



IAEA

International Atomic Energy Agency

INDC(NDS)-0725
Distr. G

INDC International Nuclear Data Committee

Report of the IAEA Nuclear Data Section to the International Nuclear Data Committee for the period January 2014 – December 2015

Edited by

Arjan J. Koning and Roberto Capote Noy
IAEA Nuclear Data Section
Vienna, Austria

July 2016

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Printed by the IAEA in Austria
July 2016

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Abstract

This report contains details of the main activities of the IAEA Nuclear Data Section (NDS) during 2014 and 2015, and is provided as information to the International Nuclear Data Committee (INDC). NDS staff and affiliated consultants have focused their work on analysing and fulfilling data development needs and ensuring adequate, trouble-free services to all users in Member States. The present information is complemented with descriptions of other related activities in the reporting period, including meetings and publications. The atomic and molecular data projects are presented to the INDC for information only, since these specific activities are reviewed in depth by the Atomic and Molecular Data for Fusion Subcommittee of the International Fusion Research Council.

July 2016

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Glossary of Abbreviations

| | |
|--------|--|
| A+M | Atomic and Molecular |
| AMDU | Atomic and Molecular Data Unit |
| ACE | A Compact ENDF library for MCNP Monte Carlo particle transport codes |
| AIPS | Agency-wide Information System for Programme Support |
| AMDU | Atomic and Molecular Development Unit |
| APID | Atomic and Plasma-material Interaction Data for fusion (IAEA journal) |
| ATOMKI | AtomMagKutató Intézet (Institute of Nuclear Research, Hungary) |
| BARC | Bhabha Atomic Research Centre, India |
| BIPM | Bureau International des Poids et Mesures |
| CCN | Code Centre Network |
| CCRA | Committees for Coordinated Research Activities (IAEA) |
| CINDA | Computer Index on Neutron Data (bibliographic database) |
| CD-ROM | Compact disk with read-only memory |
| CDR | Career Development Training |
| CEA | Commissariat à l'énergie atomique et aux énergies alternatives |
| CJD | Russian Data Center |
| CM | Consultants' Meeting (of the IAEA) |
| CPND | Charged-particle nuclear data |
| CRP | Coordinated Research Project (of the IAEA (see also RCM)) |
| CSA | Contractual Service Agreement |
| CV | Consultancy Visit |
| DCN | Data Centre Network (IAEA) |
| DDP | Data Development Project |
| DDEP | Decay Data Evaluation Project |
| DEMO | DEMONstration Power Plant |
| DMZ | De-Militarized Zone |
| DVD | Digital Video Disc |
| EGAF | Evaluated Gamma-ray Activation File |
| EMPIRE | Nuclear reaction modelling system for calculating and evaluating cross sections |
| ENDF | Evaluated Nuclear Data File |
| ENDVER | ENDF Verification software package |
| ENSDF | Evaluated Nuclear Structure Data File |
| EPICS | Electron Photon Interaction Cross Sections |
| EXFOR | Computer-based system for the compilation and international exchange of experimental nuclear reaction data (EXchange FORmat) |
| FAC | Flexible Atomic Code |
| FENDL | Fusion Evaluated Nuclear Data Library |
| FTP | file transfer protocol |
| GENIE | General Internet Search Engine for atomic data |
| GND | Generalized Nuclear Data Format |
| GRUCON | Command Language for Nuclear Data |
| GUI | Graphics user interface |
| HP | Hewlett Packard |
| IAEA | International Atomic Energy Agency, Vienna, Austria |
| IBA | Ion Beam Analysis |
| IBANDL | Ion Beam Analysis Nuclear Data Library |
| ICTP | International Centre for Theoretical Physics, Trieste, Italy |
| IFMIF | International Fusion Materials Irradiation Facility |
| IFRC | International Fusion Research Council |
| INDC | International Nuclear Data Committee |

| | |
|---------|--|
| INDL | IAEA Nuclear Data Library |
| INIS | International Nuclear Information Service (IAEA) |
| IN2P3 | National Institute of Nuclear and Particle Physics, Paris, France |
| IPPE | Institute of Physics and Power Engineering , Russia |
| IRDF | International Reactor Dosimetry File (IAEA) |
| IRDFF | International Reactor Dosimetry Fission and Fusion File |
| IRMM | Institute for Reference Materials and Measurements, Belgium |
| IT | Information Technology |
| ITAMP | Institute for Theoretical Atomic Molecular and Optical Physics |
| ITER | International Thermonuclear Experimental Reactor |
| JAEA | Japan Atomic Energy Agency, Ibaraki, Japan |
| JCPRG | Nuclear Reaction Data Centre, Hokkaido University, Sapporo, Japan |
| JEFF | Joint Evaluated Fission and Fusion Project (OECD/NEA-DB) |
| JENDL | Japanese evaluated nuclear data library |
| KAERI | Korea Atomic Energy Research Institute, Korea |
| KERMA | kinetic energy released per unit mass |
| KFAS | Kuwait Foundation for the Advancement of Sciences |
| LANL | Los Alamos National Laboratory |
| MCNP | Monte Carlo N-Particle code |
| MDPI | Multidisciplinary Digital Publishing Institute |
| MIRD | Medical Internal Radiation Dose format |
| MyEnsdf | Webtool for the processing of ENSDF files |
| n_TOF | neutron Time-Of-Flight (CERN experimental facility) |
| NAPC | Division of Physical and Chemical Sciences (IAEA) |
| NCDP | Nuclear Physics Data Center, Sarov, Russia |
| NDDU | Nuclear Data Development Unit |
| NDS | IAEA Nuclear Data Section, Vienna, Austria |
| NDSU | Nuclear Data Services Unit |
| NEA | Nuclear Energy Agency of the OECD, Paris, France |
| NEA-DB | Nuclear Energy Agency – Data Bank |
| NFRI | National Fusion Research Institute, Korea |
| NGAtlas | Atlas of Neutron Capture cross sections |
| NIST | National Institute of Science and Technology, USA |
| NJOY | NJOY nuclear data processing system |
| NNDC | National Nuclear Data Center, Brookhaven National Laboratory, Upton, USA |
| NRA | Nuclear Reaction database |
| NRDC | Network of Nuclear Reaction Data Centres |
| NRDF | Nuclear Reaction Data File |
| NSDD | Nuclear Structure and Decay Data |
| NSR | Nuclear Science References (bibliographic file related to ENSDF) |
| NUCLEUS | Nuclear Information and Knowledge Portal (IAEA) |
| NuDat | Nuclear Data (user-friendly presentation of nuclear structure data – NNDC, BNL)) |
| OASIS | IAEA Intranet |
| OECD | Organization for Economic Cooperation and Development |
| ORELA | Oak. Ridge Electron Linear Accelerator |
| ORNL | Oak Ridge National Laboratory, Oak Ridge, USA |
| PC | Personal Computer |
| PDF | Portable Document Format |
| PFNS | Prompt Fission Neutron Spectra (PFNS) for Actinides |
| PGAA | Prompt Gamma Activation Analysis |

| | |
|--------|---|
| PNPI | PETERSBURG NUCLEAR PHYSICS INSTITUTE |
| POINT | Temperature Dependent Pointwise Cross Section Library series, based on ENDF/B |
| PROBIS | Agency Programme and Budget Information System |
| PREPRO | ENDF Pre-processing code |
| RCM | Research Coordination Meeting |
| RNAL | Reference Neutron Activation Library (IAEA) |
| RIPL | Reference Input Parameter Library |
| SSA | Special Service Agreement (IAEA) |
| SSH | Secure Shell |
| TAGS | Total Absorption Gamma-ray Spectroscopy |
| TALYS | Nuclear reaction modelling code for calculating cross sections |
| TECDOC | Technical Document series published by the IAEA |
| TENDL | TALYS-based Evaluated Nuclear Data Library |
| TM | Technical Meeting (IAEA) |
| TRANS | Collection of some EXFOR entries |
| TRS | Technical Report Series |
| UkrNDC | Ukrainian Nuclear Data Centre |
| WIMS | Winfrith Improved Multigroup Scheme of reactor lattice codes |
| WIMSD | IAEA Libraries |
| WPEC | Working Party on international nuclear data Evaluation Cooperation (OECD) |
| WS | Workshop |
| XC4 | Extended computational format |
| XUNDL | Nuclear Data Library |

Preface

The IAEA Nuclear Data Section is one of four Sections within the Division of Physical and Chemical Sciences (NAPC), which in turn is one of four Divisions of the Department of Nuclear Sciences and Applications. The primary aim of the Section is the provision of high quality atomic and nuclear data to Member States of the International Atomic Energy Agency, covering both energy and non-energy related applications. The Section is comprised of three Units as shown in the organizational chart. All material in this document has been prepared by the Unit Heads. Progress reports for all projects within the Atomic and Nuclear Data Sub-programme 1.4.1 are combined, along with other related support activities during 2014–2015. The focus of this report involves the nuclear data aspects of the Sub-programme, constituting about 80% of both staff efforts and the budget of the Section.

