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Evaluated Nuclear Structure Data File

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Abstract

The Evaluated Nuclear Structure Data File (ENSDF) contains the evaluated nuclear properties of all known nuclides. These properties are derived both from nuclear reaction and radioactive decay measurements. All experimental data are evaluated to create the adopted properties for each nuclide. ENSDF, together with other numeric and biliographic files, can be accessed on-line through the INTERNET or modem. Some of the databases are also available on the World Wide Web. The structure and the scope of ENSDF are presented along with the on-line access system of the National Nuclear Data Center at Brookhaven National Laboratory.

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1 Introduction

The Evaluated Nuclear Structure Data File (ENSDF) is maintained by the National Nuclear Data Center at Brookhaven National Laboratory on behalf of the International nuclear structure and decay data (NSDD) network. The NSDD is coordinated by the International Atomic Energy Agency, Vienna.

ENSDF contains evaluated experimentally measured properties, generally of basic and applied interest, for all known nuclides. The file has been in existence for almost twenty five years and is continually maintained and updated. The nuclear structure data journal *Nuclear Data Sheets*, published by the Academic Press, San Diago, CA, is directly produced from this file and contains evaluated information for $A > 44$. The evaluations for $A < 44$ are published in the journal *Nuclear Physics*, North Holland, Amsterdam, The Netherlands but their radioactive decay data and the properties' summaries are included in the ENSDF.

2 File Structure

The ENSDF file structure is schematically shown in figure 1. The file is organized by mass number of the resulting/daughter nucleus. Within a mass number it is organized by increasing Z value. For each nuclide, i.e., for a Z value, the information is given in data sets. There is generally a separate data set for each different kind of experiment by which a nuclide has been studied. Several experiments leading to similar information may be combined under one data set. There is a summary data set, Adopted Levels, Gammas, for each nucleus which summarizes the level and gamma ray properties for the nucleus. If there is only one experiment from which all the information for a nucleus is derived then its corresponding data set is also regarded as the Adopted data set for the nucleus. There are two data sets for each mass number (A-chain), namely, Summary and Reference data sets, which respectively summarize the evaluation and give translation for the key numbers

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used in the A-chain. For complete format details of ENSDF see reference [1].

3 Evaluation

The evaluations, by A-chains, which go into ENSDF are done by the members of the international Nuclear Structure and Decay Data (NSDD) network. The data centers which are part of this international effort are given in Table I.

The evaluation philosophy for ENSDF and the *Nuclear Data Sheets* is to present the best data available from each type of experiment in a well-documented manner. The emphasis in ENSDF is on the nuclear structure and decay properties obtained from the experimental evidence or well-founded systematics and theory. This emphasis and conservative approach result in an excellent general purpose file useful for both the basic and the applied scientist. No attempt is generally made to interpolate or extrapolate results to obtain properties which have not been observed. In particular, considerable emphasis is placed on assigning J^{π} values which are based upon well established "strong" rules. Those values not meeting the criteria and based upon one or more less established criteria, so called "weak" rules, are placed in parentheses. The ENSDF evaluators often depend on specialized "horizontal" evaluations available in literature. For example, the mass recommendations of Audi-Wapstra [2], and moments from Raghavan's evaluation [3] are generally quoted. Any divergence from their values are pointed out.

All evaluations, $A > 44$, are run through the same set of analysis and checking codes resulting in uniform results. For example, all coversion coefficients given in the file are as calculated from Hager-Seltzer tables [4] supplemented with Dragoun, Plajner, Schmutzler [5] and Band, Trzhaskovskaya, M. A. Listengarten [6] values. Similarly all reduced transition probilities given are calculated using adopted half-lives, branching ratios and the conversion coefficients.

4 NNDC Online System

On-line access to computerized numeric and bibliographic nuclear physics information is available from the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory to users in the United States and Canada [7]. There is currently no charge for this service. Similar services are also available from some of the members of the International Nuclear Structure and Decay Data Network.

The NNDC on-line system consists of a number of components which can be activated by the user either by menu selection or by commands[1] . The components include database retrieval programs, file manipulation, plotting[2] and other utility functions.

4.1 Access

One can use network or remote modem to access the NNDC on-line service. The service is available on an NNDC DEC Alpha computer.

