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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

Coordination of the International Network of Nuclear Structure and Decay Data Evaluators

Summary Report of an IAEA Advisory Group Meeting

hosted by the Hungarian Academy of Sciences
at the Institute of Isotopes, Budapest

14 - 18 October 1996

Edited by D.W. Muir and V.G. Pronyaev

March 1998

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LIST OF ABBREVIATIONS

CAJaD	Centre for Data on the Structure of the Atomic Nucleus and Nuclear Reactions, Kurchatov Institute, Moscow, Russia.
CBNM	CEC Central Bureau for Nuclear Measurements, located at Geel, Belgium. Now: Institute of Reference Materials and Measurements.
CD-ROM	Compact disk with read-only memory.
CEC	Commission of the European Communities.
CNDC	Chinese Nuclear Data Center, Institute of Atomic Energy (IAE), Beijing.
CPND	Charged-particle nuclear reaction data.
DBMS	Database Management System.
ENSDF	Computer-based Evaluated Nuclear Structure Data File.
Evaluation	• Mass-chain evaluation: to obtain best data for the structure and decay of all nucides with the same mass. • Horizontal evaluation: to obtain best values of one or a few selected nuclear parameters for many nuclides irrespective of their mass.
EXFOR	Computer-based system for the compilation and international exchange of experimental nuclear reaction data.
FIZ	Fachinformationszentrum Energie, Physik, Mathematik GmbH, Eggenstein-Leopoldshafen, Germany.
IAEA/NDS	Nuclear Data Section, International Atomic Energy Agency.
ICRM	International Committee for Radionuclide Metrology.
INDC	International Nuclear Data Committee.
INEL	Idaho Nuclear Engineering Laboratory, USA.
INIS	International Nuclear Information System, operated by the IAEA.
IP	Isotopes Project at LBL.
IRMM	CEC Institute of Reference Materials and Measurements, Geel, Belgium.
JAERI	Japan Atomic Energy Research Institute.
KACHAPAG	Karlsruhe Charged Particle Group.
KISR	Kuwait Institute for Scientific Research.
LBL	Lawrence Berkeley Laboratory, University of California, USA.
LIYaF	Leningrad Institut Yademoy Fiziki: Data Centre of the St. Petersburg Nuclear Physics Institute of the Russian Academy of Sciences.
NDP	Nuclear Data Project, the Oak Ridge National Laboratory.
NDS	Nuclear Data Sheets, a journal devoted to ENSDF data.
NDS	IAEA Nuclear Data Section.
NNDC	National Nuclear Data Center, Brookhaven National Laboratory, USA.
NSDD	Nuclear Structure and Decay Data.
NSR	Nuclear Science References, a bibliographic file related to ENSDF.
ORNL	Oak Ridge National Laboratory, USA.
PC	Personal Computer.
USDOE	U.S. Department of Energy.
USNDN	U.S. Nuclear Data Network.
TUNL	Traingle Universities Nuclear Laboratory, USA.

CONTENTS

FOREWORD

The international network of nuclear structure and decay data (NSDD) evaluators, consisting of evaluation groups and data service centres, aims at a complete and periodic nuclear structure and decay data evaluation of all nuclides, the continuous publication of these evaluations and their dissemination to the scientific community. The evaluated data resulting from this concerted international effort are introduced in the Evaluated Structure and Decay Data File (ENSDF) and published in the journals Nuclear Physics A and Nuclear Data Sheets; they comprise the currently recommended "best values" of all nuclear structure and decay data and explain the way in which they were obtained from the published data. The resulting data are needed in practically all applications of nuclear technology. The recommended values are made available to users in various media such as on-line computer services, PC diskettes and compact disks, wall-charts of nuclides, handbooks, nuclear wallet cards, and others.

The international NSDD network has evolved from the pioneering work in the late fourties and early fifties by physicists from the Berkeley Radiation Laboratory and the Pasadena Institute of Technology (California) the Rijksuniversiteit at Utrecht (Netherlands) and the Nuclear Data Group (Washington and Oak Ridge). The United States effort is presently coordinated by the Executive Committee of the U.S. Nuclear Data Network. The ENDSDF master database is maintained by the US National Nuclear Data Center at the Brookhaven National Laboratory. The international co-operation is supported by the IAEA Nuclear Data Section.

Periodic meetings of this network have the objectives to maintain the coordination of all centres and groups participating in the compilation, evaluation and dissemination of NSDD, to maintain and improve the standards and rules governing NSDD evaluation, and to review the development and common use of the computerized systems and databases maintained specifically for this activity.

List of NSDD meetings

place	date	report
1. Vienna, Austria	29.4. - 3.5.1974	INDC(NDS)-60
2. Vienna, Austria	3. - 7.5.1976	INDC(NDS)-79
3. Oak Ridge, USA	14. - 18.11.1977	INDC(NDS)-92
4. Vienna, Austria	21. - 25.4.1980	INDC(NDS)-115
5. Zeist, Netherlands	11. - 14.5.1982	INDC(NDS)-133
6. Karlsruhe, Germany	3. - 6.4.1984	INDC(NDS)-157
7. Grenoble, France	2. - 5.6.1986	INDC(NDS)-182
8. Ghent, Belgium	16. - 20.5.1988	INDC(NDS)-206
9. Kuwait, Kuwait	10. - 14.3.1990	INDC(NDS)-250
10. Geel, CEC, Belgium	9. - 13.11.1992	INDC(NDS)-296
11. Berkeley, USA	16. - 20.5.1994	INDC(NDS)-307
12. Budapest, Hungary	14 - 18.10.1996	INDC(NDS)-363

INTRODUCTION

The twelfth Meeting on the Coordination of the International Network of Nuclear Structure and Decay Data Evaluators was hosted by the Hungarian Academy of Sciences at the Institute of Isotopes, Budapest. The meeting was attended by 25 scientists from 12 countries and 2 international organizations representing data evaluators, data dissemination centres and data users communities.

D. de Frenne was selected to serve as General Chairman of the meeting and M. Martin, D.W. Muir and J. Katakura were selected to chair the Task Group sessions.

The evaluated Nuclear Structure and Decay Data File (ENSDF) together with the Nuclear Science Reference (NSR) file, contain the information in computerized form on experimental and evaluated data for more than 2500 isotopes, including lifetimes and decay properties, nuclear level schemes with level excitation energies, spins, parities, branching coefficients for a different decay modes. They provide a convenient basis for the preparation of specialized, application-oriented data libraries.

The input preparation for the ENSDF and NSR databases, data processing, data retrievals and computer program development are performed presently in more than twenty data centres and research organizations. Aided by rapid developments in computer networks, good progress has been achieved in the dissemination of NSDD data in recent years. With the increased level of utilization has come greater recognition of certain shortcomings of the data. The problem of remedying these shortcomings arises both from the technical complexity of the data and the fact that limited manpower is available for making the needed improvements. It is clear that solutions will take considerable time to implement, even with an efficient sharing of the work.

Conclusions and Recommendations

IAEA Advisory Group Meeting
on the Coordination of the

Nuclear Structure and Decay Data Evaluators' Network

Meeting Organisational Issues

The meeting participants expressed gratitude for the Agency's continued support of the NSDD network, including sponsorship of biennial Advisory Group Meetings of the members of the network, and the publication of several useful technical documents, including the summary reports of these meetings.

The meeting participants wish to emphasize the special character of these biennial meetings. These meetings accomplish the major organisational tasks associated with the operation of this data network, and they provide an essential forum for addressing major scientific and technical issues expected to affect the network in the near term. To accomplish these ambitious goals requires the active participation of experts representing the 16 specialized NSDD data centres. To achieve balanced representation of the views and technical needs of this large number of data centres requires the regular participation of more than one participant per country and, in some particular cases, more than one *paid* expert from a country. We strongly recommend that the IAEA take this special need into account in the planning of future meetings of the NSDD network.

Also related to the efficient conduct of the work of the network, a key element is the timely availability of meeting summary reports. We strongly urge the Agency to continue to use, as it has in the past, the medium of unedited INDC reports for this purpose.

Future Directions for ENSDF

There were a number of lively discussions about the future direction of ENSDF. The views expressed on future developments largely correlate with what the various participants see as the main future use of the file. It is clear that it serves very well as the basis for the publication of the scientific journal Nuclear Data Sheets. It was stated that production of issues of this journal from the information in ENSDF is now highly automated.

Beyond this traditional use, there is a desire to use ENSDF in the nuclear-structure basic research community. At present, researchers find it somewhat awkward to extract "horizontal" information (especially the mass-dependence of some particular property of levels or decay processes) from ENSDF, because of its mass-chain oriented format. Such research would probably be aided by making some relatively minor changes in the data storage format, plus the imposition of more uniform procedures for data entry.

Interest was expressed in the development of new procedures for the incorporation of newly evaluated “horizontal” data into ENSDF. This will be difficult to achieve because it implies an overlap in the responsibilities of different evaluations. Further discussion of this point is required.

Some speakers went further and requested that the entire file be reorganized along horizontal lines, giving the argument that new people would be attracted to the evaluation effort by the possibility of compiling the specific data relevant to their particular research interests. The development of a separate file of specialized horizontal evaluations might serve the basic research community very well. However, such an approach appears to offer few benefits to the applied users of ENSDF, so efforts in this direction probably fall outside the scope of an Agency-supported data network.

Probably the largest group of applied users are involved in non-destructive analysis of materials based on observations of gamma- and x-ray emissions. This community already uses ENSDF extensively, but this use is hindered by the lack of completeness of the file and a presently inadequate level of error checking. This community would appear to be best served by a file in the present nuclide-oriented structure (which can easily be processed into horizontally-arranged handbooks and databases), but with the current experimental data supplemented extensively by data from theory and systematics, in order to reach the level of completeness required in the targeted applications. Some speakers warned against the confusion that is introduced by mixing experimental and theoretical data in a single file, at least without proper identification of the data source.

This suggests the approach of having two different files of nuclide-oriented information, one essentially "pure" experimental information, and a second one with a substantially higher level of completeness, achieved with the addition of information from theory and systematics. Such a separation, incidentally, is the normal situation in the reaction-data community (EXFOR vs. ENDF, for example). The persons responsible for adding the theory-based information would be very interested in horizontal-type information and would be among the beneficiaries of improved format uniformity across the experimental file, as discussed above.

No firm conclusions were reached on the restructuring of the file. However, it was agreed that it is an important topic, worthy of careful thought and further discussion. The Agency was asked to assist in further defining the specific requirements of the applied users, for example through the organization of a Consultants' Meeting on this topic. Another suggestion was to include a session on user requirements in future meetings of the NSDD network.

List of Actions

Responsible	Action
T. Burrows, NNDC	Send a message with the e-mail addresses of the discussion groups on network-related subjects (refers to action 6 of the 1994 meeting)
ENDT (European Nuclear Data Taskforce)	Seek ways and means to coordinate and stimulate nuclear data evaluation in Europe
Network (continuing action)	Keep abreast of and solicit activities in other areas where horizontal evaluations may be appropriate in the future for incorporation into ENSDF
US program manager	Address the problem spelled out in action 29 of the 1994 NSDD meeting on obvious errors in ENSDF
N. Stone (continuing action)	Prepare and disseminate a file of nuclear moments
IAEA-NDS	Arrange, if possible, NSDD meetings in conjunction with major nuclear physics conferences
Network	Assist the NNDC in coding conferences for the NSR
C. van der Leun	Write an informational article about nuclear data evaluation in NUPECC news
IAEA-NDS	Update brochure on network activity
T. Burrows, F. Chu (continuing)	Define specifications for an ENSDF input/checking program
Network	Continue the production of a journal "publication" for the mass-chain evaluations
NNDC, IAEA-NDS	Coordinate computer/distribution development activities in the distribution centers
IAEA-NDS	Nominate a chairman for the next NSDD meeting well in advance of the meeting
Network	Transmit to NNDC suggestions on how to handle NSR keynumbers, which currently have 2-digit year designators, for publications appearing after December 31, 1999, in order to maintain uniqueness and sortability
Network	Report all errors detected in ENSDF, as soon as they are found, to NNDC

TASK GROUPS

I. Evaluation

C. Reich, J. Tuli, I. Kondurov, Huo Junde, M. Martin, B. Singh, J. Dairiki, J. Blachot, D. DeFrenne, N. Stone

Issues:

1. Evaluation manpower
2. Horizontal evaluations, integration into ENSDF
3. Which horizontal evaluations should be covered
4. Technical evaluation and quality items
5. Data repository

II. Dissemination and Coordination

M. Konieczny, T. Burrows, D.W. Muir, D.R. Tilley, R. Firestone, Zhou Chunmei, P. Ekström

Issues:

6. Dissemination
7. Coordination

III. Quality, Outreach and Applications

D.W. Muir, G. Molnár, E. Menapace, F.E. Chukreev, J. Katakura

Issues:

8. Quality issues
9. Outreach
10. Application needs

Members of I + II + III: C.L. Dunford, R.A. Meyer, C. van der Leun

Task Force I - Evaluations

The priority goal of the NSDD Network is to keep the ENSDF data file current. Due to a shortage of evaluation manpower in recent years, a serious backlog has developed in the inclusion of new experimental data. The backlog will continue to grow unless this situation is rectified.

The network estimated that an evaluation-effort deficit of 25 FTE-year has developed (FTE = full-time-equivalent evaluator). In order to reduce this backlog in the next three years, an additional 8 FTE are required. In order to reduce it in a five year effort, about 5 additional FTE are required. An additional 1.5 FTE will be required for quality control.

Presently only 6 FTE are available for evaluation on a world-wide basis. When a steady state is reached after the backlog has been eliminated, maintaining the currency of ENSDF will require 8 - 10 FTE on a permanent basis.

In order to resolve this problem, the meeting <u>recommends</u> that one or more of the following actions be taken:

a) The appropriate funding agencies in each member country in the NSDD should be approached collectively, i.e. simultaneously, for support, to help fill the deficiency. The possibility that the product of such an approach could be co-ordinated through IAEA or NEA should be actively explored. The newly formed ENDT group could undertake this task.

(b) i) The minimum unit of evaluation in ENSDF will be a nuclide. All data will be evaluated and the adopted levels and gamma data sets updated.

    ii) Interconnected nuclides should be evaluated together. This could result in a complete A-chain evaluation, for example.

    iii) Jag Tuli with help from Balraj Singh will create a list of priority nuclides which will be circulated to NSDD centers in November 1996.

(c) The need to bring in new evaluators was discussed. There is no regular way to bring in new people and there have been very few in recent years. The shortage of current evaluation manpower and the "greying" of the evaluation network make this a critical issue. One suggestion was to have a crash program, like the NIRA (Nuclear Information Research Associates) program in the U.S. in 1971-3. That program supported a number of postdocs (who would otherwise have been lost to nuclear physics due to job shortages at the time) to engage in nuclear structure data evaluation. Another suggestion, which has many benefits to the program, was to bring in data coordinators in specific areas, e.g., nuclear astrophysics and high-spin data. These coordinators would spend half their time with data activities in their respective field — coordination, compilation, dissemination, and evaluation — and would spend the other half carrying out research in their field. This not only would bring in bright young people but would also secure closer relationships with the users.

(d) Alert users to new horizontal evaluations such as masses and NUBASE, via the online systems.

(e) A repository file in ENSDF format is presently available at NNDC for prepublication dataset evaluations. It is proposed to extend the use of this file to include both reviewed and unreviewed information. The feasibility of such extension should be outlined by NNDC and distributed to the NSDD.

(f) Evaluations will continue to be published as A-chain evaluations in Nuclear Data Sheets. When there are 3 or more nuclides updated in an A-chain, the whole A-chain should be published.

Task Force II - Dissemination, Co-ordination, Quality

Electronic Publications

The field of electronic publication is evolving. “Nuclear Physics” and “Nuclear Data Sheets” already have a Web presence. These provide practical advantages in the areas of archiving, cross-referencing, and review of pre-prints. At present, Wiley, Academic Press and North Holland are being provided with “print ready” information directly from the centres. In parallel to what these publishers provide on the Web, the centres also provide Web access to these data, but much more extensively, and with greatly enhanced features.

It was recognized that the current Web presence provided by the publishers is not ideal. Control over format and presentation is relinquished to the publishing houses, and can be influenced by constraints such as budget and limited expertise. However, this Web presence is evolving, and is largely driven by the efforts of members of the NSDD network. The task force recommended that the continued development of alternative publication media be strongly encouraged. The contribution of members of the NSDD network to the development of commercial publishing via transfer of technological know-how is non trivial, and should be publicized.

Some benefit of publishing electronically via a publishing house, rather than directly via the data centres, was highlighted. Formal publication via well-known publishers serves an important archiving function and provides a means of traceability.

It was recognized that printed matter is still an important medium, especially in developing countries, and is complementary to electronic media rather than mutually exclusive.

Citation

The task force discussed the mechanism of how to cite correctly data bases to which a large number of individuals have contributed, in order to adequately acknowledge the scope of participation. The task force recommended that a generic term, such as “NSDD Network”, be adopted as the author of all network publications. The name should be decided later by committee.

It was recommended that a full list of members and contributors to the NSDD network, to be used for citation purposes, be maintained and publicized by the data centres. This list should be compiled, and thereafter reviewed and updated, at the NSDD meetings.

An overview document describing the NSDD network structure and objectives would be a useful reference for individuals using the data, and for individuals wishing to become involved in the activities of the network.

WWW Presence

The task force recommended the concept of a global WWW entry point for the NSDD and NRDC networks, to be provided by the core data dissemination centres. A structure was proposed, consisting of a top level home page for the data dissemination network (name to be decided), from which links to home pages describing the structure and objectives of the NSDD and NRDC networks could be accessed. These pages would provide further links to all sites offering information related to these networks.

It was felt that a professionally designed logo was important to provide the NSDD network sites with an easily recognizable identity.

The task force supported the evolution of mirror sites to provide better network links to the data bases. However, the rapid proliferation of WWW sites (some unofficial) offering nuclear data and related information will necessitate stricter control and co-ordination to ensure that data being offer are correct and up-to-date. The task force recommended that a survey of current and planned activities in this area be carried out to assess the situation. A method, such as a QA logo, would need to be found, in order to flag the legitimacy of official sites.

The task force discussed methods of automated updates to databases held at satellite centres.

Manpower Resources

The task force noted that an increase in manpower will be required during the development phase of the WWW presence. Manpower resources will vary with time according to the evolving needs of such dissemination activities. At the present time, between 4 and 6 FTE are devoted to this work worldwide.

Recommendations from Task Force II

To summarize, the task force arrived at the following recommendations:

(a) that the continued development of alternative publication media be strongly encouraged;

(b) that a generic term, such as "NSDD Network", should be adopted for citing the author of network publications, and that a full list of members and contributors be maintained and publicized by the data centres for this purpose;

(c) that a global WWW entry point for the NSDD and NRDC networks be provided by the core data dissemination centres;

(d) that a survey of current and planned activities in Web sites offering nuclear data be carried out for better co-ordination of the work.

Task Force III - Quality, Outreach and Applications

Quality Issues

a) It would be helpful if additional mechanisms could be developed for informing the NSDD measurement community of missing or discrepant experimental data. The task force recommends that a Web page be created by the data centres for this purpose.

Co-ordination of Structure and Reaction Data Efforts

b) The task force recognized the overlapping nature of nuclear reaction and nuclear structure research and recommends that the network explore mechanisms of closer contacts.

c) The task force recommends that the network investigate a unified way of presentation of nuclear structure and nuclear reaction data in order to meet more general user needs. (Example: JEF file has both reaction and decay data).

Application needs

d) ENSDF is a data resource for various applications. To better understand these user needs, it is recommended that the Agency convene a Consultants' Meeting to bring together representatives from all major application areas, such as safeguards, industrial applications, dosimetry, environmental and medical research. Representatives of the NSDD should participate in this meeting.

e) For prompt gamma neutron activation analysis there is a need for a complete and consistent library of cold and thermal neutron capture gamma-ray and corresponding cross section data. The task force recommends that the IAEA investigate the possibility of a Co-ordinated Research Programme on this topic, involving individual researchers, as well as experimental groups from developing countries. The application of this method would help to solve the problems of environmental pollution, malnutrition, etc.

ANNEXES

Annex 1

IAEA Advisory Group Meeting on the Coordination of the International Network of Nuclear Structure and Decay Data Evaluation

Budapest, Hungary, 14-18 October 1996

hosted by the Hungarian Academy of Sciences
at the Institute of Isotopes

Scientific Secretaries: D.W. Muir, H.D. Lemmel

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Annex 2

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Berkeley, CA 94720, U.S.A.
Contact: E.B. Norman

d. Idaho National Engineering Laboratory
E.G. & G. Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83415, U.S.A.
Contact: R.G. Helmer

e. Triangle University Nuclear Laboratory
Duke University
Durham, NC 27706, U.S.A.
Contact: H.R. Weller/D.R. Tilley

f. Center for Nuclear Structure and Reaction Data
I.V. Kurchatov Institute of Atomic Energy
46 Ulitsa Kurchatov
123 182 Moscow, Russia
Contact: F.E. Chukreev

g. Nuclear Data Center
St. Petersburg Nuclear Physics Institute
Academy of Sciences of Russia
Gatchina, Leningrad Region
188 350, Russia
Contact: I.A. Kondurov

h. Fysisch Laboratorium
Princetonplein 5, Postbus 80.000
3508 TA Utrecht, The Netherlands
Contact: C. Van der Leun

i. Chinese Nuclear Data Center
Institute of Atomic Energy
P.O. Box 275 (41), Beijing, China
Contact: Liu Tong

ii. Nuclear Physics Laboratory
Jilin University
Changchun 130023, China
Contact: Huo Junde

j. Centre d'Etudes Nucléaires
DRF-SPH
Cedex No. 85
F-38041 Grenoble Cedex, France
Contact: J. Blachot

k. Nuclear Data Center
Tokai Research Establishment, JAERI
Tokai-Mura, Naka-gun
Ibaraki-Ken 319-11, Japan
Contact: A. Hasegawa

l. Institute of Physics
University of Lund
Sölvegatan 14
S-223 62 Lund, Sweden
Contact: P. Ekström

m. Nuclear Data Project
Kuwait Institute for Scientific Research
P.O. Box 24885
Kuwait, Kuwait
Contact: A. Farhan

n. Laboratorium voor Kernfysica
Proeftuinstraat 86
B-9000 Gent, Belgium
Contact: D. De Frenne

o. Tandem Accelerator Laboratory
McMaster University
Hamilton, Ontario L8S 4K1, Canada
Contact: J.A. Kuehner

EVALUATION RESPONSIBILITY

Center	Mass Chains	Center	Mass Chains
a. US/NNDC	45-50,57,58,65-73,94-97,99, 136-48,150,152,165,199	g. Russia/St P h. Holland	86,88,130-135 21-44
b. US/NDP	82,84,85,200-205,207-209, 213-236 (except 215,219,223, 227), 237-243(odd),244-266	i. PRC j. France k. Japan	51-56,195-198 101,104,107-109,111,113-117 118-129
c. US/LBL	81,83,89-93,167-194,206, 210-212, 215,219,223,227	l. Sweden m. Kuwait	59-63 74-80
d. US/INEL	87,153-163	n. Belgium	102,103,105,106,110,112
e. US/TUNL	3-20	o. Canada	64,98,100,149,151
f. Russia/MOS	1,2,164,166,238-244(even)		

Annex 3

NSDD DISTRIBUTION CENTERS

National Nuclear Data Center
Brookhaven National Laboratory
Upton, NY 11973, U.S.A.
Contact: J.K. Tuli

OECD Nuclear Energy Agency
Le Seine St. Germain
12, blvd. des Iles
F-92130 Issy-les-Moulineaux, France
Contact: N. Tubbs

Center for Nuclear Structure and Reaction Data
I.V. Kurchatov Institute of Atomic Energy
46 Ulitsa Kurchatova
123182 Moscow, Russia
Contact: F.E. Chukreev

IAEA Nuclear Data Section
Wagramerstr. 5, P.O. Box 100
A-1400 Vienna, Austria
Contact: D.W. Muir

Fachinformationszentrum Energie, Physik,
  Mathematik GmbH
Kernforschungszentrum
D-76344 Eggestein-Leopoldshafen, Germany
Contact: H. Behrens

Annex 4

IAEA Advisory Group Meeting on the Coordination of the Nuclear Structure and Decay Data Evaluators Network

Budapest, Hungary
14 - 18 October 1996

hosted by the Hungarian Academy of Sciences
at the Institute of Isotopes

AGENDA

The objectives of the meeting are to coordinate all centres and groups that participate in the compilation, evaluation and dissemination of Nuclear Structure and Decay Data (NSDD), to review the development and common use of the computerized ENSDF database maintained specifically for this activity, and to provide for the publication of evaluated NSDD in "Nuclear Data Sheets" and other print and electronic media.

The meeting should achieve a coordinated and prioritized activity plan for the next two years, in order to move the NSDD activities and databases in a direction which addresses the data needs of frontier nuclear science research areas, under consideration of budget realities.

For the Minutes of the last Meeting, 16-20 May 1994 in Berkeley, see report INDC(NDS)-307.

A. Introductory items

1. Opening statements
2. Election of chairman
3. Adoption of the agenda - compare also item C. below
4. Announcements

B. Activity reports

1. Review of actions from the last meeting
2. Short status reports by the participants
3. Report on the Decay Data Evaluation Project organized by R. Helmer
4. Brief discussion of the reports
5. Brief review of the preceding Capture Gamma Symposium and items of relevance to the present meeting.

C. What should be achieved at this Meeting?

1. Review of the long agenda. Priorities. Schedule.
2. What topics should be covered by Subgroups? or all in plenary

D. Technical items

1. Update of USNDN Activities/Accomplishments/Priorities since the 1994 NSDD meeting [Dairiki]
2. NSR [NNDC]
    - continuity, quality, up-to-datedness
    - future needs, plans, developments

3. ENSDF [NNDC]
    - data repository/quality/up-to-datedness
    - editor's responsibilities
    - assignment of mass chains to evaluators
    - guidance to evaluators: evaluation techniques, policies and guidelines, uniform nomenclature for bands
    - nuclide data sets versus mass chain data sets
    - how to handle unreviewed data
    - should review procedures be modified?
    - priorities within limitations of manpower and budget
4. Low mass chains
    - getting all data for A < 45 into ENSDF
    - future of A = 21-44 [van der Leun]
5. Electronic communications between **NNDC and evaluators**

E. Special NSDD topics/horizontal evaluations and compilations

1. Status of high-spin evaluations [Singh?]
2. Status of the compilation of superdeformed band data in ENSDF
3. Alpha decay systematics and evaluations
4. Decay data [Helmer, coordinator]
5. Nuclear astrophysics data
6. (n,γ) data, including cross-sections [Molnar]
7. Masses [Audi], moments, etc.
8. Other

F. Scientific topics

1. B. Singh: Systematics of E4 transition probabilities in even-even nuclides
2. Revisit the question of Rosel versus Hager-Seltzer tables

Any other?

G. Publications and customer services: status and plans

1. Print products
    - Nuclear Data Sheets
    - Nuclear Physics ($A \leq 44$)
    - Handbooks
2. Electronic services
    - Online System [NNDC]
    - TOI [Firestone]
    - VuENSDF [Chu, Firestone]
    - Nuclear Data and References [Browne, Ekström]
    - MacNuclide [Stone]
    - WWW [Ekström, NNDC]
    - WWW Coordination Workshops in Livermore, 13-15 August 1996; and Vienna, 30 September - 2 October 1996
    - Future plans
    - Coordination: Who develops what? Cross-linking?

3. Publicity
4. Documentation [paper by Lemmel]
    - citation of databases in publications
    - giving appropriate credit and recognition to evaluators and data centers
    - databases should include a README file with citation guidelines
    - archiving of databases

H. Other activities of interest to the NSDD Network

1. US activities, e.g. USNRDN
    - Restructuring of the US DOE nuclear data effort [Meyer]
2. NEA activities
3. IAEA activities
4. Recommendations to IAEA:
    a) What meetings or coordinated research projects should be held?
        - Update of the "X and Gamma-Ray Standards for Detector Calibration"
        - Update of the "Decay Data of the Transactinium Nuclides"
        - Else?

    b) Future of NSDD Network Meetings [paper by Lemmel]

I. Concluding items

1. Next meeting, programme, date and place
2. Miscellaneous

J. Conclusions

Annex 5

STATUS REPORTS

5.1 US Contribution to the Evaluation of Nuclear Structure & Decay Data and Related Activities

- *J. Dairiki*: Overview
- *C. Stone, R. Sutton* (CNIT): Nuclear Database Management Systems
- *R.G. Helmer, C.W. Reich*, and *R.L. Heath* (INEL): INEL Mass-Chain Evaluations and γ-ray Spectrometry Project
- *R.G. Helmer* (INEL), *E. Browne* (LBNL), and *J.K. Tuli* (BNL): Decay Data Evaluation Project
- *J. Dairiki* et al.: Isotopes Project
- *M.R. Bhat*: National Nuclear Data Center Activity Report
- *Y.A. Akovali* et al.: Nuclear Data Project (NDP)
- *D.R. Tilley*: TUNL Nuclear Data Evaluation Project

5.2 *M.R. Bhat, T.W. Burrows, C.L. Dunford*, and *S. Ramavataram*: Nuclear Science References (NSR) Task Force Report

5.3 IAEA Nuclear Data Section Progress Report

5.4 *F.E. Chukreev*: CAJAD activity in ENSDF

5.5 *J. Katakura*: Status Report of Japanese Activities in Nuclear Structure and Decay Data

5.6 *J. Blachot, G. Audi*, and *O. Bersillon*: Status Report of French activities in Nuclear Structure and Decay Data

5.7 *P. Ekström*: Nuclear Structure and Decay Data Evaluation in Sweden

5.8 *I.A. Kondurov, Yu.V. Sergeenkov*: Status Report on NSDD Activity of the PNPI Data Center

5.9 *P.M. Endt* and *C. van der Leun*: Status Report Utrecht

5.10 *D. De Frenne, E. Jacobs*: Status report Belgian Group

5.11 *B. Singh*:
1. Status Report of the Nuclear Data Project at McMaster University
2. Status Report: Evaluation of high spin and Superdeformed data for ENSDF

Overview

Janis Dairiki
Chairman, USNDN Executive Committee

This report, with contributions from all the U.S. nuclear structure data centers, describes the activities of the U.S. Nuclear Data Network (USNDN) from May 1994 to September 1996. This has been an especially productive period for the USNDN as highlighted in this overview. It should also be pointed out that many of these accomplishments result from collaborations between USNDN members themselves and with the international data and research communities.

Evaluation

In accordance with a recommendation at the 1994 international Nuclear Structure and Decay Data (NSDD) meeting, the USNDN has redirected some of its evaluation effort toward new areas of horizontal evaluations -- particularly of high-spin and decay data. Significant progress has been achieved in these new areas as indicated below:

- Mass-chain evaluations
  - 27 mass-chain evaluations completed
  - 25 new evaluations currently in the processing pipe line

- High-spin data
  - Coordination of ~1.5-2.0 FTE evaluation effort by B. Singh
  - Data in 16 A-chains updated and entered into ENSDF
  - Superdeformed band information updated continuously
  - Current primary references (and some data) provided quarterly via WWW
  - High-spin data for all nuclides updated for the *Table of Isotopes*

- Decay data
  - Coordination of evaluation effort by R. Helmer and E. Browne
  - Developed new collaborations with European colleagues
  - Work also coupled with that of IAEA specialists
  - Data for 24 nuclides evaluated

- Nuclear astrophysics data
  - Data provided in electronic form over Internet for the first time
  - Participation, with nuclear astrophysics community, in Workshop on Nuclear Data for Nuclear Astrophysics

- Relativistic heavy-ion data
  - Pilot program by the NNDC to make experimental data available to users

- Joint proposal (G. Molnar/LBNL) to compile/evaluate capture gamma data

NSR

The scope of the NSR file has been expanded to include journal articles dealing with most aspects of nuclear physics. Coverage for important primary journals like Physical Review C, and Nuclear Physics A, is now complete. To reflect this expanded coverage, the name of the file has been changed to Nuclear Science References.

Data Dissemination

The evolution of the Internet and, particularly of the World Wide Web (WWW), has changed the paradigm for nuclear data dissemination. Information can be provided easily in a variety of ways as evidenced below. Most of the future dissemination activity will center on electronic data dissemination. In August 1996 several USNDN members participated in a joint meeting with members of the U.S. Nuclear Reaction Data Network focused on "DOE Nuclear Data Program Services via the Internet" to better coordinate these activities. Some of the highlights of USNDN development and data now available on the WWW include:

> Data for A=3-20 made available in different formats; demonstrated at Long Range Planning Meeting in Durham, N.C. -- January 1995
>
> *Nuclear Wallet Cards*
>
> WWW home pages/data links -- with specific data for specific research communities, e.g., nuclear astrophysics, decay data, high-spin data
>
> *Table of Isotopes* data
>
> VuENSDF, nuclear data viewer software; the software and the data can be downloaded from WWW
>
> Gamma-ray Spectrometry Information, including extensive gamma-ray spectrum catalogues for NaI(Tl) and Ge detectors
>
> *Nuclear Data Sheets* made available on WWW by Academic Press -- July 1996
>
> A unified U.S. Nuclear Data Program WWW home page, which resulted from the joint USNDN/USNRDN meeting in August 1996

At the same time, the NNDC has continued to improve the on-line services and enhance the data analysis, retrieval and checking codes, both for users and data evaluators.

