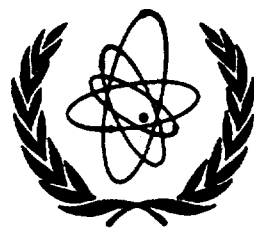




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Nuclear Data Libraries and Online Services

**An introduction to the data types and services
available from the IAEA Nuclear Data Section**

P. Obložinský and O. Schwerer

September 1998

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Abstract: The IAEA Nuclear Data Section provides convenient, costfree access to the world's most comprehensive collection of numerical nuclear physics data. These nuclear data libraries result from a worldwide cooperation of nuclear data centres coordinated by the IAEA. An introduction is given to the various nuclear data types and libraries with particular emphasis to online services via the Internet. This paper summarizes a presentation for the IAEA Workshop on "Nuclear Reaction Data and Nuclear Reactors: Physics, Design and Safety" held at ICTP Trieste, Italy, 23 February - 17 March 1998.

September 1998

NUCLEAR DATA LIBRARIES AND ONLINE SERVICES

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The IAEA Nuclear Data Section provides convenient, cost-free access to the world's most comprehensive collection of numerical nuclear physics data. These nuclear data libraries result from a worldwide cooperation of nuclear data centers coordinated by the IAEA. Here we summarize the various nuclear data types and libraries available with particular emphasis to online services via the Internet. The URL address of the IAEA Nuclear Data Services is <http://www-nds.iaea.or.at>.

1 Introduction

The IAEA holds the most comprehensive collection of nuclear data libraries worldwide. The data are available free of charge to scientists in IAEA member states on computer media (diskettes, magnetic tapes, CD-ROM), hardcopy, or online through the Internet (Worldwide Web, Telnet, FTP).

Nuclear data describe the properties of atomic nuclei and the fundamental physical relationships governing their interactions. These data characterize fundamental physical processes which underlie all nuclear technologies. Important examples of nuclear data include cross sections, half-lives, decay modes and decay radiation properties, and γ -rays from radionuclides. The scope of the data collections includes all 85 natural elements with 290 stable isotopes and more than 2500 radionuclides.

The applications of nuclear data today include all areas of nuclear science and technology:

- Energy applications: Fission power reactors; fusion reactor technology
- Non-energy applications: Waste management and environment; radiation safety; safeguards; nuclear medicine; materials analysis and process control; basic research (e.g. nuclear astrophysics) and education.

2 The data centers and their services

Both the collection and the distribution of nuclear data are organised on a world-wide scale. Two international networks are coordinated by the IAEA Nuclear Data Section: the Network of Nuclear Reaction Data Centers (Fig.1) and the Nuclear Structure and Decay Data Network (Fig.2). The data centers participating in these networks are involved in the various stages of data preparation between measurement and application (i.e. compilation, review and/or evaluation, processing, distribution, see Fig.3).

The major nuclear data centers are:

- IAEA Nuclear Data Section, Vienna, Austria
- OECD NEA Data Bank, Paris, France

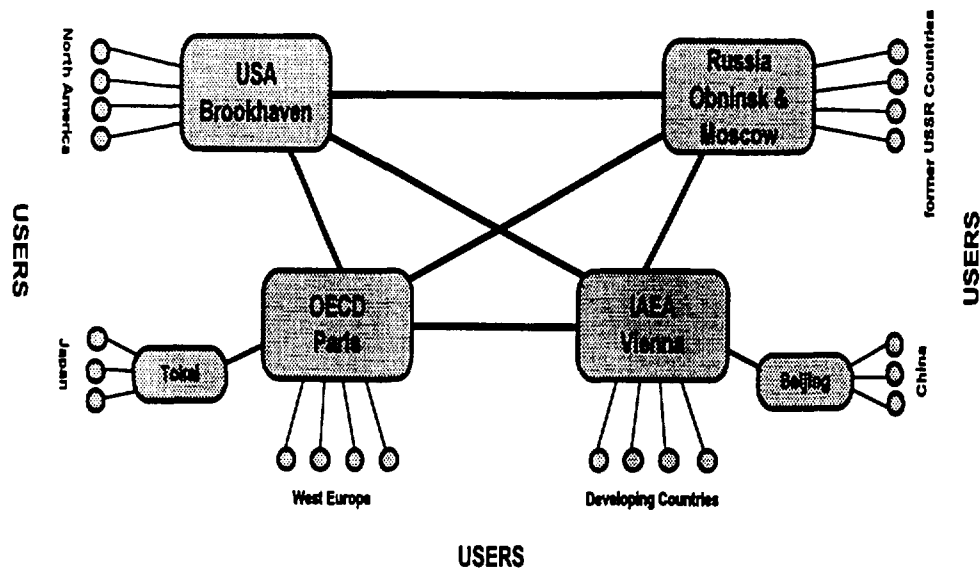


Figure 1: The Nuclear Reaction Data Centers Network

- U.S.National Nuclear Data Center, Brookhaven, USA
- Russian Nuclear Data Centers, Obninsk and Moscow, Russia
- Radiation Safety Information Computational Center, Oak Ridge, USA
- Chinese Nuclear Data Center, Beijing, China
- Japanese Nuclear Data Center, Tokai, Japan

Additional specialized data centers cooperate with the major centers in the various data center functions (in particular data compilation and evaluation). The sharing of work on a world-wide basis in the various areas of work (including data distribution) is defined partly geographically and partly by data types (scope) and is coordinated by the IAEA Nuclear Data Section, partly by organising regular data centers coordination meetings.

The type of nuclear data service varies with the type of information and the hardware configuration available. The main services offered by the IAEA Nuclear Data Section (to scientists in IAEA member states, in particular in developing countries) and the other major data centers are:

- Data upon request (**Vienna**)²: complete files on magnetic tapes, CD-ROM, diskette or by FTP; retrievals on diskettes, printout, by e-mail or FTP
- Documents upon request (**Vienna**): manuals and data library documentation; handbooks; meeting reports; research reports
- Interactive online retrieval by WWW and/or Telnet (**Vienna**, Brookhaven³, Paris restricted to members of NEA Data Bank): available 7 days a week, 24 hours a day