The International Nuclear Data Committee (INDC) along with the Atomic and Molecular Data for Fusion Subcommittee of the International Fusion Research Council (IFRC) are two standing committees that advise the Department of Nuclear Sciences and Applications at the individual Section and Unit levels. Both of these bodies provide extremely useful services to the IAEA with respect to their advice and guidance.

The main text of the report is complemented by Appendices that provide additional information on the work of the Section. Appendix I is a list of meetings and workshops organized and sponsored by the Section, Appendix II is a list of other IAEA contributed meetings, Appendix III summarizes all of the various scientific papers and publications, while Appendix IV presents all NDS Publications during 2014–2015.

Nuclear Data Section

Organization Chart

(April 2016)

Section Office (and INDC Secretariat)

Section Head: A.J. Koning
Nuclear Data Physicist
(21709/21710)

Deputy Section Head: R. Capote Noy
Nuclear Data Physicist
(21713/21711)

Section Secretary: R. Rangel Alvarez
(21710)

| Nuclear Data Services Unit | Nuclear Data Development Unit | Atomic & Molecular Data Unit |
|---|---|--|
| <u>Vacant</u> Unit Head (21717) | <u>R. Capote Noy</u> Unit Head (21713) | <u>B.J. Braams</u> Unit Head (21731) |
| <u>V. Zerkin</u> Software Engineer (21714) | <u>A. Trkov</u> Nuclear Physicist (21712) | <u>A. Vasaros</u> (IT Systems Analyst) (21724) |
| <u>N. Otsuka</u> Nuclear Data Physicist (21715) | <u>P. Dimitriou.</u> Nuclear Physicist (21708) | <u>H.-K. Chung</u> Atomic Physicist (21729) |
| <u>V. Semkova</u> Nuclear Physicist (21727) | <u>K. Nathani</u> Team Assistant (21711) | <u>M. Verpelli</u> Nuclear Data Analysts/Programmer (21723) |
| <u>L. Vrapcenjak</u> Nuclear Data Services Assistant (21725) | | |
| <u>A. Oechs</u> Team Assistant (21716) | | |
| | | <u>M. O'Connell</u> (25%) Applications Programmer (21722) |

1. NUCLEAR DATA SECTION: OVERVIEW

Both the budget and staffing level of the Nuclear Data Section (NDS) have been stable, albeit with a continuous zero real growth budget that should allow a small annual increase to accommodate inflation, but in the case of the Section this has been cancelled out by small cuts. The authorized staff level of the Nuclear Data Section (NDS) for 2014–2015 was effectively a total of 16.25, consisting of 12 professionals (P-staff) and 4.25 support staff (G-staff). One assistant (G4) position was eliminated in AMDU in 2014.

The Unit Heads have been:

- Bastiaan Braams, Atomic and Molecular Data Unit (AMDU);
- Stanislav Simakov, Nuclear Data Services Unit (NDSU, retired in February 2016);
- Roberto Capote Noy, Nuclear Data Development Unit (NDDU);

All of whom have contributed to this report.

There have been some other changes in the staff during the reporting period:

- Lidija Vrapcenjak returned from maternity leave (12 June 2014 - 14 September 2015) as Nuclear Data Services Assistant;
- Kira Nathani started a Career Development Training (CDR) (from October 2013 to July 2014) at the Marine Laboratory in Monaco (RML/NAEL), following by a temporary reassignment to NDS/NDSU as Nuclear Data Service Assistant replacing Lidija Vrapcenjak until her return from maternity leave (August 2014-August 2015). Finally, Kira Nathani returned to her original position to NDS/NDDU as Team Assistant in September 2015;
- Ann Jensby took a temporary assignment in the NDS/NDDU as Team Assistant (December 2013-March 2015);
- Malgorzata Rydeng took a temporary assignment in the NDS/NDDU as Team Assistant (1 April 2015-31 August 2015);
- Andrej Trkov started as P-staff in the NDS/NDDU on 1 January 2014 until present.
- Arjan Koning started as Section Head in July 2015 to replace Robin Forrest, who retired.

The budget and costs of NDS are outlined in Table 1 in Euro. Data for 2013 are taken from PROBIS, after that the data are taken from AIPS, but note that the total is taken from Programme and Budget 2016-2017.

Table 1. Staff and budget - summary for 2013–2017 (derived from PROBIS/AIPS).

| | 2013 | 2014 | 2015 | 2016 | 2017 |
|--------------------------------------|------------------|------------------|------------------|-------------------|-------------------|
| Authorized Staff Level | 17.25 | 16.25 | 16.25 | 16.25 | 16.25† |
| Actual Staff Level | 15.14 | 16.00 | 16.25 | 15.25 | 16.25† |
| Salary + Agency O/H Support Costs(€) | 2 217 936 | 1 921 671 | 1 990 951 | 1 990 035† | 1 990 035† |
| Technical Programme(€) | 630 654 | 673 637 | 703 062 | 736 343† | 736 343† |
| Total (€) | 2 848 590 | 2 685 712 | 2 694 013 | 2 726 378† | 2 726 378† |

† estimated figures from AIPS

2. NUCLEAR DATA COMPILATIONS

2.1. EXFOR compilation, dictionaries and bibliography

EXFOR compilation work

The EXFOR master file is produced by NDS on a regular basis for use with retrieval software through web interfaces, as well as for stand-alone programs distributed with CD-ROMs. Typically, updates of the EXFOR master file are carried out once a month and include all compilations (TRANS files) produced during the period under consideration. The ability to use a unique file for common applications facilitates the updating of the database, which needs to be done on a single file only.

Since the last reporting period, NDS staff have produced and distributed six regular transmissions of the EXFOR/CINDA dictionaries (TRANS 9107-9112) in the EXFOR, backup and archive formats. A Dictionary database (in MS-Access) was created and regularly distributed as part of the EXFOR-Editor software.

During 2013(Sept.) – 2016 (Feb.) , NDS staff distributed: (i) 15 charged-particle TRANS files (D090–D102, S017–S018) containing 236 new entries and 113 revised entries; (ii) 14 neutron TRANS files (3161–3172 and V032–V033) containing 104 new and 142 revised entries; (iii) 4 photonuclear TRANS files (G028–G034) containing 42 new and 17 revised entries. 141 new entries were compiled at NDS, 37 at UkrNDC, 42 at ATOMKI, 111 by NDPCI, 30 at CNDC, and 21 at the Korea Atomic Energy Research Institute (KAERI). M. Odsuren (National Univ. of Mongolia) and N. Kenzhebayev (Kazakh National Univ.) contribute to EXFOR by compilation of heavy-ion induced reaction data measured in West European countries and data measured in Kazakhstan.

123 TRANS files were received, checked (with feedback to the originating centres) and processed in 2013 (03 Sept) - 2016 (Feb), 107 of which were final versions that were added to the master file. All TRANS files were double-checked before being added to the EXFOR master file. These final transmissions contained 956 neutron entries (134 new, 822 revised), 832 CPND entries (400 new, 432 revised) and 195 photonuclear entries (83 new, 112 revised).

EXFOR response to actual data development projects

In order to respond to the needs of the various Coordinated Research Projects, Technical and Consultants' Meetings held by NDS, the literature was thematically scanned to indicate data still missing in EXFOR. Several working documents (Memos), which summarise the lists of such data, were prepared. Lists of articles identified by NDS for additional EXFOR compilation were distributed to the data centres for their compilation.

- **Time-of-flight point-wise data in resonance region.** Following the Consultant Meeting on “EXFOR Data in Resonance Region and Spectrometer Response Function” (October 2013), NDS has made special effort to collect time-of-flight point-wise data (cross sections, transmissions, reaction yields) for future resonance analysis in collaboration with other data centres. E. Dupont (CEA Saclay) was appointed as the reference person for the data dissemination of the n_TOF project, and he started providing various capture and fission point-wise cross sections for EXFOR compilation. These n_TOF data sets are regularly compiled by NDS and NEA DB. Also K.H. Guber (ORNL) provided total and capture cross sections as well as transmissions for various target nuclides measured at ORELA to NNDC, and their EXFOR compilation is in progress at NNDC.

- **Thermal neutron constants.** NDS prepared a list of articles cited by S. Mughabghab for his evaluation of thermal cross sections published in Atlas of Neutron Resonances (2006). NDS checked their existence in EXFOR for all relevant articles published in NDS's service area (e.g., Asia, East Europe, South America), and found 65 articles for addition to EXFOR. NNDC, NEA DB and CJD are requested to perform similar checking for articles published in their areas. NDS is also checking articles cited in E.J. Axton's report (1986) for evaluation of thermal constants, which is also used as an input to the IAEA neutron standard evaluation.
- **Reactor dosimetry cross section.** NDS scanned articles published in the Reactor Dosimetry Symposia in the relation with the CRP on "Testing and Improving the International Reactor Dosimetry and Fusion File (IRDFF)", and found 14 articles for addition to EXFOR. During this assessment, we received a valuable set of unpublished high-energy neutron (20 to 32 MeV) activation cross sections for dosimetry application from Y. Uno (JAEA) with the measured neutron source spectra of the irradiation field.
- **Fission neutrons for safeguards application.** As a part of collaboration with the Department of Safeguards, NDS prepared a list of articles cited by N.E. Holden et al. (1984, 1985) for evaluation of prompt fission neutron multiplicity distribution and average prompt fission neutron multiplicity, and found 27 articles for additional EXFOR compilation.

