

IAEA Nuclear Data Section: Progress Report for period 2022-2023

Summary of Nuclear Data Activity by Staff of the IAEA Nuclear Data Section

June 2022 – April 2023

IAEA Technical Meeting, 9-12 May 2023

Vienna, Austria

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1. Staff Changes

The authorized staff level of the Nuclear Data Section (NDS) consists of a total of 16.25 professionals and support staff. The latest staff changes include:

- Ulrike Perstl (Team Assistant) retired in April 2023.

2. Compilations

2.1 EXFOR transmission

During the reporting period, the following final tapes have been transmitted:

- 3 neutron final TRANS tapes (3208, V040-V041) containing 19 new entries and 60 revised entries;
- 2 CPND final TRANS tapes (B034, D137) containing 38 new entries and 49 revised entries;
- 1 PhND final TRANS tapes (G049) containing 7 new entries and 12 revised entries.

These include contributions from NDS, five other centres (ATOMKI, CNDC, KNDC, NDPCI, UkrNDC) as well as two individual regular compilers (Myagmarjav Odsuren, Timur Zholdybayev).

Myagmarjav Odsuren (National Univ. of Mongolia, Ulaanbaatar) is compiling heavy-ion induced reaction data measured in the area 2 countries (e.g., Germany, Italy) for area D.

Timur Zholdybayev (Institute of Nuclear Physics, Almaty) is compiling charged-particle induced reaction data measured by his group and some other groups in Kazakhstan for area D.

Two regular transmissions of the EXFOR/CINDA dictionaries (TRANS.9126–9127) were done in TRANS, DANIEL (backup) and archive format.

Number of new entries transmitted by final tapes since the NRDC 2022 meeting
(TZ: Timur Zholdybayev, MO: Myagmarjav Odsuren)

	NDS	ATOMKI	CNDC	KNDC	NDPCI	UkrNDC	TZ	MO	Sum
Neutron	6		5	0	8	0			19
CPND	8	9	*	5	8	1	3	4	38
PhND	3			0	3	1			7
Sum	17	9	5	5	19	2	3	4	64

* Area S entries are transmitted by CNDC and therefore not included in these statistics.

2.2 EXFOR quality control

During the reporting period, **71 preliminary tapes** (PRELIM) uploaded to the NDS open area for checking by NDS and other centres. Both ZCHEX and JANIS TRANS Checker are regularly used. The finalized tapes are also checked against comments from centres before uploading to the NDS open area. NDS also registers comments on EXFOR entries from users and centres to the **EXFOR Feedback List** (<https://nds.iaea.org/nrdc/error/>) and monitors the correction process by checking each preliminary tape against the feedback list.

Additionally, Alberto Rodrigo (NDS intern) found many problematic isomer production cross sections and isomeric ratios during analysis of experimental isomeric ratios extracted from EXFOR via X4Pro, and summarized the problems in memos (CP-D/1058, 1060, 1061, 1062, 1065, 1066).

2.3 EXFOR coverage control

Under the EXFOR compilation control system, **37 journal titles** are regularly scanned by NDS and registered to the EXFOR Compilation Control System (X4CoCoS), and they are listed in the **Article Allocation List** (<https://nds.iaea.org/nrdc/alloc/>). This list also includes the scanning records of 19 journal titles received from other centres. The newly published articles are also listed on <https://nds.iaea.org/exfor-master/x4compil/>. EXFOR statistics for compilers was extended by indicating waiting time for PRELIM files.

2.4 CINDA

Regular automatic updates using the EXFOR and NSR databases have been frozen because NSR database is not available since 2019. Import from EXFOR and NSR-2018 was performed once to keep maintenance system alive.

2.5 Evaluated data libraries, files and programs

Various new and revised evaluated data libraries, files and programs for data checking, processing and graphical presentation were added, developed and distributed via the NDS Web site (see below).