Other specific developments and publications in this time period include the following:

- **Software**

  VuENSDF version 1.0 released -- July 1996

  PCNudat, released on *Nuclear Data and References* CD-ROM -- June 1996

  MacNuclide -- to be released by John Wiley & Sons

- **Publications**

  Papyrus NSR CD-ROM -- June 1994

  2 editions of the *Table of Superdeformed Nuclear Bands and Fission Isomers* -- 1994, 1996

  5th edition of the *Nuclear Wallet Cards* -- July 1995

  8th edition of the *Table of Isotopes* (hard copy and CD-ROM) -- April 1996

  Nuclear Data and References (CD-ROM) -- June 1996

  Recommended Gamma Energies for Detector Calibration (draft) -- 1996

  Alpha Decay Systematics: Radius Parameters for Even-Even Nuclides -- on-line data file 1996

  Review/Evaluation of A=18-19 (Nuclear Physics **A595**, 1 (1995))

  Review/Evaluation of A=20 (draft) -- July 1996

  Nuclear Data Sheets, 33 mass chains published by USNDN members -- 1994-1996

Outreach

The USNDN has substantially increased its interactions with the research community, particularly in the forefront areas of nuclear physics. This includes more active participation in scientific conferences and user-group meetings. Demonstrations, talks, and posters presented by USNDN members during this period are detailed in the center reports. Particularly notable during this period was the participation of USNDN members in the Nuclear Science Advisory Committee Long Range Planning process. Several network members participated in the Town Meetings and, for the first time, the Long Range Plan Working Group included a member of the USNDN.

Summary

The period since May 1994 has been an especially productive one for the U.S. Nuclear Data Network as indicated in this overview. More details of these accomplishments are contained in the individual reports. In addition to the data activities described in these reports, members of the USNDN have also participated in research activities in their respective institutions and an impressive number of research publications are listed in these reports.

Nuclear Database Management Systems

Craig Stone and Robert Sutton
Department of Chemistry, San Jose State University, San Jose, CA 95192 USA
and
Scientific Digital Visions, Inc., 2 N Second St., Suite 1215, San Jose, CA 95113

We are developing software tools for accessing and visualizing nuclear data. MacNuclide was the first software application produced by our group. This application incorporates a novel database management system and visualization tools into an intuitive interface. The nuclide chart is used to access properties and to display results of searches. Selecting a nuclide in the chart displays a level scheme with tables of basic, radioactive decay, and other properties. All level schemes are interactive, allowing the user to modify the display, move between nuclides, and to display entire daughter decay chains.

Nuclides can be searched for a variety of properties and attributes. Standard properties include mass, half life, spin-parity, decay mode, decay energy, decay branch, isomer energy, isotopic abundance, and neutron cross sections for capture, scattering, and fission. Mass is expressed in terms of mass, mass excess, binding energy, and binding energy per nucleon. Custom data can be imported from text files or can be generated for reaction Q-values and separation energies. Virtually any combination of projectiles and ejectiles are used in reaction calculations. Nuclides are also specified through the periodic chart and through dialogs that restrict ranges of protons, neutrons, and nucleons.

Attributes are labels that identify a nuclide as belonging to a collection of related nuclides. Doubly magic is one example that includes He-4, O-16, and the other doubly magic nuclides. Basic attributes include stable nuclides, fission products, mono-isotopic nuclides, magic proton numbers, magic neutron numbers, even-even, odd-odd, and the other related combinations of even and odd protons or neutrons. Custom attributes are defined through external files, or can be defined through nuclides painted in the chart.

The nuclide chart can be used to display results of complex database searches. Initial searches paint nuclides in one or more of eight colored nuclide groups. Further searches are combined with the colored nuclides using logical operators. Results cause nuclides to overwrite the chart, or to be added or deleted from the chart. The AND, NAND, OR, NOR, XOR, and NOT logical operators increase the flexibility of the search routines. In the event that no combination of searches can properly describe the nuclide colored in the chart, a paint brush tool is available to select one or more nuclides.

A powerful use of MacNuclide is in producing presentation graphics. Custom nuclide charts and level schemes can be prepared and output for use in graphics applications. Color and display managers provide a suite of tools for tailoring the display to a specific situation. A text manager allows users to incorporate multiple text fonts, sizes, and styles into single labels. This is especially useful in creating labels that incorporate basic nuclear science nomenclature, such as those that use superscripts and special symbols.

MacNuclide has now been extended beyond the basic Macintosh application. A Windows'95 version has been completed and distributed. Changes to the software are underway that will allow it to be packaged in software libraries that can be linked to custom software. When completed, the nuclear software development tools can be used by developers to incorporate database access, database searching, and data visualization features in their software.

MacNuclide for the Macintosh and Windows will be released shortly through John Wiley & Sons. A contract has been signed for world-wide distribution and marketing should begin within three months. Royalties received from the sales will be reinvested in the project, allowing us to establish on-line and telephone support for customers, and to support maintenance of the database.

We have established collaborations with the NNDC to more closely tie our software into their on-line nuclear data services. A joint post-doctoral position has been created and a candidate hired. This person will work at the

NNDC to develop an editor and graphics tools for nuclear systematics displays. Part of our collaboration involves the sharing of SJSU students with the NNDC. Undergraduate and graduate students are working on projects of mutual interest, spending time at the NNDC for training and continuing their work at SJSU. Other collaborations are through a Small Business Innovation Research grant held by Scientific Digital Visions (SDV). SDV has teamed up with the NNDC and with SJSU to study issues directly related to the access of nuclear data and the updating of distributed databases.

Efforts are also under way to include other aspects of the desk-top computing within the nuclear data environment. Software tools are being developed that allow the nuclear database management system to communicate with standard scientific productivity tools. Most notable among these provide access to the nuclear properties within graphics and spreadsheet applications. Future efforts will extend the nuclear database management system beyond the desktop computer, incorporating direct network updating of local databases.

This work has been supported by U.S. Department of Energy grant DE-FG03-91-ER40630. Aspects of the networked database access are supported by U.S. Department of Energy Small Business Innovation Research Grant DE-FG03 96ER82275.

INEL Mass-Chain Evaluations and γ-ray Spectrometry Project

Activity Report for Period May 1994 to August 1996
for Presentation at October 1996 Meeting
of
International Network of Nuclear Structure and Decay Data Evaluation

R. G. Helmer, C. W. Reich, and R. L. Heath

I. Evaluations

Mass chains

We have responsibility for 12 mass chains (87 and 153-163) and are proceeding with these evaluations. Since the last International Network meeting, we have completed and submitted evaluations for A = 158 and 160. The evaluations that have been published during this period are A = 157, 158, and 159. The status of all of the evaluations is given in the National Nuclear Data Center report.

Decay data sets

As a participant in the horizontal decay-data evaluation effort for selected important radionuclides (called the Decay Data Evaluation Project), we have evaluated the decay data for a number of nuclides. As of August, we have completed and sent out for initial review those for ^{24}Na, ^{95}Zr, ^{95}Nb, ^{113}Sn, ^{139}Ce, ^{140}Ba, ^{140}La, ^{153}Gd, and ^{153}Sm; and about eleven more are expected to have been sent for initial review before the Network meeting.

II. Nuclear Data Network Activities

In response to the decisions made at the May 1994 International Atomic Energy Agency (IAEA) Advisory Group Meeting on the Coordination of the International Network of Nuclear Structure and Decay Data Evaluations, we have organized an international group, the Decay Data Evaluation Project, to carry out high-quality evaluations of decay data for radionuclides that are important in various applications. See the report of the Decay-Data Evaluation Project for the status of these activities.

We have provided publicity for the work of the Network, especially in the area of decay data with presentations at the "Canberra User's Group Meeting" in June 1994 and at the symposium Advances in "Alpha-, Beta-, and Gamma-Spectrometry", sponsored by two Working Groups of the International Committee on Radionuclide Metrology (ICRM), September 1996, St. Petersburg, Russia.

We also participated in the Coordination Workshop on “DOE Nuclear Data Program Services via the Internet”, August 1996.

III. International Activities

Contact has been maintained with ICRM and its Working Groups on Non-Neutron Nuclear Data and γ-ray Spectrometry. Both Working Groups deal with topics of interest to the DDEP. (R. G. Helmer is the only US member of ICRM that is not associated with the National Institute of Standards and Technology.)

R. G. Helmer attended the IAEA Specialists' Meeting on the Development of an International Nuclear Decay Data and Cross-Section Database, October 1994, in Vienna. He chaired the subgroup meeting on decay data. See the DDEP report for further details.

A draft manuscript has been prepared with a new set of recommended γ-ray energies for detector calibration. This was prepared in cooperation with C. van der Leun, Utrecht and updates a similar publication in 1979.

IV. γ-ray Spectrometry Data for Internet

A program has been initiated to make γ-ray spectrometry information available on Internet through a new Gamma-ray Spectrometry Center at the INEL. As envisioned, the initial content will include the spectra from the R. L. Heath γ-ray spectrum catalogues for NaI(Tl) and Ge detectors along with the associated decay schemes, tables of γ-ray energies and intensities, and text. (Future additions are expected to include spectra from large volume Ge detectors and for selected reactions.)

A contract has been established with North Carolina State University to develop computer codes to generate response functions for monoenergetic γ rays as an initial step in a program to generate γ-ray spectra for any radionuclide for any specified Ge detector.

V. INEL Measurement Activities

With the completion of the upgrade of the methodology for the analysis of the total absorption (TAGS) γ-ray spectra in both singles and coincidence modes (see the first reference in section VI), the final analyses of all of the measured spectra have been completed to determine the relative β^- intensities as a function of the excitation energy. The nuclides analyzed are: ^{89,90g,90m,91,93}Rb, $^{93\text{-}95}$Sr, $^{94\text{-}95}$Y, ^{138g}, $^{138m,139\text{-}141}$Cs, $^{141\text{-}145}$Ba, $^{142\text{-}145}$La, $^{145\text{-}148}$Ce, $^{146\text{-}147,148(2.0\text{ m}),148(2.27\text{ m}),149,151}$Pr, $^{149,151\text{-}155}$Nd, $^{152(4.1\text{ m}),153,154(1.7\text{ m}),155\text{-}157}$Pm, $^{157\text{-}158}$Sm, and ^{158}Eu. These results have been submitted for publication.

The "ground-state" (i.e., to daughter levels below a cutoff energy, typically 100 keV) β^- intensities for these nuclides have been determined in separate measurements with the same system. These results have been published, or submitted for publication.

VI. Related Publications and Presentations

Publications

"Methodology for the measurement of β^--decay intensity distributions from the analysis of total absorption γ-ray spectra," R. G. Helmer, M. H. Putnam, R. C. Greenwood, and H. Willmes, Nucl. Instr. and Meth. A351 (1994) 406.

"Beta-decay intensity distributions of fission-product isotopes measured using a total absorption γ-ray spectrometer," R. C. Greenwood, R. G. Helmer, M. H. Putnam and K. D. Watts, Proceedings of International Conference on Nuclear Data for Science and Technology, Gatlinburg, Tennessee, May 9-13, 1994, page 327.

"Beta-decay intensity distributions of fission products ^{139}Cs and ^{140}Cs measured with a total absorption γ-ray spectrometer," R. G. Helmer, R. C. Greenwood, M. H. Putnam and K. D. Watts, Nucl. Instr. and Meth. A353 (1994) 222.

"Measurement of ground-state β^--branching intensities of deformed rare-earth nuclides using a total absorption γ-ray spectrometer," R. C. Greenwood, M. H. Putnam and K. D. Watts, Nucl. Instr. and Meth. A356 (1995) 385.

"Ground-state β^--branching intensities of several fission-product isotopes measured using a total absorption γ-ray spectrometer," R. C. Greenwood, M. H. Putnam and K. D. Watts, accepted for publication in Nucl. Instr. and Meth.

"Measurement of β^--decay intensity distributions of several fission-product isotopes using a total absorption γ-ray spectrometer," R. C. Greenwood, R. G. Helmer, M. H. Putnam and K. D. Watts, submitted for publication in Nucl. Instr. and Meth.

"Delayed-Neutron Energy Spectra of $^{87-90}$Br, $^{137-139}$I, and ^{136}Te," R. C. Greenwood and K. D. Watts, submitted for publication in Nucl. Sci. Eng.

Presentations

"Radionuclide Decay Data Evaluations- Past, Present, and Future," R. G. Helmer, 1994 Canberra User's Group Meeting, June 6-10, 1994, Charlotte, North Carolina,

"International Decay Data Evaluation Project," R. G. Helmer, meeting on Advances in Alpha-, Beta-, and Gamma-Spectrometry, September 18-20, 1996, St. Petersburg, Russia

"New Editions of the Gamma-ray Spectrum Catalogues for NaI and Ge Detectors," R. L. Heath, meeting on Advances in Alpha-, Beta-, and Gamma-Spectrometry, September 18-20, 1996, St. Petersburg, Russia

Decay Data Evaluation Project

Activity Report for the Period May 1994 to August 1995
for Presentation at the October 1996 Meeting
of the
International Network of Nuclear Structure and Decay Data Evaluation

R.G. Helmer (INEL), E. Browne (LBNL), and J.K. Tuli (BNL)

I. Origin of project

At its May 1994 meeting, the participants in the International Atomic Energy Agency (IAEA) Advisory Group Meeting on the Coordination of the International Network of Nuclear Structure and Decay Data Evaluators approved the implementation of a project to carry out a special evaluation of decay data for ~250 radionuclides. This new effort has been called the Decay Data Evaluation Project (DDEP).

Its goal is to provide high-quality and well-documented evaluations for radionuclides that are important in various applications, and to publicize the existence and availability of these evaluations.

II. Participants

The participants in this project are R.G. Helmer, coordinator, Idaho National Engineering Laboratory (INEL) in the United States; M-M. Be, Laboratoire Primaire des Rayonnments Ionisants (LPRI) in France; E. Schönfeld, Physikalisch-Technische Bundesanstalt (PTB) in Germany; T.D. MacMahon, Imperial College in the United Kingdom; and J.K. Tuli, Brookhaven National Laboratory (BNL) and E. Browne, Lawrence Berkeley National Laboratory (LBNL) in the United States.

Our agreement to carry out cooperative evaluations is informal. However, the French and German laboratories have a government-level agreement to carry out cooperative evaluations, and to publish them in a Table of Radionuclides.

The participants from LPRI and PTB provide the DDEP with direct contacts in the French and German radioactivity standards laboratories, which have extensive expertise in many areas of measurements of radionuclides.

Two other European groups have indicated an interest in joining the DDEP. This possibility is being explored.

III. Methodology and procedures

During the initial work of the DDEP in 1994, Helmer and Browne established a list of ~250 radionuclides that are of importance in the various applications and other research fields. E. Browne was asked to prepare a list of radionuclides for the same purpose at the IAEA

Specialist's Meeting on the Development of an International Nuclear Decay Data and Cross-Section Database, Vienna, October 1994. The list that he provided to the IAEA in January 1995 is similar to that currently used in the DDEP.

After written exchanges of ideas, the members of this project met in May 1995 to discuss the methodologies to be used in these cooperative evaluations. Some specific facets that were agreed upon are:

> Account for (i.e., use or explicitly exclude) all measurements of a given quantity.
>
> Generally use the Limitation of Relative Statistical Weights method for averaging data. This method provides a procedure for treating discrepant data while giving the usual weighted average for statistically consistent data. MacMahon and Browne developed a PC program for its application.
>
> Use the Rösel et al. theoretical internal-conversion coefficients when theoretical values are used.
>
> Use Schönfeld's data for electron-capture probabilities for the various atomic shells, and the Schönfeld and Janssen evaluation of fluorescence yields. (References are given in Section VI.)

At this meeting, all members of the DDEP have agreed to the following procedures:

> For each evaluation, provide written documentation of all the data used, and the methods and procedures that were applied.
>
> All evaluations will be initially reviewed by another member of the DDEP. After the evaluator has considered this reviewer's suggestions, copies of the evaluation are sent for a formal review to all participants. The evaluator then considers all of the comments.
>
> Evaluations must be approved by all DDEP evaluators before they are considered final.
>
> All evaluations will be available to DDEP evaluators for publication. In particular, it is expected that they will eventually appear in the French-German Table of Radionuclides and they will be available for inclusion in ENSDF (but this may require some coordination with the corresponding A-chain evaluator).
>
> The evaluations done initially in the LPRI-PTB format will be converted to the ENSDF format by the US evaluators.
>
> After the final editing has been completed for several evaluations, they will be submitted to the IAEA for consideration for their decay data database.

Since the Table of Radionuclides will not contain comments and comments in ENSDF are quite cryptic, we are planning to provide the supporting text information in laboratory reports. These reports will contain the data, the methods, and the procedures that were used in each evaluation.

IV. Related activities

At the IAEA Specialist's Meeting on the Development of an International Nuclear Decay Data and Cross-Section Database, October 1994, R. G. Helmer chaired the subgroup meeting on decay data. This provided the maximum compatibility between the goals of the DDEP and IAEA project.

E. Schönfeld and coworker have evaluated K- and L-atomic shell fluorescence yield data, both measurements and theoretical calculations, and provided a new set of recommended values. He has also prepared a table of quantities from which electron-capture rates from the various atomic shells can be computed. The National Nuclear Data Center (NNDC) at BNL has made available these data for their computer program RADLST.

We have provided publicity for the DDEP with presentations at the Canberra User's Group Meeting in June 1994, and at a symposium sponsored by two Working Groups of the International Committee on Radionuclide Metrology (ICRM) in September 1996.

R. G. Helmer and C. van der Leun (Utrecht) have prepared a draft manuscript that presents a new set of recommended gamma-ray energies for detector calibration, and is currently used by DDEP evaluators. These new energies supersede and will eventually replace those published by R.G. Helmer, C. Van der Leun, and P.H.M. Van Assche, Atomic Data and Nucl. Data Tables 24, 39 (1979).

V. Evaluation and review status

The status of the evaluations that have been carried out under this program follows. All dates are 1996. The "form" is L for LPRI-PTB format, and E for ENSDF format.

Radio-nuclide	Evalu-ator	Initial reviewer	Form	Sent to review	Review complete	Available for ENSDF
^{75}Se	Browne, Schönfeld	Helmer	L&E	Feb.	yes	yes
^{143}Pr	Tuli	Helmer	E	March		
^{194}Ir	Browne	Helmer	L&E	March	yes	yes
^{68}Ge ^{68}Ga	Schönfeld	Browne Helmer	L	March	yes	
^{141}Ce	Schönfeld	Browne	L	May	yes	
^{188}Re	Browne	Helmer	L&E	May		
^{109}Cd	Schönfeld	Helmer	L			

^{153}Gd ^{153}Sm	Helmer	Schönfeld	L&E
^{24}Na	Helmer Schönfeld		L&E
^{95}Zr ^{95}9b	Helmer	Bé	L&E
^{113}Sn	Helmer	Browne	L&E
^{140}Ba ^{140}La	Helmer	MacMahon	L&E
^{139}Ce	Helmer	Schönfeld	L&E

Many other nuclides are being evaluated.

VI. Related publications, laboratory reports, and presentations

Publications and laboratory reports

"Tables for the Calculation of Electron Capture Probabilities," E. Schönfeld, Physikalisch-Technische Bundesanstalt report PTB-6.33-95-2 (1995).

"Evaluation of atomic shell data", E. Schönfeld and H. Janssen, Nucl. Instr. Meth. in Phys. Res. A369, 527 (1996).

Presentations

"Radionuclide Decay Data Evaluations - Past, Present, and Future," R.G. Helmer, 1994, Canberra User's Group Meeting, Charlotte, North Carolina, June 6-10, 1994

"International Decay Data Evaluation Project," R.G. Helmer, at meeting "Advances in Alpha-, Beta-, and Gamma-Spectrometry, St. Petersburg, Russia, September 18-20, 1996.

"International Decay Data Evaluation Project," E. Browne, R.G. Helmer, J.K. Tuli, "Ninth International Symposium on Neutron Capture Gamma-Ray Spectroscopy and Related Topics," Budapest, Hungary, October 8-12, 1996.

Isotopes Project

Report prepared for the October 1996 IAEA Advisory Group Meeting on
Coordination of the International Network of Nuclear Structure and Decay Data Evaluators

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August, 1996

This report summarizes the activities and accomplishments of the Isotopes Project since the IAEA NSDD meeting in May 1994. Much of the group's nuclear data evaluation activity since that time has been directed to high spin and decay data. The group has had a seminal role in modernizing the current nuclear data information system by developing effective electronic data dissemination methods. Significant and rapid progress is being made in exploiting the capabilities of the World Wide Web. The past year has been particularly productive for the group with the completion of several projects.

- Publication of the 8th edition of the *Table of Isotopes* , both on CD-ROM and in hard copy, April 1996
- Production and release of Nuclear Data and References, a new CD-ROM which contains both NSR and NuDat (with appropriate search software), June 1996 -- LBNL, Lund University, BNL collaboration
- Publication of the 2nd edition of the *Table of Superdeformed Nuclear Bands and Fission Isomers* -- LBNL, McMaster University Collaboration
- Release of version 1.0 of VuENSDF (July 1996), software which allows the user to view all the data in ENSDF in both tabular and graphical form -- LBNL, Lund University collaboration

A. Network Coordination

The USNDN Executive Committee, chaired by J.M. Dairiki, has continued to meet on a regular basis (usually via telephone conferences) to coordinate and prioritize network activities. Significant effort has been devoted to new (redirected) network activities in high-spin and decay data evaluation.

Another priority has been to promote increased interaction of the data network with the research community. This included invited talks and demonstrations at professional meetings. For example, NDN members from LBNL, ORNL, BNL and Lund University

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participated (with talks and demonstrations) in a very successful Workshop on Data Analysis held at ORNL in February 1996. Two members of the Executive Committee (J. Dairiki and J. Cizewski) presented invited talks at the Pacifichem95 meeting in Honolulu in December 1995, a joint meeting of the American, Canadian and Japanese Chemical Societies. Both talks were well received and led to discussions regarding future plans for data evaluation and dissemination, as well as the need for support for these activities by the research community.

In February 1996, the Nuclear Science Advisory Committee (NSAC) completed a new long range plan for Nuclear Science in the U.S. Network members participated in several of the town meetings held as part of the planning process and, for the first time, a member of the USNDN (J. Dairiki) was part of the Long Range Plan Working Group.

B. Data Evaluation

1. High-spin Data Evaluation

Following a recommendation at the May 1994 IAEA meeting, we have redirected some of the group's effort towards the evaluation of high-spin data. Balraj Singh has coordinated the network's effort in this field, with evaluators (~1.5 - 2 FTEs) from LBNL, Lund University, McMaster University, NNDC, and ORNL. Procedures and guidelines for evaluating high-spin data were developed and communicated to the network. Lists of nuclides of high priority are updated regularly and distributed to the NSDD. Since July 1994, isotope-ordered lists of current nuclear structure experimental papers for both high- and low-spin studies published in ten main journals are prepared by B. Singh and made available (quarterly) to the research community and evaluators via the WWW. Experimental data from many of these recent papers are also being made available via the WWW.

In collaboration with McMaster University, the Isotopes Project has selectively updated data for nuclei in the superdeformed regions with mass numbers A=81-84, 130-137, 142-154, and 189-198, entered them into the ENSDF file, and published them in the *Table of Superdeformed Nuclear Bands and Fission Isomers*. These data are updated continuously.

The Isotopes Project has compiled/evaluated high-spin data for nuclides with A=135, 153, 163, 182, 186, 188, 190, 193, 194, and 211. All except the two most recent evaluations (A=194 and A=211) have already been included in ENSDF. In addition, high-spin data for about 140 isotopes were updated for the *Table of Isotopes*. These data are available on the Isotopes Project webserver and through the NNDC.

In accordance with a recommendation from both the U.S. and the international data networks, the USNDN Executive Committee defined a position for a high-spin coordinator at LBNL to be funded jointly by the Isotopes Project and nuclear structure research funds. A search was begun in early 1995. Working closely with the research community, an excellent candidate was identified from a very strong applicant pool. Unfortunately, the hire could not be made for budgetary reasons.

2. Decay Data Evaluation

In accordance with the action items from the 1994 IAEA meeting, E. Browne (LBNL) and R. Helmer (INEL) have organized an effort to selectively update decay data for radionuclides important for applied research and detector calibration. In collaboration with colleagues at the NNDC and in France (LPRI), Germany (PTB) and the United Kingdom

(Imperial College), they prepared a list of about 250 radionuclides in this area. Evaluation of decay data for these nuclides is now underway by the collaboration; 11 completed evaluations are being circulated for review. LBNL has completed 3 decay evaluations -- ^{75}Se, ^{194}Ir, and ^{188}Re -- as part of this effort. Significant effort was also devoted to developing the guidelines and computer codes necessary to assure consistent evaluation methods and standards. All evaluations will be included in ENSDF and will be submitted to the IAEA for inclusion in its decay-data database.

3. Mass-Chain Evaluation

The Isotopes Project has permanent responsibility for evaluating 43 mass chains with A=81, 83, 89-93, 167-194, 206, 210-212, 215, 219, 223, and 227, and for adapting evaluated data with A=23-26, and 33-44 into the ENSDF format. The group has also accepted temporary responsibility for evaluating mass chains with A= 59, 76, 79, and 80, originally assigned to other centers. Since May 1994 eight mass-chain evaluations (A= 81,170, 172, 179, 182, 186, 191 and 194) were completed, five mass-chain evaluations were reviewed, and eleven mass chains (A=76, 168, 170, 172, 173, 178, 179, 180, 182, 185 and 191) were published in Nuclear Data Sheets. One mass-chain evaluation (A=93) is in progress; the majority of the remaining evaluation effort for this year is being directed toward high-spin and decay data evaluations, consistent with the priorities established at the March 1996 USNDN meeting.

4. Astrophysics Data Evaluation

At the last IAEA meeting the data network was asked to keep abreast of other areas of physics where horizontal evaluations would be appropriate. In collaboration with the LBNL Institute for Nuclear and Particle Astrophysics (INPA), the Isotopes Project in 1994 distributed a questionnaire to ~20 key members of the nuclear astrophysics community regarding the data needs for nuclear astrophysics. The response to this survey was very positive and led to increased interaction with the research community. As a result, R.G. Stokstad (LBNL) organized a nuclear astrophysics data workshop, which was held in conjunction with the Caltech symposium in memory of Willy Fowler in December, 1995. At the workshop a Steering Committee, chaired by Peter Parker (Yale), was formed and charged with ascertaining and prioritizing the data needs of the nuclear astrophysics community. The Steering Committee submitted a "white paper" to DOE in July 1996, calling for a central location for nuclear astrophysics data where evaluated data of diverse types are brought together and made available in a form that facilitates their dissemination and maximizes their utility. LBNL is developing a proposal (jointly with the Woosley group at U.C. Santa Cruz) to establish such a center at LBNL. Already, LBNL has developed a prototype nuclear astrophysics home page on the WWW and several of the existing important nuclear astrophysics databases are now available on-line for the first time.

5. Capture Gamma-ray Data Evaluation

A joint proposal to the U.S.-Hungary Science & Technology Program by G. Molnar (Institute of Isotopes, Budapest) and the Isotopes Project has been funded. This provides resources for the horizontal evaluation of capture gamma-ray data. G. Molnar and a student will spend time at LBNL in September to begin the work on this new project.

C. Data Dissemination

1. World Wide Web

The evolution of the Internet and, particularly of the World Wide Web, has changed the paradigm for nuclear data dissemination. Information can be provided easily in a variety of ways. During the past two years, the Isotopes Project has made significant and rapid progress in exploiting the capabilities of the Internet.

Linked home pages for access to data from the *Table of Isotopes*, high-spin data, nuclear astrophysics data and nuclear masses have been developed. Data are provided in a variety of formats including text, Postscript, and Portable Document Format. Links have also been provided to databases residing at other data centers. Response to the home pages has been excellent with over 136,000 individual file access requests from over 7,000 separate computer IP addresses during the past year. The rate of access to each of the home pages is continuing to climb and is summarized in Table 1.

Isotopes Project members participated in the Coordination Workshop on "DOE Nuclear Data Program Services via the Internet" held at LLNL in August 1996. Rick Firestone is a member of the committee formed at the workshop to coordinate the information dissemination activities of the U.S. Nuclear Data Program (both the nuclear structure and nuclear reaction data components).

Table 1. Summary of WWW Usage at LBNL Isotopes Project Websites

Date	TOI	Decay	VuENSDF	Astro	Hspin	Mass	IP	TOTAL
1995								
Jul	a	a	100	a	a	a	151	251
Aug	a	a	112	a	a	a	129	241
Sep	a	a	123	a	a	a	190	313
Oct	98	a	201	37	a	36	226	598
Nov	158	a	225	49	38	30	265	765
Dec	128	a	170	56	22	30	294	700
1996								
Jan	154	a	288	83	37	54	348	964
Feb	555	a	356	87	56	121	362	1537
Mar	967	a	353	101	76	155	289	1941
Apr	1157	a	425	230	141	215	325	2493
May[b]	1113	292	351	202	152	258	264	2632
Jun	1207	493	400	392	209	299	302	3302
Total	5537	785	3334	1237	731	1198	3500	16,322

a Website not established

b Data for May 1-20, 28-31 only; approximately seven days of login information lost.

2. VuENSDF

Version 1.0 of VuENSDF, developed by a collaborative effort between the Isotopes Project and Lund University, was released in July 1996. VuENSDF is designed to retrieve ENSDF and NSR information directly over the Internet from a server, from the *Table of Isotopes* CD-ROM, or from a local disk file. It displays level scheme drawings, tabular listings of nuclear levels and transitions, and NSR references. Data can be displayed by nuclear band structure and selected by coincidence relationships. Tables can be constructed according to user specifications, readily sorted by any numerical field, and output as tab-delineated records for input into other user codes. VuENSDF can search the NSR file by keynumber or author and display the keyword abstracts. Tables and drawings may be printed, and a print preview option is offered. VuENSDF can be downloaded from the Web. Running VuENSDF directly provides users with Internet access to nuclear data without requiring a WWW browser, or the program can be used as a helper application with a commercial browser.

A beta release version of VuENSDF for the PC has been available on WWW for over a year; an early alpha test version of VuENSDF for the Macintosh is also available. Frank Chu demonstrated the VuENSDF software and the *Table of Isotopes* CD-ROM at the recent Nuclear Structure Meeting at ANL, at the Gammasphere dedication activities and workshop at LBNL in December 1995, and at the October 1995 DNP meeting in Indiana. He received enthusiastic responses. Throughout its development, VuENSDF has been made available to Gammasphere users at the LBNL 88-Inch Cyclotron.

Version 2.0 is currently under development. Among the features it will offer are a nuclear chart graphical interface to the databases, enhanced ENSDF and NSR searching capabilities, full support of ENSDF comments with links between NSR keynumbers and keyword abstracts, data plotting capability, and format-free data input capability. Extension of VuENSDF to other computer platforms, possibly using JAVA software, is being explored.

3. *Table of Isotopes*

The 8th edition of the *Table of Isotopes* was published by John Wiley & Sons in April 1996. The 3168-page, 2-volume book is packaged with an interactive CD-ROM that contains the Table of Isotopes in Adobe Acrobat PDF format for viewing on PC and Macintosh personal computers, and on Unix workstations. The CD-ROM version contains a chart of the nuclides graphical index and separate indices organized for radioisotope users and nuclear structure physicists. Over 100,000 hypertext links are provided to move the user rapidly to the desired information. The CD-ROM also contains the 2nd edition of the *Table of Superdeformed Nuclear Bands and Fission Isomers*, tables of Atoms, Atomic Nuclei, and Subatomic Particles by Ivan P. Selinov, the ENSDF and NSR databases (for use with VuENSDF), and Adobe Acrobat Reader software. Yearly updates of the CD-ROM are planned; all TOI data will also be available on WWW in the future.

4. (a) PAPYRUS NSR and (b) Nuclear Data and References CD-ROMs

In 1994 the Lund-LBNL collaboration released Papyrus NSR, a CD-ROM containing the NSR file and the PAPYRUS bibliographic database management system, to facilitate literature searches on PCs. In June 1996, a new CD-ROM, *Nuclear Data and References*, was released by a Lund/LBNL/BNL collaboration, on behalf of the international nuclear data network. This CD-ROM, which updates its predecessor (PAPYRUS NSR) includes:

The Nuclear Science References (NSR) database, with over 140,000 references, updated to December 8, 1995. Retrieval of information can be done using the PAPYRUS bibliographic database management system, the same software that was used for the 1994 release.

NuDat, a numerical database of nuclear properties, accessed and managed by PCNuDat (software developed at BNL). This database includes data from ENSDF, the Nuclear Wallet Cards, the 1995 update to the Atomic Mass Evaluation, and from Neutron Cross Sections, Vol. 1 and 2.

5. Two editions of the Table *of Superdeformed Nuclear Bands and Fission Isomers*

The *Table of Superdeformed Nuclear Bands and Fission Isomers*, first published as an LBNL report in October, 1994, has been updated and the second edition published in Nuclear Data Sheets. This publication contains adopted level data for all nuclei with superdeformed bands, moment of inertia plots and level scheme drawings for all superdeformed bands, and related plots for actinide shape (fission) isomers. In addition, a complete reference list is provided for experimental and theoretical superdeformation studies and for fission isomers. Preprints of the 2nd edition were distributed at the Gammasphere Dedication Workshop held in Berkeley on December 1-2, 1995. This publication, prepared in collaboration with McMaster University, is also available as an Acrobat PDF file and has been included on the *Table of Isotopes* CD-ROM.

D. Publications

Data Evaluation

Table of Isotopes, 8th Edition, R.B. Firestone, Ed. V.S. Shirley, C.M. Baglin, J. Zipkin, and S.Y.F. Chu, John F. Wiley & Sons, Inc., April, 1996, both in hard copy and on CD-ROM

Table of Superdeformed Nuclear Bands and Fission Isomers, 2nd Edition, B. Singh, R.B. Firestone and S.Y.F. Chu, Nuclear Data Sheets **78**, 1 (1996).

