united nations
educational, scientific
and cultural
organization

international atomic
energy agency

the
abdus salam
international centre for theoretical physics

SMR/1220-9

Workshop on

Nuclear Reaction Data and Nuclear Reactors: Physics, Design and Safety

13 March - 14 April 2000

Miramare - Trieste, Italy

Nuclear Data Services Provided by the IAEA

O. Schwerer
International Atomic Energy Agency
Nuclear Data Section
Vienna, Austria

Workshop on Nuclear Reaction Data and Nuclear Reactors: Physics, Design and Safety, Trieste, 13 March - 14 April 2000

Nuclear Data Services Provided by the IAEA

O. Schwerer and P. Oblozinský
Nuclear Data Section
International Atomic Energy Agency
Vienna, Austria

I. Lecture
1. Data centers and their services
2. Nuclear data types
3. Review of important data libraries
4. Data access
5. Conclusion

II. Demonstrations

III. Exercises

Nuclear data

- ***describe*** properties of atomic nuclei and the fundamental physical relationships governing their interactions
- ***characterize*** physical processes underlying all nuclear technologies
- ***Examples:*** cross sections, half-lives, decay modes and decay radiation properties, γ-rays from radionuclides
- ***Scope:*** all 85 natural elements with 290 stable isotopes and more than 2500 radionuclides

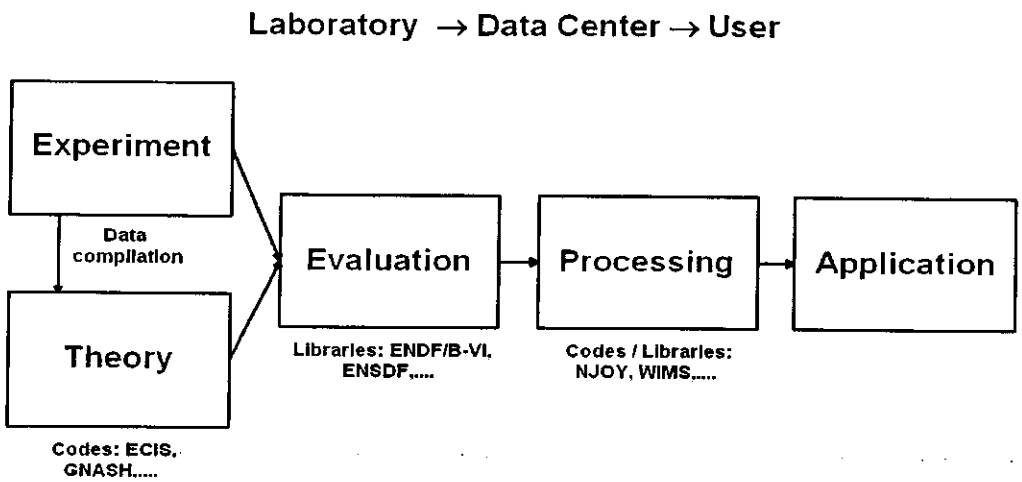
Applications of nuclear data

- Energy applications
  - Fission power
  - Fusion reactor technology
- Non-energy applications
  - Nuclear medicine
  - Materials analysis and process control
  - Safeguards
  - Radiation safety
  - Waste management
  - Environmental research
  - Basic research (e.g. nuclear astrophysics) and education

Nuclear data centers

- organize collection and distribution of nuclear data on a world-wide scale
- are involved in all stages of data preparation between measurement and application: compilation, review, evaluation, processing, distribution
- The work of international, regional and national nuclear data centers is co-ordinated by the IAEA in two specialized **data center networks** for maximum efficiency and work sharing

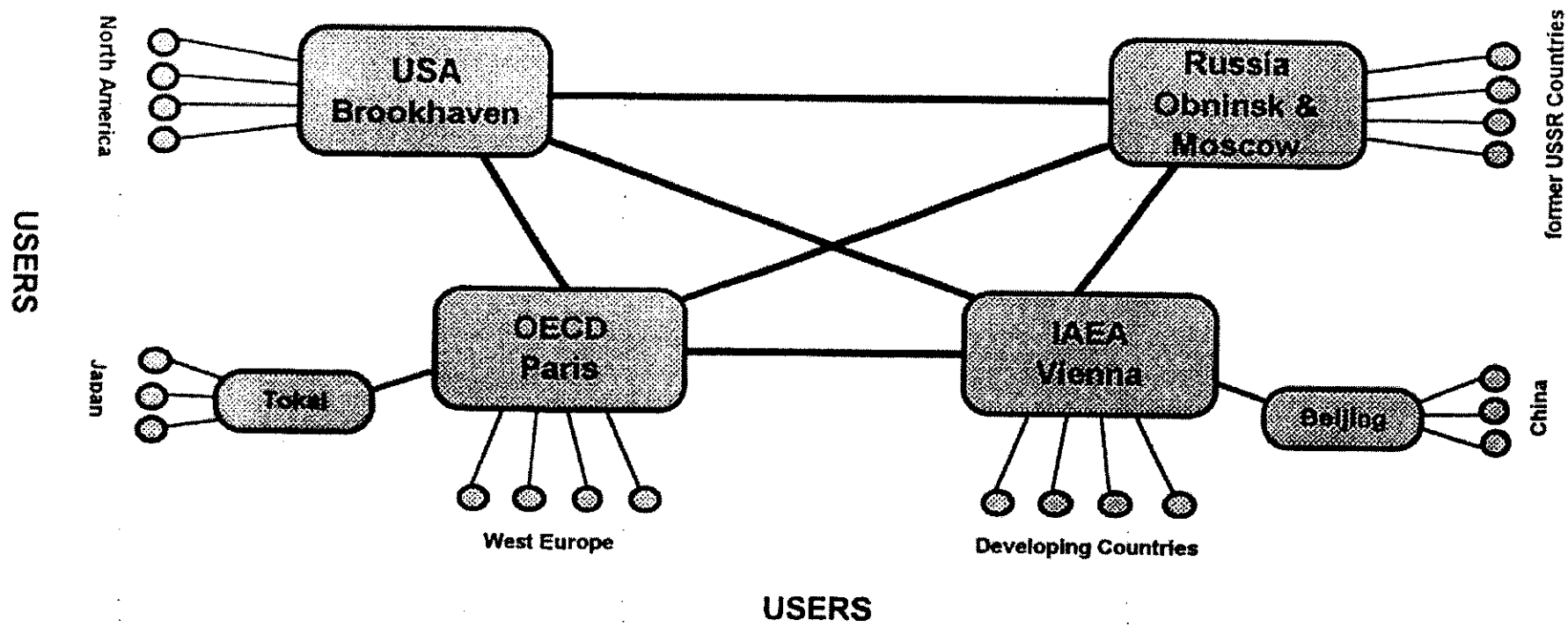
From experimental nuclear data to applications



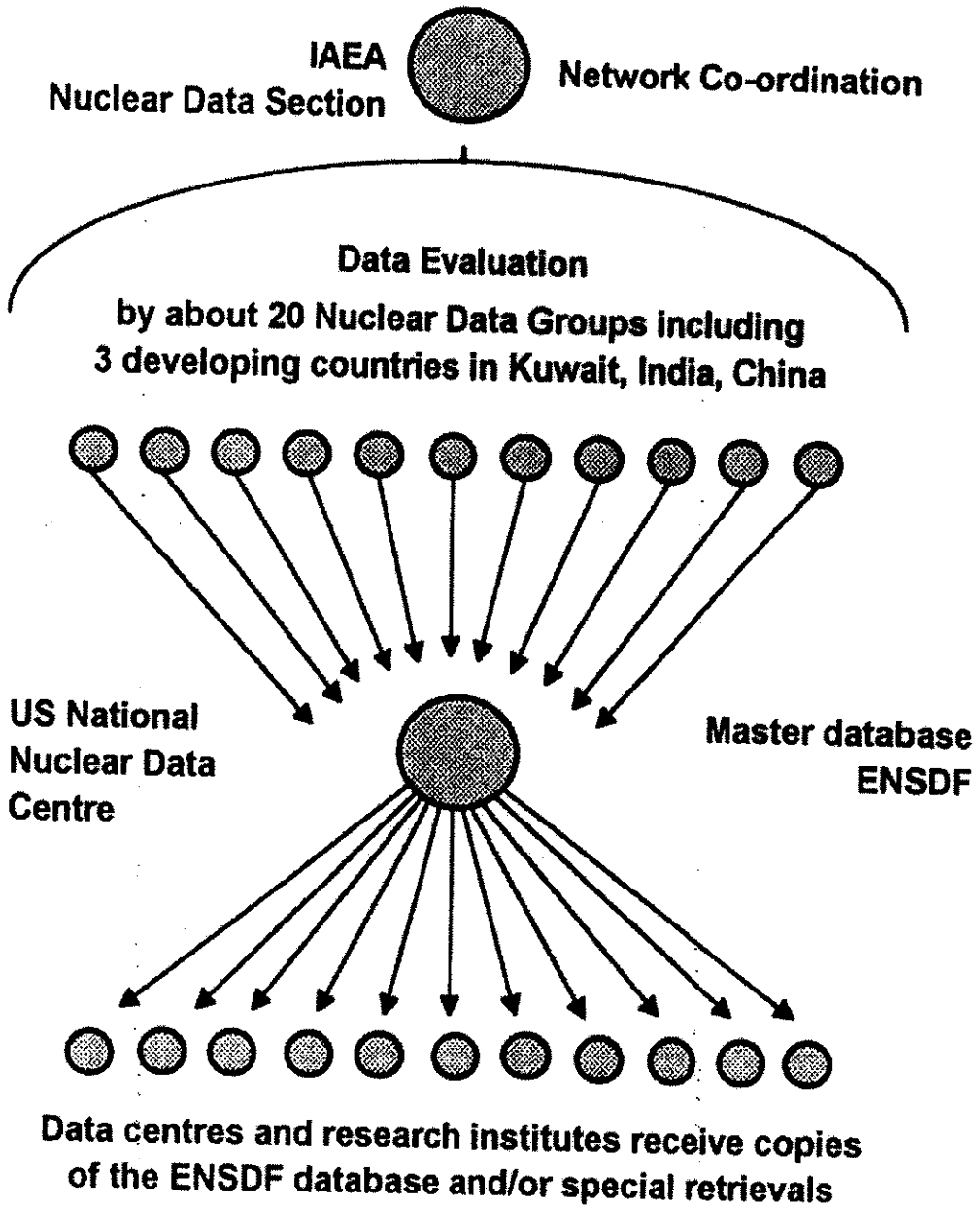
Nuclear Data Centers Networks

- **Nuclear Reaction Data Centers Network**
  - **IAEA Nuclear Data Section**, Vienna, Austria
  - **OECD NEA Data Bank**, Paris, France
  - **U.S. National Nuclear Data Center**, Brookhaven, USA
  - **Russian Nuclear Data Centers**, Obninsk and Moscow, Russia
  - **China Nuclear Data Center**, Beijing, China
  - **Japanese Nuclear Data Center**, Tokai, Japan
  - **Additional co-operating specialized centers** (Russia, Japan, Hungary, Ukraine, USA)
- **Nuclear Structure Data Centers Network**
  - **IAEA Nuclear Data Section**, Vienna, Austria (Co-ordination)
  - **U.S. National Nuclear Data Center**, Brookhaven, USA (Master database)
  - **17 data evaluation centers** in USA, Russia, Netherlands, China, France, Japan, Kuwait, Belgium, Canada, UK
  - **Data dissemination centers** (IAEA, OECD-NEA, USA, France, Sweden)

Network of Nuclear Reaction Data Centers



Network around the Evaluated Nuclear Structure Data File (ENSDF)



Web addresses of main dissemination centers

Major nuclear data dissemination centers. Additional dissemination centers with specialized scope exist e.g. in USA, Russia, Japan, Korea and other countries, and more centers contribute to data compilation and other data center functions.

Data center	**Web address**	**Main services**	**Main area of responsibility**
IAEA Nuclear Data Section, Vienna, Austria	http://www-nds.iaea.or.at	Reaction data, structure and decay data, reports; computer programs through OECD NEA Data Bank	IAEA member states with special emphasis on developing countries
US National Nuclear Data Center, Brookhaven, USA	http://www.nndc.bnl.gov	Reaction data, structure and decay data	USA, Canada
OECD NEA Data Bank, Issy-les-Moulineaux, France	http://www.nea.fr/html/databank/	Reaction data, structure and decay data, computer programs	OECD member states
Russian Nuclear Data Centers, Obninsk and Moscow, Russia	http://depni.npi.msu.su/cdfe/ (Center for Photonuclear Experiments Data)	Reaction data	Russia
China Nuclear Data Center, Beijing, China		Reaction data	China
Isotope Project, Berkeley, USA	http://isotopes.lbl.gov/isotopes/	Structure and decay data	
Department of Physics, Lund University, Sweden	http://nucleardata.nuclear.lu.se/nucleardata/	Structure and decay data	
Atomic Mass Data Center, Orsay, France	http://csnwww.in2p3.fr/amdc/	Structure and decay data	

Major Nuclear Data Centers

1 ● IAEA Nuclear Data Section, Vienna
2 ● OECD NEA Data Bank, Paris
3 ● U.S. National Nuclear Data Center, Brookhaven
4 ● Russian Nuclear Data Centers, Obninsk + Moscow
5 ○ U.S. Radiation Safety Information Computational Center (RSIC), Oak Ridge
6 ○ Chinese Nuclear Data Center, Beijing
7 ○ Japanese Nuclear Data Center, Tokai

Nuclear Data Services (1)

- Data by mail *(IAEA-NDS)*
  - Complete files on magnetic tape, CD-ROM or diskette
  - Specific retrievals on diskette, printout or by e-mail
- Hardcopy documents *(IAEA-NDS)*
  - Manuals and data library documentation
  - Handbooks
  - Meeting reports
  - Research reports
  - Nuclear Data Newsletter

Many new documents are made available also through Internet.

Nuclear Data Services (2)

- Online Services *(IAEA-NDS)*:
  - WWW (Worldwide Web):
    - Interactive access to most important libraries
    - IAEA Nuclear Data Guide
    - Documents, Links, General information
  - FTP (Internet File Transfer):
    - downloading complete files, libraries and documents
  - Telnet service (NDIS):
    - Interactive access to most important libraries, some utilities and documents
- *US-NNDC, OECD/NEA Data Bank* (restricted), partly other centers, offer similar services

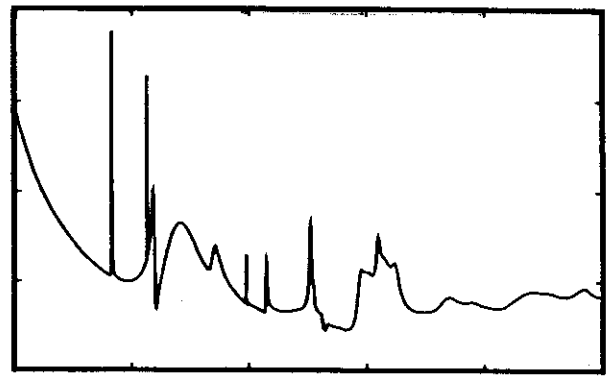
Nuclear Data Services (3)

- Nuclear data-related computer codes
  - Mostly distributed by *OECD/NEA Data Bank* (also for IAEA member states which are not NEA members)
  - Emphasis: nuclear reaction models, fission reactors
  - Some US-originated codes only through *Radiation Shielding Information Computational Center (RSICC)*, Oak Ridge, USA
  - Some utility programs and PC packages available directly from *IAEA-NDS*
- Processed data (Multigroup libraries): *NEA Data Bank*, partly *RSICC*

Nuclear Data Services (4): Trends

- Databases on CD-ROM with retrieval software (and perhaps update possibility through Internet), in parallel to online service
- "Mirror sites" to improve WWW accessibility worldwide
- *IAEA-NDS* intends to keep all ways of data distribution for medium term future, with emphasis shifting increasingly to WWW and CD-ROM

NUCLEAR DATA NEWSLETTER



Nuclear Data Section (NDS)

International Atomic Energy Agency

Vienna

Issue No. 28 **October 1999**

Staff Items
Announcement
Online News
Offline News
New Data Libraries
Computer Codes and Packages
Selected Reports and Documents
IAEA Nuclear Data Activities
Technical Co-operation
Specifications

All services provided to users are free of charge.

