IAEA-NDS- 118
Rev. 0

INTERNATIONAL ATOMIC ENERGY AGENCY

NUCLEAR DATA SERVICES

DOCUMENTATION SERIES OF THE IAEA NUCLEAR DATA SECTION

The ENSDF Radioactivity Data Base for IBM-PC and Computer Network Access

Peter Ekström and Leif Spanier

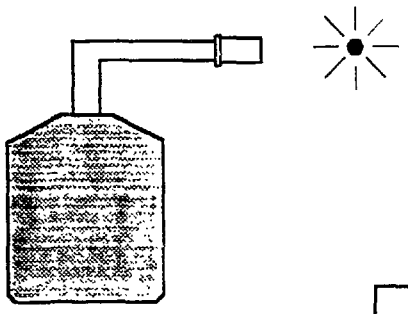
Department of Physics, Sölvegatan 14, S-223 62 Lund, Sweden

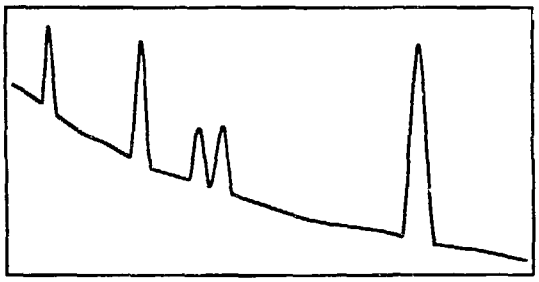
August 1989

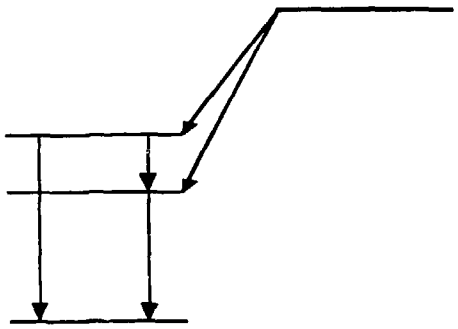
Abstract: A database for about 15000 gamma rays from 2777 radioactive nuclides derived from the international Evaluated Nuclear Structure Data File (ENSDF) is described together with supporting computer codes. The database is available on a PC diskette, costfree, from the IAEA Nuclear Data Section.

The ENSDF Radioactivity Data Base for IBM-PC and Computer Network Access

Peter Ekström and Leif Spanier







Nuclear Physics Report
LUNFD6/(NFFR-3059)/1-11 (1989)

Department of Nuclear Physics
Lund university
Sölvegatan 14
S-223 62 Lund, Sweden

The ENSDF Radioactivity Data Base for IBM-PC and Computer Network Access

Peter Ekström and Leif Spanier

Department of Physics, Sölvegatan 14, S-223 62 Lund, Sweden

August 1989

A data base system for radioactivity gamma rays is described. A base with approximately 15000 gamma rays from 2777 decays is available for installation on the hard disk of a PC, and a complete system with approximately 73000 gamma rays is available for on-line access via the NORDic University computer NETwork (NORDUNET) and the Swedish University computer NETwork (SUNET).

Introduction

In basic and applied nuclear physics one often obtains Ge(Li) gamma-ray spectra with many gamma rays, which are not immediately identifiable. One then needs some means to find out which gamma rays are known, and to which decay they belong. There are several gamma-ray catalogues, but very few where gamma rays can be easily identified from their energy, since in most catalogues the gamma rays are ordered by parent nucleus and not by energy.

Our gamma-ray catalogues [1,2] have, judging from the demand for copies and user comments, been very useful in identifying gamma rays. Since hard disks for PC:s have become cheaper and more commonplace, it was thought that an update of the catalogues should take the form of computer data bases rather than printed reports. The development of computer networks (e.g. the Swedish University computer NETwork, SUNET), also makes it feasible to access data bases on remote computers. Our ambition was to make a system which is as easy to use as a book, but considerably faster an more versatile.

This report describes the two data base systems for PC:s and (as part of an existing data base system for Nuclear Structure References [3]) for the

department's VAX8200 computer GARBO. The data bases are intended as a complement to publications of decay data (e.g. the very useful Table of Radioactive Isotopes [4]) in that they allow the experimentalist to search for possible nuclide assignments of any gamma ray with a reasonably well determined energy.