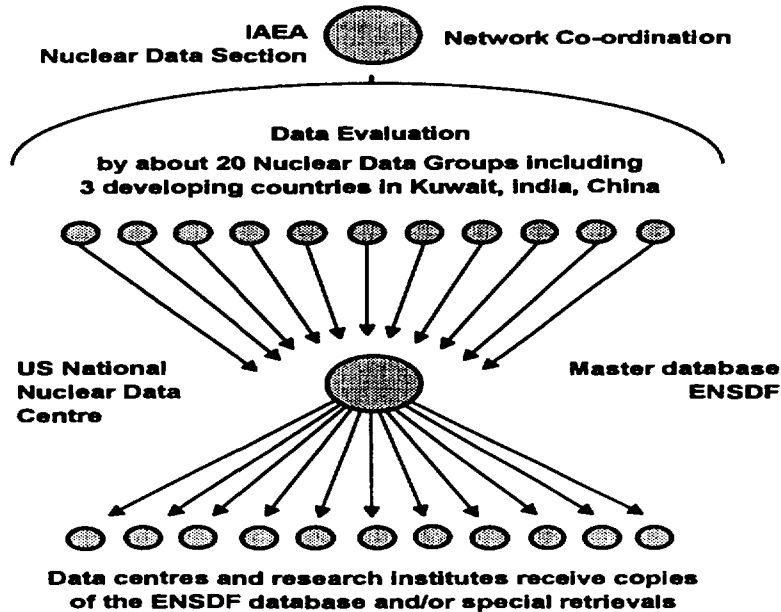


Figure 2: The Nuclear Structure Data Centers Network

- Computer codes: nuclear reaction models (Paris); processing (partly Oak Ridge⁴); fission reactors (Paris); utility programs, PC packages (**Vienna**)
- Processed data (Paris, partly Oak Ridge)

3 Nuclear Data Types

Nuclear data are commonly categorized in two main groups: nuclear reaction data, describing the interactions of various projectiles such as neutrons, protons or photons with target nuclei, and nuclear structure and decay data, describing nuclear levels, half-lives and radioactive decay radiations. For both groups, the type of information given can be experimental data or evaluated data (both numeric) or bibliographic.

- **Bibliographic data:** Typical examples are: CINDA - Computerized Index of Neutron Data (bibliographic references to neutron reaction data, covering the period from 1935 to present. It is published regularly as a book⁵ and also available online); NSR - Nuclear Science References (bibliographic data base for low and intermediate energy nuclear physics, covering the period from 1910 to present. Published in *Nuclear Data Sheets* and also available online).
- **Experimental data:** The most important example is EXFOR⁶ (EXchange FORMAT - computerized system for the storage, retrieval and international exchange of experimental nuclear reaction data, including explanatory text. This library contains

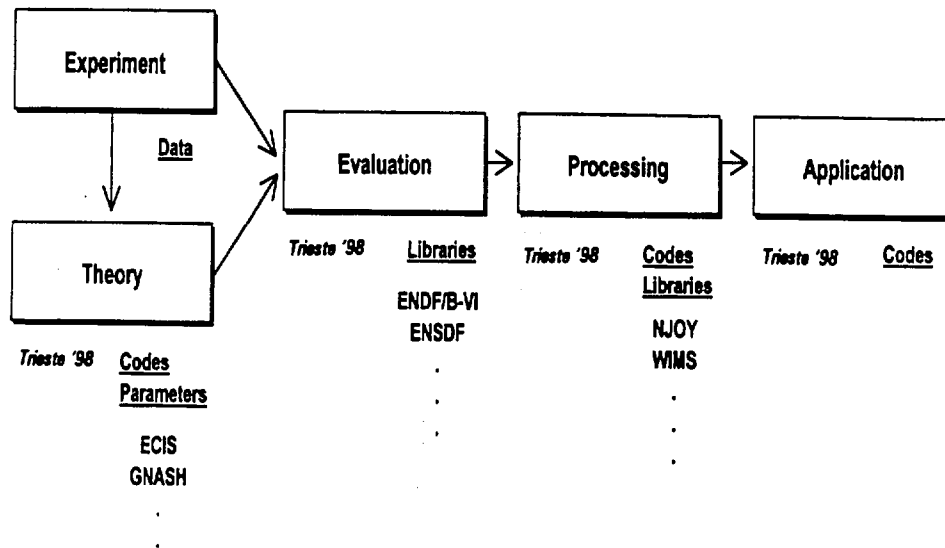


Figure 3: From experimental nuclear data to applications (Laboratory → Data Center → User). Major codes and libraries used in the nuclear data workshop (*Trieste '98*) are indicated.

reaction data for incident neutrons, charged particles and photons and is available online). CSISRS (Cross Section Information Storage and Retrieval System) is the US equivalent of EXFOR.

- **Evaluated data:** Evaluation is the process of analyzing experimentally measured nuclear physics data and combining them with the predictions of nuclear model calculations in order to arrive at a recommended value of the quantity. They are stored in specifically defined "formats" (collections of rules and procedures for computerized storage of data); often the name of the format is identical with the name of the library. Two important formats are ENDF-6 (Evaluated Nuclear Data File)⁷ for reaction data and ENSDF (Evaluated Nuclear Structure Data File) for structure and decay data. For neutron reaction data, there are several major evaluated data libraries originating in USA, Russia, Europe, Japan, and China, whereas the ENSDF library is the major library for structure and decay data. In addition, there are many other evaluated data libraries for specific purposes.
- **Reaction data:**
 - Incident neutrons: This is the most complete collection, to be found in the specialized bibliography CINDA, the experimental data library EXFOR and the major evaluated libraries⁸ ENDF/B-6⁹ (USA), BROND-2 (Russia), JEF-2 (Europe), JENDL-3 (Japan), CENDL-2 (China), and FENDL-2 (IAEA, fusion applications). These libraries cover the neutron energy range from 10^{-5} eV to 20 MeV with a high degree of completeness; data for higher energies are partly

Location: <http://www-nds.iaea.org/at/exf3.htm>

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IAEA Nuclear Data Services EXFOR database retrieval

EXFOR is the main database for experimental nuclear reaction data which are compiled, exchanged and distributed by a worldwide network of Nuclear Reaction Data Centers.

Target or product:	<input type="text" value="p-238"/>
Reaction or projectile:	<input type="text" value="n.p"/>
[Residual:]	<input type="text" value=""/>
Quantity:	<input type="text" value="cross"/>
[Energy range:]	<input type="text" value=""/>
[Cutoff date:]	<input type="text" value=""/>
Accession number:	<input type="text" value=""/>

☐ by Reaction or ☐ by Product or ☐ by Accession #

[back to Nuclear Data Services Intro](#)

Figure 4: Example of a database retrieval form at the *Nuclear Data Services* web page: EXFOR

included also.