4.1.1 Network Access

INTERNET Use TCP/IP's TELNET command:

TELNET BNLND2.DNE.BNL.GOV

(or 130.199.112.132)

WWW http://datwww.dne.bnl.gov/html/nndc.html

[1] users with ANSI- standard video terminals will get screen managed displays with menus, scrolled output, and high lighting

[2] users with graphic terminals using either Tektronix, PostScript, or Regis, have plotting capability for some of the database retrieval components

4.1.2 TELEPHONE

The NNDC VAX Alpha computer can be accessed via telephone using the commercial telephone number (516) 282-5390. Use the following communications parameters:

Protocol: ASCII only. Full duplex.

Speed: 2400 to 19200 bps.

Word: 8-bit, parity off, 1 stop bit or

7-bit, parity even, 1 stop bit.

Flow control: XON/XOFF

After getting the on-line signal, type a carriage return, wait and then type a second carriage return. The VAX login prompt should then appear on your terminal.

4.2 Trying the On-line System

The on-line system has a GUEST account which allows a potential user a limited amount of time to become acquainted with the system. After connecting to the system, enter the account name NNDC in response to the VAX login prompt **Username** and GUEST in response to the **Authorization code** prompt.

Username: NNDC

Enter NNDC assigned authorization code (or GUEST):

Enter your last name (or DEFAULT or ?) -

4.2.1 LOGOUT

When terminating a retrieval session, enter or select LOGOUT.

4.2.2 Interactive Authorization Request

Upon log out from the GUEST account, you may sign up to obtain authorization for your own account. Please provide your name, postal and e-mail address, telephone number, and a code of six or fewer characters which will be your personal authorization code. The accounts are generally activated by next business day.

You may also contact NNDC at the following address:

National Nuclear Data Center

Building 197D

Brookhaven National Laboratory

P.O. Box 5000

Upton, NY 11973-5000

Tel: (516) 282-2901, FAX: (516) 282-2806

E-Mail: NNDC@BNL.GOV or NNDC@BNL or BNL::NNDC

4.2.3 File Transfers

Computer files may also be transferred via an anonymous account on the NNDC DEC Alpha computer. Use the TCP/IP, FTP command, to connect to BNLND2.DNE.BNL.GOV (130.199.112.132). The user name of the anonymous account is "anonymous". Computer files may be transferred from/to the NNDC computer by using the FTP, GET/PUT commands.

4.3 AVAILABLE INFORMATION

4.3.1 Bibliographic Data Bases:

CINDA – Computer Index of Neutron Data – bibliographic references to neutron reaction data.

NSR – Nuclear Structure Reference file – bibliographic information for low and intermediate energy nuclear physics. The data are updated weekly.

4.3.2 Numerical Data Bases:

CSISRS – Cross Section Information Storage and Retrieval System – experimental data on neutron, photon, and charged particle reactions.

ENDF – Evaluated Nuclear Data File – evaluated nuclear reaction and decay data.

ENSDF – Evaluated Nuclear Structure Data File – evaluated experimental data on nuclear level properties, radiations, radioactive decay and reaction data for all known nuclides.

NUDAT – NUclear DATa – Adopted level and gamma-ray properties extracted from ENSDF. Radionuclide decay data derived from ENSDF. Ground and metastable state properties extracted from the Nuclear Wallet Cards. The neutron and resonance integral data extracted from Neutron Cross Sections, Vol. 1.

XRAY – Photon attenuation coefficients and cross sections. Polarized-beam scattering cross sections.

4.3.3 Other Information On-line

MIRD data base - Radioactive decay data in the format of the MIRD reports

ADDRESS - NNDC address file

NEWS - NNDC Newsletter

MASSES - The 1993 Atomic Mass Evaluation by G. Audi and A. H. Wapstra [2]

IRDF90 - International Reactor Dosimetry File (1990)

QCALC - Program to calculate reaction/decay Q-values using latest massses

SAMPLE retrievals, DOCUMENTS and computer CODES

Utilities to run nuclear physics codes (PHYSCO), PLOT retrieved data, and send electronic MAIL

File handling utilities (DIRECTORY, TYPE, SEND, DELETE)

5 World Wide Web

The NNDC on-line system can also be accessed (via TELNET) from WWW. The NNDC address on WWW is: http://datwww.dne.bnl.gov/html/nndc.html. The following is an extract from the NNDC home page

