INDC(NDS)-61/W +
special

Papers presented

at the

Consultants' Meeting on Charged Particle and Photonuclear Reaction Data

Vienna, 24-26 April 1974

and at the

Specialists' Meeting on Nuclear Data for Applications

Vienna, 29 April - 3 May 1974

Edited by

A. Calamand and A. Lorenz

Nuclear Data Section
IAEA

Vienna, July 1974

Contents

Foreword

A Consultants' Meeting on Charged Particle and Photonuclear Reaction Data and a Specialists' Meeting on Nuclear Data for Applications by the IAEA Nuclear Data Section were convened in Vienna, from 24 to 26 April and from 29 April to 3 May 1974 respectively, upon the recommendation of the International Nuclear Data Committee.

This report includes documents presented at the two meetings as well as statements made by the participants in the Specialists' Meeting concerning their home programme.

The summary reports of the two meetings, including their conclusions and recommendations, are published separately as INDC reports (INDC(NDS)-59 for the Consultants' Meeting and INDC(NDS)-60 for the Specialists' Meeting).

List of papers presented at the two meetings

Designation	Presented at the Consultants'Meetg	Presented at the Specialists'Meetg	Reference (The number refers to a page of this report)
1. Survey of current and future needs for charged particle and photonuclear reaction data, by A. Calamand	✓		INDC(NDS)-62
2. "Photonuclear Physics 1973, Where We Are and How We Got There", by E. Fuller Reprint from the Asilomar Conference on Photonuclear Reactions & Applications, March 26 - 30, 1973	✓		see original publication
3. Photonuclear Reaction Data, 1973 - NBS Special Publication 380. U.S. Department of Commerce, National Bureau of Standards, issued March 1973.	✓		-id^{o}-
4. Photonuclear Reactions, by E. Hayward. NBS Monograph 118. U.S. Department of Commerce, National Bureau of Standards, issued August 1970	✓		-id^{o}-
5. Summary of Compilation and Evaluation Activities (Photonuclear Reactions). Excerpt from recent USNDC meetings	✓		3
6. The Photonuclear Data Centre. March 1974. (Description of the centre activities).	✓		9
7. Charged Particle Cross Section (CPX) Data Center computer - based files.	✓		14
8. Charged-Particle Cross Section Data Center (Dates and Titles of Publications)	✓		19
9. Nuclear cross sections for charged-particle-induced reactions, N and O, compiled by H.J. Kim, W.T. Milner, and F.K.McGowan. NUCLEAR DATA, Section A, Volume 3, Number 2, September 1967. (Sample).	✓		see original publication
10. Reaction List for Charged-Particle-Induced Nuclear Reactions Z = 1 to Z = 98 (H to Cf), July 1972 - June 1973 by F.K. McGowan and W.T. Milner ATOMIC DATA AND NUCLEAR DATA TABLES <u>12</u>, 499-583 (1973).	✓		-id^{o}-
11. Computerized Libraries of Nuclear Data, by S. Pearlstein March 1, 1974	✓	✓	20
12. Generalized EXFOR Isoquants(Proposal by the Nuclear Data Section, reproduced from Memo 4C-3/93).	✓		33
13. Nuclear Data Section Short Guide to EXFOR	✓	✓	36
14. Principles of constructing systematized, bibliographic nuclear data files, By A.I. Abramov - Report INDC(CCP)-29/L.	✓		see original publication

List of papers presented at the two meetings (cont'd)

	Designation	Presented at the Consultants'Meetg.	Presented at the Specialists'Meetg.	Reference (The number refers to a page of this report)
15.	Photonuclear Cross Sections, by B. Buelow and B. Forkman. (Documents 15 and 16 are two chapters of the Handbook on Nuclear Activation Cross Sections, Technical Reports Series no. 156, IAEA, Vienna, 1974)	✓		see original publication
16.	Excitation Functions for Charged-Particle-Induced Reactions in Light Elements, by J. Lorenzen and D. Brune	✓		-id^{c}-
17.	Nuclear Structure Data File - Preliminary Specifications-March 29, 1974, by the Nuclear Data Project	✓	✓	40
18.	Memo of March 20, 1974 from W.B. Ewbank to the Nuclear Data Project Compilers	✓	✓	69
19.	The Digital Data Files of the Photonuclear Data Center, by H.M. Gerstenberg	✓		73
20.	Landolt-Boernstein - New series - Springer Verlag -Band I 5a - Q-values for 64 reaction types with 25 different projectiles -Band I 5b - 1800 excitation functions for charged-particle induced reactions -Band I 5c - Systematics of excitation functions for nuclear reactions induced by p,d, ^{3}He and α particles by H. Muenzel et al.	✓		see original publication
21.	The State of Work on Non-Neutron Nuclear Data in the USSR, by L.L. Sokolovskij, Yu.I. Fenin and F.E. Chukreev	✓	✓	82
22.	Computerized Libraries of Nuclear Data for Applications, by S. Pearlstein (April 1, 1974)		✓	104
23.	Nuclear Data Project, paper presented at the IWGNSRD in March 1972, by D. Horen		✓	127
24.	Non-Neutron Nuclear Data: A proposal for International Cooperation, by A. Lorenz (April 29, 1974)		✓	133
25.	Nuclear Data in Science and Technology: Structure and Scope, by A. Lorenz (April 29, 1974)		✓	to be published as INDC report
26.	Information Center for Applied Users, by G.A.Bartholomew (April 26, 1974)		✓	139
27.	Draft Recommendations IAEA Consultants Meeting on Charged Particle and Photonuclear Reaction Data (24 - 26 April 1974)		✓	see final version in INDC(NDS)-59

List of papers presented at the two meetings (cont'd)

	Designation	Presented at the Consultants'Meetg.	Presented at the Specialists'Meetg.	Reference (The number refers to a page of this report)
28.	Conclusions and recommendations of the first meeting of the IWGNSRD, Vienna, March 1972		✓	INDC(NDS)-46
29.	6th INDC Meeting, Recommendations (October 1973)		✓	142
30.	6th INDC Meeting, Subcommittees of INDC (October 1973)		✓	144
31.	6th INDC Meeting, Requirements and applications of border-line nuclear and atomic data, by D. Berenyi (Oct. 1973)		✓	148
32.	Notes on a Computerized Decay Data File, by C.M.Lederer and A. Shihab-Eldin (April 22, 1974)		✓	150
33.	NUSPEC (= Nuclear Spectroscopy Interactive Program Package) Table of Isotope Project, Lawrence Berkeley Lab., by C.M. Lederer, A. Shihab-Eldin		✓	156
34.	Draft by D. Horen (April 30, 1974)		✓	165
35.	Status of Author's Guide, by G.A. Bartholomew (April 26, 1974)		✓	169

List of statements from participants in the Specialists' Meeting, concerning their home programme on nuclear data

A. Papers presented at the

Consultants' Meeting on Charged Particle and Photonuclear Reaction data

and at the

Specialists' Meeting on Nuclear Data for Applications

SUMMARY OF COMPILATION AND EVALUATION ACTIVITIES

(Photonuclear Reactions)

7. Photonuclear Data Compilation and Evaluation— E. Fuller*

Fuller updated an earlier description of the activities of the photonuclear data center at NBS presented at the NCSAC meeting of May 1971 (see NCSAC—37). He noted that as a result of the NCSAC recommendation support in the area of photonuclear cross section compilation had increased with the National Standard Reference Data System assuming responsibility for supporting the NBS compilation effort. In addition a NIRA associate has been assigned to the project for the next two years. One of the major outputs of the center is the Photonuclear Data Index and, to date, two supplements. The objective of this project is to formulate and maintain a current photonuclear data file which can be used as source material. The original index, NBS Miscellaneous Publication 277 covers data from data from January 1955 to January 1965. The two supplements cover data from 1965 to February 1970. A new data index has been prepared in draft form and covers all publications with a cutoff data of August, 1972. It is hoped to have a final version of this document in time for the Asilomar Conference which will cover all publications from 1955 to 1973. The intention is to publish this index in Nuclear Data A.** All of the published data contained in the photoneutron index has been stored in the centers files and can be retrieved according to specific entries in the NBS photonuclear index.

The center does have plans for a compilation program. He noted that already a group at Lund had published a compilation of photonuclear data directed toward activation analysis under the title, Photonuclear Cross Sections. The authors are Bulow and Forkman. At present this compilation is available as a Nuclear Physics report No. LUNP—7208 and it will be published as a 55-page chapter in the book on activation analysis. In the center's survey of published measurements 311 targets were identified and 207 data sets. 256 isotopes are included in this body of data. The Lund group has compiled results for 55 of these cases. The NBS effort will attempt a complete description of this data body. An atlas is planned which will present 5 types of data for each target—first curves of all pertinent cross sections in a 16 X 22 cm format, second resonance parameters which give gross fits for the cross sections for photons of less than 30 MeV energy, 3) sum rule values for the total absorption cross section weighted with various powers of the photon energy, 4) tabular cross section data over energy intervals of .5 MeV, and finally 5) tables of yield data for all important or useful reactions. The yield data will include bremsstrahlung weighted cross sections at energy points of 10, 15, 20, 25, and 30 MeV for total neutron yield and measurable activities. A total of 5 man years of effort is planned for completion of this compilation.

Goldstein noted that Abramov of the Institute of Physics and Power, Obninsk, USSR had circulated a report on a CINDA type compilation of threshold photoneutron data. A translation of this report would be of value as would a response to the proposal on the part of USNDC. Fuller indicated that the NBS Photonuclear Center is planning a response to the Soviet effort. He noted that this was a limited photoneutron index covering only cross sections in the region of threshold. The index included the same article as many as 10 times. He did not believe that a need for such an expanded nuclear data index existed. Kolstad indicated that this was the first case in which the Russians have asked for our comments and cooperation and an NDC response would be desirable. Jackson stated that the character of the compilation proposed was extremely detailed including entries for every piece of data, graph, table, etc. individually. Horen noted that the material is in the CINDA Index format and questioned why this choice. It also appeared to him that the detail of the compilation was excessive. A New Action 16 was adopted on Jackson, to obtain a translation of the Abramov document to circulate it together with a letter of comment.

ACTION 16
Jackson

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*From USNDC-4A (Meeting 24-26 October 1972, National Bureau of Standards, Gaithersburg, Maryland)

**Came out as NBS SP 380 due to publication problems (see p.3)

1. Photonuclear Data Center (E.G. Fuller, H.M. Gerstenberg, and H. Vander Molen)*

NBS Special Publication 380, Photonuclear Reaction Data, 1973 was published in March. This 125-page book contains a complete index to all measurements in the field published in the period from 1955 to 1972. In addition, a brief summary is given of the gross features of the giant resonance. Included are the energy at which the cross section peaks, the maximum value reached by the cross section, the width of the "resonance" at half maximum, and the two cross section integrals which are most useful for estimating yields, $\sigma_{-0}(E_m)$ and $\sigma_{-1}(E_m)$. Data are presented both in tabular as well as graphical form for all nuclei where measurements have been made. Where a number of measurements have been made for a single nucleus, the parameters tabulated were taken from the single measurement which was felt to give the most representative picture for that nucleus.

Related to this publication is the invited paper, Photonuclear Physics, 1973, Where We Are and How We Got There, presented (EGF) at the Asilomar Conference on Photonuclear Reactions and Applications (March 1973). This contained a very brief history of the field, a review of the data now available, and finally, a summary of the results of a world-wide survey made in early 1973 of existing and proposed facilities and programs in photonuclear physics.

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*From USNDC-7 (Meeting at Oak Ridge National Laboratory, 18-20 June 1973)

1. Atlas of Photoneutron Cross Sections Obtained with Monoenergetic Photons (B. L. Berman)*

A compilation, in a uniform format and current as of early 1973, of photoneutron cross-section data obtained with monoenergetic photons from positron annihilation in flight has been issued as UCRL-74622. This atlas was distributed at the International Conference on Photonuclear Reactions and Applications in March. The USNDC has, of course, expressed its great desire that such a compilation be made available for a variety of applications purposes.

Over the years, a considerable body of data on photoneutron cross sections obtained with monoenergetic photons from the annihilation in flight of fast positrons has been acquired at the Livermore, Saclay, and General Atomic Laboratories. The data on 65 nuclei studied with annihilation photons (49 from Livermore measurements, 25 from Saclay, and two from General Atomic) are gathered together here and presented in a uniform format, in order to serve as a nucleus for a more complete compilation and evaluation (which would include data obtained with continuous bremsstrahlung radiation sources as well). The photonuclear group at the National Bureau of Standards is undertaking such a comprehensive compilation and evaluation, and the data in this atlas will be a major part of it. Meanwhile, these data are available in both graphical and digital form. It is hoped that this service to the physics community will be utilized both for purposes of theoretical analysis and for those associated with applications to other scientific disciplines and technologies.

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

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*From USNDC-7 (Meeting at Oak Ridge National Laboratory, 18-20 June 1973)

A T L A S

(of Photonuclear Cross Section Data)

The Photonuclear Data Center is developing a comprehensive, annotated compilation of selected data on the interaction of electromagnetic radiation with nuclei. The photon energies of interest range from the photodisintegration thresholds to the meson production threshold. The object is to present the best available data for each nuclide in a uniform format in such a way that it is useful not only for theoretical physicists and active experimental workers in the field but also useful for the various applied workers in fields such as medical physics, activation analysis, radiation shielding, etc.

It is planned to publish this compilation in two or three sections the first of which is scheduled for completion early in 1974. For each target nuclide or element for which sufficient data exist the compilation will give:

I. Figure 16x22 cm: Gives all pertinent cross sections as a function of E_γ. There will be a few cases where it might require up to 3 separate figures to give justice to all the available data.

II Resonance Parameters that give a gross fit to the absorption cross section for $E_\gamma < 30$ MeV.

III. Sum Rules: $\sigma_o(E_m)$, $\sigma_{-1}(E_m)$, $\sigma_{-2}(E_m)$ for total absorption cross section. E_m is the highest energy for which absorption data exist. If data go to high energies, i.e., 140 MeV, these quantities will also be given for $E_m = 30$ MeV.

IV. Table 1 - Cross Section Data
Lists all pertinent cross section data as function of E_γ. $\Delta E_\gamma = 0.5$ MeV and finer if data warrant.

V. Table 2 - Yield Data
This table will give:

1. Thresholds for all "important and/or useful" reactions.

2. Isotopic abundance.

3. Radioactivity data for end products of reactions.

4. $\sigma_{-1}(E_i)$ (E_i= 10, 15, 20, 25, 30 MeV) for:

   a. Total neutron yield.
   b. Each reaction that results in a measurable radioactivity.

VI. A selected annotated bibliography on photoparticle spectral and angular distribution data.

Photonuclear Data Center
Center for Radiation Research
National Bureau of Standards
Washington, D.C. 20234

October 1, 1973

The Photonuclear Data Center - March 1974

National Bureau of Standards
Washington, D.C. 20234

Definition

Photonuclear physics data are defined to be any experimental results that give information about the electromagnetic matrix element connecting the ground state of a nucleus with any excited state or the continuum. The transition may be induced by real or virtual photons. Data satisfying these criteria but which are not included in the Photonuclear Data Center's files are those obtained from Coulomb excitation and slow neutron capture experiments. While some such data are included in the Center's files, no attempt has been made to include all ground-state, radiation widths obtained from delayed γ-γ coincidence, Doppler shift attenuation, etc., experiments.

What the Center Does

-Systematically abstracts, collects, and indexes data from the published literature for the field of photonuclear physics.

-Maintains a library of digitized photonuclear cross section data.

-Serves as an information center for the field of photonuclear physics.

-Periodically publishes an updated cumulative index to the data published in the field and that in its files.

What the Center Has

-Copies of the more than 2000 journal papers that have been published since 1955 giving experimental data for the field.

-A file of 4200 data abstract sheets giving information and data from over 4600 separate measurements. Each sheet gives for a specific nuclide or element all of the pertinent experimental data given in a particular journal reference. (See example.)

-A library of selected cross section data in digitized form. It now contains data for over 675 curves measured for more than 99 different nuclides covering 68 elements.

-A computer-searchable index to data in the field that can generate bibliographies satisfying specific assignments of one or more of the following quantities: Nuclide studied, Reaction, Type of measurement, Excitation energy range, Source Type and Energy, Angle data, Reference number.

-A sonic delay digitizer for entering data available in graphical form only (e.g., reports, journal articles, etc.) into the cross section data library.

Services the Center Provides

-Publication of a biennally updated, completely annotated, cumulative index to the data in its files. Latest issue: Photonuclear Reaction Data, 1973, NBS Special Publication 380 (March 1973). This publication covers experimental data

Services the Center Provides (continued)

for the field of photonuclear reactions published in scientific and technical journals in the period from 1955 through 1972. (See sample page.) It may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $2.10 domestic postpaid or $1.75 G.P.O. Bookstore.

-Selected annotated indices and bibliographies covering specific types of data or reactions.*

-Information in form of data abstract sheets for specific nuclides or classes of data.*

-Within limited resources and on a case by case basis what it considers to be the best available data for specific cross sections for specified nuclei. Data are primarily furnished as data abstract sheets. As the digitized cross section library is developed, information will also be furnished in tabular or large scale graphical form.*

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*On request.

Attachments (3)
-Ref. 70Vel, NBS 418
-Sample page fr NBS 380
-Abbreviations

March 18, 1974

REF.		ELEM. SYM.	A	Z
	A. Veyssiere, H. Beil, R. Bergere, P. Carlos, A. Lepretre Nucl. Phys. A159, 561 (1970)	Pb	208	82
METHOD		REF. NO.		
		70 Ve 1		egf

REACTION	RESULT	EXCITATION ENERGY	SOURCE TYPE	SOURCE RANGE	DETECTOR TYPE	DETECTOR RANGE	ANGLE
G,N	ABX	7-31	D	7-36	BF3-I		4PI
G,2N	ABX	14-31	D	7-36	BF3-I		4PI
G,3N	ABX	23-31	D	7-36	BF3-I		4PI
G,4N	ABX	30-36	D	7-36	BF3-I		4PI

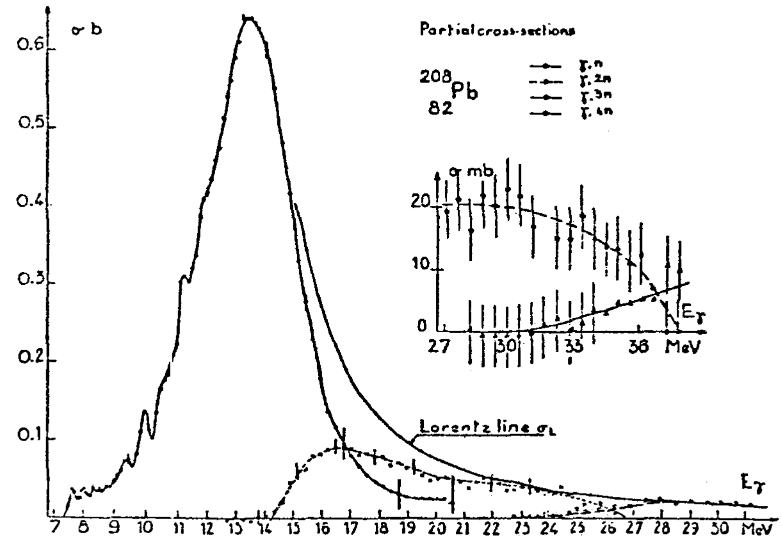


Fig. 1. Partial photoneutron cross sections $\sigma_{\gamma,n}$, $\sigma_{\gamma,2n}$, $\sigma_{\gamma,3n}$, and $\sigma_{\gamma,4n}$ of ^{208}Pb. We also show the descending part of the unique Lorentz line giving the best fit to the experimental $\sigma_{\gamma,T}(E)$ curve.

TABLE 5

Integrated cross sections and sum rule values of ^{208}Pb and ^{197}Au. The notation used is defined in the text

Refs.		E_M (MeV)	σ_0 (MeV · b)	σ_0' (MeV · b)	$\frac{\sigma_0 A}{0.06 NZ}$	$\frac{\sigma_0' A}{0.06 NZ}$	σ_{-1} (mb)	σ_{-2} (mb · MeV^{-1})
	[1])	22	4.10±0.06	5.10	1.37	1.71	280	20.5
^{208}Pb	[8])	28	2.91±0.29	2.94	0.98	0.99		14.1±1.4
	[23])	23	3.91±0.59	5.18	1.31	1.74		18.6±2.4
	present work	25	3.48±0.23	4.00	1.17	1.34	251±20	19.1±2
	[1])	22	3.00±0.05	3.99	1.06	1.40	200	14
^{197}Au	[9])	25	2.97±0.3	3.53	1.05	1.24		15.3±1.5
	present work	25	3.48±0.2	4.07	1.23	1.42	238±20	17.2±2

[1] J.Miller, C.Schuhl and C.Tzara, Nucl.Phys.32 (1962)236.
[8] R.R.Harvey, J.T. Caldwell, R.L. Bramblett and S.C. Fultz, Phys.Rev. 136 (1964)B126.
[9] S.C.Fultz, R.L. Bramblett, J.T. Caldwell and N.A. Kerr, Phys.Rev. 127, (1962)1273.
[23] T.Tomimasu, J. Phys. Soc.Jap.25 (1968)655.

[over]

KRYPTON Z=36

A	ABUND.	G,N	G,P	G,T	G,HE3	G,A	G,2N	G,NP	G,2P
		SEPARATION ENERGIES (MEV)							
78	0.35	12.0	8.2	19.9	16.9	4.4	21.1	19.4	13.5
80	2.27	11.5	9.1	19.6	18.2	5.1	19.9	19.8	15.4
82	11.56	11.0	9.9	19.5	19.6	6.0	18.8	20.1	17.4
83	11.55	7.5	9.8	19.1	17.2	6.5	18.5	17.4	18.2
84	56.90	10.5	10.7	19.4	21.0	7.1	18.0	20.3	19.4
86	17.37	9.9	11.9	19.2	22.8	8.1	17.0	20.9	21.9

REF	NUCLIDE Z A	REACTION IN,OUT	RES	EXCIT	SOURCE	DETECTOR TYPE	ANG	NUM
69HO1	36KR	G,XP	ABY	THR- 33	C 24- 33	SCI-D	90	
66BE2	36KR82	G,G	LFT	1	C 1	NAI-D	113	
						1=.777 MEV		
69HO1	36KR84	G,XP	ABY	THR- 33	C 24- 33	SCI-D	90	

RUBIDIUM Z=37

A	ABUND.	G,N	G,P	G,T	G,HE3	G,A	G,2N	G,NP	G,2P
		SEPARATION ENERGIES (MEV)							
85	72.15	10.5	7.0	16.5	19.6	6.6	19.4	17.5	17.7
87	27.85	9.9	8.6	17.1	21.8	8.0	18.6	18.5	20.5

REF	NUCLIDE Z A	REACTION IN,OUT	RES	EXCIT	SOURCE	DETECTOR TYPE	ANG	NUM
71LE1	37RB	G,N	ABX	11- 24	D 11- 24	MOD-I	4PI	375
71LE1	37RB	G,2N	ABX	17- 24	D 11- 24	MOD-I	4PI	376
61BA2	37RB	G,XN	ABY	THR- 22	C 22	THR-I	DST	
58TO1	37RB85	G,N	RLY	10- 11	C 22	ACT-I	4PI	
						THRESHOLD		
60GE3	37RB85	G,N	NOX	THR	CTHR	BF3-I	4PI	
						THRESHOLD		
69KN1	37RB85	G,N	RLY	10- 45	C 45	ACT-I	4PI	
						ISOMER YIELD		
58TO1	37RB87	G,N	RLY	9- 11	C 22	BF3-I	4PI	
						THRESHOLD		
60GE3	37RB87	G,N	NOX	THR	CTHR	BF3-I	4PI	
						THRESHOLD		
57ER1	37RB87	G,A	ABI	8- 32	C 32	ACT-I	4PI	
57ER1	37RB87	G,NA	ABI	17- 32	C 32	ACT-I	4PI	

STRONTIUM Z=38

A	ABUND.	G,N	G,P	G,T	G,HE3	G,A	G,2N	G,NP	G,2P
		SEPARATION ENERGIES (MEV)							
84	0.56	12.0	9.0	20.2	17.9	5.2	21.2	19.8	14.6
86	9.86	11.5	9.6	20.5	19.5	6.3	20.0	20.1	16.7
87	7.02	8.4	9.4	20.1	17.4	7.3	19.9	18.1	18.0
88	82.56	11.1	10.6	20.7	21.4	7.9	19.5	20.5	19.2

REF	NUCLIDE Z A	REACTION IN,OUT	RES	EXCIT	SOURCE	DETECTOR TYPE	ANG	NUM
63KA2	38SR	G,G/	RLY	1	C 6	ACT-I	4PI	
71LE1	38SR	G,N	ABX	11- 27	D 11- 27	MOD-I	4PI	378
71LE1	38SR	G,2N	ABX	19- 27	D 11- 27	MOD-I	4PI	379
61BA2	38SR	G,XN	ABY	THR- 22	C 22	THR-I	DST	
70HI1	38SR	G,XN	ABX	10- 27	C 10- 27	BF3-I	4PI	329
62CA1	38SR86	G,N	NOX	12- 30	C 30	ACT-I	4PI	
						ISOMER RATIO		
56YE2	38SR86	G,XN	ABX	11- 23	C 24	BF3-I	4PI	
63VE2	38SR87	G,G/	ABX	0- 1	D 1	ACT-I	4PI	
						ISOMERS 1=1.33 MEV		
56YE2	38SR87	G,XN	ABX	9- 23	C 24	BF3-I	4PI	
68OK3	38SR87	G,P	ABY	THR- 20	C 20	ACT-I	4PI	
56HE3	38SR88	E,E/	FMF	1- 7	D187	MAG-D	DST	
68PE1	38SR88	E,E/	RLY	1- 7	D 65, 70	MAG-D	DST	
						B(EL), 4 LEVELS		
69SH5	38SR88	E,P	ABX	14- 25	D 16- 30	MAG-D	UKN	
69SH6	38SR88	E,P	SPC	14- 30	D 30	MAG-D	UKN	
64BE7	38SR88	G,G	LFT	2	D 2	UKN-D	UKN	
						2=1.85 MEV		
56YE2	38SR88	G,XN	ABX	11- 23	C 24	BF3-I	4PI	
71BL1	38SR88	G,PI+	ABY	150-700	C150-700	ACT-I	4PI	
						SEE 68NY1		
69HA1	38SR88	P,G	RLX	15- 22	D 4- 12	NAI-D	90	207+

YTTRIUM Z=39

A	ABUND.	G,N	G,P	G,T	G,HE3	G,A	G,2N	G,NP	G,2P
		SEPARATION ENERGIES (MEV)							
89	100.00	11.5	7.1	18.1	19.9	8.0	20.9	18.2	17.7

REF	NUCLIDE Z A	REACTION IN,OUT	RES	EXCIT	SOURCE	DETECTOR TYPE	ANG	NUM
67SH1	39Y 89	E,E/	FMF	2- 3	D225	MAG-D	DST	
						2.5 MEV		
68PE1	39Y 89	E,E/	RLY	1- 3	D 65, 70	MAG-D	DST	
						5 LEVELS		
71MO3	39Y 89	E,E/	ABX	0-240	D500	MAG-D	60	
69SH6	39Y 89	E,P	SPC	10- 26	D 20	MAG-D	UKN	
68AL1	39Y 89	G,G	LFT	2	C 4	SCD-D	130	
						2=1.51 MEV		
70AR1	39Y 89	G,G	ABX	12- 30	C 32	NAI-D	DST	
						RATIO G,G/TO 2+		
58SI1	39Y 89	G,G/	ABY	2- 21	C 22	ACT-I	4PI	
63KA2	39Y 89	G,G/	RLY	1	C 5	ACT-I	4PI	
63VE2	39Y 89	G,G/	ABX	0- 1	D 1	ACT-I	4PI	
						ISOMERS 1=1.33 MEV		
58CH2	39Y 89	G,N	RLY	THR	CTHR	BF3-I	4PI	
						THRESHOLD		
60GE3	39Y 89	G,N	NOX	THR	CTHR	BF3-I	4PI	
						THRESHOLD		
62RE1	39Y 89	G,N	NOX	6- 55	C 55	THR-I	DST	
63GE1	39Y 89	G,N	RLY	11- 12	C 11- 12	BF3-I	4PI	
						THRESHOLD		
67BE2	39Y 89	G,N	ABX	THR- 28	DTHR- 28	BF3-I	4PI	
69BE4	39Y 89	G,N	ABX	11- 25	D 11- 26	MOD-I	4PI	188
71LE1	39Y 89	G,N	ABX	11- 27	D 11- 27	MOD-I	4PI	381
71SA1	39Y 89	G,N	ABY	11- 68	C 10- 68	ACT-I	4PI	
66FU2	39Y 89	G,2N	ABI	THR- 28	DTHR- 28	BF3-I	4PI	
66WA1	39Y 89	G,2N	RLY	THR-280	C150,280	ACT-I	4PI	
						ISOMER RATIO Y 87		
67BE2	39Y 89	G,2N	ABX	THR- 28	DTHR- 28	BF3-I	4PI	1+
69BE4	39Y 89	G,2N	ABX	21- 27	D 19- 28	MOD-I	4PI	189
70WA3	39Y 89	G,2N	RLY	THR-305	C150-305	ACT-I	4PI	
71LE1	39Y 89	G,2N	ABX	21- 27	D 11- 27	MOD-I	4PI	382
56YE2	39Y 89	G,XN	ABX	12- 23	C 24	BF3-I	4PI	
58KA1	39Y 89	G,XN	ABX	12- 22	C 12- 22	BF3-I	4PI	
61BA2	39Y 89	G,XN	ABY	THR- 22	C 22	THR-I	DST	
66FU2	39Y 89	G,XN	ABI	THR- 28	DTHR- 28	BF3-I	4PI	
69SH4	39Y 89	G,P	ABX	7- 24	C 17- 24	EMU-D	DST	
67TA2	39Y 89	G,XP	SPC	THR- 24	C 17, 24	EMU-D	4PI	
70WA3	39Y 89	G,PN	RLY	THR-305	C150-305	ACT-I	4PI	
68SH1	39Y 89	P,G	ABX	13- 15	D 5- 9	NAI-D	DST	
69RI1	39Y 89	P,G	ABX	12	D 5	SCD-D	90	
						5=4.97-5.15 MEV		
71UM1	39Y 89	P,G	ABX	10- 11	D 2- 3	NAI-D	0	

ZIRCONIUM Z=40

A	ABUND.	G,N	G,P	G,T	G,HE3	G,A	G,2N	G,NP	G,2P
		SEPARATION ENERGIES (MEV)							
90	51.46	12.0	8.4	20.7	18.8	6.7	21.3	19.9	15.4
91	11.23	7.2	8.7	18.6	14.9	5.5	19.2	15.6	16.3
92	17.11	8.6	9.4	15.7	17.2	3.0	15.8	17.3	17.1
94	17.40	8.2	10.3	15.9	18.5	3.8	14.9	17.8	18.9
96	2.80	7.9	11.5	16.1	20.4	4.9	14.3	18.5	21.3

REF	NUCLIDE Z A	REACTION IN,OUT	RES	EXCIT	SOURCE	DETECTOR TYPE	ANG	NUM
60RE1	40ZR	G,G	ABX	7	D 7	NAI-D	90	
66BE3	40ZR	G,G	RLX	5- 10	D 5- 10	NAI-D	135	
70AX1	40ZR	G,G	ABX	8- 13	D 8- 13	NAI-D	22	
67HU2	40ZR	G,N	ABY	THR- 22		THR-I	DST	
64DU1	40ZR	G,P	ABX	THR- 34	C 22- 34	MAG-D	DST	
							ABX	
65DU1	40ZR	G,P	ABX	18- 26	D 17- 24	EMU-D	DST	
69SH4	40ZR	G,P	ABX	8- 24	C 20, 24	EMU-D	DST	
63MI5	40ZR	G,XP	ABY	8- 22	C 22	SCI-I	DST	
69BO2	40ZR90	E,E/	FMF	2- 4	D 58	MAG-D	DST	
						2.18 TO 3.84 MEV		
70BE2	40ZR90	E,E/	ABX	0- 4	D 42- 61	MAG-D	DST	
						2.18,2.74,3.84		
68SH4	40ZR90	E,P	SPC	11- 20	D 20	MAG-D	90	
						ANALOG STATES		
69SH5	40ZR90	E,P	ABX	12- 23	D 16- 24	MAG-D	UKN	
69SH6	40ZR90	E,P	SPC	12- 22	D 16- 23	MAG-D	DST	
63AX1	40ZR90	G,G	ABX	8- 13	D 8- 13	NAI-D	135	
69RA1	40ZR90	G,G	LFT	9	D 9	NAI-D	DST	
						9=8.496 MEV		
56AX1	40ZR90	G,N	RLX	12- 23	C 12- 23	ACT-I	4PI	
						THRESHOLD		
59MU2	40ZR90	G,N	RLX	12- 24	C 12- 25	ACT-I	4PI	
62CA1	40ZR90	G,N	NOX	12- 30	C 30	ACT-I	4PI	
						ISOMERIC RATIO		
65CO1	40ZR90	G,N.	ABX	THR- 70	C 12- 70	ACT-I	4PI	
67BE2	40ZR90	G,N	ABX	THR- 28	DTHR- 28	BF3-I	4PI	10+
71LE1	40ZR90	G,N	ABX	12- 26	D 12- 26	MOD-I	4PI	384
66FU2	40ZR90	G,2N	ABI	THR- 28	DTHR- 28	BF3-I	4PI	
67BE2	40ZR90	G,2N	ABX	THR- 28	DTHR- 28	BF3-I	4PI	10+
71LE1	40ZR90	G,2N	ABX	21- 26	D 12- 26	MOD-I	4PI	385

Abbreviations Used in Photonuclear Data Index

EXCIT	Excitation energy of specified nuclide for which data are given
RES	Result of measurement, type of information

ABI	absolute integrated cross-section data $\int \sigma dE_{\gamma}$
ABX	absolute cross-section data
ABY	absolute yield data
FMF	form factor
LFT	excitated state lifetime
NOX	no cross-section data
RLI	relative integrated cross-section data
RLX	relative cross-section data
RLY	relative yield data
SPC	photon or particle energy spectrum

CPX DATA CENTER COMPUTER BASED FILES

THERE ARE THREE COMPUTER BASED FILES WHICH EXIST AT THE CPX DATA CENTER- THESE ARE THE ,,ABSTRACT FILE,, THE ,,CROSS SECTION DATA FILE,, AND THE ,,REACTION LIST FILE,, OF THESE, ONLY THE LATTER IS MAINTAINED ON A CURRENT BASIS, ALL THREE OF THE FILES EXIST ON CARDS, COMPUTER LISTINGS AND MAGNETIC TAPE.

AT THE PRESENT TIME THE REACTION LIST FILE IS KEPT UP TO DATE WITH THE EXPENDITURE OF ONLY 0.5 MANPOWER BY F. K. MCGOWAN. A PLAN IS BEING CONSIDERED IN WHICH THIS FILE WILL BE EXTRACTED FROM THE SAME LITERATURE SCAN WHICH PRODUCES ,,RECENT REFERENCES,, THIS PLAN WOULD PROBABLY REQUIRE SOME ADDITIONS TO THE NUCLEAR DATA GROUP,S KEY WORD LIST BUT THIS SHOULD NOT BE A SERIOUS PROBLEM. THE TWO MOST IMPORTANT PROBLEMS ARE TRAINING A SCANNER TO COVER SOME ADDITIONAL MATERIAL AND GETTING THE COMPUTER PROGRAMMING DONE EFFICIENTLY. IT IS NOT CLEAR WHEN THIS PLAN CAN BE FULLY IMPLEMENTED WITH THE MANPOWER THAT IS AVAILABLE.

REACTION LIST FILE

THE REACTION LIST FILE IS ESSENTIALLY COMPLETE, WITHIN THE SCOPE OUTLINED IN THE CURRENT SUPPLEMENT (SEE THE INCLOSED REPRINT), THE EXACT COVERAGE IS-

Z = 1 AND Z = 2 (H AND HE)	MAY 1969 - JUNE 1973
Z = 3 THRU Z = 99 (LI THRU ES)	1948 - JUNE 1973
COULOMB EXCITATION	1956 - JUNE 1973
THEORETICAL ANALYSIS	JULY 1970 - JUNE 1973

MOST OF THE ENTRIES FOR THE JULY 1973 - JUNE 1974 SUPPLEMENT ARE ALSO STORED ON TAPE.

EACH ENTRY CONTAINS THE TEXT MATERIAL (REACTION, PROJECTILE ENERGY, QUANTITY MEASURED AND REFERENCE) GIVEN IN THE PUBLISHED LIST AS WELL AS THE INDEX PARAMETERS DEFINED IN THE SECTION ON FILE STRUCTURE BELOW, OUR PROGRAMS INCLUDE ROUTINES FOR RETRIEVAL AND ORDERING ON THESE INDICES AS WELL AS RETRIEVAL AND ORDERING ON AUTHORS NAME, JOURNAL, VOLUME, PAGE AND YEAR.

A SUPPLEMENT TO THE REACTION LIST IS PUBLISHED ANNUALY, ALL OF THE EARLIER ISSUES ARE LISTED IN THE INTRODUCTION OF THE 1972 - 1973 SUPPLEMENT (PAGE 501), TO DATE THE FILE CONSISTS OF ABOUT 33000 REACTION ENTRIES FROM SOME 14000 PAPERS, THE COMPLETE FILE CAN BE CONTAINED ON ONE 9-TRACK, 800 BPI, BCD TAPE.

SERVICES PROVIDED

SINCE THE REACTION LIST FILE APPEARS IN THE OPEN LITERATURE IN IT,S ENTIRETY AND IS UPDATED ANNUALY, MOST OF THE SERVICE PROVIDED INVOLVES FINDING REFERENCES AND SOMETIMES DATA FOR PEOPLE WHO DO NOT CURRENTLY HAVE ACCESS THESE PUBLISHED LISTS. WE HAVE ALSO PRODUCED SPECIAL LISTS OF CERTAIN TYPES OF ENTRIES AND HAVE SUPPLIED PART OR ALL OF THE FILE ON TAPE.

REACTION LIST FILE STRUCTURE AND DEFINITIONS

```
C     FORTRAN REQUIRED FOR READING ONE REACTION LIST ENTRY
C
      DIMENSION INDX(11),RACT(10,50),REF(20)
      REAL*8 RACT,REF
      READ(1,20,END=200)INDX,NV,ICN
   20 FORMAT(I2,1X,4(2X,I3,I3),5X,I2,4X,I10,8X,I2,8X,I6)
      READ(1,30,END=200)((RACT(K,J),K=1,10),J=1,NV)
   30 FORMAT(10A8)
      READ(1,30,END=200)REF
C
C     DEFINITIONS
C
C     ICN IS OUR SYSTEN ID NO.
C     NV IS THE NO, OF ,,LINES,, IN THE ENTRY (NOT INCLUDING REF)
C     RACT CONTAINS THE REACTION, ENERGY, QUANTITY MEASURED, ETC,
C     REF CONTAINS THE REFERENCE
C
C     INDX( 1) = DATA TYPE      (SPECIFIC VALUES GIVEN BELOW)
C     INDX( 2) = Z-TARGET
C     INDX( 3) = A-TARGET
C     INDX( 4) = Z-PROJECTILE
C     INDX( 5) = A-PROJECTILE
C     INDX( 6) = Z-OUTGOING
C     INDX( 7) = A-OUTGOING
C     INDX( 8) = Z-RESIDUAM
C     INDX( 9) = A-RESIDUAM
C     INDX(10) = REACTION TYPE (SPECIFIC VALUES GIVEN BELOW)
C     INDX(11) = PROJECTILE ENERGY IN KEV
C
C     DATA TYPE       = 01 DENOTES DATA NOT PLOTTED (OBSOLETE TYPE)
C                     = 02 DENOTES ISOLATED VALUES (VALUE INCLUDED IN ENTRY)
C                     = 03 DENOTES HI-ENERGY CROSS SECTION DATA
C                     = 04 DENOTES ENERGY SPECTRA
C                     = 05 DENOTES ANGULAR CORRELATION DATA
C                     = 06 DENOTES RELATIVE DATA
C                     = 07 DENOTES TABULAR DATA (IN PAPER OR OUR FILES)
C                     = 08 DENOTES COULOMB EXCITATION DATA
C                     = 09 DENOTES ANALYSIS (THEORY)
C
C     REACTION TYPE   = 00 DENOTES ELASTIC SCATTERING
C                     = 01 DENOTES INELASTIC SCATTERING
C                     = 02 DENOTES TARGET + PROJ (INCOMPLETE SPECIFICATION)
C                     = 03 DENOTES DEFINITE REACTION (COMPLETE SPECIFICATION)
C                     = 04 DENOTES POLARIZATION (ELASTIC)
C                     = 05 DENOTES POLARIZATION (INELASTIC)
C                     = 06 DENOTES TOTAL REACTION CROSS SECTION
C                     = 07 DENOTES POLARIZATION (REACTION)
C                     = 08 DENOTES FISSION
C                     = 09 DENOTES SPALLATION
C                     = 10 DENOTES COULOMB EXCITATION
C
C     ,,REACTION TYPE,, AND ,,DATA TYPE,, ARE OPEN ENDED AND OTHER TYPES
C     MAY BE ADDED AS THE NEED ARISES,
```

CROSS SECTION DATA FILE

THE CROSS SECTION DATA FILE IS NOT COMPLETE IN ANY SENSE AND NO DATA HAVE BEEN ENTERED SINCE 1969. THIS FILE CONTAINS ABOUT 11000 ,,DATA SETS,, WITH A TOTAL OF SOME 300,000 ,,DATA POINTS,, MUCH OF THE DATA IS FOR ELASTIC AND INELASTIC SCATTERING, POLARIZATION AND TOTAL CROSS SECTION VS ENERGY MEASUREMENTS. SOME STRIPPING AND PICKUP DATA ARE INCLUDED BUT THESE DATA ARE NOT AT ALL COMPLETE EVEN FOR THE PERIOD COVERED.