3. Services

3.1 Web Services

Further improvements have been implemented in the Web EXFOR-CINDA-ENDF-IBANDL database retrieval systems and Web-Tools for nuclear data compilers and evaluators since the last NRDC meeting:

- ENDF (Evaluated Nuclear Data Files):
 - new and updated evaluated libraries in the ENDF database:
 - TENDL-2021 TALYS-based Evaluated Nuclear Data Library
 - INDEN-Oct2022 evaluations produced by International Nuclear Data Evaluators Network (coordinated by the IAEA)
 - software news:
 - plotting covariances for angular distributions of secondary particles MF34

- plotting covariances of the average number of neutrons per fission MF31
- API for search and download data of MF4 with uncertainties from MF34
- EXFOR:
 - Web interface connecting EXFOR to International Nuclear Information System INIS (experimental: for ANL, BARC, CEA, FEI, JINR reports only)
 - X5 - comprehensive presentation of EXFOR in JSON including meta-data, dictionary-info, original and computational data, data for renormalization (available on Web and in X4Pro)
 - CSV - comma separated values of EXFOR data in original, basic and computational form for Excel and other Applications (Web)
 - X5 and CSV Web interface: downloading and Html presentations as interactive tree and tables
- EXFOR-ENDF:
 - EE-View - fast experimental-evaluated data viewer (implemented for cross sections and angular distributions with uncertainties): Web interface to EXFOR-ENDF databases
 - Web-API for search and download data in JSON
- EXFOR-NSR PDF database:
 - updates: 70, added 3,237 PDF files
 - database content (PDF files):
 - total: +3, 237 => 226,127
 - EXFOR-PDF: +988 => 27,845 (78% of 35,666)
 - NSR-PDF: +2,249 => 190,886 (~79% of 241,534)
- IBANDL:
 - 3 database updates (total: 4287 Datasets)
 - Web-API to search and download list (CSV) of datasets and data (R33, JSON)

Development of the Web-Tools for EXFOR compilers, ENDF and ENSDF evaluators:

- MyExfor: 3 updates by new versions of ZCHEX and new Dictionaries
- MyEnsdf: added/upgraded codes: JAVA_NDS, FMTCHK, BrIccMixing
- new authorization system, common for Web MyExfor, MyEndf, MyEnsdf, X4NSR-PDF

The Web EXFOR-CINDA-ENDF-IBANDL database retrieval system is also functioning at BARC (India) and “Atomstandart” (Russia). Statistics for usage of the Web retrieval system are presented in figures below.

3.2 Packages and databases for Web downloading

- “X4Pro” extends EXFOR Relational database (SQLite) with experimental data points in original and computational form; comes with demo examples on Python and Fortran with (a) retrievals of CS, DA, DAP, DE, DAE, FY from local EXFOR and remote ENDF databases, (b) EXFOR data renormalization to new standards and decay data, (c)

user's modifications and various recalculations with Legendre coefficient, (e) plotting covariance data and TKE×Mass distributions coded in EXFOR, (f) populating CouchDB (NoSQL) database using X5.json, etc. Plotting is implemented using Plotly/Matplotlib packages. All codes work on Windows, Linux and MacOS. Two releases.

- (XC4+X4)/C5 of all experimental data from EXFOR for Empire/Talys and other Applications' users: two releases
- IBANDL-Archive with complete library (R33 files) and CSV-index: one release (new)

3.3 Document Services

As part of our services, Nuclear Data Services Unit (NDSU) continued supporting the Member States by disseminating IAEA-NDS and INDC reports series as well as data libraries.

The documents produced by the Nuclear Data Section are shared via links to our webpage.

Number of reports published between May 2022 and May 2023.

Report code	Country of origin	Reports
IAEA-NDS	Nuclear Data Section	3
INDC(JPN)	Japan	1
INDC(NDS)	Nuclear Data Section	15
INDC(SEC)	NDS Secretariat	1

Various Nuclear Data Packages including pilot projects under development are available for download from our webpage <https://nds.iaea.org/cdroms/>.

