

# **IAEA Nuclear Data Section: Progress Report, 2006/07**

## **Summary of Nuclear Data Studies by Staff of the IAEA Nuclear Data Section**

**1 October 2006 – 30 September 2007**

**Editors: S. Dunaeva, O. Schwerer, V. Zerkin**

IAEA Technical Meeting, 8-10 October 2007  
International Atomic Energy Agency, Headquarters  
Vienna, Austria

*Web: <http://www-nds.iaea.org/>  
e-mail: [services@iaeaand.iaea.org](mailto:services@iaeaand.iaea.org)*

### **1. Staff**

The authorized staff level of the Nuclear Data Section consists now of a total of 17 professionals and support staff, which means a reduction of one position (Mark O'Connell now only works part-time for our Section (25%)). One new staff member joined during the reported period: Daniel Abriola (effective from 1 January 2007) succeeded former staff member Andrej Trkov. Otto Schwerer retired in September 2007 after 31 years of service; hiring of his successor is currently under way.

### **2. Data Compilations**

#### **2.1 EXFOR and Dictionaries**

Over the previous year, NDS staff have distributed 7 CPND TRANS files (D050 - D056), containing 99 new entries (33 compiled at NDS, 20 at ATOMKI, 42 at UkrNDC, 4 in India) and 36 revised entries, and 3 neutron TRANS files (3121 - 3123) containing 42 new entries (15 compiled at NDS, 1 at UkrNDC, 20 at CNDC and 6 in India) and 22 revised entries. The compilations consist of new literature as well as many important old references. Also, two lists of papers (mostly "old" literature) are still on control for completeness of compilation:

1. list for Ion Beam Analysis;
2. list for Reference Input Parameters Library (RIPL).

NDS staff finished the format revision of all old NDS-originated CPND and photonuclear entries, including conversion to the new date format (4-digit years) and revised text (using upper and lower case characters) and started to revise neutron entries.

As of 24 September, 71 TRANS files were received, checked (with feedback to the originating centres) and processed, of which 69 were final versions that were added to the master file. These final transmissions contained 656 neutron entries (199 new, 457 revised), 984 CPND entries (517 new, 467 revised) and 69 photonuclear entries (37 new, 32 revised).

NDS staff have produced and distributed three regular transmissions of the EXFOR/CINDA dictionaries (TRANS 9093-9095) in EXFOR, DANIEL (backup) and archive format. The

dictionary revisions introduced in 2006/07 are now routinely in operation, and “wild cards” for REACTION SF7 have also been incorporated into the quantities dictionary 236.

## 2.2 CINDA

### CINDA Master file

The up-to-date CINDA Master File is available via the NDS compilers' Web site. An automatic update using the EXFOR database was carried out once (January 2007). References for ENDF/B-VII.0 library were generated, discussed, agreed and introduced to CINDA.

### Coverage control

Under the CINDA coverage control system, NDS staff scan over 80 journal titles (mainly through the Internet) for the purpose of compilation coverage control. From this year, the current status of compilation activities is available to EXFOR compilers on the NDS Web site. With the help of this Web site, 11 articles from the 2007 Nice conference are already compiled and available in EXFOR, and one additional compiled entry was transmitted in a preliminary TRANS file. For comparison, in the same period three years ago, no entries had been compiled from the previous ND conference (ND2004).

Over 1200 journal issues from 1990 to 2007 were added to the database for CINDA coverage control in late 2006/2007. Journal references that should be compiled elsewhere were also dispatched to the relevant centres (Japan, Russia, Hungary and NEADB).

All relevant references absent from EXFOR were sent to the responsible centres for compilation, along with pdf copies of the papers, if necessary.

EXFOR database statistics is also available from the NDS Web site:

- Contribution to EXFOR by Centres
- History (Preliminary, TRANS files, database updates)
- General statistics (contents by Quantities, Targets, Reactions, etc.)

NDS continues to save articles in pdf format. All articles previously stored on the shelf at NDS, are now stored electronically. All articles compiled during this year in the other centres have been scanned and stored in pdf format on NDS-computer. More than 2400 files were saved in pdf format during the year.