SOME OF THE DATA IN THIS FILE HAVE BEEN PUBLISHED AND A SAMPLE FROM THE LAST PUBLICATION WHICH INCLUDES A LISTING OF ALL PREVIOUS PUBLICATIONS, THE INTRODUCTORY MATERIAL AND A COUPLE OF SAMPLE PAGES IS ATTACHED. THE CONTENTS AND STRUCTURE OF THE FILE ARE DESCRIBED IN MORE DETAIL IN THE SECTION ON FILE STRUCTURE AND DEFINITIONS BELOW. ALL OF THE DATA CAN BE CONTAINED ON ONE 9-TRACK, 800 BPI, BINARY TAPE.

SERVICES PROVIDED

ALTHOUGH THE FILE IS NOT MAINTAINED ON A CURRENT BASIS, WE DO CONTINUE TO ANSWER SOME REQUESTS FOR CROSS-SECTION DATA. MOST OF THE REQUESTS ARE FROM INDIVIDUALS IN THE MEDICAL, CONTROLED THERMONUCLEAR, SPACE OR OTHER APPLIED FIELDS. IF THE REQUESTS ARE SPECIFIC AND LIMITED IN SCOPE, WE USUALLY SUPPLY THE DATA IN HARD COPY FORM. WE HAVE SUPPLIED THE COMPLETE FILE ON MAGNETIC TAPE, HOWEVER.

CROSS SECTION FILE STRUCTURE AND DEFINITIONS

```
C
C     FORTRAN REQUIRED FOR READING ONE CROSS SECTION DATA SET
C
      DIMENSION NUNDX(13),ZEQC(7),TITLE(120),XA(500),XB(500),YA(500),
     1YB(500)
      REAL*8 TITLE
      READ(1) ICN,NUNDX,ZEQC,NT,(TITLE(I),I=1,NT),
     1NE,(XA(I),XB(I),YA(I),YB(I),I=1,NE)
C
C     DEFINITIONS
C
C     ICN IS OUR SYSTEM ID NUMBER
C     NT IS THE NUMBER OF WORDS IN TITLE
C     NE IS THE NUMBER OF DATA POINTS IN THE DATA SET
C
C     NUNDX(1) = DATA TYPE (ALWAYS SET TO 1 IN THIS DATA)
C     NUNDX(2) = Z-TARGET
C     NUNDX(3) = A-TARGET
C     NUNDX(4) = Z-PROJECTILE
C     NUNDX(5) = A-PROJECTILE
C     NUNDX(6) = Z-OUTGOING
C     NUNDX(7) = A-OUTGOING
C     NUNDX(8) = Z-RESIDUAL
C     NUNDX(9) = A-RESIDUAL
C     NUNDX(10)= REACTION TYPE (YOU PROBABLY SHOULD NOT TRY TO USE)
C     NUNDX(11)= ENERGY IN KEV (IF E.GT.99998000KEV) E=99998000KEV
C     NUNDX(12)= XLABL INDEX
```

```
C      NUNDX(13)= YLABL INDEX

C      NUNDX(12)=1, 2, 3 DENOTES THETA-C.M., E-LAB, THETA-LAB
C
C      NUNDX(13)=1 DENOTES DSIGMA/DOMEGA (THETA-CM) (MB/STR)
C      NUNDX(13)=2 DENOTES SIGMA(E-LAB)              (MB)
C      NUNDX(13)=3 DENOTES DSIGMA/DSIGMA-R
C      NUNDX(13)=4 DENOTES POL(THETA-CM)             (PER-CENT)
C      NUNDX(13)=5 DENOTES POL(E-LAB)                (PER-CENT)
C
C
C      ZEQC(1)=A-PROJECTILE     ,"EXACT,,
C      ZEQC(2)=A-TARGET         ,"EXACT,,
C      ZEQC(3)=A-OUTGOING       ,"EXACT,,
C      ZEQC(4)=A-RESIDUAL       ,"EXACT,,
C      ZEQC(5)=E-LAB (MEV)
C      ZEQC(6)=Q OF REACTION (MEV)
C      ZEQC(7)=RUTHERFORD COEFF
C
C      THETA IS ALWAYS IN DEGREES
C      E-LAB IS ALWAYS IN MEV
C      POL IS ALWAYS IN PER CENT
C
C      XA(I)=THE ITH VALUE OF THE QUANTITY SPECIFIED BY XLABL
C      YA(I)=THE ITH VALUE OF THE QUANTITY SPECIFIED BY YLABL
C
C      I.E. XA(I),YA(I), ARE THE DATA POINTS
C
C      XB(I)=THE UNCERTAINTY IN XA
C      YB(I)=THE UNCERTAINTY IN YA
C
C      THE FIRST 72 CHARACTERS OF TITLE (9 WORDS) CONTAIN THE REACTION
C      AS WELL AS SOME OTHER INFORMATION (SHOWN ON THE DATA FORM),
C      THE REFERENCE AND COMMENTS ARE CONTAINED IN WORDS 10 THRU NT,
C      THE REFERENCE IS TERMINATED BY A $, COMMENTS FOLLOW THE $,
C      DATA WHICH HAVE BEEN PROCESSED FROM TABLES ARE OFTEN INDICATED AS
C      SUCH IN THE COMMENT FIELD,
C
```

ABSTRACT FILE

THIS FILE (GENERATED FOR IN HOUSE USE) PRECEDED THE REACTION LIST FILE AND IS NO LONGER MAINTAINED. IT HAS A STRUCTURE SIMILAR TO THE REACTION LIST FILE BUT IT WAS NOT SO CAREFULLY DONE OR WELL INDEXED AND DOES NOT CONTAIN AS MUCH INFORMATION. IT DOES CONTAIN SOME 1800 REACTION ENTRIES FOR Z-TARGET = 1 AND 2 FOR THE PERIOD PRIOR TO MAY 1969, AT WHICH TIME THESE NUCLEI WERE FIRST INCLUDED IN THE REACTION LIST.

CHARGED-PARTICLE CROSS SECTION DATA CENTER

Dates and Titles of Publications:

Nuclear Cross Sections for Charged-Particle-Induced Reactions - Mn, Fe, Co, ORNL-CPX-1 (July 1964), compiled by F.K. McGowan, W.T.Milner, and H.J. Kim. Available on request to the Charged-Particle Cross-Section Data Center, Oak Ridge National Laboratory, P.O.Box X, Oak Ridge, Tenn. 37830.

Nuclear Cross Sections for Charged-Particle-Induced Reactions - Ni, Cu, ORNL-CPX-2 (September 1964), compiled by F.K. McGowan, W.T. Milner, and H.J. Kim. Available on request to the Charged-Particle Cross-Section Data Center, Oak Ridge National Laboratory, P.O.Box X, Oak Ridge Tenn.37830.

Nuclear Cross Sections for Charged-Particle-Induced Reactions - Li,Be,B, compiled by H.J. Kim, W.T. Milner, and F.K. McGowan, Nuclear Data A1, 203-389 (1966), issues 3 and 4 combined $ 6.00; Academic Press, 111 Fifth Avenue, New York, N.Y. 10003.

Nuclear Cross Sections for Charged-Particle-Induced Reactions - C, compiled by H.J. Kim, W.T. Milner, and F.K. McGowan, Nuclear Data A2, 1-241 (1966), issues 1 and 2 combined $ 6.00, Academic Press, 111 Fifth Avenue, New York, N.Y. 10003.

Nuclear Cross Sections for Charged-Particle-Induced Reactions - N and O, compiled by H.J. Kim, W.T. Milner, and F.K. McGowan, Nuclear Data A3, 123-286 (1967).

Reaction List for Charged-Particle-Induced Nuclear Reactions, Z = 3 to Z = 27, 1948 - April 1969, compiled by F.K. McGowan, W.T. Milner, H.J. Kim, and Wanda Hyatt, Nuclear Data A6, 353-648 (1969).

Reaction List for Charged-Particle-Induced Nuclear Reactions, Z = 28 to Z = 99, 1948 - April 1969, compiled by F.K. McGowan, W.T. Milner, H.J. Kim, and Wanda Hyatt, Nuclear Data A7, 1-232 (1969).

Reaction List for Charged-Particle-Induced Nuclear Reactions, Z = 1 to Z = 98, May 1969 - June 1970, compiled by F.K. McGowan and W.T. Milner, Nuclear Data A8, 199 - 322 (1970).

Reaction List for Charged-Particle-Induced Nuclear Reactions, Part I: Z = 1 to Z = 98 (H to Cf), July 1970 - June 1971, Part II: Coulomb Excitation 1956 - June 1971, F.K. McGowan and W.T. Milner, Nuclear Data Tables A9, 469 - 626 (1971).

Reaction List for Charged-Particle-Induced Nuclear Reactions, Z = 1 to Z = 99 (H to Es), July 1971 - June 1972, F.K. McGowan and W.T. Milner, Nuclear Data Tables A11, 1 - 126 (1972).

Charged-Particle Reaction List 1948-1971, F.K. McGowan and W.T. Milner, Atomic and Nuclear Data Reprints Vol. 2, Academic Press 1973.

Reaction List for Charged-Particle-Induced Nuclear Reactions, Z = 1 to 98 (H to Cf), July 1972 - June 1973, F.K. McGowan and W.T. Milner, Atomic Data and Nuclear Data Tables 12, No. 6 (1973).

Computerized Libraries of Nuclear Data

S. Pearlstein

March 1, 1974

The use of nuclear data in applications is facilitated if the data are in the form of a computerized library. A library in this form can be more widely distributed, fewer processing codes need be written, and results may be more readily compared. Format extensions to include non-neutron induced reaction data in the Evaluated Nuclear Data File (ENDF) were approved by the Cross Section Evaluation Working Group December 12, 1973. Comments are sought on the adequacy of the trial format for all significant data but in particular charged particle reaction data. An ENDF tape of charged particle data in the trial format has been generated for over 250 nuclides using nuclear systematics.

The ENDF formats have been used for neutron-induced reactions, photon-interaction, and radioactive decay data. These formats are described in ENDF 102 Vol. I (BNL 50274) and Vol. II (LA-4549). Although the ENDF formats were originally constructed for neutron-induced reaction data important to reactor applications, the mathematically oriented modules in many cases can be used to store other data types as well. Since many users of nuclear data are already equipped to process neutron data files, minor modification of existing well known formats will facilitate the storage, retrieval, display, evaluation, processing, and exchange of non-neutron data. At the National Neutron Cross Section Center, the placement of experimental charged particle data in the generalized EXFOR system, used to exchange data between the world neutron data centers, eased the production of an evaluated data set. The following material has been included to show the adaptability of these formats to charged particle data:

Enclosure 1 - Experimental charged particle data in generalized EXFOR.

Enclosure 2 - Evaluated charged particle data in the trial ENDF format.

Enclosure 3 - Graphs of evaluated (p,n), (p,2n), (p,3n) reaction data using an ENDF plotting package.

Enclosure 4 - Partial list of charged particle reaction parameters obtained from nuclear systematics.

Enclosure 5 - Trial ENDF format description (Also refer to ENDF-102).

A good starting point for the production of evaluated charged particle data sets in computerized form are the extensive bibliography and data indexes such as those compiled by the Charged Particle Information Center at Oak Ridge but the assembly of carefully documented evaluations will take time. An ENDF tape of charged particle data generated from nuclear systematics as described in Enclosure 4 may be a useful first iteration of a computerized library. In some cases systematics will be notably deficient and these data sets should be replaced by improved evaluations as they become available.

I would appreciate comments about the trial ENDF formats. I would also be pleased to answer requests for the charged particle reaction data tape.

Enclosure 1

```
SUBENT        19001001       740301                                        19001  1      1
BIB                 10           19                                        19001  1      2
TITLE      (P,XN) AND (P,PXN) REACTIONS OF YTTRIUM-89 WITH 5-85            19001  1      3
           MEV PROTONS                                                     19001  1      4
AUTHOR     (G.B.SAHA,N.T.PORILE,L.JAFFE)                                   19001  1      5
INSTITUTE  (1CANMOG) MCGILL UNIVERSITY,MONTREAL,QUEBEC                     19001  1      6
REFERENCE  (J,PR,144,962,6604)                                             19001  1      7
STANDARD   (29-CU-63,P*N) S.N.CHOSHAL,PR,80,939,5000                       19001  1      8
           (29-CU-65,P*NP) S.MEGHIR,L.YAFFE,UNPUBLISHED                    19001  1      9
PART-DET   (N) NEUTRONS                                                    19001  1     10
FACILITY   (SYNCY) MCGILL SYNCHROCYCLOTRON                                 19001  1     11
METHOD     (CHSEP) CHEMICAL SEPARATION AND POSITRON COUNTING               19001  1     12
DETECTOR   (SCIN) TWO NAI(TL) COINCIDENT DETECTION OF 511 KEV              19001  1     13
           ANNIHILATION GAMMA RAYS.                                        19001  1     14
ERR-ANALYS UNCERTAINTIES INCLUDE RANDOM ERRORS ASSOCIATED WITH THE         19001  1     15
           DETERMINATION OF PHOTO PEAK AREAS,DECAY CURVE ANALYSIS,         19001  1     16
           CHEMICAL YIELDS, AND SYSTEMATIC ERRORS ASSOCIATED WITH          19001  1     17
           COUNTER EFFICIENCIES AND SPREAD IN BEAM ENERGY. NO              19001  1     18
           ERRORS IN REFERENCE CROSS SECTION OR DECAY SCHEMES WERE         19001  1     19
           INCLUDED. RANDOM ERROR FROM SCATTER OF DATA IS MUCH             19001  1     20
           SMALLER THAN TOTAL ERROR WHICH RANGES 11-22 PERCENT.            19001  1     21
ENDBIB              19                                                     19001  1     22
NOCOMMON                                                                   19001  1     23
ENDSUBENT           22                                                     19001  199999
SUBENT        19001002       740301                                        19001  2      1
BIB                  1            1                                        19001  2      2
ISO-QUANT  (39-Y-89,P*N)                                                   19001  2      3
ENDBIB               1                                                     19001  2      4
NOCOMMON                                                                   19001  2      5
DATA                 3           19                                        19001  2      6
EN         DATA       DATA-ERR                                             19001  2      7
MEV        MB         MB                                                   19001  2      8
 5.         50.        5.5                                                 19001  2      9
 8.5        352.       39.                                                 19001  2     10
 12.        720.       79.                                                 19001  2     11
 15.        712.       78.                                                 19001  2     12
 18.5       552.       61.                                                 19001  2     13
 21.5       395.       43.                                                 19001  2     14
 24.8       194.       21.                                                 19001  2     15
 27.5       103.       11.                                                 19001  2     16
 30.5       61.4       6.8                                                 19001  2     17
 33.5       43.        4.7                                                 19001  2     18
 36.8       45.        5.                                                  19001  2     19
 42.        37.        4.1                                                 19001  2     20
 48.        29.4       3.2                                                 19001  2     21
 54.        29.7       3.3                                                 19001  2     22
 60.        23.3       2.6                                                 19001  2     23
 66.        19.7       2.2                                                 19001  2     24
 72.        17.        1.9                                                 19001  2     25
 78.        14.4       1.6                                                 19001  2     26
 85.        12.        1.3                                                 19001  2     27
ENDDATA             21                                                     19001  2     28
ENDSUBENT           27                                                     19001  299999
SUBENT        19001003       740301                                        19001  3      1
BIB                  1            1                                        19001  3      2
ISO-QUANT  (39-Y-89,P*2N)                                                  19001  3      3
ENDBIB               1                                                     19001  3      4
NOCOMMON                                                                   19001  3      5
DATA                 3           18                                        19001  3      6
EN         DATA       DATA-ERR                                             19001  3      7
MEV        MB         MB                                                   19001  3      8
```

```
 15.          68.          8.8                                           19001  3     9
 18.5         352.         46.                                           19001  3    10
 21.5         495.         64.                                           19001  3    11
 24.8         1252.        163.                                          19001  3    12
 27.          1248.        162.                                          19001  3    13
 27.5         1318.        171.                                          19001  3    14
 30.5         828.         108.                                          19001  3    15
 30.5         896.         116.                                          19001  3    16
 33.5         506.         66.                                           19001  3    17
 36.8         329.         43.                                           19001  3    18
 42.          172.         22.                                           19001  3    19
 48.          112.         15.                                           19001  3    20
 54.          82.5         11.                                           19001  3    21
 60.          73.4         9.5                                           19001  3    22
 66.          60.          7.8                                           19001  3    23
 72.          54.          7.                                            19001  3    24
 78.          46.          6.                                            19001  3    25
 85.          41.          5.3                                           19001  3    26
ENDDATA                 20                                               19001  3    27
ENDSUBENT               26                                               19001  399999
SUBENT          19001004       740301                                    19001  4     1
BIB                      1            1                                  19001  4     2
ISO-QUANT   (39-Y-89,P*3N)                                               19001  4     3
ENDBIB                   1                                               19001  4     4
NOCOMMON                                                                 19001  4     5
DATA                     3           14                                  19001  4     6
EN           DATA        DATA-ERR                                        19001  4     7
MEV          MB          MB                                              19001  4     8
 30.5         55.         6.6                                            19001  4     9
 33.5         114.        14.                                            19001  4    10
 36.8         313.        38.                                            19001  4    11
 40.          385.        46.                                            19001  4    12
 42.          333.        40.                                            19001  4    13
 42.          349.        42.                                            19001  4    14
 45.          299.        36.                                            19001  4    15
 48.          168.        20.                                            19001  4    16
 54.          91.         11.                                            19001  4    17
 60.          55.4        6.6                                            19001  4    18
 66.          54.         6.5                                            19001  4    19
 72.          47.5        5.7                                            19001  4    20
 78.          36.5        4.4                                            19001  4    21
 85.          31.5        3.8                                            19001  4    22
ENDDATA                 16                                               19001  4    23
ENDSUBENT               22                                               19001  499999
ENDENTRY                                                                 1900199999999
```

Enclosure 2

```
CHARGED PARTICLE DATA IN THE ENDF FORMAT                                     0 0  0    0
 39089.                              0          0          0           49001 1451    1
 0.0         0.0                     0          0          8           09001 1451    2
 YTTRIUM-89   EVALUATED 1974 BY S.PEARLSTEIN (BNL)                      9001 1451    3
 PRIM. REF.-PHYS. REV. 144(1966)962 SAHA, PORILE, AND JAFFE             9001 1451    4
             OTHER (P,XN) DATA AGREE TO ABOUT 60 PER CENT.              9001 1451    5
             NO INDIVIDUAL PARTICLE LEVEL EFFECTS INCLUDED.             9001 1451    6
             Q VALUES-NUC. DATA A9(1971)267. WAPSTRA AND GOVE.          9001 1451    7
             DATA NEAR THRESHOLD CALCULATED FROM SYSTEMATICS OF         9001 1451    8
              KFK-767, LANGE AND MUNZEL, MODIFIED BY PEARLSTEIN         9001 1451    9
              FOR NUCL. POTENTIAL EFFECTS AT LOW ENERGIES.              9001 1451   10
                                     1        451         14            9001 1451   11
                                    63         15         10            9001 1451   12
                                    63         16         11            9001 1451   13
                                    63         17         10            9001 1451   14
 0.0         0.0                     0          0          0           09001 1  0   15
 0.0         0.0                     0          0          0           09001 0  0   16
 39089.      89.877                  0          0          0        1001900163 15   17
            -3.6100E+06              0          0          2         21900163 15   18
           2           2            21          4                      900163 15   19
 3.5700E+06 0.0         4.0000E+06 0.007      4.5000E+06 0.020         900163 15   20
 5.0000E+06 0.050       6.0000E+06 0.14       7.0000E+06 0.26          900163 15   21
 8.0000E+06 0.36        1.0000E+07 0.56       1.2000E+07 0.73          900163 15   22
 1.4000E+07 0.75        1.6000E+07 0.69       1.8000E+07 0.58          900163 15   23
 2.0000E+07 0.46        2.2000E+07 0.32       2.4000E+07 0.20          900163 15   24
 3.0000E+07 0.066       3.2000E+07 0.052      3.3000E+07 0.049         900163 15   25
 3.4000E+07 0.047       5.0000E+07 0.030      1.0000E+08 0.0085        900163 15   26
 0.0         0.0                     0          0          0          0900163  0   27
 39089.      89.877                  0          0          0        1001900163 16   28
 0.0        -1.2900E+07              0          0          2         23900163 16   29
           2           2            23          4                      900163 16   30
 1.2760E+07 0.0         1.3500E+07 0.0018     1.4000E+07 0.013         900163 16   31
 1.4500E+07 0.038       1.5000E+07 0.068      1.6000E+07 0.110         900163 16   32
 1.8000E+07 0.235       2.0000E+07 0.45       2.2000E+07 0.76          900163 16   33
 2.4000E+07 1.13        2.5000E+07 1.28       2.6000E+07 1.32          900163 16   34
 2.7000E+07 1.30        2.8000E+07 1.20       3.0000E+07 0.92          900163 16   35
 3.4000E+07 0.48        3.8000E+07 0.28       4.0000E+07 0.23          900163 16   36
 4.2000E+07 0.172       4.6000E+07 0.126      5.0000E+07 0.10          900163 16   37
 5.5000E+07 0.08        1.0000E+08 0.03                                900163 16   38
 0.0         0.0                     0          0          0          0900163  0   39
 39089.      89.877                  0          0          0        1001900163 17   40
 0.0        -2.5100E+07              0          0          2         20900163 17   41
           2           2            20          4                      900163 17   42
 2.4820E+07 0.0         2.7000E+07 0.001      2.8000E+07 0.007         900163 17   43
 2.9000E+07 0.023       3.0000E+07 0.050      3.6000E+07 0.235         900163 17   44
 3.8000E+07 0.35        4.0000E+07 0.37       4.2000E+07 0.37          900163 17   45
 4.4000E+07 0.35        4.6000E+07 0.285      4.8000E+07 0.23          900163 17   46
 5.2000E+07 0.12        5.4000E+07 0.093      5.6000E+07 0.082         900163 17   47
 5.8000E+07 0.074       6.2000E+07 0.062      7.0000E+07 0.046         900163 17   48
 8.0000E+07 0.035       1.0000E+08 0.023                               900163 17   49
 0.0         0.0                     0          0          0          0900163 17   50
 0.0         0.0                     0          0          0          0900163 17   51
 0.0         0.0                     0          0          0          0   0 0  0   52
 0.0         0.0                     0          0          0          0  -1 0  0    0
```

1. Annotated listing appears on next page.

2. Format description appears in Enclosure 5 and ENDF-102.

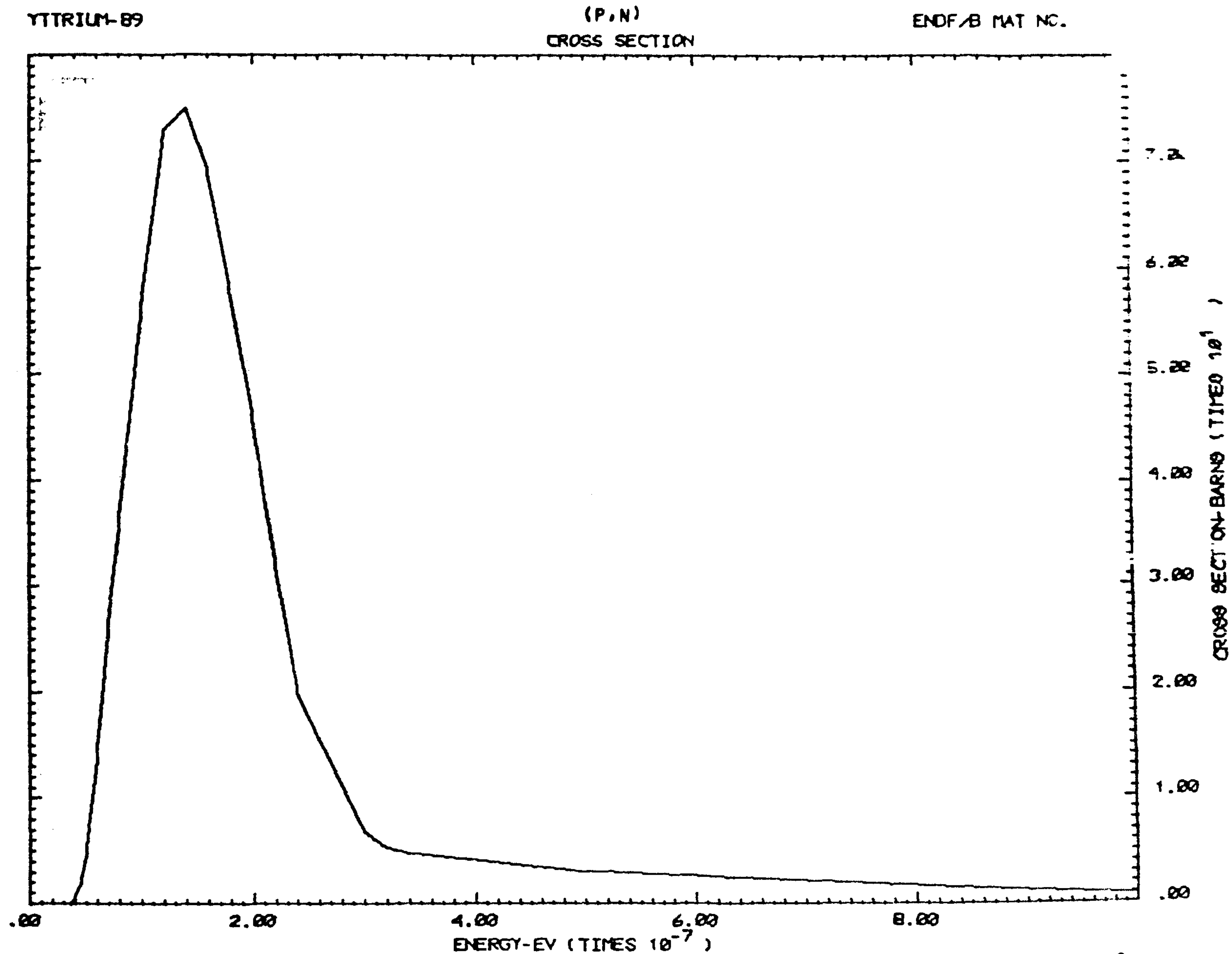
```
CHARGED PARTICLE DATA IN THE ENDF FORMAT                               0 0  0     0
39089.  1000*Z+A            0           0           0          49001 1451     1
0.0        0.0              0           0           8          09001 1451     2
YTTRIUM-89   EVALUATED 1974 BY S.PEARLSTEIN (BNL)                   9001 1451     3
PRIM. REF.-PHYS. REV. 144(1966)962 SAHA, PORILE, AND JAFFE          9001 1451     4
           OTHER (P,XN) DATA AGREE TO ABOUT 60 PER CENT.            9001 1451     5
           NO INDIVIDUAL PARTICLE LEVEL EFFECTS INCLUDED.           9001 1451     6
           Q VALUES-NUC. DATA A9(1971)267, WAPSTRA AND GOVE.        9001 1451     7
           DATA NEAR THRESHOLD CALCULATED FROM SYSTEMATICS OF       9001 1451     8
            KFK-767, LANCE AND MUNZEL, MODIFIED BY PEARLSTEIN       9001 1451     9
            FOR NUCL. POTENTIAL EFFECTS AT LOW ENERGIES.            9001 1451    10
Threshold Energy    Table of Cont.  1       451         14          9001 1451    11
                                   63  File  15  No. Cards  10      9001 1451    12
  Q Value      Target Mass         63  Reaction 16          11      9001 1451    13
               Particle Mass       63          17           10      9001 1451    14
0.0        0.0              0           0           0  Z  Z    09001 1  0        15
0.0        0.0              0           0           0          09001 0  0        16
39089.     89.877  LinX,LinY Int. 0  LinX,LogY Int. 0   0   1001 900163 15      17
          -3.6100E+06       0           0           2    No. of Regs  2 900163 15  18
        2          2        21          4                No. of Points  900163 15  19
3.5700E+06 0.0  σ    4.0000E+06 0.007       4.5000E+06 0.020        900163 15    20
5.0000E+06 0.050     6.0000E+06 0.14        7.0000E+06 0.26         900163 15    21
8.0000E+06 0.36      1.0000E+07 0.56        1.2000E+07 0.73         900163 15    22
1.4000E+07 0.75      1.6000E+07 0.69        1.8000E+07 0.58         900163 15    23
2.0000E+07 0.46      2.2000E+07 0.32        2.4000E+07 0.20         900163 15    24
3.0000E+07 0.066     3.2000E+07 0.052       3.3000E+07 0.049        900163 15    25
3.4000E+07 0.047     5.0000E+07 0.030       1.0000E+28 0.0085       900163 15    26
0.0        0.0              0           0           0          0900163  0    27
39089      89.877           0           0           0      1001900163 16    28
0.0       -1.2900E+07       0           0           2         2900163 16    29
        2          2        23          4                        900163 16    30
1.2760E+07 0.0       1.3500E+07 0.0018      1.4000E+07 0.013        900163 16    31
1.4500E+07 0.038     1.5000E+07 0.060       1.6000E+07 0.110        900163 16    32
1.8000E+07 0.235     2.0000E+07 0.45        2.2000E+07 0.76         900163 16    33
2.4000E+07 1.13      2.5000E+07 1.28        2.6000E+07 1.32         900163 16    34
2.7000E+07 1.30      2.8000E+07 1.20        3.0000E+07 0.92         900163 16    35
3.4000E+07 0.48      3.8000E+07 0.28        4.0000E+07 0.23         900163 16    36
4.2000E+07 0.172     4.6000E+07 0.126       5.0000E+07 0.10         900163 16    37
5.5000E+07 0.08      1.0000E+08 0.03                                900163 16    38
0.0        0.0              0           0           0          0900163  0    39
39089.     89.877           0           0           0      1001900163 17    40
0.0       -2.5100E+07       0           0           2         2900163 17    41
        2          2        20          4                        900163 17    42
2.4820E+07 0.0       2.7000E+07 0.001       2.8000E+07 0.007        900163 17    43
2.9000E+07 0.023     3.0000E+07 0.050       3.6000E+07 0.235        900163 17    44
3.8000E+07 0.35      4.0000E+07 0.37        4.2000E+07 0.37         900163 17    45
4.4000E+07 0.35      4.6000E+07 0.285       4.8000E+07 0.23         900163 17    46
5.2000E+07 0.12      5.4000E+07 0.093       5.6000E+07 0.082        900163 17    47
5.8000E+07 0.074     6.2000E+07 0.062       7.0000E+07 0.046        900163 17    48
8.0000E+07 0.035     1.0000E+08 0.023                               900163 17    49
0.0        0.0              0           0           0          0900163 17    50
0.0        0.0              0           0           0          0900163 17    51
0.0        0.0              0           0           0          0    0 0  0    52
0.0        0.0              0           0           0          0   -1 0  0     0
```

Incident Particle

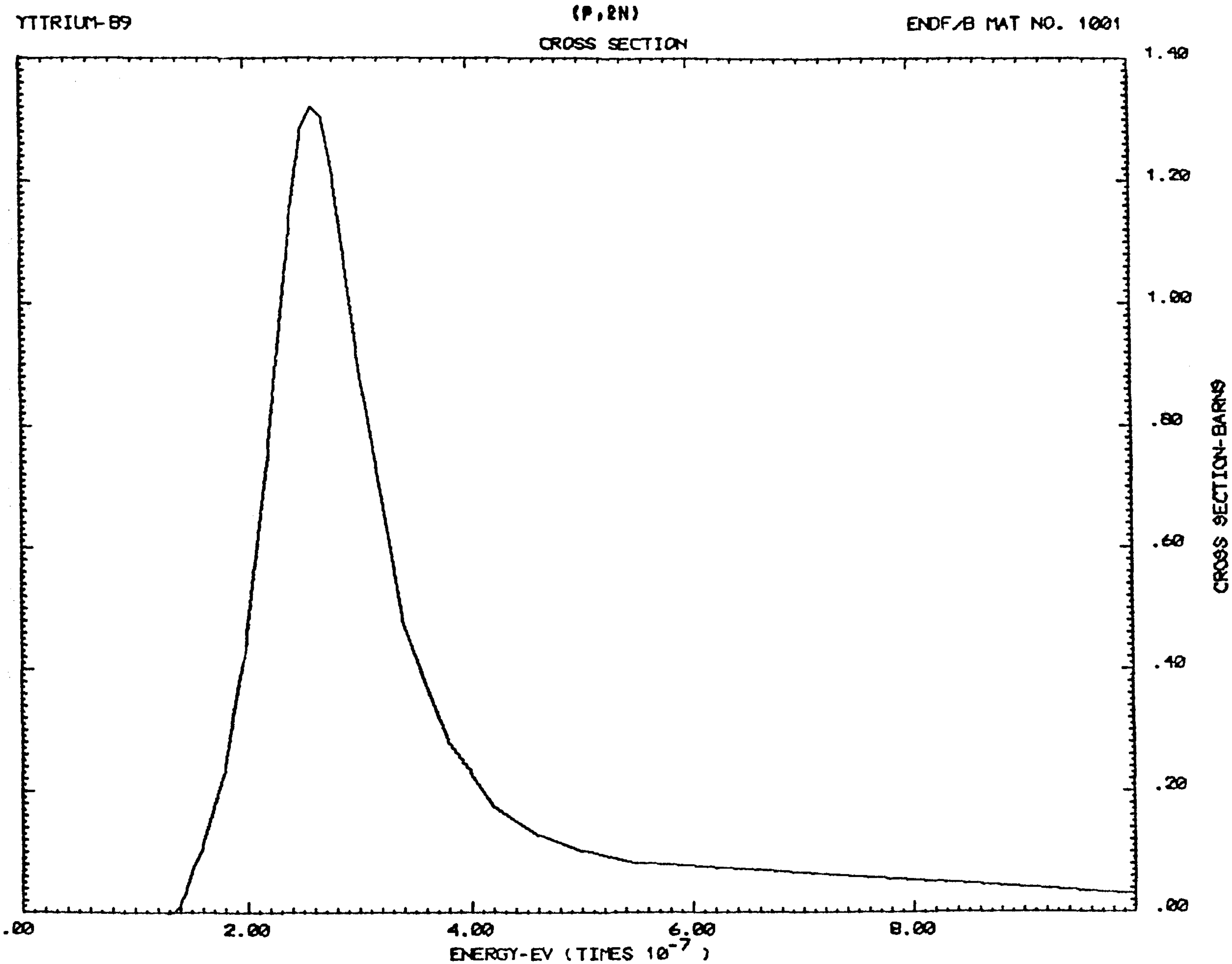
(,N) Reaction

(,2N) Reaction

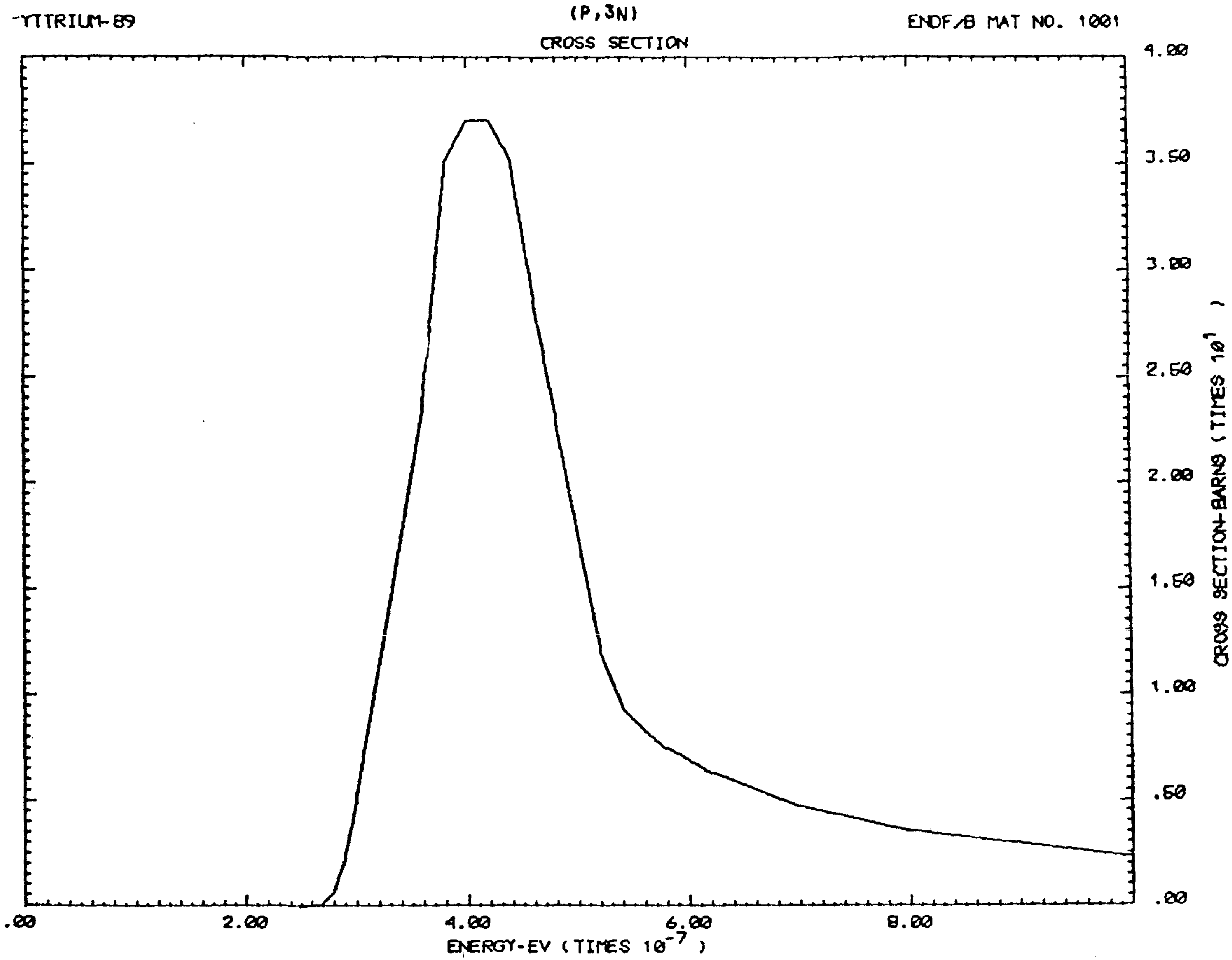
(,3N) Reaction


YTTRIUM-89
(P,N)
CROSS SECTION
ENDF/B MAT NO.
ENERGY-EV (TIMES 10^{-7})
CROSS SECTION-BARNS (TIMES 10^{1})

Enclosure 3



YTTRIUM-89
(P,2N)
CROSS SECTION
ENDF/B MAT NO. 1001
1.40
1.20
1.00
.80
.60
.40
.20
.00
CROSS SECTION-BARNS
.00
2.00
4.00
6.00
8.00
ENERGY-EV (TIMES 10^{-7})


YTTRIUM-89
(P,3N)
CROSS SECTION
ENDF/B MAT NO. 1001
4.00
3.50
3.00
2.50
2.00
1.50
1.00
.50
.00
CROSS SECTION-BARNS (TIMES 10^{1})
.00
2.00
4.00
6.00
8.00
ENERGY-EV (TIMES 10^{-7})

Enclosure 4

(P,N) REACTION

NUCLIDE	Q (MEV)	PEAK ENERGY (MEV)	PEAK XSECT (B)	AVERAGE XSECT(B) EVAPORATION SPECT T=5 MEV	T=10 MEV
23-V - 49	-3,35	11,1	4,2-1	2,1-1	1,9-1
23-V - 50	0,26	7,4	4,2-1	2,5-1	1,7-1
23-V - 51	-1,53	9,2	4,2-1	2,4-1	1,8-1
24-CR- 50	-8,41	16,4	4,5-1	1,1-1	1,6-1
24-CR- 52	-5,49	13,4	4,5-1	1,7-1	1,7-1
24-CR- 53	-1,38	9,2	4,5-1	2,4-1	1,8-1
24-CR- 54	-2,16	10,0	4,5-1	2,3-1	1,8-1
25-MN- 53	-4,53	12,5	4,7-1	1,9-1	1,8-1
25-MN- 54	-0,09	8,0	4,7-1	2,5-1	1,7-1
25-MN- 55	-1,01	9,0	4,7-1	2,5-1	1,8-1
26-FE- 54	-9,03	17,3	4,9-1	9,9-2	1,5-1
26-FE- 55	-4,24	12,4	4,9-1	1,8-1	1,7-1
26-FE- 56	-5,35	13,5	4,9-1	1,6-1	1,7-1
26-FE- 57	-1,62	9,7	4,9-1	2,3-1	1,7-1
26-FE- 58	-3,09	11,2	4,9-1	2,1-1	1,7-1
26-FE- 60	-0,56	8,6	4,9-1	2,4-1	1,7-1
27-CO- 57	-4,03	12,3	5,0-1	1,8-1	1,7-1
27-CO- 59	-1,86	10,1	5,0-1	2,2-1	1,7-1
27-CO- 60	2,04	6,1	5,0-1	2,3-1	1,4-1
28-NI- 58	-9,35	17,8	5,2-1	8,8-2	1,3-1
28-NI- 59	-5,58	14,0	5,2-1	1,5-1	1,6-1
28-NI- 60	-6,91	15,3	5,2-1	1,2-1	1,5-1
28-NI- 61	-3,03	11,4	5,2-1	2,0-1	1,6-1
28-NI- 62	-4,73	13,1	5,2-1	1,6-1	1,6-1
28-NI- 63	-0,72	9,0	5,2-1	2,3-1	1,6-1
28-NI- 64	-2,46	10,8	5,2-1	2,1-1	1,6-1
29-CU- 63	-4,15	12,6	5,3-1	1,7-1	1,6-1
29-CU- 65	-2,13	10,6	5,3-1	2,1-1	1,6-1
30-ZN- 64	-7,95	16,6	5,5-1	1,0-1	1,4-1
30-ZN- 65	-4,04	12,6	5,5-1	1,7-1	1,5-1
30-ZN- 66	-5,96	14,5	5,5-1	1,3-1	1,5-1
30-ZN- 67	-1,78	10,3	5,5-1	2,1-1	1,6-1
30-ZN- 68	-3,70	12,2	5,5-1	1,7-1	1,5-1
30-ZN- 70	-1,44	9,9	5,5-1	2,1-1	1,5-1

1. PARTIAL LIST OF NUCLIDES ON ENDF CHARGED PARTICLE TAPE.

2. DATA BASED ON PARAMETERIZATION OF THE SYSTEMATICS OF KFK-767, LANGE AND MUNZEL, MODIFIED BY PEARLSTEIN FOR NUCLEAR POTENTIAL EFFECTS AT LOW ENERGIES.