3.4 Nuclear Data Newsletters

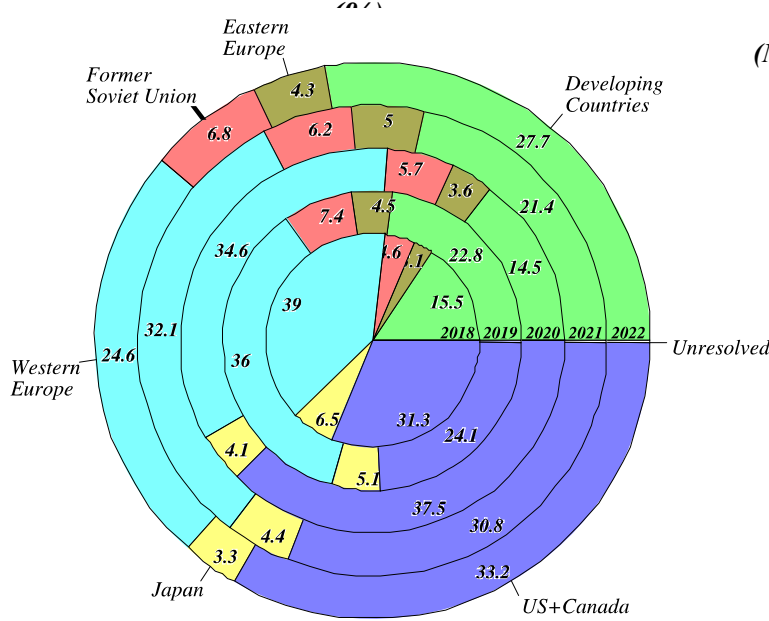
The Nuclear Data Newsletter is published twice a year (January and July) to inform the scientific community about actual NDS work, meetings held, projects, computer codes developed and new data libraries. During the reporting period, we published two issues of the Newsletter (73 and 74). Next one, No 75 is in preparation and will be published in August 2023. We currently have 89 recipients of hardcopies and 1238 recipients of electronic version.

4. Visits and Inter-centre Cooperation

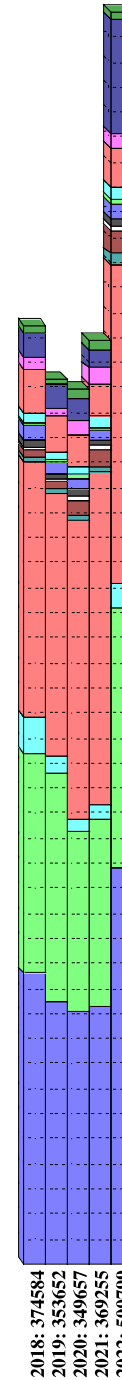
- V.Zerkin (NDS) visited NNDC (BNL, USA) from 1 to 19 May 2022 to deploy and develop ENDF-EXFOR database management system, Web retrieval system, tools and output formats; to extend schema and contents of EXFOR, ENDF and EXFOR-NSR PDF databases.
- N. Otsuka (NDS) visited JCPRG from 23 to 27 January 2023 to improve the web-based EXFOR editor (HENDEL) and EXFOR database update system.