Nuclear Data and References, PC Applications for Nuclear Science on CD-ROM, P. Ekström, Robert R. Kinsey, and Edgardo Browne (1996)

Nuclear Data Sheets for A=170, Coral M. Baglin, Nuclear Data Sheets **77**, 125 (1996)

Nuclear Data Sheets for A=76, B. Singh, Nuclear Data Sheets **74**, 63 (1995)

Nuclear Data Sheets for A=172, B. Singh, Nuclear Data Sheets **75**, 199 (1995)

Nuclear Data Sheets for A=173, V.S. Shirley, Nuclear Data Sheets **75**, 377 (1995)

Nuclear Data Sheets for A=182, B. Singh and R.B. Firestone, Nuclear Data Sheets **74**, 383 (1995)

Nuclear Data Sheets for A=185, E. Browne, Nuclear Data Sheets **74**, 165 (1995)

Nuclear Data Sheets for A=191, E. Browne and S.Y.F. Chu, Nuclear Data Sheets **74**, 611 (1995)

Nuclear Data Sheets for A=168, V. S. Shirley, Nuclear Data Sheets **71**, 261 (1994)

Nuclear Data Sheets for A=178, E. Browne, Nuclear Data Sheets **72**, 221 (1994)

Nuclear Data Sheets for A=179, C. Baglin, Nuclear Data Sheets **72**, 617 (1994)

Nuclear Data Sheets for A=180, E. Browne, Nuclear Data Sheets **71**, 81 (1994)

Table of Superdeformed Nuclear Bands and Fission Isomers, 1st edition, R.B. Firestone and B. Singh, LBL-35916 (1994)

GAMQUEST, A Computer Program to Identify Gamma Rays, E. Browne, LBL-35715 (1994)

Research

On the Half-Life of 44Ti, E.B. Norman, E. Browne, Y.D. Chan, I.D. Goldman, R.-M. Larimer, K.T. Lesko, M, Nelson, F.E. Wietfeldt, and I. Zlimen, LBNL-39029 (1996)

Evidence for Hexadecapole Collectivity in Closed-shell Nuclei, P.C. Sood, R.K. Sheline and B. Singh, Phys. Rev. **C51**, 2798 (1995)

Beta Decay of ^{228}*Ra and Possible Level Structures in* ^{228}*Ac*, P.C. Sood, A.Gizon, D.G. Burke, B. Singh, C.F. Liang, R.K. Sheline, M.J. Martin and R.W. Hoff, Phys Rev. **C52**, 88 (1995)

Gamma-ray Deexcitations in ^{168}*Tm*, B. Singh, P.C. Sood and H.W. Taylor, Phys. Rev. **C52**, 1694 (1995)

Half-lives of Microsecond Isomers in ^{151}*Eu and* ^{181}*W*, B. Singh and H.W. Taylor, Appl. Radiat. Isotopes **45**, 374 (1994)

Electron-Capture Decay of ^{231}*U*, E. Browne, I. Ahmad, K.E. Gregorich, S.A. Kreek, D.M. Lee, and D.C. Hoffman, Nucl. Instr. Meth. **339**, 209 (1994)

National Nuclear Data Center Activity Report

M. R. Bhat

August 23, 1996

This report reviews the evaluation of nuclear structure, decay data and related activities of the National Nuclear Data Center (NNDC) for the period May 1994 to August 1996.

I. New Evaluations for ENSDF

Evaluations submitted for updating ENSDF:

In 1994: 49,50,68,137; Continuous: 95

In 1995: 58,138,146,150; Continuous: 45,48,95,138;
High-spin: 138,150; Decay: 143Pr

In 1996: 84

Evaluations in Progress: 139,142,148,65Ni,66Ge

Number of A-chains reviewed:

In 1994: 7

In 1995: 6

In 1996: 5 and reviews for radioactive decay and high-spin evaluations were done.

Reviews of the page proofs of the 8^{th} edition of the Table of Isotopes for the A-chains evaluated at the NNDC were done and comments/corrections were sent to LBNL. In addition, internal reviews of continuous evaluations were also done.

II. Database Maintenance

1. The Evaluated Nuclear Structure data File (ENSDF)

The ENSDF is continuously updated on the basis of new evaluations submitted, and those done in the "continuous mode." The current status of mass-chains is discussed in a separate report accompanying this contribution. The ENSDF is distributed twice a year; generally in February and August. Usually, only those A-chains that have been modified since the last distribution are included. Users may also update their local databases easily by using the WWW ENSDF access. History records were added to all the datasets in ENSDF and a full distribution of ENSDF was made in July 1996. High-spin and radioactive decay data evaluations submitted by network evaluators have also been added to ENSDF and are available to users via the online system and WWW access. New evaluations of A=18, 19 published by the TUNL group in Nuclear Physics were added to the ENSDF.

2. The Nuclear Structure References (NSR)

All entries dealing with high-spin data were retrieved and indexed for easy retrievability. Several old entries which had some author retrieval problems or missing titles were also re-indexed. All corrections brought to the attention of the NSR file manager by evaluators and others are checked and the file is promptly updated with corrections and the user is notified by letter as to the results.

In 1994, 1995, tapes of secondary source entries from the RIKEN Data Center, Japan and Gatchina, Russia were received. These entries were checked and merged into the NSR. Monthly distributions of NSR retrievals are being transmitted to the various data centers on schedule. The four-monthly distributions are transmitted by the Internet.

The scope of the NSR file continues to be enlarged. Starting in 1993, articles which may not have nuclear structure information but deal with relevant physics are being entered into the NSR file. Such entries can be retrieved by author name; a string search of titles and keyword abstracts is being tested before implementation. Coverage for important primary journals like Physical Review C, Nuclear Physics A, is thus complete now and all articles appearing in these journals are being assigned keynumbers. Many new subject categories such as hypernuclei, relativistic effects, quark- gluon plasma have been added to the NSR dictionary. The NNDC continues to receive keyword abstracts at a reduced rate of about 10-15% of the NSR entries for Physical Review C. An updated version of the Nuclear Science References Coding Manual (BNL-NCS-51800, Rev. 08/96) has been published and also made available for access on the NNDC online system.

III. Data Dissemination

The data available from the NNDC are disseminated using different media of distribution. These include hard copy, magnetic media, and online access via TELNET or the World Wide Web (WWW) depending on the size of the data files, efficiency of communication, or user convenience as described in the following.

1. New Evaluations(Hard copy, TELNET, WWW):

New evaluations submitted to the NNDC are processed by running them through format and physics checking codes, and the errors found are corrected. A hard copy of the output is sent for review, and final checking and approval by the editor-in-chief. The final corrected evaluation is published as Nuclear Data Sheets (NDS) by the Academic Press in 11 issues/year. The December issue of the NDS is devoted to Recent References which are the yearly updates to the NSR. Beginning in July 1996, the Academic Press has made available the contents of each NDS issue on the WWW as Adobe Portable Document Format (PDF) files. The NNDC has been sending the Academic Press PostScript files of each NDS issue since August 1995 to check out the system and is working closely with it in setting up the NDS Homepage. Future plans call for providing pointers in the NDS Homepage and in the NDS PDF files to the ENSDF and the NSR at the NNDC so that a user could access additional data to supplement the information available.

There are 25 new evaluations in the processing pipe-line at present.

2. The 1995 Edition of the Nuclear Wallet Cards(Hard copy, WWW, FTP):

The 1995 Edition of the Nuclear Wallet Cards was published with a literature cutoff date of June 30, 1995. The data extracted from the ENSDF were supplemented by a systematic search through published literature, the 1993 Audi-Wapstra mass evaluations, the 8^{th} edition of the Table of Isotopes, spontaneous fission data from D.C.Hoffman et. al. (LBL-33001, 1992), the French NUBASE database by Audi et. al., and the 1995 evaluation of the Fundamental Constants. Out of the 10,000 hard copies printed, about 4,000 were sent to European nuclear physicists affiliated with the Nuclear Physics European Collaboration Committee (NuPECC), and 2900 to the members of the Division of Nuclear Physics of the American Physical Society. The contents of the Wallet Cards have been available on the WWW and FTP sites since September 1, 1995. The centerfold "yellow pages" describing Electronic Nuclear Data Access have been expanded to 12 pages and give instructions on accessing the online databases at the NNDC, other members of the U.S. Nuclear Data Network (USNDN), the Nuclear Data Section (NDS), IAEA Vienna, and the Nuclear Energy Agency Data Bank (NEADB), OECD, France. Addresses of the WWW homepages of the Division of Nuclear Physics, U.S. DOE, and the Directory of Nuclear Physics Laboratories are also given.

3. Online Data Services(Diskettes, 4 & 8mm. cassettes, TELNET, WWW, FTP):

The total number of retrievals in 1995 was 87,868 compared to 67,515 in 1994 or an increase of 30%. The NSR database continues to be the most popular with about 30% of the total number of retrievals and NUDAT the second most with about 24% in the year 1995.

The service has 2069 active user accounts from 54 countries with multiple users in each account. Out of these, about 54% users are from the United States.

Several new features have been added to the service and other improvements have been made in the last year. These include:

(i) Online Documentation: The following have been added to the documentation available online. (TELNET, WWW, FTP)

a. Portions of the ENSDF Manual (BNL-NCS-51655, Rev. 87)

b. Nuclear Science References Coding Manual (BNL-NCS-51800, Rev. 08/96)

c. Online Nuclear Data Service Manual (NNDC/ONL-96/8, IAEA-NDS-150, Rev. 08/96)

d. ENDF-102 Data Formats and Procedures for the Evaluated Nuclear Data File ENDF-6 (BNL-NCS-44945, Rev. 11/95)

(ii) ENSDF analysis and checking codes: The MS-DOS distribution of these codes is available on the WWW and FTP sites.

(iii) User Outreach: A Homepage for the U.S. Nuclear Data Network (USNDN) on the WWW was assembled using contributions from member data centers after trying out several versions. This is meant to inform new users the data activities and resources of the USNDN and how to access them. A Homepage for the U.S. Nuclear Reaction Data Network (USNRDN) has also been assembled.

(iv) ENSDF Plots: A new option has been added to the ENSDF module to generate publication style Tables, Figures, the γ-ray, or the band drawings. (TELNET)

(v) NSR Retrievals: The selection of references for NUCLIDES and TARGETS has been enhanced to specify in a simple way all isotopes for a mass or a charge number. (TELNET)

(vi) Interactive Access to ENSDF via NNDC WWW Homepage: Direct access to the ENSDF database is now available through the NNDC Web Homepage and provides users several options. These are a quick retrieval of a complete mass-chain or nuclide from the ENSDF database, listing and retrieval of added or modified mass-chains after a user-specified cut-off date and an index listing mass, publication, and literature cut-off, creation, revision, and prepublication (if available) dates. The index option allows the user to retrieve the archival or prepublication version of the mass-chain or obtain additional details on a mass-chain. These additional details are a more detailed bibliographic and revision history and a list of nuclides with their archival library creation or revision dates with the capability of retrieving either the complete mass-chain or individual nuclides.

(vii) Interactive Access to MIRD via NNDC WWW Homepage: Direct access to the MIRD (Medical Internal Radiation Dose) for calculating internal radiation dose from ENSDF data is available. (WWW)

(viii) Masses: The 1995 atomic mass evaluation of Audi-Wapstra is now available. (TELNET, WWW, FTP)

(ix) QCALC: Program for calculating reaction and decay Q-values was updated to use the 1995 atomic masses. (TELNET)

(x) Relativistic Heavy-ion Data: Two data sets of relativistic heavy-ion data measured at the AGS and containing a total of about 11,400 energy points are available for online access. Five more data sets have been coded and listings and plots of these have been sent to authors for approval. (TELNET)

(xi) Relativistic Heavy-ion WWW Homepage: A draft of the Homepage on the compilation of relativistic heavy ion data describing data sets that have been compiled, those that are being coded and processed, how to access them, and how measurers can send us their data has been assembled. (WWW)

(xii) Reaction Data Plots: Reaction database programs have been improved to produce "BNL-325 type" plots, i.e., to plot more than one experimental data sets and to overlay with evaluated data from the major evaluated data files such as ENDF/B and others. (TELNET)

(xiii) Thermal Neutron Capture Gamma Ray Tables organized by energy and nuclide are available for online access. (WWW)

(xiv) Online Statistics: These now include data access through the WWW and anonymous FTP in addition to those done via TELNET and include only data retrievals and not the cursory exploratory access via the Web.

Future plans under consideration are for providing interactive access on WWW to all the data modules of Online Service, including CINDA, CSISRS, ENDF, NSR, and QCALC, and the direct access of the ENSDF database by the Isotopes Project program VuENSDF.

IV. User Services & Network Support

The ENSDF analysis and checking codes continue to be maintained and improved; recent improvements made in them and their current status is given in a separate report accompanying this contribution.

The NNDC provides many services to the international Nuclear Structure and Decay Data (NSDD) network evaluators and others on a routine basis. At present they are:

(i) Monthly NSR updates are sent to those evaluation centers that still request them, for the A-chains assigned to them.

(ii) Complete NSR and ENSDF retrievals are sent at the start of an evaluation only to those who cannot access online the NSR or the ENSDF from the NNDC, the NEA Data Bank, Saclay, or the NDS, IAEA; others have to do their own retrievals.

(iii) Copies of hard-to-get references are sent to evaluators (with help from the NDP for older references).

(iv) ENSDF updates are sent twice a year.

(v) NSR updates are sent once in every four months.

(vi) The ENSDF physics processing codes are maintained; and corrections and updates are sent periodically.

(vii) Special retrievals are made from the NSR and the ENSDF. Requests for these specialized retrievals are satisfied on a case-by-case basis. Users are encouraged to take advantage of the full potential of the NNDC online system; only if their needs cannot be met by the system then their requests are processed in-house.

(viii) ENSDF, NSR, NUDAT updates are sent to the IAEA, and NEA Databank on a regular basis.

V. Publicity for Network Activities & User Outreach

The following is a list of items done to publicize the network activities, and its products & services:

- Information on the products and services available from the NNDC and other members of the USNDN is available on the WWW Homepages of the USNDN and the US Nuclear Reaction Data Network (USNRDN).

- Every issue of the NDS contains a brief description of the databases maintained at the NNDC and how to access them.
- The 1995 edition of the Nuclear Wallet Cards with an initial printing of 10,000 copies, has an expanded 12-page yellow colored centerfold giving information on the databases maintained by the NNDC as well as other members of the NSDD, and directions for accessing them. Further, copies of the Wallet cards have been widely distributed amongst the nuclear physics community both in the USA and in Europe. The contents of the centerfold yellow pages are also available on WWW.
- At the Society of Nuclear Medicine Annual Meeting in Minneapolis, MN, on June 12-15, 1995, online access to the NNDC databases was demonstrated by J.K. Tuli and R.R. Kinsey.
- The 1995 Nuclear Wallet Cards, and an article: Nuclear Data Resources by M.R. Bhat and J.M. Dairiki, listing the nuclear structure and reaction data resources available from the USNDN and the USNRDN were distributed to the attendees of the Symposium on Nuclear Astrophysics: A Celebration of Willy Fowler held at the California Institute of Technology to reach the nuclear astrophysics community.
- The NNDC online system was installed at the nuclear data center at Obninsk, Russia. A mirror site of the NNDC Web pages for ENSDF, the Nuclear Wallet Cards, etc., will be established at the IAEA Nuclear Data Section in September, 1996.
- The NNDC will send the 1995 Nuclear Wallet Cards for distribution as part of the registration package for the 3rd Topical Meeting on Industrial Radiation and Radioisotope Measurements and Applications (IRRMA '96) in Raleigh, NC., to reach applied users.
- At the 9^{th} International Symposium on Capture Gamma-Ray Spectroscopy and Related Topics 1996, the following papers will be presented: Nuclear Information Services at the National Nuclear Data Center, by T.W. Burrows, J.K. Tuli, and The NUDAT/PCNUDAT Program for Nuclear Data, by R.R. Kinsey, C.L. Dunford, J.K. Tuli, T.W. Burrows.

Nuclear Data Project - Status Report for NSDD, 1996

Hungary, October 14-18, 1996

This report covers the period from June 1994 to September 1996.

Staff

Yurdanur Akovali (through September 1995)[a]
Agda Artna-Cohen[b]
Junde Huo (June - August 1995)[c]
Haoqiang Jin (October 1995 - March 1996)[d]
Mary Ruth Lay (Technical aide 0.75 FTE)
Murray Martin (1.0 FTE)
Jason Robinson (May - July 1995)[e]
Shaheer Rab (through March 1995)
Marcel Schmorak (through September 1995)[b]

[a] Funding transferred to research section at ORNL
[b] Consultant 0.5 FTE
[c] Guest assignment from Jilin university PRC
[d] Post Doc 0.5 FTE
[e] Summer student

Dataset Evaluations

The mass chains 133, 200, 201, 204, 214, 218, 222, 226, 237, and 241 have been published.

The mass chains 152, 202, 216, 224, and 228 have been submitted for publication.

Reviewed update datasets for A=54 and 55 have been entered into ENSDF (Huo).

Reviewed high-spin datasets for A=174, 176, and 184 have been entered into ENSDF (Huo).

Dataset Editing

The NDP staff has provided reviews of datsets pertaining to the mass chains 49, 51, 54, 55, 64, 74, 76, 77, 111, 114, 118, 127*, 133, 137, 146, 151, 157, 158, 163, 174, 176, 184, 194, 198, 224, 228, and 237.

* co-reviewed with Jean Blachot

In addition to the above, all datasets submitted for inclusion in ENSDF are read through by the Editor-in-Chief, with comments and corrections added to those of the primary reviewer prior to returning the manuscript to the author(s). The Editor-in-Chief continues to be responsible for resolving questions involving differences of opinion between the author(s) and the reviewer.

The Superdeformed-Band section of the Table of Superdeformed Nuclear Bands and Fission Isomers, second edition, by Singh, Firestone, and Chu was reviewed.

Alpha-Decay Radius Parameters

Yurdanur Akovali has reviewed and evaluated alpha-decay data from all even-even nuclides and extracted the radius parameters. Data evaluated include parent half-lives, α-decay branchings, α energies, and relative α intensities. These recommended radius parameters form the basis for obtaining the radius parameter input needed for calculating the hindrance factors for the odd and odd-odd nuclides. A file of the even-even nuclide parameters, along with the evaluated input data, will be maintained on line at BNL.

Database Development

The NDP supports a 0.5 FTE effort in the ORNL Physics Division's Nuclear Structure Database (NSDB). The work to date has focussed on entering nuclear structure data (unevaluated) for Z=62-75, with A=155-185, a region pertinent to the Division's research interests, and on linking the database with ENSDF. Data from ENSDF have been downloaded to the NSDB, and data from NSDB can be transferred to ENSDF via the Radford ".lvl" format. Future work will involve coordination with the Network's horizontal evaluation efforts, including an extension, as needed, of the files' capabilities to incorporate data from radioactive beam experiments.

TUNL NUCLEAR DATA EVALUATION PROJECT[1]
Report to the
NUCLEAR STRUCTURE AND DECAY DATA EVALUATORS' NETWORK

D.R. Tilley
Triangle Universities Nuclear Laboratory, Durham, NC, 27708-0308 and
Department of Physics, North Carolina State University, Raleigh, North Carolina, 27695-8202

H.R. Weller, C.M. Cheves, J.F. Guillemette[2], R.M. Chasteler[3], C.M. Laymon[4]
Triangle Universities Nuclear Laboratory, Durham, NC, 27708-0308 and
Department of Physics, Duke University, Durham, North Carolina, 27708-0305

I. TUNL is responsible for data evaluations in the mass range A = 3 - 20. The current status of these evaluations is summarized below:

Nuclear Mass	Publication	Comments
A = 3	Nucl. Phys. A474, 1 (1987)	TUNL
A = 4	Nucl. Phys. A541, 1 (1992)	TUNL*
A = 5 - 10	Nucl. Phys. A490, 1 (1988)	U. Penn. (FAS)
A = 11 - 12	Nucl. Phys. A506, 1 (1990)	U. Penn. (FAS)
A = 13 - 15	Nucl. Phys. A523, 1 (1991)	U. Penn. (FAS)
A = 16 - 17	Nucl. Phys. A564, 1 (1993)	TUNL
A = 18 - 19	Nucl. Phys. A595, 1 (1995)	TUNL
A = 20	Prelim. version mailed 7/96	TUNL†

* In collaboration with G. M. Hale, Los Alamos National Laboratory
† In collaboration with S. Raman, Oak Ridge National Laboratory

Since the last NSDD meeting in 1994, a review of A = 18 - 19 was completed and published as noted above. A review of the A = 20 nuclides, in collaboration with S. Raman of Oak Ridge National Laboratory, has been issued in preliminary form, and a manuscript will be submitted to *Nuclear Physics A* in late 1996. Work has begun on a review of the A = 5 - 10 nuclides in collaboration with G.M. Hale of Los Alamos National Laboratory and H.M. Hofmann of Universität Erlangen-Nürnberg.

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[1] This work is supported by the U.S. Department of Energy, Office of High Energy and Nuclear Physics, under Contract No. DEFG05-88-ER40441 (North Carolina State University) and Contract No. DEFG05-91-ER40619 (Duke University).
[2] 1 August 1995 - 31 July 1996.
[3] 1 August 1993 - 31 July 1995.
[4] 1 January 1996 - 31 March 1996.

II. New Features of the Energy Levels of Light Nuclei Reviews

For the most part, TUNL has maintained the layout and style of the Ajzenberg-Selove reviews, but some new features have been added:

a) References to all relevant theoretical as well as experimental work are compiled, and an indication of the nature of the work is included in discussions of particular nuclear reactions or in "general" tables of one-line descriptions. In some cases, nuclear structure calculations are reviewed with the help of consulting theorists.
b) NNDC key numbers are used to achieve consistency with the Nuclear Science Reference Database.
c) Complete, rather than first-author-only, references are provided in the reference list.
d) Elsevier Science, the publisher of *Nuclear Physics A*, makes available each "Energy Levels of Light Nuclei" review in its entirety through its Nuclear Physics Electronic service on the World Wide Web.

III. ENSDF

Concurrent with the review of each mass chain, tables of adopted levels, decay and reaction data are entered by TUNL into the Evaluated Nuclear Struture Data Files (ENSDF) maintained at NNDC. The figures produced from these files in ENSDAT format are included in mailings of all "Energy Levels of Light Nuclei" reprints and preprints from TUNL.

IV. Related Activities

TUNL has continued its coverage of the literature, compiling bibliographical listings for relevant experimental and theoretical work, utilizing the resources of Triangle area libraries as well as Monthly Updates from NNDC, Current Contents on Diskette with Abstracts, and Physics Abstracts.

V. World Wide Web Services

In November of 1994, the TUNL A = 3 - 20 Nuclear Data Evaluation Group began setting up its World Wide Web site (accessible at "http://www.tunl.duke.edu/nucldata"). Encouraged by the response to demonstrations at the NSAC/DNP Long-Range-Planning Town Meeting (January, 1995) and Ion Beam Analysis Conference (May, 1995), TUNL has continued to develop new services for the nuclear science and applications communities. Currently, the following items are available:

a) Energy Level Diagrams in the style of Fay Ajzenberg-Selove for A = 4 - 20.
b) Abridged versions of TUNL's published evaluations for A = 16, 17, 18, 19, and A = 20 (preliminary).
c) An abridged version of Fay Ajzenberg-Selove's A = 5 - 10 compilation. (TUNL has received permission from *Nuclear Physics A* to put her old compilations on the Web, altered to correct errors found after publication and to use NNDC key numbers where possible. The most recent evaluation of each mass chain should be online by the end of 1996.)
d) Postscript ENSDAT output of the A = 3 - 20 ENSDF files, as well as links to the A = 3 - 20 ENSDF data sets at NNDC, which can be viewed with VuENSDF.
e) A subset of the *Eighth Table of the Isotopes* containing A = 1 - 20 nuclides.
f) Information about the status of the project and our publications.

Nuclear Science References (NSR) Task Force Report

M.R.Bhat,T.W.Burrows,C.L.Dunford, and S.Ramavataram

September 5, 1996

1. Updating of NSR Manual:

The NSR coding manual (BNL-NCS-51800, Rev. 08/96) by S. Ramavataram and C.L. Dunford has been revised by the authors. It is available as a hard copy or on the NNDC Web Homepage and the NNDC Online Service.

2. Procedures for addition of SUBJECTS:

When new SUBJECTS are added to the DICTIONARY, S. Ramavataram will notify J. Tallarine, C.L. Dunford, and P. Ekstrom in writing. An Appendix has been added to the NSR manual listing the SUBJECTS followed by a brief description. This list will be updated periodically.

3. NSR Keynumbers after the year 1999:

The problem of distinguishing the six character Keynumbers up to the year 1999 from those that are coded from the year 2000 and beyond needs some thought. Two proposals that have been suggested are:

Plan 1: Expand the Keynumbers to 7 characters with an additional character preceding the current Keynumber field; e.g., "A" to denote keynumbers in this century; with "B" indicating those from the next century. This change will involve modifying the whole file and reloading it and will also require major changes to the ENSDF database and related programs.

Plan 2: There are only about 400 references in the NSR up to the year 1940 inclusive. The first two numbers of these Keynumbers can be changed to some other alternate characters so as to distinguish them from the Keynumbers from the years 2000-2040. The retrieval codes will also have to be changed to be able to retrieve these makeshift Keynumbers. This is not as clean a solution as Plan 1 and will only defer the problem for about 45 years! Some revisions to the ENSDF may be required.

A memo dated Feb. 26, 1996 was sent to the NSDD network describing these suggestions and requesting any alternate proposals.

4. Text search retrievals:

Text search retrievals capability has been added. This can be used to search on the authors, titles of articles and keyword abstracts in order to narrow down retrievals with additional restrictions once an initial search has been made. See the next item.

5. Major Topics:

A capability to select on major topics such as: RADIOACTIVITY, NUCLEAR STRUCTURE, NUCLEAR MOMENTS, etc., is now available using the text string search. This will allow a user to narrow down retrievals. For example, after the keynumber list for the nuclide ^{133}Cs is created, all entries with a specific TOPIC could be selected.

6. SUBJECT FIELD:

If there are references which are not keywordable i.e., the subject matter of the article does not fall within one of the existing keyword TOPICS, or keyword preparation criteria, it is proposed to introduce a new SUBJECT field in the NSR entry to permit compiler produced selectors for that particular reference.

7. Data Index Line:

In principle this is a good idea; however, actual implementation does introduce some problems since the NSR file is reference oriented and not data oriented e.g., CINDA. Hence, one keynumber will be associated with different physical quantities measured in the same experiment and which are individually retrievable and which should be listed separately. In addition, in the NSR there is no "blocking" or grouping of references and data sets relating to the same work. Hence, it is not clear how useful a data index line will be in the NSR.

A proposal by T. W. Burrows on how to implement the data index line was circulated some time ago to the network. This could be a starting point in making this change. However, implementing this change, and adding the missing information for older entries is estimated to involve a large amount of work. This change is deferred for the present because of this reason. However, if there is a great demand from users for this additional feature, it will be reconsidered in the future.

IAEA Nuclear Data Section

PROGRESS REPORT

October 1996

1. Staff and Budget

The position of the Section Head was filled by D.W. Muir as of June 1996. C.L. Dunford was the Section Head from July 1993 to June 1995. In the one year's vacancy 1995/96 P. Obložinský was the Acting Section Head.

The total staff of 22 in 1993/94 had to be reduced in 1995 to 19 due to budget cuts.

In the Nuclear Data part of the Section S. Ganesan left and N. Kocherov retired without replacement and one clerical post (G. Mundy) was given up.

In the Atomic and Molecular Data Unit J. Botero left and was replaced by J. Stephens. Also R.A. Langley left, and his post will be filled with a nuclear physicist.

At present 2 P-4 posts and 1 P-3 post are advertised to be filled with nuclear physicists with programming skills. This includes the posts by H.D. Lemmel (retirement end of 1996) and A. Pashchenko (end of contract end of 1996).

2 retirees are presently working part-time: N. Kocherov (nuclear) and Wang Dahai (atomic data).

End of 1995 the programme of the Nuclear Data Section had a Peer Review by an external panel of experts chaired by Prof. Arima, Japan. The outcome was most positive, but it did not bring us back the three lost posts.

	1993	**1994**	**1995**	**1996**	**1997**	**1998**
Authourized Staff Level	22	22	19.9	19	19	19
Actual Staff Level	20.7	21.9	*18.9**	*18.1**		
Staff Expenses	1,658,000	1,712,000	1,652,000	1,638,000	1,616,000	1,616,000
Programmatic Expenses	686,000	775,000	660,000	662,000	635,000	617,000
Total Budget US$ *1993 dollars times inflation rate*	**2,344,000** *2,344,000*	**2,487,000** *2,487,000*	**2,312,000** *2,623,785*	**2,300,300** *2,736,608*	**2,251,000**	**2,233,000**

* *Estimates*

Source: 1993-96 from the 1995 NDS report to INDC
1997-98 from the Dec. 95 Draft Budget (not yet approved)

2. Data Center Operation: Data Acquisition

In the one-year period since the last NRDC meeting (May 95 to May 96) 4 EXFOR TRANS tapes have been transmitted containing 36 new **neutron EXFOR** entries including 144 new data sets (subentries), and various revised entries. That is about the same rate as in the preceding two years. It should be noted that in our service area 80% of the data is measured in China (29 entries). Others came from Bangladesh (1 entry), Brazil (2), Hungary (1). Slovakia (1) and Thailand (1). Other countries, who continue to have neutron data measurements (though not in the year of this report) are Poland, Czechia, Bulgaria, India, and Argentina.

CINDA compilation continues routinely. The CINDA95 book was published, though again with some delay due to the changeover to the new VAX Computer. The programs (including those for the main part of CINDA, the introductory text, and the Dictionaries) should now be well functioning so that no problems for CINDA96 are expected. However, due to cuts in the printing budget, the 96 issue is likely to be printed not as a cumulative issue (1988-1996) but only as a supplement to CINDA95.

The acquisition and documentation of evaluated data files continued as publicized in

Nuclear Data Newsletter No. 19, Sept. 1994,
Nuclear Data Newsletter No. 21, July 1995,
Nuclear Data Newsletter No. 22, in preparation.

Issue No. 20 was published as a special issue to advertise ENSDF and the Nuclear Structure Data Network.

Summaries of available nuclear data libraries are contained in the updated reports

IAEA-NDS-7 Rev. 96/4 - catalogue of available data libraries

IAEA-NDS-107 Rev. 10 (95/6) - joint index to
BROND, CENDL, ENDF/B, JEFF, JENDL.
IRDF, EFF, and FENDL/E.

IAEA-NDS-150 Rev. 95/10 - Online Service,
Users' Manual by C.L. Dunford and T.W. Burrows.

Important NDS products were

- the Neutron Metrology File NMF-90, which presents the updated International Reactor Dosimetry File IRDF integrated with PC codes; see IAEA-NDS171;
- a handbook on "Atomic and molecular data for radiotherapy and radiation research"; see IAEA-TECDOC-799;
- and the finalization of FENDL, the evaluated nuclear data library for fusion applications.

3. Data Center Operation: Services

The request statistics for mail shipment remain constant (with fluctuations), whereas the online request statistics show a steep increase. The online statistics include only "NDIS", the interactive Nuclear Data Information System jointly operated with NNDC. The online File Transfer Service (FTP) is not included in the statistics because we do not yet have a statistical control system for FTP.

The request statistics for **mail services** is given in Tables 1 and 2. In 1995 there were about 700 requests resulting in 1600 dispatched items, including the shipment of 1200 documents and 600 tapes/diskettes. (Note: 1 data library may require several diskettes; and 1 tape may contain several data libraries.)

In 1995 there were 4400 **online retrievals** from users in 41 countries; see Table 3.

The distribution by countries and geographical region is shown in Table 4.

One can draw the following conclusions:

The use of the online services is seriously limited by the facts

- that many of the potential users do not yet have access to Internet,
- and that for many of those who have access to Internet, the transmission quality (speed and reliability) is not yet adequate.

For this reason the conventional services by mail will have to continue in the foreseeable future at about constant level.

The online services bring additional customers but they do not reduce the number of traditional mail service customers.

While many traditional mail service customers will change over to online services, there will always be newcomers without online facilities requiring conventional services by mail.

Table 1. Data Request Statistics 1986 - 1994 for services by mail

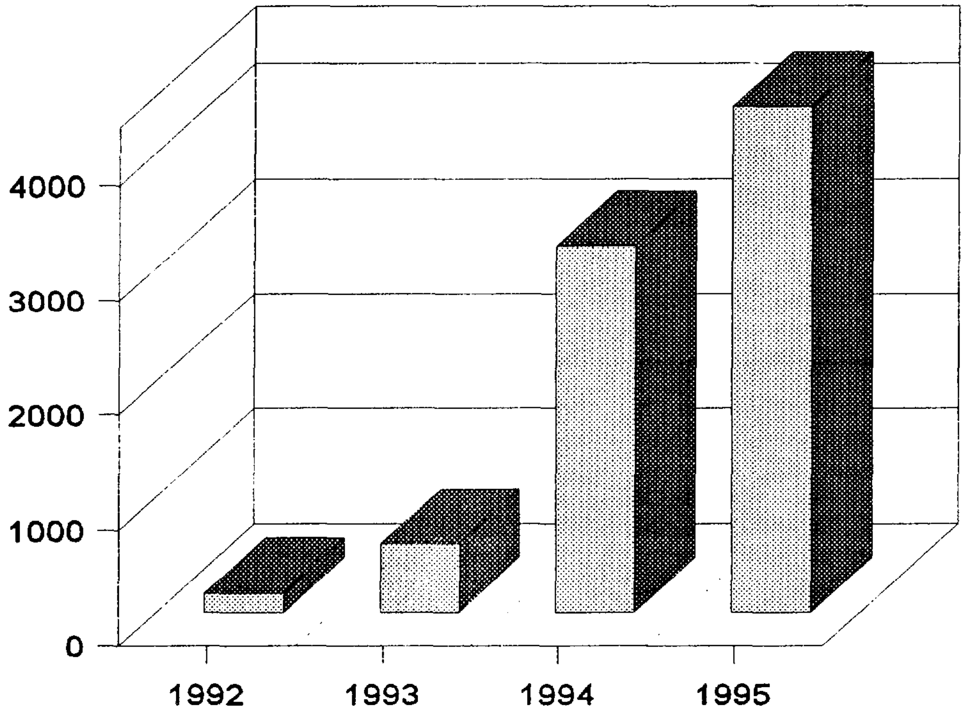
	Biblio-graphic info	Docu-ments	Expt Data	Eval Data	Data processing codes	Total
1986	11/25	405/1430	46/56	86/173	40/91	588/1775
1987	21/48	725/2166	27/28	87/147	167/214	1027/2603
1988	5/19	681/1590	34/47	110/191	77/109	907/1956
1989	10/17	564/1418	32/38	96/222	61/94	763/1789
1990	2/3	424/1916	20/32	188/360	26/32	660/2343
1991	0/0	426/1324	31/41	260/435	25/44	742/1844
1992	0/0	507/1422	27/32	237/303	142/161	913/1918
1993	0/0	299/801	18/20	190/294	73/100	580/1215
1994	0/0	524/1567	17/23	226/293	64/92	831/1975
1995	0/0	452/1155	8/16	228/357	18/28	706/1556

The notation, e.g. 86/173 under Eval Data, means that on 86 incoming requests 173 evaluated data libraries have been sent out.

