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ENSDF – THE EVALUATED NUCLEAR STRUCTURE DATA FILE

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A file on nuclear structure and decay data, ENSDF, has been implemented as a set of ADABAS files at the Fachinformationszentrum Energie, Physik, Mathematik in Karlsruhe. NATURAL and ASSEMBLER program packages have been developed for the on-line presentation of the data. Problems encountered in representing large floating point numbers and the inherent hierarchy of the data are discussed.

1. Introduction

The ENSDF data base system at the Fachinformationszentrum Energie Physik, Mathematik consists of a number of ADABAS files on nuclear structure which can be grouped into

(1) ENSDF — the Evaluated Nuclear Structure Data File,
(2) NSR — the Nuclear Structure References,
(3) MEDLIST — Nuclear Decay Data for Radionuclides.

Both files NSR and MEDLIST are closely related to the numerical data base ENSDF. NSR contains as a subset all bibliographic references used in constructing the data contained in ENSDF, whereas MEDLIST represents data which is directly derived from ENSDF-decay data sets via lengthy computer calculations with the MEDLIST code. In the sequel we are mainly concerned with the contents and structure of ENSDF and shall discuss its transformation into a relational data base, which is currently offered on-line at FIZ under the DBMS ADABAS.

1.1. Origin and status of ENSDF

The systematic collection and evaluation of data from nuclear structure experiments has been performed by the Nuclear Data Project, Oak Ridge National Laboratory for more than 30 years. These evaluated data were published from time to time in the journal Nuclear Data Sheets and it was only in the 1970's that a formal structure was designed for entering these data into computer files [1,2]. Subsequently a number of analysis and display programs were developed, which allowed the production of drawings and tables for Nuclear Data Sheets directly from the computer files. Thus these files, which contain data for all known chemical isotopes (approx. 2000), quickly became the main storage medium for evaluated nuclear structure data. During 1981 responsibility for the ENSDF master file was taken over by the National Nuclear Data Centre, Brookhaven National Laboratory. The various atomic mass regions have been allocated to nuclear structure groups throughout the world, who take part in an international effort on nuclear structure data evaluation. The contributing centres, which form the Network on Nuclear Structure and Decay Data (NSDD), are:

USA — NNDC, Brookhaven National Laboratory
NDP, Oak Ridge National Laboratory
LBL, University of California, Berkeley
INEL, EG and G, Idaho Falls
UP, University of Pennsylvania, Philadelphia

USSR	CAJaD, Institut Atomnoi Energii I.V. Kurchatova, Moscow LIYaF, Leningrad Nuclear Physics Inst. Gatchina, Leningrad Region
The Netherlands	Fysisch Laboratorium, University of Utrecht
UK	Oliver Lodge Lab., University of Liverpool
Fed. Rep. Germany	Fachinformationszentrum Energie, Physik, Mathematik, Karlsruhe
France	CEN de Grenoble, Grenoble-Gare
Japan	Japan Atomic Energy Research Institute
Sweden	University of Lund, Lund
Kuwait	Kuwait Institute for Scientific Research
Belgium	Laboratorium voor Kernfysika, Gent
Canada	Tandem Accelerator Lab., McMaster University, Hamilton, Ontario

Mass chains are evaluated, passed through a review procedure and are replaced in the master file one at a time. A turn-over cycle of approximately 5 years per mass chain is being maintained. Updates to our file, which encompass the whole mass range $A = 1$ to 263, are received from Brookhaven biannually. The size of our file is currently 52 Mbyte.

1.2. Contents and structure

The content and format of the original file have been described by Ewbank and Schmorak [1]. The basic physical unit stored in ENSDF is called a data set and describes the results of a single experiment or the combined evaluated results of a number of experiments of the same type. In appendix A an example is given of an original ENSDF data set in the format currently used by the NSDD-Network. This format is unsuitable for retrieval by ADABAS. It consists of an open-ended collection of 80-byte records of different types. In addition to a record identifying the ENSDF-data

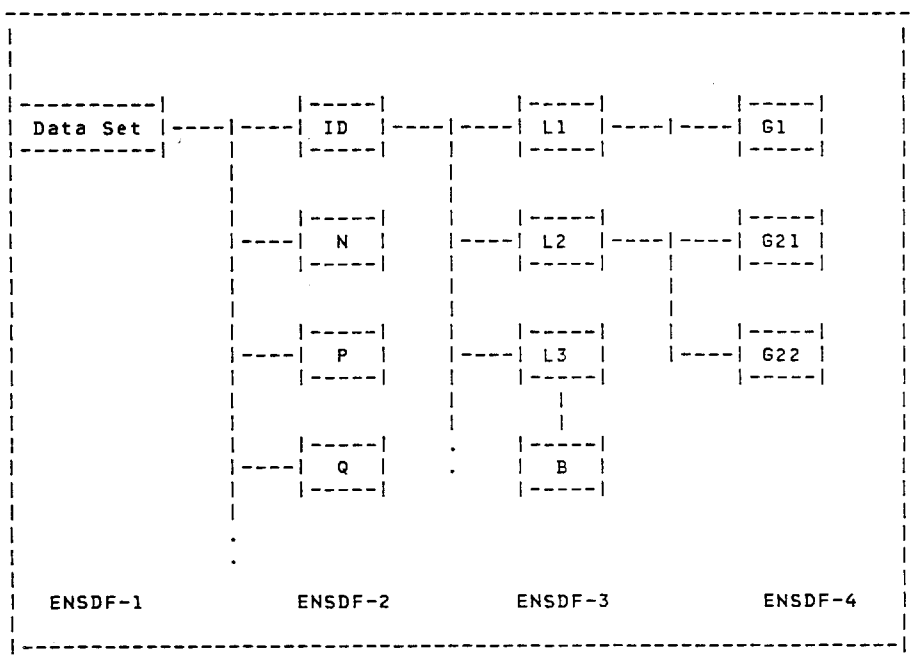


Fig. 1. Structure of ENSDF.

set (ID-record) one has different types of comment records (C, CL, CG, ...), normalization (N) and parent (P) records for decay data sets, Q-value (Q), Level (L), gamma (G), beta (B), electron capture (E), and alpha (A) records. As shown in appendix A these different records are combined in a complex hierarchical scheme. Fortunately, we are not dealing with a network structure, but rather with a tree as shown in fig. 1.