The data files required for the base were created on a VAX8200. Programs for the data base system have been written in FORTRAN 77, and compiled with VAX/VMS FORTRAN and Microsoft FORTRAN 77, version 4, for VAX and PC, respectively. Since the programs perform virtually no real number arithmetic, the PC version is compiled to make no use of a Math processor (FPU).

The PC data base contains approximately 15000 gamma rays from 2777 decay data sets. Only the *ten most intense gamma rays from each decay* are included. The complete data base on GARBO contains approximately 73000 gamma rays.

The following uses of the data base are anticipated:

(i) To look for and identify a gamma ray with a certain energy.

(ii) To obtain information such as half-life, decay mode and branching ratio of a given nuclide.

(iii) To list (with the possibility of obtaining a hard-copy) gamma rays from a certain decay.

(iv) To use the ASCII files with gamma rays and data set information in other applications, e.g. as radioactivity data for an automatic peak-search program.

Origin and treatment of data

The data have been retrieved automatically from ENSDF [5] (March 8, 1989). Please observe, however, that some data in ENSDF may be considerably older than this, since ENSDF is not continuously updated. Instead, one mass number at a time is updated with a frequency of 5-10 years. The last line in the data set header produced by the Set command of GDISP (see below) gives information on how current the data are.

First all decay data sets in ENSDF were extracted. Then gamma-ray normalization, parent half-life and branching ratio were extracted, and gamma-ray and decay properties were stored in sequential ASCII files. A number was assigned to each data set, and this number was stored with each gamma ray. Then the file with gamma rays was sorted by energy with the VMS SORT command.

The files with data set information and gamma-ray data were used as input to the program GCONV, see below.

System requirements and installation

The data base system requires the following:

IBM-XT, AT, 386 or compatible

640 kB RAM

1.7 MB hard disk space (and additional 1.6 MB temporarily for installation). Note that it is advantageous if the disk is not too fragmented. Use a commercial disk optimizer program to obtain large unused areas on the disk!

FILES=6 (or greater) in CONFIG.SYS

PC- or MS-DOS 3.2 or later

To install programs and data base, insert disk 1 in a floppy disk drive and make this drive current by typing e.g. A: <cr>. If you are installing on hard disk drive C: in sub directory \GAMMAS from floppy drive A: type

INSTALL C GAMMAS A <cr>

After installation the following files should be present on the hard disk:

gammas.bat	Batch file to facilitate running of data base program. This file should be moved to a directory present in the SET PATH command in the AUTOEXEC.BAT file
gdisp.exe	The program GDISP
gammas.dat	Direct access file with gamma ray data ordered by energy
gammas.inx	Unformatted file with gamma ray energies to serve as an index for gamma ray energy
dsets.dat	Direct access file with information on all decay data sets ordered as in ENSDF
dsets.inx	Unformatted file containing the data set number (as defined in DSETS.DAT) of each gamma ray
readme.doc	This document

Contents of distribution disks

The six distribution disks contain the following files:

Disk 1.

disk1.lab	File to identify disk 1
readme.doc	This document
install.bat	Installation initialization file
inst.bat	Installation file
gconv.exe	Program to make direct access files and index files from sequential ASCII files
gdisp.exe	Program to look for gamma rays and list decays
gammas.bat	Sample batch file to facilitate running of the program GDISP

Disk 2:

disk2.lab	File to identify disk 2
gammas1.lis	Gamma-ray data file, part 1

Disk 3:

disk3.lab	File to identify disk 3
gammas2.lis	Gamma-ray data file, part 2

Disk 4:

disk4.lab	File to identify disk 4
gammas3.lis	Gamma-ray data file, part 3

Disk 5:

disk5.lab	File to identify disk 5
gammas4.lis	Gamma-ray data file, part 4

Disk 6:

disk6.lab	File to identify disk 6
dsets.lis	Data set data file

Since the data files on disks 2-6 can quite easily be used for other applications, the contents of the files will be briefly descibed.

The gamma-ray data files contain information on all gamma rays in the data base. The file consists of fixed format records (maximum 79 bytes long), one record for each gamma ray. The records are ordered by increasing energy. Each record contains gamma-ray energy, intensity, which decay the transition belongs to, the data set number of this decay, half-life and a maximum of two energies of associated gamma rays (the strongest transitions in the decay).