- Incident charged particles and photons: less complete collection in EXFOR; only few evaluations available.
- **Structure and decay data:** Half-lives, decay schemes, nuclear level properties, energies and intensities of γ -rays and emitted particles, atomic masses. The major library is ENSDF (Evaluated Nuclear Structure Data File) which contains evaluated experimental data for most known nuclides (more than 2500) and is published in the journal *Nuclear Data Sheets*. A number of libraries, publications and computer programs are derived from or related to the ENSDF database, such as NUDAT¹⁰ (NUclear DATA), the "Table of Isotopes"¹¹, the "Nuclear Wallet Cards"¹² (properties of nuclear ground and isomeric states), or the "Isotope Explorer"¹³, a computer program for viewing ENSDF and for interactive access to nuclear structure and decay data. Other libraries include: NUBASE¹⁴, a library of nuclear and decay properties, containing mass, half-life, decay modes of ground and isomeric states for more than 3000 nuclides; "Atomic Masses 1995"¹⁵, a mass evaluation for more than 2900 nuclides.

4 Nuclear Data Libraries at IAEA

The IAEA Nuclear Data Section holds a total of about 100 nuclear data libraries representing an enormous value. These include the bibliographic libraries CINDA and NSR;

Go To: <http://www-nds.iaea.org/at/ngatlas/main.htm>

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ATLAS OF NEUTRON CAPTURE CROSS SECTIONS