Here the level ENSDF-2 represents those quantities which refer to the whole data set as such, ENSDF-3 contains the distinct excited levels of the residual nucleus, their static properties, and properties of any associated radiation (beta, alpha) feeding the levels, whereas ENSDF-4 contains all gamma lines leaving a particular level together with their associated properties. The beta ray feeding level L3 has been included in ENSDF-3 since there exists a one-to-one relationship between this type of associated radiation and the level involved. The relationship ENSDF-3 to ENSDF-4 is of the one-to-many kind.

Comment records are not shown in the diagram, but may exist on any of the levels ENSDF-2 to ENSDF-4. L-, G-, B-, E- and A-cards may have continuation cards in free format for those keyword data not catered for in the regular fixed format cards. The experimentally measured K-conversion coefficient for the gamma G22 in fig. 1, for example, is contained on a gamma continuation card in the form EKC = value enclosed in the box G22 belonging to the level L2 of the data set with identification ID.

It is clear that with open-ended structure a large amount of data can be documented. The standard fixed format records contain over 80 distinct fields, whereas another 40 quantities are regularly recorded in the form keyword = value.

At present the data contained in ENSDF is based on some 14000 different literature citations. Over 80% of the references cited are regular journal articles. Reports and Conference Proceedings constitute 8 and 5% of the total, respectively. All other sources are at a level of 1% or less.

1.3. The PL/1-version

The original ENSDF data base developed at Oak Ridge was organized as a PL/1 REGIONAL (1) file with RECSISE = BLOCKSIZE = 44×80 = 3520 bytes. The 80 byte ENSDF records were tightly packed into the blocks. Positioning within blocks was achieved by sequentially counting the 80 byte records when generating the REGIONAL(1) file and noting the position of the ID records in a separate ISAM file. Using the contents of the ID-record as an 80 byte GENERIC key the record number was retrieved and the block number calculated. Retrieval was thus strictly data set-wise using information contained in the ID-records. Typical search formulations were

FIND A = 80–82 *Z* = 36 '*DECAY*'

where a scan was performed for the term in quotation marks. Deletions from the file were performed by deleting the 80 byte ISAM-key. New data was added to the back of the REGIONAL(1) file, at the same time generating the new ISAM-key. From time to time the data bank had to be regenerated. This system worked well and is still in use at FIZ for individual mass chains. It is not suited for complex retrievals.

2. Organization of ENSDF files in ADABAS

The DBMS ADABAS together with the retrieval and programming language NATURAL offers much greater flexibility in data manipulation than the PL/1-system described above. The natural choice of associating one variable length ADABAS record with a physical ENSDF data set could not be realized because an ENSDF data set could easily be 1000 records or more in length. In version 4.1 of ADABAS the compressed input record length cannot be more than 3000 bytes. Associating an ADABAS record with an 80 byte ENSDF card was tried [3], but the field definitions proved to be complicated, the same fields had to contain more than one type of data depending on the type of record involved and even simple FIND-formulations involved the use of several descriptor fields. The data definitions eventually chosen are given in appendix B and represent the hierarchy in fig. 1.

The original ENSDF file has been split into four separate files joined by a common 8-digit key

number (A–Z–DSNR) built up from the atomic mass A (3 digits), atomic charge Z (3 digits) and the Data Set Number DSNR (2 digits). DSNR numbers the original physical ENSDF data sets sequentially from 00 to 99.

ENSDF-1 is a replica of the original file and consists of fixed and variable length fields. The contents are in alphanumeric EBCDIC code. Representing numerical quantities purely as character strings allows for great flexibility in the display, but has the disadvantage that individual numbers have to be extracted from possible accompanying text.

ENSDF-2 contains all quantities which occur in a physical data set only once. These include the identification record, the parent record for decay data sets and Q-values.

ENSDF-3 contains all information connected to a particular nuclear level. Included are beta-EC- or A-branches feeding this level, but no gammas.

ENSDF-4 contains information connected to gamma transitions in a nucleus.

Although still more than 100 descriptor field names are necessary to retrieve all interesting physical quantities, the simplified data definitions lead to improved response times, since the records in the split files are now much shorter than in the original single file data definition.

3. Internal representation of data

As can be seen from the file definition tables (appendix B), nearly all alphanumerical fields for the files ENSDF have been loaded zero-suppression (NU = Nullunterdrückung), where trailing blanks are discarded. Leading blanks are significant, however, and cannot be omitted. In preparing ADABAS records numerical data was extracted from ENSDF from all formatted or fixed field data cards. In addition certain quantities such as decay branching rates, B(E2)-values, etc. were extracted from level- or gamma continuation records. No data was searched for in COMMENT records.

ENSDF-data such as 1014.23 10 meaning 1014.23 + − 0.10 had to be converted into ADABAS-acceptable form:

Assuming that these values represent a level energy, appendix B on Internal Representation of Data shows us the format in which it appears: U10.4 for field LE, file ENSDF-3. The item is stored internally as 0010142300.

In order to be able to store a large range of numerical values, and since NATURAL V1.1 does not support floating point numbers, a pseudo-exponential representation was devised. In this scheme all numbers are modulo 50. For example in E8 format

1.23E + 03 → 53123000
0.123 → 49123000
0 (true zero) → 00000000

Negative numbers are recognized.

4. Command structure

Retrieval of data from ENSDF is performed using the programming language NATURAL. However, since we do not assume that users of the file be familiar with NATURAL, they only interact with preprogrammed packages. For convenience, some of these modules were written in ASSEMBLER-language. For example three ASSEMBLER programs are avaliable for converting data: ASMTOT converts data from normal floating point or decimal representation (1.23E–04 or 23.45) to E or U Format as described in section 3, while ASMEXP and ASMDEC revonvert the data from the file into the usual alaphanumeric form.