3. Q VALUES FROM NUCLEAR DATA A9(1971)267, WAPSTRA AND GOVE.

Enclosure 5

Format Modification: 73-9

Proposer: Non-Neutron Data Subcommittee

Date Approved: 12/12/73 (as "Experimental")

Affected Files: 51-91

Purpose:

Purpose

It is desirable to expand the ENDF/B formats to include reactions relating to neutron physics and other applications such as fusion and space shielding studies. The major types needed are charged particle induced reactions arising in neutron source reactions, other inverse neutron reactions and reactions arising from intense charged particle fluxes produced by reactor, outer space, and common accelerator sources. It is also necessary to specify which secondary particle is designated in angular and energy distributions.

The solution proposed allows these data to be included with the following advantages:

1. No changes are required to existing neutron induced data formats.

2. The same MAT no. is used for both neutron and non-neutron induced data. This is desirable since ENDF/B should contain only one MAT per target material.

3. Where appropriate, the same MT numbers are used for both neutron and non-neutron data.

4. No changes are required to codes processing the neutron data files. If the non-neutron data files are merged with the neutron files only minimal changes are required to some of these peripheral codes.

Proposed solution

Files 62-67 and 72-76 would be used in analogy to Files 2 -7 and 12-16 (Add 60 to the present MF Nos.). Formats for data uncertainties will be contained in Files 82-87 and 92-96 in analogy to Files 32-27 and 42-46.

1. MT numbers plus new ones as required would designate the exit channel(s). The exceptions would be MT = 1, 2, 3, and 4 where the exit channel would be taken the same as the entrance channel.*

2. Field 6 of the HEAD record is blank for all Files according to ENDF 102, Volumes I and II. This field will specify the ZA as 1000*Z+A of the incident particle (IZA) as a fixed point number. An IZA of 0 will designate a neutron induced reaction. Other IZA's are:

Incident Particle	IZA
gamma	1111 (defined)
beta minus	-1000
beta plus	1000
proton	1001
deuteron	1002
triton	1003
He-3	2003
alpha	2004
C-12	6012
O-16	8016
S-32	16032

IZA's for molecules and strange particles can be invented as needed.

3. An MT number is repeated for as many sections as there are incident particles for which data are specified. The convention is followed that MT numbers are arranged in order of ascending IZA. ENDF/B tapes can be supplied that do not contain merged neutron and non-neutron files.

4. According to ENDF 102 field 5 of the HEAD record is blank for all Files except File 5 for which Field 4 is blank. It is proposed that this field contain JZA, the 1000*Z+A of the particle designated in the angular or energy distribution following the same code as described above.

*MT=4 would continue to equal the sum of MT=51,52...,91. New MT's 800-819 would be defined to describe (x,n_0), $(x,n_1)\ldots(x,n_{18})$, (x,n_c), were x represents the incident particle. MT=15 would be used to define the total (x,n) cross section. Thus, for proton induced reactions field 6 of the HEAD record would contain 1001 and (p,p') total would be described by MT=4, (p,p') to discrete states and the continuum by MT=51-91, (p,n) total by MT=15, and (p,n') to discrete states and the continuum by MT=800-819. MT=15 and MT=800-819 cannot be used for neutron-induced reactions.

5. The structure of File 1 would be changed to include IZA and JZA in the dictionary. The CONT record for a non-neutron data section would contain JZA and IZA as floating point numbers in the first and second fields, respectively, so as to maintain the order in which they appear on the HEAD card of each section.

6. The structure of File 62 could be constructed analogous to neutron induced widths with the incident particle designated as in item 4 and resonance energies, widths, and other data defined by new formats and procedures to be specified at a later time.

7. Photon-induced nuclear reactions are to be handled in the same way as other non-neutron induced reactions. The word atomic should be added to the definitions for MT=501, 502, and 504 and MF = 23-26. MT = 518, 532 and 533 should be cancelled.

Examples

The structure of File 1 of a MAT containing File 3 sections for (n,np), (n,γ), and File 63 (p,γ) data and a File 4 section for (n,np) outgoing portion angular distribution data only is

[ZA,AWR,LRP,LFI,0,NXC]HEAD
[0.0,0.0,LDD,LFP,NWD,0/H(N)]LIST
[MAT,1,451,0.0,0.0,1,451,NC1,0]CONT
[MAT,1,451,0.0,0.0,3,28,NC2,0]CONT
[MAT,1,451,0.0,0.0,3,102,NC3,0]CONT
[MAT,1,451,0.0,1001.0,63,102,NC4,0]CONT
[MAT,1,451,1001.0,0,4,28,NC5,0]CONT
[MAT,1,0,0.0,0.0,0,0,0,0]SEND

The structure of File 63 containing (p,γ) data is

[MAT,63,MT=102/ZA,AWR,LIS,0,IZA=100]HEAD
[MAT,63,MT=102/T,Q,LT,0,NR,NP/E_{int}/σ(E)]TAB1
[MAT,63,0/0.0,0.0,0,0,0,0]SEND

The structure for File 4 containing (n,np) and File 64 containing (p,pα) angular distribution for the emerging proton is

[MAT,4,MT=28,/ZA,AWT,LVT,LTT,JZA=1001,0]HEAD
.....
.....
.....
[MAT,4,0/0.0,0.0,0,0]SEND
[MAT,64,MT=112/ZA,AWR,LVT,LTT,JZA=1001,IZA=1001]HEAD
.....
.....
.....
[MAT,64,0/0.0,0.0,0,0,0,0]SEND

The differential elastic distributions would be rationed to Rutherford scattering. Angular distributions for inelastic scattering and reaction data integrate to unity.

The structure of File 5 containing both (n,np) and File 65 containing energy distribution data for the emerging proton is

[MAT,5,MT=28/ZA,AWR,0,JZA=1001,NK,0]HEAD

.....

.....

.....

[MAT,5,0/0.0,0.0,0,0,0,0]SEND
[MAT,65,MT=112/ZA,AWR,0,JZA=1001,NK,IZA=1001]HEAD

.....

.....

.....

[MAT,65,0/0.0,0.0,0,0,0,0]SEND

The structure of File 6 would follow the rules for File 4.

Limitations

Simple additional tests would be required to DICTION and RIGEL and dictionary expansions made to the display codes. RIGEL can be modified by the NNCSC to output only neutron data files or only neutron and gamma files, etc. There would be no limitation to the user receiving an ENDF tape containing only neutron-induced reaction and gamma-gamma interaction data. This will probably be the normal distribution recommended by CSEWG. However, for those users requiring other types of data these may be included in the ENDF system with a minimum of modification to formats and processing codes.

Generalized EXFOR Isoquants *)

Action 33 on NDS from Ninth Four Center Meeting (Moscow, June 1973)

There have been no detailed comments on generalized isoquants as requested in action 32. A comment on possible structure can be found in Memo 4C-2/41, page 12. Therefore we do not consider this discussion as a proposal. We think that the alternative solutions presented here are capable of handling all types of reaction data. NDS definitely favors "Solution II". We would like comments from the other centers on the various methods and on implementation, so that we may prepare a final proposal by March 1.

The key problem to be faced is the method whereby information about the incident particle is provided in the isoquant construction. In the past this has been "neutron" by default or "no particle" in a few cases like spontaneous fission. We will examine two possible solutions.

Solution I. Construct additional mnemonics for the quants-field which includes the incident particle.

Examples
TØT — PTOT, DTOT, GTOT etc.
NF — PF, GF, DF etc.
N2N — P2N, G2N, D2N etc.

Advantage
1) No change is required in the present EXFOR system.

Disadvantage
1) Works nicely only if incident particle has a simple representation like neutron (N), proton (P) etc. What happens with LI-6 incident particles ?

2) Dictionaries 10 and 14 will become long, repetitious and difficult to work with.

3) Inconsistency of nomenclature in that some quantities will remain which have an assumed but not explicit first character N like TOT instead of NTOT.

4) Related to the first disadvantage is the fact that quantities representing multiple outgoing particles will be extremely complicated.

Solution II. Separate field for incident particle and reconstructed quant-field. (Currently used in WRENDA.)

* reproduced from Four Center Memo 4C-3/93

Examples   Z-S-A,N,TØT   Z-S-A,P,TØT etc.
Z-S-A,N,F   Z-S-A,P,F
Z-S-A,N,2N   Z-S-A,P,2N

Advantage

1) Incident particle separated and clearly identified with a field. Instead of the particle (N or P) a full (Z-S-A) could be given thus handling heavy particles automatically.

2) No more than normal increase in Dictionaries 10 and 14.

3) Disadvantage four of the previous solution remains but could be fixed as discussed below.

Disadvantage

1) Basic incompatibility of modifications with all previously compiled EXFOR entries. This leads to complications in processing programs allowing them to handle both versions simultaneously.

Adoption of this solution would seem to require the violation of one of the cardinal rules of EXFOR, namely "no changes to previously compiled entries can be required". Hans Potters mentioned at the Four-Center Meeting that an automatic machine modification of the isoquant field of old EXFOR files could probably be done with reasonable effort. Pamela Attree is not so sure of the "reasonable effort", she thinks there are complications, perhaps unforeseen by Hans Potters, at centres where the internal files are kept in an EXFOR-like format, complete with the ID-field.

Finally, there is the point that was suggested in Hans Potters' memo to separate the final particles in the quant-field with a slash as

Z-S-A,N,P/N   to mean $\sigma(N,PN)$

and thus generalized to

$$Z\text{-}S\text{-}A,N,Z_1\text{-}S_1\text{-}A_1\ /Z_2\text{-}S_2\text{-}A_2/\ \ldots.$$

It should be noted that a slash is currently used with a different meaning in the isoquant fields. Perhaps a different character from the permitted character set should be used instead. This proposal seems reasonable if we ever plan to compile data representing heavy particles in the exit channels and should be implemented simultaneously with Solution II if that option is selected so that major perturbations are made only once.

One minor detail which would improve visual readability is the suggestion to set off the incident particle and quantity fields with parentheses as

```
Z-S-A(N,TØT)
Z-S-A(P,2N)DA      etc.
```

This would seem to provide additional complication to the system for little return.

Implementation Procedure

Non-neutron induced data will anyway be stored in libraries separate from the neutron induced (plus spontaneous fission) library. There is no advantage of merging both into the same library, even if they have identical format.

Thus, let us start the non-neutron induced data with the new quantity scheme, without touching the present neutron-induced EXFOR. Later on one can decide what is more economical:

a) to continue to keep two different quantity-dictionaries, or

b) to convert the neutron-induced EXFOR library in a one-off program automatically to the new quantity scheme.

This can be decided only after the non-neutron induced EXFOR library is in successful operation for some period. Until that time no change in EXFOR should be made !

SHORT GUIDE TO EXFOR

Each EXFOR entry consists of several subentries. Each subentry may include two types of information (1. bibliographic, 2. numerical data). The first subentry contains only information applying to all the following subentries. Each item of bibliographic information is identified by keywords (e.g.: TITLE, METHOD, STANDARD, ISO-QUANT, etc...) which may exhibit a coded information within parenthesis (e.g.: DETECTOR (SCIN), METHOD (ACTIV), ANALYSIS (LSF), etc. ...). The meaning of most keywords is obvious. Except for ISO-QUANT and the keywords using similar codes (CMPD-QUANT, NUC-QUANT, STANDARD, RESID-NUC) the codes used are expanded in free text.

The numerical data belong to the following categories:

- numerical data which are common throughout the entry are entered in the first subentry under the DATA CONSTANTS table.
- numerical data which are common for a given subentry are entered under the DATA CONSTANTS table of this subentry.

  Each column of common data is independent and (probably) unrelated to other columns in the table.
- numerical data which are relevant to the single quantity defined by the keyword ISO-QUANT are entered in the DATA TABLE under DATA (or RATIO). ISO-QUANT stands for "isotope and quantity".

There is only one ISO-QUANT per subentry. The first subentry has no DATA-TABLE, therefore an EXFOR entry consists of at least two subentries (see example page 2). At the beginning of each table (DATA-TABLE or DATA CONSTANTS) there are two lines giving the Data-Heading keywords (e.g.: STAND, DATA, H-LIFE, etc.) and Data-Unit keywords (e.g.: MEV, B, NØ-DIM, etc. ...) for each data column. A dictionary of Data-Heading keywords is given on page 3.

```
NUCLEAR DATA SECTION, INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA.

     THE FOLLOWING INFORMATION APPLIES TO ALL SUB-ACCESSION NUMBERS
                                                 STARTING WITH 30081

BIBLIOGRAPHY & EXPERIMENTAL DESCRIPTION
     ****************************************************************
     TITLE        ANGULAR DISTRIBUTION OF GAMMA RAYS FROM INELASTIC
                   SCATTERING OF 14.1 MEV NEUTRONS BY C-12 AND O-16
     AUTHOR       (T.NISHI, ... [illegible])
     INSTITUTE     [illegible] INST. JAPAN JAER
                  (JPN[illegible])
     REP-YEAR     (55)
     REFERENCE
                  REPORT [illegible],1955
                  (R,[illegible]) [illegible] CURVES AND DATA TABLES
                  CURVES [illegible] SCALE
     STANDARD     (6-C-12,INL,,PAR) NORMALIZED TO THE TOTAL SIGMA
                   FOR EXCITATION OF THE 4.43 MEV STATE IN C-12.
     FACILITY     (ACCEL) 230 KEV DEUTERON ACCELERATOR
     N-SOURCE     (D-T) THE REACTION T(D,N)HE4 WAS USED
     METHOD       (COINC) THE COINCIDENCE CIRCUIT BETWEEN ALPHA AND GAMMA
                   DETECTORS WITH TIME RESOLUTION OF 20 NS GATED 400
                   CHANNEL PULSE HEIGHT ANALYSER,WHICH RECORDED THE GAMMA
                   RAYS SPECTRA.
     PART-DET     (G) GAMMAS
     ERR-ANALYS   NO ERROR ANALYSIS GIVEN
     DETECTOR     (SCIN) THE ALPHA PARTICLES DEFINING THE CONE OF 14.1
                   MEV NEUTRONS WERE DETECTED WITH SCINTILLATION COUNTER.
                   GAMMA RAYS FROM SAMPLES WERE DETECTED WITH A 2.5 CM
                   DIAMETER AND 5CM LONG NAI-SCINTILLATION COUNTER PLACED
                   AT 13 CM FROM THE SAMPLE.
     CORRECTION   THE CROSS-SECTIONS DETERMINED HAVE BEEN CORRECTED FOR
                  THE FOLLOWING EFFECTS:
                   .ATTENUATION OF INCIDENT NEUTRON BEAM IN THE SAMPLE
                   .ATTENUATION OF GAMMA RAYS IN THE SAMPLE
                   .ANGULAR SPREAD OF GAMMA RAYS
                   .RELATIVE DETECTION EFFICIENCY OF GAMMA RAYS FOR
                    DOUBLE ESCAPE PEAK
                  IN THE CALCULATION OF THESE CORRECTIONS THE MEASURED
                  PROFILE OF NEUTRON BEAM WAS TAKEN INTO ACCOUNT.
                  THE MULTIPLE SCATTERING CORRECTIONS WERE ONLY ESTIMATED
     STATUS       (RCIV) DATA FROM KOZLOWSKI (LETTER OF 17FEB67)
     HISTORY      (720125T) CONVERTED FROM DASTAR TO EXFOR
     ****************************************************************

DATA CONSTANTS
     STAND DEFINED ABOVE UNDER STANDARD.
     ****************************************************************
     EN           STAND
     MEV          MB
     14.1         245.
     ****************************************************************
```

Data common to all subentries in entry 30081

First subentry: information common to the entire entry

```
                         SUB-ACCESSION NUMBER 30081.002
                         ******************************

BIBLIOGRAPHY & EXPERIMENTAL DESCRIPTION
     ****************************************************************
     ISO-QUANT    (6-C-12,INE,DA,PAR) ANGULAR DISTRIBUTION
                  OF 4.43 MEV GAMMAS
     SAMPLE       (SOLID) THE SAMPLES OF GRAPHITE WERE CYLINDERS 5 CM
                   IN DIAMETER AND 5 CM LONG.
     HISTORY      (670402C) COMPILED INTO DASTAR-220
     ****************************************************************

DATA CONSTANTS
     ****************************************************************
     E
     MEV
     4.43
     ****************************************************************
```

Data common only to sub-entry 30081.002

```
DATA TABLE
     DATA DEFINED ABOVE UNDER ISO-QUANT
     ****************************************************************
     ANG          DATA         DATA-ERR
     ADEG         MB/SR        MB/SR
      30.         24.3         1.6
      45.         24.6         1.8
      60.         24.0         1.6
      75.         19.2         1.6
      90.         11.1         1.3
     120.         19.0         1.6
     135.         25.2         2.0
     ****************************************************************
```

Data defined under ISO-QUANT of subentry 30081.002

Second subentry

```
                         SUB-ACCESSION NUMBER 30081.003
                         ******************************

BIBLIOGRAPHY & EXPERIMENTAL DESCRIPTION
     ****************************************************************
     ISO-QUANT    (6-C-12,INE,LEG,PAR/RS)
     STATUS       (DEP) LEGENDRE-FIT TO ANGULAR DISTRIBUTION GIVEN IN
                  SUBENTRY .002
     ANALYSIS     (LSQ) LEAST SQUARES FIT
     HISTORY      (670402C) COMPILED INTO DASTAR-220
     ****************************************************************

DATA CONSTANTS
     ****************************************************************
     E
     MEV
     4.43
     ****************************************************************
```

Data common to subentry 30081.003

```
DATA TABLE
     DATA DEFINED ABOVE UNDER ISO-QUANT
     ****************************************************************
     NUMBER       DATA         DATA-ERR
     NO-DIM       NO-DIM       NO-DIM
     2.           0.74         0.10
     4.           0.45         0.14
     ****************************************************************
```

Data defined under ISO-QUANT of subentry 30081.003

Third Subentry

```
                         SUB-ACCESSION NUMBER 30081.004
                         ******************************

BIBLIOGRAPHY & EXPERIMENTAL DESCRIPTION
     ****************************************************************

     ... etc...
```

EXFOR ENTRY

Keyword	Explanation
EN	INCIDENT NEUTRON ENERGY, LAB-SYSTEM
EN-CM	INCIDENT NEUTRON ENERGY, C-M-SYSTEM
EN-MIN	LOW LIMIT OF INCIDENT N-ENERGY RANGE, LAB-SYSTEM
EN-CM-MIN	LOW LIMIT OF INCIDENT N-ENERGY RANGE, C-M-SYSTEM
EN-MAX	HIGH LIMIT OF INCIDENT N-ENERGY RANGE, LAB-SYSTEM
EN-CM-MAX	HIGH LIMIT OF INCIDENT N-ENERGY RANGE, C-M-SYSTEM
EN-DUMMY	DUMMY ENERGY, TO BE USED AS THE NUMERICAL EQUIVALENT OF AN INCIDENT NEUTRON SPECTRUM WHERE NO NUMERICAL ENERGY VALUE IS GIVEN BY THE AUTHOR
EN-RSL	INCIDENT-NEUTRON ENERGY-RESOLUTION
+EN-RSL	+UNSYMMETRIC ENERGY RESOLUTION
-EN-RSL	-UNSYMMETRIC ENERGY RESOLUTION
EN-ERR	ERROR OF MONOCHROMATIC INCIDENT-NEUTRON ENERGY OR UNCERTAINTY OF THE CENTRAL ENERGY IN AN INCIDENT NEUTRON-SPECTRUM.
EN-ERR1	ENERGY ERROR, IF MORE THAN ONE ERROR IS GIVEN. EXPLANATION UNDER 'ERR-ANALYS'.
EN-ERR2	SECOND ENERGY ERROR, IF MORE THAN ONE ERROR IS GIVEN. EXPLANATION UNDER 'ERR-ANALYS'
+EN-ERR	+ UNSYMMETRIC ENERGY-ERROR
-EN-ERR	- UNSYMMETRIC ENERGY-ERROR
EN-NRM	NORMALIZATION ENERGY, TO BE USED WHEN A DATA SET IS NORMALIZED TO ONE ENERGY ONLY.
EN-RES	RESONANCE-ENERGY
EN-RES-ERR	ERROR OF RESONANCE-ENERGY
MU-ADLER	MU IN ADLER ADLER RESONANCE ANALYSIS, EQUIVALENT TO RESONANCE ENERGY
E	ENERGY OF OUTGOING PARTICLE, LAB-SYSTEM
E-CM	ENERGY OF OUTGOING PARTICLE, C-M-SYSTEM
E-MIN	LOW LIMIT OF OUTGOING-PARTICLE E-RANGE, LAB-SYSTEM
E-CM-MIN	LOW LIMIT OF OUTGOING-PARTICLE E-RANGE, C-M-SYSTEM
E-MAX	HIGH LIMIT OF OUTGOING-PARTICLE E-RANGE, LAB-SYSTEM
E-CM-MAX	HIGH LIMIT OF OUTGOING-PARTICLE E-RANGE, C-M-SYSTEM
E-RSL	OUTGOING-PARTICLE ENERGY-RESOLUTION
E-ERR	OUTGOING-PARTICLE ENERGY-ERROR
E-EXC	EXCITATION-ENERGY
E-EXC-MIN	LOW LIMIT OF EXCITATION-ENERGY
E-EXC-MAX	HIGH LIMIT OF EXCITATION-ENERGY
E-LVL	LEVEL-ENERGY
E-LVL-INI	INITIAL LEVEL OF GAMMA-TRANSITION
E-LVL-FIN	FINAL LEVEL OF GAMMA-TRANSITION
E-LVL-ERR	LEVEL-ENERGY ERROR
E-LVL-MIN	LOW ENERGY-LIMIT OF A DISCRETE LEVEL-GROUP
E-LVL-MAX	HIGH ENERGY-LIMIT OF A DISCRETE LEVEL-GROUP
Q-VAL	Q-VALUE
Q-VAL-ERR	Q-VALUE ERROR
Q-VAL-MIN	LOWER LIMIT OF Q-VALUE
Q-VAL-MAX	UPPER LIMIT OF Q-VALUE
E-DGD	DEGREDATION IN NEUTRON ENERGY
E-DGD-ERR	ERROR OF DEGREDATION IN NEUTRON ENERGY
WVE-LN	WAVE-LENGTH
WVE-LN-ERR	WAVE-LENGTH ERROR
ANG	ANGLE, LAB-SYSTEM
ANG1	ANGLE DEFINITION TO BE SPECIFIED IN BIB SECTION
ANG2	SAME AS ANG1 USE ANG2,ANG3,ETC IF MORE THAN ONE ANGLE NEEDS TO BE DEFINED
ANG-CM	ANGLE, C-M-SYSTEM
ANG-MIN	LOW LIMIT OF ANGLE RANGE, LAB-SYSTEM
ANG-CM-MIN	LOW LIMIT OF ANGLE RANGE, C-M-SYSTEM
ANG-MAX	HIGH LIMIT OF ANGLE RANGE, LAB-SYSTEM
ANG-CM-MAX	HIGH LIMIT OF ANGLE RANGE, C-M-SYSTEM

Keyword (continued)	Explanation (continued)
ANG-RSL	ANGULAR RESOLUTION
ANG-ERR	ANGLE-ERROR
COS	COSINE OF ANGLE, LAB-SYSTEM
COS-CM	COSINE OF ANGLE, C-M-SYSTEM
COS-MIN	LOW LIMIT OF COS.OF ANGLE, LAB-SYSTEM
COS-CM-MIN	LOW LIMIT OF COS.OF ANGLE, C-M-SYSTEM
COS-MAX	HIGH LIMIT OF COS.OF ANGLE, LAB-SYSTEM
COS-CM-MAX	HIGH LIMIT OF COS.OF ANGLE, C-M-SYSTEM
COS-RSL	COSINE OF ANGULAR RESOLUTION
COS-ERR	COSINE OF ANGLE-ERROR
DATA	HEADING FOR COLUMN GIVING THE QUANTITY SPECIFIED UNDER 'ISO-QUANT'
DATA-CM	DATA GIVEN IN THE CENTRE OF MASS SYSTEM
DATA-MIN	LOW LIMIT OF DATUM
DATA-MAX	HIGH LIMIT OF DATUM
DATA-ERR	DATA-ERROR, EXPLANATION TO BE GIVEN UNDER 'ERR-ANALYS'
DATA-ERR1	FIRST DATA-ERROR, IF MORE THAN ONE ERROR-COL IS GIVEN. EXPLANATION UNDER 'ERR-ANALYS'
DATA-ERR2	SECOND DATA-ERROR, IF MORE THAN ONE ERROR-COL IS GIVEN. EXPLANATION UNDER 'ERR-ANALYS'
+DATA-ERR	+ UNSYMMETRIC DATA-ERROR, EXPLANATION UNDER 'ERR-ANALYS
DATA-ERR3	THIRD DATA-ERROR, IF MORE THAN ONE ERROR-COL IS GIVEN. EXPLANATION UNDER 'ERR-ANALYS'
-DATA-ERR	- UNSYMMETRIC DATA-ERROR, EXPLANATION UNDER 'ERR-ANALYS
RATIO	HEADING FOR COLUMN GIVING THE RATIO SPECIFIED UNDER 'ISO-QUANT', OR THE QUANTITY/STANDARD RATIO
RATIO-MIN	LOW LIMIT OF RATIO
RATIO-MAX	HIGH LIMIT OF RATIO
RATIO-ERR	RATIO-ERROR
RATIO-ERR1	FIRST RATIO-ERROR, IF MORE THAN ONE RATIO-ERROR IS GIVEN, EXPLANATION UNDER 'ERR-ANALYS'
RATIO-ERR2	SECOND RATIO-ERROR, IF MORE THAN ONE RATIO-ERROR IS GIVEN, EXPLANATION UNDER 'ERR-ANALYS'
+RATIO-ERR	+UNSYMMETRIC RATIO-ERROR, EXPLANATION UNDER 'ERR-ANALYS
-RATIO-ERR	-UNSYMMETRIC RATIO-ERROR, EXPLANATION UNDER 'ERR-ANALYS
STAND	HEADING FOR COLUMN GIVING THE NUMERICAL VALUE ASSUMED FOR THE ISO-QUANT SPECIFIED UNDER 'STANDARD'
STAND-ERR	STANDARD-ERROR
STAND1	FIRST STANDARD-VALUE IF MORE THAN ONE IS GIVEN. EXPLANATION UNDER 'STANDARD'
STAND2	SECOND STANDARD-VALUE IF MORE THAN ONE IS GIVEN. EXPLANATION UNDER 'STANDARD'
STAND1-ERR	ERROR OF FIRST STANDARD-VALUE
STAND2-ERR	ERROR OF SECOND STANDARD-VALUE
TEMP	TEMPERATURE
TEMP-ERR	TEMPERATURE-ERROR
H-LIFE	HALF-LIFE OF RESIDUAL NUCLEUS
H-LIFE-ERR	ERROR OF HALF-LIFE OF RESIDUAL NUCLEUS
FLAG	FLAG, MEANING OF FLAGS GIVEN UNDER THIS HEADING TO BE EXPLAINED IN BIB-SECTION UNDER 'FLAG'
NUMBER	NUMBER, USED TO SPECIFY INDICES, E.G. COEFF-NUMBERS, LEVEL-NUMBERS ETC.
NUMBER-CM	COEFFICIENT NUMBER OF LEGENDRE OR COSINE COEFFICIENTS WHEN THE FIT HAS BEEN DEDUCED FROM AN ANGULAR DISTRIBUTION IN WHICH THE ENERGIES ARE GIVEN IN THE CENTRE OF MASS SYSTEM
SPIN J	SPIN J OF RESONANCES, STRENGTH-FUNCTIONS, ETC.
MOMENTUM L	ANGULAR MOMENTUM L OF RESONANCES, STRENGTH-F'S, ETC.
PARITY	PARITY OF RESONANCE
MISC	HEADING FOR A COLUMN WITH SUPPLEMENTARY INFORMATION FOR WHICH NO DATA-HEADING KEYWORD HAS BEEN DEFINED. EXPLANATION TO BE GIVEN UNDER 'MISC-COL' KEYWORD
MISC1	FIRST MISCELLANEOUS COLUMN - IF MORE THAN ONE IS GIVEN SAME USAGE AS -MISC-(SEE ABOVE)
MISC2	SECOND MISCELLANEOUS COLUMN - IF MORE THAN ONE IS GIVEN SAME USAGE AS -MISC-(SEE ABOVE)

ISO-QUANT

This keyword is used to specify the target isotope and the quantity which is presented by the compiled data set in the DATA TABLE under DATA or RATIO. The coding is divided into 5 subfields each separated by a comma.

The first subfield specifies the target isotope by the atomic number Z, the element symbol S, the mass number A and the isomer code (for isotope in ground state, no isomer code is given) each separated by a hyphen. Mass-number 0 stands for natural isotopic composition of the element.

The other subfields specify the quantity.

NUCLEAR STRUCTURE DATA FILE

Preliminary Specifications

Nuclear Data Project

Oak Ridge National Laboratory

February 7, 1974

Revised — March 29, 1974

I. INTRODUCTION

The Nuclear Data Project at ORNL is building a computer-based file of nuclear structure data. This file contains, or will contain, the results of evaluations by the Nuclear Data Project of all experimental nuclear structure data for A > 44 which have been published in Nuclear Data Sheets. In addition, it is desirable that the files contain such new data as may have become available since the most recent revision of the Nuclear Data Sheets. In this latter activity it is necessary to solicit the assistance of the entire nuclear structure community in order that the task produces no large perturbation on the Project's principle activity of revising Nuclear Data Sheets.

This manual describes a standard input format for nuclear structure data. The format is sufficiently structured that bulk data can be entered efficiently, and at the same time, the format is flexible enough to provide a structure within which topics can be added as their importance becomes clear.

II. GENERAL STRUCTURE OF THE DATA FILE

A. Introduction

The Nuclear Structure Data File (NSDF) is made up from a collection of "data sets", each of which describes the results of a single experiment or the combined evaluated results of a number of experiments of the same type. The appearance of these data sets within the computer file is of less concern here than is the appearance of the data sets either before they enter the computer or after they have been retrieved. The Nuclear Data Project has designed a card-based (or card-image-based) external representation of a nuclear structure experiment, which may be used for preparing input to the computer file and for exchange of information retrieved from the computer file. In the remainder of this manual, we shall refer to the group of cards or card images as a data set, even though it is understood to be only an external version of the internal data set which makes up part of the data file.

B. Examples of "Data Sets"

The next few pages present examples of data sets. In all cases, the standard card formats have been used.

```
 53CO     53CO(M) DECAY                      70CE04,70JA22,72CE01                   731221
53CO   C  FROM 54FE(P,2N) E(THRESH)=26.3 MEV 4
53CO   C  DELAYED PROTON EMITTER, E(P)=1590 30, I(P)=1.5% EST. FROM SIGMA
53CO   C  NO (BETA+)(P) COIN

 64NI     64NI(P,P')                         73NDS                                  740228
64NI    L 0
64NI    L 1344                                           2
64NI    L 2275                                           0
64NI    L 2608                                           4
64NI    L 2865                                           2
64NI    L 3165                                           2 OR 4
64NI    L 3560                                           3
64NI    L 3850                                           5

 97MO     97NB B- DECAY                      73NDS 10,1     70AR11                  731221
97MO   FL E=10,J=25,Q=80
97NB    P 0.          9/2+                   72.1 M                     1936       16
97MO    L 0.0           5/2+
97MO    L 480.9         (3/2+)
97MO    L 657.9         (7/2,9/2+)
97MO    G 177.97                                                        0.005         ?
97MO    G 657.92                                                        98.5
97MO    B 1278.0       98.5                    5.4
97MO    L 719.5         (3/2+)
97MO    G 238.37                                                        0.05
97MO    G 719.47                                                        0.09
97MO    L 1024.5        (7/2,9/2+)
97MO    G 1024.53                                                       1.08
97MO    B  911.0       1.0                     6.8
97MO    L 1117.0        (7/2,9/2+)
97MO    G 1117.01                                                       0.09
97MO    B  819.0       0.09                    7.7
97MO    L 1148.6        (7/2,9/2+)                                                    ?
97MO    G 1148.56                                                       0.05 *
97MO    B  787.0       0.05                    7.9
97MO    L 1268.6        (7/2+)
97MO    G 549.25                                                        0.05
97MO    G 1268.63                                                       0.16
97MO    B  667.0       0.21                    7.0
97MO    L 1515.6        (7/2,9/2+)
97MO    G 857.50                                                        0.05
97MO    G 1515.64                                                       0.12
97MO    B  420.0       0.17                    6.4
97MO    L 1629.1        (7/2+)
97MO    G 909.57                                                        0.04
97MO    G 1148.6                                                        0.05 *
97MO    G 1629.13                                                       0.03
97MO    B  307.0       0.07                    6.3
```

SAMPLE B

98MO		98NB 2.8-S STATE DECAY		74NDS 11,247			731220	
98NB	P		(1+)	2.8 S	2	4.6E3	1 M2	
98MO	L	0	0+					
98MO	B	4600	90.6	4.5				
98MO	L	735.3	0+					
98MO	G	735.3				5.5		
98MO	B	3865	3.8	5.6				
98MO	L	787.5	2+					
98MO	G	787.5				3.0		
98MO	B	3812	0.9	6.2				
98MO	L	1432.1	2+					
98MO	G	644.6				0.8		
98MO	G	1432.1				0.8		
98MO	B	3168	1.5	5.6				
98MO	L	1758.8	(1+,2+)					
98MO	G	326.7				0.07		
98MO	G	971.3				0.8		
98MO	G	1023.5				1.5		
98MO	G	1758.8				0.14		
98MO	B	2841	2.5	5.2				
98MO	L	1985.5						?
98MO	G	1250.2				0.2		?
98MO	B	2614	0.2	6.1				
98MO	L	2207.1						
98MO	G	1419.6				0.4		
98MO	B	2393	0.4	5.6				
98MO	L	2608.5						
98MO	G	1821.0				0.1		
98MO	B	1991	0.1	5.9				

98MO		98NB 51-M STATE DECAY		74NDS 11,247			731220	
98NB	P		(4-,5-)	51.5 M	10	4.6E3	1 M1	
98MO	L	0	0+					
98MO	L	736	0+					
98MO	G	735.5						
98MO	L	787	2+					
98MO	G	787.2				97	C	
98MO	L	1432	2+					
98MO	G	644.6				4.6		
98MO	G	1431				3.1		
98MO	L	1509	4+					
98MO	G	722.3				78	CC	
98MO	B	3091	24.0	7.4				
98MO	L	1761						
98MO	G	971				1		?
98MO	G	1025				2		?
98MO	L	2018						
98MO	G	259						
98MO	G	1231						
98MO	G	2021						
		—						
		—						
98MO	L	3210						
98MO	G	1701				9.4	C	
98MO	B	— 1390	9.4	6.4				
98MO	L	3455						?
98MO	G	434				1		?
98MO	G	1946				1.5		?
98MO	G	2021				1		?
98MO	B	1145	3.5	6.5				

SAMPLE C

```
99PD      ADOPTED LEVEL                    74NDS
        Q -6037      108870    SY6286      30
        L 0              (5/2+)            21.4 M

 99NB     ADOPTED, 100MO(D,3HE)            74NDS  73Y002
        Q 3100       SY 7420   SY 8870     SY
99NB    L 0.             (9/2)+            14.3 S          4        2.7
99NB    L 369            (1/2)-            2.6 M           1        1.6          M1
99NB    L  562           (1/2,3/2)-                        1        2.5
99NB    L 816
99NB    L 970            (1/2,3/2)-                        1        0.7
99NB    L 1271           (1/2,3/2)-                        1        0.7
99NB    L 1413           (5/2,7/2)-                        3        2.3
99NB    L 1573           (5/2-,7/2-)                       (3)
        L 1746
        L 1967

 99RU     ADOPTED LEVELS                   74NDS
        Q -2052      20746P    5 8390      AP
 99RU   L      0               5/2+
 99RU   L      89.36           3/2+        20.6 NS
 99RU   L      322.2     (1/2,3/2,5/2+)
 99RU   L      340.6          (7/2+)
 99RU   L      442.8     (1/2,3/2)
 99RU   L      575.2     (7/2)
 99RU   L      617.5     (1/2,3/2)
99RU    L 618.0          (7/2+)
 99RU   L      719.2     (9/2+)
 99RU   L      734.2
 99RU   L      850.3
 99RU   L      897.2
 99RU   L     1000.2
 99RU   L     1026                                                                ?
 99RU   L     1048
 99RU   L     1070
 99RU   L     1261       (7/2+,9/2+)
 99RU   L     1292.1
 99RU   L     1313                                                                ?
 99RU   L     1382.9
 99RU   L     1497
 99RU   L     1505.1
 99RU   L     1532.9
 99RU   L     1572
 99RU   L     1662.1
 99RU   L     1749.1
 99RU   L     1761                                                                ?
 99RU   L     2058.6     (1/2-,3/2-)
 99RU   L     2268


 99MO     98MO(D,P)                        74NDS
99MO    L 0.0                                               0
 99MO   L      98                                           2
 99MO   L      236                                          4
 99MO   L      353                                          2
 99MO   L      529                                          0
 99MO   L      552                                          2
 99MO   L      619                                          2
 99MO   L      688                                          5
 99MO   L    _ 760                                         (4)
 99MO   L      798                                         (3)
 99MO   L      896                                        0,2
 99MO   L      913                                         (2)
 99MO   L      952                                          3
 99MO   L      1033                                         1
 99MO   L      1261                                         0
 99MO   L      1391                                         2
99MO    L 1453
 99MO   L      1493                                         2
 99MO   L      1549
 99MO   L      1672
 99MO   L      1722                                         1
 99MO   L      1755                                         2
 99MO   L      1812
 99MO   L      1845
 99MO   L      1930                                         0
 99MO   L      1948                                         0
```

```
99MO     ADOPTED LEVELS                   74NDS
      Q 1372.2    395917    6 9730        AP
99MO  L     0                1/2+         66.02 H
99MO  L 98            (3/2,5/2)+          16.8 US
99MO  L     235.5        (7/2,9/2)+
99MO  L     352          (3/2,5/2)+
99MO  L     525.5            1/2+
99MO  L     549          (3/2,5/2)+
99MO  L     615          (3/2,5/2)+
99MO  L     687       (9/2,11/2)-
99MO  L     753.5        (5/2,7/2)-
99MO  L     793          (3/2,5/2)+
99MO  L     889.5        (3/2,5/2)+
99MO  L     905              1/2+
99MO  L 913                                                       ?
99MO  L     945          (3/2,5/2)+
99MO  L     952          (5/2,7/2)-
99MO  L     1033         (1/2,3/2)-
99MO  L     1150         (1/2,3/2)-
99MO  L 1199                                                      ?
99MO  L 1209                                                      ?
99MO  L     1261             1/2+
99MO  L     1391         (3/2,5/2)+
99MO  L 1453                                                      ?
99MO  L 1475                                                      ?
99MO  L     1493         (3/2,5/2)+
99MO  L     1548
99MO  L     1672
99MO  L     1722         (1/2,3/2)-
99MO  L     1755         (3/2,5/2)+
99MO  L     1812
99MO  L     1845
99MO  L     1920         (1/2,3/2)-
99MO  L     1930             1/2+
99MO  L     1948             1/2+
99MO  L     1965             1/2+
99MO  L     2110
99MO  L     2200  AP
99MO  L     2360  AP
99MO  L     2430  AP
99MO  L     2490  AP
99MO  L     2540  AP
99MO  L     2641
99MO  L     2734
99MO  L     2791
99MO  L     2952                                                  ?


99TC     COUL. EXCITATION                 74NDS
99TC  L     0               9/2+
99TC  L    140.4            (7/2)+
99TC  G     140.4
99TC  L    181.7            (5/2)+
99TC  G      41.0                                     12
99TC  G     181.7                                     88
99TC  L    726.3         (7/2,9/2)+
99TC  G     586.1                                        11
99TC  G     726.3                                        89
99TC  L 761.8         (7/2,9/2)+
99TC  G     621.6                                        14
99TC  G     761.8                                        86


106MO    ADOPTED LEVELS                   74NDS                  740319
106MO Q 3300        SY
106MO L 0.0           0+                  9.5 S     5
106MO L 171.9       2 (2+)                                        ?
106MO G 171.9       2           (E2)
106MO L 522.1       5                                             ?
106MO G 350.2       5
```