Please contact us on the following addresses:

Nuclear Data Section
International Atomic Energy Agency
P.O. Box 100
A-1400 Vienna
Austria

e-mail: services@iaeand.iaea.or.at
fax: (43-1) 26007
cable: INATOM VIENNA
telex: 1-12645
telephone: (43-1) 2600-21710

Online: TELNET or FTP: iaeand.iaea.or.at
username: IAEANDS for interactive Nuclear Data Information System
usernames: ANONYMOUS for FTP file transfer;
FENDL2 for FTP file transfer of FENDL-2.0;
RIPL for FTP file transer of RIPL.
NDSONL for FTP access to files sent to NDIS "open" area.
Web: http://www-nds.iaea.or.at

N N D C

National Nuclear Data Center Newsletter

Issue # 99-2 International Cooperation in Nuclear Data September 1999

Web News

There is a test version of Nuclear Structure References (NSR), using a relational database, available on our Web page at http://ndcnt1.dne.bnl.gov/nsrq/.

Other Data Center News

Victor Zerkin (IAEA) will be visiting the data center from September 26 to October 8, 1999 to discuss the production of a new CSISRS/EXFOR CD Rom.

A new staff member, **Alejandro Sonzogni**, has joined the NNDC in August. He will be working on nuclear structure and decay data evaluation and on Nuclear Science References compilation. He has recently completed a post doctoral appointment at Argonne National Laboratory.

Network News

Scientific Digital Visions, Inc. is pleased to announce a new internet service for the nuclear science community. Known as **NSRStats,** it provides intuitive methods of accessing recent references in the Nuclear Science References (NSR) database at the NNDC. A nuclide chart shows nuclides colored by the number of references, and histogram plots show the number of references as a function of nucleon number, proton number, and neutron number. Clicking on a histogram bar retrieves those references as a formatted table. The NSRStats can be found on the web at http://trinity.digitalcreativity.com/NSRstats. The technologies used in this service were developed in collaboration with the NNDC under grants from the Small Business Innovation Research program at the DOE.

The 131st issue of the NNDC Newsletter lists recent activities in the area of Nuclear Data.

Editor: Marion Blennau
Associate Editor: Vicki McLane

National Nuclear Data Center Building 197D
Brookhaven National Laboratory
Upton, New York 11973-5000, U.S.A.
Telephone: 516 344 2901
FAX: 516 344 2806
***(Esnet)* bnl::nndc**
***(Internet)* "services@bnl.gov"**

BNL-PCP-323

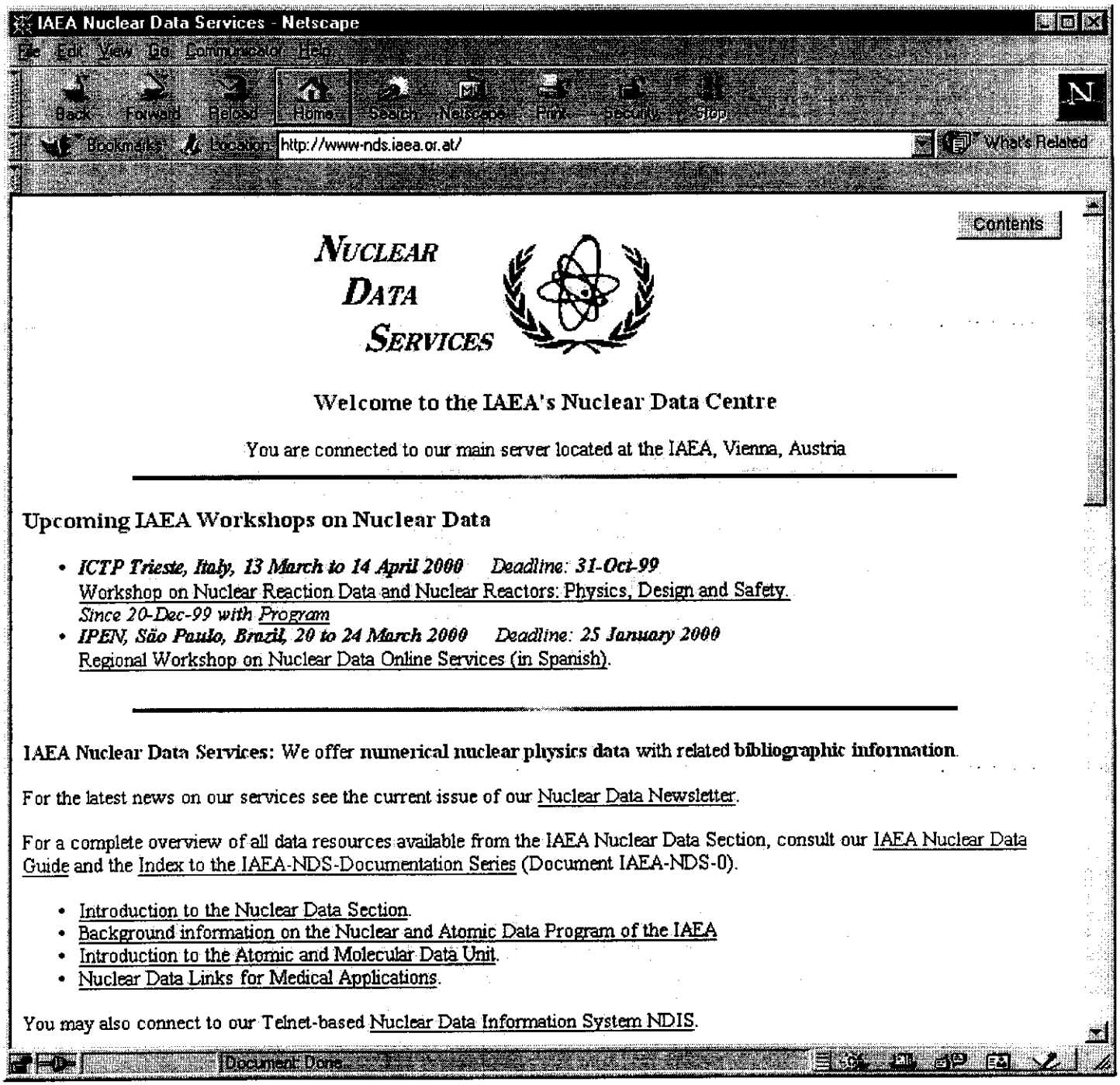
Publications and a CD available from NNDC

A limited number of copies of the following reports and a CD are available.

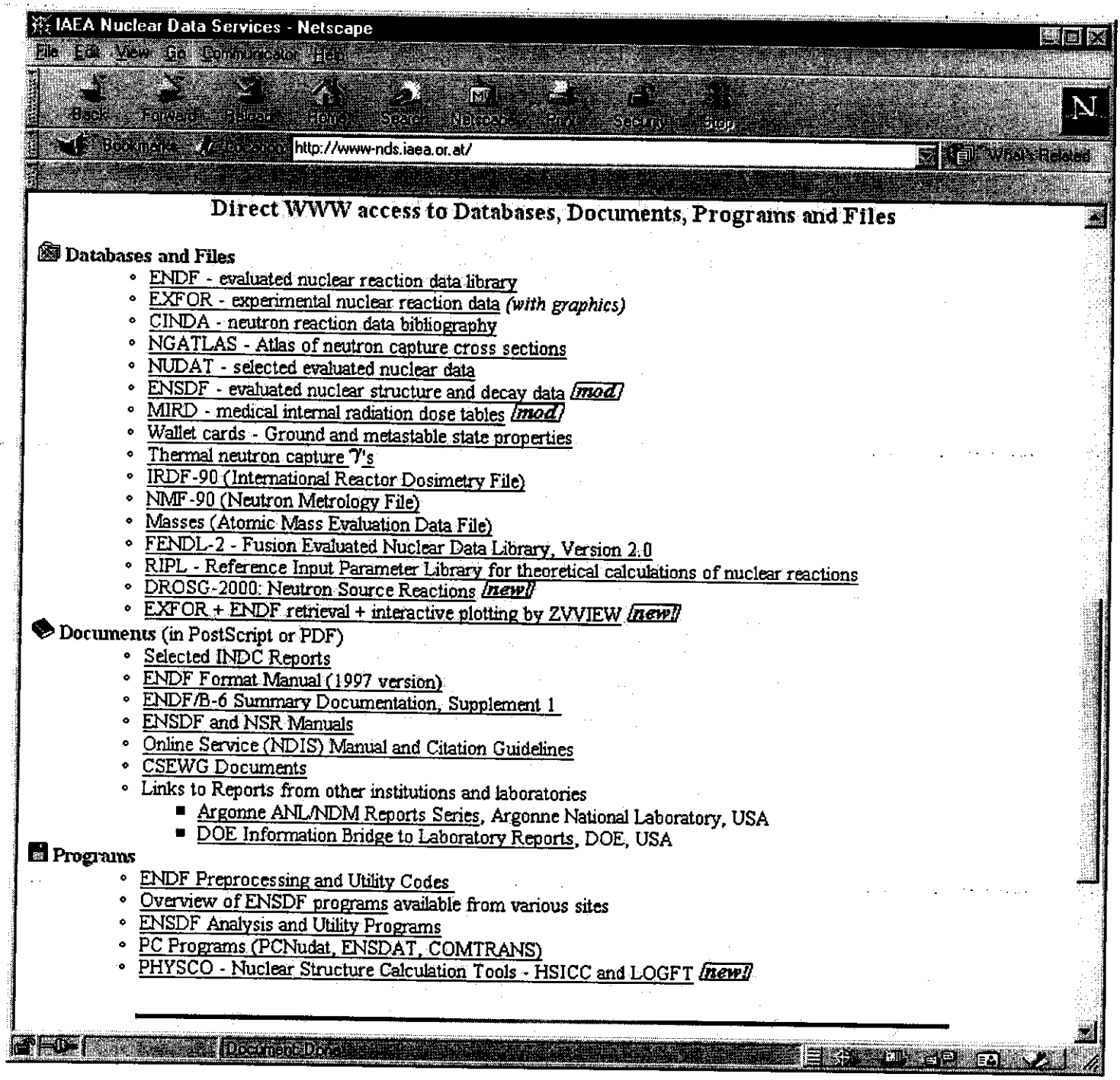
Contact: "services@bnlnd2.dne.bnl.gov".

Proceedings of the Third Specialists' Meeting on High Energy Nuclear Data, March 30-31, 1998, Japan Atomic Energy Research Institute, Tokai, Japan.

The IAEA Nuclear Data Services homepage



The IAEA Nuclear Data Services homepage (bottom of page)



2. Nuclear Data Types

- Bibliographic data
- Experimental data
- Evaluated data
- Nuclear reaction data
- Nuclear structure and decay data

Bibliographic data: important examples

- **CINDA** (*Computerized Index of Neutron DAta*)
  - Comprehensive bibliography to neutron reaction data
  - 1935 - present
  - Published regularly as a book
- **NSR** (*Nuclear Science References*)
  - Bibliographic database for low and intermediate energy nuclear physics. Main bibliography for structure and decay data and for non-neutron reaction data
  - 1910 - present
  - Published regularly in the journal *Nuclear Data Sheets (Recent References)*

Another nuclear bibliography: INIS

- INIS (International Nuclear Information System): a multi-gigabyte general nuclear bibliography maintained by IAEA
- **Not** specialized on nuclear data, **not** maintained by Nuclear Data Section. Wide scope, including reactor technology, nuclear law, nuclear medicine. Occasionally useful for nuclear data searches
- Available through WWW (license required, or through scientific library) or commercial CD-ROM

Experimental nuclear reaction data

- EXFOR
  - database for experimental nuclear reaction data for reactions induced by neutrons, charged particles and photons
  - numerical data supplemented by bibliographic and explanatory information
- CSISRS: US-NNDC implementation of EXFOR
- Related bibliographies: CINDA (neutron data), NSR

Evaluated data

- **Evaluated data** = recommended data, based on all data available from experiments and theory (critical analysis of experimental data and their uncertainties, inter- and extrapolation, supplemented with nuclear model calculations)
- **Formats** = strict rules for computerized storage of data. Most important evaluated data formats (named after main libraries):
  - **ENDF-6** (Evaluated Nuclear Data File)
  - **ENSDF** (Evaluated Nuclear Structure Data File)
- **Major libraries:**
  - Several for neutron reactions up to 20 MeV
  - One for structure and decay data: ENSDF
  - No major library for higher energy and non-neutron reaction data (only sporadic evaluations available so far)

Nuclear reaction data

- **Neutron data:** very complete collection up to 20 MeV, sporadic data for higher energies.
  - Bibliography: CINDA
  - Experimental: EXFOR
  - Major evaluated libraries in ENDF format (mostly up to 20 MeV):
    - ENDF/B-VI (USA), JEF-2 (Europe), BROND-2 (Russia), JENDL-3 (Japan), CENDL-2 (China), FENDL-2 (IAEA, fusion applications)
    - Some intermediate evaluations up to 100 MeV or 1 GeV
- **Charged particle-induced** and **photonuclear reactions:** selected experimental data in EXFOR, few evaluations
- **Heavy ion data:** some experimental data in EXFOR

Some Important Evaluated Cross Section Libraries

Main Application	Library	Origin	Comments
Neutron transport calculations	ENDF/B-VI	USA	Complete evaluations of neutron cross sections from 0 - 20 MeV for 322 materials from ^{1}H to ^{253}Es
Fusion	FENDL-2.0	IAEA-coordinated	Neutron, photon-atom, photon production, neutron activation, and charged-particle cross sections for fusion and other applications
Reactor Dosimetry	IRDF-90 Version 2	IAEA-coordinated	Neutron activation cross sections for reactor neutron dosimetry by foil activation, selected radiation damage cross sections and benchmark neutron spectra
	RRDF-98	Russia	Neutron cross sections for 22 dosimetry reactions
Activation	NGATLAS	IAEA-coordinated	Neutron capture cross sections from 10^{-5} eV to 20 MeV for 739 targets
Transmutation	MENDL-2, MENDL-2P	Russia	Activation cross sections for 505 stable and unstable targets between Al and Po for neutrons up to 100 MeV and protons up to 200 MeV
Medical Radioisotope Production	Charged Particle Cross Section Database for Medical Radioisotope Production	IAEA-coordinated project (under completion)	Production cross sections for γ-emitters, positron emitters and for monitor reactions, for protons through α-particles up to about 30 MeV
Medical Applications, Shielding	IAEA Photonuclear Data Library	IAEA-coordinated project (under completion)	Evaluated photonuclear cross sections for 164 isotopes for energies up to 140 MeV (most isotopes), up to 25 MeV for the others

Nuclear structure and decay data

- Main database: ENSDF (Evaluated Nuclear Structure Data File)
  - Half-lives, decay schemes, level properties for all known nuclides
  - Evaluations published in the journal *Nuclear Data Sheets*
  - Related bibliography: NSR (Nuclear Science References)
- NUDAT
  - Most important data extracted from ENSDF
  - Related thermal neutron data

Structure and decay data (2)

- Most other structure and decay data libraries are derived from or related to ENSDF, e.g.:
  - *Table of Isotopes* (ed. By R.B. Firestone et al., 1996), book with CD-ROM
  - *Nuclear Wallet Cards* (ground and isomeric states properties, booklet and database)
  - *NUBASE* (library of experimentally known nuclear properties: mass, half-life, decay modes of ground and isomeric states, for more than 3000 nuclides, published by G. Audi et al. in Nucl.Phys. A 624 (1997) 1 and available online
  - *Isotope Explorer,* software for retrieving and viewing ENSDF-formatted data, available online

3. Review of Important Data Libraries

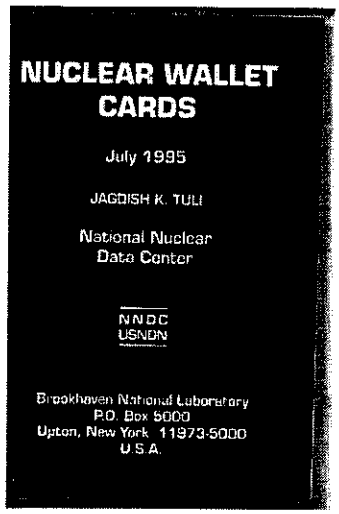
- Nuclear Wallet Cards
- NUDAT
- MIRD
- ENSDF
- CINDA
- EXFOR
- ENDF
- FENDL-2
- MENDL-2, MENDL2-P
- IRDF-90, NMF-90
- RIPL
- .....