In addition to the above, an ASSEMBLER program plays the role of a terminal-NATURAL interface, analyzes user input and defines a COMMAND level. The automatic conversion of time units (e.g. 1.73 E + 13 years to seconds) is also performed by this interface.

Due to space limitations it is not possible to describe the commands available. The use of some of the commands listed below is illustrated in section 5: retrieval examples. The following commands are active:

BASE FIND DISPLAY PLOT TAB INFO HELP MENU STOP END COST TYPE %% PRINT PRINT-L PRINT-LG SHOW SHOW-L SHOW-LG SHOW-REF

It is sufficient to enter only as many letters as are needed to uniquely identify a command. For example:

H HE HEL HELP

are all interpreted as HELP (? also means HELP).

5. Retrieval examples

⟨Comments are placed in angular brackets. Data entered from the screen are marked with '***'⟩

⟨LOGON PROCEDURE⟩

```
FIZ KARLSRUHE:  DATE  83--02-24  TIME: 10.22.34
**********************************************************************
NEUE RECHENANLAGE SIEMENS 7561, BS2000 V7.1
NATURAL V1.1 B006 A PRODUCT OF SOFTWARE AG
NEXT
*** ADA
*** ?
  1.  ENEC      ENERGY AND ECONOMIC DATA BANK
  2.  NSR       NUCLEAR STRUCTURE REFERENCES
  3.  ENSDF     NUCLEAR STRUCTURE AND DECAY DATA
  4.  MEDLIST   RADIOACTIVE DECAY DATA
PLEASE ENTER NUMBER OR NAME (OR END FOR TERMINATION)
*** ENSDF
```

⟨A list of descriptors for file ENSDF is offered⟩

```
ENTER: F = FIND D = DISPLAY (BROWSE) H = HELP
** MA EL ZA DS DA CD RF QM SN SP
   QA NR PM PN PA PJ PF PT PQ LN
   GE GI MU MF MR CC GT KT KK KL
   KM BV LE L  LT LV Q2 FT TI NO
CMD
*** HELP

DESCRIPTION OF PARAMETERS FOR FILE ENSDF (DESCRIPTORS)
```

```
MA : ATOMIC MASS OF NUCLEUS, E.G. 86 OR RANGE: 81 TO 100
EL : CHEMICAL ELEMENT NAME, E.G. SR
ZA : ATOMIC CHARGE OF NUCLEUS
DS : DATA SET NUMBER (0 FOR ADOPTED LEVELS)
DA : DATE OF ORIGINAL ENSDF-DATA SET (FORMAT: 820326)
CD : STRING TERMS IN IDENTIFICATION CARD, E.G. DECAY, ADOPTED
RF : REFERENCE KEYS (NUCLEAR STRUCTURE REFERENCES:78AB03)
QM : Q-VALUE (B-) (NOTE: ENERGIES ARE ALWAYS IN KEV)
SP : PROTON SEPARATION ENERGY S(P)
QA : Q (ALPHA)
```

CONTINUE (Y|N)?
* * * Y
NR : NORMALIZATION FACTOR FOR GAMMAS (PHOTON INTENSITIES)
PM : PARENT NUCLEUS MASS (FOR DECAY DATA SETS)
PN : PARENT ELEMENT SYMBOL
PA : EXCITATION ENERGY OF DECAYING PARENT NUCLEUS LEVEL
PJ : PARENT LEVEL SPIN
PF : PARENT LEVEL PARITY FLAG
PT : PARENT NUCLEUS (LEVEL) HALF-LIVE
PQ : GROUND STATE TO GROUND STATE Q-VALUE
LN : LEVEL NUMBER (MAX 3 DIGITS- GND STATE IS 001)
GE : GAMMA ENERGY (IN KEV-SMALLEST INCREMENT IS 0.0001)
GI : GAMMA INSTENSITY (RELATIVE)
MU : GAMMA MULTIPOLARITY
MF : MULTIPOLARITY FLAG
MR : MIXING RATIO
CC : TOTAL CONVERSION COEFFICIENT

CONTINUE (Y|N)?
* * * N
FOR INFORMATION ON ACTIVE PROGRAMS ENTER:
HELP PT (ANY DESCIPTOR NAME) OR HELP PROG
CMD

5.1. First FIND formulation for ENSDF

* * * F MA = 84 EL = SR

⟨Find all data sets with chemical element symbol Sr and mass 84. Note that the logical AND is implied. Other logical operators are not allowed. Leading blanks in alphanumerical fields are significant. Each FIND formulation stands on its own and overwrites previous results. There is no 'history' of FIND-statements⟩

PROGRAM ID-MAEM: 11 DATA SETS FOUND
PROCESS? (Y|N)
* * * Y

DATA SETS FOR MASS 84 TO 84 AND ELEMENT = SR

1	84 SR	ADOPTED LEVELS, GAMMAS		79N
2		SR 84RB B − DECAY	58B381	79N
3		SR 84Y B + DECAY (40.2M)	69ZA06, 71D001	79N
4		SR 84Y B + DECAY (4.6 S)	76IA01	79N
5		SR 76GE(12C, 4NG)	711NZZ	79N
6		SR 84SR(P, P'), (P, P'G)	73RED1	79N

7	SR 84SR(D, D')	73RE01	79N
8	SR 84SR(A, A'), (A, A'G)	73RE01	79N
9	SR COULOMB EXCITATION	63Al31	79N
10	SR 85RB(P, 2NG)	72YOZP, 74SA23	79N
11	SR 86SR(P,T)	73BA56, 73MO11	79N

CMD
* * * CMD?
BASE FIND DISPLAY SHOW SHOW-L SHOW-LG SHOW-REF
PRINT PRINT-L PRINT-LG PLOT TABLE INFO HELP
MENU STOP END %% COST TYPE
REPEAT: INPUT CANNOT BE IDENTIFIED
CMD
* * * SHOW-L NO = 1