IAEA Nuclear Data Services: Web Statistics 2018-2022

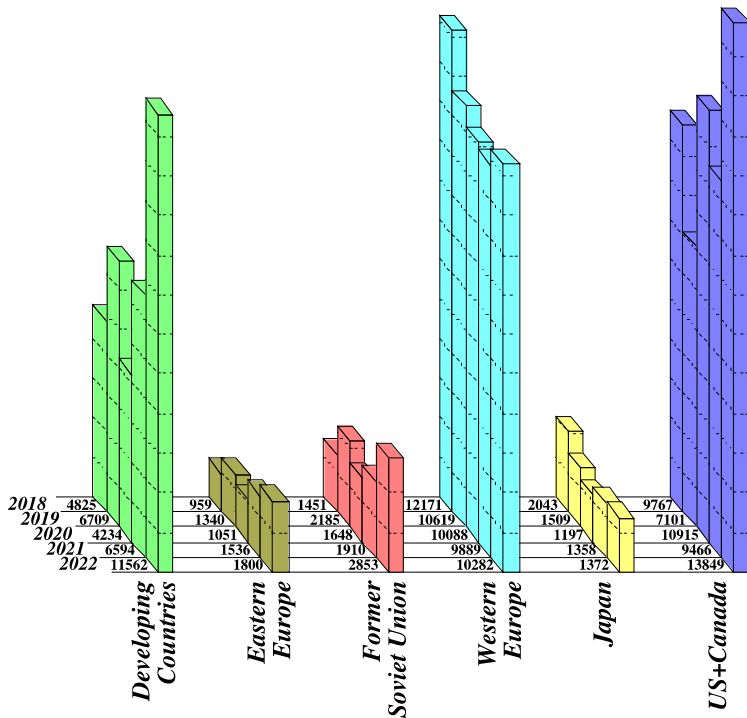
Geographical Distribution



Total per Year (Number of accesses + retrievals) *2020 extrapolated 5 months

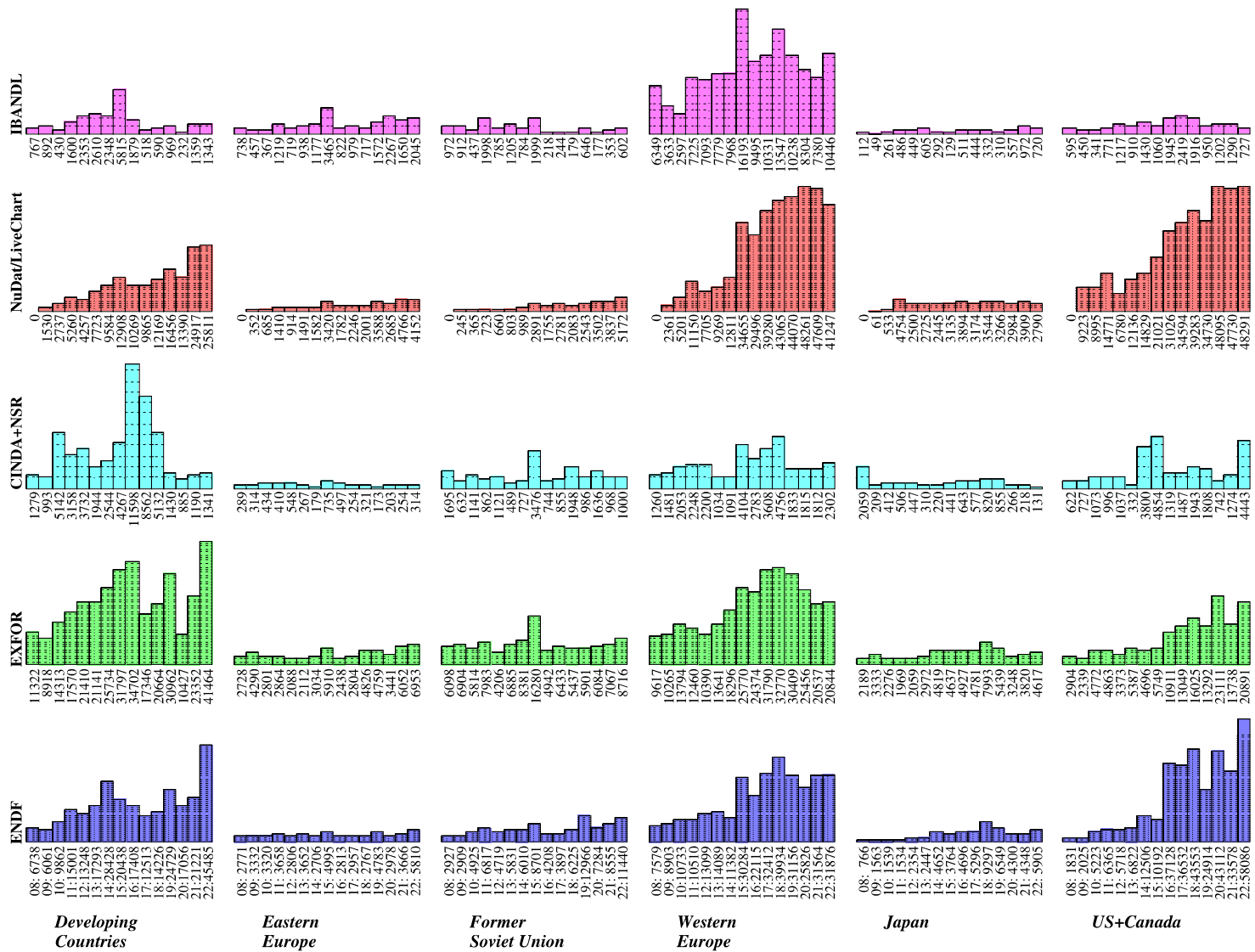


Average per Month (Number of accesses + retrievals)



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

IAEA Nuclear Data Services: Web Retrievals by Groups of Countries



5. Nuclear Data Developments

The Nuclear Data Section undertakes long term nuclear data development by implementing Coordinate Research Projects (CRP) and Data Development Projects (DDP). The staff members of NDS who manage NRDC also follow the currently running CRPs and DDPs to observe the actual trends and needs for nuclear reaction data.