1. General Information

   - NNDC Brochure (Oct 1993)
   - On-Line Access Table - NNDC Newsletter Issue # 94-3

2. Programs, Data files and Manuals

   - ENSDF programs
   - ENSDAT - Produces tables and drawings of nuclear
   - structure and decay data
   - ENDF programs
   - PCNUDAT - An MS-DOS clone of the NNDC database
   - NUDAT
   - 1993 Audi-Wapstra Atomic Masses
   - The International Reactor Dosimetry File (IRDF-90 Version 2)

- NNDC Online Data Service Manual
- Evaluated Nuclear Structure Data File (ENSDF)

NOTE: The programs, data files and manuals above may be obtained using FTP from bnlnd2.dne.bnl.gov, anonymous.

3. MIRD - Tables and drawings of nuclear decay data in the Medical Internal Radiation Dose format.
4. ENSDF Status
   - ENSDF Format Summary and Examples
   - Mirror of Table of Nuclides at Korea Atomic Energy Research Institute (To K.A.E.R.I)
5. Online Access - Use LOGIN:NNDC. This is a Telnet Connection.
6. Others
   - The American Physical Society http://aps.org/
   - The Durham/RAL HEP Databases - HEPDATA http://cpt14.dur.ac.uk:80/
   - GAMQUEST, a Computer Program to Identify Gamma Rays (from the Isotopes Project, LBL)
     http://www.lbl.gov/./LBL-Programs/Gamquest.html
   - Lund Nuclear Data Service
     http://www.fysik.lu.se/nucleardata/welcome.htm
   - NucPhysElecttronic http://www.nucphys.nl/www/pub/nucphys/npe.html
   - OECD Nuclear Energy Agency http://db.nea.fr/www_html/welcome.html
   - Table of the Nuclides from K.A.E.R.I.
     http://hpngp01.kaeri.re.kr/CoN/index.html (mirror at NNDC above)
   - T.U.N.L. Home Page http://www.tunl.duke.edu/
   - W.K.Kellogg Radiation Laboratory http://www.krl.caltech.edu/

6 ENSDF updating

Lately, the NSDD network has priortized certain A-chain and certain kinds of evaluations. Due to considerable activity in the field, a group of evaluators is concentrating on evaluating the high-spin data. Similarly, a task force of evaluators will concentrate on evaluation of radioactive nuclides of interest to applied users. The file is continuously updated with the publication of evaluations alternating in full and update modes every few years. Between the publications new data are included in the file which can be accessed through the online system.

7 Summary

Evaluated Nuclear Structure Data File is the product of a very successful continuing international collaborative effort spanning over three decades. The exposure to the file and its derivatives has increased many fold since its availability on-line. The NSDD network, which meets every two years, is always trying to improve usefulness and the quality of the file. Lately, several moves have been made to expand the scope and currency of the file to meet the growing needs of its many users. The access of the file via various media, both electronic and paper, have been under review. The ENSDF is the primary source for many publications, e.g., the *Nuclear Data Sheets*, the *Table of Isotopes 8th Edition* (under preparation), and the *Nclear Wallet Cards*. Its distribution via CD-ROM is under consoideration. ENSDF is one of the major databases which constitute the ever popular on-line system at the NNDC. Its derivative databases NUDAT and MIRD have also been very popular with the users.

8 Acknowledgements

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9 References

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2. G. Audi, A.H. Wapstra, The 1993 atomic mass evaluation, Nuclear Physics A565, 1 (1993)

3. P. Raghavan, Table of Nuclear Moments, At. Nucl. Data Table 42, 189 (1989)

4. R.S. Hager, E.C. Seltzer, Internal Conversion Tables, Nucl. Data A4, 1 (1968)

5. O. Dragoun, Z. Plajner, F. Schmutzler, Contribution of Outer Atomic Shells to Total Internal Conversion Coefficients, Nucl. Data Tables A9, 119 (1971)

6. I.M. Band, M.B. Trzhaskovskaya, M.A. Listengarten, Internal Conversion Coefficients for Atomic Numbers $Z \leq 30$, At. Nucl. Data Tables 18, 433 (1976)