124TE		124SB	B- DECAY		73NDS 10,124	69ME04		731220
124SB	P	0.	3-		60.20 D 3		2899.8	18
124TE	L	0.0	0+					
124TE	L	602.72	2+					
124TE	G	602.72	100	E2			98.36	C
124TE	B	2297.1	22.61		10.3			
124TE	L	1248.54	4+					
124TE	G	645.82	7.36	E2			7.23	CC
124TE	B	1651.3	2.45		10.6			
124TE	L	1325.50	2+					
124TE	G	722.78	11.50	E2+7.9%M1			11.25	CC
124TE	G	1325.49	1.44				1.41	C
124TE	B	1574.3	5.39		10.2			
124TE	L	1656.5	(0+)					
124TE	G	1053.8	0.009				0.009	
124TE	B	1243.3	0.009	LE	12.6	GE		
124TE	L	1747.0	(6+)				<0.05	
124TE	G	498.4	0.05	LT				C
124TE	L	1957.85	(4)+					
124TE	G	632.36	0.16				0.16	C
124TE	G	709.31	1.45				1.42	CC
124TE	G	1355.17	0.95				0.93	C
124TE	B	942.0	2.0		9.8			
124TE	L	2039.3	2+					
124TE	G	713.82	2.44				2.39	C
124TE	G	790.78	0.76				0.74	C
124TE	G	1436.66	1.04	M1,E2			1.02	C
124TE	G	2039.3	0.06				0.06	C
124TE	B	860.5	3.63		9.4			
124TE	L	2091.8	2+					
124TE	G	765.3	0.03				0.03	
124TE	G	1489.03	0.56	M1,E2			0.55	C
124TE	G	2091.8	<0.1				<0.1	
124TE	B	808.	0.68		10.0			
		—						
		—						
		—						
124TE	L	2774.87	(4+)					
124TE	G	736.	<0.13				<0.13 *	
124TE	G	816.8	0.08				0.08	C
124TE	G	1526.33	0.40				0.39	C
124TE	G	2172.	0.0010				0.0010	
124TE	B	124.9	0.53		7.5			
124TE	L	2885.9	(2,3)					
124TE	G	2283.2	0.008				0.008	
124TE	B	13.9	0.008		6.4			

178HF		177HF(N,G)	PRIMARY GAMMAS		74NDS			
	L	7625.7	2	3-,4-				S
	G	7532.6		(E1)			0.065	
	G	7319.1		(E1)			0.047	
	G	6451.0		(E1)			0.096	
	G	6357.3		(E1)			0.454	
	G	6304.9		(M1)			0.096	
	G	6241.0		(E1)			0.100	
	G	6216.1		(M1)			0.064	
	G	6192.0		(M1)			0.036	
	G	6175.4		(E1)			0.051	
	G	6110.					0.820	
	G	6092.0		(E1)			0.109	
	G	6064.3		(E1)			0.121	
	G	5988.8		(E1)			0.142	

```
178W      178HF(A,4NG), 181TA(P,4NG)      74NDS
178W   L     0.0          0+
178W   L   105.9          2+
178W   G   105.9                 E2
178W   L   342.2         (4+)
178W   G   236.3                (E2)
178W   L   694.2         (6+)
178W   G   352.0
178W   L  1141.          (8+)
178W   G   446.5
178W   L  1668.          (10+)
178W   G   527.
178W   L  2253.          (12+)
178W   G   585.
178W   L  2892.          (14+)
178W   G   639.

178LU     ADOPTED, 178YB B- DECAY         74NDS
178LU  Q 2.15E3    105.97E3  106.58E3     10
       L     0.          1(+)              28.4 M     2
       B   640.         90.  AP             4.9    AP
       L    42.4      (2+)
       G    42.4      .067       IF M1                                    4.0     LT
       L   300.    AP   (7,8,9)            22.7 M      4                           M
       L 390.8        (1+)
       G   390.8      1.00       IF M1                                    5.9     LT
       G   348.4      0.64       IF M1                                    4.2     LT
       B   250.        10.  AP              4.4    AP


178YB     ADOPTED LEVEL                   74NDS
178YB  Q 700         SY6670     SY
178YB  L 0              0+                74 M      3

178TA     ADOPTED, 178W EC DECAY          74NDS
178TA  Q    -89.     26.87E3  104.93E3    10
178TA  L      0.          1+               9.31 M    3
178TA  E 91                      100       4.7
  .    L  0.            (7)-               2.2  H    1                               M

178RE     ADOPTED LEVELS                  74NDS
178RE  Q  -2800.    AP  7720. AP   3340.  AP
178RE  L      0.        (3)                13.2 M     2

178IR     ADOPTED LEVELS                  74NDS
178IR  L      0.                          22 S      2

178PT     ADOPTED LEVELS                  74NDS
178PT  L      0.          0+               21.0 S     7
       L    169.
```

C. Summary of Data Set Structure

A data set is composed of records; each record is made up of one or more card images.

A data set must begin with an IDENTIFICATION record (with label information) and must end with an END record (a blank card). Between these two records, there will be as many additional records as are needed to describe fully the experiment or the evaluated data set.

Immediately following the IDENTIFICATION record is a group of records which contain information about the entire data set. The NORMALIZATION (N), Q-VALUES (Q), FORMAT (F), and PARENT (P) records are of this type.

The body of a data set is composed of numeric data records which describe the measured or deduced properties of levels, γ-rays, α-particles, etc. These records are associated with the level which decays (for GAMMA records) or the level which is populated (for B+, B-, EC, ALPHA records). Thus, each LEVEL record is followed by a group of records describing charged-particle decay into the level and γ-ray decay out of the level.

If a GAMMA record (or ALPHA or B+ or B-) properly belongs in a data set, but it cannot be associated with any particular level, then the record may be placed in the data set before any LEVEL records.

COMMENT records (C) may appear in the data set wherever they seem most appropriate. General remarks will usually follow the IDENTIFICATION record, while comments about a specific number should follow the record which contains that number.

III. STANDARD ONE-CARD RECORD FORMATS

A. Introduction

In most cases, all information for a RECORD can be placed on a single 80-column card. A "standard" format has been defined for each one-card record, such that the most commonly used quantities can be placed on a single card. The standard formats are described in this section for each reference. If a needed quantity is not included in the standard format or if a value will not fit within the field defined for the value by the standard format, then a FORMAT record will be required (see Section IV). If a record cannot be contained on a single card, then additional cards can be prepared as described in Section V.

B. The Standard One-Card RECORD Formats

RECORD formats are given below in the same order in which they would normally be encountered in a data set. Conditions under which each RECORD may appear or be required are given in parentheses. The format descriptions give the fields (in inclusive card-column numbers), the field names (the formal "name" of the quantity that goes into the field), and a brief field description. Card columns not explicitly included in the fields are expected to be blank. Additional information about each field can be found in the reference section noted.

1. THE IDENTIFICATION RECORD

(Required for all data sets)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
10-39	DSID	Data set identification	VI.B
40-74	DSREF	Data set references	VI.C
75-80	DATE	The date (year/month/day) when the data set was placed in the computerized data file	

2. THE FORMAT RECORD

(Required only if the standard format is not used. See Section IV)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
7	F	The letter "F" is required	
8	RTYPE	Record type being formatted	VI.D
10-80	FORMATS	A complete description of the format for records of type RTYPE; e.g., E = 10, DE = 19, J = 24, ... SYM = COL, where SYM is any quantity allowed for RTYPE records and COL is the column on RTYPE cards where the value of SYM begins	

3. THE COMMENT RECORD

(Optional with any data set)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
7	C	Letter "C" is required	
8	RTYPE	Record type being commented upon	VI.D
10-19	SYM (FLAG)	SYM = type of data being commented upon	IV.C
		FLAG = character in col. 77 of all level or gamma records to which the comment applies	
		If FLAG is omitted, there is some ambiguity about precisely which records are affected by the comment	
20-80	CTEXT	TEXT of the comment	
		Comment records may also be used to give numeric data which is not included elsewhere in the data set, e.g., X-rays, annihilation radiation	

4. THE NORMALIZATION RECORD

(Optional, used mostly with decay data sets)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
8	N	Letter "N" is required	
10-19	NR	Multiplier for converting relative photon intensity to photons per 100 decays of the parent through this decay branch	
20-21	DNR	Standard uncertainty in NR	VII
22-29	NT	Multiplier for converting relative transition intensity (including conversion electrons) to transitions per 100 decays of the parent through this decay branch	
30-31	DNT	Standard uncertainty in NT	VII
32-39	BR	Branching ratio multiplier for converting intensity per 100 decays through this decay branch to intensity per 100 decays of the parent nucleus	
40-41	DBR	Standard uncertainty in BR	VII

5. THE PARENT RECORD

(Optional, presence is desirable for decay data sets)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification for parent nucleus	VI.A
8	P	Letter "P" is required	
10-19	E	Energy of the decaying level in keV	
20-21	DE	Standard uncertainty in E	VII
22-39	J	Spin or parity or both	
40-49	T	Half-life; units must be given	VIII
50-55	DT	Standard uncertainty in T	VII

65-74	QP	Ground-state Q-value in keV (total energy available for g.s. → g.s. transition); will always be a positive number	
75-76	DQP	Standard uncertainty in QP	VII
78-79	MS	If E $\neq$ 0, then M or M1 indicates the first isomeric state; M2, the second, etc.	

6. THE Q-VALUE RECORD

(Optional in most data sets)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
8	Q	Letter "Q" is required	
10-19	Q^-	Total energy (keV) available for β^--decay of the ground state. May be negative	
20-21	DQ^-	Standard uncertainty in Q^-	VII
22-29	SN	Neutron separation energy in keV	
30-31	DSN	Standard uncertainty in SN	VII
32-39	SP	Proton separation energy in keV	
40-41	DSP	Standard uncertainty in SP	VII
42-49	QA	Total energy (keV) available for α-decay of the ground state	
50-55	DQA	Standard uncertainty in QA	VII
56-80	REF	Reference citation(s) for the Q-values	

7. THE LEVEL RECORD

(Optional, although a data set usually has at least one)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
8	L	Letter "L" is required	
10-19	E	Level energy in keV	
20-21	DE	Standard uncertainty in E	VII
22-39	J	Spin or parity or both	
40-49	T	Half-life of the level; units must be given	VIII.A
50-55	DT	Standard uncertainty in T	VII
56-64	L	Angular momentum transfer in the reaction determining the data set. Whether it is ℓ_n, ℓ_p, $\delta\ell$, etc., is determined from the DSID field of the IDENTIFICATION record	
65-74	S	Spectroscopic factor for this level as determined from the reaction in the IDENTIFICATION record	
75-76	DS	Standard uncertainty in S	VII
77	C	Comment flag; used to refer back to a particular comment record. Analogous to a footnote Letter "C" denotes an unresolved doublet or multiplet	
78-79	MS	Metastable state is denoted by M or M1 for the first isomer; M2, for the second, etc.	
80	Q	The character "?" denotes an uncertain or questionable level Letter "S" denotes a "pseudo-level" such as at the neutron or proton separation energy	

8. THE GAMMA RECORD

(Optional. Must follow the LEVEL record for the level from which the γ-ray decays. Records for γ-rays which are unassigned in a level scheme should precede the first level of the data set.)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
8	G	Letter "G" is required	
10-19	E	Energy of γ-ray photon in keV	
20-21	DE	Standard uncertainty in E	VII
22-29	RI	Relative photon intensity	
30-31	DRI	Standard uncertainty in RI	VII
32-41	M	Multipolarity of transition	
42-49	MR	Mixing ratio δ (sign must be shown explicitly if known)	
50-55	DMR	Standard uncertainty in MR	VII
56-62	CC	Total conversion coefficient	
63-64	DCC	Standard uncertainty in CC	VII
65-74	TI	Relative total transition intensity	
75-76	DTI	Standard uncertainty in TI	VII
77	C	Comment flag; refers back to a particular comment record. Analogous to a footnote	
		Letter "C" denotes unresolved doublet or multiplet	
78	ORG	Letter "C" denotes coincidence with a preceding radiation	
79	END	Letter "C" denotes coincidence with a following radiation	
80	Q	The character "?" denotes an uncertain or questionable line or an uncertain placement of the transition	
		Letter "S" denotes an expected, but as yet unobserved, transition	

9. THE β^--RECORD

(Optional. Must follow the LEVEL record for the level which is fed by the β^-.)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
8	B	Letter "B" is required	
10-19	E	Endpoint energy of the β^- in keV	
20-21	DE	Standard uncertainty in E	
22-29	IB	Intensity of the β-decay branch in percent of the total β^--decay	
30-31	DIB	Standard uncertainty in IB	VII
42-49	LOGFT	Log ft for the β^--transition	
50-55	DFT	Standard uncertainty in LOGFT	VII
77	COIN	Letter "C" denotes coincidence following radiation	
78-79	UN	Uniqueness classification for the β-decay, e.g., 1U, 2U; a blank signifies an allowed transition	
80	Q	The character "?" denotes an uncertain or questionable β^--decay Letter "S" denotes an expected or predicted transition	

10. THE EC (or EC + β^+) RECORD

(Optional. Must follow the LEVEL record for the level being populated in the decay.)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
8	E	Letter "E" is required	
10-19	E	Energy for electron capture to the level. If β^+-energy is measured, it is placed on a COMMENT record	
20-21	DE	Standard uncertainty in E	VII
22-29	IB	Intensity of β^+-decay branch in percent of the total $(\epsilon + \beta^+)$-decay	

30-31	DIB	Standard uncertainty in IB	VII
32-38	IE	Intensity of electron capture branch in percent of total $(\epsilon + \beta^+)$-decay	
40-41	DIE	Standard uncertainty in IE	VII
42-49	LOGFT	Log ft for $(\epsilon + \beta^+)$ transition	
50-55	DFT	Standard uncertainty in LOGFT	VII
77	COIN	Letter "C" denotes coincidence between β^+ and a following radiation	
78-79	UN	Uniqueness classification for ϵ, β^+ decay, e.g., 1U, 2U; blank signifies an allowed transition	
80	Q	The character "?" denotes an uncertain or questionable ϵ, β^+ branch	

11. THE ALPHA RECORD

(Optional. Must follow the LEVEL record for the level being populated in the decay.)

Field	Name	Description	Reference
Col. 1-5	NUCID	Nucleus identification	VI.A
8	A	Letter "A" is required	
10-19	E	Alpha energy in keV	
20-21	DE	Standard uncertainty in E	
22-29	IA	Intensity of α-decay branch in percent of the total α-decay	
30-31	DIA	Standard uncertainty in IA	VII
32-39	HF	Hindrance factor for α-decay	
40-41	DHF	Standard uncertainty in HF	VII
77	COIN	Letter "C" denotes coincidence with following radiation	
80	Q	The character "?" denotes uncertain or questionable α-branch	
		Letter "S" denotes an expected or predicted α-branch	

12. THE END RECORD

(Required for all data sets)

Field	Description
Col. 1-80	All columns are blank

C. Summary

The following figure summarizes the standard one-card formats for all allowed record types.

IF	PUNCH
≤	LE
<	LT
≥	GE
>	GT
≈	AP
SYST.	SY
?	?

NUCLEAR DATA SET–ORNL NUCLEAR DATA PROJECT

STANDARD FORMATS

1–5	6	7	8	9	10–19	20–21	22–29	30–31	32–39	40–41	42–49	50–55	56–62	63–64	65–74	75–76	77	78–79	80
nucleus			L		E	DE	J^{π}				T	DT	L		S	DS	C	MS	Q
nucleus			G		E	DE	RI	DRI	M		MR	DMR	CC	DCC	TI	DTI		ORG END	Q
nucleus			B		E	DE	IB	DIB			LOGFT	DFT						UN	Q
nucleus			E		E	DE	IB	DIB	IE	DIE	LOGFT	DFT						UN	Q
nucleus			A		E	DE	IA	DIA	HF	DHF									Q
nucleus			Q		Q–	DQ	SN	DSN	SP	DSP	QA	DQA	key number and date						
nucleus			N		NR	DNR	NT	DNT	BR	DBR									
nucleus		C	type		identification	comment in free form													
nucleus		F	type		symbol=														
nucleus					type of data set					key number (KN)									
nucleus			P		E	DE	J^{π}				T	DT			Q_{β}	DQ_{β}		MS	

IV. PREPARING FORMAT RECORDS

A. Introduction

If the standard one-card formats described in Section III.B are used, then there is no need to include a FORMAT record. A FORMAT record is required if the data items in a one-card record are too wide for the standard fields or if the data appear in an order different from the standard record or if data of a nonstandard type are to be included on the one-card record. Only the first card of a record may have its organization described by a FORMAT record. Continuation cards for the record will always contain their own format information (see Section V). A FORMAT record may not be used for the IDENTIFICATION record, a COMMENT record, the NORMALIZATION record, the Q-RECORD, the END record, or another FORMAT record.

B. Organization of the FORMAT Record

The FORMAT record will always contain the letter "F" in col. 7 and a character RTYPE (see Section VI.D) in col. 8 to identify the type of record the format of which is being specified by the FORMAT record. The FORMAT record must consist of only a single card; i.e., continuation cards are not allowed. The text of the FORMAT record is contained in cols. 10-80. The text consists of a series of equalities separated by commas or blanks; e.g., E = 10, DE = 20, J = 23, L = 40. In general, the form DTYPE = COL in a FORMAT record implies that the data of type DTYPE is always contained in a field beginning in column COL of the RTYPE record. By implication, the field width includes all space up to the next larger value of COL given for some other data type DTYPE.

If a FORMAT record is used, care must be taken to avoid conflicting format specifications. The same data type may not be identified with more than one location on the data record; i.e., E = 10, E = 25 is in error.

Since each field width is assumed to be the maximum available for the particular data type, it is important to specify the complete format of the record RTYPE. If the text of the FORMAT record for level records is E = 15, J = 25, T = 40, then ten card columns are allowed for E, 15 for J, and 41 columns are allowed for T. If any level record contains other information, e.g., the letter "C" for "unresolved doublet" in col. 77, then a strange value for the half-life (T) will be inferred since the information is within the field defined for "T" type information.

C. Allowed Data Types

Each record type is permitted to contain only a limited (but extendable) set of data types. For example, a GAMMA record is not allowed to contain information of data type DTYPE = J (nuclear spin). Neither may a LEVEL record contain LOG FT information. For each record type, the following table lists the data types permitted as of 11/15/73.

1. For the PARENT record

2. For the Q-VALUE record

All allowed data types are included in the standard format description in Sections III.B.5 and III.B.6.

3. For the LEVEL record

Allowed data types, E, DE, J, T, DT, L, S, DS, C, MS, Q, are described with the standard formats in Section III.B.7. Additional allowed data types are:

DTYPE	Description
MV	Level energy in MeV
DMV	"Standard" uncertainty in MV (Section VII)
UEV, UKV, UMV	Uncertainty in level energy, expressed in eV, keV, and MeV, respectively
PE	Percent uncertainty in level energy
UE	Uncertainty in level energy, given in same units as the level energy itself
A	Percent isotopic abundance
SIGNG	Thermal-neutron capture cross section
SIGNA	Total thermal-neutron absorption cross section
%EC, %SF, %IT, %B-, %B+, %A, %P, %N	Percent decay of the level by electron-capture, spontaneous fission, isomeric transitions, or emission of a β^-, β^+, α, proton, neutron
G	g-factor of the level
MOME1, MOME2, ...	Electric moments: dipole, quadrupole, ...
MOMM1, MOMM2, ...	Magnetic moments: dipole, quadrupole, ...
CONF	Nuclear configuration of the level
F	A "free-form" field (see Section IX)

4. The GAMMA Record

Allowed data types, E, DE, RI, DRI, M, MR, DMR, CC, DCC, TI, DTI, C, ORG, END, Q, are described with the standard formats in Section III.B.8. Additional allowed data types are:

DTYPE	Description
MV	Gamma energy in MeV
DMV	"Standard" uncertainty in MV (Section VII)
UEV, UKV, UMV	Uncertainty in γ-energy, expressed in eV, keV, and MeV, respectively
PE	Percent uncertainty in γ-energy
UE	Uncertainty in γ-energy, given in same units as the γ-energy itself
BE1, BE2, ...	Reduced electric transition probability (downward) given in units of $e^2 \times (\text{barns})^L$, where L = 1, 2, ...
BM1, BM2, ...	Reduced magnetic transition probability (downward) given in units of $\mu_N^2 \times (\text{barns})^L$, where L = 1, 2, ...
CEK, CEL, CEL1, ...	ce-intensity for K, L, L_1, ... conversion
KC, LC, L1C, ...	Theoretical K-, L-, L_1-conversion coefficient
EKC, ELC, EL1C, ...	Measured K-, L-, L_1-conversion coefficient
K/L, M/L, L1/L2, ...	ce-intensity ratios
PRI, PTI	Percentage uncertainty in RI, TI
URI, UTI	Uncertainty in RI, TI given in same units as RI, TI
F	A "free-form" field (see Section IX)

5. The B -Record

Allowed data types, E, DE, IB, DIB, LOGFT, DFT, COIN, UN, Q, are described with the standard formats in Section III.B.9. Additional allowed data types are:

DTYPE	Description
MV	Beta energy in MeV
DMV	"Standard" uncertainty in MV (Section VII)
UEV, UKV, UMV	Uncertainty in β-energy given in eV, keV, MeV, respectively
UE	Uncertainty in β-energy given in same units as energy

PE	Percentage uncertainty in β-energy
EAV	Average energy of the β-spectrum
F	A "free-form" file (see Section IX)

6. The EC Record

Allowed data types, E, DE, IB, DIB, IE, DIE, LOGFT, DFT, COIN, UN, Q, are described with the standard formats in Section III.B.10. Additional allowed data types are:

DTYPE	Description
MV	Energy for electron capture to a level given in MeV
DMV	"Standard" uncertainty in MV (Section VII)
UEV, UKV, UMV	Uncertainty in capture energy given in eV, keV, MeV, respectively
UE	Uncertainty in capture energy given in same units as the energy itself
PE	Percentage uncertainty in capture energy
EAV	Average energy of the β^+-spectrum
TI	Total (capture + β^+) intensity of the decay branch
DTI	Uncertainty in TI
K, L, M, N+	Probability for electron capture from the K, L, M, N+O ... shells

7. The ALPHA Record

All allowed data types are included in the standard format description in Section IV.B.11.

V. RECORDS CONTAINING MORE THAN ONE CARD

A. Card Enumeration

If all the information for a given record type cannot be contained on a single card, then it is possible to use additional cards to fully describe the record. The first card of a record will have the number 1 or a blank in col. 6. Subsequent cards will have running numbers: 2, 3, ... up to 9. It is not allowed to have continuation cards with the IDENTIFICATION record, the FORMAT record, the NORMALIZATION record, or the END record since these records consist of a single card. (The FORMAT record consists of a single card for each record type for which a special format is described.)

B. Formats for Continuation Cards

The first card of any record type has a standard format. The standard format may be overridden when necessary by a FORMAT record (Section IV). Additional cards for any record type (if permitted) do not have a standard format, and their format cannot be described with a FORMAT record. The second, third, and subsequent cards of any record type will contain structure of the type CEK = 47, %SF < 10E-3, MOME1 = 0.037 4. The data types in the general structure "DTYPE = data uncertainty" are limited to the same set of names that are allowed for describing nonstandard formats for the various record types (see Section IV). Here, however, the DTYPE identifier and the data value need not be equal, but may be connected by a relational operator from the following list:

LE	less than or equal to (≤)
LT or <	less than
GT or >	greather than
GE	greater than or equal to (≥)
AP	approximately equal to (≈)
SY	obtained from systematics
CA	calculated value

The alphabetic representations must contain a blank on either side, i.e., "_GT_", "_AP_".

VI. DETAILED FIELD DESCRIPTIONS

A. NUCID

The standard nucleus identification consists of two to five characters giving the A-value and the chemical symbol of a nucleus, e.g., 9B, 20F, 98RU, 177HF. The nucleus identification must be contained within the field defined for it (cols. 1-5 on most cards). It is recommended that the nucleus identification always begin in col. 1; i.e., it is left-adjusted. The nucleus identification must be included on every IDENTIFICATION record. It is strongly recommended that it also be included on every card of a data set except the END record. The data set will be handled correctly if all cards except the IDENTIFICATION record contain blanks in the NUCID field, but such decks are very difficult to edit.

B. DSID

The content of a data set is described in a standard way in the DSID field of the IDENTIFICATION record. The standards may be described under three general headings: 1) decay data sets, 2) reaction data sets, 3) "adopted" data sets.

1. For a data set describing the results of a measurement of radioactive decay, the DSID field contains three parts separated by one or more blanks — the decaying nucleus, the type of decay, and the word "DECAY", e.g.,

22NA	B+	DECAY
64Y	B-	DECAY
116M2IN	B-	DECAY
127MXE	IT	DECAY
133BA	EC	DECAY
214AT	A	DECAY
252CF	SF	DECAY

The decaying nucleus is identified by its standard NUCID (Section VI.A) and, if necessary, also by an embedded metastable-state code, M, M1, M2, etc. The code refers to the MS-field of the LEVEL record which describes the decaying level of the parent nucleus.

Five decay types are recognized in the DSID field:

B-	β-decay
EC, B+	electron capture and/or β^+-decay
A	α-decay
IT	isomeric state decay (γ-radiation only)
SF	spontaneous fission

2. For a data set describing results of a nuclear reaction study, the DSID field contains the target and the incoming and outgoing particles such as:

20NE(P,D)

48CA(A,A') for (α, α')

109AG(40AR,40AR')

90ZR(A,4NG)

The target nucleus and the reacting particle may be given in the standard form (see NUCID, Section IV.A). The reacting particles may alternatively be taken from the list of abbreviations:

P	proton (1H)	M+	μ-meson
N	neutron	M-	μ-meson
A	α-particle (4HE)	P+	π-meson
D	deuteron (2H)	P0	π-meson
T	triton (3HE)	P-	π-meson
G	γ-ray	NU	neutrino
		E	electron

3. An "ADOPTED" data set contains the best representation of the present experimental knowledge about the levels of a nucleus. The data set will be named, e.g.,

ADOPTED 187RE LEVELS

ADOPTED 64NI LEVELS

ADOPTED LEVELS

If all level information for a nucleus is contained in a data set for a single experiment, it is not necessary to make an ADOPTED data set as well. However, if more than one experimental data set contains level information about the nucleus, then a separate ADOPTED data set MUST be made, even if the ADOPTED data set contains only the Q-VALUE record and a simple ground-state LEVEL record.

An ADOPTED data set always contains (in its IDENTIFICATION record) a reference to the Nuclear Data Sheets or similar evaluation where the supporting data have been compared.

An ADOPTED data set contains a Q-VALUE record (e.g., as produced by the Atomic Mass Adjustment Program), which includes at least Q_β, S_n, S_p, if available.

An ADOPTED data set contains a LEVEL record for every level that has been reliably observed.

GAMMA records may also be included in an ADOPTED data set.

C. DSREF

References to supporting publications or analysis are placed in this field by means of standard Nuclear Data Project reference key numbers. If the data set describes a single measurement, then the key number of the published report of the measurement is sufficient. The DSREF file may include more than one key number, each of which refers to a particular publication. If different experimental results have been combined or modified to form the data set, then the DSREF field should also refer to the source of the combination or modification, e.g., the Nuclear Data Sheets as 73NDS, 74NDS.

The DSREF field will be used mostly internally to the Nuclear Data Project to keep records of which data have superseded or been modified by others. The DSREF field will be so assigned that distinct data sets will also have distinct DSREF fields.

D. RTYPE

A single-letter code that gives a name to the RECORD type.

RTYPE	Description
Blank	May be IDENTIFICATION record or END record
N	NORMALIZATION record
P	PARENT record
Q	Q-VALUE record
L	LEVEL record
G	GAMMA record
B	B- record
E	EC (or EC + B+) record
A	ALPHA record

In a FORMAT record, RTYPE may not be blank or "N".

VII. UNCERTAINTIES

Every experimental number entered into the data file should have an uncertainty associated with it if at all possible. Uncertainties may be numeric or non-numeric. Numeric uncertainties may be symmetric or asymmetric.

A. Standard Numeric Uncertainty

The "standard form" for expressing numeric uncertainties is as an integer uncertainty in the least significant digit(s) of the experimental number; i.e., $448.7 \pm 0.7 \rightarrow 448.7\ 7$; $0.3721 \pm 0.0014 \rightarrow 0.3721\ 14$. The RTYPE for a standard uncertainty is usually formed by adding the prefix D to the RTYPE of the datum, e.g., E, DE; RI, DRI; MV, DMV.

An asymmetric uncertainty may be written in the standard form by including signs; $0.84^{+0.10}_{-0.03} \rightarrow 0.84\ +10\ -3$. The convention on asymmetric uncertainties is that they combine algebraically with the datum, such that -3^{+1}_{-4} describes a range from -7 to -2.

B. Non-numeric Uncertainties

The non-numeric uncertainties include not only the symbols for approximate, calculated, systematics, but also the relational operators such as greater-than, less-than-or-equal-to, etc. The non-numeric uncertainty may be given either as a symbol or as a two-letter code in the uncertainty field:

Symbol	Letter code	Meaning
≈	AP	approximately
	CA	calculated
	TH	theoretical
>	GT	greater than
≥ or >=	GE	greater than or equal to
<	LT	less than
≤ or <=	LE	less than or equal to
	SY	systematics

(It is more natural to place certain of the relational operators in front of the value itself, e.g., > 1.3, LE 14, but at present these cannot always be handled by the system.)

VIII. EXPECTED AND ALLOWED UNITS

A. Half-lives must include units. Use

FS = 10^{-15} s	H = hour
PS = 10^{-12} s	D = day
NS = 10^{-9} s	Y = year
US ≡ μs = 10^{-6} s	KY = 10^{3} y
MS = 10^{-3} s	MY = 10^{6} y
S = second	GY = 10^{9} y
M = minute	

Computer-standard exponential format may be used. Examples:

3.7 PS = 3.7 E - 12 s

4.21 GY = 4.21 E 9 y

B. Signs of certain experimental quantities (nuclear moments, γ-ray mixing ratios) are as important as the numbers, themselves. If the sign is known, it should be given explicitly. If the sign is not known, then the absence of any sign is just as descriptive as the + - (or ±). If a value is known to be > 0, it must have a sign.

MEMO

March 20, 1974

To: Nuclear Data Project Compilers

From: W.B. Ewbank

Subject: Data Bank Standards

In anticipation of entering blocks of information from Nuclear Data Sheets into the computer-based data bank, the following standards are presented as minimum requirements for these data blocks. Some requirements are already in common use from preparing drawings. Other requirements are necessary or desirable for present and planned auxiliary programs. Comments are welcome and encouraged.

I. A-Chain Completeness

For each A-chain there should be at least one data set for each isotope. Usually there will be more.

II. Isotope Completeness

For each nucleus, there should be at least one data set for each distinct experiment giving level information about that nucleus. A rough guide to experiments is: "If it should be displayed in the Nuclear Data Sheets, there should be a data set".

For each nucleus there should be one, and only one, "Adopted levels" data set.

By convention, if only one data set exists for a nucleus, that data set will be treated as an "Adopted" data set. It should include the Q-record just as for any other "Adopted" data set (see IV.A below).

III. Data Set Identification

No two distinct data sets may have the same ID-record. The computer will accept only the first one. In a very few cases (e.g., capture gamma as noted below), a degeneracy may be removed artificially by adding a qualifying phrase.

Since we are using the ID-record in a "generic-key" indexing system, all data sets whose names begin with a given sequence of characters can be retrieved as a group, regardless of how the ID-records end. In general, the broadest categories should be mentioned first in the ID-record, with nuances and finer points coming later.

A. Radioactivity

For radioactivity data sets, the data set name (col. 10-39 of the ID-record) will include the parent isotope and the type of decay (B-, IT, EC, B+, A, SF). Data bank programs will make no distinction between EC and B+ as a decay type.

Isomers should be identified by their half-life, not by codes such as M, M1, etc.

Some acceptable data set names are:

63NI B- DECAY
2.6-M 99NB B- DECAY
54MN EC DECAY
3.89 79SE IT DECAY
106IN B+ DECAY

B. Nuclear Reactions

Wherever possible, the reaction should be given completely and explicitly, including the target.

Some experiments can be grouped efficiently; e.g., COUL. EXCIT. could summarize Coulomb excitation by protons, alpha particles, and heavy ions. Again, however, if you think it is necessary to display them separately in the Data Sheets, they should also be entered into the data bank as separate data sets.

Some acceptable data set names are:

169TM(N, G)
177HF(N, G) PRIMARY GAMMAS
65CU(3HE, A)
90ZR(P, P') IAS
COULOMB EXCITATION
COUL. EXCIT.
(HI, XNG) REACTIONS
181TA(P, 4NG)
181TA(N, G) E = 2 KEV

C. References

If the data set was used in a published A-chain (either as a figure or a table), you must include the year and flag: 74NDS, 71NDS.

Other principle references may be included in the reference field or may be carried on separate comment cards.

D. Date

The date when the data set entered the computer is automatically added by the system. You should not write anything in col. 75-80 of the ID-record, since it will be ignored and lost.

IV. Data Set Contents

Uncertainties should be given for all measured values and all adopted values whenever possible! Sometimes a general comment about uncertainties can obviate this requirement. However, no program can yet use an uncertainty which is not given on the same card with the primary quantity.

No more than two significant figures should be used for a standard uncertainty. The need for nonsignificant zeros can be removed by writing the measured quantity in computer-exponential style; e.g., 3500 ± 100 can be written 3.50E3 10.

A. "Adopted" Data Sets

The adopted data set for a nucleus must contain the Q-record for that nucleus.

The Q-record must include at least $Q(\beta-)$, S_n, S_p.

Each level record must include an adopted half-life (if known) and its uncertainty.

If a level decays by means other than isomeric transitions, the percent branching must be given if it is known.

Each level record may include a spin-parity only if it can be established according to NDP rules.

B. "Decay" Data Sets

1. Gamma records

Uncertainties on γ-ray energies should be included if available.

Include relative intensity (usually photon intensity) in same units as given by an author or as adopted by you after a renormalization. (You probably listed them on a Data Sheet, so they should be in a data set, anyway.)

Include γ-ray multipolarities if known or if assumed for constructing the decay scheme.

Give the total conversion coefficient if the conversion intensity is important.

2. Beta- and EC-records

Intensities should be given in percent of this type of decay, such that BR × intensity gives absolute percent per decay of the parent state.

If the IB-field on an E-record is blank, then the IE-field is presumed to contain total intensity ($\epsilon + \beta^+$).

An EC-decay data set must include a Q-card with at least a Q(β^-) entry. (I hope this restriction is temporary.)

Don't forget "1U" or "2U" in col. 78-79 for unique transitions.

3. Normalization record

Better to give all normalization information here than to "hide it" by giving total transition intensity with each γ-ray.

4. Parent record

Must be included with all decay data sets.

5. Level records

Include uncertainty in E (level) if available.

Give adopted J^π where available.

C. "Reaction" Data Sets

1. Gamma records

See notes above for "decay" data sets.

2. Level records

Give J^π only if it is established or strongly suggested by this particular reaction.

For transfer reactions, give ℓ-transfer if it is supported by an angular distribution.

WBE:sjb

The Digital Data Files of the Photonuclear Data Center

Henry M. Gerstenberg

The various files of digital data maintained by the Photonuclear Data Center are specified by the acquisition number assigned to a particular data set. Ample allowance has been made for any conceivable future demands on the system from this relatively small branch of nuclear physics. By the use of appropriate designators, each associated with a well-defined sub-area of physics, the file system could be expanded for use in other sub-areas. The major categories now being used are listed in Table I. The various categories are then defined and discussed in detail. Finally, specific examples are given.

Table I.

File Categories	Series	Range of Acquisition Number
Cross Section	00,000	1 - 9999
Spectra	10,000	10001 - 19999
Angular Distribution	20,000	20001 - 29999
Manipulated	30,000	30001 - 39999
Combination	40,000	40001 - 49999
(Not yet designated)	50,000-80,000	50001 - 89999
Evaluated Cross Section	90,000	90001 - 99999

Each file consists of a number of data sets. A particular data set consists of an identifier card and two label cards followed by an arbitrary number of comment cards and a series of data points. A data point is defined as a set of either two or three numbers depending upon whether or not a flag is indicated in the appropriate position on the identifier card for that particular data set. In the more usual case the two-number set gives abscissa and ordinate values. When the three-number set is flagged, abscissa, ordinate, and uncertainty in ordinate, are given for each data point.

The identifier card uses eight fields to specify the information contained in a given data set. The information given in these fields and their position on a card is indicated in Table II. The two label cards following the identifier card simply explain the abscissa and ordinate axes. A total of 32 character spaces is allowed on each card; the information normally starts in the first column.

Table II.

Information	Field Position	Start of Field -Right or Left Adjusted
Acquisition Number	1 - 5	Right
Number of Data Points	7 - 11	Right
Photonuclear Data Center Reference Number	13 - 18	Left
Nuclide for which data are given- (target nuclide for photon's incident, residual nucleus for capture reactions)	24 - 30	Left
Reaction	32 - 43	Left
No entry: indicates data were digitized by Data Center. 1: flag to indicate digital data were obtained directly from source.	45	-
No entry: two-number format for each data point used 1: flag to indicate three-number format for each data point, i.e., uncertainties in ordinate values are given.	47	-
Modification Code - used only for manipulated data file to define successive manipulations carried out on some original data set. Manipulations are defined by comment cards.	49 - 50	Right

<u>Cross Section File</u> - 00,000 Series (1 to 9999)

Any reaction cross section normally listed in the Photonuclear Data Index may be placed in this file. This may be digital data sent to the Center by authors or data digitized from journal articles. The intent is to use this file only for experimental cross section data that have not been modified. Thus, (γ,sn) data, derived from measured (γ,xn) data by a calculation, are <u>not</u> included. The acquisition number assigned to any data set is the lowest number currently available between 1 and 9999.

<u>Spectra File</u> - 10,000 Series (10001 to 19999)

This file contains data dealing with spectra of outgoing neutrons, protons, alpha particles, photons, etc. The acquisition number assigned to a data set is the lowest number currently available between 10001 and 19999. The energy or energies of the particles in the incident beam inducing the reaction is given on a comment card.