DATA FOR 84 SR ADOPTED LEVELS, GAMMAS 79NDS

NMBR	E-LEVEL	DELTA-E	JPI	HALF-LIFE
001	0		0 +	STABLE
001	793.09	10	2 +	5.0 PS
003	1453.74	13	(2 +)	5 NS
004	1503	3	0 +	
005	1767.45	14	(4 +)	5 NS
006	2055.91	15	(3 +)	5 NS
007	2075	5	0 +	
008	2390	5	(2 +)	
009	2447.92	15	3 −	
010	2525	5	(0 +)	
011	2598.05	24		
012	2775	5	(5 −)	
013	2807.43	19	(6 +)	5 NS
014	2880	5	(2 +)	
015	3045	5	(4 +)	
016	3175	5	(2 +)	
017	3270.25	21	(4 + ,5,6 +)	

CONTINUE (Y|N)?
* * * N
CMD
* * * SHOW-LG NO = 1
DATA FOR 84 SR ADOPTED LEVELS, GAMMAS 79NDS

NMBR	E-LEVEL	DELTA-E	JPI	T-HALF	E-GAMMA	DEL-EG	I-GAMMA
002	793.09	10	2+	5.0 PS	793.1	1	100
003	1453.74	13	(2+)	5 NS	1453.6	3	10.7
					660.7	1	100
004	1503	3	0+		709.5	30	
005	1767.45	14	(4+)	5 NS	974.4	1	
006	2055.91	15	(3+)		1262.5	3	28
					602.2	1	100
					288.3	5	9

009	2447.92		3−		1654.6	2	62
					994.2		100
					680.6		
011	2598.05	24			1144.3		
013	2807.43	19	(6+)	5 NS	1039.8		100
017	3270.25	21	(4+,5,6+)		1502.8		68
					462.8		100
021	3511.75	23			1744.4		52
					703.6	5	100
024	3923.4	11	(8+)	5 NS	1116	1	100
025	4062.47	20	(4+)		2295.3	4	37
					2006.7	5	5
					1614.5	2	30
					1255.0		100

CMD
*** SHOW-REF NO = 1

⟨Show the literature citations which have been used to construct this ENSDF Data Set by directly accessing file NSR⟩

THERE ARE 12 REFERENCES IN DATA SET 8403800

73REO1	JOUR	PRVCA	C7 210
73BA56	JOUR	PRVCA	C8 1438
69ZA06	JOUR	IANFA	33 1283
70REO3			
71KI16	JOUR	NUPAB	A177 433
730G01	JOUR	PYLBB	45B 214
73SI25	JOUR	PYLBB	45B 199
73MO11	JOUR	ZEPYA	261 155
72YOZP	REPT		INSJ 1972 Ann REPT P38
77WA08	JOUR	ADNDA	19 175
71INZZ	REPT		IPCR 1971 Annual, Vol5 R46
74SA23	JOUR	IANFA	38 758

NUMBER OF DOCUMENTS SHOWN = 12
SHOW COMPLETE DOCUMENTS (Y|N)?
*** Y
73RE01 A 800630 810414 JOUR PRVCA C7 210

73RE01 A.C. Rester, B. van Nooijen, P. Spilling, J. Konijn, J.J. Pinajian Phys. Rev. C7, 210 (1973)
84Sr(x, x′) and 84Sr(x, x′g) Measurements with 13-MeV Protons, 12-MeV Deuterons, and 18-MeV a Particles
NUCLEAR REACTIONS 84Sr(a, a′), (a, a′g), (p, p′), (p, p′g), Ea = 18 MeV; Ep = 13 MeV; 84Sr(d, d′), E = 13 MeV; measured s(Ea′, q(a′), Eg), s(Ep′, q(p′), Eg), s(q(d′)). 84 Sr deduced levels, J, p, b.
73BA56 A 800630 810414 JOUR PRVCA C8 1438

73BA56 J.B. Ball, J.J. Pinajian, J.S. Larsen, A.C. Rester
Phys. Rev. C8, 1438 (1973)

Study of 82Sr, 84Sr, and 86Sr with the (p, t) Reaction
NUCLEAR REACTIONS 84, 86, 87, 88Sr(p, t), E = 31 MeV; measured s(Et, q).
Deduced Q. 82, 84, 86Sr deduced levels, J, p, L, enhancement factors.
69ZA06 A 800701 810414 JOUR IANFA 33 1283

69ZA06 N.G. Zaitseva, B. Kratsik, M.G. Loschilov, G. Muziol, Chan Tkhan Min, H. Strusny
Izv. Akak. Nauk SSSR, Ser. Fiz. 33, 1283 (1969); Bull. Acad. Sci. USSR, 33, 1186 (1970)
CONTINUE (Y OR N)?
* * * Y
The Decay Scheme of 84Y
RADIOACTIVITY 84Y from Sr(p, xn); measured Eg, Ig, deduced log ft. 84Sr deduced levels, J, p, g-multipolarity. Ge(Li) detector.
70RE03 A 800701 810414

70RE03 A.C. Rester
Priv. Comm. (1970)
NO TITLE GIVEN
NONE
71KI16 A 800701 810414 JOUR NUPAB A177 433

71KI16 J.E. Kitching, W.G. Davies, W.J. Darcey, W.McLatchie, J. Morton Nucl. Phys. A177, 433 (1971)
Effective Interaction among 1g9/2 and 2pl/2 Neutrons in the Strontium Isotopes
NUCLEAR STRUCTURE 83, 84, 85, 86, 87Sr; calculated levels, one-nucleon S, wave functions. Effective interaction shell model.
73OG01 A 800630 810414 JOUR PYLBB 45B 214

730G01 K. Ogawa
Phys. Lett. 45B, 214 (1973)
Shell Model for Rotation-Like Spectra of Sr Isotopes
NUCLEAR STRUCTURE 80, 82, 84, 86Sr; calculated levels, J, p.
CONTINUE (Y OR N)?
* * * N
CMD
* * * TAB