EXFOR content quality assurances

NDS has started to systematically control the quality of data already stored in EXFOR to exclude erroneously or wrongly compiled data and duplications. A dedicated NRDC web page "Feedback" (<https://www-nds.iaea.org/nrdc/error/>) is now regularly updated by NDS. It collects noted mistakes from EXFOR users and compilers, which are categorised as very urgent, urgent (data, coding) and normal (bibliography etc.).

During the last two years the following specific efforts were implemented:

- **Thick target radioisotope yields.** Thick target radioisotope yields are useful to validate energy dependent isotope production cross sections, but they have not been compiled in EXFOR in a systematic manner because of absence of unified nomenclatures among the experimentalists. In order to improve the situation, NDS published a journal article to review their definitions with S. Takács (ATOMKI) in 2015. NDS plans to perform systematic corrections of the affected EXFOR entries based on the nomenclatures and definitions given in the article.
- **Neutron scattering data from Tohoku Univ.** NDS observed several problems in EXFOR entries compiling neutron scattering double differential cross sections measured at Tohoku Univ. Dynamitron. M. Ibaraki (formerly Tohoku Univ.) provided NDS 52 quasi-EXFOR entries prepared at Tohoku Univ. for submission to NEA DB. NDS compared the quasi-EXFOR entries against the corresponding EXFOR entries with M. Ibaraki and M. Baba (Tohoku Univ.), and summarized various actions to NEA DB for update of relevant EXFOR entries.

Bibliographic resources for EXFOR

The process of EXFOR compilation is made more efficient by the use of a stand-alone local database (EXFOR coverage control system). Under this system, NDS staff members scan about 90 journal titles (mainly through the Internet) for the purpose of EXFOR compilation coverage and control. All articles missing in EXFOR were dispatched to the responsible centres for compilation. The list of new articles as generated by the EXFOR coverage control

system is used to monitor the compilation process. The new article list is updated on a weekly basis. The EXFOR coverage control system, which was introduced in 2006, has proved to be of immense value in reducing compilation time.

A collection of EXFOR-relevant papers in PDF-format has been initiated for internal use and presently includes about 39,275 articles which were either found on the Internet or that have been scanned from hardcopies.

Addition of English translation information has been continued for EXFOR entries which compile data from Russian articles. Since the last reporting period, NDS newly checked availability of English translation for EXFOR related articles published in “Pis'ma v Zhurnal Fizika Elementarnykh Chastits I Atomnogo Yadra” (Physics of Particles and Nuclei Letters) and its predecessor “Kratkie Soobscheniya OIYaI” (JINR Rapid Communication). Addition of the English translation bibliographies to the relevant EXFOR entries are in progress.

The compilation of experimental cross section data in EXFOR results in the addition of about 500 new entries per year over the last decade. Such systematic NRDC work under the auspices of NDS has resulted in a milestone number of eEntries in 2015: there are now more than 22,000 compiled experiments in EXFOR.

The monthly analysis of the access statistics to the NDS web site showed that the EXFOR and NRDC requests systematically occupy the highest positions, thus indicating that the EXFOR related nuclear data services from NDS are one of the most needed and used by Member States.

2.2. Meetings dedicated to compilation of data in EXFOR

A Workshop on The Experimental Nuclear Reaction Data Database (EXFOR) was held at IAEA Headquarters, Vienna, Austria from 6 to 10 October 2014. Eleven participants from different Nuclear Reaction Data Centres and four staff from the IAEA attended the Workshop. The Workshop was organized to discuss various aspects of the EXFOR compilation process including compilation rules, different techniques for nuclear reaction data measurements, software developments, etc. At the beginning the conclusions and the recommendations of the Report NEA/DB/DOC(2014)3 “Statistical verification and validation of the EXFOR database: (n,n'), (n,2n), (n,p), (n, α) and other neutron-induced threshold reaction cross sections” were discussed. Presentations of charged-particle induced reaction cross sections, thick target yields, nuclear astrophysics data, TOF spectra in the resolved resonance region, beta-delayed neutron emission data and photonuclear data measurements provided information on the experimental technique in order to improve the quality of the EXFOR compilations. The need to compile the neutron Kerma factors, status of Kerma factors in EXFOR data library and a list of articles for compilation were discussed during the Workshop. The importance of defining the format (rules) for the compilation of neutron source spectra in EXFOR was emphasized and different proposals were discussed. Software developments related to EXFOR compilation, both stand-alone and online, were presented. In addition to discussions, several compilation and digitization exercises were carried out. The Workshop was concluded with a list of recommendations. The Summary of Workshop was distributed as the report INDC(NDS)-0672.

A Consultants' Meeting on EXFOR Compilation of Thermal Neutron Scattering Data was organized by IAEA Nuclear Data Section was organized at IAEA Headquarters, Vienna, Austria from 2 to 4 November 2015 to discuss the key characteristic of the thermal neutron scattering measurement and evaluation techniques to provide guidelines for compilation of such data in the EXFOR data library. In thermal neutron scattering not only the isotopes that compose the sample, but also the compounds, the structure and other physical properties have

to be considered, and this was discussed during the meeting, along with several measurement techniques and evaluation methods. It was pointed out that, in addition to the differential and total cross sections compiled in EXFOR, a collection of derived or complementary data, such as phonon spectra; structural parameters; thermal neutron scattering kernels etc., in a dedicated section of EXFOR or in a separate repository will provide information that will facilitate further developments in thermal neutron scattering studies and applications. The Summary of Meeting was distributed as the report INDC(NDS)-0697.

2.3. CINDA

The CINDA database was extended by information automatically imported from EXFOR and from NSR databases (four updates). All information, complete Master files and TRANS files in CINDA exchange format are available for NRDC members on the NDS web site. Full CINDA MySQL database was regularly produced and sent to NNDC (USA) and Mirror sites in BARC (India) and CNDC (China), where it is used in the Web retrieval system.

3. NUCLEAR DATA SERVICES

3.1. Web-based services and software

The NDS front page (<http://www-nds.iaea.org/>) has been continuously updated, extended and developed. Several new features and improvements have been introduced in the EXFOR/CINDA/ENDF retrieval systems: new functions, advanced plotting and new output formats.

Nuclear reaction database retrieval services

Various new evaluated data libraries, files and programs for data checking, processing and graphical presentation were added to the NDS web site and also distributed on CD-ROMs. A list of the most important extensions and/or updates performed includes:

- ENDF database and web retrieval interface has been extended to:
 - TENDL-2013, TENDL-2014: TALYS-based Evaluated Nuclear Data Library
 - JEFF-3.2: Joint Evaluated Fission and Fusion File, coordinated by NEA Data Bank, 2014
 - JENDL-4.0u2: /20160106/ of Japanese evaluated nuclear data library
 - JENDL-4.0/HE: JENDL-4.0 High Energy File 2015 (neutron, proton with energy up to 200 MeV)
 - JENDL-3.2 Japanese evaluated nuclear data library, 1994
 - EPICS-2014: Electron and Photon Interaction Cross Sections, 2014
 - FENDL-3.0 Fusion Evaluated Nuclear Data Library, 2015
 - ENDF/B-V.2: General Purpose File and Standards (converted to ENDF-6 format), USA, 1994
 - IRDFF v-1.03 and v-1.05: International Reactor Dosimetry and Fusion File, IAEA-2015
 - on-line conversion ENDF data to GND format (using LLNL package Fudge)
 - plotting MF35 & MF5: energy distributions of secondary particles with uncertainties and covariances

- New features of EXFOR Web retrieval system:
 - Public display original publication of the IAEA INDC Reports (in PDF format)
 - Calculation of cross sections for inverse reactions using detailed balance theory
 - Text search in extended EXFOR
 - Database of expert's corrections to EXFOR data on Web
 - Universal plotting with arbitrary selection and grouping columns
 - Search by author name using aliases
 - Access to all EXFOR archival data (for NRDC compilers only)
- Apart from regular extension of joined NDS-NNDC PDF collection of original EXFOR and NSR papers, it was extended to include papers from three new organizations from Canada, Russia (PNPI), France (IN2P3); corresponding relational PDF database was regularly updated – it is available via EXFOR, CINDA and NSR Web interface for NRDC and NSDD members
- Web interface to IBANDL and SigmaCalc data was extended by on-line calculations of the data for inverse kinematics
- EXFOR-CINDA dictionaries database has been prepared and regularly updated
- Full EXFOR in XC4 computational format was regularly produced and delivered to WPEC Subgroup 30
- Web pages for support management of EXFOR compilation activity were regularly updated and further developed to search for works of a given author in the EXFOR database

Server applications: Web tools for nuclear data developers

The main tasks of these tools are: checking format of users' data, run utilities (usually Fortran programs) on Web server, compare users' data with data in central databases:

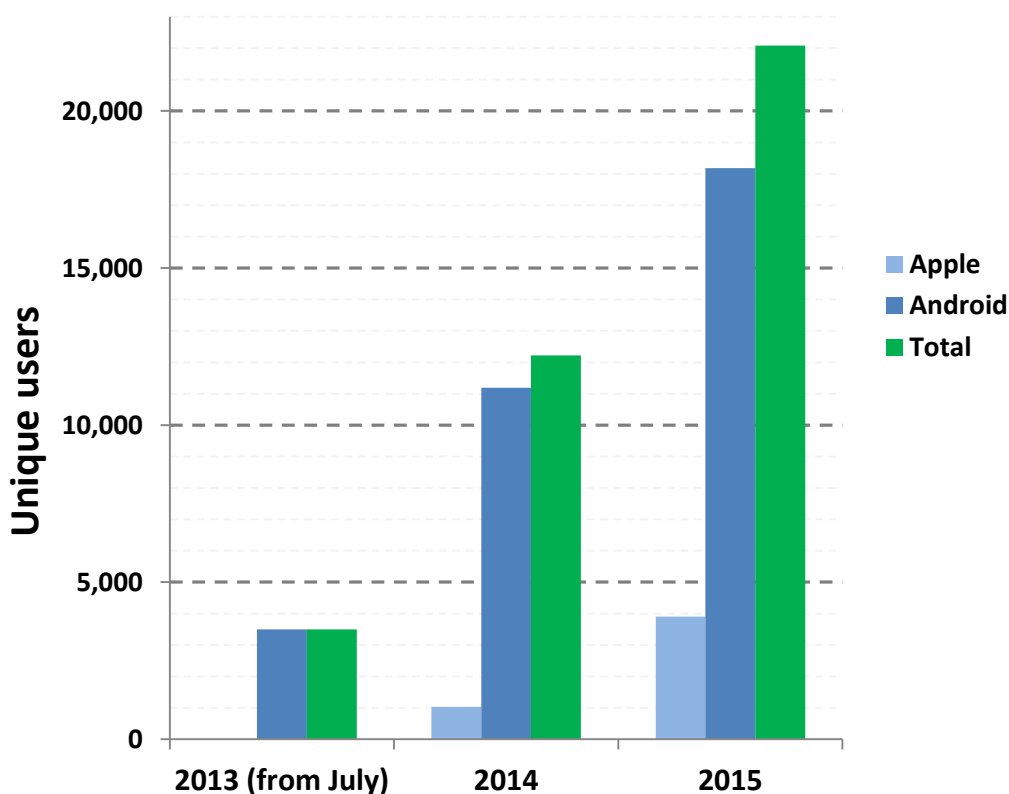
- Web tools for EXFOR was extended by possibility to upload raw data to the Web system to build EXFOR file and use Web plotting system, construct covariance matrix, calculate inverse reaction cross sections, etc.
- EXFOR interactive-tree view was extended to have editing capabilities
- MyEnsdf - Web tools for ENSDF evaluators was extended by:
 - NDSPUB (BNL) package for publishing ENSDF files with remote administrating tool
 - RULER, GABS, XPQCHK, ALPHAD, chk_ENSDF, BrIcc, BrIccMixing (codes from several organizations-members of NSDD network)
 - view of user's ENSDF files with interpreting information and as interactive tree
- Web tools for ENDF evaluators was extended by PREPRO-2015 pre-processing code and GRUCON - evaluated nuclear data processing package (KI, Russia)

Relational Database and Applications for Structure and Decay Data

- The relational database has been updated twice per year, when new releases of ENSDF master files were made available on NNDS ftp site.

- The Livechart application for mobile devices was extended and made available also on Apple iOS systems
- The database design was extended to include other libraries like XUNDL, the evaluations from the CRPs on Actinides decay, Medical Radioisotope Production, and International Reactor Dosimetry File. The increasing interest shown by the evaluators' community resulted in significant feedback on functionalities and data-processing algorithms, which has led to various updates of the platform.
- The extension of the relational database allows the merging and comparison of different data libraries, which led to the release of a new version of the RIPL discrete level segment, and to the on-going preparation of a Decay Data Portal.
- The Isotope Browser mobile application was extended in terms of data and functionalities following user feedback and requests, several releases being deployed each year. The interest shown led to the development of a version for Apple iOS devices which was made public in December 2014.

The figure below shows the total number of unique users who have ever installed the app on one or more of their devices.



An application for Android mobile devices, containing a reduced version of the relational database and a query interface, was also made available on Google and Amazon app-distribution platforms.

3.2. CD-ROM based services and publications management

CD-ROM and Document Services

For the reporting period of 2014-2015 in total 2090 PC media (CD-ROMs and DVDs) were delivered as well as 211 hardcopy documents (INDC reports, Charts of Nuclides, Nuclear Wallet Cards, etc.). In 2014, a new webpage with data libraries available for download has been introduced: <https://www-nds.iaea.org/cdroms/>, allowing our “customers” to download needed libraries and have them available for their use lot immediately. CD-ROMs can still be requested.

The publications webpage (<https://www-nds.iaea.org/publications/>), which is regularly updated with new documents, continues to be one of our most visited pages and currently about 3,713 documents can be downloaded. The availability of documents on-line has also reduced the need for hardcopies to be sent to experts.

Improvements were made to ease the access to the technical documents available, which are now divided into groups – TECDOC series, Conference Proceedings, Technical Report Series (TRS) and Scientific and Technical Information (STI/PUB) Series.

In 2014-2015 there were four Newsletter issues. The issues in 2014 covered the celebration of 50th Anniversary of NDS. All of the Newsletters have been very well received and for many scientists they prove to be a good way to stay informed about developments in the nuclear data field.

As a part of our service, hardcopies of our documents are still provided but in the light of greening the IAEA as well as the overall savings policy, upon request only.

Publication management

The project of cataloguing all the items in the NDS library which was started in May 2013 in cooperation with staff from the main IAEA library is in the final stage, and at the moment we have 2614 documents listed. NDS remains the primary custodian for all the documents, which will physically remain in the NDS library. This project also includes the cataloguing of all the Conference proceedings that NDS has available in hardcopy (330 books dating from 1957-present day).

CD-ROM Services

During reporting period, the policy in CD-ROM services was changed: instead of periodic issuing and massive production of CD/DVD-ROMs, the content of products was updated asynchronously and CD/DVD-ROMs were produced at NDS only upon user's request. Moreover, since 2014 CD products (data, programs and systems) were made available via NDS Web-site; a special system was developed to restrict his option only for human access, not allowing it for web-robots.. Currently, 17 CD-products are available on Web.

CD-DVD updates in 2014-2015:

- “EXFOR-CINDA Database and Retrieval System for Windows”: four updates;
- “EXFOR-CINDA for Applications with Endver/GUI” for Linux/Windows/Mac: two updates
- “Collection of ENDF libraries”: three updates
- “Portable Empire-3.2.2 for Windows”: one update
- “IBANDL on CD”: two updates

3.3. Statistics

Full statistics of usage of the web retrieval system are presented in Fig. 1 and Table 2.