Documentation

Elements Range

H-1 to H-2, He-3 to He-4, Li-6 to Li-7, Be-9 to Be-10, B-10 to B-11, C-12 to C-13, N-14 to N-15, O-16 to O-17, F-19 to F-20, Ne-20 to Ne-21, Na-23 to Na-24, Mg-24 to Mg-26, Al-27 to Al-28, Si-28 to Si-30, S-32 to S-34, Cl-35 to Cl-37, Ar-36 to Ar-38, K-39 to K-41, Ca-40 to Ca-44, Sc-45 to Sc-46, Ti-48 to Ti-50, V-51 to V-52, Cr-52 to Cr-54, Mn-55 to Mn-56, Fe-56 to Fe-58, Co-59 to Co-60, Ni-58 to Ni-64, Cu-63 to Cu-65, Zn-64 to Zn-70, Ga-69 to Ga-71, Ge-72 to Ge-76, As-75 to As-76, Se-74 to Se-78, Br-79 to Br-81, Kr-78 to Kr-84, Rb-85 to Rb-87, Sr-84 to Sr-88, Y-89 to Y-90, Zr-90 to Zr-94, Nb-93 to Nb-95, Mo-92 to Mo-98, Tc-98 to Tc-99, Ru-96 to Ru-101, Rh-101 to Rh-103, Pd-102 to Pd-110, Ag-107 to Ag-109, Cd-112 to Cd-116, In-113 to In-115, Sn-112 to Sn-119, Sb-121 to Sb-123, Te-124 to Te-130, I-127 to I-129, Xe-124 to Xe-136, Ba-130 to Ba-138, La-138 to La-140, Ce-138 to Ce-142, Pr-140 to Pr-142, Nd-142 to Nd-150, Pm-145 to Pm-147, Sm-147 to Sm-153, Eu-151 to Eu-155, Gd-155 to Gd-163, Tb-159 to Tb-161, Dy-163 to Dy-165, Ho-165 to Ho-167, Er-167 to Er-171, Tm-169 to Tm-171, Yb-174 to Yb-176, Lu-175 to Lu-177, Hf-178 to Hf-180, Ta-181 to Ta-183, W-182 to W-186, Re-185 to Re-187, Os-187 to Os-191, Ir-191 to Ir-193, Pt-192 to Pt-198, Au-197 to Au-199, Hg-196 to Hg-202, Tl-203 to Tl-205, Pb-204 to Pb-210, Bi-209 to Bi-210, Po-209 to Po-215, At-210 to At-216, Rn-210 to Rn-222, Ac-227 to Ac-229, Th-232 to Th-234, Pa-231 to Pa-233, U-235 to U-238, Np-237 to Np-241, Pu-239 to Pu-245, Am-241 to Am-245, Cm-247 to Cm-251, Bk-247 to Bk-249, Cf-250 to Cf-254, Es-252 to Es-256, Fm-257 to Fm-263, Md-260 to Md-264, No-259 to No-263, Lr-262 to Lr-264, Rf-261 to Rf-265, Db-262 to Db-266, Sg-266 to Sg-270, Bh-264 to Bh-268, Hs-265 to Hs-269, Mt-268 to Mt-272, Ni-270 to Ni-274, Dh-271 to Dh-275, Si-273 to Si-277, Me-275 to Me-279, H-281 to H-285, He-282 to He-286, Li-283 to Li-287, Be-284 to Be-288, B-286 to B-290, C-288 to C-292, N-290 to N-294, O-292 to O-296, F-294 to F-298, Ne-296 to Ne-300, Na-298 to Na-302, Mg-300 to Mg-304, Al-302 to Al-306, Si-304 to Si-308, S-306 to S-310, Cl-310 to Cl-314, Ar-312 to Ar-316, K-314 to K-318, Ca-316 to Ca-320, Sc-320 to Sc-324, Ti-324 to Ti-328, V-328 to V-332, Cr-332 to Cr-336, Mn-336 to Mn-340, Fe-344 to Fe-348, Co-348 to Co-352, Ni-352 to Ni-356, Cu-356 to Cu-360, Zn-360 to Zn-364, Ga-364 to Ga-368, Ge-368 to Ge-372, As-372 to As-376, Se-376 to Se-380, Br-380 to Br-384, Kr-384 to Kr-388, Rb-388 to Rb-392, Sr-392 to Sr-396, Y-396 to Y-400, Zr-400 to Zr-404, Nb-404 to Nb-408, Mo-408 to Mo-412, Tc-412 to Tc-416, Ru-416 to Ru-420, Rh-420 to Rh-424, Pd-424 to Pd-428, Ag-428 to Ag-432, Cd-432 to Cd-436, In-436 to In-440, Sn-440 to Sn-444, Sb-444 to Sb-448, Te-448 to Te-452, I-452 to I-456, Xe-456 to Xe-460, Ba-460 to Ba-464, La-464 to La-468, Ce-468 to Ce-472, Pr-472 to Pr-476, Nd-476 to Nd-480, Pm-480 to Pm-484, Sm-484 to Sm-488, Eu-488 to Eu-492, Gd-492 to Gd-496, Tb-496 to Tb-500, Dy-500 to Dy-504, Ho-504 to Ho-508, Er-508 to Er-512, Tm-512 to Tm-516, Yb-516 to Yb-520, Lu-520 to Lu-524, Hf-524 to Hf-528, Ta-528 to Ta-532, W-532 to W-536, Re-536 to Re-540, Os-540 to Os-544, Ir-544 to Ir-548, Pt-548 to Pt-552, Au-552 to Au-556, Hg-556 to Hg-560, Tl-560 to Tl-564, Pb-564 to Pb-568, Bi-568 to Bi-572, Po-572 to Po-576, At-576 to At-580, Rn-580 to Rn-584, Ac-584 to Ac-588, Th-588 to Th-592, Pa-592 to Pa-596, U-596 to U-600, Np-600 to Np-604, Pu-604 to Pu-608, Am-608 to Am-612, Cm-612 to Cm-616, Bk-616 to Bk-620, Cf-620 to Cf-624, Es-624 to Es-628, Fm-628 to Fm-632, Md-632 to Md-636, No-636 to No-640, Lr-640 to Lr-644, Rf-644 to Rf-648, Db-648 to Db-652, Sg-652 to Sg-656, Bh-656 to Bh-660, Hs-660 to Hs-664, Mt-664 to Mt-668, Ni-668 to Ni-672, Dh-672 to Dh-676, Si-676 to Si-680, Me-680 to Me-684, H-684 to H-688, He-688 to He-692, Li-692 to Li-696, Be-696 to Be-700, B-700 to B-704, C-704 to C-708, N-708 to N-712, O-712 to O-716, F-716 to F-720, Ne-720 to Ne-724, Na-724 to Na-728, Mg-728 to Mg-732, Al-732 to Al-736, Si-736 to Si-740, S-740 to S-744, Cl-744 to Cl-748, Ar-748 to Ar-752, K-752 to K-756, Ca-756 to Ca-760, Sc-760 to Sc-764, Ti-764 to Ti-768, V-768 to V-772, Cr-772 to Cr-776, Mn-776 to Mn-780, Fe-780 to Fe-784, Co-784 to Co-788, Ni-788 to Ni-792, Cu-792 to Cu-796, Zn-796 to Zn-800, Ga-800 to Ga-804, Ge-804 to Ge-808, As-808 to As-812, Se-812 to Se-816, Br-816 to Br-820, Kr-820 to Kr-824, Rb-824 to Rb-828, Sr-828 to Sr-832, Y-832 to Y-836, Zr-836 to Zr-840, Nb-840 to Nb-844, Mo-844 to Mo-848, Tc-848 to Tc-852, Ru-852 to Ru-856, Rh-856 to Rh-860, Pd-860 to Pd-864, Ag-864 to Ag-868, Cd-868 to Cd-872, In-872 to In-876, Sn-876 to Sn-880, Sb-880 to Sb-884, Te-884 to Te-888, I-888 to I-892, Xe-892 to Xe-896, Ba-896 to Ba-900, La-900 to La-904, Ce-904 to Ce-908, Pr-908 to Pr-912, Nd-912 to Nd-916, Pm-916 to Pm-920, Sm-920 to Sm-924, Eu-924 to Eu-928, Gd-928 to Gd-932, Tb-932 to Tb-936, Dy-936 to Dy-940, Ho-940 to Ho-944, Er-944 to Er-948, Tm-948 to Tm-952, Yb-952 to Yb-956, Lu-956 to Lu-960, Hf-960 to Hf-964, Ta-964 to Ta-968, W-968 to W-972, Re-972 to Re-976, Os-976 to Os-980, Ir-980 to Ir-984, Pt-984 to Pt-988, Au-988 to Au-992, Hg-992 to Hg-996, Tl-996 to Tl-1000, Pb-1000 to Pb-1004, Bi-1004 to Bi-1008, Po-1008 to Po-1012, At-1012 to At-1016, Rn-1016 to Rn-1020, Ac-1020 to Ac-1024, Th-1024 to Th-1028, Pa-1028 to Pa-1032, U-1032 