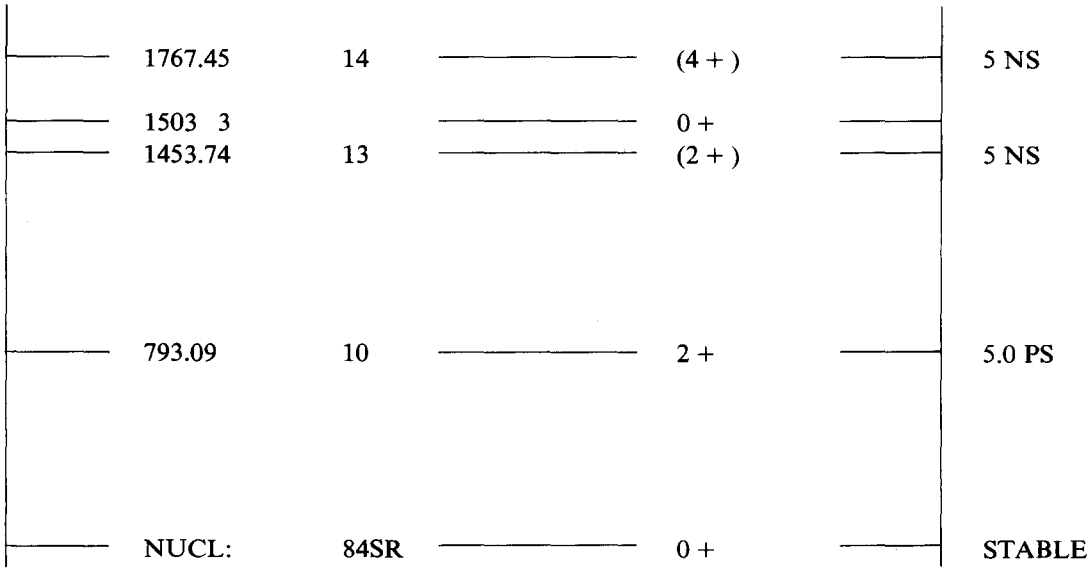
TABLE OF RESULTS FOR ENSDF

001 084 SR ADOPTED LEVELS, GAMMAS		79NDS
002 084 SR 84RB B − DECAY	58BE81	79NDS
003 084 SR 84Y B + DECAY (40.2 M)	69ZA06, 71DO01	79NDS
004 084 SR 84Y B + DECAY (4.6 S)	76IA01	79NDS
005 084 SR 76GE(12C, 4NG)	71INZZ	79NDS
006 084 SR 84SR(P, P′), (P, P′G)	73RE01	79NDS
007 084 SR 84SR(D, D′)	73RE01	79NDS
008 084 SR 84SR(A, A′), (A, A′G)	73RE01	79NDS
009 084 SR COULOMB EXCITATION	63AL31	79NDS
010 084 SR 85RB(P, 2NG)	72YOZP, 74SA23	79NDS
011 084 SR 86SR(P, T)	73BA56, 73MO11	79NDS

CMD

⟨Draw a simplified energy level diagram for the nucleus in Data Set No = 1. Shown are the excitation energies, spins/parities and half-lives of the 84Sr levels⟩

```
* * * PLOT NO = 1
SCALE FACTOR = 1
```




```
CONTINUE (Y|N), SKIP (S) ?
* * * N ⟨Note: the option S is not implemented⟩
CMD
* * * BASE
NSR     ENSDF     MEDLIST
REPEAT: INPUT CANNOT BE IDENTIFIED
CMD
```

5.2. Search for a gamma line of 660 kev in ADOPTED LEVEL data sets

⟨Note that this line was present in the SHOW-LG display of 84Sr⟩

```
* * * F GE = 660 CD = ADOPTED

DATA SETS FOR E-GAMMA FROM     660 TO     660 KEV
AND ID-STRING FROM ADOPTED     TO ADOPTED
```

1	660.70	84 SR	ADOPTED LEVELS, GAMMAS
2	660.60	85 SR	ADOPTED LEVELS, GAMMAS
3	660.83	91 Y	ADOPTED LEVELS, GAMMAS
4	660.83	117 IN	ADOPTED LEVELS, GAMMAS
5	660.20	121 I	ADOPTED LEVELS, GAMMAS
6	660.08	245 AM	ADOPTED LEVELS, GAMMAS

```
CMD
```

5.3. Search for the same gamma line in decay data sets

* * * F GE = 660 CD = DECAY

DATA SETS FOR E-GAMMA 660 TO 660 KEV
AND ID-STRING FROM DECAY TO DECAY

1	660.00	18 F	18NE EC DECAY	78AJ03
2	660.05	77 AS	77GE B − DECAY (11.30 H)	74LEY0
3	660.70	84 SR	84Y B + DECAY (40.2 M)	69ZA06, 71DO0
4	660.50	89 RB	89KR B − DECAY	
5	660.90	91 Y	91SR B − DECAY	77HO12, 73HA1
6	660.00	99 PD	99AG EC DECAY	
7	660.66	101 TC	101MO B − DECAY (14.6 M)	75WR01, 72CO1
8	660.20	104 RU	104TC B − DECAY	
9	660.20	RU	104TC B − DECAY	
10	660.83	117 IN	117CD B − DECAY (2.49 H)	
11	660.40	119 CD	119AG B − DECAY	
12	660.20	121 J	121XE B + DECAY	72MU03, 71HO0
13	660.40	131 BA	131LA B + DECAY	
14	660.71	141 BA	141CS B − DECAY	77TAZZ
15	660.80	LA	141BA B − DECAY	70MC22, 77TAZ
16	660.00	142 BA	252CF SF DECAY	72WI15, 71CH4
17	660.60	148 ND	148PR B − DECAY	76YA06
18	660.70	154 GD	154EU B − DECAY (8.8 Y)	68ME12, 77GU1

CONTINUE ? (Y|N)
* * * N

CMD
* * * H GE

ACTIVE PROGRAMS INVOLVING GE

CDGE	CDGELE	ELGE	ELGELE	GE	GELT	GEMU
MACDGELE	MAELCDGE	MAELGE	MAELGELE	MAGE	MAGEBV	MAGEGI
MAGEGT	PTGE	PTGECC	PTGEKK			

CMD

5.4. Search for gamma lines of 600 to 602 keV in neutron reactions and originating from levels with an energy of less than 1000 keV