Table 2. Shipment of Tapes and Diskettes by Year

Year	Magnetic tapes	DAT tapes	PC diskettes
1990	214		(no records)
1991	457		(no records)
1992	143		(no records)
1993	125	(no records)	367
1994	168	(no records)	486
1995	126	14	463

Table 3



NDIS - the Nuclear Data Information System

Development of the nuclear data Online Services,
which are presently used by 41 Member States.

Table 4

Nuclear Data Services in 1990 - 1995 by Geographical Region

	Services by Mail		**Online Services**	
Region	**# of countries**	**percentage of requests**	**# of countries**	**percentage of requests**
OECD countries	22	24%	17	36%
former USSR	6	7%	2	17%
East Europe	9	18%	8	40%
Asia, Australia	15	24%	6	1%
Africa and Near East	26	13%	2	3%
Latin America	15	14%	6	3%
	93	100%	41	100%
	Annual average: 700 requests resulting in the shipment of 300 data files and 2000 copies of printed materials.		4400 retrievals in 1995	
	Main users in 1995:	1. India 2. USA 3. China 4. Germany 5. Romania 6. Brazil 7. Hungary 8. Algeria 9. Argentina 10. Japan 11. UK 12. Israel	Main users in 1995:	1. Austria 2. Russia 3. Poland 4. Hungary 5. Netherlands 6. Slovakia 7. Czech Rep. 8. Italy 9. Israel 10. Germany 11. UK 12. Croatia

4. Computer Operations

End of 1995 the VAX 4000-200 computer was upgraded to a DEC-ALFA system. Details are given in the attachment.

During the past months the entire computer configuration and policy of the IAEA was reviewed, with two essential conclusions.

1. For safety reasons a "**Firewall**" is being established controlling the links between the IAEA computer network and the outside world. After various considerations it has been decided that the DEC-ALFA computer of the Nuclear Data Section will remain outside this Firewall, so that the Online Services and our links to external computers will remain unchanged. Only our electronic addresses will change.

2. The IAEA is establishing an **internal network** using the World-Wide-Web software. This requires Windows 95, and that again requires more powerful PC's than we have at present. Consequently, new PC's will have to be bought for the entire Section thus blocking the funds which had been allocated for additional upgrading of the DEC-ALFA system. This IAEA internal Web will provide for the IAEA internal communication including confidential information such as budget and personnel. It will be inside the "Firewall" to protect it against the outside, and essentially only e-mail and faxes will get through the "Firewall". We expect difficulties when transferring data files from the DEC computer which is outside the Firewall to the PC's which are inside the Firewall. Therefore, we shall need additional PC's that are outside the Firewall and linked to the DEC-ALFA.

At present, high priority is given to the development of the online services, including

- the interactive TELNET system taken over from NNDC, which includes EXFOR/CSISRS, CINDA, ENDF formatted data libraries, ENSDF, NSR, NUDAT;

- FTP services for file transfer;

- a WEB site, which is under development.

In parallel, conventional data center services by mail shipment will continue. A CD-ROM writing facility is being purchased.

5. Network Coordination

The coordination of data centers includes three networks for

- nuclear reaction data, based on the computerized systems EXFOR, CINDA, and ENDF;

- nuclear structure and decay data, based on the systems ENSDF, NSR, NUDAT;
- atomic and molecular data for fusion, based on the systems ALADIN (data) and CIAMDA (bibliographic index).

For each of these networks coordination meetings are organized in biennial intervals, with technical meetings in between, specifically for the EXFOR/CINDA cooperation.

A further network, i.e. a network of the data service centers, is developing in order to coordinate the online services. A meeting on this topic took place 30 September - 2 October 1996 between NNDC, NEA-DB, NDS and CDFE/Moscow University.

Due to IAEA internal matters the organization of these Network Meetings will have to be reviewed. The meetings are presently organized under the heading of an IAEA Advisory Group Meeting which, as the title suggests, are meant to advise the Agency on a specific topic. This is not really the case for our Network meetings which serve the coordination of the Network. The essential difference is that an Advisory Group Meeting requires only a single participant per country (with perhaps, advisers), whereas our Network meetings require one representative per Data Center, which may mean two or three participants per country. We need a recommendation from this meeting, requesting the Agency to continue to support the Network Meetings and to permit specifically, where required, more than one paid participant per country.

6. Other Activities

Attached are extracts from the Blue Books (i.e. the Agency's Programme and Budget Book), for the years 1995/96 and, as a draft, for the years 1997/98.

CAJAD activity in ENSDF.

F.E. Chukreev

Data evaluation

After Mr. E. Schurschikov stopped his activity in ENSDF all our attempts to educate new evaluators were unsuccessful.

Therefore I have been forced to remember ENSDF formalism and begin an evaluation for ENSDF again.

We finished new evaluation (it is update more exactly) for 238 mass chain now. I can not say that have creative satisfactory. This evaluation requested from us to go through the thick bushes of misprintings and errors. New experimental data is very little. The majority of these data are regarding to ^{238}Np. But the results of new investigation of ^{238} Np(n,γ) reaction , for which were used the best equipment and materials, have been interpreted by authors with using incorrect tables of internal conversion coefficients. Therefore we have been forced to recalculate authors data.

To stimulate the interest of the experimenters we constructed decay schemes for ^{238}Pa and ^{242m}Am. These decay schemes do not contradict experimental data, but the deficit of experimental data does not permit to suggest that these decay schemes are unique. May be our actions will help to excite new experiments. For example, last publication regarding to ^{238}Pa was published in 1970 year! This investigation of Mainz University was not complete. I would like to remark that ^{238}Pa decay is additional and important source of information of energy levels of ^{238}U, which is important material of nuclear energetic. Our construction of ^{238}Pa decay scheme shows, but not prove of course, that our knowledge about low-lying levels of ^{238}U contains some gaps.

I hope to have possibility to say a little about our construction for α-decay of isomer of ^{242}Am. I hope it will interesting.

Our evaluation plans include mass chains 88 and 242.

Data dissemination.

We approach step by step to WWW network. Optical cable gone in my room from central computers division of Kurchatov's Institute. This part of works is most expensive. Financial hardnesses to stop subsequent works. When needed money will be found this work will be continued.

In conclusion i would like to thank the collaborators of NNDC Drs. J.K.Tuli, T. Burrows and R. Kinsey for their codes PANDORA, FMTCHK, ENSDAT. I can not imagine the preparation data sets without these codes.

Status Report of Japanese Activities in Nuclear Structure and Decay Data

J. Katakura
Nuclear Data Center
Japan Atomic Energy Research Institute

1 Personnel

Dr. Kikuchi, General Manager of JAERI/NDC, was deceased in September. Dr. Hasegawa takes over the position. The contact person for ENSDF evaluation is Dr. Katakura.

2 Mass-chain evaluation

The Japanese group will maintain the permanently assigned mass range of 118-129.

A-Chain Evaluation Status

A	NDS publication	Status	Evaluators
118	NDS 75, 99 (1995)		Kitao
119	NDS 67, 327 (1992)		Kitao, Kanbe, Ogawa, Ohya
120	NDS 52, 641 (1987)	submitted	Kitao, Hashizume, Tendow
121	NDS 64, 323 (1991)	just started new evaluation	Tamura, Ohya, Katakura
122	NDS 71, 461 (1994)		Tamura, Katakura, Oshima
123	NDS 70, 531 (1993)		Ohya, Kitao
124	NDS 41, 413 (1984)	author post-review	Iimura, Katakura, Tamura, Kitao
125	NDS 70, 217 (1993)		Katakura, Oshima, Kitao, Iimura
126	NDS 69, 429 (1993)		Miyano, Kitao
127	NDS 77, 1 (1996)		Kitao, Oshima
128	NDS 38, 191 (1983)	author post-review	Kanbe
129	NDS 77, 631 (1996)		Tendow

3 Computer

Evaluation work is carried out with analysis codes distributed by BNL. Those codes are operational on our IBM compatible main-frame and personal computers. Most of the codes are also operative on Macintosh.

4 Other related activities on nuclear structure and decay data

4.1 Bibliographic data compilation

Computerized compilation of Japanese references (secondary sources) is being carried out by RIKEN nuclear data group continuously.

4.2 Revision of the Chart of Nuclides

The 5th edition was published in 1992 and is available. The chart is characterized by inclusion of estimated values for unmeasured beta-decay partial half-lives of the nuclides far from beta stability line. Those values are based on "Gross theory of beta decay" by Waseda University group. The data collection for the 6th edition has been done after the publication of the 5th edition. The 6th edition is scheduled to be published in 1996 fiscal year.

4.3 Gamma-rays table from ENSDF

List of gamma-rays emitted from naturally existing radioactive nuclides is now preparing.

4.4 Fission product data library for reactor decay heat estimation

Decay and fission yields data of fission products are compiled for reactor decay heat estimation. The library contains half-life, Q_β value, β and γ decay energy values, branching ratio and fission yield for 1227 fission products nuclides. Fission yield data are included for 20 fission types based on Rider and England evaluation. The decay energy values of the nuclides having no experimental data and incomplete ones are estimated by "Gross theory of beta decay" developed by the group of Waseda University. Decay data file containing more nuclides than fission products is now preparing.

Discrepant half-lives of ground states in adopted levels and decay data sets on ENSDF (1996.7 version)

T. Ichimiya, K. Kitao (Japan)

Nuclide	Adopted levels			Decay Data set			
22F	4.23	S	4	4.24	S	4	22F B-
22Ne	2.6019	Y	4	2.6088	Y	14	22Na B+
23Al	0.47	S	3	470	NS	30	23Al B+, B+P
27Mg	9.458	M	12	9.462	M	11	27Mg B-
28Al	2.2414	M	12	2.2414	M	1	28Al B-
29P	4.142	S	15	4.140	S	14	29P B+
32Cl	298	MS	1	298	MS	2	32Cl B+
32P	14.262	D	14	14.26	D	4	32P B-
45V	547	MS	6	539	MS	18	45V B+
46Sc	83.79	D	4	83.810	D	10	46Sc B-
49V	330	D	15	338	D	5	49V EC
51Cr	27.702	D	4	27.704	D	4	51Cr EC4
51Fe	305	MS	5	305.0	MS	43	51Fe EC
52V	3.743	M	5	3.75	M	1	52V B-
54Mn	312.3	D	4	312.12	D	10	54Mn EC
58Co	70.82	D	3	70.916	D	15	58Co EC
59Cr	0.74	S	24	0.76	S	24	59Cr B-
62Zn	9.186	H	13	9.26	H	2	62Zn EC
65Ni	2.5172	H	3	2.51719	H	26	65Ni B-
68Ge	270.8	D	3	270.82	D	27	68Ge EC
69As	15.2	M	2	15.23	M	16	69As EC
75Cu	1.3	S	1	1.224	S	3	75Cu B-N
75Se	119.779	D	4	119.770	D	10	75Se EC
79Ge	18.98	S	3	19.1	S	3	79Ge B-
81Ga	1.221	S	5	1.223	S	5	81Ga B-N
82Ga	0.599	S	2	0.602	S	6	82Ga B-N
82Ge	4.60	S	35	4.55	S	30	82Ge B-
82Se	1.08E+20	Y	+26-6	1.4E+20	Y	4	82Se 2B-
87Br	55.60	S	15	55.69	S	13	87BR B-N, B-
88Se	1.52	S	3	1.53	S	6	88Se B-
90Br	1.92	S	2	1.71	S	14	90Br B-N
90Sr	28.78	Y	4	28.74	Y	4	90Sr B-
92Tc	4.23	M	15	4.25	M	12	92Tc EC
94Sr	75.3	S	2	75.2	S	8	94Sr B-
96Rb	202.8	MS	33	201.3	MS	9	96RB B-N
				0.199	S	3	96RB B-
96Sr	1.07	S	1	1.06	S	3	96Sr B-
97Sr	429	MS	5	426	MS	5	97Sr B-
97Zr	16.90	H	5	16.91	H	5	97Zr B-
99Rb	50.3	MS	7	59	MS	1	99Rb B-, B-N
99Sr	0.269	S	1	270	MS	10	99Sr B-
99Y	1.470	S	7	1.47	S	2	99Y B-
101Sr	118	MS	3	114	MS	-	101Sr B-N
101Y	448	MS	19	500	MS	50	101Y B-
101Tc	14.22	M	1	14.2	M	1	101Tc B-
104Tc	18.3	M	3	18.4	M	-	104Tc B-
105Tc	7.6	M	1	7.63	M	9	105Tc B-
106Tc	35.6	S	6	36	S	1	106Tc B-
106Te	60	US	+30-10	60	US	20	106Te A
107Te	3.1	MS	1	0.0036	S	5	107Te A
109Tc	0.87	S	4	0.86	S	8	109Tc B-
109Cd	462.6	D	4	462.9	D	20	109Cd EC
109Sb	17.0	S	7	16.67	S	15	109Sb B+
111Xe	0.74	S	20	0.9	S	-	111XE A
118Cs	14	S	2	14	S	-	118CS B+
122Sb	2.7238	D	2	2.7209	D	3	122Sb EC
122La	8.7	S	7	8.5	S	6	122La EC
123Ag	0.309	S	15	0.31	S	1	123AG B-
124Cd	0.9	S	2	1.24	S	5	124Cd B-
125Sb	2.7582	Y	11	1007.4	D	4	125Sb B-
125I	59.408	D	8	59.402	D	14	125I EC
126La	54	S	2	1.0	M	3	126La B+
126Pr	3.1	S	3	3.0	S	4	126PR B+
127Cd	0.37	S	7	0.43	S	3	127Cd B-
127Pr	4.9	S	3	4.2	S	3	127Pr B+
128IN	0.9	S	1	0.8	S	1	128In B-
131Nd	27	S	2	25	S	-	131Nd B+P
132Sb	4.10	M	5	4.10	M	7	132Sb B-
133Sn	1.45	S	3	1.44	S	4	133Sn B-
133Ba	10.51	Y	5	10.52	Y	13	133Ba EC

138I	6.49	S	7	6.41	S	6	138I B-N, B-
141Ce	32.501	D	5	32.50	D	4	141Ce B-
143Cs	1.78	S	1	1.77	S	2	143Cs B-
143La	14.2	M	1	14.14	M	16	143La B-
143Ce	33.039	H	6	33.10	H	5	143Ce B-
143Pr	13.57	D	2	13.58	D	3	143Pr B-
144Ce	284.893	D	8	284.9	D	2	144Ce B-
146Sm	10.3E+7	Y	5	10.31E+7	Y	45	146Sm A
146Ho	3.6	S	3	3.9	S	8	146Ho EC
147Eu	24.1	D	6	24	D	1	147Eu B-, A
147Gd	38.06	H	12	38.1	H	1	147Gd EC
149Tb	4.118	H	25	4.13	H	3	149Tb A
150Eu	36.9	Y	9	35.8	Y	10	150Eu EC
150Tm	2.2	S	2	2.15	S	10	150Tm ECP
151Gd	124	D	1	120	D	20	151Gd A
151Tb	17.609	H	1	17.6	H	1	151Tb A
152Er	10.3	S	1	10.1	S	2	152Er A
153Pm	5.4	M	2	5.358	M	18	153Pm B-
154Ho	11.76	M	19	11.8	M	5	154Ho A
154Er	3.73	M	9	3.68	M	15	154Er EC
154Yb	0.404	S	14	0.402	S	17	154Yb A
				0.4204	S	14	154Yb EC
155Yb	1.75	S	5	1.71	S	9	155Yb A
155Tm	21.6	S	2	32	S	3	155Tm A
156Tm	83.8	S	18	86	S	4	156Tm A
156Yb	26.1	S	7	23.6	S	13	156Yb A
158Yb	1.49	M	13	1.65	M	20	158Yb A
159Gd	18.479	H	4	18.56	H	8	159Gd B-
161Hf	17	S	2	20	S	3	161Hf EC
162Ta	3.52	S	12	3.57	S	12	162Ta A
164W	6.4	S	8	6.0	S	3	164W A
165Re	2.4	S	6	2.3	S	4	165Re A
166Ho	26.83	H	2	26.80	H	2	166Ho B-
170Os	7.3	S	2	4.0	S	2	170Os A
172Pt	0.104	S	7	0.10	S	1	172Pt A
172Os	19.2	S	9	19	S	2	170Os A
173W	7.6	M	2	7.5	M	3	173W EC
175Ir	*9	S	2	4.5	S	10	175Ir A
176Au	1.25	S	30	1.08	S	17	176Au A
177Lu	6.734	D	12	6.73	D	1	177Lu B-
178Pt	21.1	S	6	21.0	S	6	178Pt A
178Hg	0.254	S	19	0.26	S	3	178Hg A
179Re	19.5	M	1	19.7	M	1	179Re EC
179Pt	**21.2	S	4	43	S	10	179Pt A
179Au	7.1	S	3	7.5	S	4	179Au A
180Hg	2.8	S	2	3.0	S	3	180Hg A
182Tl	3.1	S	10	-		-	182Tl A
182Au	***15.6	S	4	21	S	1	182Au A
182Pt	2.2	M	1	2.6	M	1	182Pt A
185Ae	4.25	M	6	4.3	M	1	185Au EC, A
185Pt	70.9	M	24	-		-	185Pt A
183Ir	58	M	6	57	M	7	181Ir EC
183Re	#70.0	H	14	70.0	D	11	183Re EC
183Hg	9.4	S	7	8.8	S	5	183Hg EC, ECP
185Ta	49.4	M	15	49	M	2	185Ta B-
185Ir	14.4	H	1	14.0	H	9	185Ir EC
185Au	4.25	M	6	4.31	M	1	185Au A, EC
185Hg	49.1	S	10	49	S	2	185Hg EC, A
188Pb	24.2	S	10	24.5	S	15	188Pb A
189Hg	7.6	M	1	7.6	M	2	189Hg EC
190Pt	6.5E11	Y	3	6.6E11	Y	3	190Pt A
195Po	4.64	S	9	4.5	S	5	195Po A
198At	##4.2	S	3	4.9	S	5	198At A
199Pt	30.80	M	21	30.8	M	4	199Pt B-
203At	7.4	M	2	7.37	M	2	203At EC
205Rn	2.8	M	1	2.83	M	12	205Rn EC
				170	S	4	205Rn A
202Bi	###1.72	H	5	1.67	H	2	202Bi EC
205Rn	2.8	M	1	170	S	4	205Rn A
				2.83	M	12	205Rn EC
207Rn	9.25	M	17	9.3	M	2	207Rn A, EC
213Th	140	MS	25	150	MS	25	213Th A
215Bi	7.6	M	2	7.7	M	2	215Bi B-
224Ra	3.66	D	4	3.62	D	1	224Ra A
235NP	396.1	D	12	396.2	D	12	235Np A, EC
226Np	35	MS	10	31	MS	8	226Np A
231U	25.3	M	5	25.	M	-	235Pu A

234Pa	6.70	H	5	6.75	H	5	234Pa	B-
235Pa	24.5	M	2	24.1	M	2	235Pa	B-
235Np	396.1	D	12	396.2	D	12	235Np	A, EC
236Pu	2.858	Y	8	2.851	Y	8	236Pu	A
237Np	2.144E+6	Y	7	2.1E+6	Y	11	237Np	A
242Cf	3.49	M	12	3.68	M	44	242Cf	A
243Np	1.85	M	15	1.8	M	3	243Np	B-
247Es	4.55	M	26	4.7	M	3	247Es	EC
254Es	275.7	D	5	275.5	D	5	254Es	A

- not given

* Weighted average of 7.2 S 13, alpha counting (92Sc16); 11 S 3, G-ray counting (92Sc16); and 13 S 2, G-ray counting (92Bo21). Other value: 4.5 S 10 (67Si02).

** From 93Me13. Others: 54 S 4 (82Bo04) and 33 S 2 (66Si08)

*** From 92Ro21. Others: 15 S 2, 13.8 S 18, 18 S 7 (93BiZY), 20 S 2 (79Ha10), 22.1 S 13 (72Fi12), 19 S 2 (70Ha18)

\# Weighted average of 67.6 D 25 (58Fo47), 71 D 3 (58Ga17), and 71 D 2 (65Bl06).

\## From alpha(t) measurements (92Hu04). Other: 4.9 S 5 (67Tr06).

\### 1.67 H 2 (66KaZY), 1.79 H 3 (70DaZM). Others: 51Ka03, 70Jo26.

Status Report of French activities in Nuclear Structure and Decay Data

Budapest ,11-18 October 1996

Jean Blachot in collaboration

with **G. Audi * and O. Bersillon**** (Nubase , Decay Data)

A) ENSDF EVALUATION

Since Berkeley 1994 , A=116, 114, 111 have been published.
All the masses have been updated every year , in particular for the high spin

List of A-chains on our responsibilty.

A-Chain	NDS with also date when update		Comments
101	NDS 63,305	1991 NDS 45 701	in review stage
103	NDS 68,311	1993 NDS 45 363	done for Gent but reponsibility Gent
104	NDS 64, 1	1991 NDS 41 325	Last update 960509
107	NDS 62,709	1991	Last update 960403
108	NDS 62,803	1991 NDS 37 289	in review stage (beginning 1996)
109	NDS 64,913	1991 NDS 41 111	Last update 960403
111	NDS 77,299	1996	
113	NDS 59,729	1990 NDS 33 1	Last update 940210,Could be sent 1997
114	NDS 75,739	1995 NDS 60,139	(HI) ready to update
115	NDS 67 1	1992 NDS 52 565	Last update 960307
116	NDS 73, 81	1994	Last update (HI) 961001
117	NDS 66,451	1992 NDS 50 63	Last update 960222

B) NUBASE

The database (NUBASE) containing the main Nuclear properties and decay properties of nuclides in their ground state and isomeric states has been continuously updated.

The description of NUBASE has already been presented in the last NSDD meeting and published in a journal (Nuc. Inst Met. A369 (1996) 511

This horizontal database is a critical compilation of ENSDF and AME. In order to be as complete as possible , this compilation is updated on the basis of recent literature.
The 1996 version (October) contains 3700 records (about 3000 ground states and 700 isomeric states with half-lives greater than 1 millisecond)
800 nuclides have been modified or added compares to ENSDF and all are referenced.

NUBASE may be used in conjunction with a PC program , NUCLEUS available from Orsay

We would like to propose for discussion at the meeting the conditions and the procedures to feed back the work of NUBASE to ENSDF.

C)DECAY DATA

The decay data sets of Ensdf have been used to build a decay data library with the help of the program RADLIST. Some complements and modifications have been added to the program.
Some differerence between the informations in the Adopted and Decay data sets of ENSDF need to be corrected , (T1/2, branching , etc ..)

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Nuclear Structure and Decay Data Evaluation in Sweden

Report prepared for the October 1996 IAEA Advisory Group Meeting
on
Coordination of the International Network of Nuclear Structure and Decay Data Evaluators

Peter Ekström

Department of Physics, Lund University*

October, 1996

This report summarizes the activities and accomplishments since the IAEA NSDD meeting in Berkeley in May 1994. The activities rely heavily on the close collaboration with the Isotopes Project at LBNL.

World Wide Web

We started experimenting with a **Web service** in November 1994. At present the Lund Web site contains the following:

- **Nuclear Data and References Home Page** with order form and downloadable updates
- Parts of the **Table of Isotopes** in PDF format (primarily the tables in the appendices)
- The program **VuENSDF with data**

A feasibility study has been performed on extending the NSR database capabilities of VuENSDF to be run on a standard Web browser via the WWW. This would have the benefit of **making the service available for almost any computer platform**. A JavaScript interface has been written, and server software will be produced to allow searches of the NSR database on nuclide, keynumber, publication year, author, keyword, target and reaction.

Peter Ekström participated in the Coordination Workshop on "DOE Nuclear Data Program Services via the Internet" held at LLNL in August 1996.

Papyrus NSR and Nuclear Data and References

In May 1994 the Lund-LBNL collaboration released **Papyrus NSR**, a CD-ROM containing the NSR file with the PAPYRUS bibliographic database management system, to facilitate literature searches on PCs. In June 1996, a new CD-ROM, **Nuclear Data and References**, was released by a Lund/LBNL/BNL collaboration, on behalf of the international nuclear data network. This CD-ROM, which updates its predecessor (Papyrus NSR) includes:

- **The Nuclear Science References (NSR) database**, with over 140,000 references, updated to December 8, 1995. Information can be retrieved using the **Papyrus™** bibliographic database management system.
- **NuDat, a numerical database of nuclear properties**, accessed and managed by **PCNuDat** (software developed at BNL). This database includes data from ENSDF, the Nuclear Wallet Cards, the 1995 update to the Atomic Mass Evaluation, and from Neutron Cross Sections, Vol. 1 and 2.

VuENSDF

Version 1.0 of VuENSDF, developed by a collaborative effort between the Isotopes Project and Lund University, was released in July 1996. VuENSDF is designed to retrieve ENSDF and NSR information directly over the Internet from a Web server, from the Table of Isotopes CD-ROM, or from a local disk file. It displays level scheme drawings, tabular listings of nuclear levels and transitions, and NSR references.

Data can be displayed by nuclear band structure and selected by coincidence relationships. Tables can be constructed according to user specifications, readily sorted by any numerical field, and output as tab-delineated records for input into other user codes. VuENSDF can search the NSR file by keynumber or author and display the keyword abstracts. Tables and drawings may be printed, and a print preview option is offered. VuENSDF can be downloaded from the Web. Running VuENSDF directly provides users with Internet access to nuclear data without requiring a WWW browser, or the program can be used as a helper application with a commercial browser.

The Lund involvement in the project has mainly been in the areas of program testing, quality control and documentation, and that a student from Lund has been working at the Isotopes Project for more than a year.

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* The **Swedish Nuclear Data Project** is supported by the **Nuclear Power Inspectorate** (SKI), the **Science Research Council** (NFR), the **Radiation Protection Institute** (SSI) and the energy companies **Barsebäck Kraft** and **Vattenfall**.

STATUS REPORT ON NSDD ACTIVITY OF THE PNPI DATA CENTER

I.A. KONDUROV, Yu.V. SERGEENKOV

Data Center of the Petersburg Nuclear Physics Institute
of the Russia Academy of Sciences
Gatchina, Leningrad region, 18830 Russia

1. Mass-chain evaluation for ENSDF

Mass-chain evaluation status in our responsibility rangeis as follows :

chain	last publication	status
A = 130	NDS **58** 765 (1989)	-
A = 131	NDS **72** 487 (1994)	+T.Borrows, M.Bhat
A = 132	NDS **65** 277 (1992)	
A = 133	NDS **49** 893 (1986)	evaluated by S.Rab (1995)
A = 134	NDS **71** 557 (1994)	
A = 135	NDS **52** 205 (1987)	+B.Singh, J.Tuli; in progress

2. Keyword references for the NSR file

During last two years we have continued preparation of the keyword references of JINR (Dubna) preprints and Communications and Proceedings of the Conference on the Nuclear Structure and Nuclear Spectroscopy.

3. INTERNET, CD-ROM

PNPI now has a satellite antenna to DESY, Germany so we have a possibility to work in the Interment media. We use:

FTP for working communication with NNDC BNL;
Telnet for on-line access to NNDC BNL and NDS IAEA ;
WWW to connect home pages of NNDC, LBNL, Lund University (n,γ-lines, VuENSDF, Table of Isotopes .....);
CD-ROM drive: NSR, PCNUDAT, TOI. We have also a device to copy CD-ROM files.

4. Nuclear Data in Neutron Activation Analysis

During the last decades we developed and widely used the NAA software package based on using data from ENSDF (decay parameters) and BNL-325 (thermal neutron cross section). The program can extract the necessary information on radioactive decay schemes of nuclei from the data files and can calculate the intensities of the gamma quanta of the nuclei produced in the neutron irradiation of a given chemical element, with the neutron flux and activation cross-section being taken into account. The basis of all the calculations is the data presented in the new NAADF file, which contains a set of data from the original ENSDF file on the decay schemes of all nuclei produced in the (n,γ) reaction.

Two methods of deducing concentration from our measurement are traditionally used:

- calculational, as described above and
- comparison with standard samples.

Participation in the "Intercomparison Runs of Reference Materials" performed under coordination of the Analytical Quality Control, IAEA gave as a result **disagreement** between "calculational" and "standard" methods for several isotopes.

We plan:

1. to search for isotopes giving such a disagreement,
2. to perform a precise evaluation and special measurements to overcome disagreements .

We need financial support for this work.

5. Constructing level scheme and merging results of measurement

More than 15 years of experience in the field of nuclear spectroscopy results to development in our Center modernized version of the GTOL (Gamma TO Level) program, GTLM. The program construct the level scheme, having as input parameters list of γ-peak positions, and can take into account *a priori* information on the Ritz combination of γ-transitions placed in the known fragment of the level scheme under investigation [1].

Reference

1. L.P.Kabina, I.A.Kondurov, P.A.Sushkov. NIM **A369** (1996) 648-650

Status report Utrecht

P.M. Endt and C. van der Leun

R.J. Van de Graaff Laboratory, Utrecht University, The Netherlands

Energy levels of A = 21-44 nuclei

The most recent (seventh) edition of the review article "Energy levels of A = 21-44 nuclei" appeared in 1990 [1]. In view of the diminishing publication rate of new spectroscopic data on sd-shell nuclei, a complete new editon is not considered for the next few years.

Instead, a *Supplement* to the 1990 review is at present being written and will hopefully come out by the end of 1997 (an estimated 200 pages in Nuclear Physics A). This supplement only lists additions to [1] on reasonably narrow and well-resolved levels. This means that most of the work on giant resonances, on heavy-ion reactions or on reaction mechanisms is omitted.

At the end of each A-chain, a comparison is given of positive-parity levels with the shell model. This model is extraordinary successful in the sd-shell.

Gamma-ray energy calibration standards

A task group of the IUPAP commission on Atomic Masses and Fundamental Constants published a consistent set of IUPAP-recommended gamma-ray energies for calibration purposes in 1979 [2].

An update of this set is desirable for three reasons:

a. a revised value is available for the lattice parameter of the Si crystals used in gamma-ray wavelength measurements,

b. a new set of adjusted fundamental constants has been published,

c. a few new (and revised) high-precision measurements have been performed.

The first two changes result in a downward overall-shift of the energies of about 6 ppm from the 1979-energies. The new adjustment of the fundamental constants results in a reduction (from 2.6 ppm to 0.3 ppm) of the uncertainty in the wavelength-to-keV conversion factor, which in 1979 was often the dominant uncertainty in the energies (on the keV scale).

A comlete analysis of all the available data will result in a new recommended list of gamma-ray energies. A preprint is expected to be available early 1997.

References

[1] P.M. Endt, Nucl. Phys. **A521** (1990) 1-830.

[2] R.G. Helmer, P.H.M. Van Assche and C. van der Leun, At. Data and Nucl. Data Tables **24** (1979) 39-48.

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Status report Belgian Group.

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During the last two years we have evaluated mass hains A=106 and A=112. We just started to evaluate mass A=102.

We also worked on a Nuclear Data Editor from which a prototype will be presented on this meeting.

However as in other countries there is a lot of pressure from the Scientific Committees of the National Fund for Scientific Research of Belgium to limit evaluation activities to the absolute minimum and even to cancel them completely. Up to now we can withstand this pressure but the question remains for how long.

Our fundamental research programme consists primarely in Ghent of (γ,γ') experiments with polarized and unpolarized bremsstrahlung on different targets as ^{56}Fe, ^{58}Ni, ^{116,124}Sn. We are also involved in future experiments on the AGOR accelerator of the KVI in Groningen where we will do experiments with polarized protons. Preservation of food by gamma and electron irradiation and sterilization of biomaterials is also continued.

Status Report of the Nuclear Data Project at McMaster University
(June 1994-September 1996) (B. Singh)

Mass-chain evaluations:

The McMaster group has permanent responsibility for the evaluation of five mass chains (64, 98, 100, 149, 151) with about 0.5 FTE financial support from the Natural Sciences and Engineering Research Council of Canada (NSERC). Since the 1994 IAEA meeting of NSDD, the following mass chains have been published or submitted:

A=149 (Update), NDS 73, 351-556 (1994).
A=64, NDS 78, 395-546 (1996).
A=100, NDS (Submitted March 1996).
A=151, NDS (Accepted for publication, July 1996).

Work is currently in progress on **A=98** last published by the McMaster group in 1992. It is expected that it will be completed and submitted by Spring 1997. Thus the ENSDF is current for the mass chains assigned to the McMaster group.