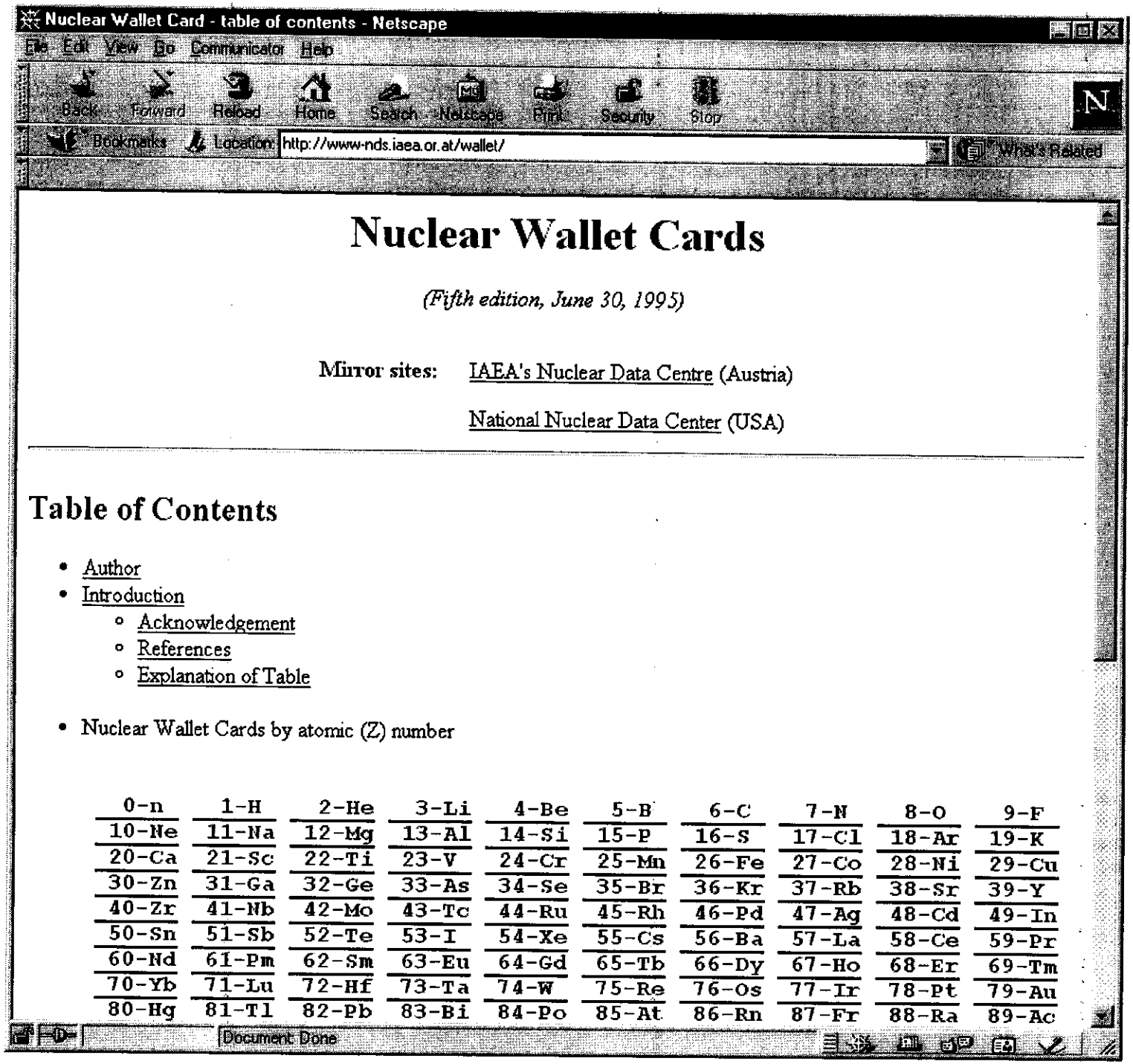
Nuclear Data Libraries at IAEA

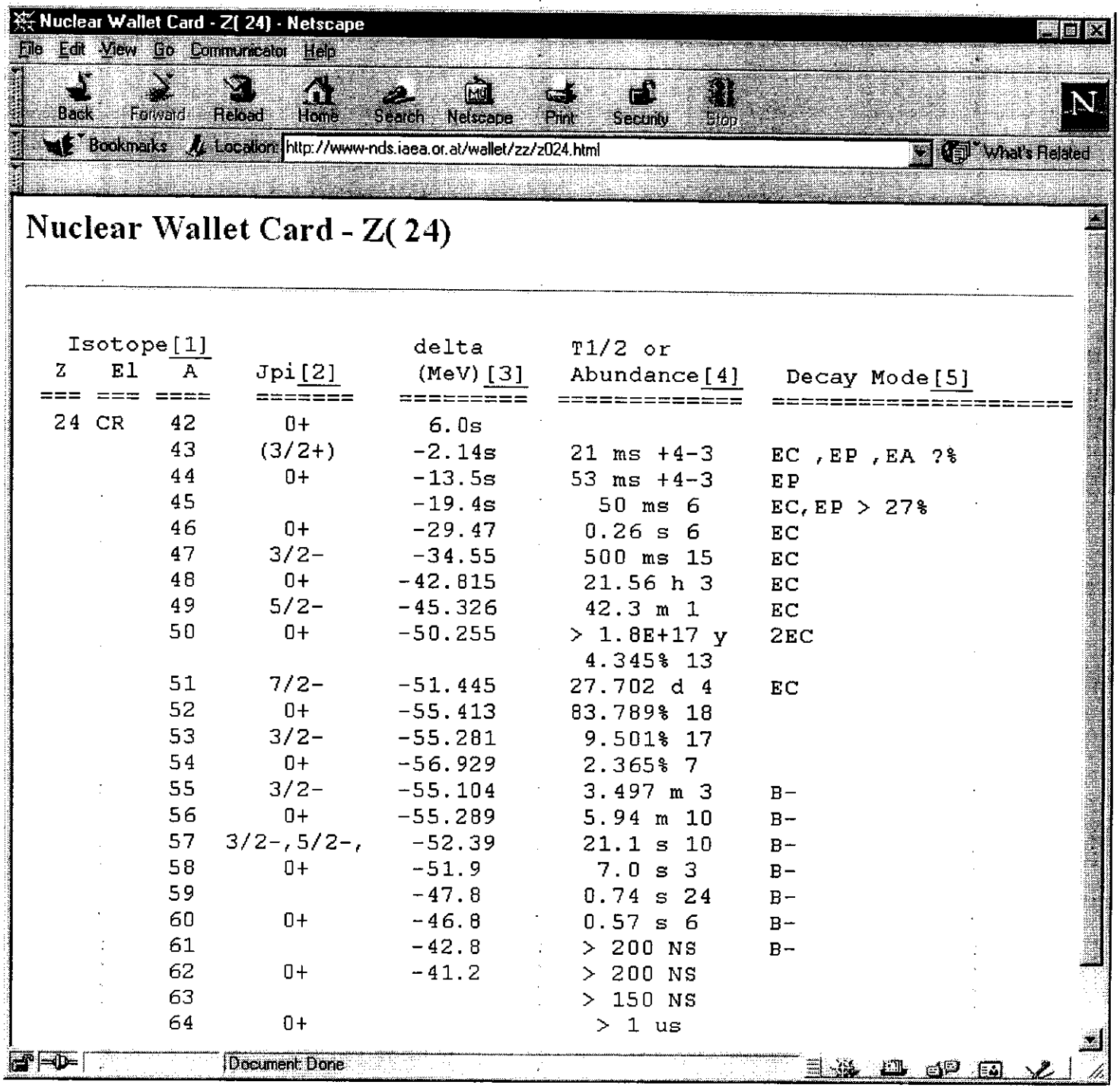
- Most comprehensive collection of nuclear data libraries worldwide - enormous value
- More than 100 libraries
- All data available free of charge to scientists in IAEA member states, on informal request or through Internet
- Overview:
  - "Index of Nuclear Data Libraries available from the IAEA Nuclear Data Section", Report IAEA-NDS-7, ed. by H.D. Lemmel and O. Schwerer (August 1998), see also *http://www-nds.iaea.or.at/reports/nds-7.pdf*
  - IAEA Nuclear Data Guide, *http://www-nds.iaea.or.at/indg_intro.html*
- Brief documentations of contents and/or format for most libraries are published in the ***IAEA-NDS-*** report series (some reports and index IAEA-NDS-0 available also online), e.g. ***IAEA-NDS-1****: EXFOR,* ***IAEA-NDS-100****: ENDF/B-VI,* ***IAEA-NDS-136****: MENDL-2*

Nuclear Wallet Cards

- Basic properties of ground and metastable states
- Available in several formats:
  - Pocket booklet (available from US-NNDC)
  - WWW: (display of tables for each element)
  - WWW as part of NUDAT (interactive retrievals by various criteria)
  - Telnet: as part of NUDAT, same functions as in WWW




Nuclear Wallet Card - table of contents - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Stop
Bookmarks Location: http://www-nds.iaea.or.at/wallet/
What's Related
Nuclear Wallet Cards
(Fifth edition, June 30, 1995)
Mirror sites: IAEA's Nuclear Data Centre (Austria)
National Nuclear Data Center (USA)
Table of Contents
Author
Introduction
Acknowledgement
References
Explanation of Table
Nuclear Wallet Cards by atomic (Z) number
0-n 1-H 2-He 3-Li 4-Be 5-B 6-C 7-N 8-O 9-F
10-Ne 11-Na 12-Mg 13-Al 14-Si 15-P 16-S 17-Cl 18-Ar 19-K
20-Ca 21-Sc 22-Ti 23-V 24-Cr 25-Mn 26-Fe 27-Co 28-Ni 29-Cu
30-Zn 31-Ga 32-Ge 33-As 34-Se 35-Br 36-Kr 37-Rb 38-Sr 39-Y
40-Zr 41-Nb 42-Mo 43-Tc 44-Ru 45-Rh 46-Pd 47-Ag 48-Cd 49-In
50-Sn 51-Sb 52-Te 53-I 54-Xe 55-Cs 56-Ba 57-La 58-Ce 59-Pr
60-Nd 61-Pm 62-Sm 63-Eu 64-Gd 65-Tb 66-Dy 67-Ho 68-Er 69-Tm
70-Yb 71-Lu 72-Hf 73-Ta 74-W 75-Re 76-Os 77-Ir 78-Pt 79-Au
80-Hg 81-Tl 82-Pb 83-Bi 84-Po 85-At 86-Rn 87-Fr 88-Ra 89-Ac
Document Done

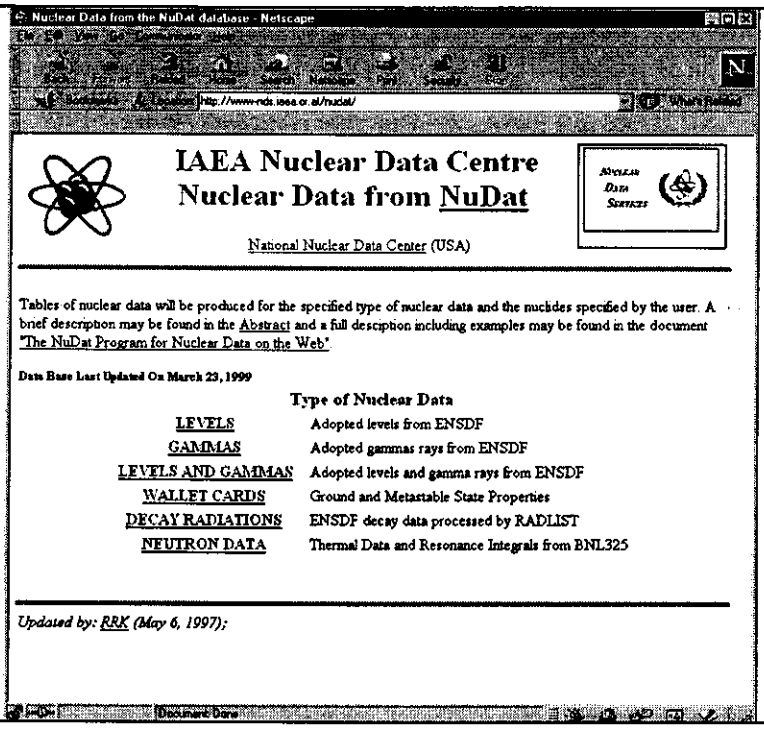


Nuclear Wallet Card - Z(24)