* * * F GE = 600 TO 602 CD = (N, $ LE < 1000

NDSET	E-GAMMA	E-LEVEL	MASS ELEM	TEXT	
1	600.60	736.90	103 RU	102RU(N,G)	73
2	600.65	873.40	105 RU	105RU(N,G)	
3	602.30	875.28	116 IN	115IN(N,G)	76
4	602.42	602.42	124 TE	123TE(N,G)	69
5	601.50	601.89	140 LA	139LA(N,G)	70
6	602.77	602.83	175 YB	174YB(N,G)	
7	602.40	653.80	235 U	234U(N,G) SECONDARY GAMMAS	72
8	602.40	970.00	U	234U(N,G) SECONDARY GAMMAS	72

CMD

5.5. Search for gamma lines of 600 to 605 keV with half-lives between 1 sec and 1 min (decay data sets)

* * * F GE = 600 TO 605 PT = 1 S TO 1 M

NDSET	E-GAMMA	LEVEL	MASS ELEM	TEXT	HALF-LIFE
25	600.00	10	99 ZR	99Y B − DECAY	1.50 E + 00
26	600.10	5	100 MO	10ONB B − DECAY	1.50 E + 00
62	600.30	0	184 PT	184AU EC DECAY	5.30 E + 01
104	601.84	8	139 CS	139XE B − DECAY	3.96 E + 01
150	602.85	4	91 SR	91RB B − DECAY	5.84 E + 01
151	602.60	57	93 SR	93RB B − DECAY	5.86 E + 00
153	602.60	8	99 ZR	99Y B − DECAY	1.50 E + 00
182	602.21	15	143 LA	143BA B − DECAY	1.45 E + 01
189	602.00	3	154 ER	154TM EC DECAY (3.0 S)	3.00 E + 00
254	603.50	2	135 I	135TE B − DECAY	1.92 E + 01
300	604.70	21	119 CD	119AG B − DECAY	2.10 E + 00
318	604.63	0	141 CS	141XE B − DECAY	1.72 E + 00
360	605.10	10	112 SN	112SB EC DECAY	5.14 E + 01
373	605.13	17	141 BA	141CS B − DECAY	2.49 E + 01
374	605.90	12	SM	141 EU EC DECAY (40.0 S)	4.00 E + 01
375	605.90	7	SM	141EU EC DECAY (3.3 8)	3.30 E + 00
376	605.56	0	142 CS	142XE B − DECAY	1.22 E + 00
377	605.20	14	143 BA	143CS B − DECAY	1.78 E + 00

CONTINUE ? (Y/N)

* * * N
CMD
* * * SHOW NO = 62

⟨Note that the SHOW command results in a display of the data set in the original ENSDF exchange format⟩

```
COMPLETE DATA FOR 184 PT
184AU EC DECAY                    74CA13          77NDS      77052
001     184AU EC DECAY                                74CA13                  77NDS     77052
002     C                %EC = 99.978
003     CG      E        OTHERS: 72FI12, 71HU02
004     CG      RI       OTHERS: 72FI12, 71HU02
005     CG      M        FROM I(G) AND I (CEK) NORMALIZED SO THAT KC(273G) = 0.075 (E2)
006     CL      J        SPIN AND PARITY VALUES ARE THOSE GIVEN UNDER "ADOPTED LEVELS"
007     N                                             0.99978
008     P       0.0                                           53.0 S   14   184AU     6990      SY
009     Q       -6990    SY
010     G       112.1    2 0.80  13
011     G       229.4    3 0.64  15
012     G       251.6    2 1.10  20
013     G       312.0    2 0.61  10
014     G       315.2    3 0.90  20
015     G       441.3    2 0.64  9
016     G       479.6    2 0.63  9
017     G       530.5    3 0.40  AP
```

```
CONTINUE (Y|N) ?
* * * N
CMD
* * * STOP
NAT0951 NORMAL END
```

6. Conclusions

ENSDF is an example of a complex hierarchical data file with many individual parameters, all of which are of interest to the one or other user. With the aid of ADABAS/NATURAL and to a lesser degree ASSEMBLER we have made the data available. With these tools it is possible to look for hidden systematic effects or correlations in data which have hitherto escaped notice. An application of this file to log ft-systematics has already been presented [4].

Although ADABAS takes care of data manipulation and file handling in an exemplary fashion, it became clear during development of the present system that a general retrieval and display package on an NATURAL/ASSEMBLER basis was urgently needed. Such a retrieval package including report generator does not exist. The present system, although written for ENSDF, was kept as general as possible and we plan to present other numerical data bases on-line in a similar fashion. Improvements should be made with regard to more flexible FIND-formulations and automatic generation of display tables depending on the descriptor fields selected by the user.