Angular Distribution File - 20,000 Series (20001 to 29999)

Angular distributions of any reaction product with respect to the incident beam direction are contained in this file. The acquisition numbering system is identical to that of the spectra file except that the range of numbers is between 20,001 and 29999. Data are normally given in terms of a Legendre polynomial expansion of the angular distribution. Point-wise data, i.e., angle vs differential cross section or yield may also be entered. The energy or range of energies of the detected particles is given as a comment.

Manipulated File - 30,000 Series (30001 to 39999)

Data from the cross section file that have been modified are found in this file. Typical examples of manipulated data would be (1) the inverse cross section as obtained by detailed balance, and (2) normalization of a cross section measured at a single angle for comparison with integrated over angle cross section data.

The acquisition number of the manipulated data is found by adding 30,000 to the acquisition numbers of the unmodified data set. If more than one manipulation of the original data set is made, then an additional two-digit integer code (a number between 1 and 99) is punched on the identifier card. These modifications are defined on the comment cards of the manipulated data sets.

Combination File - 40,000 Series (40001 to 49999)

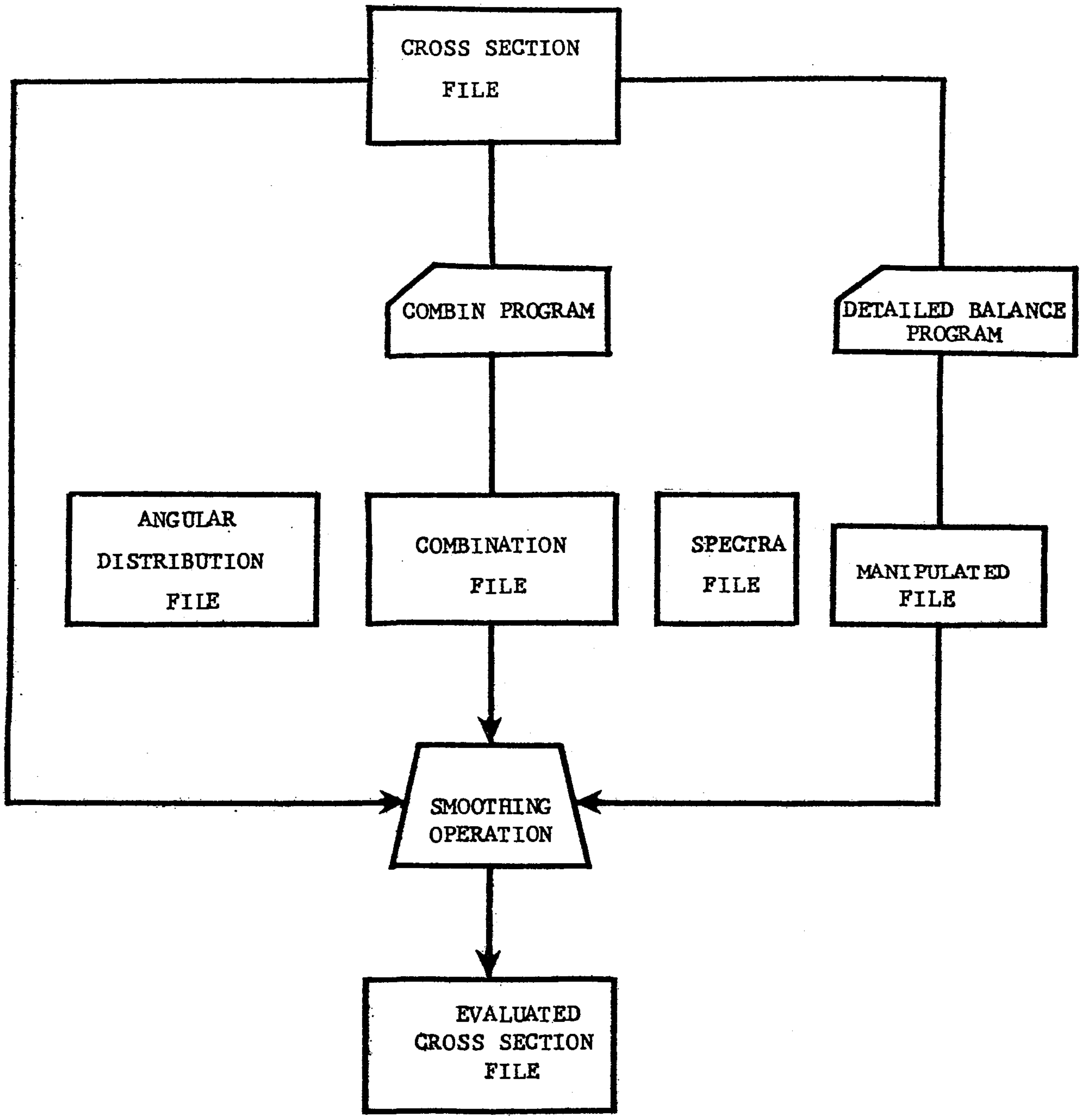
At the present time this file contains data sets that are the combination of two or more data sets from the cross section file. Most of the data in this series are created with the program COMBIN. Examples of data sets in this file are: (1) the (γ,xn) data set as obtained from the (γ,n), $(\gamma,2n)$, and $(\gamma,3n)$ data sets kept in the cross section file; (2) the cross section for a 'composite' natural element as made with the isotopic data for that element.

The data used to create this file as well as the data in the file itself are not smoothed. The emphasis is to modify the data as little as possible in obtaining the desired result. The acquisition number assigned to a data set in this file is the lowest number currently available between 40,001 and 49999.

Evaluated Cross Section File - 90,000 Series (90001 to 99999)

The contents of this file contain the 'recommended or best value' data to be used in the Atlas of Evaluated Photonuclear Cross Section Data. This file will generally consist of those cross sections which make the largest contribution to the total nuclear absorption cross section.

Except where data warrant a finer resolution, points are given at every half MeV. Cross sections are obtained by interpolating and 'smoothing' data presented in the cross section file. Cross section magnitudes are those obtained from the basic data. Any renormalizations that are felt to be necessary to obtain a 'best value' or consistency with other measurements are indicated on the comment cards. Acquisition numbering is accomplished by adding 90,000 to the cross section being evaluated.



Relationships of files and programs are discussed in the preceding pages.

Example 1. Cross Section File

The four cross sections listed here are used later to indicate how the basic measured data are used to generate other files.

```
********************************************************************************

 304    69 66BR1       59PR141 (G,N)        1
PHOTON ENERGY, (MEV)
CROSS SECTION, (MB)

 .8788+01, .4410+01, .9097+01, .0000    , .9407+01, .1517+02, .9717+01, .3175+02
 .1003+02, .3388+02, .1034+02, .4524+02, .1065+02, .4320+02, .1096+02, .5829+02
 .1126+02, .6455+02, .1158+02, .7315+02, .1188+02, .8025+02, .1219+02, .9955+02

 .2861+02, .3124+02, .2892+02, .3022+02, .2923+02,-.5320+01, .2954+02,-.2570+01
 .2985+02,-.1719+02,


 305    47 66BR1       59PR141 (G,2N)       1
PHOTON ENERGY, (MEV)
CROSS SECTION, (MB)

 .1560+02, .5370+01, .1591+02, .6320+01, .1622+02,-.1300+01, .1653+02, .9110+01
 .1684+02, .1920+01, .1715+02, .2000-01, .1746+02, .1950+01, .1777+02, .7230+01
 .1808+02, .2061+02, .1839+02, .3436+02, .1870+02, .3488+02, .1901+02, .3688+02
 .1932+02, .4834+02, .1963+02, .4282+02, .1994+02, .5934+02, .2025+02, .5613+02
 .2056+02, .5293+02, .2087+02, .4660+02, .2118+02, .5070+02, .2148+02, .4256+02
 .2180+02, .4267+02, .2211+02, .4832+02, .2241+02, .4309+02, .2272+02, .3143+02
 .2303+02, .3408+02, .2334+02, .3081+02, .2365+02, .2518+02, .2396+02, .3309+02
 .2427+02, .3137+02, .2458+02, .1378+02, .2489+02, .1157+02, .2520+02, .2037+02
 .2551+02, .2993+02, .2582+02, .1243+02, .2613+02, .1324+02, .2644+02, .1967+02
 .2675+02, .4420+01, .2706+02, .1024+02, .2737+02, .2020+02, .2768+02, .2820+02
 .2799+02, .2320+02, .2830+02, .1800+01, .2861+02, .6000+01, .2892+02, .7200+01
 .2923+02, .8000+01, .2954+02, .3000+01, .2985+02, .1670+02,


 306    17 66BR1       59PR141 (G,3N)       1
PHOTON ENERGY, (MEV)
CROSS SECTION, (MB)

 .2799+02, .7400+00, .2830+02, .5730+01, .2861+02,-.6800+00, .2892+02, .3810+01
 .2923+02, .1670+01, .2954+02, .4170+01, .2985+02, .4050+01, .3015+02, .7600+01
 .3045+02, .9180+01, .3078+02, .7500+01, .3108+02, .8780+01, .3138+02, .7620+01
 .3170+02, .1275+02, .3202+02, .1010+02, .3233+02, .1068+02, .3265+02, .1650+02
 .3296+02, .1078+02,


 225   231 64AL2        6C 12  (P,G)
PROTON ENERGY, (MEV)
CROSS SECTION, (MB)

 .9790+00, .1293-01, .1047+01, .1389-01, .1093+01, .1580-01, .1138+01, .1675-01
 .1183+01, .1771-01, .1229+01, .1961-01, .1297+01, .2104-01, .1365+01, .2295-01
 .1388+01, .2343-01, .1456+01, .2486-01, .1524+01, .2582-01, .1616+01, .2488-01

 .1331+02, .1989-01, .1335+02, .2370-01, .1345+02, .2086-01, .1354+02, .1896-01
 .1361+02, .1755-01, .1370+02, .1851-01, .1379+02, .1947-01
********************************************************************************
```

Example 2. Spectra File

This file contains data dealing with the spectra of neutrons, protons, alpha-particles, photons, etc. Shown below is an example of a neutron spectrum obtained with a peak bremsstrahlung energy of 14 MeV.

```
********************************************************************************

10033    14 65MU1       73TA181 (G,N)
NEUTRON ENERGY, (MEV)
(DN/DE)/E
C   DATA TAKEN WITH A PEAK BREMSSTRAHLUNG ENERGY OF 14 MEV.

 .6020+00, .3091+05, .1005+01, .1691+05, .1391+01, .8331+04, .1793+01, .4042+04
 .2212+01, .1931+04, .2598+01, .9804+03, .3001+01, .5613+03, .3404+01, .3679+03
 .3807+01, .2640+03, .4210+01, .1757+03, .4598+01, .1299+03, .5017+01, .7663+02
 .5403+01, .4730+02, .5804+01, .1418+02

********************************************************************************
```

Example 3. Angular Distribution File

Angular distribution of any reaction products are contained in this file. The sample below gives $-A_2/A_0$ for a Legendre polynomial fit to the neutron angular distribution obtained with a peak bremsstrahlung energy of 13 MeV. The neutron energy ranged from about .5 to 3.5 MeV.

```
********************************************************************************

20001    12 66MU1       73TA181 (G,N)
NEUTRON ENERGY, (MEV)
ANGULAR DISTRIBUTION, (-A2/A0)
C   BREMSSTRAHLUNG BEAM WITH PEAK ENERGY OF 13 MEV WAS USED.  NEUTRON
C   ENERGY RANGED FROM ABOUT .5 TO 3.5 MEV.

 .5999+00,-.3185-02, .1187+01, .2535-02, .1672+01, .5184-02, .2132+01, .1104-01
 .2541+01, .2970-01, .2912+01, .5158-01, .3270+01, .8940-01, .3577+01, .1177+00
 .3909+01, .1460+00, .4228+01, .1616+00, .4394+01, .1678+00, .4561+01, .1740-

********************************************************************************
```

Example 4. Manipulated File

The (γ,p) cross section derived from the (p,γ) cross section, given by data set 225, by means of the detailed balance program.

```
********************************************************************************

30225    231 64AL2      6C 12  (G,P)
PHOTON ENERGY, (MEV)
CROSS SECTION, (MB)
C   (P,G) CROSS SECTION USED TO GET (G,P) CROSS SECTION USING DETAILED
C   BALANCE PROGRAM.

 .1687+02, .2809+00, .1693+02, .3203+00, .1697+02, .3785+00, .1701+02, .4158+00
 .1705+02, .4548+00, .1710+02, .5206+00, .1716+02, .5852+00, .1722+02, .6669+00

 .2846+02, .1863+01, .2854+02, .1967+01, .2863+02, .2070+01

********************************************************************************
```

Example 5. Combination File

A sample of the data set in the combination file. This data set gives the total neutron yield cross section, (γ,xn). It was obtained by combining data sets #s 304, 305, and 306 from the cross section file along with the appropriate neutron multiplicity factors.

```
********************************************************************************
40020    69 66BR1        59PR141 (G,XN)        1
PHOTON ENERGY, (MEV)
CROSS SECTION, (MB)
C    (G,XN) OBTAINED FROM (G,N)+2*(G,2N)+3*(G,3N). USED DATA SETS NUMBER 304,
C    305, AND 306. DATA CUTS OFF AT 29.85 MEV-THE LIMIT OF THE N AND 2N DATA.

 .8788+01, .4410+01, .9097+01, .0000    , .9407+01, .1517+02, .9717+01, .3175+02
 .1003+02, .3388+02, .1034+02, .4524+02, .1065+02, .4320+02, .1096+02, .5829+02
 .1126+02, .6455+02, .1158+02, .7315+02, .1188+02, .8025+02, .1219+02, .9955+02
 .1250+02, .1221+03, .1281+02, .1379+03, .1312+02, .1614+03, .1343+02, .1933+03
 .1374+02, .2229+03, .1405+02, .2510+03, .1436+02, .2894+03, .1467+02, .3143+03
 .1498+02, .3356+03, .1529+02, .3310+03, .1560+02, .3199+03, .1591+02, .2923+03
 .1622+02, .2661+03, .1653+02, .2404+03, .1684+02, .2094+03, .1715+02, .1837+03
 .1746+02, .1656+03, .1777+02, .1572+03, .1808+02, .1512+03, .1839+02, .1371+03
 .1870+02, .1250+03, .1901+02, .1288+03, .1932+02, .1385+03, .1963+02, .1116+03
 .1994+02, .1345+03, .2025+02, .1219+03, .2056+02, .1167+03, .2087+02, .9241+02
 .2118+02, .9423+02, .2148+02, .9906+02, .2180+02, .1033+03, .2211+02, .9612+02
 .2241+02, .9840+02, .2272+02, .8668+02, .2303+02, .9568+02, .2334+02, .8204+02
 .2365+02, .7299+02, .2396+02, .8762+02, .2427+02, .7864+02, .2458+02, .5461+02
 .2489+02, .4046+02, .2520+02, .5160+02, .2551+02, .6190+02, .2582+02, .5890+02
 .2613+02, .3172+02, .2644+02, .4221+02, .2675+02, .3158+02, .2706+02, .4130+02
 .2737+02, .5490+02, .2768+02, .5117+02, .2799+02, .5864+02, .2830+02, .3354+02
 .2861+02, .4120+02, .2892+02, .5605+02, .2923+02, .1569+02, .2954+02, .1594+02
 .2985+02, .2836+02
********************************************************************************
```

Example 6. Evaluated Cross Section File

Samples of evaluated data for Pr-141. Smoothing of the data was done on data sets #s 305 and 306 as found in the cross section file.

```
********************************************************************************
90305    26 66BR1        59PR141 (G,2N)        1
PHOTON ENERGY, (MEV)
CROSS SECTION, (MB)
C    SMOOTHED DATA POINTS.  MARCH,74 HMG

 .1750+02, .4977+01, .1800+02, .1624+02, .1850+02, .2960+02, .1900+02, .4227+02
 .1950+02, .5442+02, .2000+02, .5734+02, .2050+02, .5566+02, .2100+02, .5236+02
 .2150+02, .4833+02, .2200+02, .4441+02, .2250+02, .4064+02, .2300+02, .3675+02
 .2350+02, .3326+02, .2400+02, .3023+02, .2450+02, .2688+02, .2500+02, .2367+02
 .2550+02, .2062+02, .2600+02, .1760+02, .2650+02, .1541+02, .2700+02, .1303+02
 .2750+02, .1090+02, .2800+02, .9070+01, .2850+02, .7234+01, .2900+02, .5760+01
 .2950+02, .4018+01, .3000+02, .2760+01

90306    12 66BR1        59PR141 (G,3N)        1
PHOTON ENERGY, (MEV)
CROSS SECTION, (MB)
C    SMOOTHED DATA POINTS.  MARCH,74 HMG

 .2750+02,-.4751+00, .2800+02, .8382+00, .2850+02, .2111+01, .2900+02, .3367+01
 .2950+02, .4655+01, .3000+02, .5976+01, .3050+02, .7235+01, .3100+02, .8504+01
 .3150+02, .9755+01, .3200+02, .1100+02, .3250+02, .1223+02, .3300+02, .1348+02
********************************************************************************
```

Examples of Computer-Drawn Cross Section Data

Figure 1 is an example of the computer-drawn cross section data for praseodymium. The open circles show the σ(γ,n) data from the data set #305 as found in the cross section file. The points show these data after smoothing. The smoothed data were then interpolated, to obtain values at every half MeV, and placed in the evaluated cross section file as data set #90305. The σ(γ,3n) data (the crosses show the basic data and the line shows the smoothed data) were handled in a similar way.

Figure 2 shows the σ(p,γ) data set #225 as found in the cross section file. These data were used as input to the detailed balance program; the output was the inverse reaction cross section and is shown in Fig. 3. The output was placed in the manipulated file as data set #30225.

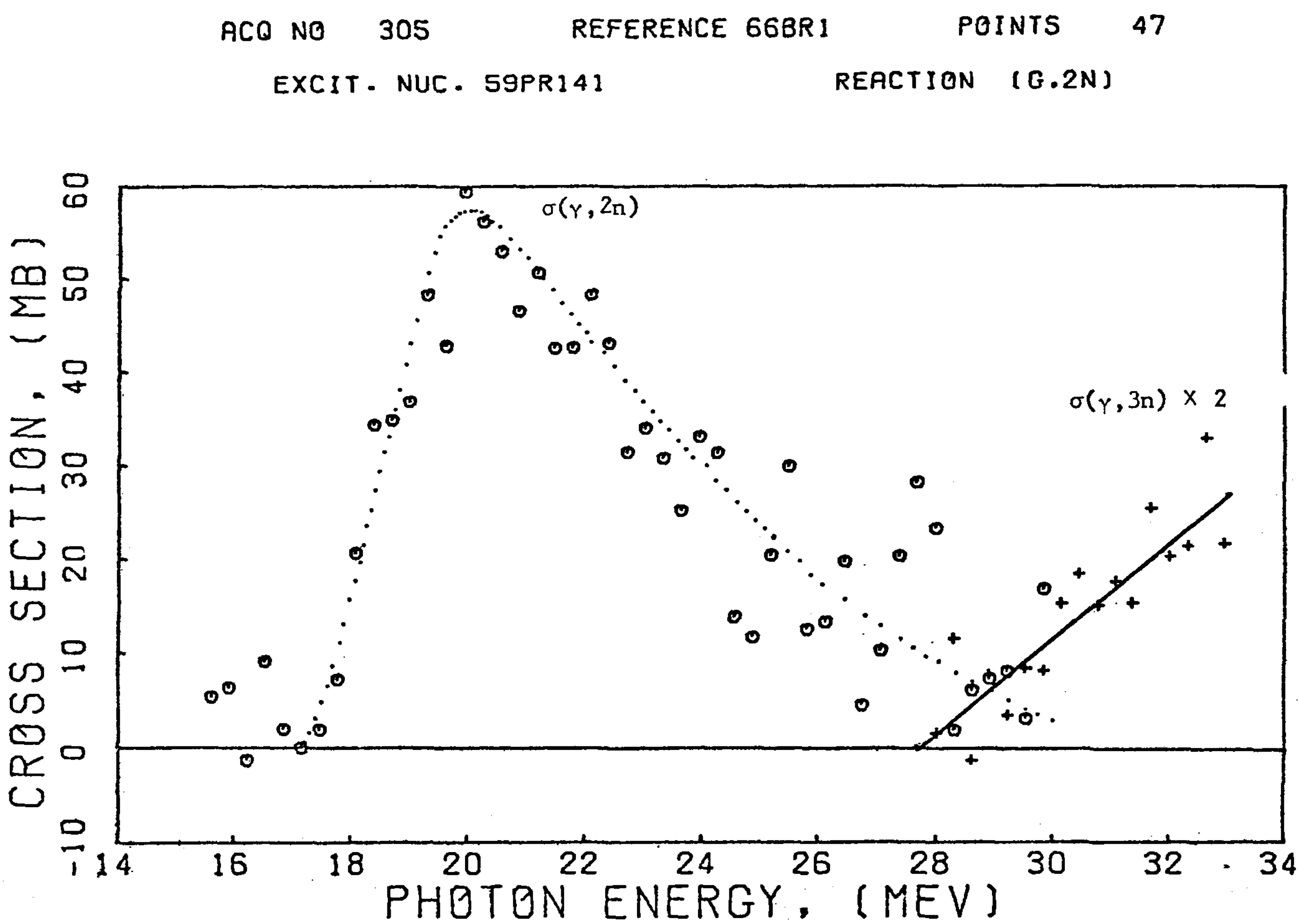


Fig. 1

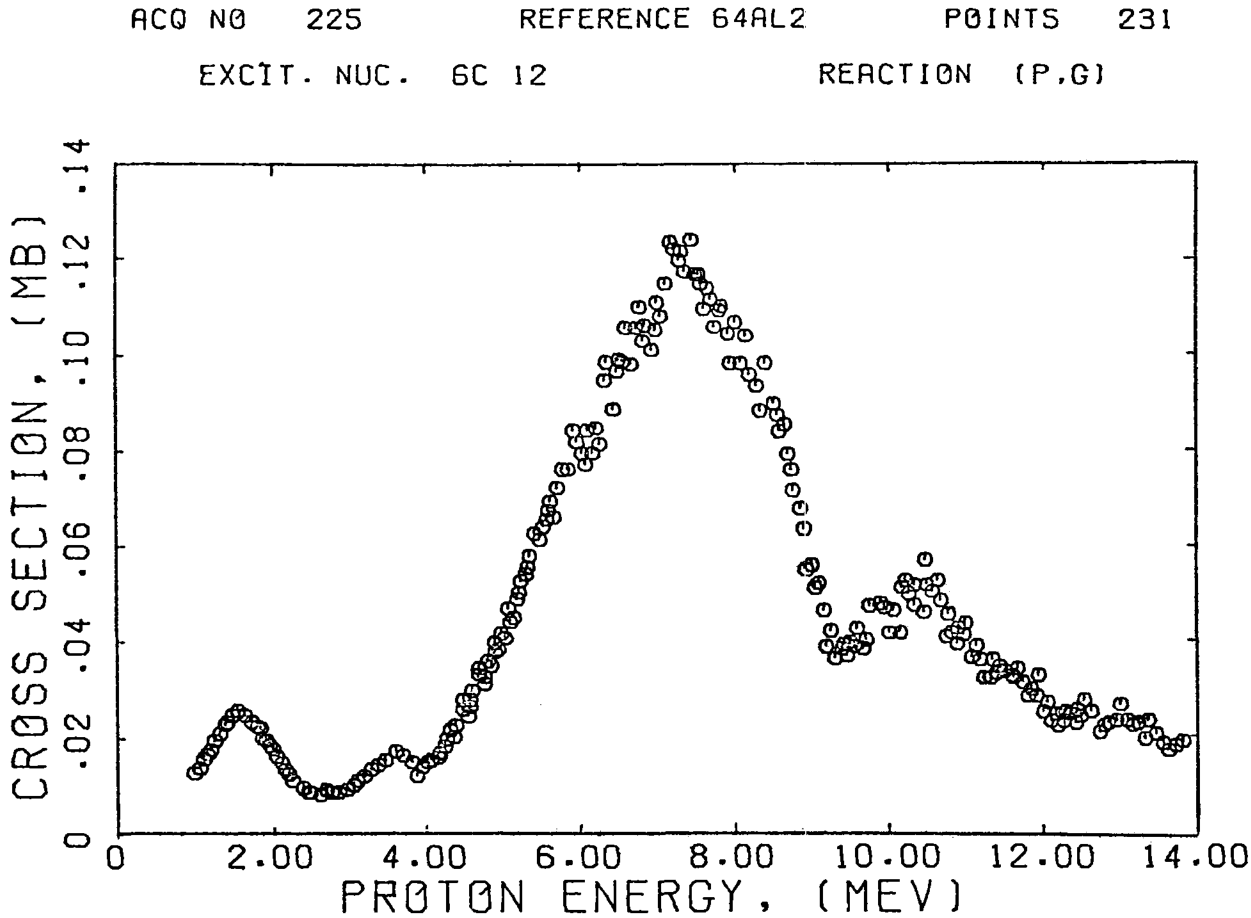

ACQ NO 225
REFERENCE 64AL2
POINTS 231
EXCIT. NUC. 6C 12
REACTION (P,G)
CROSS SECTION, (MB)
0 .02 .04 .06 .08 .10 .12 .14
0 2.00 4.00 6.00 8.00 10.00 12.00 14.00
PROTON ENERGY, (MEV)

Fig. 2

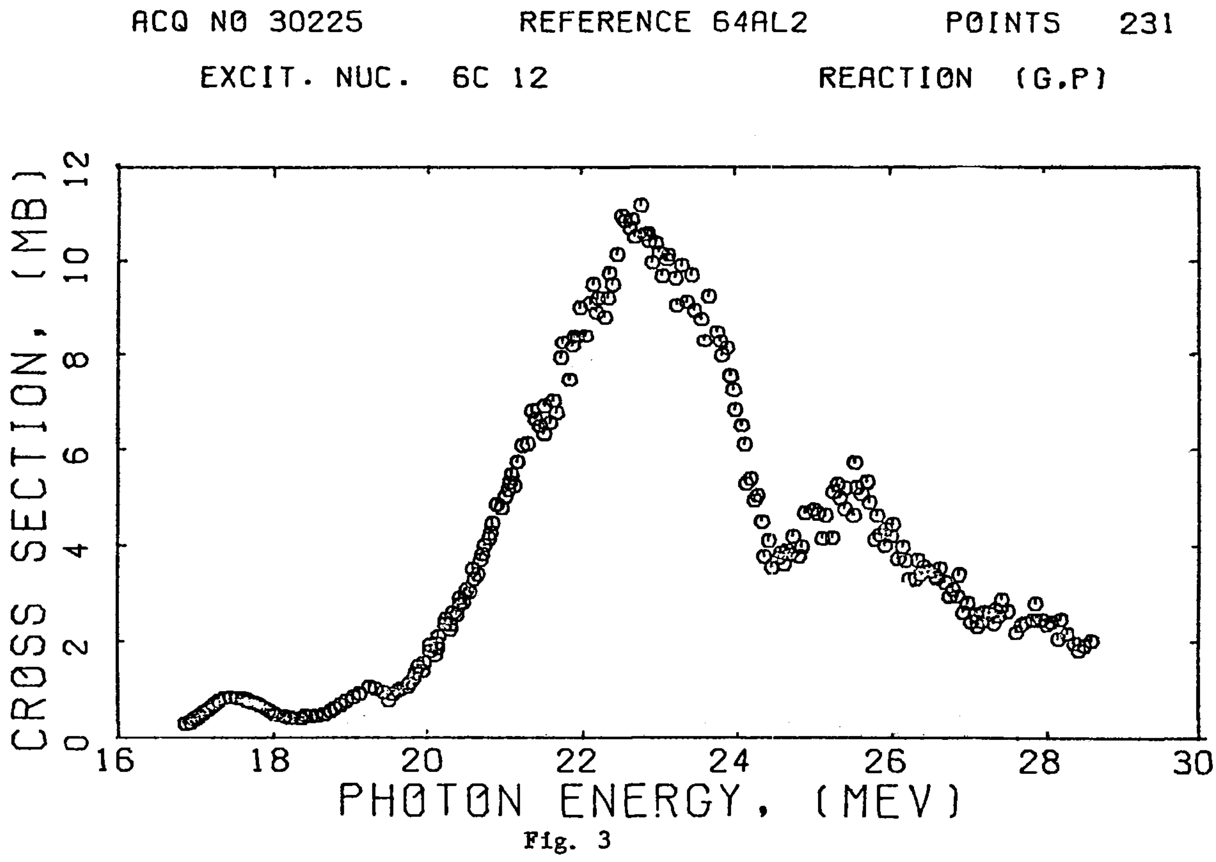

ACQ NO 30225
REFERENCE 64AL2
POINTS 231
EXCIT. NUC. 6C 12
REACTION (G,P)
CROSS SECTION, (MB)
0 2 4 6 8 10 12
16 18 20 22 24 26 28 30
PHOTON ENERGY, (MEV)

Fig. 3

I.V. Kurchatov Institute of Atomic Energy

The State of Work on Non-Neutron Nuclear Data in the USSR (Working Material for IAEA Consultants Meeting on Charged Particle and Photonuclear Reaction Data and for the IAEA X-Center Meeting in April-May 1974)

Authors:

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F.E. Chukreev

Moscow, 1974

(Translated from Russian by the IAEA)

I. BASIC INFORMATION ON THE CENTER FOR NUCLEAR STRUCTURE AND REACTION DATA OF THE STATE COMMITTEE ON THE UTILIZATION OF ATOMIC ENERGY

In accordance with the recommendations of the International Working Group on Nuclear Structure and Reaction Data (1) the State Committee on the Utilization of Atomic Energy of the USSR decided to set up a Center for Nuclear Structure and Reaction Data. This Center has been established in the I.V. Kurchatov Institute of Atomic Energy in Moscow. At present the staff of the Center consists of fifteen people including five physicists, two of whom are theoreticians and three experimentalists. The Head of the Center is Mr. F.E. Chukreev. Apart from the physicists, the Center also has technical staff who deal with the computing operations of the Center and assist the physicists in their work. The Center has its own Videoton 1010B computer with a set of peripheral equipment for input, output and storage of information.

The Center is working in close contact with the Data Center at the Leningrad Institute of Nuclear Physics of the USSR Academy of Sciences at Gatchina, with the Nuclear Data Center at Obninsk and with a number of groups of physicists working at various research institutes and higher educational establishments in the USSR.

The first phase of activity of the Center, which was set up in 1972, involves three main tasks:

1. Accumulating a sufficiently large amount of information on atomic nuclei and nuclear reactions;
2. Establishing the computer capability to deal with the accumulated material;
3. Surveying and analysing the nuclear data requirements of Soviet scientists[1/].

The first of these tasks is being performed in close collaboration with the Center at the Leningrad Institute of Nuclear Physics.

1/ Here and below by "nuclear data" we mean only non-neutron nuclear data.

Both Centers assemble all information on nuclei without attempting any preliminary evaluation. The collection of information is one of the main tasks of the Centers and is being done by rational division of the work between them with subsequent exchange of all the information collected. Unless sufficiently complete information is available in a form which facilitates access to the evaluator and permits automation of the routine work, it will be difficult to attract highly qualified physicists to work on the evaluation of the nuclear data necessary for solving scientific and technical problems.

The solution of the second task - the setting up of a system for retrieving information from the files of the Center - is closely coupled with the establishment of strict formats of storing information and this question will be considered below.

It is intended that the Center will not only collect information but will also organize the evaluation of the data necessary for solving scientific and technical problems within the scope of the State Committee on the Utilization of Atomic Energy and for fundamental research.

The Center shall provide non-neutron nuclear data for the following principal applied fields:

1. Reactor construction
2. Nuclear fusion research
3. Safeguards technology
4. Material analysis using nuclear-physics methods
5. Production and application of synthetic radioactive isotopes
6. Shielding and dosimetry
7. Medical applications of radioisotopes
8. Nuclear physics, astrophysics, etc.

A more detailed account of the requirements of each of these fields is given in Ref. (2).

At the moment it is difficult for us to define more clearly the field of activity of the Center, because our analysis of user requirements is not yet complete and a list of priorities has not yet been worked out. Nonetheless it can be said that in the field of reactor construction the bulk of the work on evaluating nuclear data will be concerned with problems related to monitoring neutron fluxes inside reactors. To solve these problems it is necessary to know:

(a) The thermal and resonance activation cross-sections of elements used as neutron detectors (Na, Mn, Cu, ^{103}Rh, V, Dy, ^{177}Lu, W, Ag, Pt, Au) and the lifetimes and decay schemes of product nuclei. In order to estimate the background, the same data are necessary for constructional materials (Ni, Al, Fe, Cd) and nuclear fuel (^{235}U, ^{238}U, ^{239}Pu);

(b) Activation cross-sections of elements used as threshold detectors (O, P, S, Al, Mg, Fe) and the lifetimes and decay schemes of product nuclei.

One of the main tasks of the Center is to provide non-neutron nuclear data for research on controlled thermonuclear reactions which is being conducted intensively at institutes of the State Committee on the Utilization of Atomic Energy. For this research it is necessary to have data on the interaction cross-sections of light nuclei at energies of several MeV. It is also necessary to have data on the gamma-ray spectra and lifetimes of nuclei produced by interaction of the products of thermonuclear reactions with construction materials, and materials which can be used for breeding tritium (Li, Be, C, F, Nb, Mo, Zr).

An analysis of the nuclear data necessary for thermonuclear research is given in Refs (3, 4).

The above list of the principal applied fields of science and technology which need to be supplied with non-neutron nuclear data cannot, of course, be considered conclusive. The present trend of applying to other fields methods devised to solve nuclear problems will undoubtedly present evaluators with new, perhaps not just purely nuclear problems.

II. WHAT NUCLEAR DATA ARE REQUIRED IN PRACTICE ?

The range of nuclear data needed for the widespread introduction of nuclear techniques to science and engineering was adequately described at the 1973 Paris Symposium on Nuclear Data in Science and Technology. One of the main conclusions of this symposium is that apart from data on the structure of nuclei, their radioactive transformations and nuclear-reaction cross-sections, it is also very necessary to have data on the stopping power of various substances and the ways in which the energy of nuclear radiation is dissipated in various media.

On the whole, the practical requirements for nuclear and atomic data are properly reflected in the draft questionnaire sent out by Mr.A.Lorenz (5). In our opinion this questionnaire needs to have only one thing added to it and that is a line for "nuclear moments of excited states".

III. THE STRUCTURE OF INTERNATIONAL COLLABORATION IN THE COLLECTION, EVALUATION AND DISSEMINATION OF NUCLEAR DATA

Considerable experience has now been gained in the operation of the four neutron centers (Obninsk, Brookhaven, Saclay, Vienna). Future international collaboration in the field of non-neutron data should, of course, be organized on the basis of the methods recommended for international co-operation in the field of neutron data.

At the same time, however, these methods should not just be transferred mechanically since there is a much greater volume of non-neutron nuclear data, having a wider sphere of application.

In our opinion, the establishment of an international network of non-neutron nuclear data centers should be accomplished in several stages:

(1) Arranging the exchange of information on published nuclear-physics research.

(2) Organizing joint evaluation; exchanging evaluated data;

(3) Setting up a system for the collection and exchange of experimental data (of the EXFOR type).

This point of view is based on the fact that sufficient experience has been gained in the preparation of keywords abstracts, and co-operation can soon be commenced. Our specific proposals relating to the establishment of an exchange system are given below (Section N).

It is impossible to carry out joint work or co-ordinated work on nuclear data evaluation without establishing accessible, comprehensive libraries of abstracts, with easy automatic search for the material required.

The collection and exchange of experimental data, recorded in a definite format, as is now done in the neutron centers, are problems demanding a solution - the format must be worked out and improved on the basis of the operating experience gained by evaluators. The volume and scope of the experimental data to be compiled by the centers will have to be dictated by the evaluators. Publications on non-neutron nuclear data contain a large and continuously growing volume of information: experimental techniques are improving, the number of reaction channels studied simultaneously is increasing, etc.

Another important question is the proper balance between centralization and de-centralization with regard to the collection, evaluation and distribution of nuclear data. In principle, two systems can be envisaged.

The <u>first system</u> is based on a central "bank" of information, into which material from regional centers is fed, and which reproduces the material and supplies it to all the centers.

The <u>second system</u> involves direct two-way connections between the regional centers similar to the procedure adopted for neutron data. Since the 4-center system has been proven to be satisfactory in practice, we can see no reason for the adoption of any new system of inter-center co-operation. All that is necessary is to draw up common data-preparation rules, depending only slightly on the type of computer technique, thus reducing the number of computer programmes required for the exchange procedure.

If the centers prepare the information according to a standard pattern, not depending on the computer technique employed, no additional programmes will be required generally. With this type of information preparation, a central "bank" is simply not necessary.

IV. PROPOSALS FOR THE EXCHANGE OF INFORMATION ON NUCLEAR-PHYSICS RESEARCH

No significant development of work on the collection, evaluation and distribution of non-neutron nuclear data is possible without joint efforts by the centers in different countries. Without a clearly defined system of international collaboration it is not possible to perform satisfactorily the evaluation of non-neutron nuclear data and the job of the national centers may thus be rendered difficult.

In our opinion, the first step of international collaboration in this field is to agree on the exchange of information on nuclear physics from which the major part of the non-neutron nuclear data derives. We believe that the development of a future world-wide information system for data on the structure of the atomic nucleus and nuclear reactions should start with the exchange of bibliographic material (e.g. keyword abstracts). These abstracts could be produced jointly, the work involved being divided in some way between the physicists of many countries. With the essential condition that all the information collected must be exchanged, this division of the work is convenient for the following two reasons:

(1) It increases the speed with which information on work performed is supplied to the evaluators and this enables the latter to deal with a wide range of initial data.

(2) It overcomes the language difficulties, which at the moment sometimes result in annoying errors when the work of Soviet scientists is abstracted abroad.

If the editors of nuclear-physics journals adopt the IWGNSRD recommendations (1) and the abstracting is done in keywords, data on the works performed will be supplied to the information network more quickly and language difficulties will be overcome. At the same time, however, a complication arises which we think is worthy of attention. If the abstracts are to be prepared by the authors of the works themselves, their contents will strongly reflect the personal views of the authors and the abstracts will thus be subjective. This kind of subjectivity may be particularly marked in the "comments" section (relating to the parameters of the experimental facility). This greatly complicates the subsequent work of evaluation. In performing the evaluation, therefore the evaluator should without difficulty be able to establish contact with the author in order to seek clarification regarding the methods used.

As long as editors do not all publish keyword abstracts, the abstracting should be divided among a number of regional centers, depending on the language and the place of publication. With this kind of division, as soon as the abstracts of nuclear-physics works were published (or even earlier), they could be added to the libraries of groups or organizations requiring nuclear data.

The Soviet centers would themselves undertake the abstracting of works published in the Russian language.

V. KEYWORD ABSTRACTS IN VARIOUS SYSTEMS (INIS, EXFOR, NDP). RECOMMENDATIONS.

As has already been stated above, international collabiration in the collection, evaluation and dissemination of non-neutron nuclear data should start with the exchange of abstracts, written in some system of "keywords", of nuclear-physics works which have either been published or are being prepared for publication.

Before proceeding to deal with specific recommendations on a common "keyword" system for all national centers and on the methods of preparing abstracts on the basis of this system, we should like to deal in somewhat greater detail with three already existing systems and to assess the advantages and disadvantages of each of them. Here, we shall consider only that part of the keyword abstract in which the actual content of the work is described.

THE NDP SYSTEM

To gain a better idea of the changes in the content of abstracts of papers in the keyword system adopted by the Nuclear Data Project group, we must turn to the year 1969. In Nuclear Data Sheets Vol. 3, No. 1 (1969) we find the following abstracts:

^{37}S D 67Wil4: E_β, J_β, E_γ, J_γ

^{37}Cl R 67JeO1: ^{36}S(p,γ), E = 1.147, Eγ, Jγ, p, γ (theta), sigma (Eγ), width

These abstracts give a definite idea of the content of the paper, but they are not very satisfactory for an evaluator embarking on work with reference materials. Such an abstract can serve merely as a kind of useful reference guide. It was therefore quite natural that the NDP group itself found this type of abstract unsatisfactory and that it went over to the type used in 1973, i.e.

^{37}Cl R 72A151: NUCLEAR REACTION ^{34}S (α, pγ), E = 10, 12, 14 MeV; measured sigma (E, Eγ, theta), $\gamma\gamma$-coin. ^{37}Cl deduced levels, J, π, mixing ratio. PHSTB 6 303

^{35}P D 72Go31: RADIOACTIVITY ^{35}P; measured Eγ, $\beta\gamma$-coin, $T_{\frac{1}{2}}$; deduced J, π, log ft, Q. ^{35}S deduced levels. PRVCA C6 820

(N.D. Sheets, Vol. 9, No. 6 (1973) and Vol. 9 No. 1 (1973) respectively.)