## 2.3 Evaluated data libraries, files and programs

Various new or revised evaluated data libraries, files and programs for data checking, processing and graphical presentation were added to the NDS Web-site and distributed on CD-ROM:

- NuDat-2 for interactive searching and plotting of nuclear structure and decay data, updated to version 2.4
- PREPRO 2007. ENF/B Pre-Processing Codes, March 2007
- Stopping Power for light ions, compilation by H. Paul (Univ. Linz), updated twice
- EXFOR - CINDA Database and Retrieval System, Version 1.95, data updated January 2007 (CD-ROM)

- ENDVER/GUI and EXFOR-CINDA package; Integrated Tools for ENDF-Evaluators, Version 1.4, January 2007

### 3. Services

#### Web Services

Further improvements have been implemented in the EXFOR-CINDA-ENDF retrieval systems since the previous NRDC meeting:

- interactive Web plotting: zoom by mouse, actions by one click, extended functionality
- output EXFOR data in R33-IBANDL format: angular distributions; includes plotting
- several new evaluated libraries are included to ENDF database: ENDF/B-VII.0 (NNDC, 2006), IAEA-Standards, IAEA Thermal Scattering Law Nuclear Data Library (2006), IAEA charged-particle library for medical radioisotope production (2001); first materials from IBA-Eval (Differential charged-particle cross sections for ion beam analysis, Gurbich and Trkov);
- “EXFOR+” (extended EXFOR format) output was implemented on EXFOR Web-service
- “IRDF-2002 extension” project support: includes EXFOR-ENDF Web services for selected materials from the basic libraries and for new evaluations (not public).

The system is successfully functioning at NNDC, in BARC (India) and IPEN (Brazil). Statistics of usage of the Web retrieval system are presented in Fig. 1.

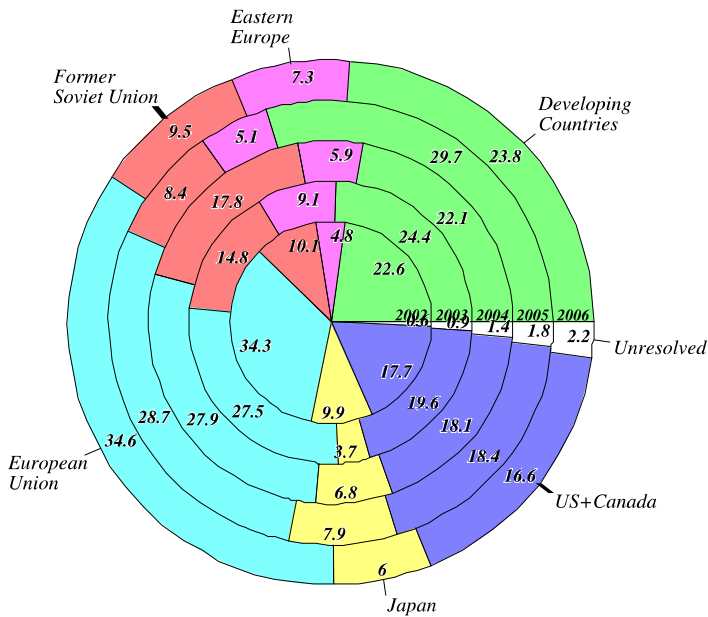
#### CD-ROMs

- “EXFOR/CINDA for Windows” CD was issued twice.
- “EXFOR/CINDA for Applications” for Linux and Windows was also issued twice; also distributed together as part of EndVer/GUI-CD and Empire-package. The package has also been adapted to Mac (using X-Windows support system).