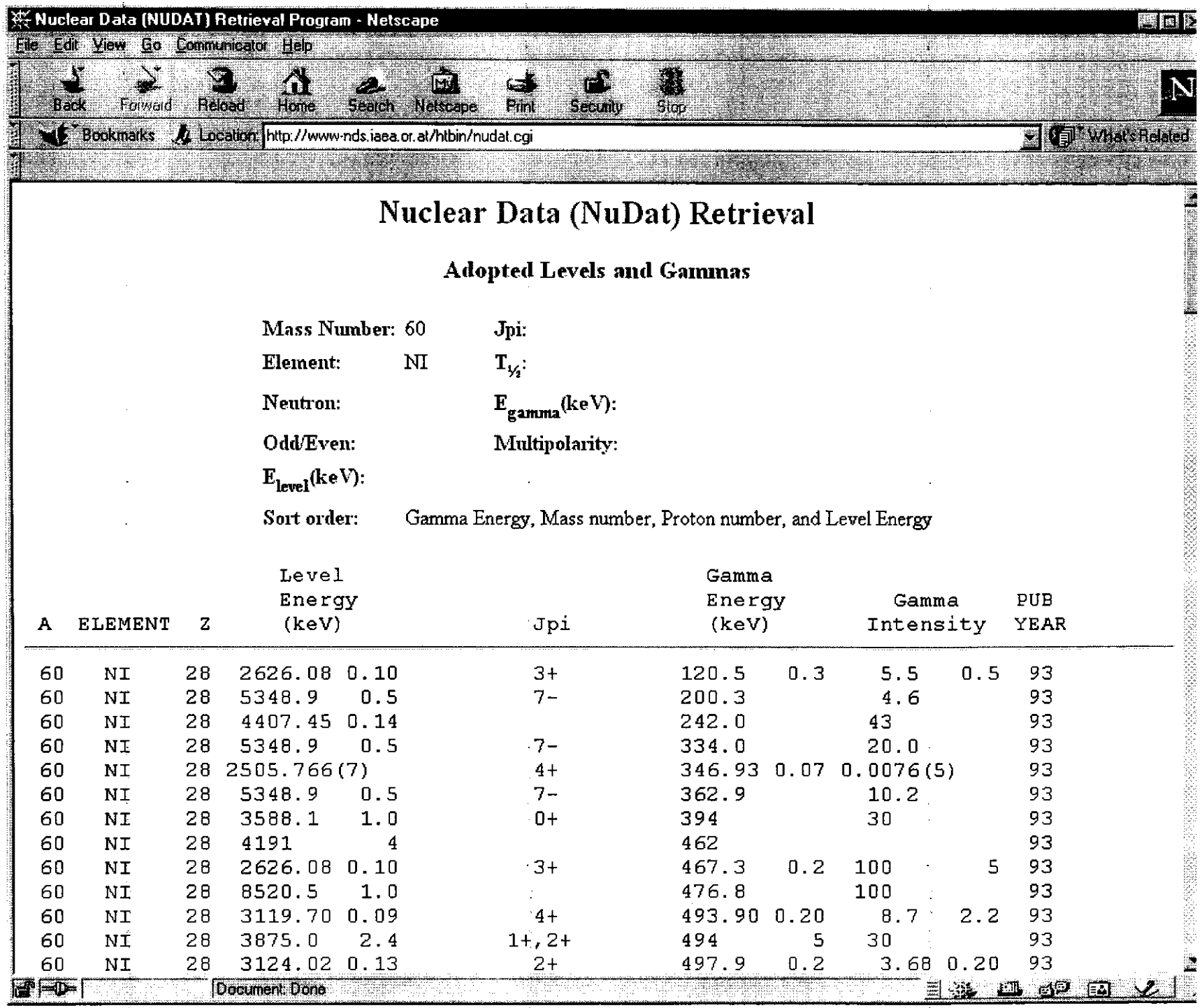
Z	El	A	Jpi[2]	delta (MeV)[3]	T1/2 or Abundance[4]	Decay Mode[5]
24	CR	42	0+	6.0s		
		43	(3/2+)	-2.14s	21 ms +4-3	EC ,EP ,EA ?%
		44	0+	-13.5s	53 ms +4-3	EP
		45		-19.4s	50 ms 6	EC,EP > 27%
		46	0+	-29.47	0.26 s 6	EC
		47	3/2-	-34.55	500 ms 15	EC
		48	0+	-42.815	21.56 h 3	EC
		49	5/2-	-45.326	42.3 m 1	EC
		50	0+	-50.255	> 1.8E+17 y 4.345% 13	2EC
		51	7/2-	-51.445	27.702 d 4	EC
		52	0+	-55.413	83.789% 18	
		53	3/2-	-55.281	9.501% 17	
		54	0+	-56.929	2.365% 7	
		55	3/2-	-55.104	3.497 m 3	B-
		56	0+	-55.289	5.94 m 10	B-
		57	3/2-,5/2-,	-52.39	21.1 s 10	B-
		58	0+	-51.9	7.0 s 3	B-
		59		-47.8	0.74 s 24	B-
		60	0+	-46.8	0.57 s 6	B-
		61		-42.8	> 200 NS	B-
		62	0+	-41.2	> 200 NS	
		63			> 150 NS	
		64	0+		> 1 us	

NUDAT

- User-friendly extract of most important data (for applications) from ENSDF, plus thermal neutron data (cross sections and resonance integrals)
- Consists of 6 modules:
  - Levels / Gammas / Levels and Gammas / Wallet Cards / Decay Radiations / Neutron Data
- Available online through WWW and Telnet. Interactive retrievals by various criteria
- PC version can be downloaded (PCNUDAT). (Superseding 1996 CD-ROM version "Nuclear Data and References")



NUDAT/ Adopted Levels and Gammas for ^{60}Ni



Nuclear Data (NuDat) Retrieval

Adopted Levels and Gammas

Mass Number: 60 **Jpi:**

Element: NI **$T_{½}$:**

Neutron: **E_{gamma}(keV):**

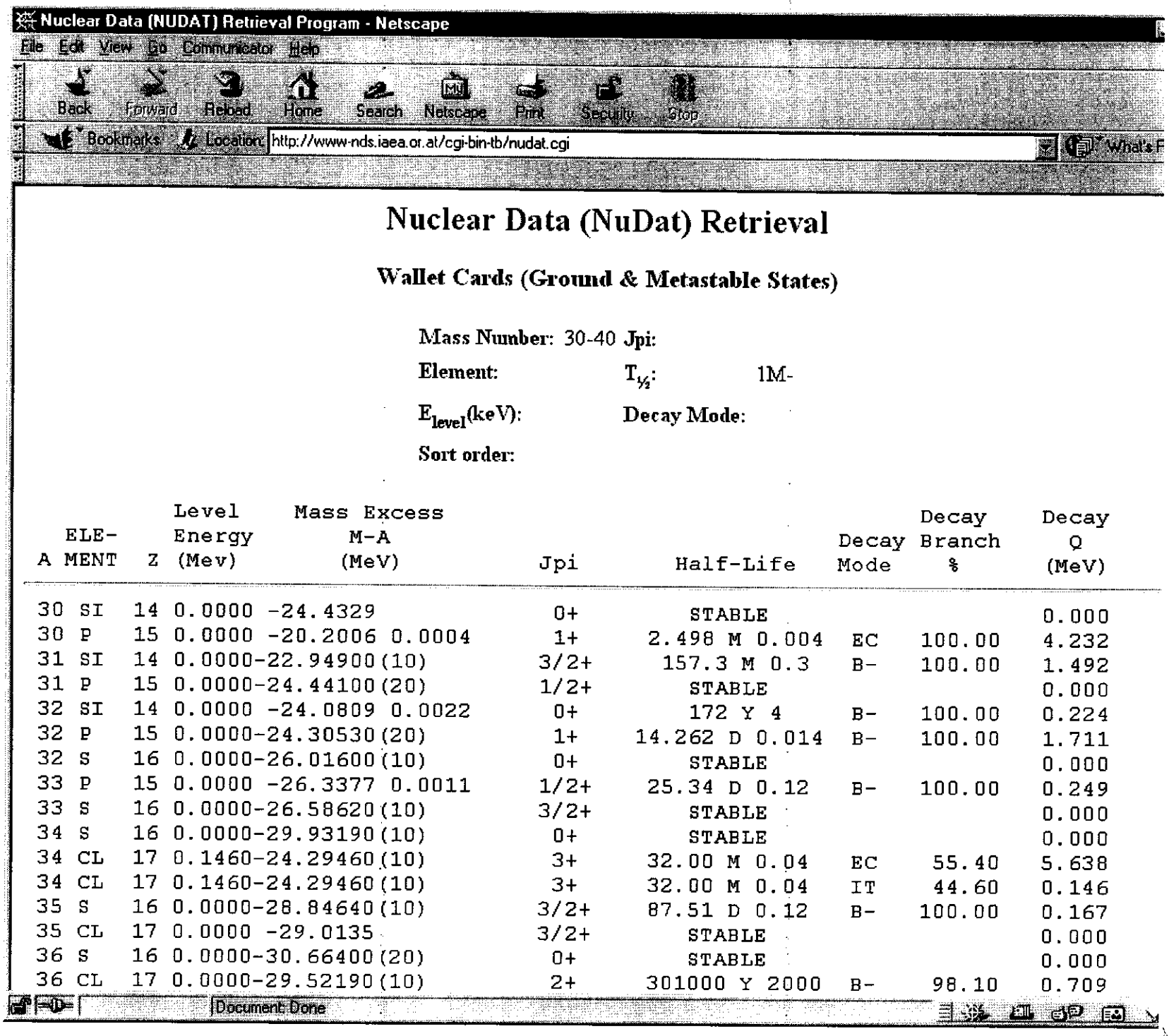
Odd/Even: **Multipolarity:**

E_{level}(keV):

Sort order: Gamma Energy, Mass number, Proton number, and Level Energy

A	ELEMENT	Z	Level Energy (keV)	Jpi	Gamma Energy (keV)	Gamma Intensity	PUB YEAR
60	NI	28	2626.08 0.10	3+	120.5 0.3	5.5 0.5	93
60	NI	28	5348.9 0.5	7-	200.3	4.6	93
60	NI	28	4407.45 0.14		242.0	43	93
60	NI	28	5348.9 0.5	7-	334.0	20.0	93
60	NI	28	2505.766(7)	4+	346.93 0.07	0.0076(5)	93
60	NI	28	5348.9 0.5	7-	362.9	10.2	93
60	NI	28	3588.1 1.0	0+	394	30	93
60	NI	28	4191 4		462		93
60	NI	28	2626.08 0.10	3+	467.3 0.2	100 5	93
60	NI	28	8520.5 1.0		476.8	100	93
60	NI	28	3119.70 0.09	4+	493.90 0.20	8.7 2.2	93
60	NI	28	3875.0 2.4	1+,2+	494 5	30	93
60	NI	28	3124.02 0.13	2+	497.9 0.2	3.68 0.20	93

NUDAT/
Wallet Cards
Retrieval for
A=30-40,
$T_{1/2}$>1 min



A	ELEMENT	Z	Level Energy (Mev)	Mass Excess M-A (MeV)	Jpi	Half-Life	Decay Mode	Decay Branch %	Decay Q (MeV)
30	SI	14	0.0000	-24.4329	0+	STABLE			0.000
30	P	15	0.0000	-20.2006 0.0004	1+	2.498 M 0.004	EC	100.00	4.232
31	SI	14	0.0000	-22.94900(10)	3/2+	157.3 M 0.3	B-	100.00	1.492
31	P	15	0.0000	-24.44100(20)	1/2+	STABLE			0.000
32	SI	14	0.0000	-24.0809 0.0022	0+	172 Y 4	B-	100.00	0.224
32	P	15	0.0000	-24.30530(20)	1+	14.262 D 0.014	B-	100.00	1.711
32	S	16	0.0000	-26.01600(10)	0+	STABLE			0.000
33	P	15	0.0000	-26.3377 0.0011	1/2+	25.34 D 0.12	B-	100.00	0.249
33	S	16	0.0000	-26.58620(10)	3/2+	STABLE			0.000
34	S	16	0.0000	-29.93190(10)	0+	STABLE			0.000
34	CL	17	0.1460	-24.29460(10)	3+	32.00 M 0.04	EC	55.40	5.638
34	CL	17	0.1460	-24.29460(10)	3+	32.00 M 0.04	IT	44.60	0.146
35	S	16	0.0000	-28.84640(10)	3/2+	87.51 D 0.12	B-	100.00	0.167
35	CL	17	0.0000	-29.0135	3/2+	STABLE			0.000
36	S	16	0.0000	-30.66400(20)	0+	STABLE			0.000
36	CL	17	0.0000	-29.52190(10)	2+	301000 Y 2000	B-	98.10	0.709

NUDAT/ Decay Radiations for ^{66}Cu

Nuclear Data (NUDAT) Retrieval Program - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Stop

Bookmarks Location: http://www-nds.iaea.or.at/cgi-bin-tb/nudat.cgi What's Related

Nuclear Data (NuDat) Retrieval

Decay Radiations

Mass Number: 66 **Radiation:**

Element: CU **Radiation Energy (keV):**

$T_{1/2}$: **Radiation Intensity:**

Decay Mode:

Sort order: Mass number, Proton number, Half-Life, and Radiation

A	ELEMENT	Z	Decay Mode	Half-Life	Rad. Type		Radiation Energy (keV)		Radiation Intensity (%)		Dose (G-RAD /UCI-H)
66	CU	29	B-	5.120 M 0.014	B-		79.2	0.7	0.0037	0.0003	0
66	CU	29	B-	5.120 M 0.014	B-		266.2	0.6	0.220	0.005	0.0012
66	CU	29	B-	5.120 M 0.014	B-		628.1	0.6	9.01	0.09	0.121
66	CU	29	B-	5.120 M 0.014	B-	TOT	1066.6	0.7	100.00	0.13	2.27
66	CU	29	B-	5.120 M 0.014	B-		1112.1	0.6	90.77	0.09	2.15
66	CU	29	B-	5.120 M 0.014	G		833.0	1.0	0.220	0.005	0.0039
66	CU	29	B-	5.120 M 0.014	G		1039.20	0.20	9.23	0.09	0.204
66	CU	29	B-	5.120 M 0.014	G		1332.5	1.5	0.0037	0.0003	0.0001
66	CU	29	B-	5.120 M 0.014	G		1872.		0.00023	(23)	0

This program and the accompanying data base has been produced by the National Nuclear Data Center located at the Brookhaven National Laboratory Upton, N.Y., USA, with funding from the U.S. Department of Energy. Neither the BNL nor the USDOE make any warranty or assume any legal responsibility for the contents of the data base.

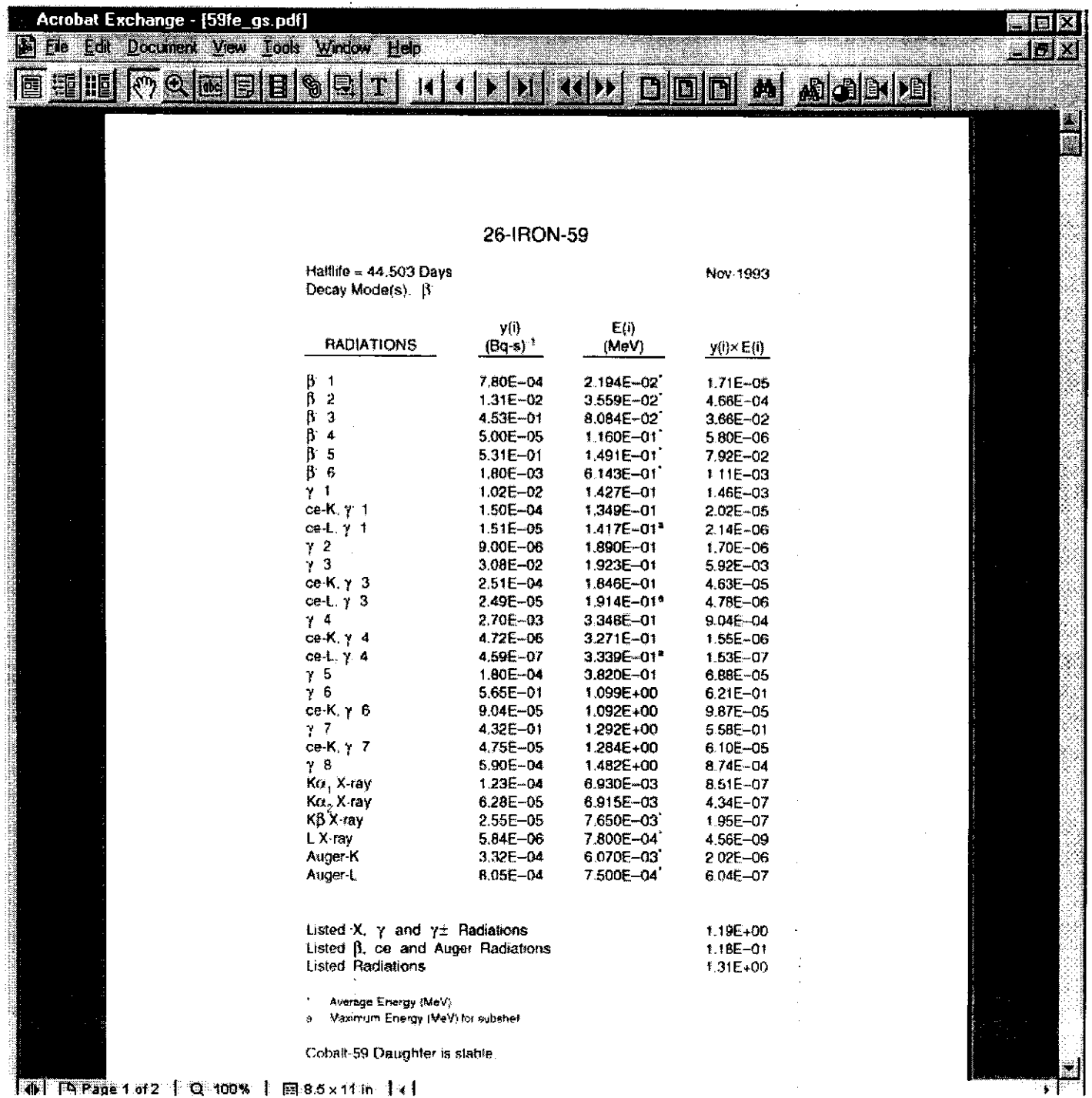
Document: Done

MIRD - "Medical Internal Radiation Dose"