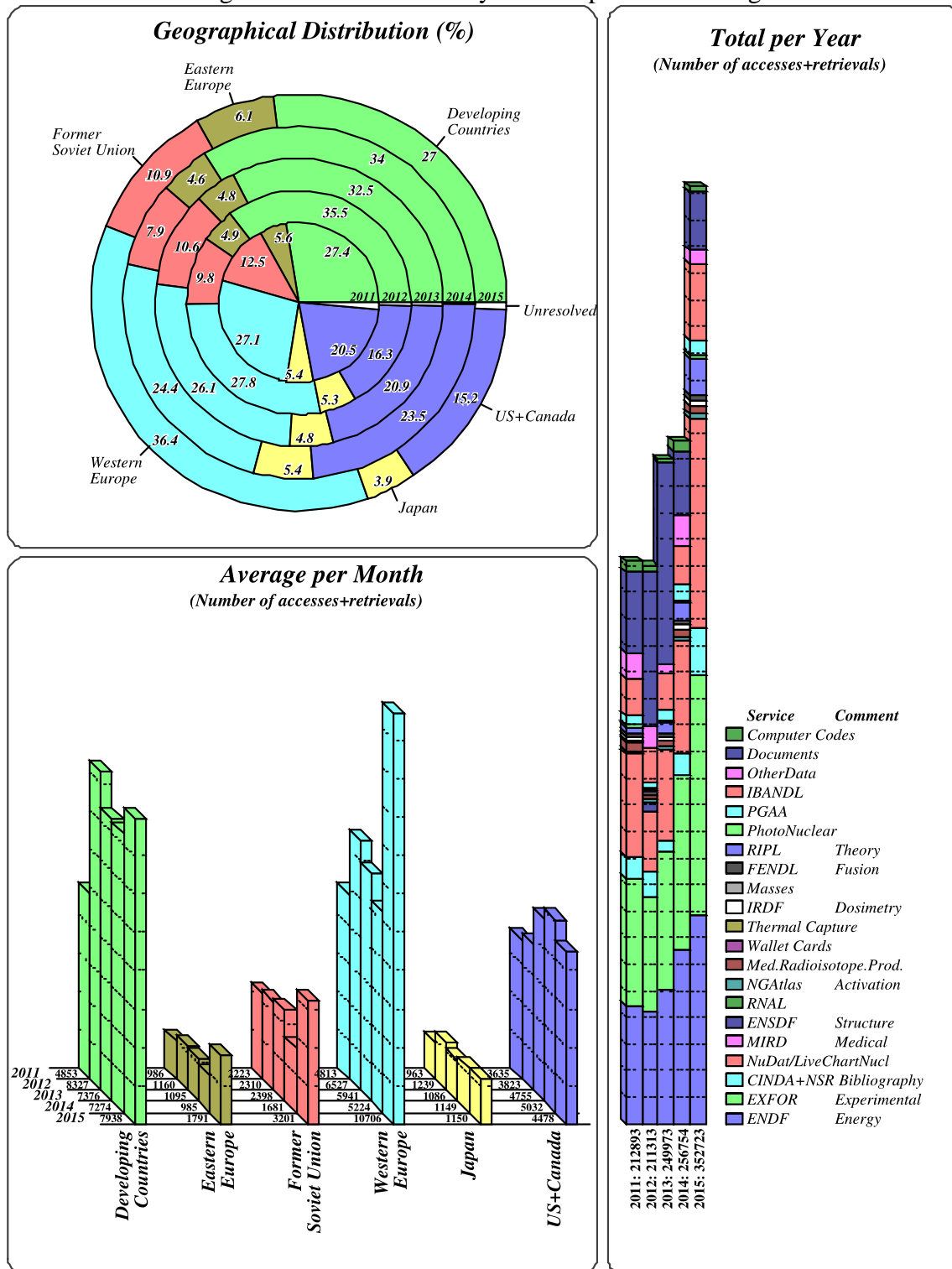


Fig. 1. Nuclear data access and retrievals from IAEA-NDS, 2011–2015.

This figure and table present the external user access to the IAEA NDS web servers (without Mirror-sites), including distribution over geographical area and technical topics. The total number of data and documents retrievals is showing an increasing trend in general. In some

specific cases, there are some decreases observed due to various reasons (e.g., a drop during 2012 as a result of unavailability of NDS web services caused by the security shutdown). It can be seen that the increased demand arises mainly from customers for ENDF, EXFOR and LiveChart databases and services.

Table 2. Statistics of internet access to the main databases and documents for the period 2011-2015.

| Database | 2011 | 2012 | 2013 | 2014 | 2015 |
|-----------------|----------------|----------------|----------------|----------------|----------------|
| ENDF | 44 279 | 43 0826 | 52 100 | 65 598 | 79 458 |
| EXFOR | 47 878 | 41 031 | 52 077 | 65 110 | 90 847 |
| LiveChart | 38 711 | 22 567 | 31 247 | 43 219 | 79 888 |
| Documents | 30 300 | 57 443 | 77 075 | 24 970 | 22 479 |
| Others | 51 725 | 46 446 | 37 474 | 57 857 | 80 051 |
| Total | 212 893 | 211 313 | 249 973 | 256 754 | 352 723 |

Statistics of users downloaded CD/DVD-ROMs from www-nds via web-cdrom-page in 2015:

| | 2015 |
|--------------------------|-------------|
| EPICS2014.zip | 47 |
| Empire322zv2win.zip | 38 |
| x4cdrom-2013-10-04.zip | 28 |
| x4app-2014-02-04.tar.gz | 28 |
| IBANDL-CD-2014-03-13.zip | 19 |
| INDL_TSL_2005.zip | 9 |
| NGATLAS.zip | 9 |
| WIMSD.zip | 9 |

4. NETWORK COORDINATION

4.1. International network of Nuclear Reaction Data Centres (NRDC)

NDS coordinates the international network of Nuclear Reaction Data Centres by organising its annual meetings. This network consists of 13 nuclear data centres including the four core neutron data centres. Biennial meetings of the data centre heads are designed to generate administrative recommendations on nuclear reaction data exchange and the development of shared databases and services. Technical matters associated with data exchange are also considered, and a dedicated technical meeting is held annually. Bilateral visits and consultancies are also used to identify and solve problems associated with data exchange and database development.

The annual Technical and biennial Meeting of the NRDC Data Centres Heads was held at Congress Centre of Slovak Academy of Sciences, Smolenice, Slovakia, from 6 to 9 May 2014 (see INDC(NDS)-0661). This combined meeting was attended by 22 participants and IAEA staff from 13 cooperating data centres of eight Member States and two international organizations. In total 56 working papers were presented at the meeting and the results of the discussions were summarized as 31 conclusions and 89 actions. The meeting participants agreed that NCDP (Sarov) will be responsible for compilation of charged-particle induced reaction data measured in former USSR countries (except for Ukraine) due to discontinuation

of CAJaD (Moscow). The participants also agreed that data corrected (e.g., renormalized) or derived (e.g., by integration of differential data) by other than the authors may be exceptionally compiled when they are published in peer-reviewed journals with detailed descriptions of the procedure.

The Technical Meeting of the International Network of Nuclear Reaction Data Centres was held at IAEA Headquarters in Vienna, Austria, from 21 to 23 April 2015 (see INDC(NDS)-0686). The meeting was attended by 22 participants and IAEA staff from 12 cooperating data centres of eight Member States and two international organizations. In total 34 working papers were presented at the meeting and the results of the discussions were summarized as 18 Conclusions and 87 Actions. The meeting participants agreed that compilation of integral data is desirable for simple or clean benchmarks, namely integral experiments performed under well-characterized neutron fields (e.g., ^{252}Cf (s.f.) prompt fission neutron field, but it is not necessary for complex benchmarks (e.g., benchmarks characterizing devices rather than nuclear data) because they are compiled in existing integral benchmark databases (e.g., ICSBEP, SINBAD).

Another role of NDS in the coordination of NRDC is organization of workshops to train compilers and transfer professional knowledge and technical skills. For the reporting period there were three workshops devoted to EXFOR, one of them in Vienna. Detailed information on these workshops is given in Section 7 (Technology transfer).

Bilateral visits:

- N. Otsuka (NDS) to CNDC. Discussion on compilation of Chinese experimental nuclear reaction data published in Chinese journals. 17-21 November 2014 and 19-23 October 2015.
- N. Otsuka (NDS) to ATOMKI. Discussion on improvement of EXFOR entries for thick target radioisotope yields. 23-27 February 2015.
- N. Otsuka (NDS) to JCPRG. Update of ENDF database and the Japanese NRDF/EXFOR editor. 23-27 March and 14-18 December 2015.

4.2. International network of Nuclear Structure and Decay Data Evaluators (NSDD)

The NDS is the coordinator of this network which consists of 15 Data Centres from all over the world. As such it organises the biennial meetings of the network, and assists in the dissemination of the data produced and maintained by the network (Evaluated Nuclear Structure Data File).

The 21st meeting of the NSDD network was held at the IAEA headquarters, in Vienna, from 20 to 24 April 2015 (INDC(NDS)-0687). It was attended by 36 scientists from 15 Member States involved in the compilation, evaluation and dissemination of nuclear structure and decay data. The first two days were dedicated to a combination of organisational, administrative, technical reviews and discussion papers, addressing particular topics in which progress has been made and problems that have been encountered over the previous two years. The third day was devoted to the IAEA project on updating and modernizing the ENSDF analysis codes (see DDP on Improvement of Analysis Codes for NSDD Evaluations), the need for which was discussed at the previous NSDD meeting. New codes were presented, while the status of the remaining codes was reviewed and proposals for future improvements were discussed. Specific mass chain activities, horizontal evaluations and technical issues including several proposals for ENSDF, were debated over the final two days.

Problems are still being experienced in maintaining suitable numbers of mass chain evaluators (expressed as FTE – Full Time Employment) due to the dispersion of efforts of existing evaluators. Other important issues raised at the meeting was the need for providing online track records of the entire ENSDF database that would allow for traceability and quality assurance, and for redefining the priorities of ENSDF evaluations to address specific applications-driven data needs. The latter is also compounded by the decreasing numbers of mass chain evaluators in the USA and the rest of the world. Re-organizing ENSDF in terms of nuclide evaluation as an alternative to mass-chain evaluation was an approach that the ENSDF coordinator (NNDC-BNL) needs to explore in the immediate future.

It was agreed that NDS would continue coordinating the effort on updating and modernizing the ENSDF analysis codes, as well as providing re-fresher training to the existing less-experienced evaluators (see Specialized Workshop for NSDD Evaluators). Member States should support the continued efforts of the Network to train new evaluators by providing the proper working environment in their respective institutions. Thanks to IAEA efforts, four out of the five supported evaluators have successfully completed their mass-chain evaluations under their IAEA contracts, and some of them are working on the second mass chain. In addition, two new NSDD Data Centres have joined the network, as a direct consequence of the IAEA support program: Hungary and Romania.