The advantage of the latter svstem of keyword abstracts over the earlier system is obvious and consists in the fact that the rules for compiling the abstracts include appropriate grammatical and syntactical rules. Obviously there is no need here to speak in detail about the rules for compiling the keyword abstracts which are applied at present by the Nuclear Data Project group and which have been very fully described by Dr. W.B. Ewbank. Nevertheless, the introduction of the verbs "measured", "deduced", etc. is of evident advantage. These action words divide the (experimental) paper very exactly into two essentially different parts, the "measured" and the "deduced", which is very important for the evaluator. As a result, the content, and also the significance, of the abstract are much more complete and clear. Placing a comment at the end of the abstract adds greatly to the information concerning the nature of the experiment and the methods used. One other undoubted advantage of abstracts based on the NDP system is the fact that, for all their laconicism and rigorous form, they can be read satisfactorily by both human subjects and machines.

THE INIS SYSTEM

To make a better comparison of the various systems, we need to present two abstracts for one and the same paper:

067619 Coban, A.; Lisle, J.C.; Murray, G.; Willmott, J.C.
States of ^{74}Se observed following decay of ^{74}Br.

Particles Nucl. (1972) v. 4 p. 108-125

[01] energy levels; energy-levels transitions; multipolarity; parity, selenium 74; spin.

[02] angular correlation; beta-plus decay; branching ratio; bromine 74; energy spectra; ft value; gamma radiation; gamma spectra; K capture; nuclear properties, parity; q-value; spin.
(INIS Atomindex, Vol. 4, No. 15 (1973).

^{74}Br D 72Co32; RADIOACTIVITY ^{74}Br measured E_γ, I_γ, $\gamma\gamma$-coin, $\gamma\gamma$ (theta), $T_{\frac{1}{2}}$, J(ce); deduced log ft. ^{74}Se deduced levels, J,π , $T_{\frac{1}{2}}$, JCC. PANUA 4 108
(N.D. Sheets, Vol. 9, No. 1 (1973)).

Apart from the disadvantage that the INIS abstract is longer than the NDP one, it has what we consider to be a further drawback in that it does not show very clearly what has been measured by the authors and what has been accomplished as a result of their measurements and certain theoretical assumptions. As mentioned above, this is extremely important for the work of the evaluator. Moreover, a comparison of these two abstracts demonstrates clearly the advantages of the grammatical rules adopted by NDP, which afford a means of reducing the length of the abstract, it can be comprehended quite easily by the human reader, but it is still at the level of the 1969-type NDP abstract.

THE EXFOR SYSTEM

This system is intended mainly for the exchange of all the information contained in a paper and it is therefore extremely cumbersome and very difficult for the human subject to read. Since in the initial stage of getting international co-operation under way it is not worthwhile - nor is it feasible, owing to the complexities and uncertainties involved - to consider the question of exchanging all information derived directly from an experiment, we believe that the introduction of EXFOR as a standard system would be inappropriate.

From everything that has been said above it follows that, in our opinion, the most suitable system for preparing abstracts is that adopted by the Nuclear Data Project group and based on the use of key words. However, even that system requires a slight modification, which consists in the following:

In our opinion, it is necessary to elaborate and issue rules for the compilation of abstracts in key words, taking into account all of the codes to be used in the exchange (see below); also, to make certain refinements in these ruels, bearing in mind the need for mechanical searches of abstracts containing useful information for work under consideration.

V. PROPOSALS FOR THE EXCHANGE OF INFORMATION BETWEEN REGIONAL CENTERS (NON-NEUTRON NUCLEAR DATA)

V.1 Information on the gradual compilation of data at each Centre is published by IAEA communications to this effect are sent from the individual centres on the subject of non-neutron nuclear data.

V.2. Exchange channels

We believe that exchanges of material of the different centres should take the form of a direct exchange between the centres, like that of the centres concerned with neutron data. All that is required is to modify the existing rules for the preparation of materials by the centres so as to avoid complex processing.

V.3. Content of exchanged information

1. Key-word abstracts of papers available to all users of national centres.

2. Evaluated data: at present the most practical arrangement is the exchange of abstracts.

V.4. Technical conditions for the exchange of abstracts prepared in keyword form

V.4.1. Symbols

Capital letters of the Latin alphabet, Arabic numerals, special symbols such as "space" or " " and the control symbols "carriage return" and "raise line" are employed as they are the most widely available to all users. The special symbols used for dividing up the fields of the abstract include ":" "!", " " and "&". If other symbols - for example, the letters of national alphabets of lower-case Latin letters - it is essential to point this out in the accompanying documentation.

Basis for the above instructions:

1. GOST-13052-67, "Alphabetical-numerical codes for computers";
2. ISO recommendation 646-71, "Six- and seven-bit set of symbols for information exchange and processing".

V.4.2. Machine codes

For the coding of these symbols in a form which could be adopted for computer processing it is necessary to use the seven-bit code ASCII or the BCD code. The code type (ASCII or BCD) must be indicated in the accompanying documentation.

If the number of symbols is increased, a table with their codes must be included in the accompanying documentation.

Basis for the above instructions:

1. GOST-13052-67, "Alphabetical-numerical codes for computers";
2. ISO recommendation 646-71, "Six-and seven-bit set of symbols for information exchange and processing", and ISO-2022, "Means of expanding the seven-bit set of symbols".

V.4.3. Machine-readable media for information exchange

These are nine-track 12.7 mm magnetic tapes with the standard track arrangement (see GOST-12065-66, "Magnetic tape for computers", and ISO recommendation 1863, "Nine-track magnetic tape (32 bytes per mm)"), a recording density of 800 bytes per inch (32 bytes per mm) and tape start and end markers (foil).

If the amount of information to be exchanged is not very great (not more than 100-200 kilobytes), one may use the eight-track standard paper tape - either in the form of a roll or folded like a concertina (Leporello folding) - 25.4 mm wide and a step length of 2.54 mm (in accordance with GOST-10860-68, "Perforated tapes for computers").

V.4.4 Arrangement of information on tapes

When magnetic tapes are used for information exchange, the arrangement of the information bits and the parity byte (which is added to any odd number of "units" in a transverse row) by track number may differ from ISO Recommendation 962, "Arrangement of a seven-bit code of symbols on a nine-track 12.7 mm tape", since the arrangement of information by magnetic tape track has not yet been standardized in the Soviet Union (see GOST-10265-66, "Magnetic tape for computers").

This also applies to the special longitudinal and parity control symbols at the end of a record and to the size of the space between records.

Whereever possible one should comply with the above-mentioned ISO Recommendation 962 and ISO Recommmendation 1001, "Marking of magnetic tape and file structure for information exchange".

If the recording method differs from these recommendations, one must specify: the arrangement of the information bits by track number; whether there are control symbols at the end of a record, the size of the interval between records and, whether there is any special record denoting the end of a file.

In all cases one should indicate in the accompanying documentation the number of files, the number of records in a file, the record length and the number of bytes in a record; if there is a record heading or a control sum obtained by means of a "mathematical guarantee", this should also be specified.

When perforated tape is used for information exchange, there must be a label at the beginning of the perforated tape and the arrangement of the seven-bit code must correspond to GOST-15029-69, "Arrangement of a seven-element binary code on perforated tapes", and it is essential to have in the eight track a check that the number of perforations in any transverse row is even.

GENERAL COMMENT

These recommendations for the development of a standard for information exchange within a system of non-neutron nuclear data centres are based on those Soviet standards and ISO recommendations which do not contradict one another. The ISO recommendations were prepared by the ISO technical committee TC/97 on "Computers and information processing", in which the Soviet Union has played an active role.

VI. ESTIMATE OF THE TRUE VALUE OF A MEASURED QUANTITY

Let us assume that one has the results of n independent measurements of some quantity and that these results (x_1, x_2, ... x_n) are free of crude and systematic errors (i.e. that incorrect results have been discarded, and that corrections for systematic errors have already been made). Estimating the true value $\underline{a}$ of a measured quantity means:

1. Indicating a function $f(x_1, x_2 \ldots x_n)$ of the measurement results which gives a sufficiently good approximation to the value of $\underline{a}$ (such a function is called a point estimate or simply an estimate of the value of $\underline{a}$);

2. Indicating the boundaries of the interval which, with a specified probability, covers the true value of $\underline{a}$ (such an estimate is called a confidence estimate).

The following point and confidence estimates of the true value $\underline{a}$ of a measured quantity are given on the assumption that random measurement errors are subject to the normal law of probability distribution and that only symmetrical confidence estimates having the form of the inequality

$$|a - \bar{x}| < \varepsilon$$

are considered.

If one knows for the results x_1, x_2 ... x_n of random measurements the values of the weights or the ratios of these values

$$p_1 ; p_2 ; \dots p_n = \frac{1}{\sigma_1^2} ; \frac{1}{\sigma_2^2} \dots \frac{1}{\sigma_n^2}$$

where σ_i^2 is the dispersion of x_i, then the confidence estimate of the true value a of the measured quantity has the form

$$|a - \bar{x}| < t(P;k)\, S_{\bar{x}}$$

where the point estimate

$$\bar{x} = \frac{1}{p} \sum_1 p_i x_i \,, \quad p = \sum p_i$$

and the empirical standard

$$S_x = \sqrt{\frac{\sum_i' p_i (x_i - \bar{x})^2}{p(n-1)}}$$

In the formula for the confidence stimate, $k = n-1$ (the number of degrees of freedom), P is the confidence coefficient and the value of the factor $t(P;k)$ is taken from tables compiled with the help of a Student distribution.

If, on the other hand, the mean square error of the independent measurements σ_i is not known beforehand, one uses instead the empirical standard

$$S = \sqrt{\frac{1}{n-1} \sum_1' (x_i - \bar{x})^2}$$

which serves as an estimate oof the parameter σ.

In such a case the confidence estimate assumes the form

$$|a - \bar{x}| < t(P, k) \frac{S}{\sqrt{n}}$$

while the point estimate

$$\bar{x} = \frac{1}{n} \sum_1' x_i$$

We finally have the following two expressions for point estimates of the quantity a for known and unknown σ_i:

$$a = \bar{x} \pm S_{\bar{x}}$$

$$a = \bar{x} \pm \frac{1}{\sqrt{n}} S$$

The value of the empirical standard, like the actual measurement results, is subject to random fluctuations. If we determine S_n from a very large number of measurements, we obtain a value which may differ by a small amount from its limiting value σ. When n is not large, however, then S_n is affected by random errors, these errors obviously being smaller the greater the value of n. Exactly as with the measurement results, there exists a distribution law which offers the possibility of estimating a confidence coefficient relating to the probability that the value of S_n determined from n measurements will differ from σ by a given factor.

If we define χ^2 in such a way that

$$\chi^2 = \frac{(n-1)S_n^2}{\sigma^2}$$

the distribution law for this quantity will be known as a χ^2-distribution, characterized by a definite assymetry which is particularly strong for low values of n. For larger values of n this distribution becomes a normal one, with a dispersion

$$\sigma(S_n^2) = \sigma\sqrt{\frac{1}{2(n-1)}}$$

This formula makes it easy to estimate an error in the determination of σ. Generally speaking, the formula holds for $n > 30$, but for very rough estimates it may also be used for lower values of n.

If $n = 25$, $\sigma(S_n^2) = \frac{1}{7}\sigma$ i.e. σ is determined to within about 15%. In this case there is obviously no sense in performing calculations of S_n to more than two significant figures, i.e. one should write $S_n = 2.3$ rather than 2.34 or $S_n = 0.52$ rather than 0.5231.

If $n = 50$, the accuracy of the determination of S_n is about 10%.

If n = 10, the error in the determination of S_n exceeds 25% and one should as a rule perform calculations to one significant figure if that figure is greater than 3 and to two significant figures if the first figure is less than 3. If S_{10} = 0.523, then we take one significant figure - i.e. S_{10} = 0.5; if S_{10} = 0.124, one should write S_{10} = 0.12.

SYSTEMATIC ERRORS AND STATISTICAL WEIGHTING

Taking account of systematic errors constitutes one of the most complex problems facing the evaluator. Although it is assumed that, in publishing their results, authors will take account of systematic errors and make the appropriate corrections, a simple analysis of the results nevertheless shows that this is not entirely the case.

An analysis of data on the measurement of a single gamma transition with an energy of 5298 keV in the $^{14}N(n,\gamma)\,^{15}N$ reaction shows the following. In 10 publications in which the gamma spectrum for the above reactions was measured, the following values are quoted for this transition: 5298.53±0.30; 5299.03±0.43; 5296.7* ± 0.4; 5298.3±0.3; 5297.6±0.7; 5298.2±1.5; 5297.8±0.35; 5298±1; 5298.1±0.6 and 5298.25 ±0.08. The mean value quoted by us in reference [6] is 5298.21 ± 0.32. The gamma transition energy value marked by an asterisk deviates rather sharply from the group of values as a whole. However, to attribute this to an "aberration" on the part of the experimenters would appear to be incorrect, since another line in their spectrum, 5267.8, also deviates from the general block of data, whereas two further gamma lines, 5561.5 and 5532.7, fit perfectly into it. In our opinion this can be explained by the existence of a systematic error in a particular sector of the spectrum. Unfortunately this is only a hypothesis, and it is therefore very difficult to propose something definite as regards eliminating inaccuracies of this kind. In these cases the best procedure would seem to be to regard the value as an "aberration" and leave it out of the evaluation.

Just as important, in the evaluator's work, as taking account of systematic errors, is allowance for the statistical weighting of a particular measurement result. In the above-quoted formulae for point evaluation and confidence interval, the statistical weighting is determined only by scatter. In actual fact the situation is not like this. In a way, the statistical weighting assigned to a measured value obtained in a work should include such factors as the quality of the instrument, the measurement method and even the reputation of the experimenter, i.e. the level of confidence in his results. The development of generally accepted criteria governing attribution of more objective statistical weighting to the results of each work is extremely complex and is a task for the future. At present we can only use the value σ for introducing statistical weighting into the point evaluation and the confidence interval.

VII. THE CENTRE'S PLANS TO ESTABLISH FILES OF EVALUATED DATA TO MEET THE REQUIREMENTS FOR SUCH DATA

Analysis of the requirements of scientists working both for the State Committee on the Utilization of Atomic Energy and in institutes of the USSR Academy of Sciences has shown that the primary requirements for nuclear data for non-energy purposes are very wide and are as follows:

1. Decay schemes of radioactive isotopes (more accurately, knowledge of all those radiations which accompany radioactive decay);

2. Activation cross-sections for beams of charged particles and photons;

3. Energy losses on passage of charged particles and photons through matter.

These are the requirements of a wide circle of scientists representing not only physics but also medicine, oceanography, agriculture etc.

From this list it is clear that the requirements of Soviet scientists are practically the same as those of scientists in other countries.

To meet these requirements, we propose to establish files of evaluated data on tape. Experience of operating centres shows that without an automatic system of retrieving and disseminating evaluated data it is difficult to meet the requirements of consumers.

It is quite clear that even the stablishment of only three files will require several years of intensive work by a very large group of experimentalists and evaluation specialists.

We expect to complete first the file on radiations accompanying radioactive decay, since the maximum amount of information exists in this field. We are not yet in a position to state the date of completion of this work, because new experimental research makes it continually necessary to refine existing data.

VIII. GROUP OF EVALUATORS IN THE USSR

Apart from this Centre, there exist a number of groups of highly-qualified physicists engagen in compilation and evaluation work in the USSR (see Ref. [1]).

IX. FORMULATION OF GUIDE FOR AUTHORS

The preferences of the editors of nuclear physics publications are presented in Ref. [1]. In this connection it is appropriate to raise the question of a guide for authors. A suitable basis for such a guide would be the "Recommendations on methods of communicating results" by Taylor, Parker and Langenberg [7].

It should be noted that this "Guide" is in obvious contradiction to the policy followed by the overwhelming majority of editors of nuclear-physics publications. The editors require results with descriptions of the methods involved kept to a minimum.

The only way out of this contradiction is to apply as widely as possible the system of depositing articles at information centres and publishing only the abstracts. However, authors will only do this unwillingly, preferring to reduce their texts. This is obviously because the authors fear that their deposited work will never be read by anybody.

X. AN INTERNATIONAL PUBLICATION ON COMPILATIONS AND EVALUATIONS

Such a publication should be in the form of a small journal appearing 2 - 3 times a year. It should contain information on new compilations and evaluations appearing in print or in the form of tape files. This publication will help avoid duplication of effort at information centres.

REFERENCES

[1] Conclusions and Recommendations 1st meeting of the Int. Working Group on Nucl. Structure and Reaction Data, Vienna, 13 - 17 March 1972

[2] KULAKOV, V.M., RUDAKOV, V.P., Paper presented to the 1st Meeting of the Int. Working Group on Nuclear Structure and Reaction Data, Vienna, 13 - 17 March 1972.

[3] CHERNILIN, Yu.F., YANKOV, G.B., - 2nd Int. Conference on Nuclear Data for Reactors, Helsinki 1970, Conf. Proceedings, Vol. 1, p.49, IAEA Vienna, (1970)

[4] YANKOV, G.B., Paper presented at the Conference on Neutron Physics, Kiev, 1971.

[5] Memorandum and draft questionnaire prepared by A. Lorenz, 6 Feb. 1974.

[6] SOKOLOVSKIJ, L.L., IGNATOCHKIN, A.E., Energii i intensivnosti γ-luchej dlya calibrovki Ge(Li) detektorov v diapozone 3 - 10 MeV (Gamma-ray energies and intensities for calibrating Ge(Li) detectors in the range 3 - 10 MeV) in Nuclear Data in Science and Technology (Proc. Symp. Paris, 1973) 2, IAEA, Vienna (1973) 431.

[7] TAYLOR, B., PARKER, V., LANGENBERG,D., Fundamental constants and quantum electrodynamics), page 21, Moscow, Atomizdat (1972).

Computerized Libraries of Nuclear Data for Applications

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The Evaluated Nuclear Data File (ENDF) formats described in ENDF 102 Vol I (BNL 50274) were primarily constructed for neutron cross section data. The widespread acceptance of ENDF further demonstrated the advantages of computerized libraries and led to extensions of the format to include other data.

Two types of nuclear data useful in applications are radioactive decay and capture gamma ray energy spectra. Although the basic data might be compiled in considerable detail pertaining to nuclear structure, it is often desirable to process the data into simpler forms for certain applications consisting of such quantities as average radiation energies and major intensities.

Formats and procedures for radioactive decay data in ENDF are described in Appendix A. The information described is important to reactor fission product burnup, decay heat, and other applications. These formats were largely developed by O. Ozer of BNL, C. W. Reich of Aerojet Nuclear, and R. E. Schenter of HEDL. Data for over 825 nuclides were supplied in the ENDF format cooperatively by the Gamma Ray Spectrum Catalogue and the Hanford Engineering Development Laboratory group. In the number relating to fission products there were 57 delayed neutron precursors, 6 alpha emitters, 712 unstable nuclides, and 113 stable nuclides. There are beta-ray spectra and/or gamma-ray spectra for 200 nuclides.

In response to suggestions that the 4 world neutron data centers also exchange neutron capture gamma-ray spectra a draft proposal of the information felt important enough to be included was prepared by M. R. Bhat of BNL. This is described in Appendix B. The reduction of experimental capture gamma-ray data to evaluated data sets supplemented by theory where necessary has been performed for a number of nuclides. One such report is ENDF-186 (BNL 50379) by M. R. Bhat et al. entitled "Neutron and Gamma Ray Production Cross Sections for Silicon". The ENDF formats for photon production data are divided into four main parts consisting of multiplicities and transition probability arrays, photon production cross sections, photon angular distributions, and continuous photon energy spectra. The ENDF formats are described in ENDF-102 Vol. 2 (LA-4549) and will not be presented here.

The cases discussed here are examples of nuclear structure data reduced to forms suitable for reactor shielding and decay heat applications but which have use in other applications as well. Other types of nuclear data that are needed in the form of computerized libraries can probably be developed along similar lines.

Appendix A

Enclosure 1.	ENDF Formats and Procedures for Radioactive Decay Data
Enclosure 2.	Kr-85 Data in the ENDF Format
Enclosure 3.	Kr-85 ENDF Data Processed by Code LISTFC (Described in ENDF-110)

6.7 Formats for Radioactive Decay Data (MT=457)*

The spontaneous radioactive decay data is given in section 457. This section is given for materials that are single nuclides in their ground state or an isomeric state (An isomeric state is defined as one having a larger than 0.1 second half life.) The main purpose of MT=457 is to describe absolutely the energy spectra resulting from radioactive decay and give average parameters useful for applications such as decay heat studies. The information in this section can be divided into three parts:

I. General information about the material

ZA	=	Designation of the original (radioactive) nuclide (= 1000*Z+A)
LIS	=	Isomeric state flag for original nuclide (LIS=0, ground state; LIS = 1, first isomeric state; etc.)
$T_{\frac{1}{2}}$	=	Half-life of the original nuclide (seconds)
$\Delta T_{\frac{1}{2}}$	=	Uncertainty in the half-life (should be treated as one sigma variance)
NAV	=	Total number of average decay energies given.
$\bar{E}_x, \Delta \bar{E}_x$	=	Average decay energy (eV) of x radiation and its uncertainty (eV) for decay heat applications. The β, γ, and α energies are given in that order with space reserved for zero β or γ entries. All non-γ and non-α energies are presently included as β energy. The α energy includes the recoil nucleus energy.

II. Decay mode information - for each mode of decay:

NDK	=	Total number of decay modes given
RTYP	=	indicates the mode of decay. decay modes defined:

Variable	Mode of decay	
0.0	γ	Gamma decay (not used for Mode of Decay)
1.0	β^-	Beta decay
2.0	β^+	Positron and/or electron capture decay
3.0	IT	Isomeric transition(will in general be present only when the state being considered is an isomeric state)
4.0	α	Alpha decay
5.0	β^-,n	Neutron emission (generally given for delayed neutrons)
6.0	SF	Spontaneous fission

RFS = Isomeric state flag for daughter nuclide. (Fixed point number)

Q = Total decay energy (eV) available in the corresponding decay process. (This is not necessarily the same as the maximum energy of the emitted radiation. In the case of an isomeric transition Q will be the energy of the isomeric transition. For both β^+ and β^-, Q equals the energy corresponding to the mass difference between the initial and final atoms.)

Δ Q = Uncertainty in Q value (eV).

BR = Fraction of the decay which proceeds by the corresponding decay mode. (Eg. If only β^- occurs and no isomeric states in the daughter nucleus are excited then BR = 1.0 for β^- decay)

Δ BR = Uncertainty in BR

III. Resulting radiation spectra

STYP = decay type (Use Mode of Decay variable list)

NSP = total number of spectra. (NSP may be zero)

E and Δ E = energy (eV) or radiation produced (E_{β^-}, E_{β^+}, E_γ,etc.)

I and Δ I = intensity of radiation produced. (arbitrary units)

ICC and Δ ICC = internal conversion coefficient

F and Δ F = normalization factor (absolute intensity/relative intensity).

NE = total number of energy points

6.7.1 Formats

The structure of this section always starts with a HEAD record and ends with a SEND record. The section is divided into subsections as follows:

[MAT,1/457/	ZA	AWR	LIS	b	b	NSP	]	HEAD
[MAT,1/457/	$T_{1/2}$	$\Delta T_{1/2}$	b	b	2*NAV	NAV		
	$\bar{E}_\beta$	$\Delta \bar{E}_\beta$	$\bar{E}_\gamma$	$\Delta \bar{E}_\gamma$	$\bar{E}_\alpha$	$\Delta \bar{E}_\alpha$	]	LIST

[MAT,1/457/	ZA	AWR	b	b	6*NDK	NDK /	
	$RTYP_1$	RFS_1	Q_1	ΔQ_1	BR_1	ΔBR_1	
	.						
	.						
	.						
	$RTYP_{NDK}$	RFS_{NDK}	Q_{NDK}	ΔQ_{NDK}	BR_{NDK}	ΔBR_{NDK}]	LIST
[MAT,1,457/	STYP	b	b	b	6*(NE+1)	NE/	Repeat NSP times [omit if NSP=0]
	F	ΔF	b	b	b	b	
	E	ΔE	I	ΔI	ICC	ΔICC]	LIST
[MAT,1,0/	b	b	b	b	b	b]	SEND

*The section MT=453 is renamed: Induced reaction branching ratios.

6.7.2 Procedures

1. The initial state of the parent nucleus is designated by LIS which equals 0 for the ground state and equals n for the nth isomeric state. Only isomeric states are included in the count of LIS. (In other Files isomeric and non-isomeric states may be included in the count of levels.) Radioactive decay data need be given only for initial isomeric states with half-lives greater than 0.1 seconds.

2. The average energy $\bar{E}$ and its uncertainty $\Delta\bar{E}$ is presently given for three types of radiation although the format does not limit the number. The average decay energy and its uncertainty for beta, gamma, and alpha radiation must be specified in that order with space reserved for zero or unknown information. The average alpha energy also includes the recoil energy but the alpha energy alone can be separated out by multiplying by the usual $\frac{M_R}{M_R + M_A}$ factor, where M_R and M_A are the masses of the recoil nucleus and alpha particle respectively. The beta radiation includes the contribution from beta, positron, and conversion electron decay and presently includes the average delayed neutron energy as well.

3. The symbol RTYP indicates the mode of decay as determined by the initial event. A nucleus undergoing beta decay to an excited state of the daughter nucleus which subsequently decays by gamma emission is in the beta decay mode. In general an RTYP=0, indicating gamma mode of decay will not be used since decay initiated by gamma emission is classified as an isomeric transition requiring RTYP=3. An isomeric state of the daughter nuclide resulting from the decay of parent nuclides is designated by RFS (fixed point number) following the procedures used for LIS. Q represents the total energy available in the decay process and is equal to the energy difference between the initial and final states. The branching ratio BR for each decay mode is given as a fraction and the sum over all decay modes must equal unity.

4. The energy spectra should be specified if known. The decay type STYP should be specified using the RTYP variable list. Gamma spectra are described using STYP=0. Relative intensities can be specified and normalized absolutely by multiplication by F. If absolute spectra are given, F must equal unity. The intensity I should total the contributions from all decays leading to radiation within a particular decay type STYP having an energy $E \pm \Delta E$. The internal conversion coefficient should be the sum of all the partial conversion coefficients.

```
ENDF/B-IV FISSION PRODUCT FILE (PRELIMINARY)                                  0 0  0      0
3.60850+ 4 8.42698+ 1          0          0          0          2 138 1451      1
0.00000+ 0 0.00000+ 0          0          0          8          0 138 1451      2
36-KR- 85  ANC        EVAL-FEB74 C.W.REICH  DECAY DATA            138 1451      3
  PREPARED FOR FILE   7/73                      CWR               138 1451      4
  REFERENCES  Q - 1973 REVISION OF WAPSTRA-GOVE MASS TABLES.      138 1451      5
             OTHER DATA  NDS-1971                                 138 1451      6
  FIRST-FORBIDDEN,UNIQUE SHAPE CORRECTION CONSIDERED IN DERIVING  138 1451      7
  )E-BETA  FOR GROUND-STATE BETA TRANSITION                       138 1451      8
          HALF-LIFE N.E.HOLDEN CHART OF THE NUCLIDES (1973)       138 1451      9
          AND PRIVATE COMMUNICATION (SEPT.,1973).                 138 1451     10
                               1        451         12            138 1451     11
                               1        457         12            138 1451     12
                                                                  138 1  0     13
3.60850+ 4 8.42698+ 1          0          0          0          2 138 1457     14
3.38381+ 8 6.30722+ 5          0          0          4          2 138 1457     15
2.25190+ 5 0.00002+ 0 2.23000+ 3 0.00000+ 0                       138 1457     16
3.60850+ 4 8.42698+ 1          0          0          6          1 138 1457     17
1.00000+ 0 0.00002+ 0 6.87200+ 5 2.00000+ 3 1.00000+ 0 2.00000+ 0 138 1457     18
 .00000+ 0 0.00002+ 0          0          0         18          2 138 1457     19
1.00000+ 0 0.00002+ 0 0.00000+ 0 0.00000+ 0 0.00000+ 0 0.00000+ 0 138 1457     20
1.73200+ 5 2.00002+ 3 4.34000+ 1 1.10000+ 0 0.00000+ 0 0.00000+ 0 138 1457     21
6.87200+ 5 2.00002+ 3 9.95660+ 1 1.10000- 2 0.00000+ 0 0.00000+ 0 138 1457     22
0.00000+ 0 0.00002+ 0          0          0         12          1 138 1457     23
1.00000+ 0 0.00002+ 0 0.00000+ 0 0.00000+ 0 0.00000+ 0 0.00000+ 0 138 1457     24
5.13980+ 5 3.00002+ 1 4.34000+ 1 1.10000+ 0 0.00000+ 0 0.00000+ 0 138 1457     25
                                                                  138 1  0     26
                                                                  138 0  0     27
                                                                    0 0  0     28
3.60850+ 4 8.42698+ 1          0          0          0          2 139 1451      1
0.00000+ 0 0.00002+ 0          0          0          6          0 139 1451      2
36-KR- 85M ANC        EVAL-FEB74 C.W.REICH  DECAY DATA            139 1451      3
     PREPARED FOR FILE  7/73                    CWR               139 1451      4
     REFERENCES  Q - 1973 REVISION OF WAPSTRA-GOVE MASS TABLES.   139 1451      5
        OTHER DATA  F.K.WOHN ET AL. NUCL. PHYS. A152,561(1970)    139 1451      6
          HALF-LIFE N.E.HOLDEN CHART OF THE NUCLIDES (1973)       139 1451      7
          AND PRIVATE COMMUNICATION (SEPT.,1973).                 139 1451      8
                               1        451         10            139 1451      9
                               1        457         13            139 1451     10
                                                                  139 1  0     11
3.60850+ 4 8.42698+ 1          1          0          0          2 139 1457     12
1.61280+ 4 3.60002+ 1          0          0          4          2 139 1457     13
2.26080+ 5 0.00002+ 0 1.83220+ 5 0.00000+ 0                       139 1457     14
3.60850+ 4 8.42698+ 1          0          0         12          2 139 1457     15
1.00000+ 0 0.00002+ 0 9.91700+ 5 2.00000+ 3 7.88000- 1 1.30000- 2 139 1457     16
3.00000+ 0 0.00002+ 0 3.04470+ 5 5.00000+ 1 2.12000- 1 1.30000- 2 139 1457     17
1.00000+ 0 0.00008+ 0          0          0         12          1 139 1457     18
1.00000+ 0 0.00002+ 0 0.00000+ 0 0.00000+ 0 0.00000+ 0 0.00000+ 0 139 1457     19
8.40700+ 5 2.00002+ 3 7.88000+ 1 1.30000+ 0 0.00000+ 0 0.00000+ 0 139 1457     20
0.00000+ 0 0.00002+ 0          0          0         18          2 139 1457     21
1.40000+ 0 0.00002+ 0 0.00000+ 0 0.00000+ 0 0.00000+ 0 0.00000+ 0 139 1457     22
1.50990+ 5 5.00002+ 1 5.38000+ 1 1.80000+ 0 4.55000- 2 9.00000- 4 139 1457     23
3.04470+ 5 5.00002+ 1 1.00000+ 1 4.00000- 1 5.09000- 1 2.40000- 2 139 1457     24
                                                                  139 1  0     25
                                                                  139 0  0     26
                                                                    0 0  0     27
                                                                   -1 0  0      0
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Enclosure 3

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36-KR- 85  ANC        EVAL-FEB74 C.W.REICH  DECAY DATA
 PREPARED FOR FILE   7/73                    CWR
 REFERENCES  Q - 1973 REVISION OF WAPSTRA-GOVE MASS TABLES.
           OTHER DATA  NDS-1971
 FIRST-FORBIDDEN,UNIQUE SHAPE CORRECTION CONSIDERED IN DERIVING
 )E-BETA  FOR GROUND-STATE BETA TRANSITION
          HALF-LIFE N.E.HOLDEN CHART OF THE NUCLIDES (1973)
          AND PRIVATE COMMUNICATION (SEPT.,1973).
```

```
KRYPTON-85                              DECAY DATA                      ENDF/B MATERIAL NO.  138
(GROUND STATE)
                                  HALF-LIFE             1.0730E+01 +/-  2.0000E-02  Y
                                  AVERAGE BETA ENERGY   2.2519E+05 +/-  0.0000E+00 EV
                                  AVERAGE GAMMA ENERGY  2.2300E+03 +/-  0.0000E+00 EV

DECAY TYPE     PRODUCT STATE             Q-VALUE(EV),                 BRANCHING RATIO

BETA                               6.8720E+05 +/-  2.8000E+03     1.0000E+00 +/-  0.0000E+00

INTENSITIES                              BETA                I-ABS/I-REL =  1.0000E+00 +/-  0.0000E+00

    ENERGY +/- ERROR  (EV)          INTENSITY +/- ERROR

 1.7320E+05      2.0000E+03         4.3400E+01      1.1000E+00
 6.8720E+05      2.5000E+03         9.9566E+01      1.1000E-02

INTENSITIES                              GAMMA               I-ABS/I-REL =  1.0000E+00 +/-  0.0000E+00

    ENERGY +/- ERROR                INTENSITY +/- ERROR                  INTERNAL CONV. COEFF.

 5.1398E+05      3.3000E+01         4.3400E+01      1.1000E+00           0.0000E+00      0.0000E+00
```

```
36-KR- 85M ANC        EVAL-FEB74 C.W.REICH  DECAY DATA
    PREPARED FOR FILE  7/73                  CWR
    REFERENCES  Q - 1973 REVISION OF WAPSTRA-GOVE MASS TABLES.
        OTHER DATA  F.K.WOHN ET AL. NUCL. PHYS. A152,561(1970)
          HALF-LIFE N.E.HOLDEN CHART OF THE NUCLIDES (1973)
          AND PRIVATE COMMUNICATION (SEPT.,1973).
```

KRYPTON-85 — DECAY DATA — ENDF/B MATERIAL NO. 139

(1ST EXCITED STATE)

HALF-LIFE	4.4800E+00 +/-	1.0000E-02	H
AVERAGE BETA ENERGY	2.2608E+05 +/-	0.0000E+00	EV
AVERAGE GAMMA ENERGY	1.8322E+05 +/-	0.0000E+00	EV

DECAY TYPE	PRODUCT STATE	Q-VALUE(EV),	BRANCHING RATIO
BETA		9.9170E+05 +/- 2.0000E+03	7.8800E-01 +/- 1.3000E-02
ISOM.TRNS.		3.0447E+05 +/- 5.0000E+01	2.1200E-01 +/- 1.3000E-02

INTENSITIES — BETA — I-ABS/I-REL = 1.0000E+00 +/- 0.0000E+00

ENERGY +/- ERROR (EV)		INTENSITY +/- ERROR	
8.4070E+05	2.0000E+03	7.8800E+01	1.3000E+00

INTENSITIES — GAMMA — I-ABS/I-REL = 1.4000E+00 +/- 0.0000E+00

ENERGY +/- ERROR		INTENSITY +/- ERROR		INTERNAL CONV. COEFF.	
1.5099E+05	5.0000E+01	5.3800E+01	1.8000E+00	4.5500E-02	9.0000E-04
3.0447E+05	5.0000E+01	1.0000E+01	4.0000E-01	5.0900E-01	2.4000E-02

Appendix B

Storage and Retrieval of Neutron Capture Gamma-Ray Spectra

M. R. Bhat

Storage and Retrieval of Neutron Capture Gamma-Ray Spectra

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1. Background

Recently, it has been suggested that neutron resonance capture gamma ray data should be stored in the CSISRS data files along with the neutron cross section data. Such information is needed for studying nuclear structure and for obtaining accurate values of neutron binding energies. In addition, the data are necessary for shielding and energy deposition calculations and "prompt" activation analysis. It is necessary to record the gamma spectra with the best possible resolution and supplement it with coincidence and angular correlation measurements and other data for the basic physics needs. However, for shielding applications the gamma spectra need be given in broad bands 0.5 MeV or so wide. For activation analysis a few of the more intense gamma rays are needed and it may not be necessary to catalogue every gamma transition observed. In storing the capture gamma rays, one is immediately faced with the enormous volume of the data. The data as recorded by a Ge(Li) detector may contain a few hundred gamma rays measured at thermal neutron energy and a few neutron resonances. Lower energy gamma rays measured with a crystal diffraction spectrometer have resolved thousands of gamma rays in a limited energy region (E_γ < 1.5 MeV) in the case of a few rare earth nuclei. A rough order of magnitude estimate indicates that the total data will be of the order of 5 x 10^6 data points. The size of the current CSISRS-2 library is about 1.2 x 10^6 data points. Therefore, the capture gamma library could be handled by the existing programs and techniques. The entry of new data into the library could be further facilitated if the experimenter sends his data on magnetic tape in a standard format. However, one cannot help asking the question: is it necessary to store all the capture gamma ray data in all its detail? The following are a few alternate suggestions which should be considered.

One such suggestion is to leave out the weak gamma rays whose intensities are below a certain value. This would reduce the size of the data files. Besides, gamma rays which are very weak in all the resonances may be due to background, impurities or quirks of the fitting program so that no one would miss them. The immediate reaction to this proposal is that this implies an evaluation and that the data files should contain every bit of information the experimenter thought worth reporting.

Another suggestion that is usually put forth is to bunch the gamma rays into bins a few hundred keV wide. This proposal may be even more repugnent than the first one because it implies loss of information by degrading the experimental data to suit a particular application, e.g.: shielding calculations. Besides, this loss of information will be felt when more sophisticated future applications need the details.

An easy way out is to propose that every bit of detail in the measured data should be entered into the data files. These are needed of course for nuclear structure studies though coincidence measurements and other data are necessary to make use of them. Besides, one always has the feeling that if all such data are not available somewhere they are for ever lost to the scientific community and somehow the sum total of human endeavor would be the lesser for it. Besides, it is usually said that if thousands of gamma lines were worth measuring then they are worth storing though some of the silent minority might wonder were they worth measuring?

Assuming that the proposal to store the detailed gamma spectra as reported by the experimenter is generally acceptable it appears necessary to decide what kind of primary and auxiliary information should be stored and the formats for doing it.

Some thoughts on the physics information of the data one should store are discussed in the rest of this memorandum. It seems more appropriate to go into the details of the format and the mechanics of storage and retrieval after the physics content has been agreed upon. Capture data can be coded within existing formats and more efficient formats are under development. Though one should mention again that it would very convenient if the data is available on a magnetic tape directly from the experimenter. This would obviate the need to code the data manually from the printed page with its attendent errors and delay.

A few enquiries at likely places have shown that at present capture data is not available on magnetic tape or any easily transmittable form. The only exception seems to be the one data set of Rasmussen et al. on thermal capture.

2. Introduction

This memorandum discusses the details involved in entering resonance neutron capture gamma ray data in the CSISRS data files and the exchange format. Such data used to be measured with NaI(Tℓ) detectors or with one of a group of magnetic spectrometers. With the advent of Ge(Li) detectors, the quality of the capture gamma ray data showed great improvement because of better detector resolution and appreciable efficiency. In the meantime, high resolution crystal diffraction spectrometers were also developed, spurring further improvements in the different types of magnetic spectrometers. The result of all these advances in experimental techniques has been the collection of large amounts of capture gamma ray data of excellent quality and very good energy resolution. Thus, it is not unusual to find publications reporting hundreds of well-resolved gamma rays measured over quite a few neutron resonances. With the development of more intense pulsed neutron sources and time-of-flight arrangements capable of better energy resolution, it is to be expected that one would be able to measure capture data in more resonances up to quite high energies. With such an enormous increase in the quantity of experimental data, it is very important to decide at the outset what different types of data are to be entered in the data files, at what stage of the analysis the experimental data is to be considered as primary data, and other related problems. Some of these questions are discussed in the following pages and a few answers suggested.

3. Experimental Data

The first question one should try to answer is whether the data entered in the files be in the form of say the pulse-height spectrum as recorded by a multi-channel analyzer. The answer is a definite no for the following reasons. Apart from the fact that such data tend to be very voluminous, (4096 channel analyzers are common these days) the main objection against such a procedure is that the raw data are very dependent on a particular experimental arrangement, and it would be very difficult to find a common basis for comparison between data from different sources. Thus, the raw data from Ge(Li) detectors is very dependent on all the different instrumental variables like the detector resolution, efficiency, background, scattering from the surroundings, data collection time, counting rate corrections, detector size and configuration, to name only a few. It would be almost impossible to list all the characteristics of the apparatus needed to analyze the data by suitable unfolding procedures. This confusion could be further compounded by the fact that data from different types of apparatus are available in different gamma energy regions and would have to be combined to give a composite picture of the whole gamma spectrum. Hence, it is evident that the data that are entered into the files should not be the raw data but the end product of a type of unfolding best done by the experimenter who is most familiar with his apparatus.

The result of such preliminary analysis is usually given as gamma ray energies and their intensities (photons/100 neutron captures) either for incident thermal neutrons or for capture in a specific neutron resonance. In addition, other auxiliary data like the spins of neutron resonances, spin-parity of bound nuclear states, polarization data, (n,γ) and (d,p) corrélations and a number of different pieces of information are reported in the published literature. Therefore, the next question to be answered is which of these should be coded into the data files and which should be left out.