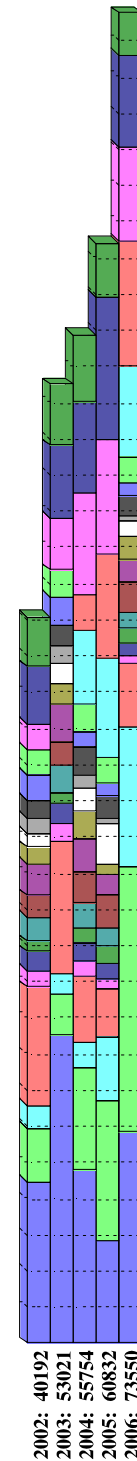
# NDS+IPEN+BARC

## Nuclear Data Services: Web Statistics

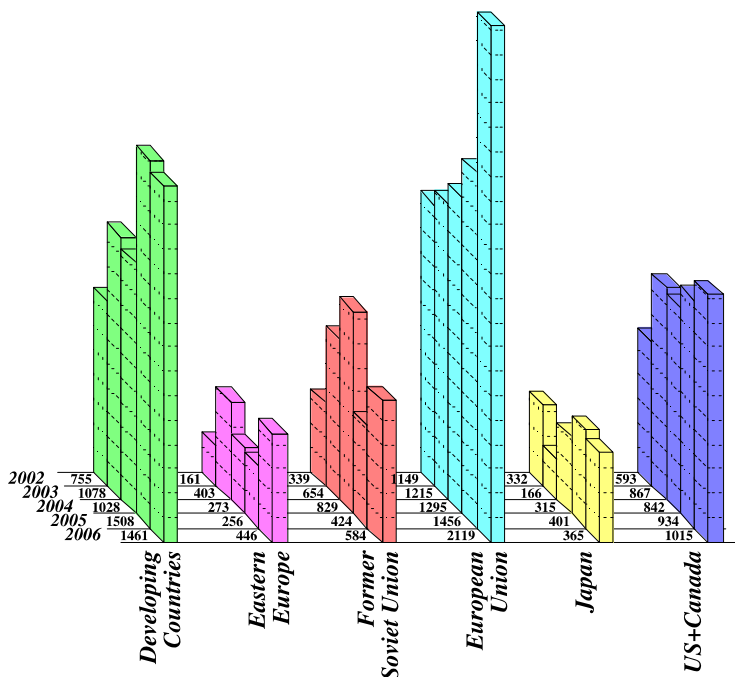
**Geographical Distribution (%)**



**Total per Year**  
(Number of accesses + retrievals)



**Average per Month**  
(Number of accesses + retrievals)



- | Service               | Comment      |
|-----------------------|--------------|
| Computer Codes        |              |
| Documents             |              |
| OtherData             |              |
| IBANDL                |              |
| PGAA                  |              |
| PhotoNuclear          |              |
| RIPL                  | Theory       |
| FENDL                 | Fusion       |
| Masses                |              |
| IRDF                  | Dosimetry    |
| Thermal Capture       |              |
| Wallet Cards          |              |
| Med.Radio.Prod.       |              |
| NGAtlas               | Activation   |
| RNAL                  |              |
| ENSDF                 | Structure    |
| MIRD                  | Medical      |
| NUDAT                 |              |
| CINDA+NSRBibliography |              |
| EXFOR                 | Experimental |
| ENDF                  | Energy       |

## 4. Software

### CINDA software

A program to import information from ENDF database has been created and checked with Henriksson (NEA-DB) and Otsuka (JCPRG); ENDF/B-VII.0 was processed.

### EXFOR software-tools

ZCHEX checking program was regularly updated. Executables for Windows and Linux with (complete set of dictionaries) are maintained on the NDS compilers' Web-site. Two new versions were released:

#### *December 2006:*

- Windows/Linux: EXFOR Dictionary 9093
- finds missing '(' in REACTION keyword
- allows isomer extensions "-L","-L1","-L2" in REACTION and DECAY codes
- Wildcards for SF7 during checking of SF5-8: done using Dictionary-33 (under testing)
- indication of SAN in the right column of error-message
- input file name is indicated in the error file and on the user's terminal
- length of input file name is expanded from 50 to 65

#### *June 2007:*

- Windows/Linux/Mac: EXFOR Dictionary 9094
- Wildcards for SF7 during checking of SF5-8: improved algorithm - now uses all Dictionary-33 and 227; (full test and Dict-236 having only wildcards)
- debugging (according to Maev, 2007-06-06 e-mail)
- adopted to Mac OS X (using g77 fortran compiler)

#### *September 2007:*

- Windows/Linux/Mac: EXFOR Dictionary 9095 (wildcards only)
- debugging: correct processing of N1,N2 in DATA and COMMON

XTRACT program (originally written in NNDC) was adapted to Linux and Windows and released on NDS Web site.