The following mass chains have been published or submitted in association with the Isotopes Project at Berkeley (with ~0.5 FTE financial support from LBNL):

A=76 (Update), NDS 74, 63-164 (1995).
A=182 (High-spin update) NDS 74, 383-460 (1995) (Joint with R.B. Firestone)
A=172 NDS 75, 199-376 (1995)
A=194 NDS (In Press 1996) (Joint with E. Browne)

Data for superdeformed bands:

In an attempt to keep the ENSDF more current for recent data on superdeformed structures, a collaborative effort with the Isotopes Project at Berkeley has been continuing since 1993 to evaluate and update data on superdeformation in nuclei. A first **Table of Superdeformed Bands and Fission Isomers** was published (by B. Singh and R.B. Firestone) as an LBL report in Spring 1994. This compilation was distributed worldwide to high-spin researchers and network evaluators. The data files, for 'Adopted' and 'Reaction' datasets were incorporated in the ENSDF. A second revised and updated version of this table was published (by B. Singh, R.B. Firestone and S.Y.F. Chu) in **Nuclear Data Sheets 78, 1-218 (1996)**. This publication contains data on all superdeformed bands (~170 bands in 58 nuclides) known up to April 1996, complete bibliography and charts of moments (dynamic) of inertia for all SD bands. Recently, new papers which appeared (up to about the end of September 1996) were also incorporated and the data files for all the 62 nuclides (~175 SD bands) were sent to Brookhaven for inclusion in ENSDF. These data are also made available on WWW. We intend to update SD-band data on all nuclides on a continuous basis.

Evaluation of high-spin data:

As part of an effort to keep the ENSDF more current on voluminous new high-spin data produced with large detector arrays, the McMaster group completed A=64 primarily for the new high-spin data. Presently work is going on A=89 nuclides which have a large amount of new high-spin data. Since McMaster University has a strong high-spin experimental research program (under the leadership of Dr. J.C. Waddington), it is likely that some of our future effort in data evaluation will be directed in this field, while keeping our mass-chain responsibility.

In association with the Isotopes Project at Berkeley, high-spin data on the following mass chains have been updated and included in ENSDF: A=135, 163, 182, 188, 190, and 211.

Review of Mass-chain evaluations:

The following mass chains were reviewed during 1994-96: A=131, 191, 170, 124, 81, 93.

Current Reference Lists and associated data tables, level schemes:

The compilation/evaluation of superdeformed data on a continuous basis necessitated consultation of current literature that was still not documented in NSR. Since June 1994, lists of current high-spin experimental papers published in prime nuclear physics journals were kept as computer files. The high-spin research groups at Berkeley, McMaster and other laboratories expressed interest in such very current lists. Thus it was considered appropriate to distribute these lists, quarterly, to high-spin researchers through e-mail and WWW. Four such lists, the latest covering literature up to the end of September 1996, have been distributed. During the last year, similar lists for papers on radioactive decays and low spin reactions have also been prepared and made available on WWW.

For most of the current high-spin papers in these lists, the Isotopes Project (R.B. Firestone and J. Zipkin) at Berkeley has entered asscociated gamma-ray and level-scheme data accessible in tabular and ENSDF formats. These data are made available on WWW.

Other Research Activities:

In collaboration with R.K. Sheline, systematics of E4 transitions have been investigated through the whole range of even-even nuclides and a horizontal compilation has been prepared for all known first 4+ to ground state E4 transitions. This project is still in progress.

In collaboration with J. Kern at Fribourg, Switzerland , in-beam gamma-ray measurements on the level structure of odd-odd ^{168}Tm were carried out as two separate one-week experiments, the first one for excitation function measurements and the second for angular distribution data. A long gamma-gamma coincidence run is still planned. From the first two runs the results are being analysed.

Following research papers were published as a result of above collaborations:

B. Singh, P.C. Sood and H.W. Taylor, Gamma-ray Deexcitations in ^{168}Tm,
Phys. Rev. C52, 1694 (1995)

P.C. Sood, A. Gizon, D.G. Burke, B. Singh, C.F. Liang, R.K. Sheline, M.J. Martin and R.W. Hoff, Beta-decay of ^{228}Ra and Possible Level Structures in ^{228}Ac,
Phys. Rev. C52, 88 (1995).

R.K. Sheline, B. Singh, P.C. Sood and S.Y.F. Chu, Evidence of Hexadecapole Collectivity in Even-even Nuclei, Proc. Int. Conf. Nuclear Structure,
Rovello, Italy, May 1995, p273-280.

P.C. Sood, R.K. Sheline and B. Singh, Evidence for Hexadecapole Collectivity in Closed-shell Nuclei, Phys. Rev. C51, 2791 (1995).

B. Singh and H.W. Taylor, Half-lives of Microsecond Isomers in ^{151}Eu and ^{181}W,
Appl. Rad. & Isot. 45, 374 (1994).

Status report: Evaluation of high-spin and Superdeformed data for ENSDF
(June 1994-September 1996) (B. Singh)

At the May 1994 IAEA(NSDD) meeting:

Action item #12, p19, INDC(NDS)-307 (1994):

'Singh	Organize effort to a level of about 2 FTEs to evaluate the data from heavy-ion induced gamma-ray spectroscopy experiments'.

March 1996 USNDN meeting:

Under 'Recommendations' (p8 BNL-NCS-63270)

Out of the 5 FTE available for the evaluation effort in the U.S. during the next year, about 60% or 3 FTE should be devoted to high-spin data and an additional 0.5 FTE assigned for decay data evaluations.

Completed work:

High-spin updates since 1994 NSDD meeting:

A=138: Tuli, BNL
A=153, 193: Baglin, LBNL
A=154: Reich, INEL
A=163: Singh, LBNL + Ekstrom, Lund
A=135, 182, 188, 190, 211: Singh, LBNL
A=174, 176, 184: Huo, ORNL
114Te, 116Te: Blachot, Grenoble
90Mo: Browne, LBNL

A=89: Singh, McMaster (work in progress)
90Tc: Browne, LBNL (work in progress)

SD bands: A=81-87, 129-137, 142-155, 189-198
(62 nuclides, ~175 SD bands):
Singh, McMaster & LBNL; Firestone and Chu, LBNL.
First publication: June 1994 as LBL-report
Second publication: NDS 78, 1-218 (May 1996)
Updated September 1996; literature covered to that presently on library shelves
ENSDF format data files sent to BNL September 22, 96
Continuous update planned in future.

High-spin updates (since 1994 NSDD meeting), later completed as full mass chains:

A=214, 218, 222, 226: Akovali, ORNL
A=197: Chunmei, Beijing
A=194: Browne and Singh, LBNL
A=191: Browne and Chu, LBNL
A=150: DerMateosian and Tuli, BNL
A=64: Singh, McMaster

Compilation of high-spin data for TOI:

During 1995-96, High-spin data for ~100 nuclides in the range A=139-200 were compiled by F. Chu, LBNL for TOI. The data files in ENSDF format are available at LBNL and BNL.

Current high-spin references and associated data files:

Since June 1994, prompted by the continuous update of SD band data, reference lists of current high-spin papers published in prime journals in nuclear physics have been kept (by B. Singh, McMaster) as computer files. Since some researchers in high-spin physics at McMaster, Berkeley and other laboratories expressed interest in receiving such lists, these have been made available to them, on a quarterly basis, through e-mail and WWW. In addition spectroscopic data in these papers are compiled in ENSDF format (by R. Firestone and J. Zipkin, LBNL) and made available on WWW in tabular and ENSDF formats. The latest quarterly reference list posted on WWW covers literature to that available presently on library shelves.

Priority Lists of Nuclides for evaluation:

At the 1994 NSDD meeting and later at US NDN meetings in 1994 and 1996, a need was expressed for generating priority lists of nuclides for high-spin updates. Two such lists have been prepared since 1994, the criteria being the age of mass chain in ENSDF and number of new papers containing high-spin data. These lists were generated based on a computer search (by J. Tuli, BNL) of total number of gamma-ray papers in reactions for all nuclides, followed by actual scanning (by B. Singh, McMaster) of keywords of references for nuclides with at least two new papers. One such list ordered by nuclides together with relevant keynumbers was circulated to the network in April 1996.

J^{π} and Multipolarity assignments in (HI,xnγ) reactions

October 25, 1994 Revised February 2, 1995

(B. Singh)

1. In (HI,xnγ) experiments the following techniques are generally used to determine spins and parities of levels and multipolarity of γ-transitions:

a) **Angular distributions:** $\gamma(\theta)$-measurement of intensity of a γ-ray as a function of the angle with respect to the beam axis or the nuclear spin axis.

b) **Angular Correlations:** $\gamma\gamma(\theta)$ (DCO): measurement of intensity of one γ-ray relative to another γ-ray (of known multipolarity) with the two γ-rays detected at two different angles with respect to the beam direction in a γ-γ coincidence arrangement.

c) **Linear Polarization of γ-rays:** measurement of relative intensities, in a Compton polarimeter arrangement, of scattered radiations in planes perpendicular and parallel to the reaction plane (plane defined by the beam direction and the incident γ-ray).

d) **Internal conversion coefficients**: measurement of conversion coefficients or subshell ratios from electron spectra or from γ-ray intensity balances.

2. The first two techniques (a,b) may determine ΔJ between two states but cannot determine $\Delta\pi$. For low J(<6 or so), $\gamma(\theta)$ may be sensitive to choice of J_i and J_f, also.

The linear polarization measurement complements the first two techniques to determine $\Delta\pi$. Conversion coefficients determine the multipolarity of a transition thus implying ΔJ and $\Delta\pi$.

In experiments with heavy ions, due to the complexity of γ-ray spectra, it is mainly the DCO (directional correlation of γ-rays from oriented states of nuclei) type of measurements which prove to be more practical than the others quoted above.

3. In $\gamma(\theta)$ data the values of A_2 and A_4 depend on ΔJ, the mixing ratio $\delta((L+1)/L)$ and the degree of alignment. some typical values are given in the table below with the following assumption:

a) Angle θ is measured with respect to the beam direction. If θ is measured with respect to the nuclear spin axis, the sign of A_2 is reversed.

b) In actual practice many authors take for the degree of alignment $\sigma/J = 0.3$. This is usually determined by measuring $\gamma(\theta)$ for standard $\Delta J=2$ transitions. Here σ = half-width of the Gaussian describing the m-state population. The attenuation caused by the degree of alignment affects only the magnitudes of A_2 and A_4. Level lifetimes are assumed to be small so that alignment is maintained.

ΔJ	Multipolarity	Sign of A_2	Sign of A_4	Typical Values	
				A_2	A_4
2	quadrupole	+	-	+0.3	-0.1
1	dipole	-		-0.2	0.0
1	quadrupole	-	+	-0.1	+0.2
1	dipole + quadrupole	+ or -	+	+0.5 → -0.8	+0 → +0.2
0	dipole	+		+0.35	0.0
0	quadrupole	-	-	-0.25	-0.25
0	dipole + quadrupole	+ or -	-	+0.35 → -0.25	0 → -0.25

4. In $\gamma\gamma(\theta)$(DCO) a γ-γ coincidence matrix, constructed from data from sets of detectors at two angles (θ_1 and θ_2 relative to the beam direction) is analyzed to deduce a ratio R defined by

$$R(DCO)=\frac{[I_\gamma(\theta_1)\,xI_\gamma^{gate}(\theta_2)]}{[I_\gamma(\theta_2)\,xI_\gamma^{gate}(\theta_1)]}$$

The gating transition is usually of known ΔJ (1 or 2). Other definitions of R(DCO) are also used in the literature, based on a different combination of intensities above. In that case the values of R(DCO) will be somewhat different.

The numerator and denominator in the above equation are two (2-dimensional) areas deduced from the (θ_1 x θ_2) coincidence matrix. The actual ratio depends upon the angles used in an experiment. Some typical values of R(DCO) (for $\sigma/J \approx 0.3$) are as follows:

ΔJ_γ^{gate}, Multipolarity	ΔJ_γ	Multipolarity	Typical R(DCO)
2, quadrupole	2	quadrupole	1.0
2, quadrupole	1	dipole	0.56 (θ_1=37°,θ_2=79°)
2, quadrupole	1	dipole + quadrupole	0.2-1.3 (θ_1=37°, θ_2=79°)
2, quadrupole	0	dipole	1.0
2, quadrupole	0	dipole + quadrupole	0.6-1.0 (θ_1=37°, θ_2=79°)
1, dipole	2	quadrupole	(1/0.56) (θ_1=37°, θ_2=79°)
1, dipole	1	dipole	1.0
1, dipole	0	dipole	~1/0.56

5. γ-ray linear polarization data (in a Compton polarimeter arrangement) can differentiate between electric and magnetic transitions and are analyzed in conjunction with $\gamma(\theta)$ and/or $\gamma\gamma(\theta)$ data to deduce the multipolarity of a transition and $\Delta\pi$ of levels involved. See reference 7 (Kim et al) for details.

6. The interpretation of internal conversion coefficient data is as given in earlier rules in NDS for spin and parity assignments. Note that electron data usually give K-, L- ... conversion coefficients or sub-shell ratios whereas intensity balance arguments give total conversion coefficients.

7. If $T_{1/2}$ (level) is known or a limit can be assumed (based on coincidence resolving time, for example), RUL (recommended upper limits for Weisskopf estimates) may serve to eliminate the M2 option for a $\Delta J=2$ quadrupole transition.

8. From systematics of population of high-spin states (yrast or near yrast), the spins are generally assumed to be in ascending order as the excitation energy increases.

9. If the level structure is collective (regular cascade pattern), intraband $\Delta J=2$ transitions are considered to be of E2 type, and $\Delta J=1,0$ transitions with significant admixtures to be of M1+E2 type. If the transition is pure dipole (δ(Q/D)=0), it is generally assumed to be E1 since, for M1 transitions, a small E2 admixture is expected when dealing with a collective level spectrum. Such assignments are difficult to make if the levels display non-collective (irregular pattern of levels) structure or if the level structure corresponds to oblate M1-bands.

10. In strongly coupled bands, (deformation aligned) a comparison of experimentally deduced value of g_K (from mixing ratio δ(E2/M1) and assumed g_R and Q_0) with that calculated on the basis of a proposed quasi-particle configuration may lead to the assignment of parity to a band.

11. A comparison of experimental and calculated Routhians and particle alignments (from cranked shell-model calculations) for suggested quasi-particle configurations may give information about the parity of a rotational band.

Useful references for $\gamma(\theta)$, $\gamma\gamma(\theta)$(DCO), γ (linear polarization) data:

1. Yamazaki, T., Nucl. Data Tables **A3**, 1 (1967). :$\gamma(\theta)$
2. Der Mateosian E. and Sunyar A.W., At. Data and Nucl. Data Tables, **13**, 391 (1974); ibid. 407 (1974). :$\gamma(\theta)$
3. Taras, P. and Haas, B., Nucl. Instr. Methods **123**, 73 (1975). :$\gamma(\theta)$ (Sign of mixing ratio (Q/D) in this paper is opposite to that used in ENSDF. :$\gamma\gamma(\theta)$(DCO)
4. Ekstrom, L.P. and Nordlund, A., Nucl. Instr. Methods **A313**, 421(1992).
5. Kramer-Flecken, A., et al., Nucl. Instr. Methods **A275**, 333(1989). :$\gamma\gamma(\theta)$(DCO)
6. Aoki, T. et al., At. Data Nucl. Data Tables, **23**, 349(1979). γ(Lin Pol.)
7. Kim, J.S. et al., Phys. Rev. **C12**, 499(1975). γ(Lin Pol.)
8. Krane, K.S., Steffen, R.M. and Wheeler, R.M., Nuclear Data Tables **A11**, 351(1973). $\gamma\gamma(\theta)$(DCO).

APPENDICES

1. *E. Browne*: Limitation of Relative Statistical Weights, a Method for Evaluating Discrepant Data
2. *Y.A. Akovali*: Review of alpha-decay data from doubly-even nuclei
3. *B. Singh et al.*: Systematics of E4 (0_1^+ to 4_1^+) transitions in even-even nuclides
4. *F.E. Chukreev*: An Attempt to Construct Decay Scheme of ^{242m}Am α Decay
5. *V.E. Makarenko*: FISOM - The Nuclear Database for Fission Isomer Properties
6. *G.L. Molnár*: The Ninth Capture Gamma-Ray Symposium at Budapest
7. *G.L. Molnár* and *J. Östör*: Horizontal Evaluation of Neutron Capture Gamma-Ray Data
8. *H.D. Lemmel*: Citation of databases in publications
9. Evaluated Nuclear Structure Data
10. *Victoria McLane*: Citation Guidelines for Nuclear Data Retrieved from Databases Resident at the Nuclear Data Centers Network

Limitation of Relative Statistical Weights, a Method for Evaluating **Discrepant** Data

A Proposal to the *Nuclear Structure and Decay Data Evaluators Network*

Edgardo Browne
September 1996

I. Description of the problem

The evaluation of data that are statistically discrepant, that is, data for which $\chi^2/(N-1) > 1$, is a usual problem for evaluators. Several methods have been developed [1] during the years to produce a recommended *average* for a discrepant set of data. Most of them are based on the assumption that the experimental uncertainties are incorrect in some (or all) of the measured values. Each of these *ad hoc* methods presents a criterion for identifying the 'incorrect' values and adjusts their reported uncertainties so the data set becomes statistically consistent ($\chi^2/(N-1) = 1$).

Evaluators of nuclear structure and decay data usually apply conventional methods of statistical analysis. Most of them calculate a weighted average and use the larger of the *internal* and *external uncertainty.* This is one of the simpler methods mentioned in Ref. 1. However, the validity of the weighted average for a *discrepant* set of data may be questionable [2,3]. Moreover, the lack of a well-established procedure to be used by *all* evaluators for the analysis of data, precludes a direct comparison of recommended values reported by different evaluators. It is obvious that there is a need to agree upon and establish such a procedure. That procedure should include guidelines for data rejection, and suggest a *single* method for producing a recommended average.

II. Proposed Solution

I recommend the following procedure for handling *discrepant* data:

- **Subjective Rejection of Unreliable Measurements**, based on information contained in the publication, or obtained from other sources.
- **Statistical Rejection of Data**, based on a criterion that identifies statistical outliers. Chauvenet's criterion [4] is simple and does the job. The criterion identifies a measured value x_i as an outlier if $|x_u - x_i| > ps$. Where x_u is the unweighted average, $s^2 = \Sigma(x_i - x_u)^2/(N-1)$ is the sample variance, $p = 0.91772 + 1.0168 \log N$, and N is the number of measured values. The evaluator has the discretion to reject outliers.
- **A Simple Method for the Production of a Recommended Average.**
  The *Limitation of Relative Statistical Weights* [5] is a straightforward method that avoids unnecessary and extensive manipulation of the experimental data. This method, which is based on the premise that "at least two measured values must contribute significantly to any proper evaluation," is not necessarily aimed to reducing $\chi^2/(N-1)$ for the data set. The method considers it unreasonable to use the weighted average as the recommended value for a *discrepant* set of *two* measurements. If the discrepancy

cannot be resolved, then equal weight should be given to each measurement, and thus the unweighted (or equally weighted) average is the recommended value.
As an extension to sets of data with three or more *discrepant* measurements, the method establishes that ***no single measurement should have a relative weight greater than 50%***. If such a measurement exists, the evaluator should increase its uncertainty to reduce the relative weight to 50%, before recalculating both a weighted average and $\chi^2/(N-1)$. If $\chi^2/(N-1) < 2$, then the weighted average is the recommended value. Otherwise the recommended value would be the weighted or the unweighted average, depending on whether the uncertainties in these average values allow them to overlap each other.

The *Limitation of Relative Statistical Weights* method was used in the "Co-ordinated Research Programme (CRP) on the Measurement and Evaluation of X- and Gamma-ray Standards for Detector Efficiency Calibration" by the IAEA Nuclear Data Section [3]. It has been extensively used at the National Physical Laboratory (NPL), Teddington, for the evaluation of half-lives [2,6], and at AEA Technology, Harwell, for the evaluation of half-life and gamma-ray emission probability data [7]. The USNDN Subcommittee on Formats and Procedures endorsed its recommendation in March 1996, and the international Decay Data Evaluation Project (DDEP) collaboration has already adopted it and is using it.

III. Available Software

We have developed, in collaboration with T.D. MacMahon, LWEIGHT, a computer program that uses the *Limitation of Relative Statistical Weights* method for calculating averages. The program, which identifies statistical outliers, calculates *recommended averages* and their *uncertainties* for several sets of input data. I am attaching a write-up of LWEIGHT.

References

1. M.U. Rajput and T.D. MacMahon, *Techniques for evaluating discrepant data*, Nucl. Instr. and Meth. in Phys. Res. **A312**, 289 (1992)
2. M.J. Woods and A.S. Munster, *Evaluation of Half-life Data*, NPL Report RS(EXT)95, February 1988
3. *X-ray and gamma-ray standards for detector calibration*, IAEA Report TECDOC-619, September 1991
4. D. De Soete, R. Gijbels and J. Hoste, *Neutron Activation Analysis*, p. 505 (Wiley, 1972)
5. W.L. Zijp, ECN-197, Petten, The Netherlands (1985)
6. M.J. Woods, S.E.M. Lucas, *Half-life of ^{90}Sr - measurement and critical review*, Nucl. Instr. and Meth. in Phys. Res. **A369**, 534 (1996)
7. A.L. Nichols, *Evaluation of activation product decay data*, Nucl.Instr. and Meth. in Phys. Res. **A369**, 516 (1996)

Review of alpha-decay data from doubly-even nuclei

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Abstract: Alpha-decay data from doubly-even nuclei throughout the periodic table are reviewed and evaluated. From these data, nuclear radius parameters are calculated by using the Preston formula for α-decay probabilities. The radius parameters for each element behave rather regularly as a function of neutron number. They show minima at the major closed shells, increase sharply for parents just above the closed shells, and decrease smoothly toward the next shell closure. The same trend is observed for α reduced widths calculated using the Rasmussen formalism. Any irregularity or large departure from this behavior indicates probable incorrect input data. This systematic behavior can also be utilized to estimate partial half-lives.

Alpha-hindrance factors, HF, defined as the ratios of experimental to theoretical partial half-lives of α transitions, are powerful tools in obtaining spectroscopic information about nuclear states. Various models have been introduced in order to understand the α-decay process and to calculate the penetrability of α particles through a barrier.

In one of the early models[1], a preformed α particle inside a nucleus was treated as being in a rectangular potential field with a depth of V_0 and an effective nuclear radius, $R=r_0 A^{1/3}$, where A is that of the daughter nucleus; for distances larger than this radius, the field is a Coulomb potential between α particle and daughter nucleus. The spin-independent part of the Preston equations[1] is used widely[2]. The nuclear radius parameter R (or r_0) for an even-even nuclide is determined by defining the calculated transition probability for an α transition from parent's ground state to ground state in the daughter nucleus to be equal to the experimental transition rate, that is HF≡1.0 for such a transition. In the calculation of hindrance factors for α transitions from odd and odd-odd nuclei, the radius parameters are chosen from the r_0 values for the neighboring even-even nuclei.

In a later model[3], nuclear-barrier penetration was calculated by using an optical-model potential derived from the analysis of α-particle scattering data. A centrifugal barrier was added to the nuclear potential to take *l* dependence into account.The α-decay rates are discussed in terms of reduced widths, defined by $\delta^2= \lambda h/P^2$ where P is the penetrability factor, λ is the decay constant and h is the Planck's constant. The Rasmussen formalism is used by many researchers[4].

With a better understanding of the nuclear potential and with the availability of faster computing capabilities, interest in exploring the α-decay process has increased recently. There are numerous excellent theoretical studies where absolute transition rates have been calculated for various nuclei[5]. These studies will not be reviewed here; the reader is referred to papers given in Ref.5 and the earlier references quoted in them.

The purpose of this study is to provide a tool for estimating half-lives and α-decay branchings for not-yet-discovered nuclei, as well as to provide evaluated α-decay data for even-even nuclei. In this study, the experimental α-transition rates and their hindrance factors for all known even-even α emitters are examined. For calculations of hindrance factors, experimental half-lives of parent nuclei, α-decay branchings, α energies and relative α intensities are needed. All available data[6] for these experimental quantities have been reviewed, evaluated and listed in Table 1. The nuclear radius parameters given in this table are calculated by using the Preston formula[1]. As mentioned above, for α transitions from odd and odd-odd nuclei the radius parameters obtained from these r_0 parameters are to be used in the computation of hindrance factors. A systematic study of hindrance factors for α transitions between various orbitals has been done previously and rules for hindrance factors were deduced[7].

The calculated radius parameters for all nuclides decrease gradually with increasing neutron number between closed shells; they reach minima at the N=126, the only major closed shell for α decaying nuclei, increase sharply just above this closed shell, and decrease again with increasing neutron number toward the next major shell with a slight minimum at the N=152 minor closed shell. A similar pattern has been observed[4] for α reduced widths for these s-wave α transitions.

The regular behavior of r_0 parameters (and δ^2's) is often utilized to calculate some unmeasured property of an observed α transition, such as its partial α half-life, or to predict some nuclear properties for yet unobserved α decays. In these cases, the r_0 parameter for a nucleus is obtained from the r_0 systematics by extrapolation or interpolation, and the desired properties are computed from this radius parameter. Examples below illustrate some of the methods used for (i) estimating the half-life of a nucleus; (ii) estimating branching ratio for α-decay; (iii) choosing the best half-life of a nucleus from various measured values.

- A 7428-keV α group following the ^{166}Er(^{36}Ar,xn) reaction was observed[8] and identified as decaying from neutron-deficient ^{196}Rn. The r_0 systematics suggests r_0=1.56±0.02, which leads to $T_{1/2}$(7428-keV α)=7±3 ms. The partial half-life of ^{196}Rn for β decay was estimated as ≈5 seconds from gross beta calculations[9]. These calculated partial half-lives predict that the α branching for ^{196}Rn is 99.9% and the β branching is ≈0.14%. The calculated half-life of 7 ms agrees well with the time difference of 5 ms measured between residues in ^{166}Er(^{36}Ar,xn) reaction and the α detection[8].
- In the decay of ^{228}Pu, only one α group with energy of 7810 keV has been observed[10]; its half-life has not been measured, and no other mode of decay has been detected. From a separate systematic study[7] of hindrance factors for α's to the first 2^+ states, the intensity of the 7810-keV α transition to the ground state of ^{224}U is deduced as 75%. From the radius parameter of r_0 =1.525±0.015, the partial half-life for α decay is calculated to be 0.28±0.10 seconds. Together with the partial half-life of 90 seconds for β decay[9], the total half-life and α and β decay branchings of ^{228}Pu are predicted to be $T_{1/2}$=0.28±0.10 seconds, 99.7% and 0.3%, respectively.

The r_0 values placed in parentheses in Table 1 are obtained from the systematics of radius parameters that are calculated in this work, and $T_{1/2}$ or α branchings listed in parentheses are the values computed using the corresponding r_0 values. It is hoped that this table will serve as a useful tool for analyzing new results and estimating the α-decay properties for nuclei in new regions to be studied.

The author is greatful to Mrs. Mary Ruth Lay for preparing the table and for editing the manuscript. The author wishes to thank Dr. Murray Martin for valuable discussions.

Table 1. Calculated r_0 parameters and the data used in calculations

Parent	Parent $T_{1/2}$	α-branching ratio	r_0(daughter) (10^{-13} cm)	Eα_0 (keV)	I α (per 100 α)
^{106}Te	60 μs *30*	1.0	1.70 4	4128 *9*	100
^{108}Te	2.1 s *1*	0.49 *4*	1.632 14	3318 *4*	100
^{110}Te	18.6 s *8*	(6.7×10^{-6})	(1.57 5)	2624 *15*	100
^{110}Xe	(0.05 *s)*	(0.87)	(1.70 6)	3745 *15*	100
^{112}Xe	2.7 s *8*	0.008	1.64 9	3211 *7*	100
^{144}Nd	2.29×10^{15} y *16*	1.0	1.596 9	1852.3 *18*	100
^{146}Sm	10.31×10^{7} y *45*	1.0	1.569 8	2455 *4*	100
^{148}Sm	8×10^{15} y *2*	1.0	1.57 2	1932.3 *12*	100
^{148}Gd	74.6 y *30*	1.0	1.570 3	3182.680 *24*	100
^{150}Gd	1.79×10^{6} y *8*	1.0	1.572 12	2734 *7*	100
^{150}Dy	7.17 m *5*	0.36 *5*	1.566 10	4235.1 *17*	100
^{152}Gd	1.08×10^{14} y *8*	1.0	1.574 7	2146.6 *15*	100
^{152}Dy	2.38 h *2*	0.00108 *11*	1.584 13	3628 *4*	100
^{152}Er	10.3 s *1*	0.91 *4*	1.567 4	4804.3 *16*	100
^{154}Dy	3.0×10^{6} y *15*	1.0	1.54 4	2870 *5*	100
^{154}Er	3.7 m *3*	0.0047 *13*	1.551 24	4168 *3*	100
^{154}Yb	0.409 s *2*	0.92 2	1.5570 25	5330.9 *17*	100
^{156}Yb	26 s *2*	0.10 2	1.596 19	4687 *4*	100
^{156}Hf	23 ms *1*	0.97 3	1.552 6	5873 *4*	100
^{158}Yb	1.60 m *10*	0.000021 *13*	1.52 6	4065 *8*	100
^{158}Hf	2.85 s 7	0.44 *3*	1.562 7	5267 *4*	100

Table 1. Calculated r_0 parameters and the data used in calculations

Parent	Parent $T_{1/2}$	α-branching ratio	r_0(daughter) (10^{-13} cm)		$E\alpha_0$ (keV)	I α (per 100 α)
^{158}W	0.9 ms *3*	1.0	1.581	36	6437 *30*	100
^{160}Hf	13.6 s *2*	0.007 *2*	1.548	20	4780 *3*	100
^{160}W	91 ms *5*	0.87 *8*	1.557	10	5912 *5*	100
^{162}Hf	39.8 s *4*	$7{\times}10^{-5}$ *1*	1.576	13	4308 *8*	(>99.5)
^{162}W	1.3 s *1*	0.46 *3*	1.569	9	5534 *3*	100
^{162}Os	1.7 ms *7*	0.998	1.563	33	6618 *10*	100
^{164}W	6.0 s *3*	0.038 *12*	1.567	24	5149.8 *23*	(>98.9)
^{164}Os	21 ms *1*	0.990 *10*	1.553	13	6321 *7*	100
^{166}W	18.8 s *4*	$3{\times}10^{-4}$ *1*	1.509	25	4739 *4*	(>98)
^{166}Os	220 ms *7*	0.72 *13*	1.558	16	5990 *6*	(>95.4)
^{166}Pt	0.3 ms *1*	1.0	1.551	28	7110 *15*	100
^{168}Os	2.1 s *1*	0.44 *4*	1.563	11	5676 *4*	(>94)
^{168}Pt	2.0 ms *4*	1.0	1.554	17	6832 *10*	100
^{170}Os	8.1 s *10*	0.085 *34*	1.550	37	5407 *4*	(97 *3*)
^{170}Pt	14.7 ms *5*	(0.993 *3*)	1.562	9	6548 *6*	100
^{172}Os	19.2 s *9*	0.011 *2*	1.569	20	5105 *10*	(95 *5*)
^{172}Pt	0.096 s *3*	0.94 *6*	1.558	8	6314 *4*	(98 *2*)
^{174}Hf	$2.0{\times}10^{15}$ y *4*	1.0	1.55	2	2437.4 *25*	(99.9 *1*)
^{174}Os	44 s *4*	0.00020 *10*	1.53	4	4760 *10*	(>88.5)
^{174}Pt	0.90 s *1*	0.67 *6*	1.546	11	6038 *4*	(>96.5)
^{176}Pt	7.5 s *35*	0.40 *3*	1.551	24	5751.2 *20*	99.74 *13*
^{176}Hg	18 ms *10*	(0.986 *14*)	1.55	3	6767 *10*	(>98)
^{178}Pt	21.1 s *20*	0.046 *31*	1.544	30	5446 *3*	97.3 *24*
^{178}Hg	266 ms *25*	0.95 *+5-26*	1.545	10	6430 *6*	(98 *2*)
^{180}Pt	52 s *3*	0.0030 *15*	1.53	4	5140 *10*	(92 *8*)
^{180}Hg	2.56 s *2*	0.48 *5*	1.533	8	6119 *5*	99.87 *3*
^{180}Pb	4 ms *+4-2*	1.0	1.53	5	7230 *40*	100
^{182}Pt	3.0 m *2*	0.00031 *7*	1.533	26	4843 *5*	(>83)
^{182}Hg	10.83 s *6*	0.152 *8*	1.522	5	5866 *5*	98.94 *11*
^{182}Pb	55 ms *40*	1.0	1.51	6	6920 *10*	(>88.6)
^{184}Pt	17.3 m *2*	$1.7{\times}10^{-5}$ *7*	1.536	31	4502 *10*	(>87.8)
^{184}Hg	30.6 s *3*	0.0126 *20*	1.512	11	5535 *15*	99.44 *10*
^{184}Pb	0.55 s *6*	(>0.89)	1.505	13	6628 *6*	(>82.4)
^{186}Os	$2.0{\times}10^{15}$y *11*	1.0	1.49	3	2761.3 *17*	(>95)
^{186}Pt	2.2 h *2*	$1.4{\times}10^{-6}$	1.49	3	4230 *20*	(94 *6*)
^{186}Hg	1.38 m *7*	$1.8{\times}10^{-4}$ *5*	1.504	27	5094 *15*	(94 *6*)
^{186}Pb	4.83 s *5*	(0.55 17)	(1.50	2)	6332 *7*	98.0 *18*
^{188}Pt	10.2 d *3*	$2.9{\times}10^{-7}$ *5*	1.470	17	3922 *5*	(95 *5*)
^{188}Hg	3.25 m *15*	$4.0{\times}10^{-7}$ *8*	1.481	28	4610 *20*	(96 *4*)
^{188}Pb	24 s *2*	0.10 *5*	1.498	39	5983 *5*	99 *1*