4. Specific Data Quantities

T e choice of quantities for coding into the data files should perhaps be governed by their use in practical applications. This pragmatic view point does not make such a choice very easy because apart from a few obvious examples the data needed for practical use is limited only by the fruitfulness of ones imagination and how sophisticated the applications are. A list of these quantities is given below as a starting point. This choice was suggested by present applications or those expected in the near future. This list could be enlarged at a future date as dictated by new applications and the experience gained by entering the capture gamma data into the data files. It may be that the list is too long as it is.

For convenience, these quantities have been divided into two broad groups viz: those that belong to the DATA or CØMMØN subsections of EXFOR and those that correspond to auxiliary or supplementary information and should be given in the BIBLIOGRAPHIC section. They are listed on the left-hand side column of these tables and on the right-hand side are given comments either explaining or justifying their choice.

I. DATA or CØMMØN Sections

Quantity	Comments
E_R	Resonance energy.
$J_R^{\pi_R}$	Resonance spin-parity. Independently known or determined from capture γ angular distribution data, multiplicity or ratio of low energy secondary γ rays, or polarization experiments.

Quantity	Comments
ℓ_R	Resonance angular momentum.
$\Gamma_{nR}, \Gamma_{\gamma R}, \Gamma_{FR}, \Gamma_R$	Neutron, gamma, fission and total widths of the resonance.
E_{n_1}, E_{n_2}	Energy limits of the neutron beam. This would specify the range of neutron resonances covered as in the average capture measurements with an internal target. This could also define a filtered beam, e.g., the 24 keV beam with an Fe filter.
$E_{\gamma i}$	Energy of the i-th gamma-ray.
$I_{\gamma i}$	Intensity of the discrete gamma-ray, given as number of photons/neutron capture.
$E_{\gamma_1}, E_{\gamma_2}$	Energy limits of a group of unresolved gamma rays.
$\nu(E)$	Number of γ-rays per capture per unit energy interval in the continuum.
$\Gamma_{\gamma i}$	Individual γ-ray width in eV.
$\frac{d\sigma_{\gamma i}}{d\,\Omega}(E_n,\theta)$	Differential cross section for producing a gamma-ray $E_{\gamma i}$ at neutron energy E_n at angle θ.
$\frac{d\sigma_{\Delta E_\gamma}}{d\,\Omega}(\Delta E_n,\theta)$	Differential cross-section for producing a gamma continuum E_γ to $E_\gamma + \Delta E_\gamma$ by neutron of energy E_n to $E_n + \Delta E_n$ at angle θ. This quantity could also contain a mixture of discrete and continuum γ-rays.
$\nu_n(E) = \frac{\nu(E)}{\int_0^U \nu(E)dE}$	Normalized energy distribution of the whole γ spectrum where ν has been defined before and U is an upper limit of integration, usually $U = B_n$ (B_n = binding energy).

II. BIBLIOGRAPHIC INFORMATION Section

EL, ML	Multipolarity of the γ-ray.
δ_L	Mixing ratios of different multipoles.

Quantity	Comments
$J_i^{\pi_i}$	Spin-parity of initial state, which may be a bound state or a neutron resonance.
$J_f^{\pi_f}$	Spin-parity of final state.
$T_{1/2}$	Half-life of a bound state if it is an isomeric state.
T_{if}	Transition probability for a γ transition from initial state i to final state f.
α_{pair}	Internal pair formation coefficient (usually denoted by Γ), if experimentally determined.
α_K, α_L, α_M, etc.	Internal conversion coefficients for K, L, M, etc. shells if experimentally determined, for: (a) Primary γ-rays: These are of theoretical interest and are used to assign multipolarities for these transitions. (b) Low Energy Secondary γ-rays: These are important in practical applications involving calculations of energy deposition in moderately thin aggregates of matter. Because of this process, there is a decrease in intensity of the low-energy γ-rays as some of them are internally converted, depending on their multipolarity, etc., with the appearance of intense peaks of the characteristic x-rays. Such a softening of the γ-spectrum and a change in its energy distribution materially affects the amount of energy absorbed in a shield or a sample.
ω_K, ω_L, ω_M, etc.	Flourescence yields of K, L, M, etc. shells. These define the ratio of the number of photons emitted when vacancies in an atomic shell are filled to the number of primary vacancies in the shell. These are important as they determine the actual number of x-ray quanta emitted.
$\frac{\Gamma_\gamma}{\langle D \rangle}$	Photon strength function.
$\sigma_{\gamma Direct}$	Direct capture cross section, i.e., the capture cross section between resonances as calculated from off-resonance capture (valid for well separated resonances).

Quantity	Comments
B_n	Binding energy of the neutron in the nucleus (Z,A+1) where (Z,A) is the target.
$\bar{B}_n = \dfrac{\sum_i a_i \sigma_{ci} B_{ni}}{\sum_i a_i \sigma_{ci}}$	Effective binding energy of an element containing more than one isotope where a_i is the fractional abundance of the i-th isotope, σ_{ci} its thermal capture cross section, and B_{ni} its binding energy.
$S_n = \sum_i I_{\gamma i} E_{\gamma i} + \int_o^{B_n} E_\gamma \nu(E_\gamma) dE_\gamma$	This quantity, formed by summing over the discrete γ-rays and integrating over the continuum (after allowing for internal conversion etc.), may be called the "observed total γ-ray energy." It is sometimes called "observed binding energy," but this is not a good choice because B_n is the observed binding energy determined, e.g., by measuring the energy of a primary transition to the ground state of the nucleus (Z,A+1) in thermal capture. The ratio S_n/B_n gives a measure of the total γ-ray yield observed in an experiment. Because of missed γ-rays or because of the finite low-level bias of the measuring apparatus, this ratio may not be equal to one. In this case, the intensities are sometimes arbitrarily renormalized to make this ratio equal to one so as to have energy balance.
Polarization data	Results of measurements of either the circular or linear polarization of individual γ-rays, and the nuclear structure information derived from them.
Coincidence measurements	Results of such measurements on members of a cascade and information derived from them. For fissile nuclei, capture γ-rays are detected by measuring them in anti-coincidence with fission neutrons.
Ratios of low-energy secondary γ-rays	Resonance spins or nuclear level density parameters like σ, a, etc. determined from such data.
Angular correlation measurements	Perturbed or unperturbed angular correlation data and the nuclear structure information derived from them.
Conversion factor from intensities to widths	If this information is given by the author, it should be included. Usually it is based on thermal capture data.

Quantity	Comments
Neutron source	Type of neutron source, e.g., filtered beam, with its width and intensity distribution, or whether the target is inside a reactor as in the average capture technique, crystal spectrometer, etc. Also state of polarization of the neutron beam.
Target	State of polarization or of alignment of the target.
Detectors	NaI(Tℓ), Ge(Li) detectors. Crystal diffraction spectrometers: (a) curved crystal, (b) flat crystal. Magnetic spectrometers of various types.

5. Example of Coded Article

In this section an example of a coded article is given and some thoughts on the experience are expressed. The article is on thermal and resonance neutron capture in natural antimony. The experiment described in this article is a two parameter experiment, i.e., with the neutron and the gamma-ray energies as being independent variables. The exchange format is basically suited for accommodating the results of a one parameter experiment. Therefore, in coding the data of this experiment in the exchange format, one is immediately faced with its limitations and the tedium of repetition it imposes. In addition, a concise two dimensional table conveying a lot of information is broken into a number of disjointed columns of numbers. Therefore, it appears desirable to find a more efficient coding procedure.

There are two possible solutions to this problem. The first solution is to leave the exchange format unchanged and to strip the data tables to suit it. This could be done by a computer program which acts as a "compiler" and makes the coding of an article as it appears in the literature into the exchange format less painful. This has already been done at the NNCSC by D. I. Garber who has a working program which does the conversion (private communication). The second solution is to change the exchange format so that it can contain a two dimensional table in a sensible, efficient fashion. If the coded information bears a one-to-one correspondence to the published data tables, it would be desirable but not necessary. There have been many suggestions as to how to implement these changes. A concentrated effort in this direction in the near future is indicated.

In concluding this section, an attempt is made to estimate the size of the capture gamma data library assuming the neutron and gamma-ray resolutions available now. Looking at some of the BNL fast chopper data the number of high energy primary gamma-rays observed per resonance varies from about 50 to 130. Let's assume an average of 100 for this number and a similar number for the low energy secondary gamma-rays. Further, if it is assumed that one can measure capture spectra in about 100 resonances per isotope with the best possible time-of-flight arrangement, for all the 300 or so stable isotopes available, one gets a grand total of 6×10^6 data points. This is perhaps an upper limit to such a number and as such may be considered to include more than one set of measurements available on an isotope.

```
ENTRY           12345                        5
SUBENT          12345001
BIB
INSTITUTE      (1USABNL)
REFERENCE      (J,PR/C,2,1115,70)
AUTHOR         (M,R,BHAT,R,E,CHRIEN,D,I,GARBER,O,A,WASSON)
TITLE           GAMMA RAYS FROM THERMAL AND RESONANCE NEUTRON CAPTURE
                IN SB-121 AND SB-123
FACILITY       (CHOPF) FAST CHOPPER AT THE BROOKHAVEN HIGH FLUX BEAM
                REACTOR, FLIGHT PATH 21,66M, CHOPPER RPM 10K, FOR
                THERMAL CAPTURE RUNS 1,5K,RPM
N-SOURCE       (REAC) REACTOR
METHOD         (TOF) TIME-OF-FLIGHT
SAMPLE         (POWDR) NATURAL ANTIMONY IN POWDER FORM, WEIGHT 854GM,
DETECTOR       (GELI) GERMANIUM LITHIUM DETECTOR 10C,C VOLUME ALSO A
                37C,C DETECTOR,
PART-DET       (G) GAMMAS
STATUS         (APRVD) APPROVED BY AUTHOR
HISTORY        (730401C)
ENDBIB
NOCOMMON
ENDSUBENT
SUBENT          12345002
BIB
ISO-QUANT      (51-SB-121,NG/WID,,PAR)
FLAG           (1,)  INDICATES UPPER LIMIT
COMMENT         BINDING ENERGY OF NEUTRON IN SB-122 IS 6806,6+-2,KEV
                FINAL STATE ENERGIES MAY BE OBTAINED BY SUBTRACTING
                PRIMARY GAMMA-RAY ENERGIES GIVEN BELOW FROM THIS,
ENDBIB
COMMON
EN-RES         SPIN J        MOMENTUM L
EV             NO-DIM        NO-DIM
6,24           3,            0,
ENDCOMMON
DATA
E              E-ERR         DATA          DATA-ERR      FLAG
KEV            KEV           EV            EV            NO-DIM
6806,6         2,0           0,1      -03                1,
6745,0         2,0           0,24     -030,03      -03
6728,4         2,0           0,1      -03                1,
6613,2         2,0           0,32     -030,03      -03
   .            .             .             .
   .            .             .             .
   .            .             .             .
   .            .             .             .
4331,3         2,0           0,42     -030,09      -03
ENDDATA
ENDSUBENT
   .
   .
   .           One Subentry/Neutron Resonance
   .
   .
SUBENT          12345003
BIB
ISO-QUANT      (51-SB-0,NG,INT,,PAR/SPA)
COMMENT         INTENSITIES NORMALIZED TO 1,10PHOTONS/PER 100 NEUTRON
                CAPTURE FOR THE 6523,6KEV GAMMA RAY AS GIVEN BY N,C,
                RASMUSSEN ET,AL, NUCL,DATA,VOL,A5,61,1968
ENDBIB
```

```
COMMON
EN=DUMMY
EV
Ø,Ø253
ENDCOMMON
DATA
E             E-ERR        DATA
KEV           KEV          PH/1ØØ
68Ø6,6        2,           Ø,16
6745,6        2,           Ø,11
6728,9        2,           Ø,72
6716,8        2,           Ø,13
6524,7        2,           1,18
     .          .            .       Intensities Given as Photons/100 Captures
     .          .            .
     .          .            .
     .          .            .
4659,2        2,           Ø,25
4642,Ø        2,           Ø,2Ø
4624,7        2,           Ø,14
46Ø5,Ø        2,           Ø,15
4565,Ø        2,           Ø,17
ENDDATA
ENDSUBENT
     .
     .
     .          One Subentry/Neutron Resonance
     .
     .
ENDENTRY
```

Paper submitted to the meeting of the IWGNSRD (March 1972)

by D. HOREN,

Nuclear Data Project

29 April 1974

Mr. Chairman, following a pleasant walk in the sun and some time spent reading and contemplating, I now feel that an elaboration of my remarks of yesterday is possible. Although what I propose to present is still not completely to my liking, I offer it for your consideration.

First, it now appears as though a number of countries have made or are on the verge of making some sort of committment to fostering nuclear data compilations for either or both basic and applied uses. In particular, I would refer to the papers presented here by our colleague from the USSR (i.e., documents 9, 13), from France (doc.), and possibly some others (please forgive me as I did not take all the documents with me when I left), as well as some verbal comments from the representative from Japan and others.

Now, I certainly feel that this working group should do everything possible to encourage these proposed committments ! If you are also of this opinion, then we must examine the numerous proposals that have been made to see how best we can do this.

After having read a number of the documents presented at this meeting, it is rather apparent that much has been proposed. This ranges from very simple proposals all the way to extremely elaborate ones. Obviously the situation is much too complicated for a rational being. However, since I consider man basically to be an irrational being, I will try to present a rational proposal which I would hope each of you will consider irrational and thereby maximize the probability that it will be acceptable.

I start with the following assumptions:

a) This working group will certainly not be able to change the whole field of compilations and effect an ideal situation (if it could ever agree as to what that would be) in a finite time.

b) This working group might suggest, recommend or whatever you will that all present day compilers henceforth cooperate and maximize the total efficiency. However, I think the best we could do here is recommend that the USA and USSR cooperate and provide sufficient rocketry to remove all the present compilers from their reference system so they could ponder the situation in a purely subjective manner.

c) There already exists a solid foundation of compilers and aids (such as reference systems, etc.) which could be expanded if one could specify the degree to which this is needed.

References - Now let us get down to be specific.

There presently exist a number of indexing systems to the literature. Each of these apparently is not completely satisfactory to all users. Now we (as well as others) have found certain deficiencies with some systems and were not able to have these sufficiently resolved to suit our purpose. Hence, we are presently committed to continuing our system of Recent References, with the intention of modifying the keywording to correct a number of constructive criticisms (for example, those by E.G. Fuller). In addition, we plan to modify our format so as to make the published references more useful. This will take the form of indexing papers under more headings, including papers which pertain to reaction mechanisms and theory.

Hence, in the area of indexing of references I recommend the following:

Immediate Action

References:

1. We try to expand the usage of keywords to all journals.
2. We try to improve the keyword system.
3. We try to get authors to seriously keyword their papers (as they presently do for Nuclear Physics) and educate them if necessary as to needs and benefits for them.
4. We do not worry about possible duplication at this time.

5. We delegate a committee to begin a detailed examination of all indexing systems to determine whether there is a need to develop a completely new system. This must be done not only from the point of view of trying to obtain a system that would satisfy every possible usage, but, as Fuller points out, bearing in mind the mundane question of cost and funding, as well as the time it would take to produce same.

Compilations: Here, we must recognize that there presently exist a number of different compilations which are being done in different ways. In addition, there apparently exist a number of situations for which either new compilations are needed or at least specific evaluated data are required. Now a number of people have apparently recommended going ahead and developing super computer systems which they assume will satisfy all these requests for information. Personally, I feel that if you first take the time to examine many of these so-called pressing needs you might find

a) that a number of them can easily be satisfied

b) that it may not be too time-consuming to answer a number of others, and this could probably be done much more efficiently without the use of super computer programs,

c) and finally if you are not careful the needs will disappear before you even begin to start programming !

Now before making my recommendations in this area, I would just like to note that we at the Data Project are working on a computerized data system for "selective" quantities. Most of the ones we will include have a very high usage rate, and many of them we will have to reproduce in future compilations.

Immediate Action:

In this area, I recommend the following:

1. We do not concern ourselves with the detailed manner in which

the present groups are doing their compilations.

2. We recommend the establishment of a world-wide list of compilers and their tabulations.

3. We recommend that the different compilation groups indicate to what extent they are willing to respond to user requests. Try to set up a system whereby specific requests would be handled by that group which is best "suited" to do so. For instance, requests for radioactive decay data where the parameters are desired to an accuracy of better than 2% would be submitted to the Euratom group, etc.

4. We recommend the establishment of national nuclear data centres and encourage people to send their data to same, after having defined "data".

5. Establish a means by which such centres can communicate.

6. Encourage the international exchange of compilers.

   In this regard, let me say the following. I certainly would try to encourage any nation that is interested in supporting in whole or to a "reasonable" degree one of its compilers for six months to a year at the Nuclear Data Project, and would be interested in hearing any informal comment in this regard. It has been suggested, that such a stay might possibly be arranged on a direct basis, or possibly by using the IAEA as an intermediary.

7. Set up a committee to examine the real needs for a super data file. If it is concluded that such is warranted, then the committee must examine the potential costs and possible funding for same.

Applied Uses

Immediate Action:

1. Establish a committee to collect, tabulate and examine the uses of non-neutron nuclear data.

2. Develop a request list for users of applied nuclear data.
3. Encourage existing compiling groups to respond to such a request list as indicated under compilations.
4. Encourage new people who are interested in entering the compilation field to consider doing compilations that are not already being done, but have been established to be necessary as the basis of the request lists.

NON-NEUTRON NUCLEAR DATA: A PROPOSAL FOR INTERNATIONAL COOPERATION

A. Lorenz
Nuclear Data Section
IAEA, Vienna, 29 April 1974

FOREWORD

In context of this presentation the term "nuclear data" is used primarily as an abbreviation for nuclear structure and decay data.

In order to help the discussions which will ensue in the course of this meeting, it is important to recognize from the start the diverse and separable aspects of the subject of our meeting. If one considers the title "Nuclear Data for Applications", one recognizes three distinct groups of people involved, namely the experimental and theoretical physicists, the producers of nuclear data, the evaluators of these data, and the users of these data. Although this simplified picture is not applicable in all cases, by and large, these groups have operated independently of each other, where the main means of communication between these groups has been the medium of publication.

Perhaps, this existing situation and a possible resulting future situation can best be represented in the form of a diagram, shown in Figure 1, which illustrates the data flow from the data producers to the data users.

The current situation, shown on the left-hand side of the diagram, is characterized mainly by a flow of data through the medium of publications (e.g. Physical Review articles by authors, Nuclear Data Sheets and Tables by evaluators). In certain isolated situations cooperation between individuals or groups of experimental physicists and evaluators exist, as for instance in the case of Dr. Endt's group in Utrecht. Also, some personalized service is provided mostly on a national basis to nuclear data users by evaluation centres, as in the case of the Nuclear Data Project at Oak Ridge.

The future situation, as shown in the right-hand side of the diagram, is not suggested to replace the current situation, but to complement it. Basically it suggests the formalization of the links between data producers and evaluators, and between data evaluators and data users, in the form of international cooperation agreements. Even though the arrows indicate a one-way flow of data, it does not imply any exclusion of feedback from users to evaluators and experimenters in the form of data requests. The omission of any other possible links (such as direct links between the given boxes) has been done for the sake of simplicity.

To summarize then, the object of this meeting, and of the subsequent cooperation in the field of nuclear data is to improve the existing situation and achieve a more coordinated cooperative system aimed at an improved service to data users. As indicated on the far-right of the diagram of Figure 1, this effort would require:

- Coming to an international agreement to create a coordinated and systematic method to exchange and compile experimental nuclear data.
- Coming to an international cooperative agreement to coordinate and share the nuclear data evaluation task, and
- Evaluating the possible extension of the scope of the activity of existing neutron data centers to form an international network of nuclear data dissemination centers.

The implication of these three considerations must be viewed in context of the existing data centers and evaluation groups, and the current information exchange practices.

First, since we are starting with an existing framework, any new system of international cooperation in the field of nuclear data should take advantage of existing working practices.

Second, because of the existence of basically two separate sets of nuclear data organizations, one consisting of a number of centres or groups dealing primarily with the compilation and evaluation of nuclear data, and the other, consisting of the four internationally coordinated neutron data centres, already active in the dissemination of neutron data information, it would be of advantage to consider the questions of coordination of compilation and evaluation of nuclear data separately from those of dissemination.

Thus, on one hand we have a potential network of compilation and evaluation centres, which would coordinate the compilation, distribution and evaluation of experimental nuclear data, and on the other, an existing network of dissemination centres which would coordinate the distribution of evaluated nuclear data to users.

With regard to the compilation and evaluation of nuclear data, it would be highly desirable to maintain the functions of the existing groups and centres within the framework of the proposed cooperation. Furthermore, in order to alleviate the workload of the systematic evaluation of nuclear structure and decay data performed currently only by a few groups, all existing evaluation groups and possibly new groups of interested physicists, should be encouraged to share in the compilation and evaluation task within the framework of an internationally coordinated programme.

Two basic questions to be resolved in this context are: 1) how to divide the workload, and 2) how to coordinate this effort in order to achieve an efficient exchange and distribution of the basic experimental data and their bibliographies among the cooperating centres.

With regard to the dissemination of evaluated nuclear data, it would seem to be highly logical to entrust this function to the existing four regional neutron data centres. These centres are already recognised and known by a large fraction of the scientific user community for the services they perform in the field of neutron data. Also, these centres and associated facilities exist, and already have a mechanism for the international exchange and dissemination of nuclear data information. It would therefore be considerably more economical and efficient, both from financial as well as time considerations, to utilize the existing network to disseminate these data.

The main question which arises in this context is the extent to which the existing neutron data centres are prepared to shoulder the burden of disseminating the non-neutron nuclear data generated by the compilation and evaluation centres. The question of the actual volume and diversity of data involved, and estimates of the man-power needed to perform this task would have to be discussed to help the neutron data centres assess the effect of such an extension within the context of their individual programmes.

The coordination aspect of the dissemination of nuclear data suggested above could be undertaken by the IAEA Nuclear Data Section. This center has a unique international vantage point as well as connections with a wide variety of applied nuclear data users associated with in-house as well as external IAEA programmes.

Clearly, it would have been difficult and laborious to include at this stage all aspects and details, implicit or even self-evident, of this suggested international collaboration. This proposal reflects the views of the Nuclear Data Section and is suggested to be considered as a basis for further discussion.

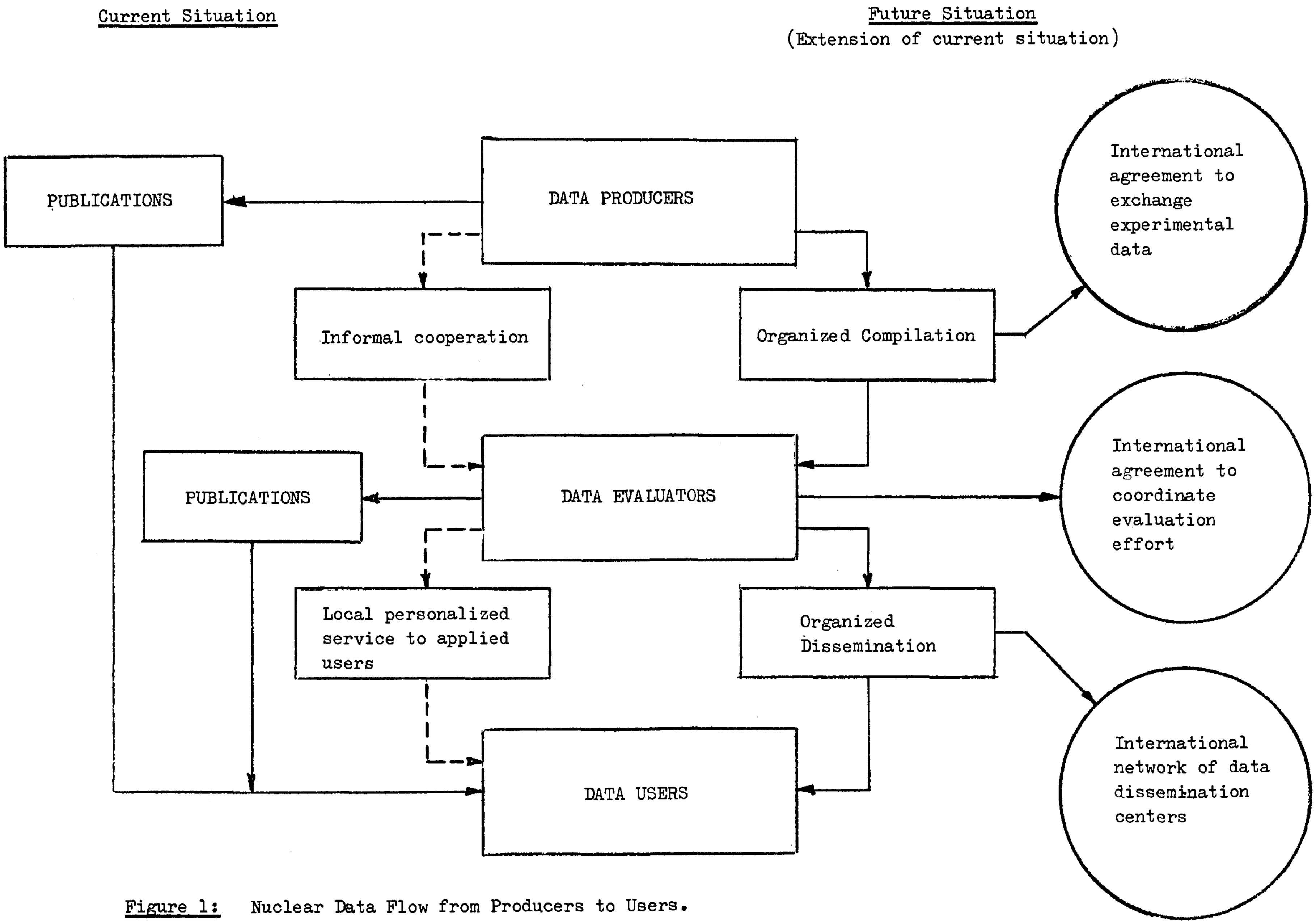

Figure 1: Nuclear Data Flow from Producers to Users.

April 26, 1974

TO Participants of Specialists Meeting on Nuclear Data for Applications

FROM G.A. Bartholomew

INFORMATION CENTER FOR APPLIED USERS
(Agenda Item VIII)

It is recognized that one difficulty encountered by the nuclear data user particularly in applied fields far removed from nuclear science is that he doesn't know what information is available and where to go to find it; in extreme cases he may not even completely understand what data he needs. To aid this user, and ipso facto all other more informed users as well, an "information center" (or network of information centers) is envisaged.

The information centers' function would be to maintain a compilation of compilations, a list of data centers, compilers, and experts in nuclear data, a roster of compilation or repackaging projects in progress. It might also issue a newsletter to all data centers and other relevant laboratories and possibly also maintain a request list. The activities of the center or centers are seen as entirely passive in the sense that no direct attempt would be made to organize or influence any data program but merely to publicize what is in fact going on and what is available in the data field. The center would expect to be kept fully informed of all compiling activities, cooperative links, etc. in order to maximize its effectiveness.

It would seem that such an activity, once set up, would be a much smaller operation than data collection or evaluation itself and might be an activity taken on by an existing data center or centers in addition to normal activities. Indeed, data centers already perform many of these functions quite naturally, all that is needed is to set up a formal system and publicize the existence of the service to users.

It would seem logical that the system should be centered at IAEA with possibly other centers in each country or region. It seems possible that in many instances a casual user is more likely to become aware of a local (national) nuclear information center than of an international center and may feel it easier to contact the local center. Thus the idea of a network of centers, with "headquarters" in Vienna, seems an ultimate goal. Rather than attempt to set this up at once, it would perhaps be more logical to begin with the Vienna center and add others as convenient to do so. All centers could have duplicate information files but coordinated and updated from Vienna.

A major problem for the success of the center would be to publicize its existence and availability for the casual, uninformed user from distant fields. For this purpose all of the publicity channels open to the Agency and other modes of communication, e.g. by advertisements in various scientific and trade journals etc. would have to be used extensively until the existence of the service became widely known.

As an extension of the service for applied users the information center could also supply a service to the nuclear data field, for example by informing someone planning a new compilation whether such a compilation was not already underway by another group or similarly, through the request list, to keep scientists fully informed on measurements needed or underway.

Sixth Meeting of INDC
Vienna, 8-12 October 1973

Formal recommendations to the Director General

1. International Working Group on Nuclear Structure and Reaction Data

One of the major decisions taken by INDC at this meeting was to assume responsibility for the international coordination of non-neutron nuclear data programmes. This was in particular demonstrated by the creation of a standing subcommittee on non-energy applications of nuclear data. In arriving at this decision the activities of the International Working Group on Nuclear Structure and Reaction Data (IWGNSRD) convened by the Agency in March 1972 at its Headquarters were essential. IWGNSRD was successful for example in

a) helping to assess the requirements for non-neutron nuclear data in various fields of application, and exploring ways in which these needs could be met;

b) reviewing the existing compilation and evaluation activities;

c) bringing to the attention of major journals the need for improved nuclear data presentation, and

d) assisting the Agency in planning the programme for the Symposium on Applications of Nuclear Data in Science and Technology held in Paris in March 1973.

With the above decision INDC endorses the wish of the IAEA to transfer the responsibilities of IWGNSRD to INDC. Certain operational functions will be delegated to a Study Group on Nuclear Data for Applications (see recommendation in Appendix III.2.). It asks the Director General to bring to the attention of the IWGNSRD its appreciation for the substantial and successful contributions of the participants in the IWGNSRD to the Agency's nuclear data programme.

2. Study Group Meeting on Nuclear Data for Applications

Following the Symposium on Applications of Nuclear Data held in Paris in March 1973, a joint meeting of members of INDC and IWGNSRD recommended that detailed suggestions should be sent as soon as possible to the IAEA/NDS on the technical agenda of a so-called "X-centres Meeting" to be convened early in 1974, and that the topic "International Enquiry on Long Term Data needs of IAEA member states" be placed on the agenda of the next INDC meeting.

These actions were carried out and following the discussion on 12 October 1973, the INDC recommends to the Director General that an IAEA Study Group Meeting entitled "Nuclear Data for Applications" be held in Vienna on 29 April - 3 May 1974. This meeting is supposed to start the international coordination of compilation and exchange of nuclear level schemes and decay data for applied purposes. Further meetings should be envisaged to implement in detail this coordination and to extend to further topics in this general area.

Report of Ad-hoc Sub-Committee on the roles of the standing sub-committees of INDC

Members:

Rose (Chairman)	Divatia	Rowlands
Berenyi	Grinberg	Schmidt
Cierjacks	Rogosa	Usachev

This ad-hoc sub-committee was set up to reconsider the roles of the standing sub-committees in view of the INDC decision to set up a fourth standing sub-committee on "non-energy" applications. The recommendations are as follows.

1. Nuclear standard reference data

The role of this sub-committee is unchanged though a change in membership will probably be required to reflect the varying technical topics likely to be considered. We wish to emphasize that the accuracy of standards at which we are aiming in any particular case must be of direct relevance to some practical problem - i.e., we have no specific interest in improved accuracy for its own sake.

2. Discrepancies in important nuclear data and evaluations

The role of this sub-committee is also unchanged, though again a change in membership will probably be required.

3. Energy applications of nuclear data

The role of this sub-committee is to make recommendations on policy concerning the assessment and satisfaction of nuclear data requirements in the whole area of the nuclear energy industry and to monitor interfaces between producers and users of nuclear data.

It is suggested that the nuclear energy area be divided into a number of fields, e.g.

Reactor cores	Waste disposal
Shielding	Inpile radiation measurements
Fuel processing	Fusion
Safeguards	

and that the sub-committee's major attention be given to only one or two fields at any one time.

4. Non-energy applications of nuclear data

The role of this sub-committee is to make recommendations on policy concerning the assessment and satisfaction of nuclear data requirements and to monitor the interfaces between producers and users of nuclear data in all applications relevant to the business of the IAEA except the nuclear energy area.

To accomplish these ends it will need, for example, to decide on a workable breakdown into user areas, to identify the existing national and international organizations in the various fields and find appropriate methods of working with them to produce carefully considered lists of nuclear data requests and to decide on methods whereby the satisfaction of these requests will be achieved. It will need to consider the demand for suitable repackaged data at the crucial technical level for the users. It should encourage the cooperation between the neutron and non-neutron nuclear data centres wherever this could be helpful to the objectives of the INDC.

An example of a possible breakdown into applied subject areas is the following.

Biology and Medicine

- neutron dosimetry
- electron dosimetry
- radioisotope dosimetry

Radioisotope application

biology	materials
agriculture	medicine

Activation analysis

- neutron
- charged particle
- photon

Industrial application

- X-ray fluorescence data
- activation techniques

/Note that this list illustrates that the division could be by technique or subject area or both./

Since this sub-committee is a policy recommending body on nuclear data production and compilation, complete technical expertise on all user-topics is not essential provided that the necessary specialist advice is available to it.

The same philosophy would ensure that INDC itself would not need to expand from its present size.

Members of the four standing subcommittees of INDC

1. Subcommittee on nuclear standard reference data

Liskien, BCMN Geel, CEC,	acting chairman
Grinberg, France	
Michaudon, France	
Rose, UK	
Smith, USA	
Yankov, USSR	
Lemley, IAEA/NDS	ex-officio member

2. Subcommittee on discrepancies in important nuclear data and evaluations

Joly, France	chairman
Cierjacks, FRG	
Motz, USA	
Nishimura, Japan	
Rowlands, UK	
Sukhoruchkin, USSR	
Goldstein, USA,	corresponding member
Lemmel, IAEA/NDS	ex-officio member

3. Subcommittee on energy applications of nuclear data

Motz, USA	chairman
Benzi, Italy	
Cierjacks, FRG	
Condé, Sweden	
Gemmell, Australia	
Nishimura, Japan	
Ricabarra, Argentina	
Rowlands, UK	
Yankov, USSR	
Dunford, IAEA/NDS	ex-officio member

- cont'd.

4. Subcommittee on non-energy applications of nuclear data

Rogosa, USA	chairman
Berenyi, Hungary	
Cross, Canada	
Divatia, India	
Fröhner, NEA/CCDN	
Grinberg, France	
Rose, UK	
Slaus, Yugoslavia	
Usachev, USSR	
Zelenkov, USSR	corresponding member
Lorenz, IAEA/NDS	ex-officio member

Sixth Meeting of INDC
Vienna, 8-12 October 1973

Requirements and applications of border-line nuclear and atomic data

(D. Berényi)

1. One of the main conclusions of the IAEA Symposium on Applications of Nuclear Data in Science and Technology held in Paris in March this year was the great need for data on the border-line between nuclear and atomic data.

The fact is that there are several fields of application which are connected to, or have an origin in the nuclear techniques, partly already mentioned during this meeting, especially in the report of the ad-hoc sub-committee headed by Dr. Rose (see Appendix IV). Such fields are e.g.

X-ray data (energy and relative intensity, absorption coefficient, electron and charged particle cross sections, etc.)

in radioisotope X-ray fluorescence analysis,
analysis by X-rays excited by electrons and charged particles in accelerators
ECSA (electron spectroscopy concerned with applications)
X-ray microprobe analysis, etc.

Absorption and scattering data for different radiations (cross sections for absorption and scattering, angular distributions, effective atomic numbers, etc.)

in dosimetry, medical and biological applications, industrial applications, etc.

2. The task is similar as it was in the case of the non-neutron or "non-energy" nuclear data in general, partly carried out last year in IWGNSRD:

to survey and summarize the tabulations available to discuss whether the tables above meet the claims and needs

to initiate compiling new tabulations (as e.g. the excellent recent table on X-ray fluorescence yields made by Bambynek and numerous other scientists in an international collaboration) and measurements.

3. Several "energy" and "non-energy" fields are concerned with the data topics in question but it seems to be most adequate that the problems of border-line nuclear and atomic data should be covered by the future fourth "non-energy" sub-committee. Consultations, request lists are, however, necessary with and from experts of the fields concerned.

NOTES ON A COMPUTERIZED DECAY-DATA FILE*

C.M. Lederer and A. Shihab-Eldin

April 22, 1974

I. INTRODUCTION

S. Pearlstein recently described a format for data on radioactive decay[1] to be included in the Evaluated Nuclear Data File (ENDF). In these notes, we would like to expand on his comments, and to suggest some modifications of the content, and general procedures for revision and for application of the file. The restriction to decay data is intended only to focus on the most important type of data for a broad range of applications, not to exclude other types of data.

II. CONTENT OF THE DATA FILE

A. The objective is to create the simplest file that will provide best values for each radioactive-decay property: half-lives; decay modes and branching ratios, masses and Q-values, natural abundances, and the energies and intensities (absolute whenever possible) of all radiations (α, β, γ, x-ray, conversion electron, Auger, neutron, photon, spontaneous fission).

All such quantities need not be tabulated, but should be derivable from the data in the file.

B. The suggested content of the file would be similar to that proposed by Pearlstein[1], except as follows:

1. For electromagnetic (γ) transitions, the intensity normalization factor, energies, (relative) photon intensities, and multipolarities (+admixture) would be tabulated. Multipolarities could then be used to compute conversion-electron intensities with the help of theoretical internal conversion coefficients. (For the rare, anomalous transitions measured conversion coefficients would be given in addition to the multipolarity.)

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* Presented to the IAEA Specialists Meeting on Nuclear Data, April 29 - May 3, 1974, Vienna.

The multipolarity should be included whenever possible, with a "type code", such as:

Type	
0	Multipolarity determined experimentally (from conversion and/or angular distribution, polarization data)
1	Multipolarity inferred from level assignment (spin, parity, etc.)
2	Multipolarity is a rough estimate, based on half-life (or limit), uncertain level assignments, etc.
3	Anomalous transition; specific measured conversion coefficients given.

The multipolarities and electron capture branching (see II.B.2 below) can be used to derive Auger intensities and (where not explicitly tabulated) x-ray intensities.

Measured x-ray and $\gamma^{\pm}$ intensities would also be included in the γ-ray listings.

2. Electron-capture, as well as β^- and β^+ transitions would be included in the tabulated data (daughter-level energy, transition intensity, "1u" or "2u" unique-transition indicator). For EC/β^+ transitions, the total (EC+β^+) intensity would most commonly be tabulated; however, a separate β^+ intensity would also be included if measured (with reasonable accuracy).

3. Some minor revisions of format seem desirable, such as:

   $t_{1/2}$ given as measured, with units, rather than in seconds

   Beta transitions should be tabulated as E_{level}, I, ["1u" or "2u"], not $E_{endpoint}$, I, ...

   Energies in MeV or keV, not eV.

   In general, the "rigidity" of the ENDF format should be avoided to permit more natural, error-free data entry. Where this is not possible, data may be keypunched in another format and converted before entry into the data file (by a program).

III. CRITERIA FOR THE EVALUATION OF DATA

A. The best value, whether measured or "derived", should be tabulated for each quantity. Specific examples of derived data are:

1. β^- endpoint energies (the final level energy + Q-value) and intensities will almost always be derived from the decay scheme.

2. The best β^+ intensities are often obtained using theoretical β^+/EC ratios and the level scheme.

3. In some cases, γ-ray intensities are best obtained from conversion data and/or the level scheme, plus theoretical conversion coefficients.

   For example:

   a) The best intensities of the transition in ^{180m}Hf decay are derived from known transition intensities and theoretical total conversion coefficients[2]

   b) The intensity of the 48 keV 2+ → 0+ transition in the decay $^{236}\mathrm{Pu} \xrightarrow{\alpha} {}^{232}\mathrm{U}$ is best estimated as:

   $I_\alpha(\to 2+,4+ \text{ states})/(1+\alpha_{\text{total}}^{\text{theory}})$

   (The measured value is low by a factor of 2, and is undoubtedly wrong.)

4. The best (or only) x-ray intensities may be those derived from the calculated K-vacancies (from conversion + electron capture). This is almost always true of Auger intensities.

B. The proposed use of derived data suggests the importance of guidelines regarding the accuracy of theoretical quantities. It would be desirable to adopt general guidelines that could be revised from time to time.

For example:

Theoretical Quantity		Assumed Uncertanty
ICC (Hager & Seltzer)		∿2%
ICC (other)		?
EC/β^+ and EC subshell ratios (Oak-Ridge, Berkeley computer codes)	allowed transitions	∿5%
	forbidden or unique	∿10%
Fluorescence Yields[3]	K	∿2%
	L	?

C. Systematic Data

It would be both wise and expedient to accept certain types of data from "horizontal" compilations - masses and Q-values[4], isotopic abundances[5], etc. When such compilations are revised periodically, the data could be transferred automatically into the file; it need not be included in the compilation of individual isotopes.