7. C. L. Dunford, T. W. Burrows, Online Nuclear Data Service, Rept. NNDC/ONL-93/10 (periodically revised)

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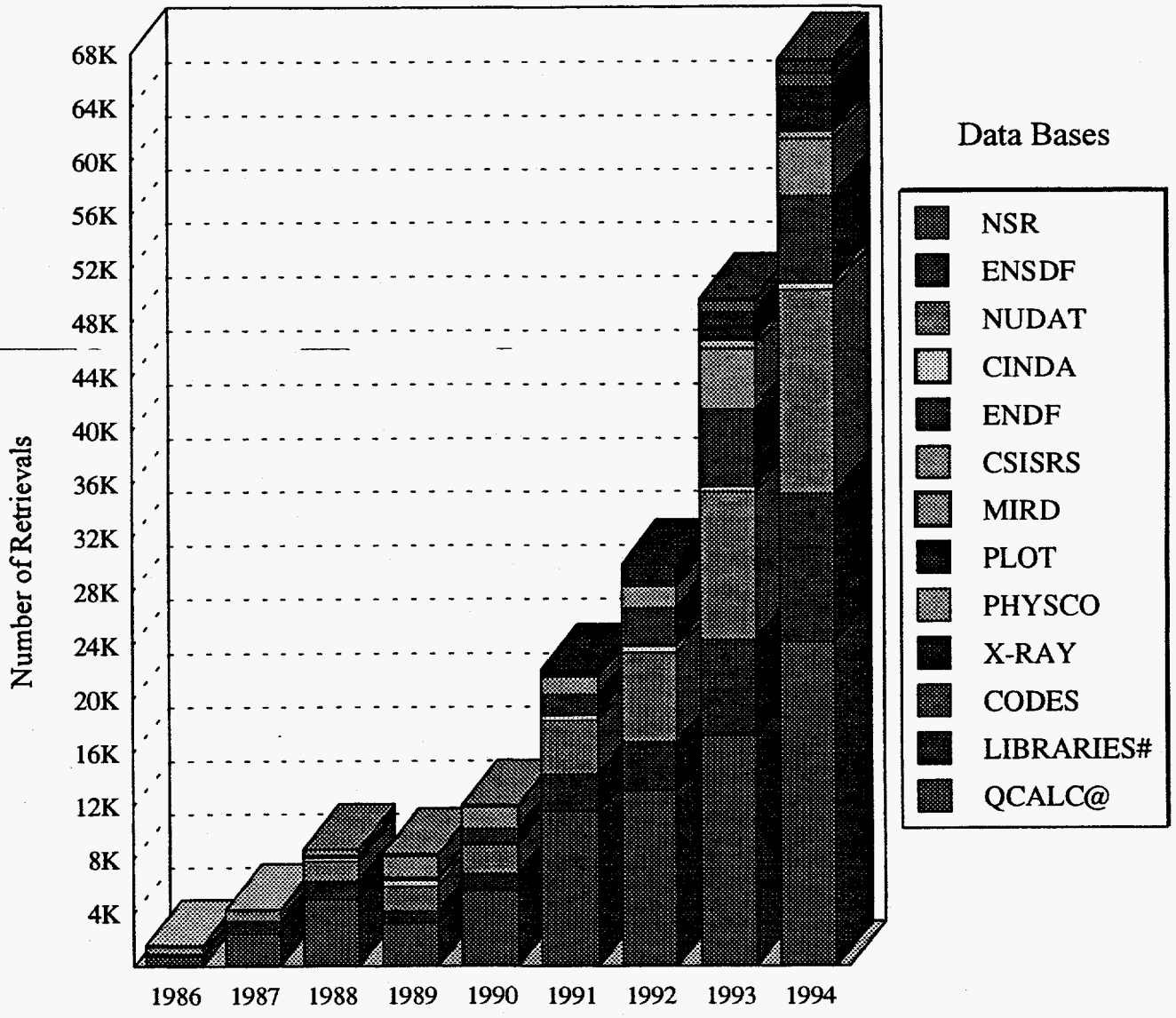
NNDC On-Line Data Service Retrievals 1986-1994