to U-1036, Np-1036 to Np-1040, Pu-1040 to Pu-1044, Am-1044 to Am-1048, Cm-1048 to Cm-1052, Bk-1052 to Bk-1056, Cf-1056 to Cf-1060, Es-1060 to Es-1064, Fm-1064 to Fm-1068, Md-1068 to Md-1072, No-1072 to No-1076, Lr-1076 to Lr-1080, Rf-1080 to Rf-1084, Db-1084 to Db-1088, Sg-1088 to Sg-1092, Bh-1092 to Bh-1096, Hs-1096 to Hs-1100, Mt-1100 to Mt-1104, Ni-1104 to Ni-1108, Dh-1108 to Dh-1112, Si-1112 to Si-1116, Me-1116 to Me-1120, H-1120 to H-1124, He-1124 to He-1128, Li-1128 to Li-1132, Be-1132 to Be-1136, B-1136 to B-1140, C-1140 to C-1144, N-1144 to N-1148, O-1148 to O-1152, F-1152 to F-1156, Ne-1156 to Ne-1160, Na-1160 to Na-1164, Mg-1164 to Mg-1168, Al-1168 to Al-1172, Si-1172 to Si-1176, S-1176 to S-1180, Cl-1180 to Cl-1184, Ar-1184 to Ar-1188, K-1188 to K-1192, Ca-1192 to Ca-1196, Sc-1196 to Sc-1200, Ti-1200 to Ti-1204, V-1204 to V-1208, Cr-1208 to Cr-1212, Mn-1212 to Mn-1216, Fe-1216 to Fe-1220, Co-1220 to Co-1224, Ni-1224 to Ni-1228, Cu-1228 to Cu-1232, Zn-1232 to Zn-1236, Ga-1236 to Ga-1240, Ge-1240 to Ge-1244, As-1244 to As-1248, Se-1248 to Se-1252, Br-1252 to Br-1256, Kr-1256 to Kr-1260, Rb-1260 to Rb-1264, Sr-1264 to Sr-1268, Y-1268 to Y-1272, Zr-1272 to Zr-1276, Nb-1276 to Nb-1280, Mo-1280 to Mo-1284, Tc-1284 to Tc-1288, Ru-1288 to Ru-1292, Rh-1292 to Rh-1296, Pd-1296 to Pd-1300, Ag-1300 to Ag-1304, Cd-1304 to Cd-1308, In-1308 to In-1312, Sn-1312 to Sn-1316, Sb-1316 to Sb-1320, Te-1320 to Te-1324, I-1324 to I-1328, Xe-1328 to Xe-1332, Ba-1332 to Ba-1336, La-1336 to La-1340, Ce-1340 to Ce-1344, Pr-1344 to Pr-1348, Nd-1348 to Nd-1352, Pm-1352 to Pm-1356, Sm-1356 to Sm-1360, Eu-1360 to Eu-1364, Gd-1364 to Gd-1368, Tb-1368 to Tb-1372, Dy-1372 to Dy-1376, Ho-1376 to Ho-1380, Er-1380 to Er-1384, Tm-1384 to Tm-1388, Yb-1388 to Yb-1392, Lu-1392 to Lu-1396, Hf-1396 to Hf-1400, Ta-1400 to Ta-1404, W-1404 to W-1408, Re-1408 to Re-1412, Os-1412 to Os-1416, Ir-1416 to Ir-1420, Pt-1420 to Pt-1424, Au-1424 to Au-1428, Hg-1428 to Hg-1432, Tl-1432 to Tl-1436, Pb-1436 to Pb-1440, Bi-1440 to Bi-1444, Po-1444 to Po-1448, At-1448 to At-1452, Rn-1452 to Rn-1456, Ac-1456 to Ac-1460, Th-1460 to Th-1464, Pa-1464 to Pa-1468, U-1468 to U-1472, Np-1472 to Np-1476, Pu-1476 to Pu-1480, Am-1480 to Am-1484, Cm-1484 to Cm-1488, Bk-1488 to Bk-1492, Cf-1492 to Cf-1496, Es-1496 to Es-1500, Fm-1500 to Fm-1504, Md-1504 to Md-1508, No-1508 to No-1512, Lr-1512 to Lr-1516, Rf-1516 to Rf-1520, Db-1520 to Db-1524, Sg-1524 to Sg-1528, Bh-1528 to Bh-1532, Hs-1532 to Hs-1536, Mt-1536 to Mt-1540, Ni-1540 to Ni-1544, Dh-1544 to Dh-1548, Si-1548 to Si-1552, Me-1552 to Me-1556, H-1556 to H-1560, He-1560 to He-1564, Li-1564 to Li-1568, Be-1568 to Be-1572, B-1572 to B-1576, C-1576 to C-1580, N-1580 to N-1584, O-1584 to O-1588, F-1588 to F-1592, Ne-1592 to Ne-1596, Na-1596 to Na-1600, Mg-1600 to Mg-1604, Al-1604 to Al-1608, Si-1608 to Si-1612, S-1612 to S-1616, Cl-1616 to Cl-1620, Ar-1620 to Ar-1624, K-1624 to K-1628, Ca-1628 to Ca-1632, Sc-1632 to Sc-1636, Ti-1636 to Ti-1640, V-1640 to V-1644, Cr-1644 to Cr-1648, Mn-1648 to Mn-1652, Fe-1652 to Fe-1656, Co-1656 to Co-1660, Ni-1660 to Ni-1664, Cu-1664 to Cu-1668, Zn-1668 to Zn-1672, Ga-1672 to Ga-1676, Ge-1676 to Ge-1680, As-1680 to As-1684, Se-1684 to Se-1688, Br-1688 to Br-1692, Kr-1692 to Kr-1696, Rb-1696 to Rb-1700, Sr-1700 to Sr-1704, Y-1704 to Y-1708, Zr-1708 to Zr-1712, Nb-1712 to Nb-1716, Mo-1716 to Mo-1720, Tc-1720 to Tc-1724, Ru-1724 to Ru-1728, Rh-1728 to Rh-1732, Pd-1732 to Pd-1736, Ag-1736 to Ag-1740, Cd-1740 to Cd-1744, In-1744 to In-1748, Sn-1748 to Sn-1752, Sb-1752 to Sb-1756, Te-1756 to Te-1760, I-1760 to I-1764, Xe-1764 to Xe-1768, Ba-1768 to Ba-1772, La-1772 to La-1776, Ce-1776 to Ce-1780, Pr-1780 to Pr-1784, Nd-1784 to Nd-1788, Pm-1788 to Pm-1792, Sm-1792 to Sm-1796, Eu-1796 to Eu-1800, Gd-1800 to Gd-1804, Tb-1804 to Tb-1808, Dy-1808 to Dy-1812, Ho-1812 to Ho-1816, Er-1816 to Er-1820, Tm-1820 to Tm-1824, Yb-1824 to Yb-1828, Lu-1828 to Lu-1832, Hf-1832 to Hf-1836, Ta-1836 to Ta-1840, W-1840 to W-1844, Re-1844 to Re-1848, Os-1848 to Os-1852, Ir-1852 to Ir-1856, Pt-1856 to Pt-1860, Au-1860 to Au-1864, Hg-1864 to Hg-1868, Tl-1868 to Tl-1872, Pb-1872 to Pb-1876, Bi-1876 to Bi-1880, Po-1880 to Po-1884, At-1884 to At-1888, Rn-1888 to Rn-1892, Ac-1892 to Ac-1896, Th-1896 to Th-1900, Pa-1900 to Pa-1904, U-1904 to U-1908, Np-1908 to Np-1912, Pu-1912 to Pu-1916, Am-1916 to Am-1920, Cm-1920 to Cm-1924, Bk-1924 to Bk-1928, Cf-1928 to Cf-1932, Es-1932 to Es-1936, Fm-1936 to Fm-1940, Md-1940 to Md-1944, No-1944 to No-1948, Lr-1948 to Lr-1952, Rf-1952 to Rf-1956, Db-1956 to Db-1960, Sg-1960 to Sg-1964, Bh-1964 to Bh-1968, Hs-1968 to Hs-1972, Mt-1972 to Mt-1976, Ni-1976 to Ni-1980, Dh-1980 to Dh-1984, Si-1984 to Si-1988, Me-1988 to Me-1992, H-1992 to H-1996, He-1996 to He-2000, Li-2000 to Li-2004, Be-2004 to Be-2008, B-2008 to B-2012, C-2012 to C-2016, N-2016 to N-2020, O-2020 to O-2024, F-2024 to F-2028, Ne-2028 to Ne-2032, Na-2032 to Na-2036, Mg-2036 to Mg-2040, Al-2040 to Al-2044, Si-2044 to Si-2048, S-2048 to S-2052, Cl-2052 to Cl-2056, Ar-2056 to Ar-2060, K-2060 to K-2064, Ca-2064 to Ca-2068, Sc-2068 to Sc-2072, Ti-2072 to Ti-2076, V-2076 to V-2080, Cr-2080 to Cr-2084, Mn-2084 to Mn-2088, Fe-2088 to Fe-2092, Co-2092 to Co-2096, Ni-2096 to Ni-2100, Cu-2100 to Cu-2104, Zn-2104 to Zn-2108, Ga-2108 to Ga-2112, Ge-2112 to Ge-2116, As-2116 to As-2120, Se-2120 to