Appendix A. Original ENSDF data set

Example of an ENSDF data set in exchange format of length 80 bytes. The file ENSDF-1 contains original ENSDF records.

```
103RU      103TC B- DECAY (54.2 S)                    70HEZU, 73HEZK, 75BA60    79NDS     791212
103TC   P  0.0                                        54.2   S      8           2.48E+3   10
103RU C    OTHERS: 63KI16, 65FEZZ, 70UY01, 72TR08
103RU C    103TC ACTIVITIES PRODUCED BY 104RU(G,P): 75BA60, 73HEZK, 70UY01
103RU C    PRELIMINARY PARTIAL LEVEL SCHEME GIVEN; ABSOLUTE INTENSITIES ARE
103RU2C    UNDETERMINED; G-PLACEMENTS ARE PARTLY FROM SEMI GG-SPECTRA (73HEZK)
103RU C                EG, RI ARE FROM 73HEZK (SEMI), UNLESS OTHERWISE NOTED
103RU C    Q-= 2480 100 (78BE51) BG; OTHER: 2350 100 (63KI16, 77WA08)
103RU CL   J(B)           FROM L = 2 (D,P), (D,T): 71FO01, 70DI05
103RU CL   J(C)           SEE OTHER EXP: (D,P), (D,T), (N,G), (A,NG), 103RU IT DECAY
103RU CG   E(A)           TRANSITION IDENTIFIED IN COIN SPECTRA
103RU  G   401.4          3 4.0          8
103RU  L   0.0            (3/2+)                     39.35 D  5                                  C
103RU CL   T              39.35 D 5      (71DE11),   39.5 D 3 (65FL02), 39.4 D 4 (59CA12),
103RU2CL                  39.7 D 6 (57WR37), 39.8 D 4 (52KO27)
103RU  B                                                                                        ?
103RU CB                  APPRECIABLE IB TO E(LEVELS) = 0.0+2.8 EXPECTED IN
103RU2CB                  ANALOGY TO 105TC B- DECAY (75SU02)
103RU  L   2.8            (5/2+)                                                               C
103RU  G   2.8                                                                                  S
103RU CG   E              UNOBSERVED; REQUIRED FOR LEVEL TI BALANCE
103RU  L   136.0          3/2+, 5/2+                                                           B
103RU  B   2.25E+3        15                                                                   C
103RU CB   E              PLACEMENT FROM 2250B(136G)-COIN DOES NOT EXCLUDE FEEDING
103RU2CB                  TO 346 LEVEL
103RU  G   133.4          3
103RU CG   E              FROM 75BA60
103RU  G   136.0          1 100                                                                 C
103RU  L   174.2          1/2+
103RU CL   J              FROM L = 0 (D,P), (D,T)
103RU  G   174.2          1 17           2                                                      C
103RU  L   213.4
103RU CL                  BR: IG(210.7G)/IG(213.6G)/IG(77.5G) = 100/5.6/1.85 VIA (A,NG)
103RU  G   77.5           0.07           CA                                                       C
103RU CG   E              FROM 75KL04 (A,NG); OTHER: 74.8 3 (73HEZK) COIN SPECTRA ONLY
103RU  G   210.7          4              CA                                                     C
103RU CG   RI             FROM 346 LEVEL IG-BR AND DOUBLET IG = 58 6
103RU CG   E              FROM 75KL04 (A,NG)
103RU  G   213.4          3 0.22         CA
103RU CG   RI             FROM 213 LEVEL IG-BR (75KL04) VIA (A, NG)
103RU  L   346.2          3/2+, 5/2+                                                           B
103RU CL                  BR: IG(346G)/IG(243G)/IG(210.2G) = 100/25 6/61 9 VIA (A,NG)
103RU  B   2.13E+3        10                                                                   C
103RU CB   E              AVG OF EB = 2100 150, 2150 150 (78BE51), BG-COIN, ON LINE MS
103RU  G   172.0          5 1.2          5                                                       C
103RU  G   210.25         1054           CA                                                     CC
103RU  G   343.3          3 20           2
103RU  G   346.2          1 88           8                                                      C
103RU  L   405.7          3/2+, 5/2+                                                           B
103RU  G   269.6          3 3.0          5                                                       C
103RU  G   403.0          3 12           1
103RU  L   500.8
103RU  G   287.2          3 3.3          5                                                       C
103RU  G   364.9          5 1            LT                                                   A  C?
103RU  G   500.8          3 12           1
103RU  L   562.8          3/2+, 5/2+                                                           C
103RU  B   1.93E+3        15                                                                   C
103RU CB   E              AVG OF EB = 1880 200, 1990 200 (78BE51) BG-COIN, ON LINE MS
103RU  G   216.4          5 1            LT                                                   A  C?
```

103RU	G	351.2	5 1	LT	A C?
103RU	G	388.5	3 13	2	
103RU	G	426.7	5 1	LT	A ?
103RU	G	562.8	1 40	4	C
103RU	L	661.0			
103RU	G	487.3	5		A C?
103RU	G	661.0	3 3.7	4	
103RU	L	691			?
103RU	G	555.3	5		A C?
103RU	L	774.4			
103RU	G	637.8	5 1.5	CA	A C
103RU	CG	RI	FROM BR: IG(639.0G)/IG(774.9G) = 0.53 VIA (N,G)		
103RU	G	774.4	5 2.8	4	
103RU	L	905.1			
103RU	G	768.8	5 2.7	4	C
103RU	G	902.2	3 4.1	6	
103RU	G	905.1	3 2.0	3	
103RU	L	940.3			
103RU	G	804.3	3 1.7	3	C
103RU	G	937.7	3 2.6	5	

Appendix B. Table on the internal representation of data

The following table contains information on the internal representation of data in the files ENSDF-1 to ENSDF-4. This information is needed whenever the NATURAL programming language is used to extract data from the files. The files NSR and MEDLIST only contain data in alphanumerical form.

The first column is the ADABAS-field name, which can directly be used in FIND, HISTOGRAM, WRITE and DISPLAY statements in NATURAL. The second column, if present, represents the external field name offered to the user in CMD mode (SHOW DES command). In addition we have

DE: The field is a descriptor field.

MU: Multiple value field.

NU: Zero suppression has been used (leading zeros for numerical fields and trailing blanks for alphanumerical field have been eliminated).

FI: Fixed length field (not NU). The values 0 and blank are included in the descriptor file and may explicitly be searched for.

U8 8-digit numerical field, no implied decimal places (e.g. 123 is represented as 00000123).

U10.4: 10-digit numerical field with 4 implied decimal places (e.g. 1023.45 is represented as 0010234500).

E4: Pseudo-exponential field of length 4. The number 0.123 is truncated and represented as 4912.

T8: Time field (contains seconds in E8 format)

A8: Alphanumerical field of length 8.