The data set data file contains information on all data sets (a data set describes one decay mode of a parent nuclear state). Each fixed format record contains information on one data set. The maximum record length is 109 bytes. In addition to the complete data set identification (parent nucleus, decay mode) each record contains reference information, excitation energy of the parent state, half-life and branching ratio.

The program GCONV

This program converts the sequential ASCII files with gamma-ray data and data set information into direct-access files. In addition, unformatted index files for gamma-ray energies and data set numbers are created. These index files are used to facilitate quick access to gamma-ray data and data set information. The program is only used for installation, so it is deleted from the hard disk after installation.

The program GDISP

This program is used to display and list gamma-ray data. The introductory page and the help page are shown in the appendix. Commands are given by entering the first letter+<cr>. Gamma-ray energies should be entered in keV as normal decimal numbers (decimal point may be omitted).

Most commands are self evident, see the sample session and description in the appendix, so only two will be discussed:

D(ecay)

This command is used to search for information on a certain decay. Input a string that defines the decay (e.g. 60CO B-, note that CAPITAL letters have to be used), and the program will output a line for each data set that is consistent with the string. The set (data set) number should be remembered for the Set command, see below. The Decay command may take some time on slow computers, since the whole file containing the data set information has to be scanned.

S(et)

This command gives detailed information on a selected (by the set number) decay. All gamma rays in the decay present in the data base are listed in order of increasing energy. The listing may be written to a file.

The program GDISP starts by reading in the gamma-ray index file and the data set index file into arrays in core. Both index files have one entry per gamma ray present in the data base.

The gamma-ray index file contains all gamma-ray energies (real numbers) in the data base in the same order as the gamma-ray data are stored in the gamma-ray data file. When a certain energy is requested, the nearest is very quickly localized in the array, and the corresponding array element index gives the location of the gamma-ray data in the direct access file.

The data set index file contains the data set number (integer) for each gamma ray. This index is used (for the Set command) to extract all gamma rays from a certain decay (data set).

Computer network access to the complete base on GARBO

The radioactivity gamma-ray data base has been added as an extra option to the Nuclear Structure Reference system NSR_BASE resident on the VAX8200 of

the Department of Physics. The reference system and how to access it is described in ref. [3].

Access is possible from any VAX connected to the NORDic University computer NETwork (NORDUNET, of which the Swedish University computer NETwork SUNET is a part) by entering:

$SET HOST GARBO
Username: NSR_BASE
Password: NSRBASE

and answering a few questions. The radioactivity data base is accessed with the command GAMMAS. The data base resident of GARBO contains all gamma rays from decay data sets in ENSDF, approximately 73000 gamma rays. Access to the data base is via a VAX/VMS version of the program GDISP. It is possible to extract gamma-ray listings if a list is made in GDISP. These lists may subsequently be transferred with the VAX/VMS MAIL system.

Ordering information

You can obtain the installation files for the Radioactivity Gammas Database free of charge by sending *six 5 1/4 inch formatted 360 kB floppy disks* to Peter Ekström under the above address.

Programs and data files may be freely copied for non-commercial use only. If you find the data base useful, we would be very grateful if you would write and tell us what you use it for. This would help us to obtain funding for nuclear data activities in the future.

Acknowledgements

The present work was supported by a grant from the Swedish Nuclear Power Inspectorate (SKI), the National Defence Research Establishment (FOA), the National Committee for Used Nuclear Fuel (NAK), the National Institute for Radiation Protection (SSI), Studsvik Energiteknik and Vattenfall.

References

1) Catalogue of gamma rays from radionuclides, L P Ekström and P Andersson, Nuclear Physics Report LUNFD6/(NFFR-3050)/ 1-198/ (1983)

2) Catalogue of gamma rays from radionuclides ordered by nuclide, L P Ekström and P Andersson, Nuclear Physics Report LUNFD6/(NFFR-3052)/ 1-250/ (1984)

3) NSR_BASE - program package for the on-line retrieval of references from the Nuclear Structure Reference file, User's guide, L P Ekström and M Bergström, Nuclear Physics Report LUNFD6/(NFFR-3058)/ 1-27/ (1988)

4) Table of Radioactive Isotopes, E Browne and R B Firestone, John Wiley & sons, 1986

5) ENSDF, the Evaluated Nuclear Structure Data File, produced by in international collaboration under IAEA, and edited and maintained by the National Nuclear Data Center, Brookhaven National Laboratory

Appendix

Sample session with GDISP

This session has been run with the VAX/VMS version of the program, but the PC version gives almost identical output (except that there are fewer gamma rays). The session illustrates the Help facility, looking for a gamma with the energy 661.6 keV, and listing the gamma rays in the decay of 60Co. Data entered by the user are marked with an exclamation mark (!). The output reproduced on the following pages will be discussed below in order to help the user to interpret it.

