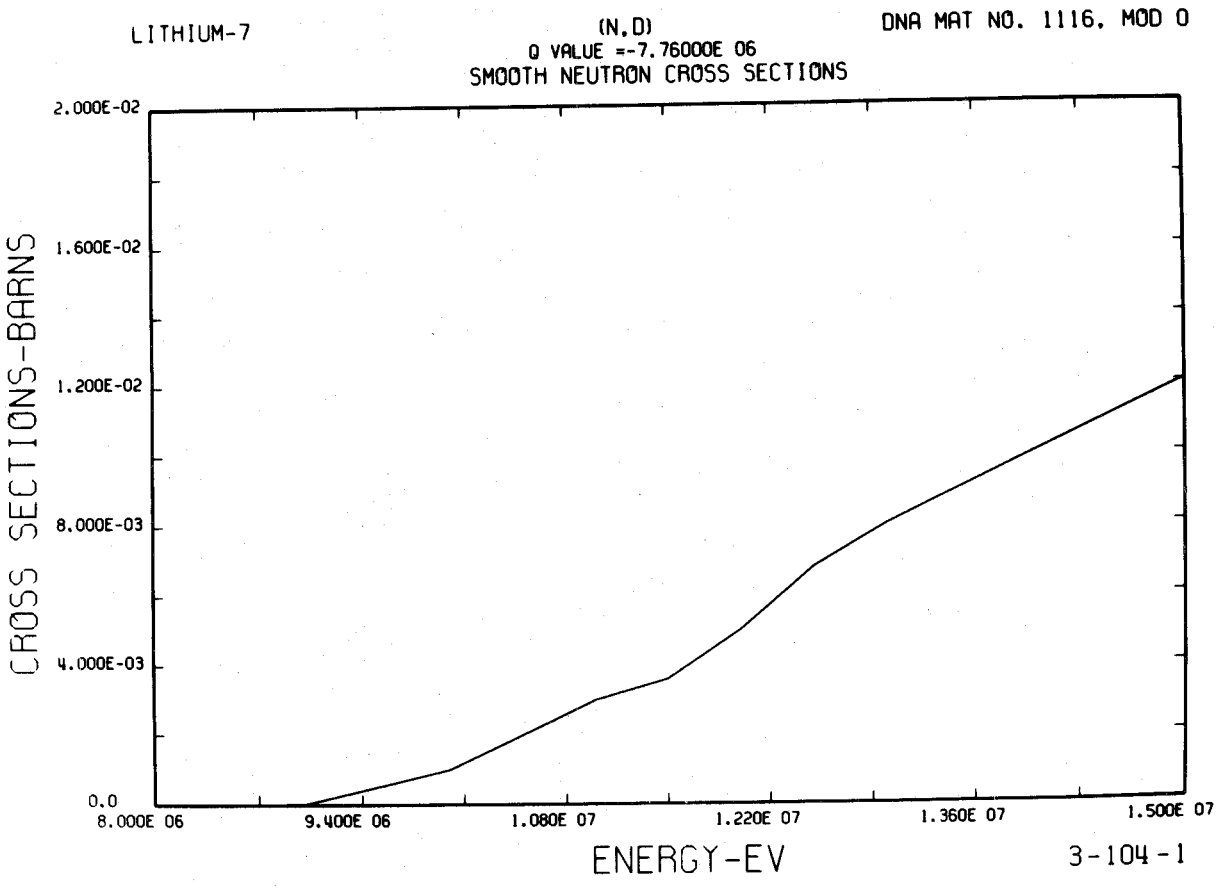


Fig. 37. $^{7}Li(n,d)$.