- Based on ENSDF, data processed with code "RADLST". Input: only nuclide selection
- Output: Tables with intensities, energies and dose of all produced radiations, including X-rays, Auger electrons, etc., and decay scheme plots
- Output in HTML/GIF or PostScript
- NUDAT option "Decay radiations" provides similar function (table only)
- "Advanced" or "custom" tables: use RADLST separately (available for downloading)

MIRD Output

("Medical Internal Radiation Dose")



26-IRON-59

Halflife = 44.503 Days
Decay Mode(s). β⁻

Nov-1993

RADIATIONS	y(i) (Bq-s)⁻¹	E(i) (MeV)	y(i)×E(i)
β⁻ 1	7.80E−04	2.194E−02*	1.71E−05
β⁻ 2	1.31E−02	3.559E−02*	4.66E−04
β⁻ 3	4.53E−01	8.084E−02*	3.66E−02
β⁻ 4	5.00E−05	1.160E−01*	5.80E−06
β⁻ 5	5.31E−01	1.491E−01*	7.92E−02
β⁻ 6	1.80E−03	6.143E−01*	1.11E−03
γ 1	1.02E−02	1.427E−01	1.46E−03
ce-K, γ 1	1.50E−04	1.349E−01	2.02E−05
ce-L, γ 1	1.51E−05	1.417E−01a	2.14E−06
γ 2	9.00E−06	1.890E−01	1.70E−06
γ 3	3.08E−02	1.923E−01	5.92E−03
ce-K, γ 3	2.51E−04	1.846E−01	4.63E−05
ce-L, γ 3	2.49E−05	1.914E−01a	4.78E−06
γ 4	2.70E−03	3.348E−01	9.04E−04
ce-K, γ 4	4.72E−06	3.271E−01	1.55E−06
ce-L, γ 4	4.59E−07	3.339E−01a	1.53E−07
γ 5	1.80E−04	3.820E−01	6.88E−05
γ 6	5.65E−01	1.099E+00	6.21E−01
ce-K, γ 6	9.04E−05	1.092E+00	9.87E−05
γ 7	4.32E−01	1.292E+00	5.58E−01
ce-K, γ 7	4.75E−05	1.284E+00	6.10E−05
γ 8	5.90E−04	1.482E+00	8.74E−04
$K\alpha_1$ X-ray	1.23E−04	6.930E−03	8.51E−07
$K\alpha_2$ X-ray	6.28E−05	6.915E−03	4.34E−07
Kβ X-ray	2.55E−05	7.650E−03*	1.95E−07
L X-ray	5.84E−06	7.800E−04*	4.56E−09
Auger-K	3.32E−04	6.070E−03*	2.02E−06
Auger-L	8.05E−04	7.500E−04*	6.04E−07

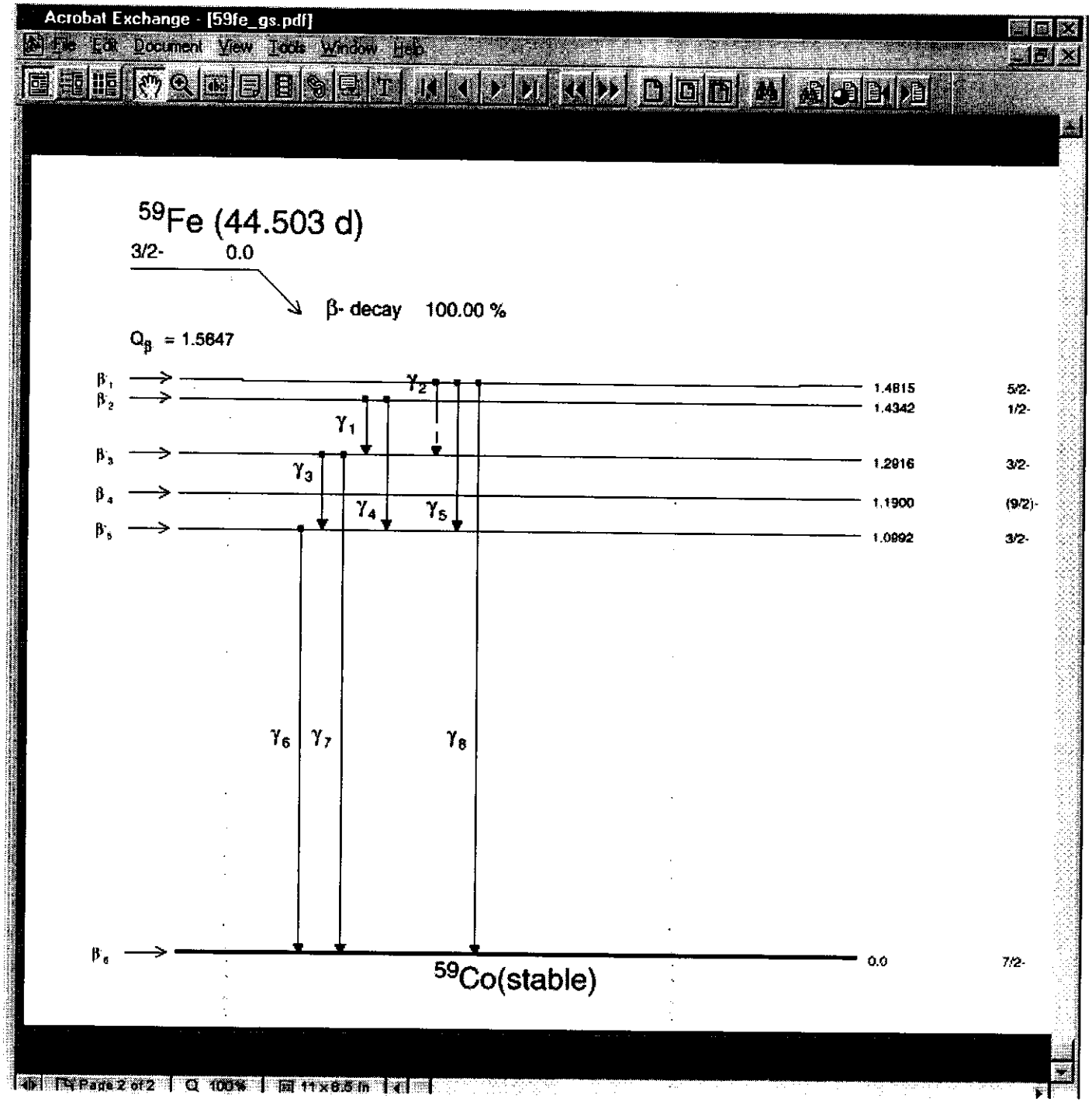
Listed X, γ and γ± Radiations	1.19E+00
Listed β, ce and Auger Radiations	1.18E−01
Listed Radiations	1.31E+00

* Average Energy (MeV)
a Maximum Energy (MeV) for subshell

Cobalt-59 Daughter is stable.

MIRD Output

("Medical Internal Radiation Dose")

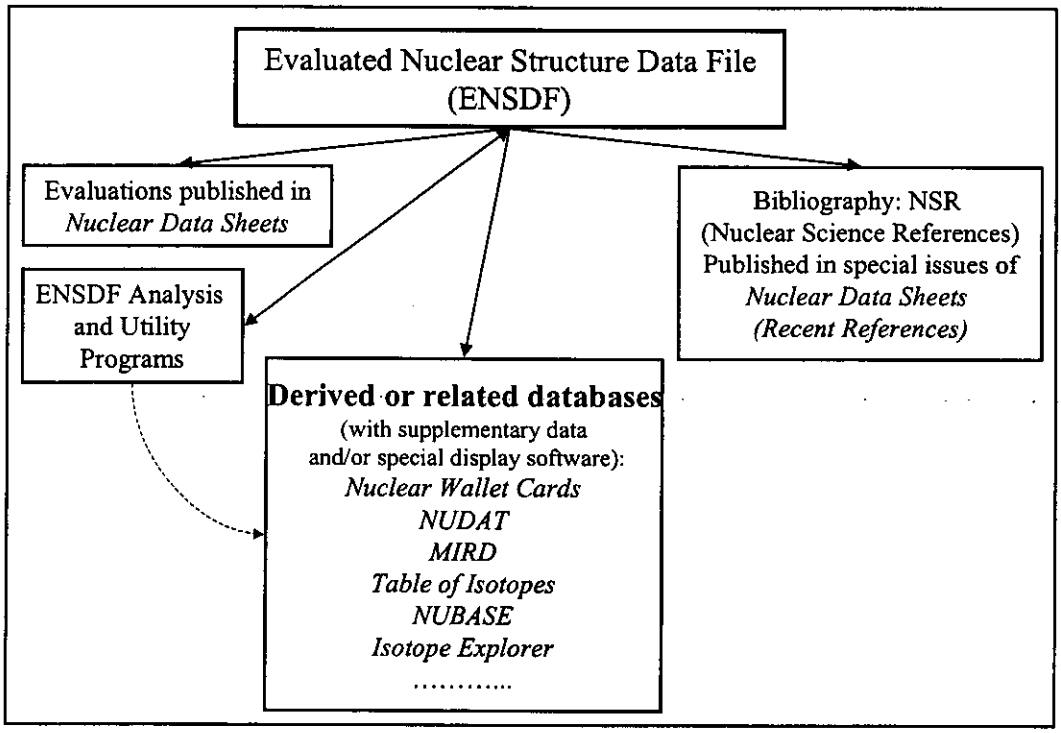


Radiation doses in MIRD, NUDAT

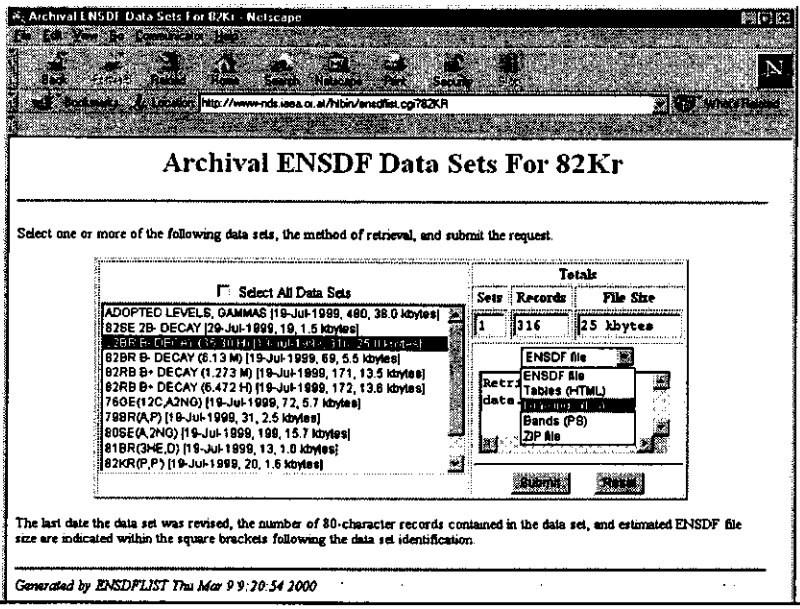
- MIRD and NUDAT calculate *Equilibrium Dose Rates* ("Dose") from ENSDF decay data
- Units: MeV/decay (MIRD), g·rad/μCi·h (NUDAT/Decay Radiations)
- 1 MeV/decay = 2.13 g·rad/μCi·h
- Reference: T.W.Burrows, *The Program RADLST* (documentation available online in PostScript)

ENSDF (Evaluated Nuclear Structure Data File)

- "Master library" for structure and decay data
- International evaluation effort coordinated by IAEA, master file maintained by US-NNDC
- Covers mass range 1 - 266
- Organized by nuclide; several "data sets" per nuclide
- Evaluations done for mass chains (e.g. A=235), published in journal *Nuclear Data Sheets*
- Special internal format
- Standard output: Tables and/or plots (ASCII, PostScript)
- Retrievals: full functionality only through Telnet, WWW interface has (so far) limited options



ENSDF: Data sets for ^{82}Kr



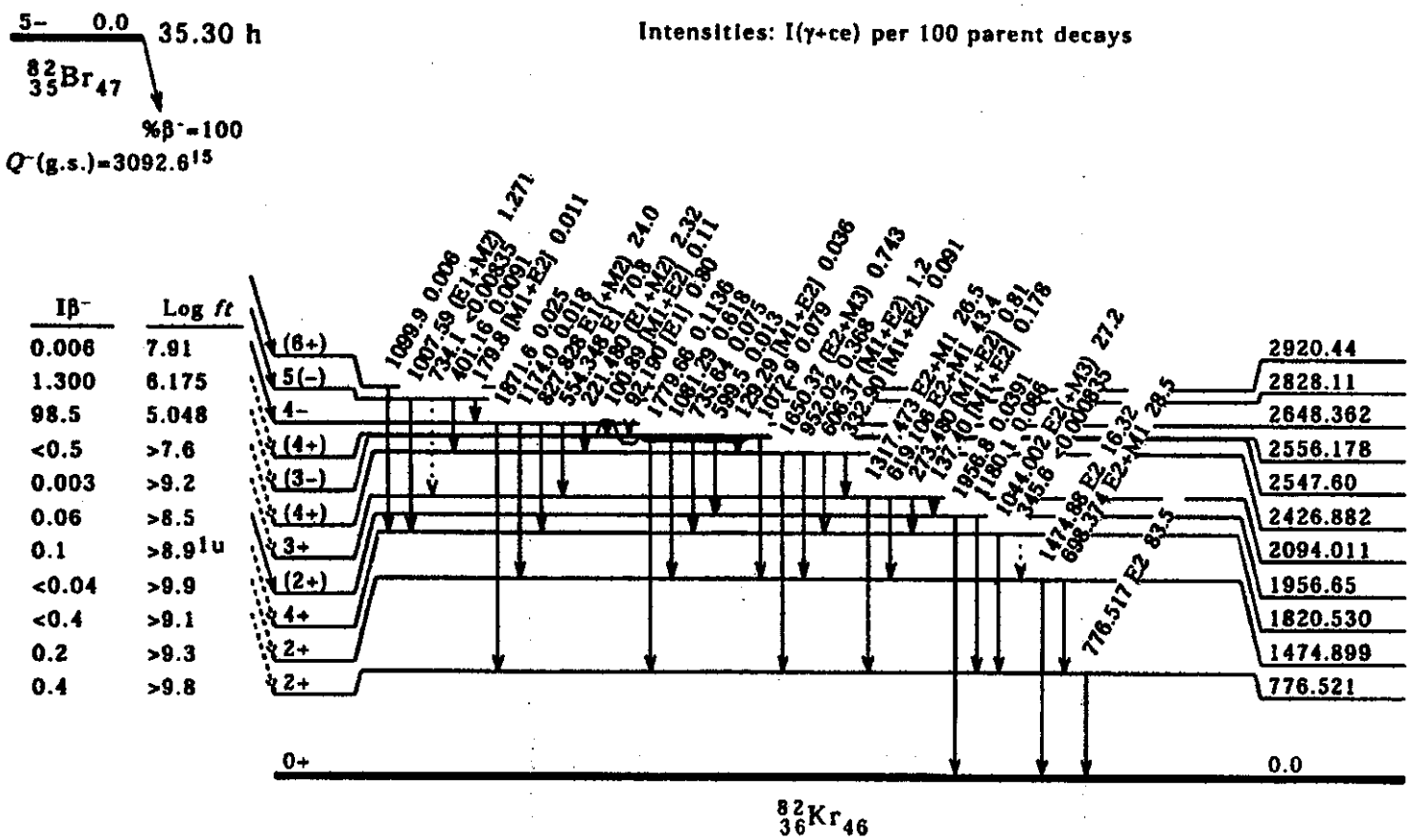
ENSDF Plot (^{82}Br β-decay)

$^{82}_{36}Kr_{46}$ $^{82}_{36}Kr_{46}$

^{82}Br β⁻ Decay (35.30 h) 1983Me08 (continued)

Decay Scheme

Intensities: I(γ+ce) per 100 parent decays



$^{82}_{36}Kr_{46}$

ENSDF:
Table output

$^{82}_{36}Kr_{46}$

^{82}Br β⁻ Decay (35.30 h) 1983Me08 (continued)

γ(^{82}Kr) (continued)

Measurement of anisotropy of γ's emitted by oriented nuclei: 1977Ca26. Deduced δ.
Measurements of conversion coefficients: 1958Be81, 1956Wa24. Magnetic spectrometer. Measured Ice. Deduced α(exp) from comparison with entire β spectrum. Quoted values are weighted averages of both measurements.
Iγ normalization: ΣI(γ+ce) to g.s.=100 since g.s. β transition is highly forbidden.