A Specialized Workshop for NSDD Evaluators was held in the week following the NSDD meeting, from 27 to 29 April 2015.

A new online database of Nuclear Magnetic Dipole and Electric Quadrupole Moments, based on the latest printed compilations of N.J. Stone (INDC(NDS)-0658, INDC(NDS)-0650), has been made available on the IAEA NDS web server (www-nds.iaea.org/nuclearmoments/). The database offers user-friendly retrieval options for all the latest published nuclear moments, available either in the printed compilations or in the literature, including DOI and NSR links. Future plans include adding search criteria and plotting functions.

NDS staff will continue to support and coordinate the efforts of the network, by focusing future activities on the two major issues raised at the last meetings, i.e. improving the ENSDF analysis codes and offering specialized training to less-experienced evaluators. Additional efforts will be made to create awareness of the need for preserving and extending the NSDD evaluation skills and activities beyond the existing 15 Data Centres, to the major stakeholders and other communities. The LiveChart retrieval system will also be continuously improved.

Individual Contracts:

It has been a long-standing recommendation, from the first NSDD meetings, that the NDS provides support to new evaluators in the form of contracts and by organizing ICTP and specialized IAEA training Workshops. In addition to that, the NDS has also provided support to the improvement and modernization of the ENSDF codes, as well as to making the horizontal compilation of nuclear moments available online through a user-friendly retrieval system.

In the years 2014-2015, the NDS paid 34 500 Euro for contracts with five NSDD evaluators to perform mass chain evaluations, and two contractors to provide a new ENSDF Analysis code and an online retrieval application for nuclear moments. In more detail:

Mass chain evaluations:

Abusaleem (Jordan): 6000 Euro

Dhindsa (India): 8000 Euro

Erturk (Turkey): 2500 Euro-contract ended.

Lalkovski (Bulgaria): 4000 Euro-contract successfully completed in 2015

Timar (Hungary): 2500 Euro-contract successfully completed in 2014

Three contracts were completed in 2014 and 2015 and two contracts remain active.

One Contractual Service Agreement (CSA) for the amount of 6500 Euro was awarded to Theodoros Mertzimekis (Greece) from 2014 to 2015 to update, adapt and install the Online Database of Nuclear Moments on the IAEA NDS Web server, and to continue keeping it up-to-date. The database is available on <http://www-nds.iaea.org/nuclearmoments>

One Contractual Service Agreement (CSA) for the amount of 5000 Euro was awarded to Michael Birch (Canada) to write a new Java code (JGAMUT) to produce adopted levels and gammas, from the multiple decay and reaction data sets in ENSDF. This beta-version of this code has been delivered to the NDS and is being tested by members of the NSDD network.

5. ATOMIC AND MOLECULAR DATA

The mission of the Atomic and Molecular Data Unit (AMDU) is to establish and maintain internationally recommended databases on atomic, molecular and plasma-material interaction (A+M+PMI) processes and related materials structure data for use in fusion energy research and other plasma science and technology applications. These databases and other information are accessible through the Unit's web pages at <http://www-amdis.iaea.org/>. (AMDIS stands for Atomic and Molecular Data Information System.)

The Unit maintains a numerical database (ALADDIN) and other numerical datasets, a bibliographical database (AMBDAS), a search engine (GENIE) to find and access numerical data hosted elsewhere, and a Wiki-style Knowledge Base on A+M+PMI data for fusion. Coordinated Research Projects (CRPs) are organized to encourage worldwide collaboration in the production and validation of new data. Technical Meetings and Consultants' Meetings are held to support the activities of the Unit and coordinate database activities throughout Member States. Among the recurring meetings of that kind are the coordination meetings of the International Atomic and Molecular Data Centres Network (DCN), those of the Code Centres Network (CCN) and meetings devoted to quality assessment of A+M and PMI data. In cooperation with ICTP the Unit regularly organizes a workshop addressed primarily to young researchers in an area such as plasma modelling with use of A+M+PMI data, plasma spectroscopy, plasma-material interaction, or atomic processes in plasmas. The Unit also cooperates in more advanced code and data-oriented workshops.

The AMDU is advised by the Subcommittee on Atomic and Molecular Data of the International Fusion Research Council (IFRC). Priorities for data evaluation are also assessed by the DCN. The IFRC Subcommittee on Atomic and Molecular Data and the DCN each meet biennially, in alternate years.

5.1. Numeric databases

ALADDIN is the principal numeric database maintained by the unit. The interface is split into two broad categories of data: atomic and molecular collisions, which include photon impact processes, electron impact processes and heavy particle collisions, and particle-surface interaction, which includes reflection, penetration, physical sputtering, chemical sputtering

and radiation-enhanced sublimation. Data in ALADDIN come largely from coordinated research projects, consultancies and other activities of the AMDU and are recommended data at the time of their compilation.

In 2015, an entire collection of heavy particle collision data sets compiled by Japan Atomic Energy Agency (JAEA) and Kyoto University published in the periods from 1980 to 2008 was uploaded to ALADDIN.

Several further numerical datasets that do not fit well into the ALADDIN framework are accessible through the AMDU home page. This includes a comprehensive collection of rate coefficients calculated by the FLYCHK code for processes of direct collisional ionization, excitation autoionization, radiative recombination, dielectronic recombination and radiative cooling for each atomic and ionic system up to $Z=79$ (Au).

A comprehensive collection of calculated data based on the Flexible Atomic Code (FAC) [Can. J. Phys. 86: 675-689 (2008)] is available for energy levels, radiative transition rates, collisional excitation cross sections, radiative recombination and photoionization cross sections, autoionization rates and collisional ionization cross sections for atoms and ions from $Z=2$ (He) to $Z=14$ (Si). A data set of the fine-structure levels of the ground and excited configurations, oscillator strengths and electron-impact excitation cross-sections, photoionization and electron-impact ionization cross-sections provided by Los Alamos National Laboratory (LANL) is also available for Ar, Cl and Si ions.

5.2. Bibliographic database

AMBDAS, the Atomic and Molecular Bibliographic Data System, contains about 50,000 entries going back to 1950s of articles and reports on atomic, molecular and particle-material or plasma-surface interaction data relevant to fusion energy research. The broad categories in AMBDAS are structure and spectra, atomic and molecular collisions and surface interactions. Entries are classified by process and reactants and classified as experimental or theoretical. Relevant energy values or energy ranges are also provided.

During 2014-2015 the structure and spectra part of AMBDAS was updated with bibliographical data obtained from the NIST Atomic Spectroscopy Group. The electron collisions part was updated due to compilations by DCN collaborators from KAERI and National Fusion Research Institute (NFRI, Korea).

5.3. Knowledge Base Wiki

The Unit uses Wikimedia technology to maintain a Knowledge Base on data sources, data production, data needs, applications of data and related information about atomic, molecular and plasma-material interaction data in fusion energy research and related fields. These wiki pages are among the most visited area of the AMDU website. The information on the wiki is addressed to fusion plasma researchers and atomic, molecular and materials physicists in a way that complements our traditional databases with the aim to encourage collaboration and initiate relevant new research. We had hoped that the maintenance of these pages would become a community effort, but in practice all the editing is done within the Unit and the development has been rather low key in 2014-2015. A new list of researchers and research group in A+M/PMI collision experiments and theory is being compiled.

5.4. Coordinated Research Projects (CRP)

The final report of the CRP on Light Element Atom, Molecule and Radical Behaviour in the Divertor and Edge Plasma Regions was produced in 2014 and appeared in the IOP Journal of Physics: Conference Series in January 2015. This CRP was concerned with data on processes including excitation, ionization, recombination and heavy particle collisions for ions of hydrogen, helium, lithium, beryllium, boron, carbon, nitrogen and oxygen and molecules of these atoms.

The CRP on Spectroscopic and Collisional Data for Tungsten from 1 eV to 20 keV had its 3rd and final RCM in October 2014. Tungsten is the wall material in the regions of high heat and particle flux in JET and in ITER. As an impurity in the plasma, tungsten radiates very strongly, because it does not get fully stripped of electrons. The main objective of this CRP was to provide atomic data to support transport modelling and the interpretation of spectroscopic measurements of tungsten in all regions of the plasma from the wall to the core. The final report of this CRP appeared in 2015 as a special issue “Atomic Data for Tungsten” of the *Atoms* journal (published by MDPI). As a follow-up to the CRP a consultancy meeting on Recommended Data for Atomic Processes of Tungsten Ions was held in September 2015.

The CRP on Atomic and Molecular Data for State-Resolved Modelling of Hydrogen and Helium and their Isotopes in Fusion Plasma is continuing, but did not meet in 2014–2015. It has its 3rd and final meeting in March 2016. This CRP is devoted to the development of data for collisional, photon-induced and radiative processes for species H , H^+ , H^- , He , He^+ , He^{2+} , He^- , H_2 , H_2^+ , H_3^+ , HeH^+ , He_2^+ and their isotopic variants. The principal focus is on data that are resolved with respect to the vibrational (in the case of molecules) excited state of the incoming and outgoing particles. In addition the data should be complete and consistent for hydrogen isotopes H , D and T .