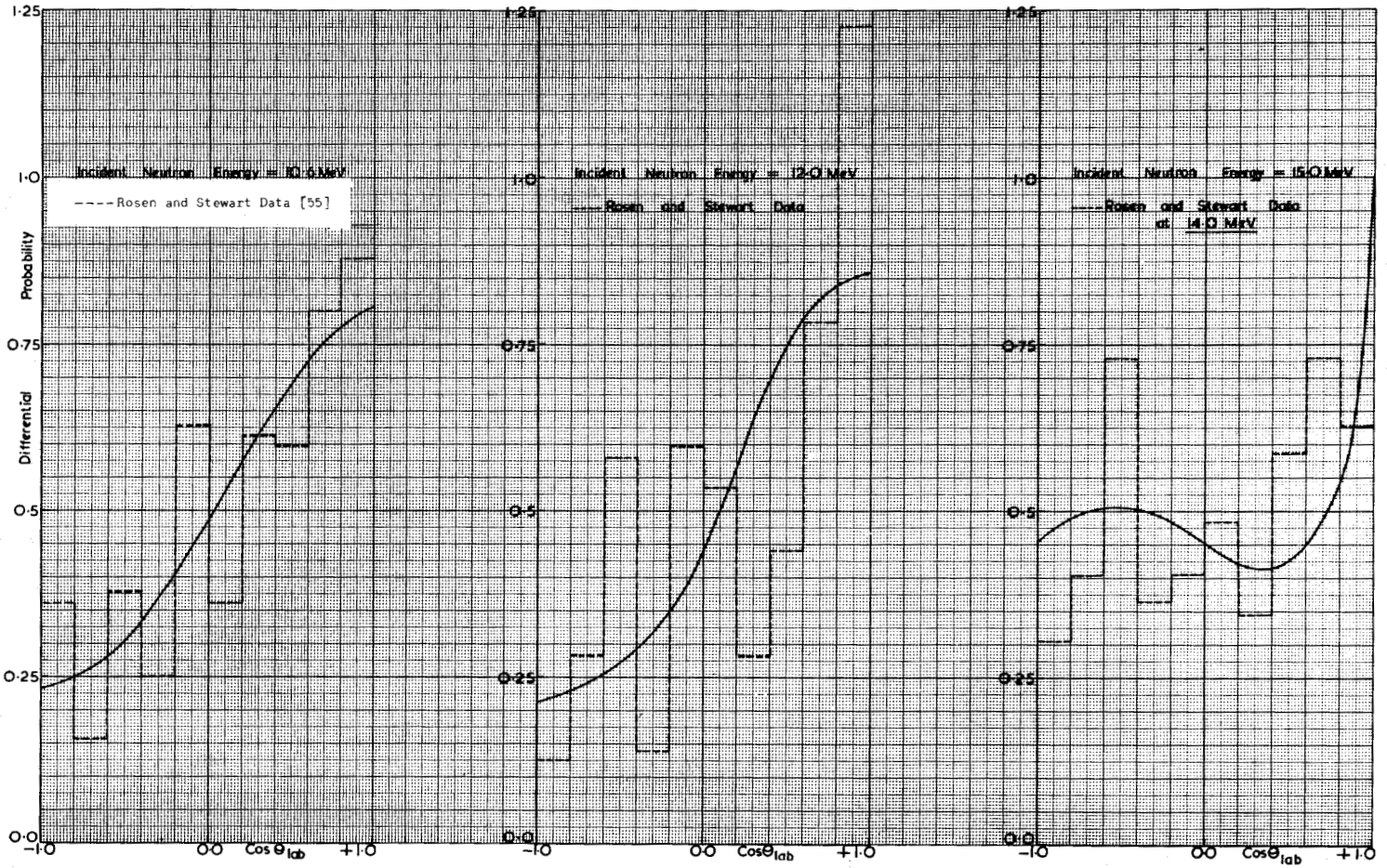


Fig. 38. Some angular distributions of the secondary neutrons from the $^{7}Li(n,n')\alpha t$ reaction (10.6 MeV $\leq$ E $\leq$ 15.0 MeV).