First the file name of the (optional) output file for decay listings is entered. An introductory text on the program and data base is then displayed. The help option is chosen by entering H <cr>. In addition to the commands, the help text gives the correct interpretation of symbols, which may occur in the data.

When the number 661.6 is entered, the program displays the nearest gamma-ray energy in the middle of the page surrounded by the nine next lower and higher entries. The user can browse through the table with P <cr> and <cr>.

In addition to the energy, the intensity of most gamma rays is given. Note that for internally converted transitions only the fraction of the intensity which decays by gamma quanta rays is listed. A minus (-) sign signifies that no intensity was given in ENSDF, either because it was not known or because the transition is completely converted (e.g. 0-->0 transitions). If a % sign is present to the right of the intensity field, the intensity is given in normalized units: *gamma ray intensity per 100 decays of parent.*

The decay column gives the parent nucleus and the decay mode. EC is electron capture, B+/- is beta +/- decay and IT is isomeric transition.

The set column gives the number of the data set. This number is used to extract the complete decay with the Set command.

The half-life is given in the following units:

AS	attoseconds (10**-18 s)	S	seconds
FS	femtoseconds (10**-15 s)	M	minutes
PS	picoseconds (10**-12 s)	H	hours
NS	nanoseconds (10**-9 s)	D	days (24 H)
US	microseconds (10**-6 s)	Y	years (365.256 D)
MS	milliseconds (10**-3 s)		

The columns with associated gamma rays list the two strongest gamma rays in the decay. These columns are useful, together with the nuclide assignment and the half-life, for identifying an unknown gamma ray.

After the gamma-ray listing the Decay command is demonstrated. This command can be used to search for any decay(s) in the data base. If, for instance, you are interested in mass number A=123, entering 123 on the prompt will yield a list of all decays for which the parent nucleus has mass number 123. In addition to the data set identification, the data set number is given (for use with the Set command).

The Set command prompts the input of a data set number, and produces (in addition to all gamma rays in the decay present in the base) some information on the decay:

Excitation energy refers to the parent state (in most cases the ground state, but for isomeric states this number is >0).

The half-life is given in the units listed above. Branching is <1 for the cases where the parent state has more than one decay mode, in which case there ought to be at least one additional data set with the alternative decay mode.

The reference field contains key numbers of references used for the data. These key numbers can be decoded with the Nuclear Data Sheet issue indicated in the 'Published in' field. The last entry is the date of entry of the data set into ENSDF.

```
NSR data base, enter command: GAMMAS !

Do you want the data set gamma ray listings on a file? Then type
the file name, e.g. DECAY.OUT (else <cr>): DECAY.OUT !


                  ********************************
                  * GDISP, vers 1.1, August 1989 *
                  ********************************

        * A program to assist identifying and to list
        * radioactivity gamma rays

        Leif Spanier and Peter Ekstrom,
        Department of Nuclear Physics,
        Solvegatan 14, S-223 62 Lund, Sweden

        Data are taken from ENSDF (the Evaluated Nuclear
        Structure Data File) from 8 March 1989.
        ENSDF is edited and maintained by the National Nuclear
        Data Center, Brookhaven National Laboratory, on behalf
        of the International Network for Nuclear Structure Data
        Evaluation.
             Number of gamma rays in data base:  73318
             Number of decay data sets:           2777
             List file:                    DECAY.OUT


Egamma (dec.number) Previous Next - + First Last Set Decay Help Introd Exit
h !


   ***************** HELP TEXT ****************************
   Egamma          : Type a number and the program will display the known
                     gamma rays that are closest to this energy.
  Only the first character is necessary for the following commands:
   Previous        : Displays previous page.
   Next            : Displays next page.
   <cr>            : Carriage Return (<cr>) displays next page.
   -               : Displays the gamma rays 5 pages above.
   +               : Displays the gamma rays 5 pages below.
   First           : Displays the first page.
   Last            : Displays the last page.
   Set             : Displays information about a decay.
   Decay           : Search for mass number or nucleus.
   Help            : Displays this text.
   Introd          : Displays the introductory text.
   Exit            : Exit from the program.
  If errors are given in output they are in the format
  12.345 67  which means  12.345+-0.067
    % - Absolute intensity per 100 decays of parent
    ? - Questionable gamma or placement.  S - Expected, not observed
    GT,GE,LT,LE,AP,SY,CA - >,>=,<,<=, approximately, systematics, calculated
Egamma (dec.number) Previous Next - + First Last Set Decay Help Introd Exit
661.6 !
```

```
661.6
```