### Full EXFOR in C4 format.

Programs producing full EXFOR database in extended C4 format were developed (discussed within WPEC SG30 ). Full C4 Master-file is maintained on EXFOR compiler's site. Two files were released.

### Flexible ENDF database explorer.

New development - implements a sequential search/scan/view the data; allows the user to select the sequence of data observation "on the fly" and provides an additional convenient service. Now implemented only for ENDF, but will include EXFOR as well.

## 5. Nuclear Data Development

Although nuclear data developments are outside the immediate operations of the NRDC, we give a brief summary below.

### Co-ordinated Research Projects (CRPs):

- *Improvement of the Standard Cross Sections*: completed, all materials with IAEA Publishing Section
- *Nuclear Data for the Production of Therapeutic Radioisotopes*: database completed, report in preparation
- *Reference Input Parameter Library for Non-Energy Applications: (RIPL-III)*: on-going
- *Development of a Reference Database for Ion Beam Analysis*: on-going
- *Updated Decay Data Library for Actinides*: on-going
- *Reference Base for Neutron Activation Analysis*: on-going
- *Evaluated Nuclear Data Files of Charged Particle Interactions for Medical Therapy Applications* started in 2007
- *Minor Actinide Neutron Reaction Data (MANREAD)* started in 2007

### Data development projects:

- **Phase-Space Database for External Beam Radiotherapy (2006-2008)**

A new IAEA phase-space (*phsp*) format has been established. The new *phsp* database is designed to disseminate phase-space data of those accelerators and  $^{60}\text{Co}$  units used in radiotherapy through the compilation of existing data that have been properly validated.

- **IRDF-2002 dosimetry library**

Evaluated data files have been assembled, checked and uploaded onto the NDS Web server <http://www-nds.iaea.org/irdf2002/>, complete with draft documentation. The results were published as Technical Reports Series No. 452, IAEA, Vienna, Austria, 2006. A Consultants' Meeting was held in January 2007 to discuss the needs for new data for reactor dosimetry and possible extensions to other higher neutron energy applications (including the problem of adequate covariance data).

- **Updates to the WIMS-D library package**

An updated version of the XnWlup package for display and intercomparison of the library data has been provided by Indian researchers. The new WIMS-D library package is available on Web site <http://www-nds.iaea.org/wimsd/>, on CDROM, and as a publication: WIMS-D library update, F. Leszczynski, D. López Aldama, A. Trkov, STI/PUB/1264, IAEA, Vienna, Austria, 2007, ISBN 92-105006-2.

- **Neutron data file for Cd in the resolved resonance region**

Work is on-going to produce an updated and evaluated nuclear data file of resonance parameters in ENDF-6 format for the cadmium isotopes.

- **Nuclear model parameter sets for the RIPL-2 database**

Database maintenance tools and several new nuclear model parameter sets were included in the RIPL-II database through consultancy visits and service agreements. The extended database is available on Web site <http://www-nds.iaea.org/RIPL-2/>.

- **Ion Beam Analysis Nuclear Data Library (IBANDL)**

The database was created in spring 2004 and has been extended on a continuous basis since that time.

- **Input to JEFF project**

Original NDS staff interest and technical expertise in the formulation of JEFF-3.1 has resulted in some limited studies for the JEFF project. Over 60 well-defined decay scheme evaluations were undertaken in preparation for the release of the JEFF-3.1 decay data library from 2003 to 2006, and continue as support to the European Fusion programme (approximately 20 radionuclides per year). NDS staff have also actively participated at the JEFF Sub-Group on Decay Data and Fission Yields.

- **TM on Nuclear data for the International Fusion Material Irradiation Facility (IFMIF)**

A TM on “Nuclear data for the International Fusion Materials Irradiation Facility (IFMIF)” was held on 4-6 October 2005 (for a summary see INDC(NDS)-0478). The overall objective of the meeting was to review the status of the nuclear databases used to assess radiation damage to the structural components of the IFMIF test facility. Participants have identified and agreed on a proposal to be submitted to the Agency for the creation of an appropriate CRP.

## **6. Publications**

### **a) Papers presented at the Nice Nuclear Data Conference (ND2007)**

International Conference on Nuclear Data for Science and Technology, April 22-27 2007  
Nice, France.