5.1. Coordinated Research Projects (CRP)

- Recommended Input Parameter Library (RIPL) for fission cross section calculations (2017-2021): *Ongoing*.
- Updating fission yield data for applications (2020-2025): *Ongoing*.

5.2 Data Development Project (DDP)

- Intercomparison of PIGE analysis codes to calculate PIGE yields for the analysis of bulk samples: *Ongoing*
- Evaluation of nuclear moments: *Ongoing*
- Verification of data processing codes for generating ACE-formatted files: *Ongoing*
- Stopping power database: *Ongoing*
- Nuclear data libraries for advanced systems: Fusion devices: *Ongoing*
- Nuclear Data for Medical Applications: *Ongoing*
- Maintain the international Neutron Standards file and evaluation techniques: *Ongoing*

6. Training Activities (Schools, Workshops)

- Joint ICTP-IAEA Workshop on “Nuclear Structure and Decay Data: Experiment, Theory and Evaluation”, 3-14 October 2022, Trieste, Italy.

7. Nuclear Data Journal Publications (2022-2023)

Spectrum averaged cross section measurements of lutetium using standard ^{252}Cf neutron source

M. Schulc, R. Capote, et al., *Appl. Radiat. Isot.* **188** (2022) 110378.

Impact of reactor neutron spectrum on measured spectrum averaged cross sections

M. Kostal, R. Capote, et al., *Ann. Nucl. Energy* **179** (2022) 109418.

EXFOR-based simultaneous evaluation of neutron-induced uranium and plutonium fission cross sections for JENDL-5

Naohiko Otuka, Osamu Iwamoto, *J. Nucl. Sci. Technol.* **59** (2022) pp. 1004-1036.

The effect of heavy reflector on neutronic parameters of core

M. Kostal, R. Capote, et al., *Ann. Nucl. En.* **168** (2022) 108898.

Production cross sections of samarium-153 and -145 via alpha-particle-induced reactions on natural neodymium

M. Aikawa, M. Sakaguci, N. Ukon, Y. Komori, H. Haba, N. Otuka, S. Takács, *Appl. Radiat. Isot.* **187** (2022) 110345.

Nuclear data uncertainty in iterative neutron spectrum unfolding

Katsumi Aoki, Tadahiro Kin, Naohiko Otuka, *J. Nucl. Sci. Technol.* **59** (2022) pp. 907-914.

EXFOR-NSR PDF database: a system for nuclear knowledge preservation and data curation

V.V. Zerkin, B. Pritychenko, J. Totans, L. Vrapcenjak, A. Rodionov, G.I. Shulyak *J. Instrum.* **17** (2022) P03012.

Iterative Bayesian Monte Carlo for nuclear data evaluation

E. Alhassan, D. Rochman, A. Vasiliev, M. Hursin, A.J.Koning, H. Ferroukhi, *Nucl. Sci. Tech.* **33**(2022) 50.

Impact of H in H₂O thermal scattering data on criticality calculation: uncertainty and adjustment

D.A. Rochman, A. Vasiliev, H. Ferroukhi, A. Koning, J.-Ch. Sublet, *EPJ Nucl. Sci. Technol.* **8** (2022) 3.

Advanced breakup-nucleon enhancement of deuteron-induced reaction cross sections

M. Avrigeanu, D. Rochman, A.J. Koning, U. Fischer, D. Leichtle, C. Costache, V. Avrigeanu, *Eur. J. Phys.* **A58** (2022) 3.

Radioisotope products and the Medicine of the future: an IAEA perspective

A. Jalilian, A. Korde, V. Starovoitova, J.Jr. Osso, A. Koning, N. Pessoa Barradas, C. Horak, M. Denecke, *Bull. Sci. Cent. Expert Eval. Med. Prod.* (2022) 539.163:615.31:615.849.