ORNL-TM-3859

Internal Distribution

1. R. G. Alsmiller
2. H. F. Bauman
3. S. E. Beall
4. L. L. Bennett
5. W. B. Cottrell
6. G. W. Cunningham
7. J. G. Delene
8. J. R. Engel
9. T. B. Fowler
10. A. P. Fraas
11. H. W. Hoffman
12. J. D. Jenkins
13. H. T. Kerr
14. J. T. Kriese
15. P. R. Kasten
16. M. I. Lundin
17. R. N. Lyon
18. R. E. MacPherson
19. H. C. McCurdy
20. J. R. McNally, Jr.
21. A. J. Miller
22. A. M. Perry
23. H. Postma
24. B. E. Prince
25. G. L. Ragan
26. M. W. Rosenthal
27. Myrtleen Sheldon
28. M. J. Skinner
29. O. L. Smith
30. I. Spiewak
31. D. Steiner
32. D. A. Sundberg
33-37. M. L. Tobias
38. D. R. Vondy
39. G. D. Whitman
40-41. Central Research Library
42. Y-12 Document Reference Section
43-45. Laboratory Records Department
46. Laboratory Records Department (RC)

External Distribution

47. Arnold Aronson, Reactor Physics Division, Brookhaven National Laboratory, Upton, New York 11973
48. S. Blow, Materials Physics Division, B. 521.1, AERE, Harwell, Didcot, Berks., United Kingdom
49. H. Brockmann, KFA - Juelich/IRE, D517 Juelich, Postfach, Germany
50. E. Linn Draper, Jr., Nuclear Reactor Laboratory, University of Texas, Austin, Texas 78712
51. Donald Dudziak, T-1B, Los Alamos Scientific Laboratory, P. O. Box 1663, Los Alamos, New Mexico 87544
52. J. Darvas, KFA-Juelich/IRE, D517 Juelich, Postfach, Germany
53. A. J. Impink, Jr., Mechanical Engineering Department, Carnegie-Mellon University, Pittsburgh, Pa. 15626
54. W. H. Kohler, INTERATOM, 506 Bensberg/Koln, Postfach, Germany.
55. G. P. Lahti, Shielding Section, Nuclear Systems Division, NASA Lewis Research Center, Cleveland, Ohio 44135
56. Guy Lavergne, C.R.E.N., University of Quebec, Quebec, Canada
57. J. D. Lee, Lawrence Radiation Laboratory, L-301, P. O. Box 808, Livermore, California 94550
58. B. R. Leonard, Jr., Battelle-Northwest, P. O. Box 999, Richland, Washington 99352
59. Charles Maynard, Engineering Research Building, University of Wisconsin, Madison, Wisconsin 53706
60. D. W. Muir, GRPT-2, Los Alamos Scientific Laboratory, P. O. Box 1663, Los Alamos, New Mexico 87544
61. Sol Pearlstein, National Neutron Cross Section Center, Brookhaven National Laboratory, Upton, New York 11973

62. P. J. Persiani, Applied Physics Division, Argonne National Laboratory, 9700 Cass Avenue, Argonne, Ill. 60439
63. D. L. Prezbindowski, Analytical Physics, Pacific Northwest Laboratories, Richland, Washington 99352
64. A. Edward Profio, Associate Professor, Dept. of Chemical and Nuclear Engineering, University of California, Santa Barbara, California 93106
65. F. L. Ribe, Los Alamos Scientific Laboratory, P. O. Box 1663, P-15, Los Alamos, New Mexico 87544
66. J. L. Russell, Jr., Gulf General Atomic, P. O. Box 608, San Diego, California 92112
67-71. Director, Controlled Thermonuclear Research Division, U. S. Atomic Energy Commission, Washington, D. C. 20545
72-74. Director, Division of Reactor Licensing, U. S. Atomic Energy Commission, Washington, D. C. 20545
75-76. Director, Division of Reactor Standards, U. S. Atomic Energy Commission, Washington, D. C. 20545
77-93. Manager, TIC, Oak Ridge (17) for distribution to Members of ACRS Committee
94. Research and Technical Support Division, ORO
95-96. Technical Information Center, AEC, Oak Ridge, Tenn.