Table 1. Calculated r_0 parameters and the data used in calculations

Parent	Parent $T_{1/2}$	α-branching ratio	r_0(daughter) (10^{-13} cm)		$E\alpha_0$ (keV)	I α (per 100 α)
^{190}Pt	6.5×10^{11} y *3*	1.0	1.474	10	3180 *6*	(98.5 *15*)
^{190}Pb	1.2 m *1*	0.0021 *7*	1.462	25	5581 *4*	99.90 *2*
^{190}Po	2.0 ms *+5-10*	0.9987 *13*	1.54	4	7482 *20*	(99.5 *5*)
^{192}Pb	3.5 m *1*	5.9×10^{-5} *6*	1.500	9	5112 *5*	(99.8 *2*)
^{192}Po	0.034 s *3*	0.995 *5*	1.511	8	7167 *7*	(99.6 *4*)
^{194}Pb	12.0 m *5*	7.3×10^{-8} *29*	1.432	23	4640 *20*	(99.9 *1*)
^{194}Po	0.392 s *4*	0.93 *7*	1.511	6	6842 *6*	99.71 *6*
^{196}Po	5.8 s *2*	0.94 *5*	1.511	6	6520 *3*	99.978 *13*
^{198}Po	1.76 m *3*	0.57 *2*	1.4965	34	6182.0 *22*	99.9987 *3*
^{198}Rn	57 ms *9*	0.994 *6*	1.551	10	7205 *5*	99.93 *2*
^{200}Po	11.5 m *1*	0.111 *3*	1.4803	26	5861.9 *18*	100
^{200}Rn	1.06 s *2*	0.86 *14*	1.516	9	6902.4 *25*	99.986 *3*
^{202}Po	44.7 m *5*	0.0192 *7*	1.4719	31	5588.1 *17*	100
^{202}Rn	9.85 s *20*	0.90 *10*	1.517	7	6639.5 *19*	99.9982 *6*
^{202}Ra	0.7 ms *+33-3*	1.0	1.60	+5-10	7860 *60*	100
^{204}Po	3.53 h *2*	0.0066 *1*	1.4617	17	5377.1 *12*	100
^{204}Rn	1.24 m *3*	0.73 *1*	1.5035	26	6418.9 *25*	100
^{204}Ra	45 ms *+55-21*	(0.997 *3*)	1.533	4	7488 *12*	(99 *1*)
^{206}Po	8.8 d *1*	0.0545 *5*	1.4550	17	5223.7 *15*	100
^{206}Rn	5.67 m *17*	0.63 *6*	1.492	7	6260.6 *25*	(99.96 *4*)
^{206}Ra	0.24 s *2*	(0.97 *3*)	1.527	8	7272 *5*	(99.2 *8*)
^{208}Po	2.898 y *2*	0.999958 *4*	1.4296	8	5114.9 *14*	99.99976 *7*
^{208}Rn	24.35 m *14*	0.62 *7*	1.476	6	6140.1 *17*	99.953 *4*
^{208}Ra	1.3 s *2*	(0.95 *5*)	1.495	14	7133 *5*	(99.5 *5*)
^{210}Pb	22.3 y *3*	1.9×10^{-8} *8*	1.449	42	3720 *20*	100
^{210}Po	138.4 d *1*	1.0	1.40882	10	5304.33 *7*	99.99879 *4*
^{210}Rn	2.4 h *1*	0.96 *1*	1.4571	33	6041 *3*	99.9944 *3*
^{210}Ra	3.7 s *2*	(0.96 *4*)	1.487	6	7019 *5*	(99.7 *3*)
^{212}Po	0.299 μs *2*	1.0	1.5212	4	8784.86 *12*	100
^{212}Rn	23.9 m *12*	1.0	1.4343	34	6264 *3*	99.950 *5*
^{212}Ra	13.0 s *2*	(0.85 *15*)	1.467	10	6899.2 *17*	(99.85 *15*)
^{212}Th	30 ms *+20-10*	(0.997 *3*)	1.510	27	7802 *10*	(98.8 *12*)
^{214}Po	164.3 μs *20*	1.0	1.5394	6	7686.82 *7*	99.9895 *6*
^{214}Rn	0.27 μs *2*	1.0	1.532	6	9036 *9*	(99.95 *5*)
^{214}Ra	2.46 s *3*	0.99941 *4*	1.4552	21	7137 *3*	(99.81 *19*)
^{214}Th	100 ms *25*	(0.999 *1*)	1.492	16	7678 *10*	(99.5 *5*)
^{216}Po	0.145 s *2*	1.0	1.5408	9	6778.3 *5*	99.9981 *3*
^{216}Rn	45 μs *5*	1.0	1.5649	8	8050 *10*	(99.6 *4*)
^{216}Ra	182 ns *10*	1.0	1.541	5	9349 *8*	(99.97 *3*)
^{216}Th	0.028 s *2*	1.0	1.466	6	7921 *8*	(99.5 *5*)

Table 1. Calculated r_0 parameters and the data used in calculations

Parent	Parent $T_{1/2}$	α-branching ratio	r_0(daughter) (10^{-13} cm)		$E\alpha_0$ (keV)	I α (per 100 α)
^{218}Po	3.10 m *2*	0.99980 *2*	1.5379	7	6002.35 *9*	99.9989 *11*
^{218}Rn	35 ms *5*	1.0	1.559	8	7129.2 *12*	99.87 *1*
^{218}Ra	25.6 μs *11*	1.0	1.563	4	8389 *6*	(99.5 *5*)
^{218}Th	109 ns *11*	1.0	1.554	9	9666 *10*	100
^{218}U	1.5 ms *+73-7*	1.0	1.46	+4-9	8625 *25*	(99.1 *9*)
^{220}Rn	55.6 s *1*	1.0	1.5555	2	6288.08 *10*	99.89 *2*
^{220}Ra	17 ms *2*	1.0	1.556	8	7457 *7*	99.0 *4*
^{220}Th	9.7 μs *6*	1.0	1.566	9	8790 *20*	(99.3 *7*)
^{222}Rn	3.8235 d *3*	1.0	1.5487	2	5489.52 *30*	99.92 *1*
^{222}Ra	38.0 s *5*	1.0	1.5423	23	6559 *5*	96.9 *1*
^{222}Th	2.8 ms *3*	1.0	1.539	8	7982 *8*	97 1
^{224}Ra	3.66 d *4*	1.0	1.5419	6	5685.37 *15*	94.91 *7*
^{224}Th	1.05 s *2*	1.0	1.536	5	7170 *10*	79 *2*
^{224}U	0.7 ms *+5-2*	1.0	1.527	30	8466 *12*	(96 *4*)
^{226}Ra	1600 y *7*	1.0	1.5397	4	4784.34 *25*	94.45 *5*
^{226}Th	30.57 m *10*	1.0	1.5385	8	6336.8 *10*	75.5 *3*
^{226}U	0.30 s *10*	1.0	1.529	18	7570 *20*	85 *5*
^{228}Th	1.912 y *2*	1.0	1.5332	8	5423.15 *22*	72.2 *11*
^{228}U	9.1 m *2*	0.975 *25*	1.524	9	6680 *10*	70 *5*
^{230}Th	7.538×10^{4} y *30*	1.0	1.5331	13	4687.0 *15*	76.3 *3*
^{230}U	20.8 d *21*	1.0	1.531	5	5888.4 *7*	67.4 *4*
^{232}Th	1.40×10^{10} y *1*	1.0	1.5361	22	4012.3 *14*	78.2 *13*
^{232}U	68.9 y *4*	1.0	1.5288	6	5319.23 *14*	68.0 *4*
^{234}U	2.455×10^{5} y *6*	1.0	1.5216	5	4774.6 *14*	71.38 *16*
^{234}Pu	8.8 h *1*	0.06 *3*	1.518	39	6202	68
^{236}U	2.342×10^{7} y *3*	1.0	1.527	3	4493.5 *21*	74 *4*
^{236}Pu	2.858 y *8*	1.0	1.5103	3	5767.53 *8*	69.14 *33*
^{238}U	4.468×10^{9} y *3*	1.0	1.536	3	4198 *3*	79.0 *27*
^{238}Pu	87.7 y *1*	1.0	1.5075	2	5499.03 *20*	70.91 *10*
^{240}Pu	6563 y *7*	1.0	1.5168	3	5168.13 *15*	73.51 *36*
^{240}Cm	27 d *1*	0.997 *3*	1.4949	18	6290.5 *5*	71.1 *5*
^{242}Pu	3.75×10^{5} y *2*	1.0	1.5143	9	4902.3 *14*	76.45 *17*
^{242}Cm	162.8 d *2*	1.0	1.5013	10	6112.72 *8*	74.1 *17*
^{244}Pu	8.00×10^{7} y *9*	0.99879 *4*	1.5062	10	4589 *1*	80.6 *8*
^{244}Cm	18.1 y *1*	1.0	1.4979	7	5804.77 *5*	76.4 *12*
^{244}Cf	19.4 m *6*	1.0	1.5103	25	7209 *4*	75 *3*
^{246}Cm	4.76×10^{3} y *4*	0.999737 *4*	1.4946	10	5385.7 *9*	80.7 *11*
^{246}Cf	35.7 h *5*	0.999996 *2*	1.4953	9	6750.0 *10*	79.3 *10*
^{248}Cm	3.48×10^{5} y *6*	0.9161 *16*	1.4963	8	5078.41 *25*	81.9 *4*
^{248}Cf	333.5 d *28*	0.999971 *3*	1.4851	24	6258 *5*	80.0 *10*

Table 1. Calculated r_0 parameters and the data used in calculations

Parent	Parent $T_{1/2}$	α-branching ratio	r_0(daughter) (10^{-13} cm)		$E\alpha_0$ (keV)	I α (per 100 α)
^{248}Fm	36 s *3*	0.93 *7*	1.490	13	7870 *20*	80 *20*
^{250}Cf	13.08 y *9*	0.99923 *3*	1.4836	5	6030.22 *20*	84.7 *6*
^{252}Cf	2.645 y *8*	0.96908 *8*	1.50126	20	6118.10 *4*	84.3 *3*
^{252}Fm	25.39 h *5*	0.999977 *2*	1.4670	8	7039 *2*	84.0 *5*
^{252}No	2.27 s *18*	0.731 *19*	1.490	5	8415 *6*	83.6 *20*
^{254}Cf	60.5 d *2*	0.00310 *16*	1.517	4	5833 *5*	83 *1*
^{254}Fm	3.240 h *2*	0.999408 *2*	1.4888	8	7192.1 *17*	85.0 *5*
^{254}No	54 s *6*	0.90 *4*	1.465	7	8093 *14*	86 *2*
^{256}Fm	157.6 m *13*	0.081 *3*	1.500	3	6917 *5*	87.6 *12*
^{256}No	2.91 s *5*	0.9950 *6*	1.4765	19	8448 *6*	87 *2*

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Systematics of E4 (0_1^+ to 4_1^+) transitions in even-even nuclides

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For even-even nuclides, while BE2 and BE3 systematics have been compiled extensively (see Raman et al., ADNDT 36, 1 (1987) for BE2 and Spear, ADNDT 42, 55 (1989) for BE3), the data for BE4 have only been partially presented by Endt, ADNDT 55, 171 (1993), ibid 26, 47 (1981), ibid 23, 547 (1979), ibid 23, 3 (1979). This report presents a compilation of BE4 values from first 0^+ (ground state) to first 4^+ state.

First 4^+ states in even-even nuclides:

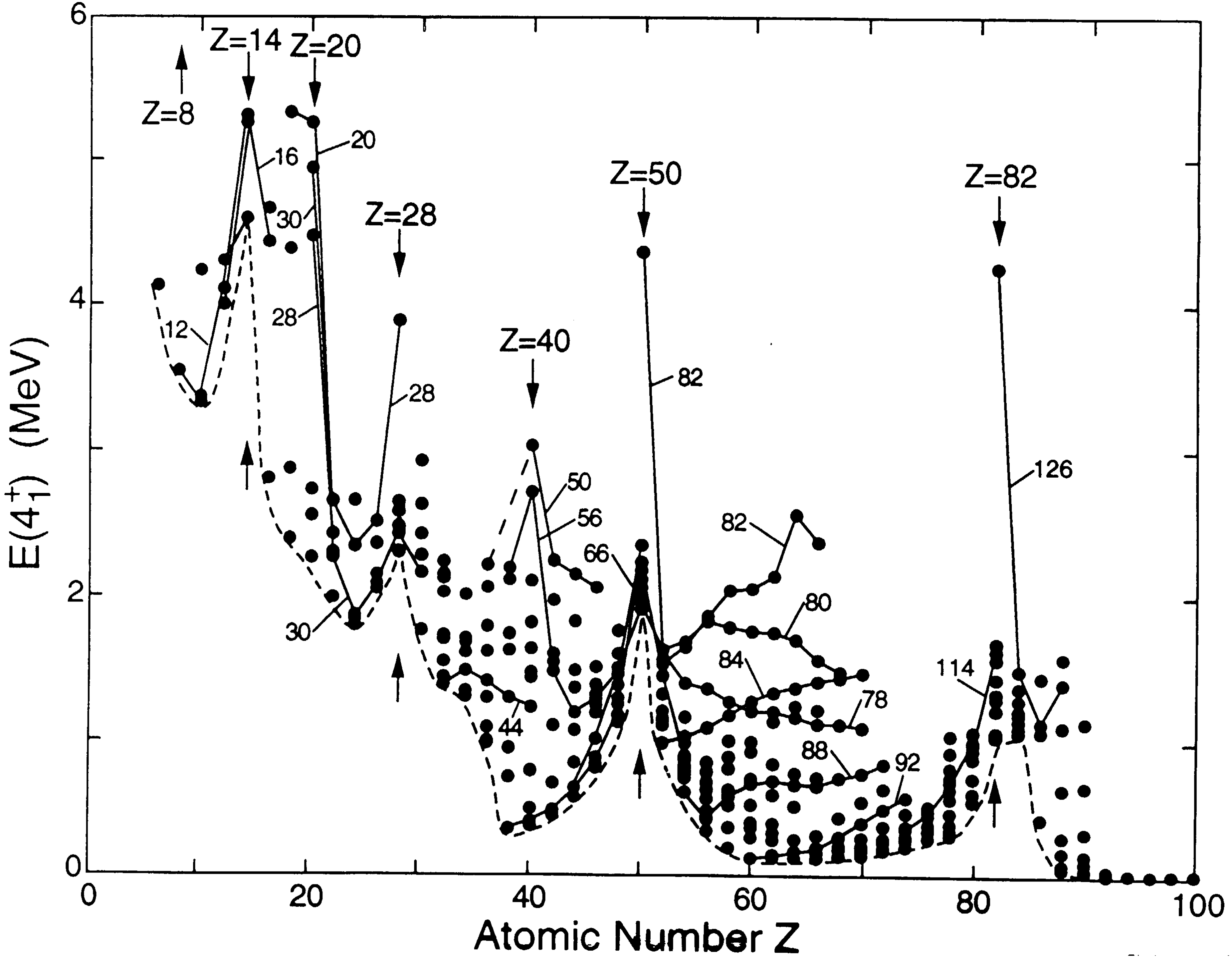
According to ENSDF retrieval:
~ 430 known states
Based on information from ENSDF and literature:
BE4 data available for ~ 110 cases

Methods:
Model-independent:
(e,e') : 49
Coul. Ex. : 28 (total ~50)
Lifetime and Gamma-ray branching: 2 (total 4)

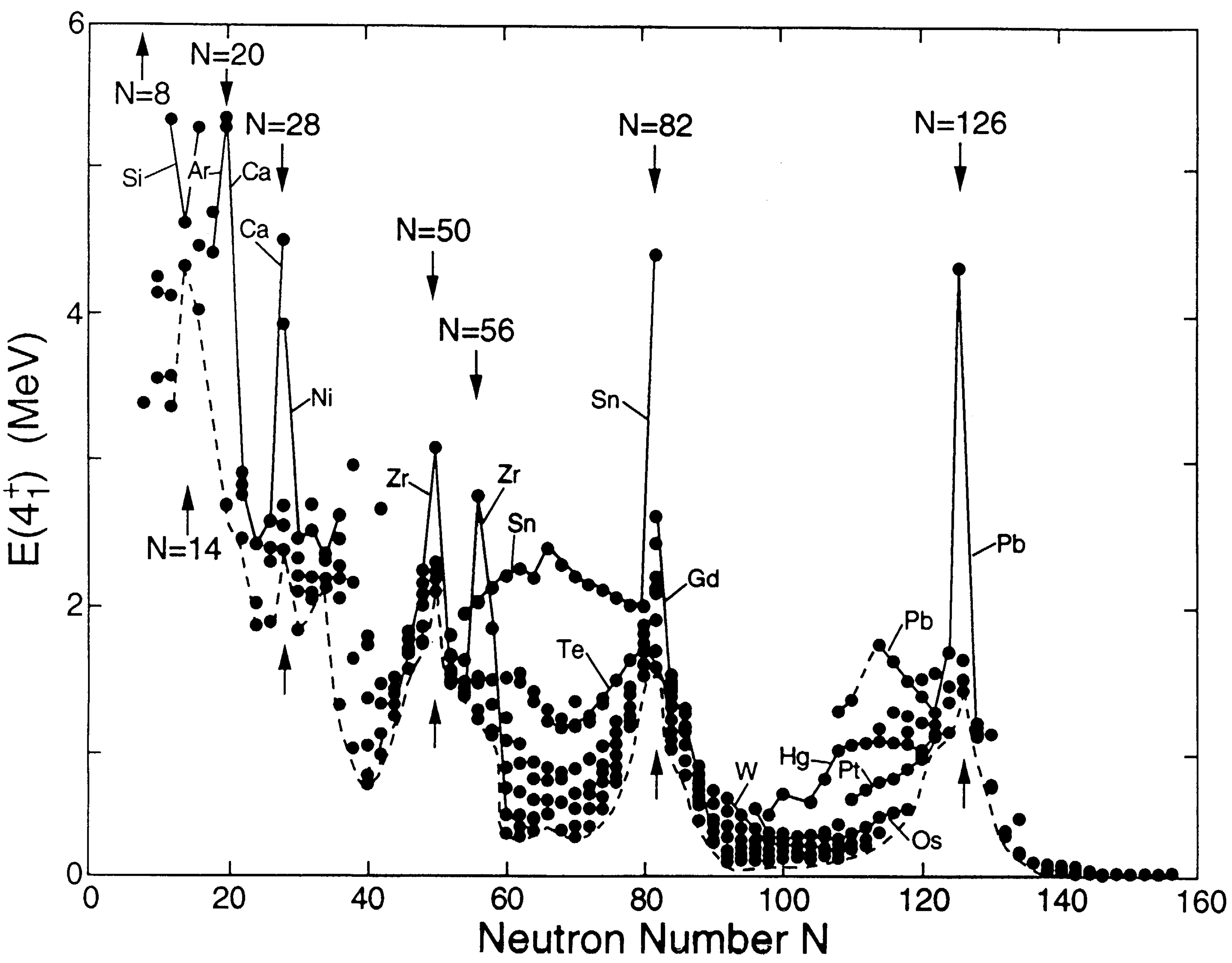
Model dependent:
(p,p'): 18
(Alpha,alpha'): 10
(pi,pi'): 2

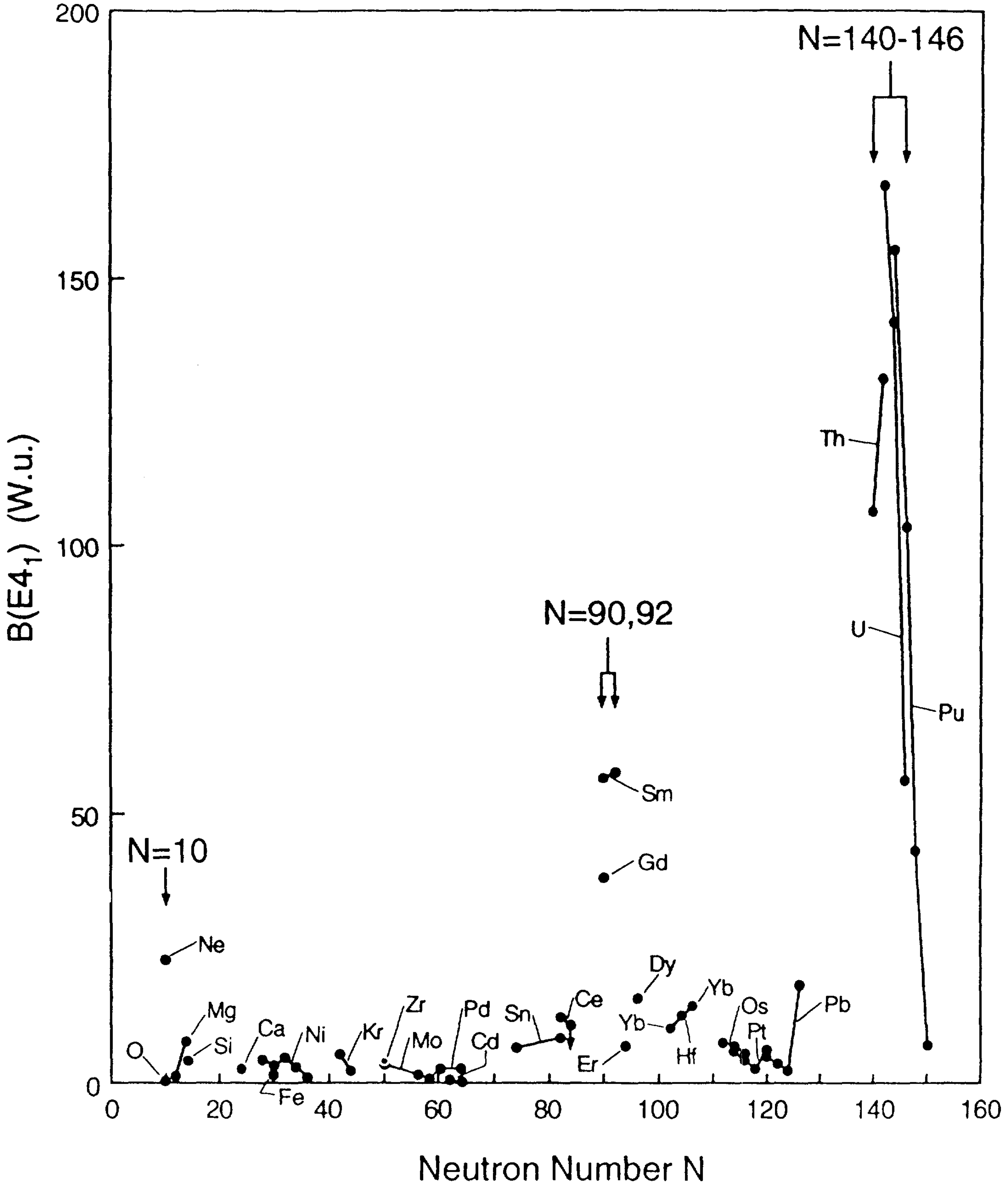
BE2 (0^+ to 2^+): known for ~ 280 nuclide
BE3 (0^+ to 3^-): known for ~150 nuclides
BE2 and BE3 from mainly model-independent methods

The following figures present the data in a graphical format for energies and associated BE4 values of first 4+ states as a function of proton and neutron number. The detailed tables list the BE4 values (in s.p.u.) scanned from the literature.

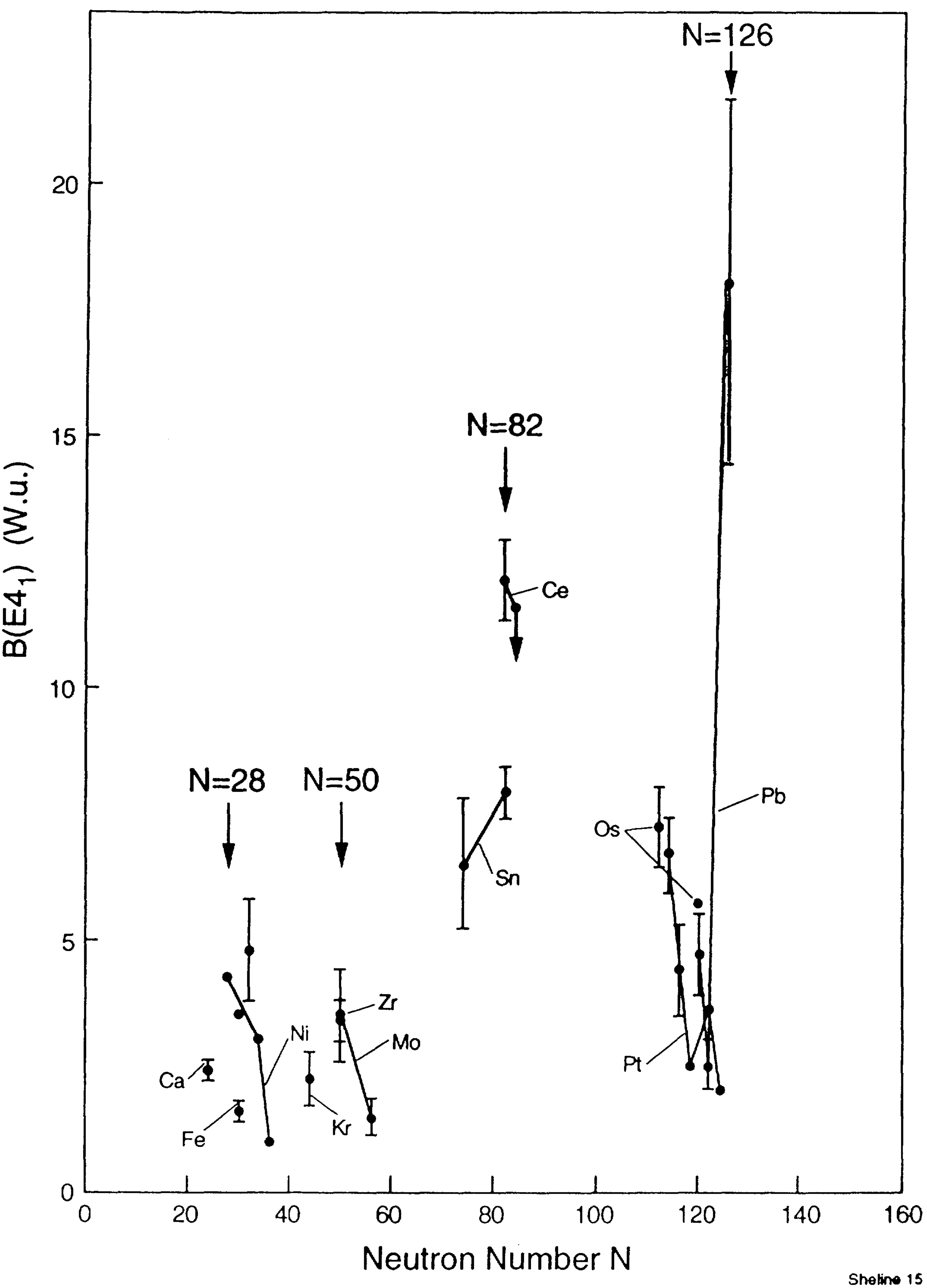


Z=8
Z=14
Z=20
Z=28
Z=40
Z=50
Z=82
12
16
20
28
30
28
30
50
56
44
66
82
82
80
84
78
88
92
114
126
E(4_1^+) (MeV)
0
2
4
6
0
20
40
60
80
100
Atomic Number Z


N=8
N=20
N=28
N=14
N=50
N=56
N=82
N=126
Si
Ar
Ca
Ca
Ni
Zr
Zr
Sn
Sn
Te
Gd
W
Hg
Pt
Os
Pb
Pb
E(4_1^+) (MeV)
Neutron Number N
0
2
4
6
0
20
40
60
80
100
120
140
160



Sheline 14 17GM



Sheline 15 17GM

BE4(W.u.) values for first 4+ states in even-even nuclides

Nucleus	Z	N	Energy	BE4(W.u.)	Method	Reference
16O	8	8	10356	3.6 13	(e,e')	73Be49
18O	8	10	3554.8	0.77 8	(e,e')	91Ma14
				0.72 7	(e,e')	82No04
20Ne	10	10	4247.7	23 5	(e,e')	73Si31
				37 8	(e,e')	71Ho20
				25.5 4	(pi,pi')	95Bu01
					(A,A')	71Re09
					(p,p')	69De15
24Mg	12	12	4122.9	0.97 14	(e,e')	78Za07
				< 0.1	(e,e')	72Na06, 71Ho20
					(p,p')	69De15
28Si	14	14	4617.9	4.4 5	(e,e')	72Na06, 71Ho20
					(A,A')	71Re09
					(p,p')	69De15
36S	16	20	6514.4		(A,A')	90Ho19
					(p,p')	90Ho19
42Ca	20	22	2752.4	2.9 4	(A,A')	67Li13
44Ca	20	24	2283.1	2.7 2	(e,e')	71He08
				1.3 3	(A,A')	67Li13
46Ti	22	24	2009.8	7.6 3	(e,e')	71He08
				0.6	(A,A')	74Re01
				340 260	(T1/2,%Ig)	
					(p,p')	87Fu03, 68Pe10
48Ti	22	26	2295.6	3.4 2	(e,e')	71He08
				3.0 10,2.3 6	(pi,pi')	88Oa01
					(p,p')	89Hi05
50Ti	22	28	2674.9	4.7 2	(e,e')	71He08
				2.8 8	(pi,pi')	87Oa01
				3.3 7	(A,A')	67Yn01
				0.5	(A,A')	70Br07
					(A,A')	74Re01
50Cr	24	26	1881.3	2.4	(e,e')	83Li02
52Cr	24	28	2369.6	4.7	(e,e')	83Li02
				3.2 6	(e,e')	64Be32
				3.1 5	(pi,pi')	87Oa01
				1.5 2	(A,A')	66Pe16
				0.36	(A,A')	70Br07
					(p,p')	85Fu10, 69Pe02
54Cr	24	30	1823.9	7.1	(e,e')	83Li02
54Fe	26	28	2538.1	3.9 7	(pi,pi')	87Oa01
				1.4 3	(pi,pi')	87Oa01
				2.5 4	(A,A')	66Pe16
				0.5	(A,A')	70Br07
					(p,p')	85Fu10, 80Ad03, 70Ma46
					(n,n')	86Me01

56Fe	26	30	2085.1	1.0 4	(pi,pi')	87Oa01
				0.4 3	(pi,pi')	87Oa01
				1.7 2	(A,A')	75Gi04
					(p,p')	69Pe02
					(d,d')	68Ma36
					(n,n')	86Me01
58Ni	28	30	2459.1	3.5 11	(e,e')	61Cr01
				4.5 10	(A,A')	67Ja08
				3.5 2	(p,p')	69Gr17
					(p,p')	88Fu03
60Ni	28	32	2505.7	4.8 10	(e,e')	69To08
				5.8 10	(e,e')	61Cr01
				5.5 8	(A,A')	78Fa03
				3.9 3	(p,p')	69Gr17
					(p,p')	89Va02
					(A,A')	87Ba78, 85Al24
					(d,d')	74Ba74
62Ni	28	34	2336.3	3.0 3	(p,p')	69Gr17
				4.1	(p,p')	69Be20
				1.7	(A,A')	70Br07
					(d,d')	74Ba74
64Ni	28	36	2609	6.0 2	(e,e')	88Br10
				1.0	(A,A')	87Ba78
				1.6	(A,A')	85Al24
				0.85	(A,A')	70Br07
				2.8	(p,p')	69Be20
					(d,d')	74Ba74
64Zn	30	34	2306.7	0.9 3	(e,e')	77Ne05
					(p,p')	68Jo16
70Ge	32	38	2153.5	0.6	(A,A')	87Sc31
					(A,A')	89Ro12
					(p,p')	93Mo05
72Ge	32	40	1728.3	1.6	(A,A')	87Sc31
					(A,A')	89Ro12
					(p,p')	93Mo05
74Ge	32	42	1463.8		(A,A')	89Ro12
					(p,p')	82Ta16, 93Mo05
76Ge	32	44	1410.1	1.1	(A,A')	87Sc31
					(p,p')	93Mo05, 83Ra32
74Se	34	40	1363.2		(p,p')	86Og01, 83Ma59
76Se	34	42	1330.9		(p,p')	93Mo05, 86Og01, 84De01, 83Ma59
					(n,n')	84Ku09
78Se	34	44	1502.8		(p,p')	86Og01, 83Ma59, 93Mo05, 84De01
					(A,A')	88Ba35
80Se	34	46	1701.2		(A,A')	88Ba35
					(p,p')	86Og01, 84De01, 83Ma59, 93Mo05
82Se	34	48	1735.1		(p,p')	86Og01, 83Ma59, 84De01

78Kr	36	42	1119.5	5.5 11	(p,p′)	79Sa14
80Kr	36	44	1436.0	2.3 5	(p,p′)	79Sa14
82Kr	36	46	1820.5	1.5 3	(p,p′)	79Sa14
84Kr	36	48	2094.9	2.9	(p,p′)	79Sa14
				1.8	(p,p′)	74Ar29
86Kr	36	50	2249	4.2	(p,p′)	79Sa14
				2.7	(p,p′)	74Ar29
86Sr	38	48	2229.7	1.1 1	(e,e′)	92Ki20
88Sr	38	50	4299.6		(p,p′)	78KaZV
90Zr	40	50	3076.9	3.4 9	(e,e′)	84He02
				5.6	(A,A′)	86La18
				1.6 2	(A,A′)	68Ma30
92Zr	40	52	1495.5	4.7 7	(A,A′)	68Be.A
				6.6	(A,A′)	86Si17
					(d,d′)	92Se02
					(p,p′)	66St15
94Zr	40	54	1469.6	6.1	(A,A′)	86Si17
					(d,d′)	86Fr24
					(p,p′)	68Di05, 66St15
96Zr	40	56	2857.4	4.8	(A,A′)	86La18
					(p,p′)	66St15
92Mo	42	50	2282.6	2.7 8	(e,e′)	90Mi07
				2.7 8	(A,A′)	75Bu04
				3.0 3	(A,A′)	68Ma30
					(p,p′)	75Bu04, 71Lu07
94Mo	42	52	1573.7	14 2	(p,p′)	92Pi08
				7 2	(A,A′)	75Bu04
					(p,p′)	87Fr07, 71Lu07
					(d,d′)	92Pi08, 78Wa11
96Mo	42	54	1628.2	2.7 8	(A,A′)	75Bu04
					(p,p′)	87Fr07, 71Lu07
					(d,d′)	78Wa11
98Mo	42	56	1510.0	1.5 4	(p,p′)	92Pi08
				1.6 5	(A,A′)	75Bu04
					(d,d′)	92Pi08, 77Pe18, 78Wa11
100Mo	42	58	1136.1	1.0 2	(p,p′)	92Pi08
					(p,p′)	87Fr07
					(d,d′)	92Pi08, 78Wa11
104Pd	46	58	1323.6	1.3 2	(e,e′)	91We15
				0.28 10	(p,p′)	92Pi08
					(A,A′)	92Ri02
					(d,d′)	92Pi08
106Pd	46	60	1229.2	1.8 4	(e,e′)	91We15
				1.8 5	(p,p′)	92Pi08
					(A,A′)	92Ri02
					(d,d′)	92Pi08
108Pd	46	62	1048.2	2.6 5	(e,e′)	91We15
				0.77	(A,A′)	92Ne07