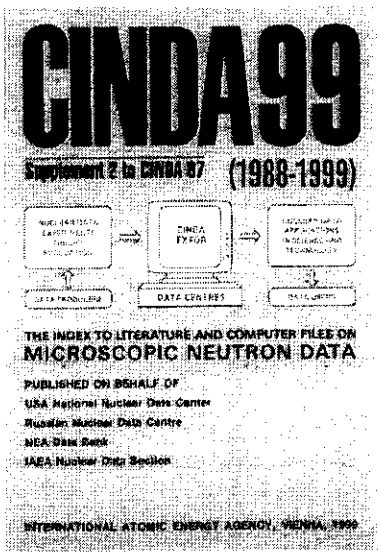
Eγ[†]	E(level)	Iγ[†b]	Mult.[‡]	δ[§]	α	Comments
92.190 *16*	2648.362	0.86[&] *4*	[E1]		0.115[a]	α(K)=0.102; α(L)=0.0110; α(M)=0.00178.
100.89 *8*	2648.362	0.084 *8*	[M1+E2]		0.5 *4*	α(K)=0.4 *4*; α(L)=0.06 *5*; α(M)=0.010 *9*.
129.29 *3*	2556.178	0.036 *7*	[M1+E2]		0.21 *15*	α(K)=0.18 *13*; α(L)=0.024 *18*; α(M)=0.004 *3*.
137.40 *5*	2094.011	0.182 *2*	[M1+E2]		0.17[a] *12*	α(K)=0.15 *10*; α(L)=0.019 *14*; α(M)=0.0031 *23*.
179.8 *2*	2828.11	0.012 *9*	[M1+E2]		0.07[a] *4*	α(K)=0.06 *4*; α(L)=0.007 *5*.
221.480[@] *2*	2648.362	2.71[&] *8*	(E1+M2)	+0.5 *3*	0.025 *15*	α(K)=0.021 *13*; α(L)=0.0025 *16*.
273.480 *8*	2094.011	0.96[&] *3*	(M1+E2)	+0.18 *6*	0.0098 *4*	δ; or δ=+2.6 *5*.
332.90 *3*	2426.882	0.108 *5*	[M1+E2]		0.009[a] *4*	α(K)=0.0085 *3*; α(L)=0.00093 *4*.
(345.6)	1820.530	<0.001				α(K)=0.008 *3*; α(L)=0.0009 *4*.
401.16 *6*	2828.11	0.0109 *9*				
554.348[@] *2*	2648.362	84.7[&] *8*	E1			α(exp)=0.00069 *7*.
599.5 *3*	2556.178	0.016 *9*				α=0.00077; α(K)=0.00067.
						Eγ: the value 559.5 quoted by 1983Me08 is probably a misprint (compare 599.5γ observed by 1970Me02).
606.37	2426.882	1.45	(M1+E2)	−0.34 *10*		α=0.00144 *3*; α(K)=0.00126 *2*; α(L)=0.00013.
619.105[@] *4*	2094.011	52.0[&] *5*	E2+M1	+1.97 *6*		α(exp)=0.0015 *2*.
						δ: other: δ=2.2 *4* from oriented nuclei (1977Ca26).
698.374[@] *5*	1474.899	34.1[&] *3*	E2+M1	+2.1 *4*		α=0.00165; α(K)=0.00144; α(L)=0.00016.
						α(exp)=0.00090 *13*.
						δ: other: δ=2.7 *3* from oriented nuclei (1977Ca26). δ(E0)=0.1 *+2-1* (1973Ca10).
(734.1)	2828.11	<0.01				α=0.00120 *2*; α(K)=0.00105 *1*; α(L)=0.00011.
735.64 *7*	2556.178	0.09 *1*				
776.517[@] *3*	776.521	100.0[&] *10*	E2			α(exp)=0.00085 *9*.
827.828[@] *6*	2648.362	28.77[&] *29*	E1(+M2)	+0.09 *4*		α=0.00093; α(K)=0.00082.
952.02 *3*	2426.882	0.44 *2*				α(exp)=0.00029 *4*.
1007.59 *3*	2828.11	1.522[&] *15*	(E1+M2)	+0.07 *5*		α=0.00033 *1*; α(K)=0.00029 *1*.
1044.002[@] *5*	1820.530	32.6[&] *3*	E2(+M3)	+0.05 *4*		α=0.00019 *1*; α(K)=0.00019 *1*.
1072.9 *1*	2547.60	0.095 *19*				α(exp)=0.00038 *3*.
1081.29 *5*	2556.178	0.74 *2*				α=0.00040 *1*; α(K)=0.00040 *1*.

CINDA (Computer Index of Neutron Data)

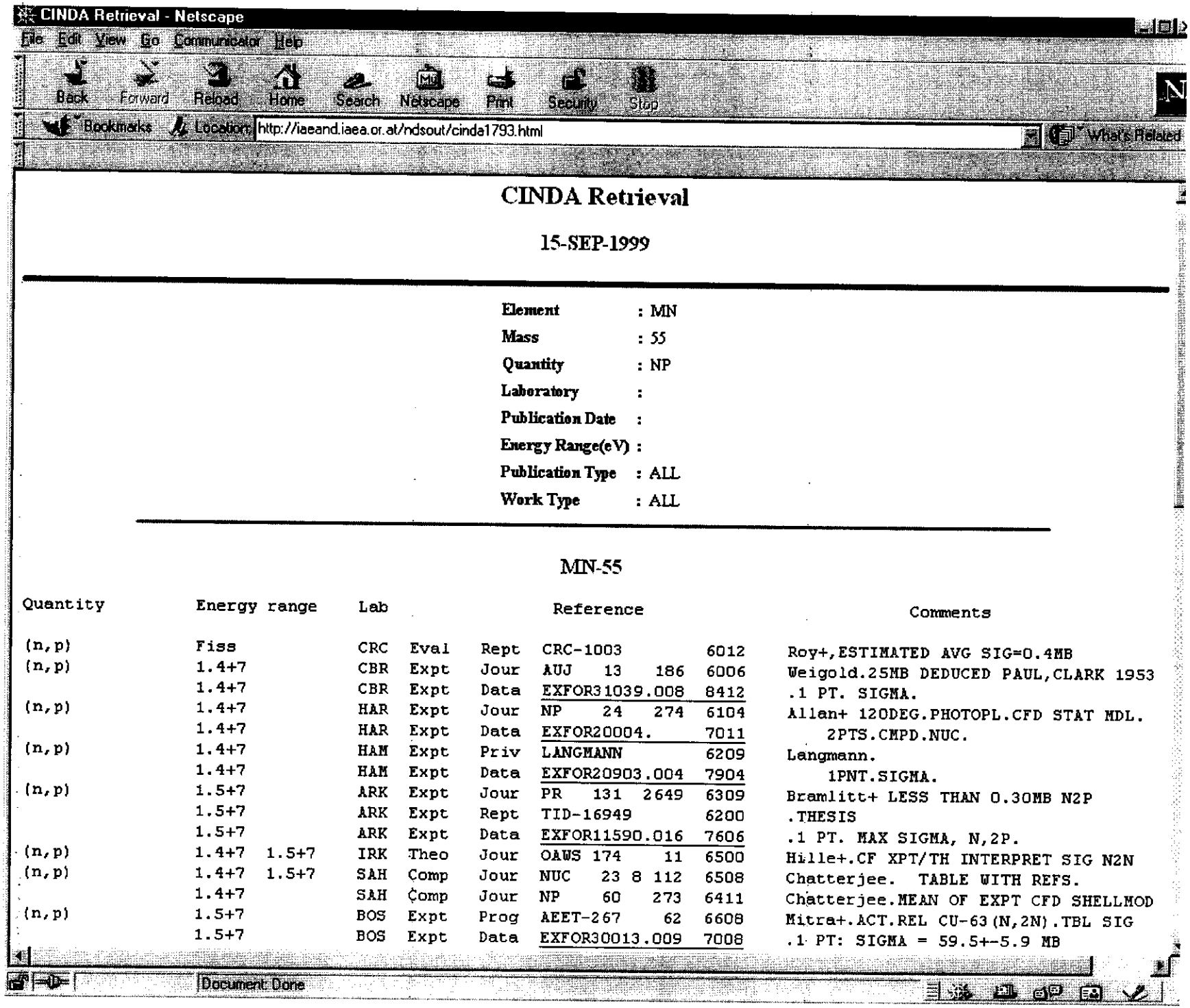
- Bibliography of neutron data (literature, inofficial publications, computer files); (γ,n), (γ,f) and spontaneous fission data also included
- Entries primarily sorted by nuclide, reaction/quantity, laboratory; therefore separate entries for each measured reaction of one publication
- Unique feature: all entries describing the same experiment are listed together ("CINDA blocks")
- Extension of database to include **charged-particle induced** and (all) **photonuclear** reactions is under preparation (2001?)

CINDA products and retrievals

- CINDA book
  - Complete file contained in several volumes:
    - Archival 1935-1987 (5 volumes)
    - CINDA97 (1988-1997)
    - CINDA99 (Supplement to CINDA97)
- Selective online retrievals through WWW and Telnet. WWW output with hyperlinks to EXFOR
- Complete file on CD-ROM about to be released



CINDA Retrieval for $^{55}Mn(n,p)$



CINDA Retrieval - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Stop

Bookmarks Location: http://iaeand.iaea.or.at/ndsout/cinda1793.html What's Related

CINDA Retrieval

15-SEP-1999

Element : MN
Mass : 55
Quantity : NP
Laboratory :
Publication Date :
Energy Range(eV) :
Publication Type : ALL
Work Type : ALL

MN-55

Quantity	Energy range		Lab			Reference		Comments
(n,p)	Fiss		CRC	Eval	Rept	CRC-1003	6012	Roy+,ESTIMATED AVG SIG=0.4MB
(n,p)	1.4+7		CBR	Expt	Jour	AUJ 13 186	6006	Weigold.25MB DEDUCED PAUL,CLARK 1953
	1.4+7		CBR	Expt	Data	EXFOR31039.008	8412	.1 PT. SIGMA.
(n,p)	1.4+7		HAR	Expt	Jour	NP 24 274	6104	Allan+ 120DEG.PHOTOPL.CFD STAT MDL.
	1.4+7		HAR	Expt	Data	EXFOR20004.	7011	2PTS.CMPD.NUC.
(n,p)	1.4+7		HAM	Expt	Priv	LANGMANN	6209	Langmann.
	1.4+7		HAM	Expt	Data	EXFOR20903.004	7904	1PNT.SIGMA.
(n,p)	1.5+7		ARK	Expt	Jour	PR 131 2649	6309	Bramlitt+ LESS THAN 0.30MB N2P
	1.5+7		ARK	Expt	Rept	TID-16949	6200	.THESIS
	1.5+7		ARK	Expt	Data	EXFOR11590.016	7606	.1 PT. MAX SIGMA, N,2P.
(n,p)	1.4+7	1.5+7	IRK	Theo	Jour	OAWS 174 11	6500	Hille+.CF XPT/TH INTERPRET SIG N2N
(n,p)	1.4+7	1.5+7	SAH	Comp	Jour	NUC 23 8 112	6508	Chatterjee. TABLE WITH REFS.
	1.4+7		SAH	Comp	Jour	NP 60 273	6411	Chatterjee.MEAN OF EXPT CFD SHELLMOD
(n,p)	1.5+7		BOS	Expt	Prog	AEET-267 62	6608	Mitra+.ACT.REL CU-63(N,2N).TBL SIG
	1.5+7		BOS	Expt	Data	EXFOR30013.009	7008	.1 PT: SIGMA = 59.5+-5.9 MB

Document Done

EXFOR

- Unified computerized system (library and format) by which international, regional and national data analysis centers exchange experimental nuclear reaction data
- Compilation and exchange coordinated by IAEA
- CSISRS = US implementation of EXFOR
- Coverage is complete for neutron data (in particular up to 20 MeV)
- Coverage less complete (but improving) for higher energy neutrons, charged particle-induced and photonuclear data
- More than 60 000 data sets, more than 3 million data points

More on EXFOR

- Library contains numerical tables and structured abstract with experimental and bibliographic information
- Neutron data: bibliographic link to CINDA (non-neutron data will be added to CINDA in 1-2 years)
- Main users:
  - Evaluators (EXFOR database is starting point for all evaluations)
  - Applied users, if no evaluation available
  - Anybody measuring or calculating cross section data

Access to EXFOR

- Available for interactive retrievals through WWW and Telnet (~one reaction at a time)
- CD-ROM with retrieval program (similar functionality as WWW/Telnet)
- Complicated retrievals available individually on request from IAEA-NDS (diskette, tape, file transfer, e-mail, printout)
- Output in various formats:
  - Standard format (EXchange FORmat)
  - Computational formats for plotting and further processing
  - "Edited listing" (abbreviations expanded): on request from IAEA
  - Online plots for intercomparison with evaluated data