Se-2124, Br-2124 to Br-2128, Kr-2128 to Kr-2132, Rb-2132 to Rb-2136, Sr-2136 to Sr-2140, Y-2140 to Y-2144, Zr-2144 to Zr-2148, Nb-2148 to Nb-2152, Mo-2152 to Mo-2156, Tc-2156 to Tc-2160, Ru-2160 to Ru-2164, Rh-2164 to Rh-2168, Pd-2168 to Pd-2172, Ag-2172 to Ag-2176, Cd-2176 to Cd-2180, In-2180 to In-2184, Sn-2184 to Sn-2188, Sb-2188 to Sb-2192, Te-2192 to Te-2196, I-2196 to I-2200, Xe-2200 to Xe-2204, Ba-2204 to Ba-2208, La-2208 to La-2212, Ce-2212 to Ce-2216, Pr-2216 to Pr-2220, Nd-2220 to Nd-2224, Pm-2224 to Pm-2228, Sm-2228 to Sm-2232, Eu-2232 to Eu-2236, Gd-2236 to Gd-2240, Tb-2240 to Tb-2244, Dy-2244 to Dy-2248, Ho-2248 to Ho-2252, Er-2252 to Er-2256, Tm-2256 to Tm-2260, Yb-2260 to Yb-2264, Lu-2264 to Lu-2268, Hf-2268 to Hf-2272, Ta-2272 to Ta-2276, W-2276 to W-2280, Re-2280 to Re-2284, Os-2284 to Os-2288, Ir-2288 to Ir-2292, Pt-2292 to Pt-2296, Au-2296 to Au-2300, Hg-2300 to Hg-2304, Tl-2304 to Tl-2308, Pb-2308 to Pb-2312, Bi-2312 to Bi-2316, Po-2316 to Po-2320, At-2320 to At-2324, Rn-2324 to Rn-2328, Ac-2328 to Ac-2332, Th-2332 to Th-2336, Pa-2336 to Pa-2340, U-2340 to U-2344, Np-2344 to Np-2348, Pu-2348 to Pu-2352, Am-2352 to Am-2356, Cm-2356 to Cm-2360, Bk-2360 to Bk-2364, Cf-2364 to Cf-2368, Es-2368 to Es-2372, Fm-2372 to Fm-2376, Md-2376 to Md-2380, No-2380 to No-2384, Lr-2384 to Lr-2388, Rf-2388 to Rf-2392, Db-2392 to Db-2396, Sg-2396 to Sg-2400, Bh-2400 to Bh-2404, Hs-2404 to Hs-2408, Mt-2408 to Mt-2412, Ni-2412 to Ni-2416, Dh-2416 to Dh-2420, Si-2420 to Si-2424, Me-2424 to Me-2428, H-2428 to H-2432, He-2432 to He-2436, Li-2436 to Li-2440, Be-2440 to Be-2444, B-2444 to B-2448, C-2448 to C-2452, N-2452 to N-2456, O-2456 to O-2460, F-2460 to F-2464, Ne-2464 to Ne-2468, Na-2468 to Na-2472, Mg-2472 to Mg-2476, Al-2476 to Al-2480, Si-2480 to Si-2484, S-2484 to S-2488, Cl-2488 to Cl-2492, Ar-2492 to Ar-2496, K-2496 to K-2500, Ca-2500 to Ca-2504, Sc-2504 to Sc-2508, Ti-2508 to Ti-2512, V-2512 to V-2516, Cr-2516 to Cr-2520, Mn-2520 to Mn-2524, Fe-2524 to Fe-2528, Co-2528 to Co-2532, Ni-2532 to Ni-2536, Cu-2536 to Cu-2540, Zn-2540 to Zn-2544, Ga-2544 to Ga-2548, Ge-2548 to Ge-2552, As-2552 to As-2556, Se-2556 to Se-2560, Br-2560 to Br-2564, Kr-2564 to Kr-2568, Rb-2568 to Rb-2572, Sr-2572 to Sr-2576, Y-2576 to Y-2580, Zr-2580 to Zr-2584, Nb-2584 to Nb-2588, Mo-2588 to Mo-2592, Tc-2592 to Tc-2596, Ru-2596 to Ru-2600, Rh-2600 to Rh-2604, Pd-2604 to Pd-2608, Ag-2608 to Ag-2612, Cd-2612 to Cd-2616, In-2616 to In-2620, Sn-2620 to Sn-2624, Sb-2624 to Sb-2628, Te-2628 to Te-2632, I-2632 to I-2636, Xe-2636 to Xe-2640, Ba-2640 to Ba-2644, La-2644 to La-2648, Ce-2648 to Ce-2652, Pr-2652 to Pr-2656, Nd-2656 to Nd-2660, Pm-2660 to Pm-2664, Sm-2664 to Sm-2668, Eu-2668 to Eu-2672, Gd-2672 to Gd-2676, Tb-2676 to Tb-2680, Dy-2680 to Dy-2684, Ho-2684 to Ho-2688, Er-2688 to Er-2692, Tm-2692 to Tm-2696, Yb-2696 to Yb-2700, Lu-2700 to Lu-2704, Hf-2704 to Hf-2708, Ta-2708 to Ta-2712, W-2712 to W-2716, Re-2716 to Re-2720, Os-2720 to Os-2724, Ir-2724 to Ir-2728, Pt-2728 to Pt-2732, Au-2732 to Au-2736, Hg-2736 to Hg-2740, Tl-2740 to Tl-2744, Pb-2744 to Pb-2748, Bi-2748 to Bi-2752, Po-2752 to Po-2756, At-2756 to At-2760, Rn-2760 to Rn-2764, Ac-2764 to Ac-2768, Th-2768 to Th-2772, Pa-2772 to Pa-2776, U-2776 to U-2780, Np-2780 to Np-2784, Pu-2784 to Pu-2788, Am-2788 to Am-2792, Cm-2792 to Cm-2796, Bk-2796 to Bk-2800, Cf-2800 to Cf-2804, Es-2804 to Es-2808, Fm-2808 to Fm-2812, Md-2812 to Md-2816, No-2816 to No-2820, Lr-2820 to Lr-2824, Rf-2824 to Rf-2828, Db-2828 to Db-2832, Sg-2832 to Sg-2836, Bh-2836 to Bh-2840, Hs-2840 to Hs-2844, Mt-2844 to Mt-2848, Ni-2848 to Ni-2852, Dh-2852 to Dh-2856, Si-2856 to Si-2860, Me-2860 to Me-2864, H-2864 to H-2868, He-2868 to He-2872, Li-2872 to Li-2876, Be-2876 to Be-2880, B-2880 to B-2884, C-2884 to C-2888, N-2888 to N-2892, O-2892 to O-2896, F-2896 to F-2900, Ne-2900 to Ne-2904, Na-2904 to Na-2908, Mg-2908 to Mg-2912, Al-2912 to Al-2916, Si-2916 to Si-2920, S-2920 to S-2924, Cl-2924 to Cl-2928, Ar-2928 to Ar-2932, K-2932 to K-2936, Ca-2936 to Ca-2940, Sc-2940 to Sc-2944, Ti-2944 to Ti-2948, V-2948 to V-2952, Cr-2952 to Cr-2956, Mn-2956 to Mn-2960, Fe-2960 to Fe-2964, Co-2964 to Co-2968, Ni-2968 to Ni-2972, Cu-2972 to Cu-2976, Zn-2976 to Zn-2980, Ga-2980 to Ga-2984, Ge-2984 to Ge-2988, As-2988 to As-2992, Se-2992 to Se-2996, Br-2996 to Br-3000, Kr-3000 to Kr-3004, Rb-3004 to Rb-3008, Sr-3008 to Sr-3012, Y-3012 to Y-3016, Zr-3016 to Zr-3020, Nb-3020 to Nb-3024, Mo-3024 to Mo-3028, Tc-3028 to Tc-3032, Ru-3032 to Ru-3036, Rh-3036 to Rh-3040, Pd-3040 to Pd-3044, Ag-3044 to Ag-3048, Cd-3048 to Cd-3052, In-3052 to In-3056, Sn-3056 to Sn-3060, Sb-3060 to Sb-3064, Te-3064 to Te-3068, I-3068 to I-3072, Xe-3072 to Xe-3076, Ba-3076 to Ba-3080, La-3080 to La-3084, Ce-3084 to Ce-3088, Pr-3088 to Pr-3092, Nd-3092 to Nd-3096, Pm-3096 to Pm-3100, Sm-3100 to Sm-3104, Eu-3104 to Eu-3108, Gd-3108 to Gd-3112, Tb-3112 to Tb-3116, Dy-3116 to Dy-3120, Ho-3120 to Ho-3124, Er-3124 to Er-3128, Tm-3128 to Tm-3132, Yb-3132 to Yb-3136, Lu-3136 to Lu-3140, Hf-3140 to Hf-3144, Ta-3144 to Ta-3148, W-3148 to W-3152, Re-3152 to Re-3156, Os-3156 to Os-3160, Ir-3160 to Ir-3164, Pt-3164 to Pt-3168, Au-3168 to Au-3172, Hg-3172 to Hg-3176, Tl-3176 to Tl-3180, Pb-3180 to 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V-3388, Cr-3388 to Cr-3392, Mn-3392 to Mn-3396, Fe-3396 to Fe-3400, Co-3400 to Co-