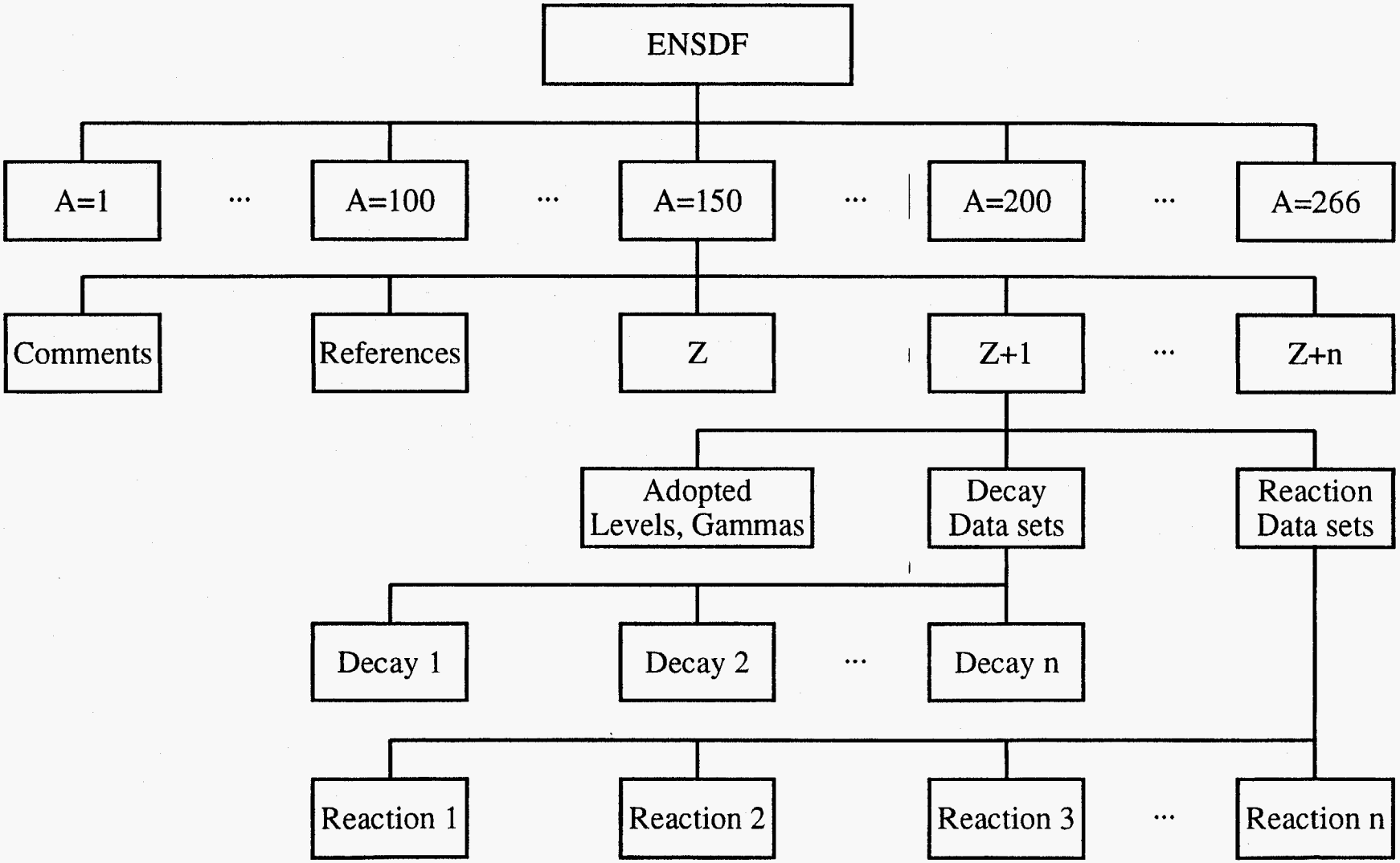


1993 Audi-Wapstra Atomic Mass Evaluation. - Added November, 1993. International Reactor Dosimetry File (IRDF) - Added June 10, 1994