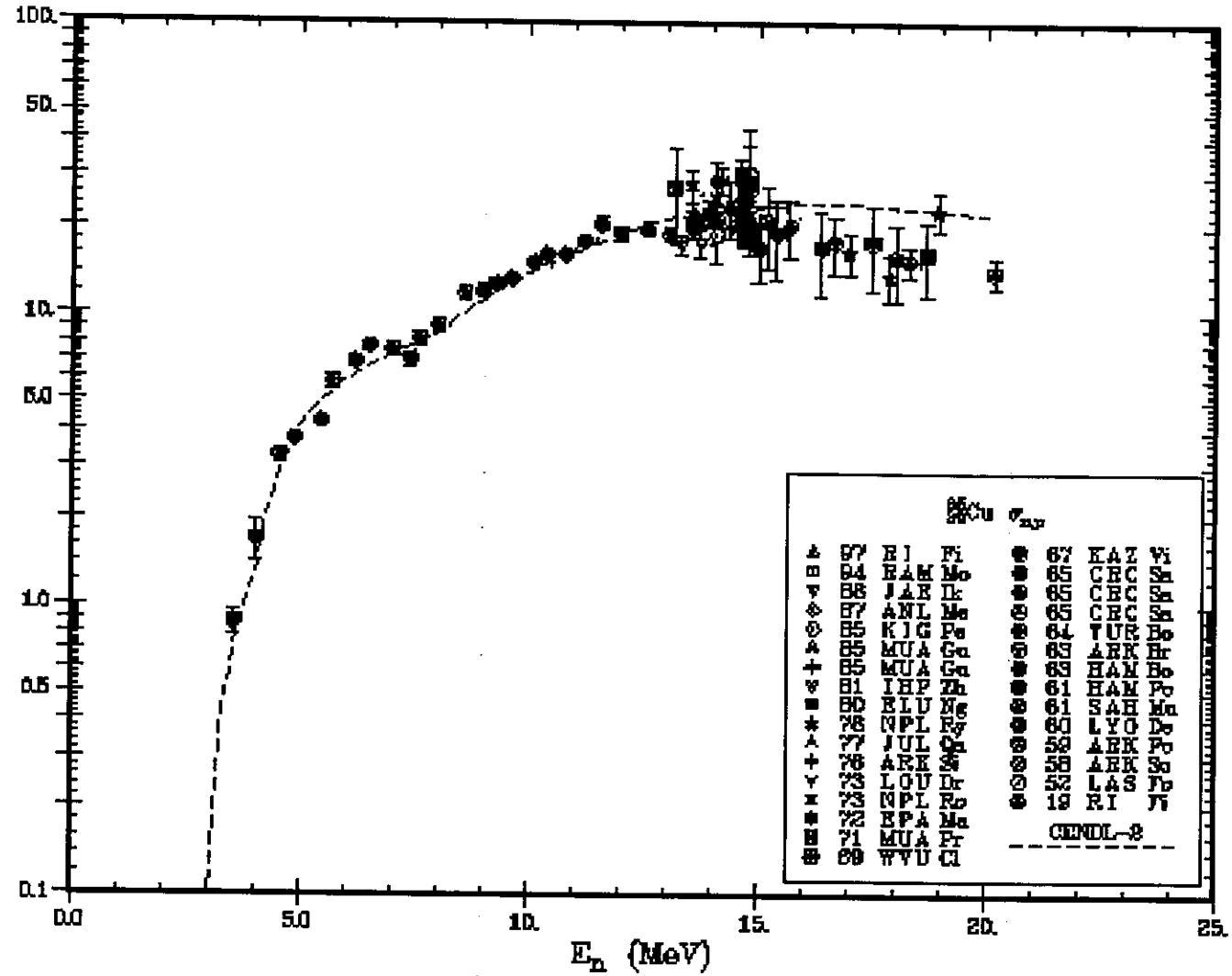
```
SUBENT         C0484002   19990420                                    C0484002     1
BIB                 4         14                                     C0484002     2
REACTION    (12-MG-24(A,N)14-SI-27,,SIG)                            C0484002     3
SAMPLE      Magnesium oxide target enriched to 99.94% 24Mg with a   C0484002     4
             thickness 150 (30) microg/cm**2, prepared by           C0484002     5
             evaporation onto 0.025 cm thick tantalum disc.         C0484002     6
DECAY-DATA  (14-SI-27,4.16SEC,B+)                                   C0484002     7
ERR-ANALYS  (DATA-ERR) Overall uncertainty of 23% includes          C0484002     8
             uncertainties from:                                    C0484002     9
             - target thickness                          20.0%;     C0484002    10
             - calibrated source strength                 5.6%;     C0484002    11
             - least squares fitting and                            C0484002    12
               variation in counting efficiency           6.0%;     C0484002    13
             - correction factor for absorption                     C0484002    14
               in the tantalum backing                   8.0%;     C0484002    15
             - effective number of incident particles    3.0%.     C0484002    16
ENDBIB             14                                               C0484002    17
NOCOMMON            0          0                                     C0484002    18
DATA                3         15                                     C0484002    19
EN-CM       DATA         DATA-ERR                                    C0484002    20
MEV         MB           MB                                          C0484002    21
  7.27        1.8          .4                                       C0484002    22
  7.48       27.4         6.3                                       C0484002    23
  7.7         8.8         2.                                        C0484002    24
  7.91        9.6         2.2                                       C0484002    25
  8.13       24.3         5.6                                       C0484002    26
  8.34       34.1         7.8                                       C0484002    27
  8.55       44.9        10.3                                       C0484002    28
  8.77       49.9        11.5                                       C0484002    29
  8.98       40.3         9.3                                       C0484002    30
  9.2        51.2        11.8                                       C0484002    31
  9.41       49.8        11.5                                       C0484002    32
  9.63       50.2        11.6                                       C0484002    33
  9.84       51.3        11.8                                       C0484002    34
 10.06       62.7        14.4                                       C0484002    35
 10.27       59.2        13.6                                       C0484002    36
ENDDATA            17                                               C0484002    37
ENDSUBENT           3                                               C048400299999
```

STANDARD FORMAT (EXFOR)

```
REQUEST      993917001   19990917         4                          0  0     0
PHYSENT             1          0        15 7.2700E+06 1.0270E+07    1  0     0
 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00    1  1     0
 7.2700E+06 0.0000E+00 0.0000E+00 1.8000E-03 4.0000E-04 4.0000E-04    1  1     1
 7.4800E+06 0.0000E+00 0.0000E+00 2.7400E-02 6.3000E-03 6.3000E-03    1  1     1
 7.7000E+06 0.0000E+00 0.0000E+00 8.8000E-03 2.0000E-03 2.0000E-03    1  1     1
 7.9100E+06 0.0000E+00 0.0000E+00 9.6000E-03 2.2000E-03 2.2000E-03    1  1     1
 8.1300E+06 0.0000E+00 0.0000E+00 2.4300E-02 5.6000E-03 5.6000E-03    1  1     1
 8.3400E+06 0.0000E+00 0.0000E+00 3.4100E-02 7.8000E-03 7.8000E-03    1  1     1
 8.5500E+06 0.0000E+00 0.0000E+00 4.4900E-02 1.0300E-02 1.0300E-02    1  1     1
 8.7700E+06 0.0000E+00 0.0000E+00 4.9900E-02 1.1500E-02 1.1500E-02    1  1     1
 8.9800E+06 0.0000E+00 0.0000E+00 4.0300E-02 9.3000E-03 9.3000E-03    1  1     1
 9.2000E+06 0.0000E+00 0.0000E+00 5.1200E-02 1.1800E-02 1.1800E-02    1  1     1
 9.4100E+06 0.0000E+00 0.0000E+00 4.9800E-02 1.1500E-02 1.1500E-02    1  1     1
 9.6300E+06 0.0000E+00 0.0000E+00 5.0200E-02 1.1600E-02 1.1600E-02    1  1     1
 9.8400E+06 0.0000E+00 0.0000E+00 5.1300E-02 1.1800E-02 1.1800E-02    1  1     1
 1.0060E+07 0.0000E+00 0.0000E+00 6.2700E-02 1.4400E-02 1.4400E-02    1  1     1
 1.0270E+07 0.0000E+00 0.0000E+00 5.9200E-02 1.3600E-02 1.3600E-02    1  1     1
ENDPHYSENT                                                                199999999
ENDREQUEST                                                          9999999999999
```

COMPUTATIONAL (TABLE) FORMAT

EXFOR Retrieval (WWW)
Plot for $^{65}Cu(n,p)$ Comparison of experimental data with evaluation from CENDL-2



ENDF (Evaluated Nuclear Data File)

- ENDF-6: internationally agreed format for evaluated nuclear reaction data (and related decay data). Used for major libraries ENDF/B-VI, JEF, BROND, JENDL, CENDL, and others
- ENDF/B-VI: Version 6 of the U.S. nuclear data library and released by NNDC Brookhaven
  - Contents: for summary see report IAEA-NDS-100
  - Format Manual: IAEA-NDS-76 Rev.5 (1997) (=BNL-NCS-44945=ENDF-102)
  - Summary documentation of evaluations: BNL-NCS-17541, 4th ed. (=ENDF-201), 1991, with supplement (1996)

ENDF/B-VI Library Organization

- **ENDF/B-VI General Purpose Library** (neutron data 0-20 MeV, 320 materials from ^{1}H to ^{99}Es. ***Sept.1999 update: some materials extended to 150 MeV***)
  - Basic file
  - 300 K point data file (Resonance parameters converted to cross sections)
- **Subfiles** for *Standards, Dosimetry, Neutron activation, Fission products cs data, Actinides cs data* are included in General Purpose file but are available separately

- Other **sublibaries** for:
  - Incident charged particles ***(Additional materials added to proton sublibrary in Sept.1999 update)***
  - Decay data
  - Photo-atomic interaction
  - Thermal scattering law data
  - Fission product yields (neutron-induced and spontaneous)
  - High-energy (up to 1 GeV), incident neutrons and protons, few materials only
- Kept separately, to be requested separately (partly integrated in online service)

Access to major ENDF libraries

- Major libraries ENDF/B-VI, JEF, BROND, JENDL, CENDL available online through Telnet and WWW (interactive, retrieval by material, reaction and data type, energy)
- Various utilities for file handling, plotting, pre-processing: ENDF *Pre-Processing Codes* and *Utility Codes*, available for downloading
- CD-ROM (libraries and codes), only from IAEA *(WINENDF)*
- Output:
  - ENDF-format (all definitions coded with numerical flags)
  - Table format and plots available online

ENDF File Structure

- "Sublibrary" determines incident particle and basic data type (neutron data, proton data, decay data,...)
- Hierarchical file organization:
  - "Tape" (Unit of data release, full sublibrary or update)
    - Material (MAT number, up to 4 digits)
      - File (MF number): Data category
        - Section (Reaction Type, MT number).

File numbers (MF):
1=General information
2=Resonance parameters
3=reaction cs
4=angular distributions
5=energy distributions
6=energy-angular distributions
8=decay data
etc.

Reaction Type numbers (MT):
1=total cs
16=(z,2n) cs (z=projectile dep. on sublibrary)
102=(z,γ) cs
103=(z,p) cs
etc.

ENDF-6 format ("File 3" = cross sections)

Mass

various flags

ZA	2.605600+4	5.545400+1	0	0	0	02631	3103	1
Q	-2.913000+6	2.913000+6	0	0	3	492631	3103	2
	2	2	12	4	49	22631	3103	3
2.965500+6	0.000000+0	3.000000+6	7.001900-9	4.000000+6	6.001600-6	2631	3103	4
4.250000+6	3.201000-5	4.500000+6	1.403800-4	4.600000+6	2.406500-4	2631	3103	5
4.800000+6	5.775600-4	5.000000+6	1.069500-3	5.250000+6	2.294100-3	2631	3103	6
5.500000+6	4.798200-3	5.750000+6	8.479100-3	6.000000+6	1.273100-2	2631	3103	7
6.200000+6	1.645300-2	6.400000+6	1.917500-2	6.600000+6	2.375600-2	2631	3103	8
6.800000+6	2.758300-2	7.000000+6	2.728100-2	7.500000+6	3.534700-2	2631	3103	9
8.000000+6	4.173200-2	8.500000+6	4.767000-2	9.000000+6	5.514500-2	2631	3103	10
9.500000+6	5.907100-2	1.000000+7	6.690700-2	1.050000+7	7.572400-2	2631	3103	11
1.100000+7	8.241000-2	1.150000+7	9.069500-2	1.200000+7	1.033500-1	2631	3103	12
1.220000+7	1.056500-1	1.240000+7	1.093000-1	1.260000+7	1.116300-1	2631	3103	13
1.280000+7	1.143600-1	1.300000+7	1.152300-1	1.340000+7	1.169200-1	2631	3103	14
1.380000+7	1.166700-1	1.420000+7	1.135900-1	1.460000+7	1.093400-1	2631	3103	15
1.500000+7	1.042200-1	1.550000+7	9.512100-2	1.600000+7	8.625100-2	2631	3103	16
E	σ	E	σ	E	σ	MAT	MF	MT

File No.

Reaction Type No.

Library 300 K, ENDF/B-VI
Projectile Neutron projectile
Target 26-Fe-56
Reaction MT = 103 (n,p)
Quantity MF = 3 Reaction Cross Section
Q-value = -2.9130 MeV

Retrieved energy range is 2.9655 to 150.0 MeV.
Average cross section = 6.956 millibarns
Average 1/E weighted cross section = 20.25 millibarns

Energy MeV	Sigma Barns	Energy MeV	Sigma Barns	Energy MeV	Sigma Barns
2.9655	0.00000E+00	3.0000	7.00190E-09	4.0000	6.00160E-06
4.2500	3.20100E-05	4.5000	1.40380E-04	4.6000	2.40650E-04
4.8000	5.77560E-04	5.0000	1.06950E-03	5.2500	2.29410E-03
5.5000	4.79820E-03	5.7500	8.47910E-03	6.0000	1.27310E-02
6.2000	1.64530E-02	6.4000	1.91750E-02	6.6000	2.37560E-02
6.8000	2.75830E-02	7.0000	2.72810E-02	7.5000	3.53470E-02
8.0000	4.17320E-02	8.5000	4.76700E-02	9.0000	5.51450E-02
9.5000	5.90710E-02	10.000	6.69070E-02	10.500	7.57240E-02
11.000	8.24100E-02	11.500	9.06950E-02	12.000	0.10335
12.200	0.10565	12.400	0.10930	12.600	0.11163
12.800	0.11436	13.000	0.11523	13.400	0.11692
13.800	0.11667	14.200	0.11359	14.600	0.10934
15.000	0.10422	15.500	9.51210E-02	16.000	8.62510E-02
16.500	7.97880E-02	17.000	7.16250E-02	17.500	6.62760E-02
18.000	6.12960E-02	18.500	5.68120E-02	19.000	5.26480E-02
19.500	5.09680E-02	20.000	5.05530E-02	20.000	0.00000E+00
150.00	0.00000E+00				

Same data in "Narrow Table" format

FENDL-2 (Fusion Evaluated Nuclear Data Library)