The CRP on Data for Erosion and Tritium Retention in Beryllium Plasma-Facing Materials had its second meeting in August 2014. Beryllium is used on the JET tokamak and is planned to be used on ITER. Because of its toxicity the experimental database on beryllium is sparse. Key processes studied in this CRP are physical and chemical sputtering by H , He and Be , trapping and reflection of hydrogen (H , D , T) on beryllium surfaces in the plasma environment, the transport of hydrogen in beryllium and means to extract trapped tritium. In addition the CRP is concerned with data for mixed materials, especially Be -(H,D,T,He), Be - C , Be - N , Be - O and ternary and higher mixtures, and data for the principal plasma impurities as projectiles.

The CRP on Plasma-Wall Interaction with Irradiated Tungsten and Tungsten Alloys in Fusion Devices had its second RCM in September 2015. The critical issue for this CRP is tritium retention and how it is influenced by radiation damage. Pure crystalline tungsten has an extremely low affinity for tritium, but this good property is impacted the wrong way by the neutron fluency in DEMO or in a fusion reactor. Investigations into properties of irradiated fusion materials are hampered by the unavailability of an adequate neutron source and by the great difficulty of relevant first principles computations. Therefore the material properties, the resistance to sputtering and ablation, and the behaviour of trapped tritium in tungsten-based materials after neutron irradiation are still poorly known.

The new CRP on Plasma-wall Interaction with Reduced-activation Steel Surfaces in Fusion Devices had its first RCM in December 2015. This CRP has the objective to enhance the knowledge base and develop new databases on interaction of fusion plasma with reduced-

activation steel alloys that are considered for fusion. The CRP will seek to quantify the erosion due to exposure to plasma and to quantify the retention and transport properties of tritium in the surface.

5.5. Data and Code Centre Network meetings

The International Atomic and Molecular Data Centre Network (DCN) meets every two years to discuss data needs and coordinate activities. At the DCN meeting in Vienna in November 2015 activities of 8 data centres in the network were presented and in addition there were presentations from guests of 4 data projects oriented towards astrophysical and industrial plasma applications. Discussions were held and recommendations developed on current activities in data development and data exchange, data evaluation, data exchange formats, maintenance of bibliographical databases and on priorities for data development and evaluation, new meetings and information exchange. The shared goal is provision of a comprehensive curated, evaluated and recommended database for A+M+PMI processes relevant in fusion devices.

The Code Centre Network (CCN) had its fourth meeting in July 2015 at the IAEA in Vienna. The CCN has a different focal topic at different meetings and this time the meeting was concerned with uncertainty assessment of data for plasma-material interaction, including uncertainties associated with interatomic potentials, density-functional theory (DFT) simulations, molecular dynamics (MD) simulations, kinetic Monte Carlo (KMC) simulations and rate equation simulations for hydrogen retention and migration in fusion materials.

5.6. Other AMDU meetings

The Unit organized the IAEA decennial Technical Meeting on Atomic, Molecular and Plasma-Material Interaction Data for Fusion Science and Technology, hosted by NFRI in Daejeon. There were 68 participants (44 from outside Korea) including the organizers and the meeting had 36 talks and 12 posters. NFRI made all local arrangements and also supported the participation by 9 invited speakers plus air travel by one of the organizers. This is one of the fruits of the Practical Arrangements on “Cooperation in the area of the evaluation of atomic, molecular and plasma-material interaction data relevant to fusion” that were established between IAEA and NFRI in early 2013 with a duration of 3 years.

Several meetings were held on topics connected to data evaluation and uncertainty estimates. The most important of these was the “Joint IAEA-ITAMP Technical Meeting on Uncertainty Assessment for Theoretical Atomic and Molecular Scattering Data” held in July 2014 at the Institute of Theoretical Atomic, Molecular and Optical Physics (ITAMP), Harvard-Smithsonian Center for Astrophysics, in Cambridge, Massachusetts, USA. This meeting brought together a total of 26 people working on electron collisions with atoms, ions, and molecules, heavy-particle collisions, and electronic structure of atoms and molecules to discuss ways to obtain reasonable uncertainty estimates for calculations using the various methods of collision physics. There was also a consultancy meeting on “Guidelines for Uncertainty Quantification of theoretical atomic and molecular data” (June 2015), one on evaluation of data for electron collisions with Be and other light elements, and one (already mentioned) on data for processes of tungsten ions in plasma.

The Unit organized 2 events in cooperation with ICTP and held at ICTP in Trieste. The one-week Joint ICTP-IAEA Conference on Models and Data for Plasma-Material Interaction in

Fusion Devices in November 2014 brought together researchers from fusion energy science and materials science in order to review advances in computational studies of plasma-material interaction processes and evolution of material microstructure in fusion devices, including effects of radiation damage and with special interest in hydrogen (tritium) trapping and transport in wall material. The two-week Joint ICTP-IAEA Advanced School and Workshop on Modern Methods in Plasma Spectroscopy in March 2015 was designed to provide training and information exchange for plasma physicists, plasma spectroscopists, and other users of atomic data for fusion, astrophysics and laser and plasma applications. Both ICTP events were aggressively advertised by us and attracted a highly qualified mix of participants from developing and developed countries.

5.7. Other AMDU activities

The Unit cooperated in the organization of the 16th International Workshop on Radiative Properties of Hot Dense Matter (RPHDM 2014) that was held 29 September through 3 October in Vienna. Hyun Chung served on the Organizing Committee and as local contact. There were 105 scientific participants and the meeting was very successful.

The Unit cooperated in the Third Spectral Lineshapes in Plasmas (SLSP) code comparison workshop that was held in Marseille, France, 2-6 March 2015. Line shapes are used in plasma diagnostics, hence our interest. This workshop followed the model of the well-established Non-local Thermodynamic Equilibrium code comparison workshops in which we have cooperated earlier. Test cases are specified about 6 months in advance, participants prepare their calculations and at the workshop the results are compared in detail with the objective of understanding differences among codes. The Unit also cooperated in the International Workshop on Models and Data for Plasma-Material Interaction (MoD-PMI) in Marseille in May 2015; a meeting that developed out of our ICTP conference 6 months earlier.

Special issue publications: In addition to the final reports of 2 CRPs the Unit helped to produce a special issue “Spectral Line Shapes in Plasmas” in the Atoms journal (MDPI) based on the first and second SLSP code comparison workshops and a special issue “Critical Assessment of Theoretical Calculations of Atomic Structure and Transition Probabilities” also in the Atoms journal was published after the 3rd CCN meeting. A special issue of Journal of Nuclear Materials on “Models and data for plasma-material interaction” (2015) was developed based on the ICTP-IAEA event on PMI in 2014.

The Unit supported the atomic physics codes widely used by fusion and plasma community. FAC (Flexible Atomic Codes), cFAC (a modified version of FAC) and GRASP2K (an atomic structure code package) are made available through the Unit’s home page. In order to facilitate the use of FAC and cFAC data, a FLYFAC code to take cFAC data and produce ionization distributions and spectroscopic properties is under the development. The FLYFAC code will be freely available with training material. A project to make the SCFLY code, a version of FLYCHK code for plasma spectroscopy publically available is on the way.

Unit staff participated in international meetings and we highlight only 2 such events. AMDU was invited to speak about uncertainty estimates for calculated data at the Workshop on Measurement Uncertainty organized at the Bureau International des Poids et Mesures (BIPM) in Sèvres, France, in June 2015. AMDU was also invited to a workshop on “Sensitivity, Error and Uncertainty Quantification for Atomic, Plasma, and Material Data” held in Stony Brook

University, Institute for Advanced Computational Science, in USA, in order to discuss the uncertainty quantification of A+M/PMI data for fusion applications.

One noteworthy honour: atomic physicist Hyun Chung shared the 2015 John Dawson Award for Excellence in Plasma Physics Research of the American Physical Society. The citation reads: “For creative and novel use of the hard x-ray free electron laser to isochorically create high density plasmas and accurately measure the ionization potential depression, and for new theory that addresses discrepancies with long standing models and provides stimulus for continued developments.”

6. NUCLEAR DATA DEVELOPMENT

Nuclear data development activities are primarily aimed at improving the quality and quantity of nuclear data available for distribution to all Member States through the following functions:

- Coordinated Research Projects;
- Data Development Projects;
- Individual research contracts and Special Service Agreements with experts in specific fields;
- Specialised technical meetings;
- Work undertaken directly by NDS staff.

Immediate outputs of these activities include:

- Creation of new databases designed and dedicated to various energy and non-energy applications;
- New contributions or improvements to existing databases;
- Technical documents related to the database description, verification and validation;
- Systems for nuclear data evaluation;
- Software tools for data manipulation including visualisation and verification;
- User manuals where appropriate.