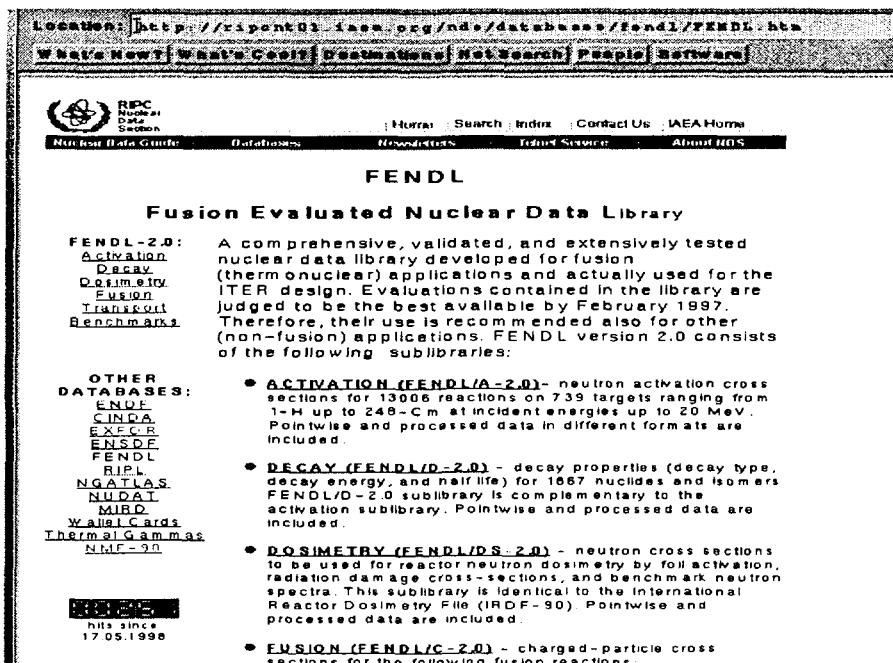


Figure 7: The FENDL web page



the experimental reaction data library EXFOR; all major evaluated neutron data libraries; various special purpose neutron data libraries (e.g. for thermal neutron scattering, fission products, actinides, neutron activation, and others); structure and decay data libraries; many special purpose files and libraries (partly for use on personal computers) for special applications. All libraries and the related documentation are available free of charge to scientists in IAEA member states. An overview is given in the document *"Index of Nuclear Data Libraries available from the IAEA Nuclear Data Section"*¹⁶.

Selected examples of special purpose libraries:

- **FENDL-2 (Fusion Evaluated Nuclear Data Library)**¹⁷: This is a recent example of a worldwide effort coordinated by the IAEA. The complete library includes basic evaluated neutron reaction data for 63 materials as well as derived working libraries (processed data). Aimed primarily at fusion applications, the data are useful also for a variety of other applications. The major "customer" for FENDL is ITER (International Thermonuclear Experimental Reactor), the common fusion project of USA, Russia, Europe and Japan (design activity 1992-1998). FENDL-2 consists of 810 files (1 Gbyte of data) and is available online from the IAEA Nuclear Data Section.
- **X-ray and γ -ray standards for detector calibration (XG Standards)**¹⁸: This is a PC diskette which contains for selected nuclides their half-lives and the energies and emission probabilities of γ -rays and X-rays suitable for detector and efficiency calibration.