Energy (keV)			Intensity		Decay	Set	Half-life		Associated gammas	
661.5	7	?	0.91 22	%	201BI EC	2248	108 M	3	629.1	936.2
661.5	3		25.0 10	%	50MN B+	199	1.75 M	3	1098.0	783.3
661.5	2		69 7	%	148HO EC	1436	9 S	1	1688.3	504.3
661.5	5		5.304	%	117I B+	958	2.3 M	1	325.9	274.4
661.5	3		1.8 5	%	154HO EC	1555	3.25 M	10	334.6	412.4
661.55	15		0.022 9	%	151PM B-	1485	28.40 H	4	340.08	167.75
661.58	7		0.88 13	%	99SR B-	665	270 MS	10	125.12	536.12
661.58	12		2.54 25	%	204BI EC	2295	11.22 H	10	899.15	374.76
661.6	1		-	%	89NB B+	525	14.5 M	1	1082.6	1057.1
661.6	1		1.90 10	%	88NB B+	526	7.8 M	1	1057.1	1082.6
661.62	22		0.056 12	%	155DY EC	1572	10.0 H	3	226.918	184.564
661.64	11		0.19 4	%	93RB B-	577	5.7 S	1	432.61	213.43
661.660	3		-	%	137BA IT	1238	2.5513 M	7		
661.660	3		85.21 7	%	137CS B-	1237	30.0 Y	2		
661.7	3		4.33 15	%	143CS B-	1332	1.77 S	2	195.554	232.421
661.8	4		3.0 7	%	181RE EC	1930	19.9 H	7	365.5	360.7
661.9	7		0.32 13	%	186IR EC	2009	16.64 H	3	296.89	137.157
661.9	5		30 8		142XE B-	1316	1.22 S	2	571.83	657.05
661.9	1		0.30 6	%	157HO EC	1603	12.6 M	2	279.97	341.16

```
---------------------------------------------------------------------------
Egamma (dec.number) Previous Next - + First Last Set Decay Help Introd Exit
d !
Look for a specific nucleus or decay by exact match.
Format: MassnumberElementsymbolBlankDecaymode
Items may be excluded from left or from right,
for example: 60CO B- or 60CO or CO or 60
See the decay column for other examples.
Type decay (<cr> to skip) : 60CO !
Scanning data set information file, wait.....
Data set no:    257     Decay: 60CO IT DECAY
Data set no:    258     Decay: 60CO B- DECAY (5.2704 Y)
Data set no:    259     Decay: 60CO B- DECAY (10.47 M)
Egamma (dec.number) Previous Next - + First Last Set Decay Help Introd Exit
s !
Type data set number : 258 !

Decay              : 60CO B- DECAY (5.2704 Y)        Data set number  :   258
Excitation energy: 0.0          keV
Half-life          : 5.2704 Y  13          Branching        : 1.0
References         : 76CA18,68HA03
Published in       : 86NDS                 In ENSDF on      : 860805
```

Energy (keV)		Intensity	
346.93	7	0.0076 5	%
826.28	9	0.0076 8	%
1173.237	4	99.900 20	%
1332.501	5	99.9820 10	%
2158.77	9	0.00111 18	%
2505		2.0E-6 4	%

```
------------------------------
Do you want this set on the list file type <cr> (N for no):
Egamma (dec.number) Previous Next - + First Last Set Decay Help Introd Exit
e !
        END OF GDISP
```