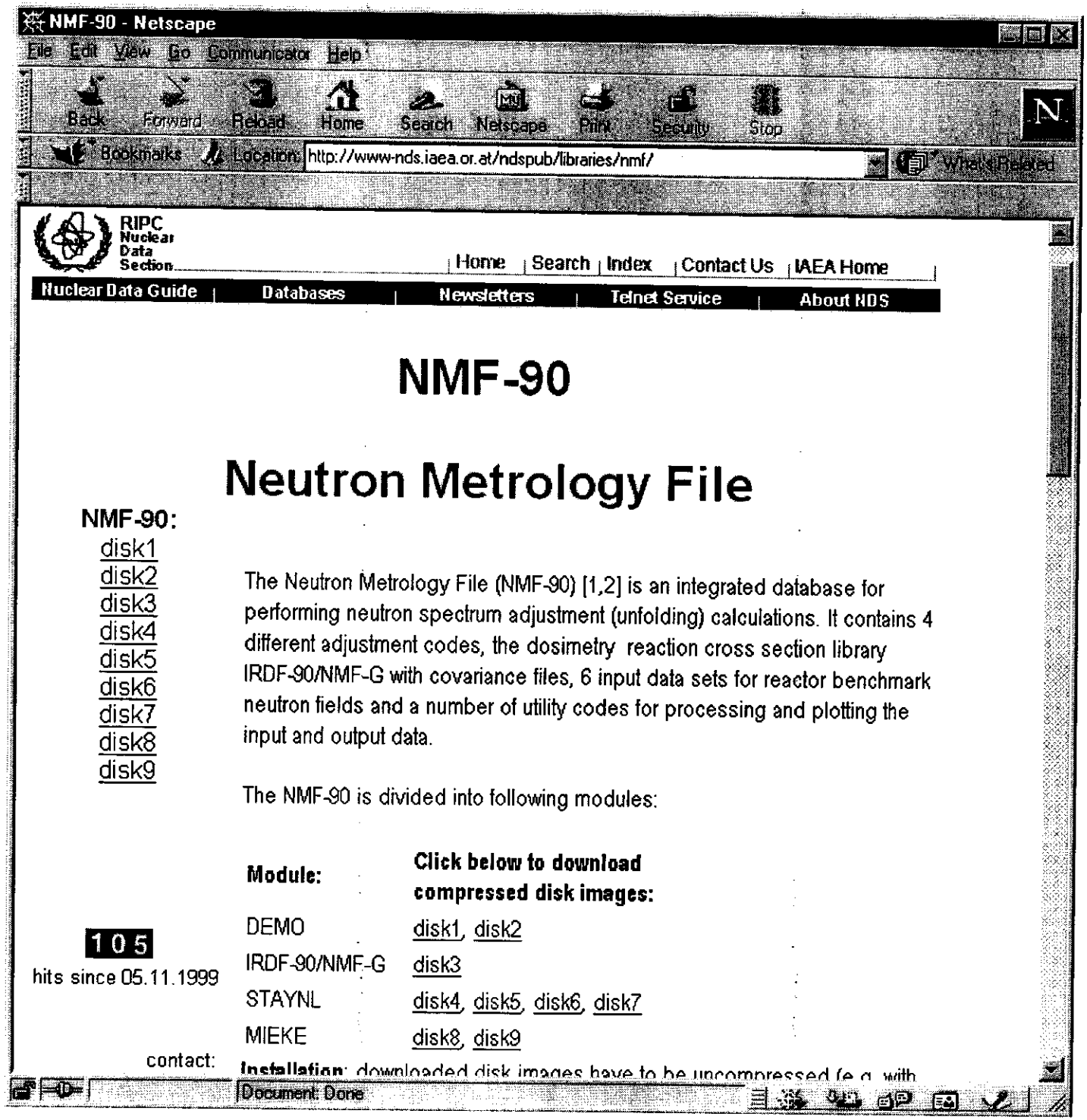
- Result of worldwide effort coordinated by IAEA
- Aimed at fusion applications (ITER project)
- Extensively tested, therefore recommended also for other applications
- Sublibraries:
  - FENDL-E/2.0: Transport: n-interactions, γ-production for 57 nuclides; photon-atom interactions for 34 elements; basic data as well as processed data for MCNP and multigroup calcs
  - FENDL/A-2.0: Activation (636 nuclides, 11000 reactions)
  - FENDL-C-2.0: Fusion (light charged-particle fusion reations)
  - FENDL/D-2.0: Decay data for 2900 nuclides
  - FENDL/DS-2.0: Neutron activation reactions from IRDF-90
- Available for downloading from IAEA web pages and on CD-ROM
  - 47 directories, 810 files, 1 Gbyte data

MENDL-2 and MENDL2-P (Medium Energy Nuclear Data Library)

- Libraries for activation and transmutation (formation of radioactive product nuclides) at indermediate energies, for 505 stable and unstable target nuclides between ^{26}Al and ^{210}Po, by Shubin et al., Obninsk, Russia
- Based largely on calculations
- MENDL-2: Neutron-induced reactions up to 100MeV, altogether 57500 reactions
- MENDL2-P: Proton-induced reactions up to 200MeV, altogether 87000 reactions
- Available by FTP or off-line

Databases for Reactor Dosimetry

- IRDF-90: International Reactor Dosimetry File (Version 2 of 1993): Cross sections for neutron dosimetry by foil activation, radiation damage cross sections, benchmark neutron spectra. Available for downloading
- RRDF-98: Russian Reactor Dosimetry File. Cross sections and covariance data for 22 reactions, available for downloading
- NMF-90: Neutron Metrology File. Integrated database for neutron spectrum unfolding calculations (PC codes and data). Available for downloading.


NMF-90 - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Stop
Bookmarks Location: http://www-nds.iaea.or.at/ndspub/libraries/nmf/
What's Related
RIPC Nuclear Data Section
Home Search Index Contact Us IAEA Home
Nuclear Data Guide Databases Newsletters Telnet Service About NDS
NMF-90
Neutron Metrology File
NMF-90:
disk1
disk2
disk3
disk4
disk5
disk6
disk7
disk8
disk9
The Neutron Metrology File (NMF-90) [1,2] is an integrated database for performing neutron spectrum adjustment (unfolding) calculations. It contains 4 different adjustment codes, the dosimetry reaction cross section library IRDF-90/NMF-G with covariance files, 6 input data sets for reactor benchmark neutron fields and a number of utility codes for processing and plotting the input and output data.
The NMF-90 is divided into following modules:
Module:
Click below to download compressed disk images:
DEMO disk1, disk2
IRDF-90/NMF-G disk3
STAYNL disk4, disk5, disk6, disk7
MIEKE disk8, disk9
105
hits since 05.11.1999
contact:
Installation: downloaded disk images have to be uncompressed (e.g. with
Document: Done

Data for Actinides and Fission Products

- Neutron cross sections for actinides, fission product yields, and cross sections and decay data for fission products, are included in major evaluated neutron data libraries
- Some special libraries:
  - **WIND** and **WIND-2**: For waste incineration. Neutron cross sections for U, Np, Pu isotopes up to 100 MeV. Proton data for ^{238}U. Neutron activation data for ^{239}Pu up to 2 GeV.
  - **"Maslov"** library: Evaluated neutron reaction data for Np, Pu, Am and Cm isotopes (1995-98)
  - **SGNucDat** (Nuclear Data for Safeguards). Actinides and fission products data for safeguards. Available on diskette and as handbook

RIPL (Reference Input Parameter Library for Nuclear Model Calculations)

- Result of IAEA coordinated project
- Input parameters for theoretical calculations of nuclear reaction cross sections
- Contents:
  - Atomic masses and deformations
  - Discrete level schemes
  - Average neutron resonance parameters
  - Optical model parameters
  - Level densities
  - Gamma-ray strength functions
  - Continuum angular distributions
- Available for downloading from IAEA web pages and on CD-ROM. Description available also as a handbook (IAEA-TECDOC-1034)

X-ray (Photo-atomic) Cross-Section and Attenuation Data

- Several databases with different user interfaces, partly identical data (mostly based on work by J.H. Hubbell et al., N.I.S.T., USA)
  - **"XCOM"** (Photon cross sections 1 keV - 100 GeV) and **"X-ray Form Factors, Attenuation and Scattering Tables"** (up to 1 MeV), N.I.S.T. web server *http://physics.nist.gov/PhysRefData/contents-xray.html*
  - **EPDL97** (Evaluated Photon Data Library, 1 eV - 100 GeV), Livermore Nat.Lab, USA (available on CD-ROM from IAEA)
  - **"XRAY"** and **"POLSCAT"** modules of IAEA Telnet service (1 keV - 100 GeV)
  - **ENDF/B-VI Photo-Atomic** Interaction Library (10 eV - 100 MeV) (WWW)
  - **JEF-2/Photo-Atomic** Interaction Library (10 eV - 100 MeV)
  - **XMuDat**: Photon attenuation data on PC. Mass attenuation, mass energy-transfer, mass energy-absorption coefficients for photons between 1 keV and 50 MeV. Program by R. Nowotny (Univ. Vienna), data sources: Boone and Chavez (1996), Hubble and Seltzer (1995).
    Diskettes or downloading from WWW

Some other useful data...

- *X-ray and gamma-ray standards* for detector calibration (1991). Handbook IEA-TECDOC-619, diskette, WWW under *http://www.nts-ltd.demon.co.uk/IAEA/menu619.htm*
- *Thermal neutron capture gammas*: spectra by target or by energy, available from WWW
- *NGAtlas*: Neutron capture cross sections from 10^{-5} to 20 MeV compiled from various evaluations, by Kopecky et al.
  Tables (WWW) and graphs (handbook INDC(NDS)-362)
  Graphs available online through K.A.E.R.I. webserver under *http://hpngp01.kaeri.re.kr/CoN/index.html*
- *QCALC:* Utility for calculation of Q values and reaction threshold energies (Telnet)
- *ESTAR, PSTAR, ASTAR*: PC package for calculating stopping powers and ranges of electrons, protons and helium ions, by M.J. Berger (N.I.S.T., USA), 1993. Available on diskette

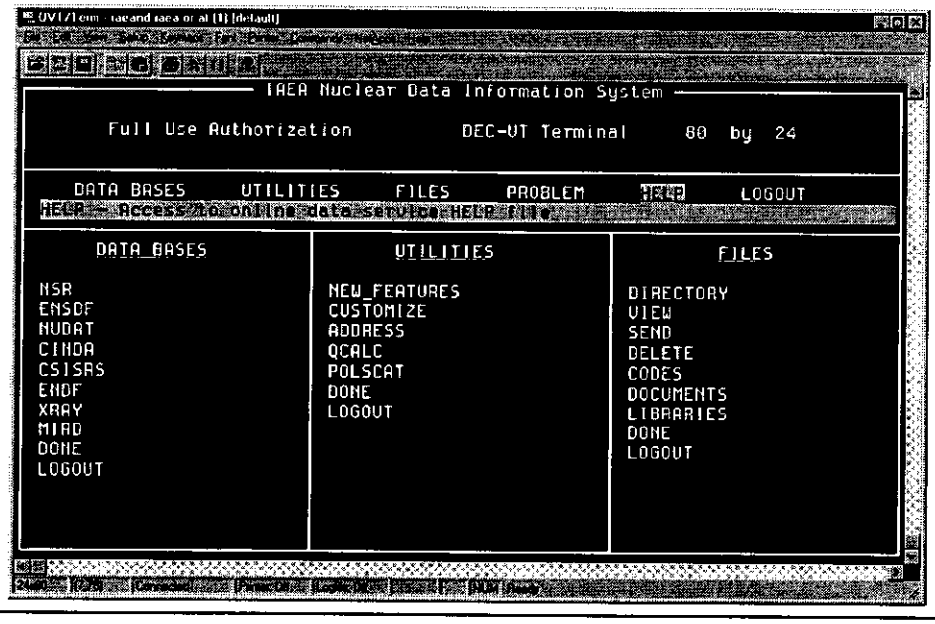
4. Data Access

- WWW (Worldwide Web)
  - ***IAEA Nuclear Data Services*** homepage:
    http://www-nds.iaea.or.at
    Software: Web browser; recommended: Adobe Acrobat Reader (for PDF files), GhostScript/GhostView (for PostScript documents)
  - General IAEA homepage:
    http://www.iaea.org "Worldatom"
    http://www.iaea.org/tecatom.html "Tecatom"

Telnet: NDIS (*Nuclear Data Information System*)

- Remote login to IAEA-NDS computer
  Access dialog:
  telnet iaeand.iaea.or.at
  iaeands *(username)*
  guest *(or authorization code)*
  y *(for ANSI type terminal), then follow menu*
- Telnet program: start directly from PC, or through your Web browser (follow link from *Nuclear Data Services* homepage)
  Highly recommended: Use VT Terminal Emulator such as *QVT/Term*, for convenient usage
- NDIS = the IAEA's first online service (since 1992).
  Interactive access to main databases, files, programs and utilities
- Reason for using NDIS:
  - Still some unique features not yet available through WWW
    (Full ENSDF and NSR functionality, QCALC (Q-values), Address database)
  - Technical alternative to WWW

Telnet service NDIS: Starting screen



FTP (Internet file transfer)

- Command: ftp iaeand.iaea.or.at
- IAEA-NDS keeps several FTP accounts requiring no password:
  - ANONYMOUS contains several complete libraries and utility codes
  - FENDL2 contains FENDL-2 files
  - RIPL contains RIPL files
  - NDSONL contains files saved by NDIS users
  - NDSOPEN for bilateral file exchange

Off-line

- Data on tape, CD-ROM, diskette, hardcopy
- Customized retrievals, questions
- e-mail:
  services@iaeand.iaea.or.at for data requests,
  online@iaeand.iaea.or.at for questions on online services, or
  schwerer@iaeand.iaea.or.at
- Fax: +43-1-26007
- Mail:

  Nuclear Data Section
  International Atomic Energy Agency
  P.O.Box 100
  A-1400 Vienna, Austria

Alternative entry points

- Same basic data are available online (or on CD-ROM) from various sources
- Possible reasons for using alternative sources:
  - Better network connection to your location
  - Different user interface
- Possible problems:
  - Sources from outside the *Data Centers Networks* may not always be fully up-to-date
  - Some products available only commercially

Alternative entry points: Examples

- **U.S. National Nuclear Data Center** (NNDC)
  http://www.nndc.bnl.gov
  Close cooperation with IAEA-NDS, similar WWW and Telnet services
- ***Isotope Explorer***
  Software for interactive access and display of ENSDF data, from Lawrence Berkeley National Lab.(USA) and Lund Univ.(Sweden)
  http://ie.lbl.gov/isoexpl/isoexpl.htm (Windows version)
  http://www.pixe.lth.se/ensdf/ (New experim.version without installation)
- **K.A.E.R.I. Table of Nuclides** (Korea Atomic Energy Res.Inst.)
  Basic nuclear properties and cross sections
  http://atom.kaeri.re.kr/
- **T-2 Information Service**, Los Alamos, USA
  Nuclear Data Viewer and other services
  http://t2.lanl.gov/data/data.html

How to reference the data

- Data obtained from databases of the Nuclear Data Centers Networks should be properly cited
- Citation should include
  - original source of information **and**
  - database from which data were extracted (which may contain essential information not existing in a published article) with date of retrieval
- Example: How to cite the MENDL-2 library
  - Yu.N. Shubin, V.P. Lunev, A.Yu. Konobeyev, A.I. Ditjuk, "Cross-section data library MENDL-2 to study activation as transmutation of materials irradiated by nucleons of intermediate energies", report INDC(CCP)-385 (International Atomic Energy Agency, May 1995). Data library MENDL-2 received from the IAEA Nuclear Data Section
- Detailed citation guidelines for data retrieved online:
  - V. McLane, Citation Guidelines for Nuclear Data Retrieved from Databases Resident at the Nuclear Data Centers Network, Report BNL-NCS-63381 (July 1996). Available online in PostScript from *http://www-nds.iaea.or.at/ndspub/documents/online/*

5. Conclusion

- Starting point for nuclear data searches:
  IAEA Nuclear Data Services, *http://www-nds.iaea.or.at*
  - Most complete collection of nuclear data libraries with documentations published in *IAEA-NDS*- report series
  - Online services (WWW, Telnet service "NDIS", FTP)
  - Customized retrievals and off-line data service available cost-free on request
- What are the most important databases for your field of application? Send your feedback to IAEA-NDS
- Data requests and feedback: e-mail to
  services@iaeand.iaea.or.at

The Vienna International Centre (IAEA headquarters)