**The art of collecting experimental data internationally: EXFOR, CINDA and the NRDC network**

by H. Henriksson, O. Schwerer, S. Maev, N. Otuka

**Status and future work of the NEA Working Party on International Nuclear Data Evaluation Cooperation**

by A. Koning, Jun-ichi Katakura, P. Obložinsky, A. Nichols, C. Nordborg

**The aims and activities of the International Network of Nuclear Structure and Decay Data evaluators**

by A. Nichols, J. Tuli

**Experimental studies to improve specific actinide decay data**

by F.G. Kondev, M.A. Kellett, I. Ahmad, J.P. Greene, and A.L. Nichols

**Inelastic neutron scattering cross section of  $^{187}\text{Os}$  at 30 keV**

by M. Mosconi, M. Heil, F. Kappeler, A. Mengon, and R. Plag

**Design study for a new spallation target of the n\_TOF facility at CERN**

by C. Carrapico, S. Andriamonje, E. Berthoumieux, I. Goncalves, F. Gunsing, A. Mengoni, P. Vaz, V. Vlachoudis, and the n\_TOF Collaboration

**CANDIDE – Coordination action on nuclear data for industrial development in Europe**

by I. Blomgren, E. Bauge, D.C. Ott, S. Czifrus, E. Gonzalez, H. Henriksson, R. Jacqmin, A. Koning, D. Lecarpentier, E. Malambu, A. Mengoni, R. Mills, A. Plompen, G. Rimpault

**Capture cross section measurements of  $^{186,187,188}\text{Os}$  at n-TOF: The resolved resonance region**

by K. Fujii, M. Mosconi, P. M. Milazzo, F. Kappeler, A. Mengoni, and the n-TOF Collaboration

**EMPIRE ultimate expansion: resonances and covariances**

by M. Herman, S. F. Mughabghab, P. Oblozinsky, D. Rochman, M. T. Pigni, T. Kawano, R. Capote, V. Zerkin, A. Trkov, M. Sin, B. V. Carlson, H. Wienke, and Young-Sik Cho

**Development of IAEA nuclear reaction databases and services**

by V. Zerkin and A. Trkov

**The Global Assessment of Nuclear Data, GANDR**

by D.W. Muir, A. Trkov, I. Kodeli, R. Capote and V. Zerkin

**Experimental studies to improve specific actinides decay data**

by F.G. Kondev, M.A. Kellett, I. Ahmad, J.P. Greene and A.L. Nichols

**Evaluation of the  $^{103}\text{Rh}$  neutron cross-section data in the unresolved resonance region for improved criticality safety**

by L.C. Mihailescu, I. Sirakov, R. Capote, et al.

**Deformation dependent TUL multi-step direct model**

by H. Wienke, R. Capote, M. Herman et al.

**Lane consistency of the dispersive coupled channel optical model potential**

R. Capote, E. Soukhovitskii, et al.

**Extension of the nuclear reaction model code EMPIRE to actinides' nuclear data evaluation**

by R. Capote, M. Sin, A. Trkov, et al

**New cross section measurements for neutron-induced reactions on Cr, Ni, Cu, Ta and W isotopes obtained with the activation technique**

by V. Semkova, R. Capote, R. Jaime Tornin, et al

**Improved lead and bismuth (n, $\gamma$ ) cross sections and their astrophysical impact**



by C. Domingo-Pardo, A. Mengoni, R. Capote, et al. (n\_TOF Collaboration).

**The neutron capture cross sections of  $^{237}\text{Np}$  and  $^{240}\text{Pu}$  and its relevance in the transmutation of nuclear waste**

by C. Guerrero, A. Mengoni, R. Capote, et al. (n\_TOF Collaboration)

**Capture cross section measurements of  $^{186,187,188}\text{Os}$  at n\_TOF. The resolved resonance region**

by K. Fujii, A. Mengoni, R. Capote, et al. (n\_TOF Collaboration).

**Measurements of the  $\text{Au}(n,\gamma)$  cross section at n\_TOF toward a new standard**

by C. Massimi, A. Mengoni, R. Capote, et al. (n\_TOF Collaboration).