* File ENSDF-1 *

KA		DE		U8	A–Z-DSNR
KF		DE		U2	sequence number
NM	MA	DE		U3	nuclear mass
EL	EL	DE	FI	A2	chemical element
CA		MU	NU	A74	card images (max.40)

* File ENSDF-2 *

KN		DE			U8	A–Z-DSNR
MA	MA	DE			U3	atomic press number
ZA	ZA	DE			U3	atomic charge
DS	DS	DE			U2	data set number (adopted levels = 0)
EM		DE	FI		A2	chemical element
DA	DA	DE			U6	data of DS in master file
PF		DE	FI		A1	spin/parity flag for parent levels
TX			NU		A65	text in DS identification record
CD	CD	DE	NU	MU	A12	terms occurring in ID-record: DECAY, (D,P)
RF	RF	DE	NU	MU	A6	references in DS (key from NSR)

Q-value record

QM	QM	DE	NU		U10.4	Q-value for B − decay
DM		DE	NU		E4	error in QM
SN	SN	DE	NU		U10.4	neutron binding energy
DN		DE	NU		E4	error in SN
SP	SP	DE	NU		U10.4	proton binding energy
DP		DE	NU		E4	error in SP
QA	QA	DE	NU		U10.4	alpha separation energy
DB		DE	NU		E4	error in QA

Normalization record (for DECAY data sets)

NR	NR	DE	NU		E8	normalization factor for photon intensities (IG*NR = intensity/100 decays through this branch)
DR			NU		E4	error in NR
NT			NU		E8	norm factor for transition intensities
DT			NU		E4	error in NT
NS			NU		E8	norm factor for branching: IG*NR*BR is photon intensity per 100 decays of parent
DZ			NU		E4	error in NS
NB			NU		E8	norm factor for beta intensities: IB*NB is beta intensity per 100 decays through this branch
DY			NU		E4	error in NB

Parent card

PM	PM	DE	NU		U3	parent nuclear mass
PN	PN	DE	NU		A2	parent chemical element
PA	PA	DE	NU		U10.4	excitation energy of decaying level
XA		DE	NU		E4	error in PA
PJ	PJ	DE	NU	MU	A4	spin and parity
PO			NU		A16	time field (original format)
PT	PT	DE	NU		E8	time field (exponential format)
XT		DE	NU		E4	error in PT
PQ	PQ	DE	NU		U10.4	ground-state to ground-state Q-value
XQ		DE	NU		E4	error in PQ

Statistics of data sets

S1		DE	NU		U4	number of cards in DS
S2		DE	NU		U4	number of comment cards
S3		DE	NU		U4	number of level cards
S4		DE	NU		U4	number of gamma cards
S5		DE	NU		U4	number of beta cards
S6		DE	NU		U4	number of EC cards
S7		DE	NU		U4	number of alpha cards
S8			NU		U4	number of Q-value cards
S9			NU		U4	number of normalization cards
SZ			NU		U4	number of parent cards
SY			NU		U16	number of comment cards CL to CE
SX			NU		U15	number of comment cards CA to CP
* File ENSDF-3 *						
K3		DE			U8	A–Z-DSNR
MA	MA	DE			U3	mass (subdescriptor)
LN	LN	DE			U3	level number
EL		DE	FI		A2	chemical element
QE		DE	FI		A1	(?) level flag
PF		DE	FI		Al	spin-parity flag

Level card

LE	LE	DE	NU		U10.4	level energy
LD			NU		E4	error in LE
PJ	LJ	DE	NU	MU	A4	spin and parity
LO			NU		A16	time field (original format)
LT	LT	DE	NU		E8	time field (exponential format)
DT			NU		E4	error in LT
LV	LV	DE	NU		A3	L-value field
SU			NU		A12	spectrosocpic factor
EC		DE	NU		U6.3	%EC branching of level
SF		DE	NU		U6.3	%SF branching of level
IT		DE	NU		U6.3	%IT (isomeric transition)
BE		DE	NU		U6.3	%B − branching
BP		DE	NU		U6.3	%B + branching
AD		DE	NU		U6.3	%A-decay
PD		DE	NU		U6.3	%P-decay
ND		DE	NU		U6.3	%N-decay
ET		DE	NU		U6.3	%(EC + b +)-decay
GF		DE	NU		E8	g-factor
DG			NU		E4	Error in GF
M1		DE	NU		E8	MOMMl (magnetic moment)
Dl			NU		E4	error in Ml
Q2	Q2	DE	NU		E8	MOME2 (quadrupole moment)
D2			NU		E4	error in Q2
B2		DE	NU		E8	BE2 (up)

F2			Nu	E4	error in B2
B3		DE	NU	E8	BE3 (up)
F3			NU	E4	error in B3
BB		DE	NU	U10.4	exp. beta endpoint energy
BD			NU	E4	error in BB
IB			NU	U6.3	B-intensity
IE			NU	U6.3	EC-intensity
TI	TI	DE	NU	U6.3	total (B + EC) intensity
ZT			NU	E4	error in TI
FT	FT	DE	NU	U6.3	logit-value
FL			NU	E4	error in FT

* File ENSDF-4 *

KG		DE		U8	A–Z-DSNR
LN	LN	DE		U3	level number
UN			FI	Al	gamma uncertainty flag
GE	GE	DE	NU	U10.4	gamma energy (keV)
GU		DE	NU	E4	uncertainty in GE
GI	GI	DE	NU	E8	gamma intensity (relative)
RD			NU	E4	uncertainty in GI
MU	MU	DE	NU	A8	gamma multipolarity
MF	MF	DE	NU	Al	multipolarity flag
MR	MR	DE	NU	A10	mixing ratio
CC	CC	DE	NU	E6	total conversion coefficient
DC			NU	E4	error in CC
GT	GT	DE	NU	E6	total transition intensity (including CC)
GD			NU	E4	error in GT
KT	KT	DE	NU	E8	total experimental CC
ZT			NU	E4	error in KT
KK	KK	DE	NU	E8	experimental K-CC
ZK			NU	E4	error in KK
KL	KL	DE	NU	E8	experimental L-CC
ZL			NU	E4	error in KL
KM	KM	DE	NU	E8	experimental M-CC
ZM			NU	E4	error in KM
BV	BV	DE	NU	E8	B(E2) (down)
ZV			NU	E4	error in BV
UM			NU	A6	uncertainty in mixing ratio

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