					(p,p')	75Ko12
110Pd	46	64	920.7	3.3 5	(e,e')	91We15
				2.7 6	(p,p')	92Pi08
					(A,A')	92Ri02
					(d,d')	92Pi08
106Cd	48	58	1493.8		(p,p')	94Pe23, 69Lu02
108Cd	48	60	1508.4		(p,p')	94Pe23
110Cd	48	62	1542.4	0.2 2	(e,e')	91We15
				0.16 4	(p,p')	92Pi08
					(p,p')	94Pe23, 69Lu02
					(d,d')	92Pi08
112Cd	48	64	1415.4	0.09 1	(p,p')	92Pi08
				0.7 3	(d,d')	94He22
				0.8 2	(p,p')	89De40
					(p,p')	94Pe23, 69Lu02
					(d,d')	92Pi08
114Cd	48	66	1283.7		(p,p')	94Pe23, 69Lu02
116Cd	48	68	1219.4		(p,p')	69Lu02
112Sn	50	62	2247.6		(p,p')	80Bl01
116Sn	50	66	2390.9	4.1	(p,p')	70Be20
					(p,p')	83Wi07
118Sn	50	68	2280.3	1.7 2	(e,e')	92Wi06
				2.3	(p,p')	70Be20
120Sn	50	70	2194.5	1.9	(p,p')	70Be20
122Sn	50	72	2142.1	3.5	(p,p')	70Be20
124Sn	50	74	2101.6	6.5 14	(e,e')	67Ba52
				4.9	(p,p')	70Be20
132Sn	50	82	4415.6	7.9 5	(T1/2,%Ig)	94Fo14
136Xe	54	82	1694.4		(p,p')	72Se17
134Ba	56	78	1400.6	1.7 2	(Coul. Ex.)	85Bu01
138Ba	56	82	1898.6	3.6	(A,A')	72Ba98
				4.1	(p,p')	74La06
140Ce	58	82	2083.2	11.4 13	(e,e')	92Ki10
				12.1 8	(T1/2,%Ig)	
				21 4	(e,e')	70Pi06
				7.8, 6.8	(A,A')	72Ba02
				6.9	(p,p')	77Sh06
142Ce	58	84	1219.4	7.9 8	(e,e')	91Ki13
				< 12	(Coul. Ex.)	88Ve08
142Nd	60	82	2101.3	13.2	(e,e')	91Sa27
				15.9 9	(p,p'),(d,d')	93Pi06
				8 2	(p,p')	89Tr03
144Nd	60	84	1314.5	6.0 8	(e,e')	93Pe10
				11 1	(p,p'),(d,d')	93Pi06
					(p,p')	91Co01

146Nd	60	86	1043.2	4.5 8	(e,e')	93Sa07
				6.1 3	(p,p'),(d,d')	93Pi06
148Nd	60	88	752.2	8.2 1	(p,p'),(d,d')	93Pi06
150Nd	60	90	381.5	40 3	(e,e')	93Sa06
				25 11	(Coul. Ex.)	77Wo02
				34 3	(p,p'),(d,d')	93Pi06
				47	(p,p')	88Wu01
144Sm	62	82	2190.8	10.4	(p,p')	93Mu06
				5.8	(p,p')	74La06
				4.9	(p,p')	71Ba80
					(3He,3He')	79Pa08
150Sm	62	88	773.2		(p,p')	93Pe16
					(3He,3He')	79Pa08
152Sm	62	90	366.5	56 3	(e,e')	77Na01, 78Ca18
				36 3	(e,e')	76Co08, 78Ca18
				56 11	(Coul. Ex.)	77Fi01
				37 14	(Coul. Ex.)	74Sh12
				120	(A,A')	89Ob02
				106	(p,p')	93Pe16
				63 4	(p,p')	87Ic04
				40	(d,d')	83Ha16
				59	(3He,3He')	79Pa08
154Sm	62	92	266.8	57 3	(e,e')	76Co08
				60 21	(e,e')	77HoZf
				102 16	(Coul. Ex.)	77Fi01
				99 20	(Coul. Ex.)	83Ro11
				72	(A,A')	87Ic04
				65	(p,p')	93Pe16
				89 5	(p,p')	87Ic04
				79	(d,d')	83Ha16
				90	(n,n')	83La10
					(3He,3He')	79Pa08
148Gd	64	84	1416.4	7.9	(p,p')	90De22
154Gd	64	90	371.0	38 3	(e,e')	86He09
				73 19	(Coul. Ex.)	77Sc33
				107 24	(Coul. Ex.)	77Wo02
156Gd	64	92	288.2	58 7	(Coul. Ex.)	77Ro08
				64 10	(Coul. Ex.)	77Fi01
				6.2	(p,p')	81Go13
158Gd	64	94	261.4	28 +42-25	(Coul. Ex.)	77Ro26
				37 24	(Coul. Ex.)	74Wo01
					(A,A')	68He24
160Gd	64	96	248.5	29 13	(Coul. Ex.)	77Ro26
				18 12	(Coul. Ex.)	74Sh12
				62 5	(p,p')	87Ic04
156Dy	66	90	404.2	11 +23-11	(Coul. Ex.)	77Ro27
158Dy	66	92	317.3	6 +10-6	(Coul. Ex.)	77Ro27
162Dy	66	96	265.7	16 11	(Coul. Ex.)	72Er04
164Dy	66	98	242.2	12 +12-9	(Coul. Ex.)	74Wo01
				14 12	(Coul. Ex.)	74Sh12

				22 5	(p,p')	87Ic04
162Er	68	94	329.6	6 +18-6	(Coul. Ex.)	77Ro27
164Er	68	96	299.4	3 +9-3	(Coul. Ex.)	77Ro27
166Er	68	98	265.0	19	(e,e')	76Co08
				17	(e,e')	77Cr.A
				12 7	(Coul. Ex.)	77Fi01
				21 +21-19	(Coul. Ex.)	75Le22
				10 +12-9	(Coul. Ex.)	74Wo01
				24 7	(A,A')	92Ka07
				15 5	(p,p')	92Ka07
				13 2	(p,p')	84Ic01
				21 8	(p,p')	83Ro11
168ER	68	100	264.1	2 +8-2	(Coul. Ex.)	74Le16
				7 +17-7	(Coul. Ex.)	74Sh12
				8 +12-8	(Coul. Ex.)	72Er04
				0.8 6	(A,A')	86Go02
				< 3	(A,A')	92Ne07
				6 +5-3	(A,A')	75Le22
				8 3	(p,p')	84Ic01
170Er	68	102	260.1	11 +16-11	(Coul. Ex.)	72Er04
168Yb	70	98	286.6	7 +14-7	(Coul. Ex.)	77Ro27
172Yb	70	102	260.3	9 +12-9	(Coul. Ex.)	75Wo08
				< 2	(A,A')	87Go29
174Yb	70	104	253.1	1.9	(e,e')	79Sa.A
				8 +14-8	(Coul. Ex.)	75Wo08
				3 +13-3	(Coul. Ex.)	74Sh12
				10 +19-9	(Coul. Ex.)	73GrXL
				1.8	(A,A')	68He24
				< 0.6	(p,p')	84Ic01
176Yb	70	106	271.7	1.7	(e,e')	76Co08
				2.3, 14	(e,e')	77Cr.A
				14 +14-13	(Coul. Ex.)	79Ri13,75Wo08
				< 0.9	(A,A')	92Ka07
				0.3	(A,A')	70Ap03
				1.8 11	(p,p')	92Ka07
				< 0.35	(p,p')	92Pe02
				0.9 5	(p,p')	84Ic01
176Hf	72	104	290.2	12 +14-9	(Coul. Ex.)	77Ro08
				103 41	(Coul. Ex.)	77Ro08
178Hf	72	106	306.6	9 +16-9	(Coul. Ex.)	77Ro26
				79 47	(Coul. Ex.)	77Ro26
				27	(A,A')	68He24
				1.2 4	(p,p')	86Og02
180Hf	72	108	308.6	8 +9-8	(Coul. Ex.)	77Ro26
				72 36	(Coul. Ex.)	77Ro26
				1.1 8	(p,p')	92Pe02
				5.2	(p,p')	86Og02
182W	74	108	329.4	6.7 9	(p,p')	86Og02
				66 +90-30	(Coul. Ex.)	75Le22
				27 20	(A,A')	81Ba01
				15	(A,A')	75Le22
				10 +14-10	(p,p')	85La15
				5.9 18	(n,n')	81De02

184W	74	110	364.1	10 7	(A,A')	74Le16
				75 56	(Coul. Ex.)	75Le22
				30 17	(A,A')	81Ba01
				10 1	(p,p')	86Og02
				10 2	(n,n')	81De02
186W	74	112	396.6	11 8	(A,A')	75Le22
				23 7	(A,A')	81Ba01
				10 +29-10	(Coul. Ex.)	75Le22
				9 2	(n,n')	81De02
186Os	76	110	434.1	(115)	(Coul. Ex.)	76Ba06
188Os	76	112	477.9	7.2 8	(e,e')	88Bo08
				(128)	(Coul. Ex.)	76Ba06
190Os	76	114	547.8	6.7 7	(e,e')	88Bo08
				(148)	(Coul. Ex.)	76Ba06
192Os	76	116	580.3	6.9 6	(e,e')	88Bo08
				5.2 6	(e,e')	84Re02, 84Re10
				12.6 10	(p,p')	87Ic04
				5.5 7	(p,p')	89Ba54
				(50)	(Coul. Ex.)	76Ba06
					(A,A')	81Ba49, 76Ba06
192Pt	78	114	784.6	5.9	(A,A')	78Ba20
194Pt	78	116	811.3	4.3 9	(e,e')	88Bo08
				7.3 25	(Coul. Ex.)	88Fe04
				7 5	(Coul. Ex.)	78Ba38
				1.3	(A,A')	76Ba35
				5.1 5	(p,p')	91Se04, 90Se13
				3.3 3	(p,p')	81De12
					(n,n')	87Hi04
196Pt	78	118	876.9	3.4 7	(e,e')	92Po09
				2.5 3	(e,e')	88Bo08
				3.3 7	(e,e')	85Bo14
				1.7 12	(Coul. Ex.)	92Li14
				2 +5-2	(Coul. Ex.)	88Fe08
				4.5 34	(Coul. Ex.)	86Gy04
				1.0	(A,A')	76Ba35
				4.3 3	(p,p')	91Se04
				5.7	(p,p')	81De12
198Pt	78	120	985.1	2.8 2	(p,p')	90Se13
				12 12	(Coul. Ex.)	88Fe08
				1.9	(A,A')	76Ba35
				5.7, 4.1	(p,p')	81De12
198Hg	80	118	1048.5	1.5 6	(e,e')	89BuZP
				0.8	(p,p')	91Ho07
200Hg	80	120	947.2	0.84	(p,p')	91Ho07
202Hg	80	122	1119.7	3.6	(p,p')	91Ho07
204Hg	80	124	1128.4	5.5 7	(e,e')	89BuZP
				6.0	(p,p')	91Ho07
202Pb	82	120	1382.9	4.7 8	(T1/2,%Ig)	
204Pb	82	122	1274.0	3.6	(e,e')	84Pa02
				2.5 5	(T1/2,%Ig)	

206Pb	82	124	1684	2.0	(e,e')	84Pa02
					(p,p')	95Ma44
208Pb	82	126	4323.2	18.1 13	(e,e')	82He03
				15	(e,e')	71Na24
				27 2	(e,e')	68Zi02
				26 8	(e,e')	61Cr01
				19	(d,d'),(A,A')	80Mo18
				13.2 14	(A,A')	67Al14
					(p,p')	95Ma44, 75Wa18
226Ra	88	138	211.5	101 15	(Coul. Ex.)	93Wo05
230Th	90	140	174.1	106 28	(Coul. Ex.)	73Be44
232Th	90	142	162.1	100 5	(e,e')	76Co08
				90	(e,e')	77Cr.A
				156 35	(Coul. Ex.)	74Ba43
				130 35	(Coul. Ex.)	73Be44
				122 5	(p,p')	86Ta12
				83 5	(p,p')	81Ro09, 79Ki14
					(Muonic X)	86Zu01, 78Cl03, 74Da03
					(A,A')	76Da17
234U	92	142	143.4	167 54	(Coul. Ex.)	73Be44
				94 12	(Muonic X)	84Zu02
236U	92	144	149.5	140 50	(Coul. Ex.)	73Be44
					(p,p')	81Ro09
					(A,A')	76Da17
238U	92	146	148.4	98 5	(e,e')	76Co08
				80	(e,e')	77Cr.A
				56 30	(Coul. Ex.)	73Be44
				76 8	(Muonic X)	84Zu02
				110 7	(p,p')	86Ta12
				63 5	(p,p')	81Ro09
				53 8	(p,p')	79Ki14
					(p,p')	82Ha02, 79Br27
					(A,A')	76Da17, 74Fr05
					(n,n')	82Ha34
					(Muonic X)	78Cl03, 74Da03
238Pu	94	144	146.0	154 54	(Coul. Ex.)	73Be44
240Pu	94	146	141.7	104 48	(Coul. Ex.)	73Be44
					(Muonic X)	84Zu02
242Pu	94	148	147.3	43 +40-32	(Coul. Ex.)	73Be44
					(Muonic X)	84Zu02
					(d,d')	72El08
244Pu	94	150	153	7 +42-7	(Coul. Ex.)	73Be44
244Cm	96	148	142.3	0 +19-0	(Coul. Ex.)	73Be44
246Cm	96	150	142.0	0 +19-0	(Coul. Ex.)	73Be44
248Cm	96	152	143.8	0 +26-0	(Coul. Ex.)	73Be44

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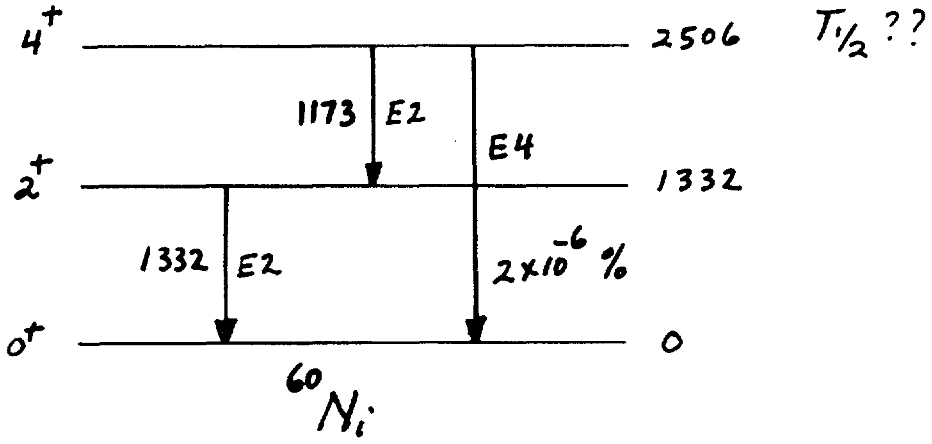
Halflife of 2506, 4^+ level in ^{60}Ni:



Available data :

BE4(e,e′)(Wu)=5.8 10 (61Cr01), 4.8 10 (69To08)

%Iγ branching of 2506-keV gamma ray=2.0E-6 4 (78Fu05)

DSA data: ≤4 ps (J. Phys. G6, 1131 (1980))
0.9_{-4}^{+12} ps (Nucl. Phys. A318, 236 (1979))
3.3 ps 5 (Izv. Ak. SSSR 39, 165 (1975))
0.5_{-2}^{+19} ps (Nucl. Phys. A207, 577 (1973))

In **NDS 1993 and NDS 1986** for **A=60**:

$T_{1/2}$(2506 level)=**0.30 ps 9** ; with comment:
"From measured ratio BE2/BE4 (78Fu05) and adopted %Iγ branching."

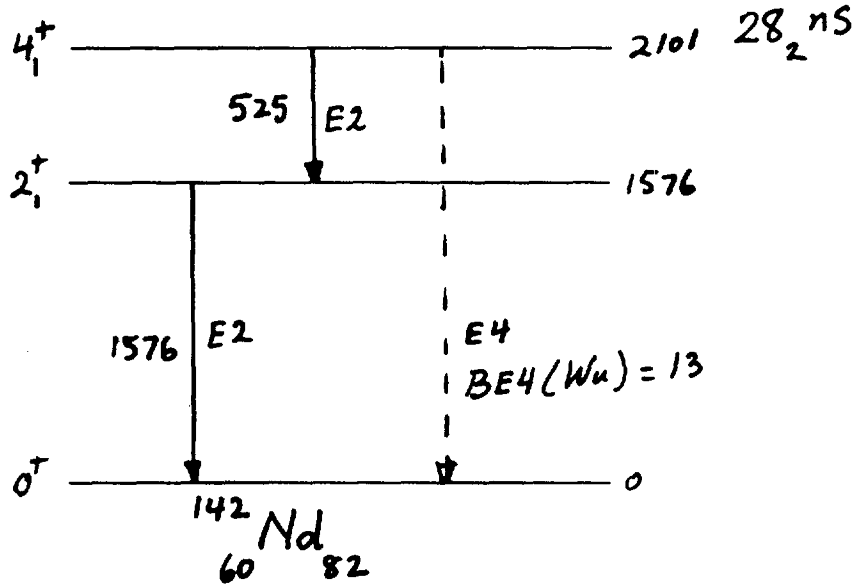
This halflife gives BE4(Wu)=20 7, in disagreement with
5.3 10 from (e,e′).

Also deduced BE2(Wu)=59 (too large?)
BE2(Wu) for 1332γ(2^+ to 0^+) is 13.5

From averaged BE4(e,e′) and %Iγ branching,
T1/2=1.1 ps **3** which gives BE2=16 4 (more realistic).

Observation of E4 gamma ray in ^{142}Nd ?

BE4(Wu)(e,e′)=13 (Nucl Phys A535, 669 (1991))



From measured BE4 and $T_{1/2}$, %Iγ ~0.25

This branching should be observable with large detectors.

Possible reactions: (n,n′γ) and ^{130}Te(^{16}O,4nγ)

AN ATTEMPT TO CONSTRUCT DECAY SCHEME OF ^{242m}Am α DECAY

F.E.Chukreev

The isomeric state in ^{242}Am nucleus ($T_{1/2}$(g.s.) = 16.02 (2) h; $T_{1/2}$(isomer) = 141(2) yr) belongs to a comparatively limited range of atomic nuclei revealing substantial longer half-lives for isomeric states as compared to the respective ground state figures. The isomeric state of ^{242}Am decays by two branches showing both electromagnetic transition with the probability of 99.54% and α-decay with the probability of 0.46% down to ^{238}Np daughter nucleus. The ground state of ^{242}Am also reveals two decay branches, the first being electron capture to ^{242}Pu (17.3%) and the second being β-decay to ^{242}Cm (82.7%). The half-life of ^{242}Pu is much more longer as that one of ^{242}Am isomeric state. This is not the case for ^{242}Cm, shorter half-life of which ($T_{1/2}$ = 162.79(9) d) makes the study of ^{242m}Am radiation spectra rather complicated task due to α and γ- decay channels opened for the ^{242}Cm daughter nucleus.

As a consequence of the ^{242m}Am decay features mentioned there is an evidence for the relevant experimental data not to be completed and to contain some contradictions. Thus every new experiment dealing with the decay of this isomeric state results in an appearance of one more treatment of the experimental data to deduce a level scheme. But, up to now, there is not such a scheme published available in the terms of transition energies and intensities getting a balance.

Data Sources

The main relevant data sources are scarce. α-particle spectra are published in Refs.1,2. The first deals with the spectrum measured by means of a large magnetic spectrometer provided with photographic registration. The second is devoted to the same spectrum observed with the help of a semiconductor spectrometer of a good resolution the latter being, of course, worse then that one of magnetic facility. The main goal of the latter study was to construct ^{238}Np level scheme and to assign the transitions involved. In addition to ^{242m}Am α-decay spectrum, γ-rays and conversion electrons following neutron capture by ^{237}Np were measured together with γ-rays and γγ-coincidences originating from the ^{242m}Am decay. All those measurements were carried out by means of the high quality equipment. Actually Ref.2 is the first scienc publication of the data on the γ-rays from the ^{242m}Am decay mode. Our knowledge of those radiations was limited previously to the data of Ref.3 being quoted as a private communication of F.Asaro. At the same time those results were not presented completely thus obviously lowering their validity. The paper (ref 2.) mainly contains an interpretation of the experimental data, but not these data .

What is the basic hardness which prevents one to evaluate the data on ^{242m}Am decay? The point is that ^{242m}Am α-decay mainly (nearly 89%) brings the parent nucleus down to the 5^- level of the ^{238}Np daughter while , as it is generally adopted, the respective ground state has a spin value equal to 2 and positive signature of parity. At such condition the easier way for the 5^- state to decay could be E1-type transition down to anyone of low-laying states with $J^{\pi}=4^+$, with the intensity of nearly 80-90%. ^{238}Np nucleus has a number of such states being sufficient enough. But there is not any such transition observed. Instead of, γ-ray spectrum demonstrates many lines of lower intensity proving the strong sharing in ^{238}Np excitation energy. Ref.2 reports on 75 lines observed with 49.37 keV quantum having the maximum intensity (29.1(9)%). All other transitions have substantially lower intensities.

At these circumstances to balance transition flows one could adopt one of the following hypotheses.

1. α-decay is accompanied by the quanta which ***are not observed*** due to the background.

Following the α-decay a long-living isomeric state is populated in ^{238}Np with high probability and ***it is not still observed***. From our point of view this hypothesis also seems to be important. An experiment, where activities of ^{242m}Am and ^{238}Np were compared, is unknown for us.

We studied an opportunity to construct the decay scheme using the first hypothesis.

To achive to balnced decay scheme we have had to introduce 3 additional quanta. This decay scheme is presented on Figure.

Transition energy, keV	Number of quanta per 100 alphas	Multip olarity	Number of transitions per 100 alphas
14.38	4.17	E1	27.54
41.64	0.15	M1 + E2	78.19
41.86	0.0012	M1 + E2	0.63

14.38 keV quantum will be hidden by L X-radiation (14.3-15.0 keV) of Pu and Cm revealing the total intensity of about 8000 quanta per 100 a-particles. Similarly, two other quanta will be masked by γ-emission of ^{242}Pu (42.13 keV) with intensity of nearly 10 quanta per 100 a-particles. There are also other sources of the background which do not simplify a task of the observation of those hypothetical radiations.

To make clear the system of γ-transitions taking place along with ^{242m}Am α-decay one feels the need of new α-γ, α-ce and ce-γ coincidence measurements, because the old "private" communications devoted to the subject do not meet new measurements performed, in particular, on the properties of radiations accompanying thermal neutron capture by ^{237}Np nucleus.

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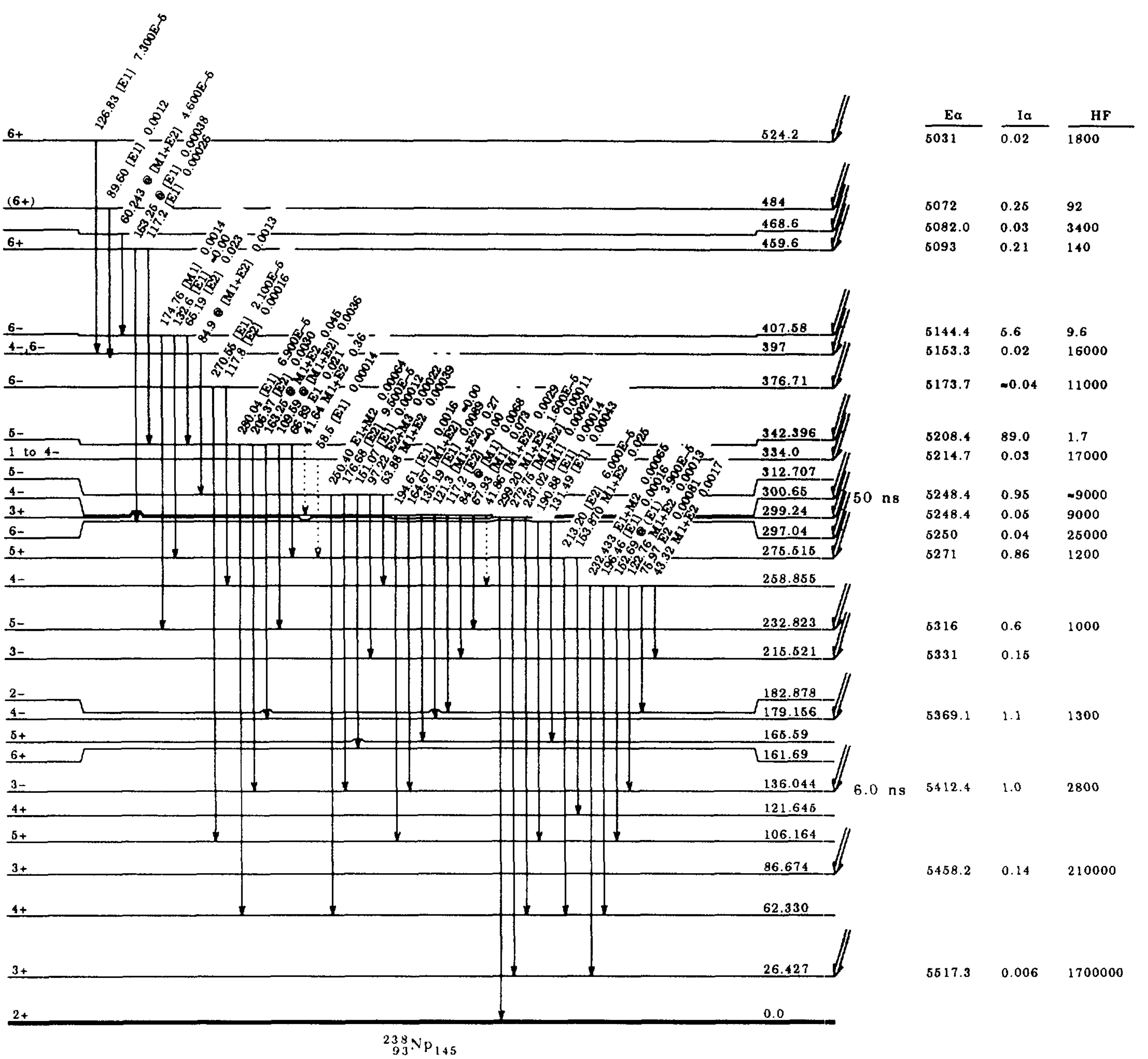
^{242}Am α Decay (141 y) 90Ho02,79Ba07

Decay Scheme

@ Multiply placed; intensity suitably divided
Intensities: I(γ+ce) per 100 parent decays



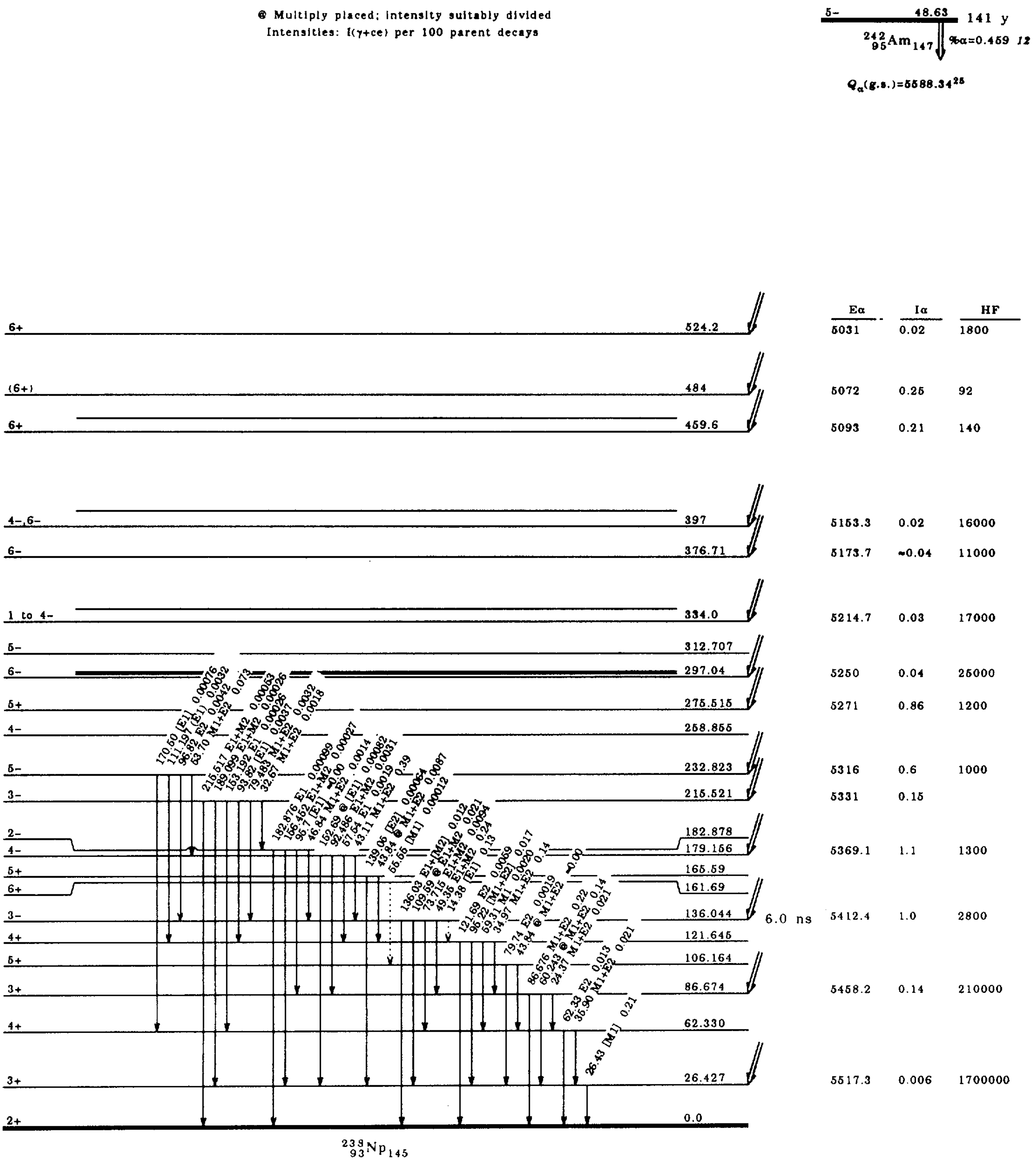
Eα	Iα	HF
5031	0.02	1800
5072	0.25	92
5082.0	0.03	3400
5093	0.21	140
5144.4	5.6	9.6
5153.3	0.02	16000
5173.7	≈0.04	11000
5208.4	89.0	1.7
5214.7	0.03	17000
5248.4	0.95	≈9000
5248.4	0.05	9000
5250	0.04	25000
5271	0.86	1200
5316	0.6	1000
5331	0.15	
5369.1	1.1	1300
5412.4	1.0	2800
5458.2	0.14	210000
5517.3	0.006	1700000

From NNDC(BNL)
program ENSDAT

^{242}Am α Decay (141 y) 90Ho02,79Ba07 (continued)

Decay Scheme (continued)

@ Multiply placed; intensity suitably divided
Intensities: I(γ+ce) per 100 parent decays



			Eα	Iα	HF
6+	524.2		5031	0.02	1800
(6+)	484		5072	0.25	92
6+	459.6		5093	0.21	140
4-,6-	397		5153.3	0.02	16000
6-	376.71		5173.7	≈0.04	11000
1 to 4-	334.0		5214.7	0.03	17000
5-	312.707				
6-	297.04		5250	0.04	25000
5+	275.515		5271	0.86	1200
4-	258.855				
5-	232.823		5316	0.6	1000
3-	215.521		5331	0.15	
2-	182.878				
4-	179.156		5369.1	1.1	1300
5+	165.59				
6+	161.69				
3-	136.044	6.0 ns	5412.4	1.0	2800
4+	121.645				
5+	106.164				
3+	86.674		5458.2	0.14	210000
4+	62.330				
3+	26.427		5517.3	0.006	1700000
2+	0.0				

From NNDC(BNL)
program ENSDAT

FISOM
(FISsion ISOMers)

THE NUCLEAR DATABASE FOR FISSION ISOMER PROPERTIES

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Fission isomers discovered in the form of spontaneous fission with anomalously short half-life are considered to be a prospective tool to study complex structure of fission barriers of actinide nuclei in uranium-berkelium region. Generally, the problem deals with the behaviour of nuclear matter at extremely large deformations one meets in fission. In addition, the nature of fission isomers (shape on spin) still seems to be an open question.

The FISOM database has an internal structure similar to the main trends of the Nuclear Data Sheets. Namely, a set of entries is organized in the form of electronic tables (or sheets) belonging to a specific nuclide.

A user starts with an immediate pane of Fission Isomer Island (Z - N plot) to select the nucleus under interest. Choosing the latter one is allowed to enter the list of the specific data items containing both isomeric and groundstate figures as follows:

* half-life;
* level data (height, and spin parity assignment);
* decay data (branching ratios, intensities and level scheme involved);
* excitation functions for various reactions;
* fission fragment data;
* spectroscopic data (quadruple momentum, and momentum of inertia, etc.)