**Simultaneous measurement of the neutron capture and fission cross section of  $^{233}\text{U}$**

by E. Berthoumieux, A. Mengoni, R. Capote, et al. (n\_TOF Collaboration).

**Neutron-induced fission of actinides from resonant reactions to spallation**

by L. Audouin A. Mengoni, R. Capote, et al. (n\_TOF Collaboration).

**Measurement of the  $^{90,91,92,93,94,96}\text{Zr}(n,\gamma)$  and  $^{139}\text{La}$  cross sections at n\_TOF**

by G. Tagliente, A. Mengoni, R. Capote, et al. (n\_TOF Collaboration).

**Measurement of the neutron induced fission of  $^{235}\text{U}$ ,  $^{233}\text{U}$  and  $^{245}\text{Cm}$  with the FIC detector at CERN n\_TOF facility**

by M. Calviani, A. Mengoni, R. Capote, et al. (n\_TOF Collaboration).

**b) Other publications**

**New measurement of neutron capture resonances in Bi-209** by C. Domingo-Pardo, R. Capote, A. Mengoni, et al., *Phys. Rev. C* **74** (2006) 025807:1-10.

**Uncertainty estimation in IMRT absolute dosimetry verification** by F. Sánchez-Doblado, G.H. Hartmann, J. Pena, R. Capote et al., (to be submitted to *Int. J. Radiation Oncology, Biology and Physics*).

**Fission of light actinides: Th-232(n,f) and Pa-231(n,f) reactions** by M. Sin, R. Capote, A. Ventura, M. Herman and P. Obložinský, *Phys. Rev. C* **74** (2006) 014608 1-13.

**Resonance capture cross section of  $^{207}\text{Pb}$**  by C. Domingo-Pardo, R. Capote, A. Mengoni et al. (n\_TOF Collaboration) *Phys. Rev. C* **74**, 055802 (2006)

**Measurement of the neutron capture cross section of the *s*-only isotope  $^{204}\text{Pb}$  from 1 eV to 440 keV by C. Domingo-Pardo, R. Capote, A. Mengoni *et al.* (n\_TOF Collaboration) *Phys. Rev. C* **75**, 015806 (2007)**

**The  $^{139}\text{La}(n,\gamma)$  cross section: Key for the onset of the *s*-process** by R. Terlizzi, by C. Domingo-Pardo, R. Capote, A. Mengoni *et al.* (n\_TOF Collaboration) *Phys. Rev. C* **75**, 035807 (2007)

## 7. Network Meetings

- 17th Meeting of the **Nuclear Structure and Decay Data (NSDD) Network**, June 11-15, 2007, Petersburg Nuclear Physics Institute, Saint-Petersburg, Russia
- **CMs on XML**  
The IFRC Subcommittee on Atomic and Molecular Data and the Data Centres Network (DCN) have both recommended that the IAEA encourage the use of XML for exchange of data among the DCN members. To fulfil this goal the IAEA NDS has organized a number of Consultants' Meetings attended by researchers in fusion and astrophysics with experience in both data issues and XML schema. Recent meetings include 11-13 October 2006 in Paris, 2-3 April 2007 in Vienna and 1-2 October 2007 in Vienna. A preliminary version of a schema is scheduled to be made available by the end of 2007.

## 8. Workshops 2007/2008

- Workshop on **Nuclear Data for Science and Technology: Medical Applications**. ICTP Trieste, Italy, 12 - 23 November 2007
- Workshop on **Nuclear Structure and Decay Data: Theory and Evaluation**. ICTP Trieste, Italy, 28 April – 9 May 2008
- Workshop on **Nuclear Reaction Data for Advanced Reactor Technologies**. ICTP Trieste, Italy, 19 - 30 May 2008

## 9. Visits and Inter-centre Cooperation

- G. Pikulina and S. Taova (Sarov) to NDS, 16-23 May 2007: Development of EXFOR-Editor.
- V. Varlamov and S. Taova (Sarov) to NDS, 8-10 October 2007: Development and deployment of EXFOR-Editor.
- S. Dunaeva (IAEA/NDS) to BARC, Mumbai, India, 26 October – 4 November 2007: EXFOR compilation in India