D. Other policies on evaluation may be established as desired. Such policies should serve the goal described in section II.A. They should be helpful in obtaining quality and uniformity, but not unnecessarily time-consuming for the compiler.

E. Citations, Notes

The policy of giving only general reference notes, as exemplified in reference[1], is not very satisfying in a scholarly sense; but it would seem to be the only viable way to deal with data that is often highly "derived" or "evaluated". We concur with the examples in reference[1] that references and explanatory comments should be kept to a minimum in the data file. The primary responsibility for the quality of the data must be with the compiler-evaluator.

IV. MECHANISM FOR REVISION OF THE DATA FILE

The following procedures are suggested in order to facilitate establishment and revision of the data file with a minimum of effort, but in such a way as to encourage improvement of the data whenever possible.

A. Accept the current decay-data section of ENDF as an initial starting point.

B. Establish a "passive review" procedure, whereby data for new isotopes or revisions of existing data can be proposed, reviewed, and entered into the data file.

1. Proposed revisions would be submitted at any time by compilation-evaluation groups or other qualified scientists. [A "revision" would (preferably) consist of a complete set of data for one or more isotopes.]

2. A review committee would have responsibility for judging whether the proposed revision is of adequate quality (or, in the case of isotopes already on file, if the new data is a sufficient improvement).

   Individual committee members would review proposed changes in or additions to the data and recommend acceptance or rejection to the committee periodically.

3. Committee members could also accept from data users or themselves initiate requests for the revision or addition of data in the file. A request list could be established and distributed to compilation-evaluation groups and other potential compilers.

C. In general, the procedures for revision of the data file should be similar to those used for neutron data (CSWEG committee). However, we would prefer them to be less formal and simpler, with more reliance placed on reputable compilers.

V. APPLICATIONS

The proposed content of the data file will, as described above, permit the user to obtain a complete set of decay data (all radiations, etc.) for a given isotope or isotopes. Certain quantities (eg. conversion-electron energies and intensities) would require the use of programs in addition to tabulated data in the file. Some such "computed" quantities could also be pre-computed and tabulated in the file - for example, average energies ($\Sigma E_i \times I_i$) for each radiation type, which are already being compiled[1]

Many programs of the type required already exist. For example, the Table of Isotopes Project has programs for computing internal conversion coefficients and beta-decay properties (log ft, EC/β^+ and EC subshell ratios, average beta energies). These and other programs (α-decay hindrance factors, Clebsch-Gordan coefficients, etc.) are available as an on-line program package, accessible from a standard teletype connected to our computer center via a telephone. In the future, we plan to add programs to this package that will permit access to a data file and provide both tabulated data and calculated quantities based on the data. We also provide magnetic tapes containing the Hager-Seltzer Tables[6] upon request.

Further development and dissemination of programs can procede along the lines of programs used with ENDF.

REFERENCES

1. S. Pearlstein "*Computerized Libraries of Nuclear Data for Applications*", (April 1, 1974).

2. L.J. Jardine and C.M. Lederer, Lawrence Berkeley Laboratory Report 208, (submitted to Nucl. Instr. Methods), (February, 1974).

3. W. Bambynek et al., Revs. Modern Phys. 44, 716 (1972).

4. N.B. Gove and A.H. Wapstra, Atomic Mass Tables; the most recent is Nuclear Data Tables A11, no. 2,3 (1972).

5. N.E. Holden, "G.E. Charts" and unpublished data.

6. R.S. Hager and E.C. Seltzer, Nuclear Data Tables A4, 1 (1968); reprinted in Atomic and Nuclear Data Reprints 1, 1 (1973).

NUSPEC*

(Nuclear Spectroscopy Interactive Program Package)

Table of Isotopes Project

Lawrence Berkeley Laboratory

I. Introduction

This is a brief "how to use it" write-up for off-site use of the NUSPEC program package. Section II explains how to connect a teletype to the LBL computer center via telephone lines; section III explains how to call up and run the programs.

NUSPEC consists of a group of programs callable from an executive monitor routine. Programs currently available include:

ICC	Interpolated internal conversion coefficients and subshell ratios (Hager and Seltzer)
LOGFT	Calculated log ft values, EC/β^+ ratios, EC shell ratios, and average beta energies.
HF	Hindrance factors for alpha decay (One-body model, Preston equations)
CLEB	Clebsch-Gordan coefficients
AVG	Number-averaging program (weighted or unweighted).
FSM	"The suggestion box" This allows you to send messages on problems encountered in your use of NUSPEC programs, or other thoughts you wish to convey to us. (Compliments will be accepted graciously.)

More programs will be added in the future.

C.M. Lederer
A. Shihab-Eldin
L.J. Jardine

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* Programs developed under the auspices of the U.S. Atomic Energy Commission and the U.S. National Bureau of Standards.

II. How to Connect to the Computer Via a Dial-Up Line.

Note: The LBL telephone number (central switchboard) is: (415) 843-2740

In case of problems, the following extensions may be useful:

Computer center (for problems with the teletype connect system or the B-machine)	ext. 6211 (FTS - dial (415) 843-6211)
C.M. Lederer, Table of Isotopes Project (for problems with the NUSPEC programs)	ext. 5995 (FTS - dial (415) 843-5995)

Steps 1-6 below are the normal sequence for accessing LBL computers with a teletype and modem. Step 7 is required only if phone contact is broken after a job has begun.

1. Set the full-half duplex switch on the modem to full duplex. Turn the modem on.

2. Phone to one of the following teletype-port extensions at LBL:

   6351 (for normal, 10 CPS teletypes)

   5752 (for 30 CPS teletypes)

3. As soon as the carrier signal (high-pitched whistle) is heard, place the phone quickly on the modem cradle. Set the teletype "off-line-local" switch to line.

4. To test the connection, type:

   >TR (R stands for the "RETURN" key)

   The computer should respond with the time and date. You are now connected, and can skip to step 5. If the computer fails to return the time and date:

   a) If the teletype is "frozen", strike the "break" key.

   b) If there is no "echo", or print of typed characters, type a colon (:); if this doesn't cure the problem try step "e" below.

   c) If the computer responds to >TR with a question mark, try >TR again. If this still fails, type >BR to check the status of the B-machine. (If the computer returns B DISCONNECTED FROM RECC, the computer is down.) Try @R to get the latest "broadcast message" on the computer status. As a last resort, call ext. 6211 and gripe.

d) Type >DC(R) , in the case that the last dialer hung up before disconnecting from a job.

e) Type >PF(R) to insure that the teletype is not in paper-tape mode.

f) Try >T(R) again.

5. Now begin the NUSPEC job, as described in the following section (III).

6. When done, make sure the job has concluded (the last teletype response should be JOB ENDED - DISCONNECTED) before hanging up!

7. If phone contact is broken while a job is running (after the "jobcard" has been entered), the program may continue to run (and use up connect time!), but cannot be reliably accessed. If this happens:

a) Call the computer center (ext. 6211)

b) Ask for the "I/O desk"

c) Ask the I/O person to have the B-machine operator kill the job. Be sure to identify the job by job name (returned when you enter the jobcard - NUSPECØ4 in the example on the next page); your name (the last thing on the jobcard); and the fact that the job is in the B-machine.

d) Re-dial to the computer (steps 1-4 above), and check the job status by typing:

>>NUSPCØ4(R)   (>>job name(R))

The computer should respond:

NUSPCØ4 JOB CONCLUDED

or

NUSPCØ4 IN OUTPUT QUEUES...

If the job is still running, wait a few minutes and check again.

e) Then start a new job, as in the following section

III. How to Run a NUSPEC Job.

The following example of an acutal job shows how to

1. start a NUSPEC job, and
2. call and use two of the programs:
   a) CLEB, to obtain one C-G coefficient
   b) ICC, to obtain one conversion coefficient

LINES YOU TYPE ARE UNDERLINED TO DISTINGUISH THEM FROM THE COMPUTER'S RESPONSES.

READ THE FOLLOWING NOTES 1, 2 AND 7 BEFORE BEGINNING. (The other notes are useful, but less essential.)

```
                  (The computer prints "!" when return key is struck.)
>LOG!                                                          (See note 1 below)
LOGIN  CP-25  TTY-071  12.46.52.**BKY56B*B*02/25/74.
ENTER JOB CARD OR ↑END                          (See note 2)
NUSPC,12,40,20000. account, name!
NUSPC04 LOGGED IN.  SESAME 1.0 ENTERING ↑EDIT        (wait for OK before
OK - ↑EDIT                                            proceeding)
1 LIBCOPY,BDG,CONTROL/XR,NUSPEC.!
↑RUN!                                          (This line must be correct.
TOI EXECUTIVE MONITOR. PROGRAMS ARE -          If you notice a mistake after
ICC                                            striking return, retype the
LOGFT                                          line before typing ↑RUN!)
HF
CLEB
AVG
FSM
LIST
STOP
     PROGRAM=
```

At this point, enter the program you want. A sample sequence for obtaining one Clebsch-Gordan coefficient and one internal conversion coefficient is:

```
   PROGRAM=CLEB!

 PROGRAM CLEB IS IN
DO YOU WANT GENERAL INSTRUCTIONS?N!
DO YOU WANT I-K(DEFORMED NOTATION)?N!

SPHERICAL NOTATION.OPTION?J1,J2,J3,M1,M2,M3
DO YOU WANT DETAILED INSTRUCTIONS FOR J-M?N!
J1,J2,J3,M1,M2,M3=1,1,2,0,1,1!

RESULTS

--J1---J2---J3---M1---M2---M3-     CLEBCOEFF------CLEBSQUARE
 1.0  1.0  2.0  0.   1.0  1.0       .7071068        .5000000
DO YOU WANT MORE J-M CLEB COEFF?N!
DO YOU WANT I-K CLEB?(CLEB EXITS IF NO)N!

CLEBTY STOP, CONTROL BACK TO MONITOR
MONITOR RETURNING -
NEXT PROGRAM=ICC!

ICC HAGER-SELTZER INTERPOLATION PROGRAM
DO YOU WANT INSTRUCTIONS?N!
Z=HG!
ENTER UP TO 10 SHELLS OR RATIOS.
ENTER OK TO END LIST
 1. SHELL=TOTAL!
 2. SHELL=OK!
ENTER UP TO 25 ENERGIES.
ENTER OK TO END LIST
 1. E=411.8!
 2. E=OK!
ALL MULTIPOLARITIES?N!
ENTER UP TO 7 MULTIPOLARITIES.
ENTER OK TO END LIST
1. MULTIP.=E2!
2. MULTIP.=OK!

 Z= 80 INTERPOLATED ICC

   E       E2

  TOTAL

  411.80   4.43
          ( -2)
MORE ICC?N!
MONITOR RETURNING -
NEXT PROGRAM=STOP!
JOB ENDED - DISCONNECTED
```

Notes:

1. If the computer responds to >LOG(R) with ALREADY CONNECTED, type >DC(R) , and then try >LOG(R) again.

2. The "jobcard" must be entered quickly. It includes the following information that you must provide:

   "account", which must be your account number.

   "name" - your name

   NUSPC is the job name. The computer appends a 2-digit sequence number. The job name with sequence number (NUSPCØ4 in the example) must be used when reconnecting to a job (see note 9b below), or when requesting that an operator kill the job (see II.6.c.).

3. All programs offer instructions for use when called from the monitor. These instructions and subsequent requests for user input should make it easy to use the programs without additional instructions.

4. Some general notes on data entry are:

   a) All "yes-or-no" questions may be answered Y(R) or N(R) .

   b) "Real" quantities (eg. energies, intensities) may be entered as either decimal numbers, integers, or exponential numbers. Examples are:

105.03	0.9999
105	1
1.05E2	9.999E-1

   "Integer" quantities (eg. mass number) must be integers.

   c) Z (atomic number) may be either the atomic number, or the element symbol (without capitalization) - eg. NA for sodium (Z=11).

   d) Energies are in keV in program ICC, in MeV in LOGFT and HF.

   e) Strike the RUBOUT key to delete the last character typed,
      the LINEFEED key to delete the entire line,
      the RETURN key to send anything to the computer.

   (Once RETURNed, a line cannot be rescinded.)

5. All programs ask MORE____? after printing the results of each computation If you answer no, the program stops, and execution returns to the monitor. (The job does not end.)

6. If you don't understand how to answer any program's request for input, type ↑DROP(R) . The program will abort, and execution returns to the monitor. (The job does not end.) You can request the same program again and accept its offer of instructions, if you wish.

7. To end a job, when the monitor routine asks:

   NEXT PROGRAM=

   answer

   STOP (R)

   Be sure to do this when you are finished. After the computer responds:

   JOB ENDED - DISCONNECTED

   you can hang up.

8. There are several ways to interrupt long printouts of results. To stop the current line of printout, strike the LINEFEED key. The computer will skip the rest of the line and continue with the printing of the next line.

   To terminate long printouts:

   a) while the teletype is printing, strike any character, followed by the return key. The teletype should stop after finishing the current line.

   b) When the teletype has stopped, again type any character*, followed by the return key. The program may print several more lines of output, and then asks:

      END TTY PRINT?

      If you answer yes, the remainder of the printout will be skipped.

9. Any user input line that begins with > or @ is a special system command. The input line is completely ignored by NUSPEC programs.

   Some system commands have already been described (>T, >LOG, >B, >DC, @). A further explanation of some useful ones is given here in brief:

---

* Avoid (or use advisedly) the characters Y or N; if the printout is already near completion, this character may be taken as the answer to the next request for data input, rather than as a signal to end print. The next request for input will be the yes-or-no continuation request, eg. MORE LOGFT?

a) >B R — returns the status of the B-machine, in which you are running.

b) >DC R — will disconnect from the job*. This is a good idea if you must leave a teletype that is awaiting input for more than a few minutes**, since it avoids some connect-time charges. The job is <u>reconnected</u> by typing

>RC.NUSPCnn R — where nn is the correct sequence number for your job (>RC. NUSPCØ4 R in the above example). Then type

>N R — to avoid receiving unwanted "dayfile" messages in the middle of the program output, and answer the question the program asked before you disconnected.

c) >>NUSPCnn R — returns the status of the job. If the nn is omitted, the status of the job with the highest sequence number is returned. Possible status for an active job could be

XEQ - 66B (executing)
WAIT TTY ACTIVITY
WAIT MEMORY
WAIT FOR PSS (when first calling a program)

JOB CONCLUDED or IN OUTPUT QUEUES... (indicates the NUSPC job was stopped or failed; a new one must be started.)

JOB STATUS UNKNOWN (indicates a major computer failure is in progress.)

(Note: Be sure you have asked about the correct job name + sequence number before you panic.)

d) @ R — returns the last "broadcast message" on the status of the computers. (It is a good idea to check this before trying to begin a job.)

e) @nnn Message.. R — sends a one-line "Message..." to teletype number nnn. nnn must be a 3-digit number - use leading zeros if necessary. (Your own teletype number is returned when you LOG in to start a job.) The message will be printed only if the receiving teletype is connected to a line and turned on.

---

* Disconnect <u>only after input has been requested</u>, not while waiting for a program to begin, or for the monitor to return.

** Warning: Jobs inactive for longer than about 2 hours will be killed automatically by the system.

10. Don't leave idle jobs running: the teletype connect-time charge is ≈$4.00/hour.

(All computing charges, except connect-time, are limited by the 40 CU tir limit on your jobcard [40 CU's ≈$2.00]. Most jobs should require less than this amount.)

Draft Statement by D. Horen, 30 April 1974

1. Compilation of General Nuclear Structure, properties by mass chain

The major groups which appear to be foremost at the present time as regards the compilation of general nuclear structure properties by mass chain are: Meyerhof and Tombrello ($A < 5$), F. Selove ($5 \leq A \leq 20$), P.M. Endt and L. van der Leun ($21 \leq A \leq 44$), the Nuclear Data Project at ORNL ($A \geq 45$) and Dzhelepov and Peher and coworkers (all A). As has been noted previously, there has already begun to be some efforts to communicate and collaborate among these groups.

a) Since it has been clearly documented that the compilations produced by these groups are used extensively by basic researchers, applied workers and those who prepare their types of compilations, the participants strongly feel that it is essential that these groups continue to be supported and strengthened to ensure continuity of their efforts.

b) In view of the fact that a number of the participants have expressed a concern as to whether the present groups have, or will have, adequate means to maintain the compilations for which they have "assumed" responsibility on a reasonable basis (e.g. within about a 4-yr. cycle), it is recommended that a study group (possibly the INDC) be set up to query the relevant groups involved.

c) At the same time, it is strongly recommended that other groups which evolve interests in these areas be encouraged to do so in close consultation with the already existing groups.

2. Regarding the question (i.e., either philosophical or practical) of establishing an international division of the compilation of general nuclear structure properties by mass chain, the participants note the following:

a) Historically, the existing groups have evolved in their own ways and have developed their own particular methods and expertise.

b) One might offer scientific, political and possibly economic reasons for recommending a more international participation (e.g., the establishment of many groups each of which would assume responsibility for a specified number of mass chain compilations).

c) One should, however, recognize that in the process of carrying out such a possible program as indicated in b), certain problems would undoubtedly arise (e.g. logistics, evolution of systematic procedures, etc.).

Since the present meeting is supposed to consider recommendations which will result in the maximum benefit to the users of such compilations, the participants are extremely concerned that if a new order of things does materialize such that

a) the existing groups are forced to obtain outside assistance due to lack of direct support, or that

b) some formal international agreement develops to distribute the load,

c) every effort be made to assure that the broadening compilation base be effected in a manner which will maximize the output and quality of these type compilations.

3. More Specialized Compilations of Structure Properties.
Here, the participants note a variety of compilation efforts ranging over a broad spectrum. In particular, they devote their attention to two major categories.

a) Specific Decay Scheme compilations such as those prepared by the Euratom Group.

b) Nuclear Decay Scheme at Properties compilations which draw heavily upon the General Nuclear Structure Properties by Mass Chain type compilations as mentioned above. Here one notes the Table of Isotopes, the various Charts of the Nuclides, etc. The participants recommend that support also be continued for these necessary and proven compilation efforts. The participants see an existing and potentially unique role associated with the precision-type compilations of the Euratom group in the areas of radioactivity, possible questions which might arise in a legal sense involving the use and specification of nuclear radiations, and specialized applications.
The extensive use of the Table of Isotopes and Charts of the Nuclides by applied users has been extensively documented. Again, the participants recommend that workers interested in participating in these type compilations be encouraged to do so, and to communicate with the presently leading groups in these fields, i.e., the Euratom Group for the precision type decay scheme compilations and the Table of Isotopes for the broadly based user type in an attempt to coordinate their efforts and draw upon existing expertise.

4. Dissemination of Compiled Data

The dissemination of compiled data is presently accomplished by a variety of means, some of which are as follows:

a) Publication in primary research journals

b) Publication in commercial journal of books

c) Private communications

d) Computerized formats

e) Data or Information centers

The participants recognize the merrits and needs for all of these methods, but in view of the expansion in the general usage of much of the compiled data, they recommend that computerization efforts be speeded up, with particular emphasis given to facilitating exchange.

April 26, 1974

TO Participants of Specialists Meeting on Nuclear Data for Applications

FROM G.A. Bartholomew

STATUS OF AUTHOR'S GUIDE

Following distribution on 18 August, 1972 to editors of some 50 nuclear physics journals (a list supplied by A. Wapstra) of the recommendations drawn up by IWGNSRD (attached), journal responses were obtained as follows:

1. Phys. Rev. Letters 29 (Oct. 72) 9 editorial note
2. Nuclear Instr. and Meth. 105 (1972) 395 " "
3. Nuclear Physics A202 (1973) No.3 and several subsequent issues - back cover spread
4. Phys. Rev. C7 (1973) No. 3 Additional Information for Contributors (appears periodically in journals)
5. Can. J. Physics - recommendations to be sent to authors of poorly organized manuscripts
6. Dissertation Abstracts - recommendations sent to Deans and Librarians of schools using the abstracts
7. Indian J. Phys. - editors stated journal already follows recommendations

Following a recommendation of the joint meeting of INDC and IWGNSRD members March 17, 1973 (after the Paris Symposium) a letter was written to the Secretary General IUPAP to acquaint him of these efforts and to suggest IUPAP may wish to support the activity in whatever way it felt appropriate.

Recommendation to Editors of journals

1. While brevity is a cardinal virtue, the description of the experiment should be in sufficient detail to enable the reader to judge the reliability of the data presented and of the precision claimed. Naturally a reference to such a description in an earlier publication would be equally acceptable.

2. A clear statement of the errors (systematic or statistical) of the result and how they are derived is essential.

3. If the results are relative to or depend on some other measured or calculated quantity this should be clearly indicated, its value(s) and its error given and its origin stated.

4. a) Data should clearly stand out from the text, e.g. in tables.
   b) Within tables, the authors' new measurements should be kept separate from values derived from other sources.
   c) Experimental data should be distinguished from results derived using theoretical Nuclear Models.

5. If an extensive tabular presentation of the data does not form part of the published paper but is available in a laboratory report or from a data centre this should be explicitly brought out.

6. Previously published material, e.g. abstracts, laboratory reports, conference reports, etc., which are superseded by the paper presented should be explicitly indicated.

7. It would be desirable if the abstract would be supplemented by the use of the keyword system following the practice of "Nuclear Physics".

B. Statements from participants in the Specialists' Meeting, concerning their home programme on nuclear data

1. Present compilational activities in The Netherlands

P.M. Endt

1. Atomic masses (Instituut voor Kernfysisch Onderzoek, Amsterdam). The last compilation in this series, by A.H. Wapstra and N. Gove, appeared in Nuclear Data Tables (1972).

2. a) Mass-chain compilations covering the A = 21-44 region by P.M. Endt and C. van der Leun (Utrecht University). The last issue in this series (No. V) appeared in Nucl.Phys. A214 (1973) 1.

   b) Compilations of the strengths of gamma-ray transitions between bound states (by the same authors). One paper appeared in Atomic Data and Nuclear Data Tables 1 (1974) 67; a second is scheduled to appear in Nucl.Phys.

None of these activities is subsidized. For the authors they are a part-time occupation. There is no paid staff or full-time secretarial help.

2. Remarks on the dissemination of non-neutron nuclear data

D. Horen, Nuclear Data Project, ORNL

1. Since the neutron 4-centers already have a system for international exchange of nuclear data, I recommend that this network be utilized in the following ways:

The centers learn of non-neutron data needs for applied areas. (Suppose from internal data committees e.g.) but also see below. They would then consult within their respective areas with compilers, etc. and try to get information into a format for exchange. That is, assuming information is available. If not, of course they will have to convince (in conj. with compilers) the funding agents to support. I believe if governments agree to an unrestricted exchange of whatever gets compiled, then the "system" essentially exists. The pressures for what gets into the files from the compilers will come from a very natural source, i.e, essentially internally generated. The IAEA NDS would have a natural position in the scheme of things without having to get bogged down in politics, entering to individual wishes of countries, etc. It is already a part of the system and it would continue its already existing role of holding meetings etc. to determine needs.

Of course if these seem clearly defined and should result in recommendation to put data into the "system", I think the decision should be either through, say the INDC or agreement of the 4 centres.

Of course, this should be discussed with 4-centers involved and allow them to consult with their funding agents.

3. Current Status of the Table of Isotope Project, Berkeley, USA

A. Shihab-Eldin

Progress:

As of April, 1974, the first compilation of 220 mass chains has been completed. The total compiler effort since the project began in 1971 is 15.5 compiler-years. Computer processing of the tabular data is now in routine use; the data are keyboarded and edited with a special on-line terminal system ("IRATE"). Proofreading of tabular data is well underway and will continue concurrently with compilation effort. Computer-produced level schemes are now being made and proof-reading of the level schemes is beginning.

Projection:

July 1976 is the target date for publication of the seventh edition of the Table of Isotopes. In order to maintain the present quality of effort without delaying the completion of the Table, it was decided to adopt a variable literature cut-off date for both the decay data and the reaction data of each mass chain. The cut-off date for the decay data of a particular mass chain will be the date of the first compilation if that is after July 1973; otherwise it will be the date of recompilation, i.e. updating. The cut-off date for reaction data will be the date of the first compilation with only very selective updating.

Automation:

Automation of the processing of both tabular and level-scheme data is progressing well. A major breakthrough last year was the completion of programs that check level-scheme data (input on punched cards) and produce plots of the data. These programs require little or no graphic input information, and also store the input data on the MSS (chipstore) system at Berkeley in a form suitable for editing.

We are currently entering data from a substantial backlog at a rate of about 1 mass chain per day; about 100 mass chains have been entered to date. The data are stored on the IBM data cell with magnetic tape backup.

4. The state of non-neutron nuclear data:

in France and within the Euratom evaluation group

J. Blachot, B. Grinberg, J. Legrand (France), and
W. Bambynek (Euratom).

I. Evaluation of Decay scheme parameters

The need for decay scheme data, evaluated with precision, becomes more and more evident in various fields. What is required for each data is a unique recommended value and a stated associated accuracy. Some examples can be given. The users of radioactivity standards are numerous and belong to very varied fields; what they require is the best possible standard. This implies for the radiometrologists, who prepare and deliver these standards, that they could rely upon very good and indisputable data. In the field of nuclear energy there is a need for evaluated decay scheme data of, for example, the following radionuclides: ^{252}Cf, ^{237}Np, ^{238}Pu, ^{241}Am. The reactor people are interested in good data for long-lived fission products. They are also interested in those radionuclides which can be used as monitoring detectors. These examples are only some, among others, which could be given.

Euratom Group

The so-called Euratom Group was started for the reasons given above. The critically evaluated decay properties of ^{60}Co, ^{58}Co and ^{51}Cr and the evaluation rules adopted by the group have been published.* For the moment, the activity of the group has been interrupted for exclusively practical reasons. It is strongly hoped that evaluators from as many countries as possible, will join and reinforce the group - so as to allow a reasonable amount of radionuclides to be evaluated within a reasonable time.

French table of evaluated radionuclide decay scheme parameters

Due to the temporary interruption of the Euratom evaluation group, and also because of the requests from numerous users, it was decided to publish a table of evaluated radionuclide data under the auspices of the French Atomic Energy Commission. The evaluation was based on the Euratom group rules, but is not as exhaustive as mentioned above: for each nuclide the nubmer of evaluated data is smaller. The evaluation of 200 radionuclides is planned. The first publication (second semester of 1974) will contain about 30 radionuclides; it is envisaged to bring the work to an end within 5 years. The accomplishment of this work is greatly facilitated by the existence of the Nuclear Data Sheets and the Recent References of Nuclear Data Project. It is evident that when the Euratom Group will resume its activity, the data evaluated by the Euratom group will be incorporated in the French table. This table is established under the scientific responsibility of J. Legrand.

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* Atomic Energy Review, 11, 3 (1973)

II. Library of Nuclear Data for the "Fission Products"

1. Neutron rich isotopes are classified by A-chain from 71 (Zn) to 170 (Tm), with the following data;

   - Half life and uncertainty,
   - Decay mode (QB^-, QB^+, Alpha) with the energy uncertainty and intensity,
   - β^- energies and intensities, and
   - γ-ray energies and intensities with uncertainties.

An indication is given whether the intensities are absolute or relative, and all data are referenced. Other information or comments are given at the end of each isotope. Seventy to eighty percent of the data have been taken from the "Nuclear Data Sheet".

2. The main users of this library are people working in fission reactor technology. The 1972 - 1973 version of the library was written in an "ENDF/BIII format on magnetic tape [1], and can be obtained from CCDN (Saclay).

3. The library is being continuously revised and extended. A new edition is scheduled to be released this summer as a CEA Report. We have chosen to use a simpler format for updating the library. Later on the new library will be converted to the ENDF format by using a program.

4. A sample of a computer listing for two isotopes is enclosed herewith. This library is established under the scientific responsibility of J. Blachot (CENG).

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[1] C. Devillers et al Meeting IAEA March 1973

50 SN127M
******

T= 4.400 +/- 0.100 M 72NDS

	ENERGIE +/- ERREUR		KEV	BRANCHEMENT +/- ERREUR		% A
CBF-	3200.000	0.0	72NDS	100.000	0.0	

** BETAS- NB-= 1 72NDS

ENERGIE +/- ERREUR		KEV	INTENSITE +/- ERREUR		% ABSOLU
2700.000	100.000		0.0	0.0	

** GAMMAS NG = 3 70HES

ENERGIE +/- ERREUR		KEV	INTENSITE +/- ERREUR		% RELATIF
491.300	0.100		100.000	0.0	
1348.000	0.100		5.300	1.400	
1564.000	0.200		4.400	1.800	

COMMENTAIRES
CMN POSITION ISOMERE INCONNUE 7/2/74 J.B.

52 TE127F
******

T= 109.000 +/- 2.000 J 72NDS

	ENERGIE +/- ERREUR		KEV	BRANCHEMENT +/- ERREUR		% A
CBF-	781.260	5.000	71WAP	2.400	0.0	
E1T	88.260	0.0	72NDS	97.600	0.0	

** BETAS- NB-= 4 72NDS

ENERGIE +/- ERREUR		KEV	INTENSITE +/- ERREUR		% ABSOLU
64.000	0.0		0.010	0.0	
130.000	0.0		0.002	0.0	
152.000	0.0		0.001	0.0	
723.000	0.0		2.400	0.0	

** GAMMAS NG = 5 67APS

ENERGIE +/- ERREUR		KEV	INTENSITE +/- ERREUR		% ABSOLU
57.630	0.080		56.000	5.000	
593.300	0.100		0.240	2.000	
628.600	0.300		0.090	2.000	
651.000	2.000		0.030	1.000	
658.900	0.100		1.300	10.000	

COMMENTAIRES
CMN AUT REF 73KAL1 72KAL IGA M + F = 0.0099 IGR

5. Summary of Nuclear Data Evaluation at BCMN, GEEL

W. Bambynek

In the Joint Research Centers of the European Community little work is done on compilation and evaluation of nuclear non-neutron data. There is the European working group on evaluation of radionuclide decay data. The philosophy and the rules are published (Atomic Energy Review 11, 515 (1973), and have been explained by Dr. Grinberg at this meeting.

At the CBNM (Geel) 4 physicists are working part time on evaluations in addition to their experimental work. It belongs to the principles of our evaluation group that the evaluators are experimenters working actively in the field.

The "Euratom group" is not limited to members of the European Community. Every laboratory or group that has an interest to join our effort is invited.

6. Status Report of the NEA Neutron Data Compilation Centre, Saclay, France

F. Froehner

The Centre de Compilation de Données Neutroniques (CCDN) operated by the Nuclear Energy Agency (NEA) of the OECD at Saclay (France) is part of the world-wide 4-centre network of neutron data centres, servicing Western Europe and Japan. It has its own small computer and a permanent staff of 17 (8 physicists, 2 programmers, computer and clerical staff). Regular data exchange with the sister centres (NNCSC Brookhaven, IAEA/NDS Vienna, CJD Obninsk) ensures that the same data are available at all centres. The CCDN data base consists of essentially four computer files, namely

(1) the bibliographic file CINDA with about 110 000 entries for 20 000 publications;

(2) the numeric file NEUDADA with about 2 000 000 measured data points and associated non-numeric information;

(3) evaluated files in various formats (ENDF, UKNDL, KEDAK etc) with about 600 000 evaluated data points;

(4) the international request file WRENDA with more than 1000 official requests for neutron data measurements.

These files contain mostly neutron data, but in response to user needs more and more other nuclear data are becoming available, e.g. photon interaction data, nuclear structure and decay data for fission products etc.

The services of the CCDN consist of

(1) data dissemination service: all data users can order retrievals from the computer files - either directly if they work in the CCDN service area, or indirectly through their regional centre. During the last year the CCDN received

- 560 requests for measured data,
- 150 requests for evaluated data,
- 20 requests for CINDA retrievals.

These requests were often quite complicated so that on the average 5-6 computer searches of the files had to be made. In addition, about 35 requests for plots were satisfied. The normal time delay between receipt of a request and dispatch of the answer (listing, tapes, plots...) is 2-3 days.

(2) publications: The contents of the CINDA file are published annually in book form. CCDN produces the tape which is used to steer the printing. The CCDN Newsletter announces recent additions to the files, whereas the Neutron Nuclear Data Evaluation Newsletter (NNDEN) informs on neutron data evaluation activities. Special-purpose tabulations are produced directly from the computer files, e.g. EANDC 95 "U", a tabulation of neutron threshold reaction cross sections for dosimetry and other applications.

7. Remarks on Computerized Nuclear Data Files

S. Pearlstein

On the subject of nuclear data for applications I am more optimistic than ever before. The sophistication of the user has advanced to the point where the transport of neutrons and photons, and fission product burnup and decay are calculated from first principles with encouraging results. This good-turn of events has made the user, measurer, compiler and evaluator of nuclear data more dependent on each other. The entry of the large scale user of data has also made computerized files more important. I have submitted some examples to this Meeting (see papers 11 and 12 given in section A of this report) and would be pleased to receive comments on the material.

8. Compiling Projects at Chalk River Nuclear Laboratories (CRNL)

G.A. Bartholomew

CRNL does not have an ongoing formal data compilation program. Various compilations have been produced in the natural course of activities at the laboratory, for example in neutron capture γ-rays, fission product yield data, nuclear g-factors, γ-rays ordered by energy, and others.

Physics Division (CRNL) is willing to aid in nuclear data compilation activities originating elsewhere to a degree compatible with existing research programs and objectives but there is no present plan to allocate staff permanently to compilation activities. We welcome requests for help or collaboration in compiling; we would take all such approaches seriously but would treat them on an individual basis.

Coordinated programmatic nuclear data activities in Canada have, till now, been limited to neutron cross section and related data for the reactor program; these activities were under the surveillance of the Nuclear Data Committee, Chalk River. Steps are now being taken in an effort to broaden this coordination to other types of nuclear data and to take in nuclear activities at more laboratories. This reorganization may eventually result in greater scope for cooperative compiling programs in Canada.

9. SUMMARY OF NUCLEAR DATA ACTIVITIES AT THE AAEC ESTABLISHMENT AT LUCAS HEIGHTS, AUSTRALIA

B.J. Allen

Our interests are in applications rather than nuclear physics, the main ones being properties of fission products, and new methods of analysis.

The level scheme and decay data have been punched on cards for all nuclei up to zinc. However, this activity has stopped in view of the US task force efforts on fission product libraries. These libraries are in a format called ENDF/B4, and we would hope to receive any such additions to ENDF files when available. Some work could be done here if it was not just duplication of overseas work.

Bibliographic References

A bibliography of "Prompt Nuclear Analysis" (papers up to mid-1973) has been completed, and is scheduled for publication in the Atomic Energy Review. Copies are available. This could be updated on an annual basis and computerised.
Note: This is a bibliography of applications, not of data.

Experimental Data

1. (a) "keV Neutron Capture Gamma Rays" has been published (Nuclear Data 11 (6) (1973) and there are no plans for revising this (there is little activity in this field at the moment).

   (b) Thermal Neutron Capture Gamma Rays. This consists primarily of the data of Rasmussen et al., HFCRL-69-071 as listed by Duffey et al. NIM 80 (1970) 149; Sentfle et al. NIM 93 (1971) 425). The data have been included in a computer file for use in "Neutron Capture Analysis". It is planned to replace the sensitivity values ($S = \sigma_c\ I_\gamma/A$) by a more complete listing of σ_c, I_γ/A) by a more complete listing of σ_c, I_γ, detector efficiency, etc. It would not be difficult to use an alternative format or to up-date this compilation periodically with new results. However, insufficient manpower is available to carry out an evaluation of such data except perhaps for one or two cases as part of a cooperative program.

   (c) Proton Induced Gamma Rays. We have plans to begin listing these in a format compatible with (b) for use in analysis using (p,X_γ) reactions. Presumably the parameters needed will be: proton energy (resonance), angle of observation, total gamma yield, E_γ, I_γ (branching ratios). Once again, insufficient manpower is available for evaluations.

   (d) Charged Particle Reactions. Reactions such as (d,p) etc. are also useful in analysis and suitable compilation of proton energy groups (etc.) will be needed eventually (for example, all proton energies and intensities for a particular incident particle energy).

(e) A-chain Evaluations. We are not interested in becoming involved in this work, but could bring the requirements to the notice of other nuclear physics laboratories in Australia and New Zealand.

2. A unified format would be desirable for γ-decay data whether from radioactivity, (n,γ), or charged particle reactions. This could then be used in automated search and attributor techniques (see 1(a) above).

3. There would be no point in the exchange of raw Ge(Li) data, but only derived gamma ray intensities.

Evaluated Data

There is no evaluation in progress, but we would be willing to consider work on one or two cases of (n,γ) reactions as part of a cooperative program.

10. Statement of the Liverpool University Position

J.F. Sharpey-Schafer

The Liverpool University has for many years been producing nuclear structure data as part of its programme to improve the understanding of nuclear properties. Our emphasis in the last few years, has been on level spins, parities, lifetimes, branching ratios and multipolarities. We would like to see evaluated compilations, of the type produced by P.M. Endt and C. Van der Leun for $21 \leqslant A \leqslant 44$, extended to $A \geqslant 45$ as we find the present compilations very inadequate. We would also like to see the turn -round time for these compilations reduced from the present 4 to 5 years to 2 to 3 years.

As a contribution to sharing the burden of this work it is conceivable that we would be able to organize the production of a compilation of evaluated data, for instance for $45 \leq A \leq 60$ or $61 \leqslant A \leqslant 74$. We would not however wish to do this if others would prefer to make this contribution themselves and we would not want to tread on any toes in this direction. However, if others agree with this need and if some international delegation of areas of responsibility can be made, we would be most willing to make an attempt to pull our weight.

11. Report from Sweden on activities in the field of evaluation and compilation of nuclear data.

L. Stroemberg

In Sweden there is no permanent group set up to perform compilation or evaluation work within the non-neutron nuclear data area.

Since about a year there exists however a National Nuclear Data Committee consisting of people from the reactor industry, universities and other institutions involved in basic and applied nuclear research. The Committee's main purpose is to coordinate the activities in the field and to disseminate information regarding ongoing and planned activities. The Committee also annually distributes a Progress Report on the activities in the country.

In the past, groups of specialists have taken part in evaluation activities as a part of an international cooperation as, for instance, the contributions by Brune and Lorenzen on the excitation functions for charged particle reactions for activation analysis purposes and the one by Forkman and Bülow on photonuclear reactions.

A similar situation is expected to exist even in the future, that is evaluation of data only on a rather limited scale might be possible. For many years research groups at different institutes have been working on problems associated with nuclear structure and decay data. Thus, the experience and the expertise exist and many groups could be considered as potential contributors. At the present time two groups have pronounced their interest in joining an international cooperation effort in the following areas a) Nuclear structure data, level schemes, spins etc. in the region $Z = 20 - 28$ and b) Decay data for short-lived fission products.

The first group is the one headed by Professor Bergqvist at Lund which have been doing an extensive study of nuclei in the f7/2 shell with different particle reactions and the second group the one at Studsvik working under Professor Rudstam. These groups are however pure research groups which normally do not have funds for this type of work. It is therefore our hope that this specialist's meeting come out with such recommendations that would facilitate the financing of such projects.

12. "The National Nuclear Data Libraries" at the Institutul de Fizică Atomică, Bucarest

Al. I. Bădescu-Singureanu, N. Deciu, Ḑ. Gheorghe,
N. Mateescu, Silvia Mateescu, S. Răpeanu

Summary of a report* on the Romanian National Nuclear Data Libraries: The main problem of the organization of the evaluated nuclear data for reactors computerized libraries, the solutions adopted by the most important national libraries: ENDF (USA), UKNDL (GB), KEDAK (FRG), and the general organization of the Romanian evaluated microscopic nuclear data library "DANEM-I" from the I.A.P., are presented.

The content of this report is:

1. The nuclear data for reactors and their evaluation
2. The evaluated nuclear data computerized library
3. The main national evaluated nuclear data computerized libraries
4. Comparison between the computerized libraries ENDF, UKNDL and KEDAK.
   - 4.1 The library contents
   - 4.2 The classifications principle of the stored informations
   - 4.3. The recorded data identification
   - 4.4 The stored data processing
   - 4.5 The physical medium on which the information is stored
5. The IAEA (Vienna) recommendations concerning the evaluated nuclear data library formats.
6. The evaluated microscopic nuclear data library "DANEM-I" from the I.A.P.
   - 6.1 The library contents
   - 6.2 The library structures
   - 6.3 The stored data processing. References

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* Studii Cercetari de Fizica,
26, 9 (1974, to be published)

13. REPORT ON THE YUGOSLAV NUCLEAR DATA ACTIVITIES

G. Paic

The increasing usage of nuclear methods (the building of a nuclear power plant, two betatrons and a linac for medical treatment, radio-pharmaceutical production, etc.) in Yugoslavia has brought up the necessity to consider some nuclear data evaluation in the fields in which the need has been recognized. We are for the moment involved in some evaluation work on the K_α/K_β ratios of X-ray emission for some nuclei.

We are therefore interested in the development of some work in specific areas and horizontal compilation work.