Every item contains relevant references and comments given by the evaluator. Horizontal evaluation feature is available by setting up the respective search filter option to the name of the parameter.

The database mainframe is provided with Info and Help windows as a part of interactive interface.

As far as the original database together with supporting code package are developed within the Excel Microsoft Office media, the entire built-in services of the letter are available to be applied for e.g. plot and chart editing.

The Ninth Capture Gamma-Ray Symposium at Budapest

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The *Ninth International Symposium on Capture Gamma-Ray Spectroscopy and Related Topics* was held at Budapest, Hungary between 8-12 October 1996. It has continued the traditions of a series of symposia, started at Studsvik, Sweden in 1969. Eight topical sessions were organized around subjects related to capture: from nuclear structure physics to nuclear astrophysics, fundamental physics, practical applications and so on. There were 175 participants from 32 countries, presenting over 70 talks and 110 posters. The conference proceedings will be published[1] in about April 1997 by Springer Hungarica and distributed by Springer-Verlag.

For the first time in this series has a special session been devoted to nuclear data, with the purpose to present the broad scope of present-day international nuclear data activities to the researchers and, on the other hand, let the data people have a feedback concerning urgent nuclear data needs. The session has been a great success and this is partly due to the excellent work of the responsible committee members, namely R.A. Meyer, the INDC chairman (Advisory Committee), G. Audi, J. Dairiki, J. Kopecky, P. Oblozinsky and K. Shibata (Program Committee), who have helped the local organizers to put together a most interesting show. The other key factor contributing to the success of this special session has been to have the AGM on the Coordination of the Nuclear Structure and Decay Data Evaluators' Network as a follow-up of the Capture Gamma-Ray Symposium, that allowed for at least half of the AGM attendants (12 people) to participate in both events.

The plenary session, chaired by G. Audi, consisted of three invited talks by R. A. Meyer (DoE, USA), R. B. Firestone (LBL. USA) and P. Oblozinsky (IAEA NDS, Vienna) on recent developments in data evaluation and dissemination, including Internet services. In the afternoon poster sessions, chaired by J. Dairiki, ten invited posters were presented. The accompanying software demonstrations of *VuENSDF* and *Nucleus*, as well as of the CD-ROM versions of the new *Table of Isotopes*, *Nuclear Structure References*, *PC-Nudat* and other computer programs particularly attracted attention.

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1. Proc. Ninth Int. Symp. on Capture Gamma-Ray Spectroscopy and Related Topics, eds. G. L. Molnár, T. Belgya and Zs. Révay (Springer-Verlag Budapest, Berlin, Heidelberg), 1000 pages, in print.

Horizontal Evaluation of Neutron Capture Gamma-Ray Data

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Abstract: A new library of cold and thermal neutron capture gamma-ray data is being prepared in the form of a relational database for various applications, in a joint effort between the Institute of Isotopes, Budapest and R. B. Firestone of the Isotopes Project at Lawrence Berkeley Laboratory. The database will contain gamma-ray energies and absolute intensities per capture (whenever available), as well as thermal neutron-capture cross sections and isotopic abundances. Hence both isotopic and elemental information may be retrieved, depending on the kind of application.

1. Status of data sources

The most reliable and complete source of information for thermal neutron capture gamma-ray data is the Evaluated Nuclear Structure and Decay Data File (ENSDF), produced in an international effort by expert evaluators. A current version of ENSDF has been included in the CD-ROM supplement to the 8th edition of the Table of Isotopes.[1] Updates of data for mass chains are also available in printed form in the journal Nuclear Data Sheets, and for light nuclei (A<44) in the journal Nuclear Physics.[2,3] References to the original papers are included in the section Nuclear Structure References (NSR), also available on line from Brookhaven and Vienna, as well as on CD-ROM.[4] In addition, there is one compilation of thermal neutron capture gamma-ray data for <u>elements</u>.[5] Close examination of the aforementioned sources of information has led us to the following conclusions.

- ENSDF contains (n,γ) data for <u>nuclei</u>, i.e. for individual isotopes of each chemical element.
- Capture gamma-ray data for nuclei with mass A<44 are missing from ENSDF since they have not been included explicitly in the original evaluation printed in Nuclear Physics.
- Capture data for nuclei with mass number A$\geq$44 are systematically included in ENSDF but the normalization of absolute gamma-ray intensities is often missing or ambiguous.
- References to original (n,γ) papers are included in NSR for <u>all</u> nuclei.
- Elemental data of Ref. 5 come essentially from a single series of measurements with moderate precision. These data have never been evaluated and, according to the users' experience, contain numerous errors. Besides, no uncertainties have been included.[6]
- Data from Ref. 5 for light elements and data from ENSDF for nuclides with A$\geq$44 have recently been put together on a World Wide Web home page but only relative gamma-ray intensities without uncertainties are given[7]

2. Working strategy

In order to produce an evaluated library of thermal neutron-capture gamma rays for elements the following working strategy has been adopted:

- Deduce elemental gamma-ray energies and intensities from the isotopic data
- Compare these with the measured elemental data
- Create the library and make it available to ENSDF evaluators for final check.

Needed:

⇒ Capture gamma-ray energies and absolute intensities for isotopes.

⇒ Thermal neutron-capture cross section for isotopes.

⇒ Elemental abundances.

While cross sections and abundances are available on line, extraction of energies, and especially intensities, requires a large amount of data evaluation work.

Done so far:

⇒ A "Thermal Neutron Capture home page" has been set up at LBL where the information available to date is concentrated: *http://isotopes.lbl.gov/isotopes/ng.html*

⇒ Capture gamma-ray data for nuclei with A≥44 have been retrieved from ENSDF.

⇒ References to capture gamma papers for light nuclei have been retrieved from NSR (124 items).

References

1. R. B. Firestone; edited by V.S. Shirley, *"Table of Isotopes"*, 8th edition (John Wiley, 1996), supplemented with a CD-ROM version
2. *A = 5 -10:* F. Ajzenberg-Selove, *Nucl. Phys.* A490, 1 (1988)
   A = 11-12: F. Ajzenberg-Selove, *Nucl. Phys.* A506, 1 (1990
   A = 13-15: F. Ajzenberg-Selove,*Nucl. Phys.* A523, 1 (1991)
   A = 16-17: D.R. Tilley, H.R. Weller and C.M. Cheves, *Nucl. Phys.* A564, 1 (1993)
   A = 18-19: D.R. Tilley, H.R. Weller C.M. Cheves and R.M. Chasteler, *Nucl. Phys.* A595, 1 (1995)
   A = 20: F. Ajzenberg-Selove, *Nucl. Phys.* A475, 1 (1987)
3. *A = 21-44:* P. M. Endt, *Nuc. Phys.* A521, 1 (1990)
4. P. Ekström R. R. Kinsey and E. Browne, *Nuclear Data and References, a* CD-ROM containing NSR (LBL 1996)
5. M. A. Lone, R. A. Leavitt and D. A. Harrison, *"Prompt Gamma Rays from Thermal Neutron Capture"*, Atomic Data Nucl. Data Tables 26, 511 (1981)
6. G. Molnár and R. M. Lindstrom, in: *Proc. of a Specialists' Meeting on Measurement, Calculation and Evaluation of Photon Production Data*, eds. C. Coceva , A. Mengoni and A. Ventura, NEA/NSC/DOC(95)1 (ENEA Bologna, 1995)
7. J. K. Tuli, Thermal Neutron Capture Gamma-Ray Tables, in: WWW home page of the National Nuclear Data Center (BNL, 1991-1996)

Citation of databases in publications

H.D. Lemmel 96/10/10

With the frequent updating of electronic databases new problems of Archiving of databases have come up and also the question of Citation Guidelines for citing databases in publications.

The Nuclear Reaction Data Centers issued a general citation guideline, see example 1.

For ENDF/B-6 the citation guideline is given in example 2.

For ENSDF our present guideline is given in example 3. This is not perfect and should be improved.

Guidelines drafted by V. McLane for citing NSR and ENSDF are given in example 4.

While the Nuclear Reaction Data Centers did not finish this topic at their June 1996 Meeting in Brookhaven, it was recommended

- that every database should have instructions how it should be cited;
- that for online services the key word "citation" should be clearly visible within each database, so that the citation instructions could be easily found under this keyword;
- that for ftp servers a file AAACITE.TXT should be created for each datafile, to display the citation instructions.

In this connection it was noted that for many databases a representative publication which could be used in citations, is lacking.

Example 1:

When quoting a computer-based data library in a publication it is recommended

- to give first the print reference in which the author(s) describe(s) the generation of the data;
- to give thereafter the database reference which contains the numerical data, including the version of the database;
- and then to mention the data center or the online service from which the data w~~h~~ere received.

Example 2:

ENDF/B-6

The U.S. Evaluated Nuclear Data Library
for Neutron Reaction Data

by the US National Nuclear Data Center
- 1990 including revisions up to May 1995

Citation guideline:

a) *citing the evaluation of one material*

Author(s), "Neutron reaction data evaluation of ...", report ... (place, year) [or, if no report is available: Undocumented]. Data file ENDF/B-VI MAT 1234 Rev. 2 (date) by the U.S. National Nuclear Data Center on behalf of the Cross-Section Evaluation Working Group. Data received on tape (or retrieved online) from the IAEA Nuclear Data Section.

b) *citing the entire library*

P.F. Rose (ed.), "ENDF/B-VI Summary Documentation", report BNL-NCS-17541 (ENDF-201), (Brookhaven National Laboratory 1991). Data Library ENDF/B-VI, update 1995, by the U.S. National Nuclear Data Center ... etc. as above.

c) *citing the format*

P.F. Rose, C.L. Dunford (ed.), "Data formats and procedures for the Evaluated Nuclear Data File ENDF-6", report BNL-NCS-44945 (ENDF-102) Rev. 10/91 (Brookhaven National Laboratory 1991).

Example 3:

ENSDF

The Evaluated Nuclear Structure Data File

maintained by the U.S. National Nuclear Data Center on behalf of the
International Nuclear Structure and Decay Data Network, sponsored by the
International Atomic Energy Agency

Citation guideline:

The ENSDF database or data retrieved from it should be cited as follows:

> M.R. Bhat, “Evaluated Nuclear Structure Data File (ENSDF)”, Int. Conf. on Nuclear Data for Science and Technology, Jülich 1991, Proceedings p. 817. ENSDF data retrieved on ... (date!) From the Online Service of ... (US National Nuclear Data Center or IAEA Nuclear Data Section).

Example 4

Extracts from a draft by V. McLane, Jan. 1996

Nuclear Science References (NSR)

Data included in Nuclear Science References are compiled, checked, organized, and distributed by the National Nuclear Data Center. The database should be cited as follows.

Example:

> Data extracted from the NSR database,* through the NNDC Online Data Service.
> *National Nuclear Data Center, **Nuclear Science References**, version of (date).

The citation to be used when citing the NSR formats is:

> S. Ramavataram and C.L. Dunford, *Nuclear Structure References Coding Manual*, Brookhaven National Laboratory Report **BNL-NCS-51800**, Rev. 1 (1996).

ENSDF: see the following three pages

Evaluated Nuclear Structure Data

Evaluated Nuclear Structure Data File (ENSDF)

ENSDF is produced by the International Nuclear Structure and Decay Data Network (see Appendix B), and is maintained by the National Nuclear Data Center.[6] The data are available at the National Nuclear Data Center, the NEA Data Bank, IAEA Nuclear Data Section, the Russian Nuclear Data Center (CJD), and the Russian Nuclear Structure and Reaction Data Center (CaJaD) (see Appendix A).

Referencing individual evaluations

To reference individual mass chains or parts of mass chains, cite the author and the published version of the evaluation. This will be found under MASS_STATUS when accessing the ENSDF database through the Online Data Service, or toward the end of the COMMENTS data set of the mass chain. The citation will automatically be generated if the data are displayed using the code ENSDAT.[7]

Example:

COMMENT section records:

```
56    C  AUTH      HUO JUNDE
56    C  CIT$NDS 67, 523 (1992)
```

Citation:

Huo Junde, ***Nucl. Data Sheets* 67**, 523 (1992). Data extracted from the ENSDF database, version (date), using the NNDC Online Data Service.

Many mass chains are periodically updated between published evaluations. In this case, a reference to the database version should be included in the citation. For example, an evaluation published in the **Nuclear Data Sheets** in 1990 will have 90NDS on the first record of the ENDF-formatted data set; if the data set was revised in 1993 based on new data, 90NDS+93 will appear at the right on this record, followed by the date of entry into the database. The COMMENTS data set will contain information on the revision, and there should also be documentation in the data set.

Example:

1st record of COMMENT section:

```
50   COMMENTS                                       90NDS+93   931112
```

Citation:

T.W. Burrows, ***Nucl. Data Sheets* 61**, 1 (1990), and interim evaluation, T.W. Burrows (1993). Data extracted from the ENSDF database, revision of Nov. 11, 1993, using the NNDC Online Data Service.

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[6] The Network is described in the ***IAEA Nuclear Data Newsletter***, issue 20 (1994).

[7] For data processed through the Online Service at NNDC or NDS, the plots are generated using the code ENSDAT.

Referencing ENSDF

When referencing the Evaluated Nuclear Structure Data File (ENSDF) as a whole, for example, if the data used span many mass chains as in a study of systematics, the citation should include the revision date of the database. The citation should read, for example:

> Data extracted from the ENSDF database, using the NNDC On-Line Data Service, file revised as of *(date)*. ENSDF is produced by members of the International Nuclear Structure and Decay Data Network, and maintained by the National Nuclear Data Center.

The reference to be used when citing the ENSDF format is:

> J.K. Tuli, *The Evaluated Nuclear Structure Data File (ENSDF)*, Report **BNL-NCS-51655** (1987), National Nuclear Data Center, Brookhaven National Laboratory, USA.

For the reference to be used when citing the ENSDF database, see Online Data Service, page 10.

Prepublication Data

Data obtained from the prepublication data base should be treated as a preprint. It should not be cited without express permission of the authors.

Tables and Figures

When using tables and figures produced by the NNDC or NDS Online Service, the citation should read:

> Plots produced using the code ENSDAT, written by R.R. Kinsey, National Nuclear Data Center, Brookhaven National Laboratory.

MIRD

When using data extracted from the MIRD database, the citation should read, for example:

> Data produced using the MIRD Program, and extracted from the Evaluated Nuclear Structure Data File (ENSDF), *date*, both maintained by the National Nuclear Data Center, Brookhaven National Laboratory. Additional calculations performed by the program RADLST.*
>
> *T.W. Burrows, *The Program RADLST*, Report **BNL-NCS-52142** (1988), National Nuclear Data Center, Brookhaven National Laboratory.

NUDAT

Data retrieved from the NUDAT database should have the following citation with reference to the Online Data Service used and the version date of the file.

Example:

> Data extracted from the NUDAT database, version (date), throught the NNDC Online Data Service...

The following citations should be appended depending on the type of data used.

Levels, Gammas

...using data from the Evaluated Nuclear Structure Data File (ENSDF), maintained by the National Nuclear Data Center, Brookhaven National Laboratory.

Wallet Cards (Ground and Metastable State Properties)

based on the Nuclear Wallet Cards.[*]

[*] J.K. Tuli, **Nuclear Wallet Cards,** July, 1995, and subsequent updates by J.K. Tuli from the Evaluated Nuclear Structure Data File (ENSDF) and from G. Audi and A.H. Wapstra, *The 1995 Update to the Atomic Mass Evaluation., Nucl. Phys.* **A595**, 409 (1995).

Decay Radiations

...using data from the Evaluated Nuclear Structure Data File (ENSDF), maintained by the National Nuclear Data Center, Brookhaven National Laboratory. Additional calculations performed by the program RADLST.[*]

[*] T.W. Burrows, *The Program RADLST,* Report **BNL-NCS-52142** (1988), Brookhaven National Laboratory.

Neutron Data (Thermal Cross Sections and Resonance Integrals)

...based on an evaluation by S.F. Mughabghab.[*]

[*] S.F. Mughabghab, M. Divadeenam, N.E. Holden, **Neutron Cross Sections, Volume 1. Neutron Resonance Parameters and Thermal Cross Sections.** Part A: Z=1-60. Academic Press (New York. 1981)

S.F. Mughabghab, **Neutron Cross Sections, Volume 1. Neutron Resonance Parameters and Thermal Cross Sections.** Part B: Z=61-100. Academic Press (New York. 1984).

QCALC

To reference calculations performed by the program QCALC:

Data produced by the code QCALC, written by T.W. Burrows, National Nuclear Data Center, Brookhaven National Laboratory, and based on the Audi-Wapstra Atomic Mass Tables.[*]

[*] G. Audi and A.H. Wapstra, *The 1995 Update to the Atomic Mass Evaluation., Nucl. Phys.* A595, 409 (1995).

Reprinted from:
BNL-NCS-63381 (INFORMAL REPORT)

Citation Guidelines for Nuclear Data Retrieved from Databases Resident at the Nuclear Data Centers Network

written by

Victoria McLane

on behalf of the

Nuclear Data Centers Network

July 1996

National Nuclear Data Center
Brookhaven National Laboratory
Upton, NY 11973-5000

Introduction

This documents outlines the proper method of citing data obtained from each of the Nuclear Data Centers Network databases.

The Nuclear Data Centers Network[1] is a world-wide cooperation of nuclear data centers under the auspices of the International Atomic Energy Agency. The Network organizes the task of collecting, compiling, standardizing, storing, assessing, and distributing the nuclear data on an international scale. Information available at the Centers includes bibliographic, experimental, and evaluated databases for nuclear reaction data and for nuclear structure and radioactive decay data. The objective of the Network is to provide the information to users in a convenient, readily-available form. To this end, online data services have been established at three of the centers: the National Nuclear Data Center (NNDC), the Nuclear Data Section of the International Atomic Energy Agency (NDS), and the OECD Nuclear Energy Agency Data Bank (NEADB). Some information is also available at the NNDC and NEADB WorldWideWeb sites.

Data source

Data obtained from the databases residing at the member organizations of the Nuclear Data Centers Network should be properly cited. In general, there should be a citation of the original source of the information used, as well as of the database from which the data were extracted. The source of the information should be cited as:

- Data retrieved *(or extracted)* from the *(center name)* Online Data Service,
- Data retrieved *(or extracted)* from the *(center name)* WorldWideWeb site,
- Data received by electronic file transfer from *(center name)*,
- Data received from *(center name)*[2].

These data bases may contain essential information which does not exist in a published article. Since the databases are periodically updated, it is important to include the date and/or revision number of the version of the database used.

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[1] The Nuclear Data Center Network and the participating centers are described in report **INDC(NDS)-324** (1995).

[2] For information received by mail or electronic mail.

Bibliographic Information

When information retrieved from one of the Centers' bibliographic databases is used in a review article or other survey of available information, the database used should be cited; the citation should include the version (date) of the database used.

Nuclear Science References (NSR)

Data included in Nuclear Science References are compiled, checked, organized, and distributed by the National Nuclear Data Center.[3] The database should be cited as follows.

> National Nuclear Data Center, **Nuclear Science References**, version of (date). Information extracted from the NSR database *[Source]*.

The citation to be used when citing the NSR formats is:

> S. Ramavataram and C.L. Dunford, *Nuclear Science References Coding Manual*, Report **BNL-NCS-51800**, Rev. 08/96 (1996) Brookhaven National Laboratory, U.S.A.

Computerized Index to Neutron Data (CINDA)

Data included in CINDA are compiled by the Neutron Data Centers (i.e., NNDC, NEADB, NDS, and the Russian Nuclear Data Center (CJD)). The database should be cited as follows.

> Nuclear Data Centers Network, **CINDA95, Index to the Literature and Computer Files on Microscopic Neutron Data**,[4] (International Atomic Energy Agency, Vienna, Austria, 1995). Information extracted from the CINDA database, version *(date)*, *[Source]*.

The CINDA format should be cited as follows:

> NEA Data Bank, ***CINDA Coding Manual***, unpublished, February 1990.

---

[3] Contributions to the compilation of Japanese references are made by the Institute of Physical and Chemical Research (RIKEN), Japan, and of Russian references by at the St. Petersburg Nuclear Physics Institute, Gatchina.

[4] The CINDA publication is issued every year. Please refer to the latest issue.

Experimental Reaction Data

The data in the Experimental Nuclear Reaction Database are compiled in the EXFOR format and exchanged among the members of the Nuclear Data Centers Network (see Appendix A).[5]

Referencing individual data sets

When citing data extracted from this database, always cite the individual references. However, the data entries are often more up-to-date than the original reference; the entries may be updated, sometimes repeatedly, either when the author revises the data, or when the EXFOR compiler receives additional information about the data. Therefore, for unique identification of the data used, the EXFOR data set should also be referenced, and the date of the last revision should be given.[6] (Note that the authors receive proof copies of the data before it is entered into the database and in the case of any major revision to the data set).

Example:

> A.B. Author, et al., ***J. Nucl. Phys.*** **12**, 345 (1979). Data retrieved from the CSISRS database, file EXFOR 12345.002 dated April 5, 1980 *[Sour ce]* .

<u>Notes on finding the information needed to reference a data set</u>:

1. The <u>authors</u> of an EXFOR/CSISRS data set may be found under the keyword 'AUTHOR' in the BIB section.
2. <u>References</u> for the data given in an EXFOR entry may be found under the keyword 'REFERENCE' in the BIB section. If more than one reference is given, the first is the primary reference.
3. The <u>subentry number</u> of the data set (e.g., 12345. or 12345.002) will be given at the beginning of each data set displayed in an online retrieval, or, for a file in the EXFOR format, may be found on the SUBENT record of the data set, immediately following the SUBENT keyword.
4. The <u>revision date</u> will be given at the beginning of each data set displayed in an online retrieval, or, for a file in the EXFOR format, is given on the SUBENT record of the data set, immediately following the data set number. The format of the date is *yymmdd*, where *yy* is the last 2 digits of the year, *mm* is the integer equivalent for the month, and *dd* is the day of the month.

---

[5] This data is available from the CSISRS database at NNDC and NDS, and from the EXFOR database at NEADB.

[6] Do not use old EXFOR retrievals. In case of doubt, check with the Data Center responsible for the database from which you retrieved the data.

Referencing the EXFOR format

To reference the EXFOR data in general, for example, when discussing the EXFOR format, the citation to be used is:

> Nuclear Data Centers Network, *EXFOR Systems Manual: Nuclear Reaction Data Exchange Format*, Report **BNL-NCS-63330** (1996), compiled and edited by V. McLane, National Nuclear Data Center, Brookhaven National Laboratory, U.S.A.

Referencing the CSISRS database

For the reference to be used when citing the CSISRS database, see Online Data Service, page 10.

When using plots produced from the CSISRS database, the citation should read:

> Plots produced using the code BNL325, written by C.L. Dunford, National Nuclear Data Center, Brookhaven National Laboratory.

Evaluated Data Libraries in the ENDF Format

Five major evaluated nuclear data libraries are produced in the ENDF format and exchanged by the members of the Nuclear Data Centers Network: BROND, CENDL, ENDF/B, JEF, and JENDL. Each of these libraries is maintained by one of the member Centers.

Referencing individual evaluations

For individual evaluations, the reference should contain the author of the evaluation, along with a reference to the appropriate documentation. In addition, the library name, MAT number, the MOD or revision number, and the institution(s) which are responsible for the evaluation should be included. All these data are readily available in File 1, MT 451, of each evaluation. Where a published document prepared by the authors of the evaluation is available, this document should be cited directly. If such a document does not exist, the documents describing the contents of the library from which the data has been extracted should be used as a reference (see Referencing an Evaluated Library, following).

> A.B. Name, Report **ANL/NDM-129** (1994), Argonne National Laboratory, U.S.A., ENDF/B-VI evaluation, MAT # 4831, Revision 1, July 1995; data retrieved from the ENDF database *[Source]* .

Referencing an evaluated library

The following citations are proposed for referencing a specific evaluated data library in its entirety.

BROND-2

The Russian Library of Evaluated Neutron Reaction Data is produced and maintained by the Russian Nuclear Data Center (CJD). The most current version of this library is BROND-2; the citation should read:

> A. I. Blokhin, et al., *Current Status of Russian Nuclear Data Libraries*, **Nuclear Data For Science and Technology**, Volume 2, p. 695, edited by J. K. Dickens (American Nuclear Society, LaGrange Park, IL, 1994).

CENDL-2

The Chinese Evaluated Nuclear Data Library is produced by the Chinese Nuclear Data Center and the Nuclear Data Committee of China, and is maintained by the Chinese Nuclear Data Center. The most current version of this library is CENDL-2; the citation should read:

> Chinese Nuclear Data Center, *CENDL-2, The Chinese Evaluated Nuclear Data Library for Neutron Reaction Data*, Report **IAEA-NDS-61, Rev. 3** (1996), International Atomic Energy Agency, Vienna, Austria.

ENDF/B-VI

The Evaluated Nuclear Data File (ENDF/B) is produced by members of the Cross Section Evaluation Working Group, and is maintained by the National Nuclear Data Center. The current version of this library is ENDF/B-VI; the citation should read:

> Cross Section Evaluation Working Group, *ENDF/B-VI Summary Documentation*, Report **BNL-NCS-17541 (ENDF-201)** (1991), edited by P.F. Rose, National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY, USA.

JEF-2

The Joint Evaluated File (JEF) is produced by the NEA Joint Evaluation Project, and maintained by the NEA Data Bank. The current version of this library is JEF-2; the citation should read:

> C. Nordborg, M. Salvatores, *Status of the JEF Evaluated Data Library*, **Nuclear Data for Science and Technology**, edited by J. K. Dickens (American Nuclear Society, LaGrange, IL, 1994).

JENDL-3

The Japanese Evaluated Nuclear Data Library is produced by the JAERI Nuclear Data Center and the Japanese Nuclear Data Committee, and is maintained by the JAERI Nuclear Data Center; the current version of the library is JENDL-3; the citation should read:

> T. Nakagawa, et al., *Japanese Evaluated Nuclear Data Library, Version 3, Revision 2*, ***J. Nucl. Sci. Technol.* 32**, 1259 (1995).

Referencing the ENDF format

The citation to be used when referencing the ENDF format is:

> The Cross Section Evaluation Working Group, *Data Formats and Procedures for the Evaluated Nuclear Data File ENDF-6*, Report **BNL-NCS-44945 (ENDF-102)** (1995) edited by V.McLane, et al., National Nuclear Data Center, Brookhaven National Laboratory, U.S.A.

For the reference to be used when citing the ENDF database, see Online Data Service, page 10.

Plots

When using tables and drawings produced from the ENDF database through the Online Data Service at NNDC or NDS, the citation should read:

> Plots produced using the Online Service retrieval code package written by C. L. Dunford, National Nuclear Data Center, Brookhaven National Laboratory.

Multigroup Libraries

If the evaluated data are used to generate a multigroup library, the report describing the multigroup library should contain a table referencing the evaluations used. The table should include the library name and version, material, material number (MAT), modification number (MOD) or revision number, authors, and institution for each evaluation.

Example:

Library	**Material**	**MAT #**	**MOD**	**Author**	**Institute**
ENDF/B-VI	^{58}Ni	2825	2	D. Larson, et al.	ORNL
JENDL-3	^{62}Ni	2837	3	S. Iijima	NAIG

Evaluated Nuclear Structure Data

Evaluated Nuclear Structure Data File (ENSDF)

ENSDF is produced by the International Nuclear Structure and Decay Data Network (see Appendix B), and is maintained by the National Nuclear Data Center.[7] The data are available at the National Nuclear Data Center, the NEA Data Bank, IAEA Nuclear Data Section, the Russian Nuclear Data Center (CJD), and the Russian Nuclear Structure and Reaction Data Center (CaJaD) (see Appendix A).

Referencing individual evaluations

To reference individual mass chains or parts of mass chains, cite the author and the published version of the evaluation. This will be found under MASS_STATUS when accessing the ENSDF database through the Online Data Service, or toward the end of the COMMENTS data set of the mass chain. The citation will automatically be generated if the data are displayed using the code ENSDAT.[8]

Example:

COMMENT section records:

```
56    C  AUTH      HUO JUNDE
56    C  CIT$NDS 67, 523 (1992)
```

Citation:

Huo Junde, ***Nucl. Data Sheets* 67**, 523 (1992). Data extracted from the ENSDF database, version (date), *[Source]* .

Many mass chains are periodically updated between published evaluations. In this case, a reference to the database version should be included in the citation. For example, an evaluation published in the **Nuclear Data Sheets** in 1990 will have 90NDS on the first record of the ENDF-formatted data set; if the data set was revised in 1993 based on new data, 90NDS+93 will appear at the right on this record, followed by the date of entry into the database. The COMMENTS data set will contain information on the revision, and there should also be documentation in the data set.

Example:

1st record of COMMENT section:

```
50   COMMENTS                                   90NDS+93  931112
```

Citation:

T.W. Burrows, ***Nucl. Data Sheets* 61**, 1 (1990), and interim evaluation, T.W. Burrows (1993). Data extracted from the ENSDF database, revision of Nov. 11, 1993, *[Source]*.

---

[7] The Network is described in the ***IAEA Nuclear Data Newsletter***, issue 20 (1994).

[8] For data processed through the Online Service at NNDC or NDS, the plots are generated using the code ENSDAT.

Referencing ENSDF

When referencing the Evaluated Nuclear Structure Data File (ENSDF) as a whole, for example, if the data used span many mass chains as in a study of systematics, the citation should include the revision date of the database. The citation should read, for example:

> Data extracted using the NNDC On-Line Data Service from the ENSDF database, file revised as of *(date)*. M. R. Bhat, *Evaluated Nuclear Structure Data File (ENSDF)*, **Nuclear Data for Science and Technology**, page 817, edited by S. M. Qaim (Springer-Verlag, Berlin, Germany, 1992).

Referencing the ENSDF format

The reference to be used when citing the ENSDF format is:

> J.K. Tuli, *Evaluated nuclear structure data file*, ***Nucl. Instr. Meth.*** **A 369**, 506 (1996).

For the reference to be used when citing the ENSDF database, see Online Data Service, page 10.

Prepublication Data

Data obtained from the prepublication data base should be treated as a preprint. It should not be cited without express permission of the authors.

Tables and Figures

When using tables and figures produced by the NNDC or NDS Online Service, the citation should read:

> Plots produced using the code ENSDAT, written by R.R. Kinsey, National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY, U.S.A.

MIRD

When using data extracted from the MIRD database, the citation should read, for example:

> Data produced using the MIRD Program, and extracted from the Evaluated Nuclear Structure Data File (ENSDF), *date*, *[Source]* . Additional calculations performed by the program RADLST, T.W. Burrows, *The Program RADLST*, Report **BNL-NCS-52142** (1988), National Nuclear Data Center, Brookhaven National Laboratory, U.S.A.

NUDAT

Data retrieved from the NUDAT database should have the following citation with reference to the Online Data Service used and the version date of the file.

> R. R. Kinsey, et al., *The NUDAT/PCNUDAT Program for Nuclear Data*, paper submitted to the 9th International Symposium of Capture-Gamma-Ray Spectroscopy and Related Topics, Budapest, Hungary, October 1996. Data extracted from the NUDAT database, version (date), *[Source]* ...

QCALC

To reference calculations performed by the program QCALC:

> Data produced by the code QCALC, written by T.W. Burrows, National Nuclear Data Center, Brookhaven National Laboratory, and based on the Audi-Wapstra Atomic Mass Tables, G. Audi and A.H. Wapstra, *The 1995 Update to the Atomic Mass Evaluation.*, ***Nucl. Phys.*** **A595**, 409 (1995).

Photo-Atomic Interaction Data

When referencing calculations from the XRAY program, the Online Data Service from which the data were extracted should be referenced. The following specific citations should be made depending on the calculations performed.

> Data extracted from the XRAY database, version (date), *[Sour ce]* ...

The following citations should be appended depending on the type of data used.

Attenuation Coefficients

> ...using a modification of the program XCOM, M.J. Berger and J.H. Hubbell, *XCOM: Photon Cross Sections on a Personal Computer*, Report **NBSIR 87-3597** (1987), National Institute for Standards and Technology, U.S.A.

Polarized Scattering

<u>Photon-interaction Data</u>

> ...using photon-interaction data are taken from the ENDF/B-VI library, D.E. Cullen, et al., *Tables and Graphs of Photon-Interaction Cross Sections from 10 eV to 100 GeV Derived from the LLNL Evaluated Photon Data Library (EPDL)*, Report **UCRL-50400**, Vol. 6, Parts A+B (1989), Lawrence Livermore National Laboratory, U.S.A.

<u>Polarized scattering calculations</u>

> ...and based on work by A.L. Hanson, ***Nucl. Instr. Meth.*** A **290**, 167-171 (1990), ***Nucl. Instr. Meth.*** A **264**, 471-483 (1988), and ***Nucl. Instr. Meth.*** A **264**, 484-487 (1988).

Atomic Masses

Data taken from the MASSES library, should be referenced as follows.

> G. Audi and A.H. Wapstra, *The 1995 Update to the Atomic Mass Evaluation.*, ***Nucl. Phys.*** **A595**, 409 (1995). Data extracted from the MASSES library *[Sour ce]*.

Online Data Service

The reference to be used in citing the Online Data Service systems are:

At NNDC and NDS:

> C.L. Dunford and T.W. Burrows, *Online Nuclear Data Service*, Report **IAEA-NDS-150** (NNDC Informal Report **NNDC/ONL-95/10**), Rev. 95/10 (1995)[9], International Atomic Energy Agency, Vienna, Austria.

At NEADB:

> *General User's Guide to the NEA Online Services*, Report **DBG-030.11** (1993), NEA Data Bank, Paris, France.

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[9] Periodically updated.

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username: ANONYMOUS for FTP file transfer
username: FENDL for FTP file transfer of FENDL-1 files, FENDL2 for FENDL-2 files
For users with web-browsers: http://www-nds.iaea.or.at