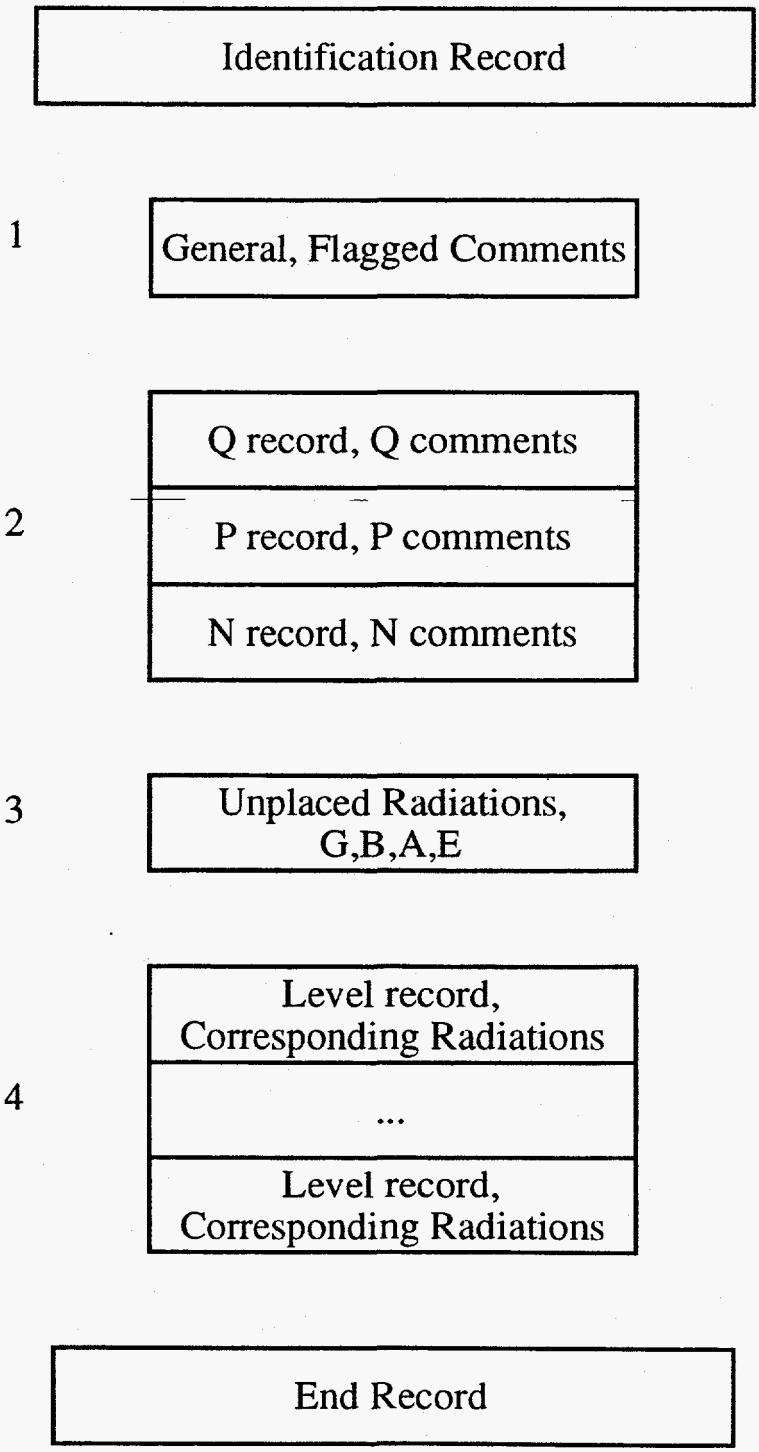
@ Added July 27, 1994

EVALUATED NUCLEAR STRUCTURE DATA FILE

Organization Chart



DATA SET STRUCTURE



Summary

ENSDF Standard One-Record Formats

Record Type	1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
Identification	NUCID* [redacted] DSID DSREF PUB DATE
General Comment	NUCID *# [redacted] CTEXT
Flagged Comment	NUCID *#$ SYM(FLAG) CTEXT
Normalization	NUCID [redacted] N NR
Production Normalization	NUCID PN NRxBR
Parent	NUCID [redacted] P E
Q-Value	NUCID* Q Q
Level	NUCID* L E
Gamma	NUCID* G E
Beta	NUCID* B E
Electron Capture	NUCID* E E
Alpha	NUCID* A E
Reference	AAA [redacted] R KEYNUMBER REFERENCE
Particle	NUCID* E
Cross Reference	NUCID [redacted] X DSID [redacted]
Source Reference	NUCID [redacted] S DSID DSREF [redacted]

Table I
International Nuclear Structure and Decay Data Network

National Nuclear Data Center
Brookhaven National Laboratory
Upton, NY 11973, USA
Contact: M. Bhat

Nuclear Data Project
Oak Ridge National Laboratory
Oak Ridge, TN 37831, USA
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