Location: <http://www-nds.iaea.or.at/ensdf/ensdfframe.html>

[What's New?](#) [What's Cool?](#) [Database News](#) [Web Search](#) [People](#) [Software](#)

Evaluated Nuclear Data Files W³ Retrieval System  
Data Base Last Updated On May 9, 1997



Evaluated Nuclear Data Files - Introduction

The Evaluated Nuclear Data Files W³ Retrieval System provides almost all the capabilities of the ENDF module of the NDS Online Data Service. The following selection criteria *must* be specified:
[Nuclide & Projectile Library](#)

Evaluated Nuclear Data Files W³ Retrieval System *

This page consists of four frames which are from top to bottom:

1. The title frame consists of the title and latest revision date of the Evaluated Nuclear Data Files database and links to the NDS home pages.
2. The working frame is used to display the context sensitive help available in most of the

Evaluated Nuclear Data Files - Material Selection		
The following form allows the specification of a nuclide and projectile or a compound for an ENDF retrieval.		
Material 	Projectile 	Explanation
Material <input type="text"/>	N <input type="text"/>	Enter as AAAZZ or ZZ-AAA. Use the last two digits of the atomic number for Z>103. Isomeric levels may be given as ZZ-AAA-M1 where M1 is the first isomeric level, M2 is the second, etc.
FE-56 <input type="text"/>		

[Nuclide and Projectile](#) [Library](#) [MT/MT](#) [Output](#) [Energy Range](#) [Submit](#) [Info Summary](#) [Reset](#)

Figure 8: The ENDF web page

- Nuclear Data for Safeguards (SGNucDat): a PC database (also available as a handbook¹⁹) containing nuclear data needed for the development and application of nuclear materials accounting techniques.

5 Online Services

Distribution via electronic networks has become a main way of distributing numerical nuclear data in the past years. The IAEA Nuclear Data Section, like most of the other nuclear data centers, is offering a variety of electronic services while at the same time the more conventional data services (e.g. mailing data on tapes or diskettes) will be continued for the foreseeable future. The basis of the electronic services is the Internet, a "network of networks" which links many thousands of local networks and millions of computers. Within the Internet protocol, several methods of data transfer are in use:

- **Worldwide Web** (Other names: WWW, W3, Web). Originally developed by CERN, Switzerland, for the high energy physics community, now in use as a medium for scientific, commercial and any other type of information. It is based on hypertext (text containing links to other documents allowing the user to conveniently navigate between documents and websites). The *IAEA Nuclear Data Services* web page can be found at the web address (URL) <http://www-nds.iaea.or.at> and contains interactive access to most of the main databases including EXFOR, CINDA, ENSDF, NUDAT,

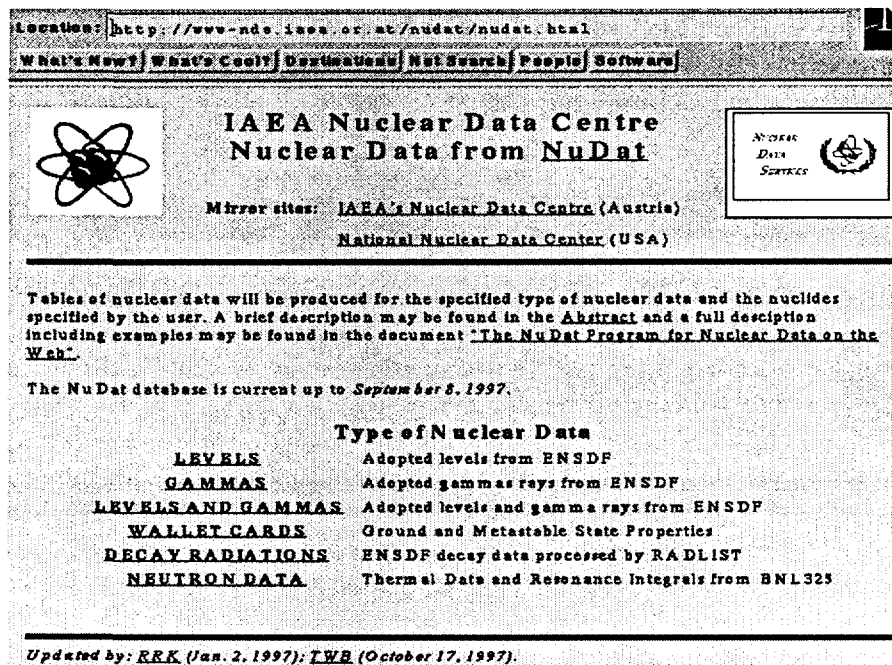


Figure 9: The NUDAT web page

ENDF (collection of main evaluated cross section libraries), NGATLAS (atlas of neutron capture cross sections²⁰) and others (Figs.4-9); an overview of all nuclear data libraries and databases available from the IAEA (the *IAEA Nuclear Data Guide*); access to download complete files (such as FENDL-2, IRDF-90, Atomic Mass Evaluation) as well as to various documents, manuals (in PostScript) and nuclear data utility programs; the latest issues of the IAEA's Nuclear Data Newsletter, and a link to the Telnet nuclear data service NDIS.

- **FTP** (File Transfer Protocol). The IAEA Nuclear Data Section keeps several accounts for file transfer requiring no password (all accessible by the FTP address *iaeand.iaea.or.at*): ANONYMOUS (read-only), contains several complete libraries, utility codes and documents for public use; FENDL2 (read-only), contains the data library for fusion applications FENDL-2; NDSOPEN (read and write), used for bilateral file exchange; NDSOINL (read-only), contains files saved by users of the Telnet-based online system NDIS (Nuclear Data Information System) to "local area"; RIPL (read-only), contains the new Reference Input Parameter Library²¹.
- **TELNET**: the standard Internet protocol for remote login. This is the method used to connect to the IAEA's first online nuclear data service NDIS which was introduced in 1992. The starting command for NDIS is *telnet iaeand.iaea.or.at*, then the username *iaeands* has to be entered. A detailed manual is available online in PostScript or as a hardcopy²². This type of online service has lost some of its importance to the rapidly

expanding WWW technology but is still considered very useful by many users and will be kept in parallel for the foreseeable future. NDIS provides access to the main interactive nuclear databases (as listed above under WWW) as well as to PostScript documents and utility programs.

6 Future developments

Within the Internet-based services, the shift towards Web-based interfaces, as a convenient alternative to FTP- and Telnet-based services, is in good progress and will continue. However, in consideration of the varying needs, in particular of users in developing countries having very diverse hardware and networking infrastructure, all currently used distribution methods, including conventional mail services, will be continued at least for the next several years.

The data available online will be supplemented gradually with "minor" (specialized) databases (so far typically distributed on diskettes) and with more electronic versions of hardcopy documents and reports. At present, the limiting factor for electronic distribution of large documents or full libraries is often the capacity of the network connection (bandwidth). Possible solutions are the distribution of databases on CD-ROM (possibly with a web-type user interface) and the possibility of (automatic) updates through Internet; and the creation of regional copies of the "Nuclear Data Services" website (the "mirror site" concept). It may be necessary to implement both solutions in parallel to satisfy all users' needs for the coming years.

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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 transfer of RIP;
NDSOHL for FTP access to files sent to NDIS "open" area.

Web: <http://www-nds.iaea.or.at>