6.1. Coordinated Research Projects

An historical perspective of CRPs within the NDS can be seen in Fig. 2 which covers the previous 6 years of such activities (2009–2015), and the planned activities for 2016 and beyond. As can be seen from this figure sufficient CRP commitments presently exist, and two new CRPs will start in 2016.

During the course of 2014–2015 there were six Nuclear Data (ND) CRPs at different stages of development, which are summarized in Table 3, from where it can also be seen that two ND CRPs were completed since 2009. Additionally, two new CRPs were approved in 2015 for which contracts/agreements were awarded, and their first RCMs are planned in 2016. It is important to note that the Unit is also organizing Data Development Projects (DDP) featuring a complexity similar to a CRP (e.g., the Neutron Standard DDP described in the next Section).

Additionally, the outstanding Technical Reports of the CRPs “Reference database for ion beam analysis” (2005-2010) and “Reference database for neutron activation analysis” (2005-2010) were published as **IAEA TECDOC-1780** (December 2015) and **INDC(NDS)-0693** (October 2015) coordinated by P. Dimitriou and A. Trkov, respectively.

The Neutron activation analysis portal was updated (www-nds.iaea.org/naa/).

Table 3. Status of Coordinated Research Projects Dedicated to Nuclear Data

| No. | Short title | Duration | Participants (contracts) | Project Officer | Status | Section |
|-----|--|---------------------|--------------------------|---------------------|---|---------|
| 1 | Prompt fission neutron spectra of actinides | 2009–2015 F41026 | 12 (6) | Capote Noy | Completed (2015) Published: <i>Nuclear Data Sheets</i> 131 (2016) 1-106 | 6.1.1 |
| 2 | Nuclear data for charged-particle monitor reactions and medical isotope production | 2012–2017 F41029 | 14 (6) +1 CSA | Capote Noy | On-going | 6.1.2 |
| 3 | Development of a reference database for Particle Induced Gamma-ray Emission Spectroscopy (PIGE) | 2011–2015 F41028 | 12 (6) | Dimitriou (Abriola) | Completed (2015) document in preparation | 6.1.3 |
| 4 | Testing and improving the International Reactor Dosimetry and Fusion File (IRDFF) | 2013–2018 F41031 | 13 (5) | Simakov/Trkov | On-going | 6.1.4 |
| 5 | Primary radiation damage cross sections | 2013–2018 F44003 | 18 (1) | Simakov/Koning | On-going | 6.1.5 |
| 6 | Reference database for beta-delayed neutron emission | 2013–2018 F41030 | 12 (3) | Dimitriou | On-going | 6.1.6 |
| 7 | RIPL for fission cross section calculations | 2016-2021 F41033 | 10(4) | Capote Noy | Approved (07/2015) 1st RCM Summer 2016 | 6.1.7 |
| 8 | Updating the Photonuclear Data Library and generating a reference database for photon strength functions | 2016-2020 F41032 | 14(8) | Dimitriou | Approved (2015) 1st RCM April 2016 | 6.1.8 |

Fig. 2. Coordinated Research Projects - previous 6 years and the immediate future.

| CRPs - Technical reports | 2009 | 2010 | 2011 | 2012 | 2013 | (6) 2014 | (6) 2015 | (6) 2016 | (6) 2017 | (5) 2018 |
|---|-------------|-------------|-------------|-------------|-------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Technical report (Capote Noy): <i>Nuclear Data Sheets 131</i> (2016) 1-106 | | | | | | | | | | |
| Prompt fission neutron spectra of actinides | | | | | | | | | | |
| Technical report (Dimitriou) | | | | | | | | | | |
| Development of a reference database of Particle-Induced Gamma-ray Emission Spectroscopy (PIGE) | | | | | | | | | | |
| Technical report (Capote Noy) | | | | | | | | | | |
| Nuclear data for charged-particle monitor reactions and Medical isotope production | | | | | | | | | | |
| Technical report (Dimitriou) | | | | | | | | | | |
| Reference Database for beta-delayed Neutron Emission | | | | | | | | | | |
| Technical report (Simakov/Trkov) | | | | | | | | | | |
| Testing and improving the International Reactor Dosimetry and Fusion File (IRDFF) | | | | | | | | | | |
| Technical report (Simakov/Koning) | | | | | | | | | | |
| Primary radiation damage cross sections | | | | | | | | | | |
| Technical Report (Capote Noy) | | | | | | | | | | |
| RIPL for fission cross section calculations | | | | | | | | | | |
| Technical Report (Dimitriou) | | | | | | | | | | |
| Updating the photonuclear data library and generating a reference database for photon strength functions | | | | | | | | | | |

6.1.1. Prompt Fission Neutron Spectra (PFNS) for actinides

Status: completed – database assembled.

Document was prepared and published in a peer-reviewed journal at no cost to the IAEA as *Nuclear Data Sheets* **131** (2016) 1-106.

Objectives:

- To make available existing experimental information on prompt fission neutron spectra (PFNS) relevant to fission reactor applications, that can be processed and used by users worldwide.
- To incorporate available experimental information on PFNS for major actinides into evaluated nuclear data files.
- To recommend evaluations of PFNS with covariances from thermal to 20 MeV incident neutron energy.

Activity:

- Technical Report (peer-review paper) published.
- Implementation of new PFNS evaluations and/or CRP recommendations into existing libraries on-going.

Outputs:

- CM was held at the IAEA, Vienna, Austria, 24–27 November 2008 [1].
- First RCM was held at the IAEA, Vienna, Austria, 6–9 April 2010 [2].
- Second RCM was held at the IAEA, Vienna, Austria, 13–16 December 2011 [3].
- Third RCM was held at the IAEA, Vienna, Austria, 21–24 October 2013 [4].
- A technical document on PFNS evaluation techniques was published in 2015 [5].
- Technical contributions by IAEA staff and CRP participants have been presented at relevant conferences and published in peer-reviewed literature.
- CRP final technical report published in a peer-review journal [6].
- Documentation of previous Russian experiments translated [7-9].
- A CRP webpage containing new evaluations is available www-nds.iaea.org/pfns

References:

- [1] R. Capote Noy, V. Maslov, E. Bauge, T. Ohsawa, A. Vorobyev, M.B. Chadwick and S. Oberstedt, Summary Report of Consultants' Meeting on Prompt Fission Neutron Spectra of Major Actinides, IAEA Vienna, Austria, 24–27 November 2008, **INDC(NDS)-0541**, January 2009.
- [2] R. Capote Noy, Summary Report of the First Research Coordination Meeting on Prompt Fission Neutron Spectra of Major Actinides, IAEA Vienna, Austria, 6-9 April 2010, **INDC(NDS)-0571**, December 2010.
- [3] R. Capote Noy and Patrick Talou, Summary Report of the 2nd Research Coordination Meeting on Prompt Fission Neutron Spectra of Major Actinides, IAEA Vienna, Austria, 13–16 December 2011, **INDC(NDS)-0608**, 2013.
- [4] R. Capote Noy, Summary Report of the 3rd Research Coordination Meeting on Prompt Fission Neutron Spectra of Major Actinides, IAEA Vienna, Austria, 21–24 October 2013, **INDC(NDS)-0655**, December 2014.
- [5] D.L. Smith, D. Neudecker, R. Capote Noy, "Prompt Fission Neutron Spectrum Evaluation Techniques", **INDC(NDS)-0678**, February 2015.
- [6] R. Capote et al, "Prompt Fission Neutron Spectra of Actinides", *Nuclear Data Sheets* **131** (2016) 1-106 (approved on October 2015, published in January 2016).

- [7] A.A. Boytsov, A.F. Semenov, B.I. Starostov, **INDC(CCP)-0459** (July 2014).
 [8] B.I. Starostov, V.N. Nefedov, A.A. Boytsov, **INDC(CCP)-0458** (July 2014).
 [9] V.N. Nefedov, B.I. Starostov, A.A. Boytsov, **INDC(CCP)-0457** (July 2014).

6.1.2. Nuclear data for charged-particle monitor reactions and medical isotope production

Status: On-going

Objectives:

- Update of existing beam monitor data, including uncertainties and extension of energy range where appropriate. Inclusion of additional monitor reactions.
- Undertake evaluations of reaction data for emerging diagnostic and therapeutic radionuclides as identified in the report **INDC(NDS)-0591**.
- Identification and correction of deficiencies in existing recommended data.
- Re-evaluation of decay data as identified in the report **INDC(NDS)-0591**.
- Measurement of new decay and cross section data as identified in the report **INDC(NDS)-0591**.
- Deduce from the microscopic cross sections the integral yield data as a function of incident energy, and compare with experimental thick target yields available in the literature.

For all radionuclides:

- Carry out new measurements when required.
- Prepare missing entries of experimental data for inclusion in the EXFOR database.
- Assemble the new evaluated data library in ENDF-6 format.

Activities:

- A related CM was held at the IAEA Vienna, 3–5 September 2008, **INDC(NDS)-0535**.
- A planning CM was held at the IAEA Vienna, 21–24 June 2011 [1]
- First RCM was held at the IAEA Vienna, Austria, 3–7 December 2012 [2].
- A related CM was held at the IAEA Vienna, 9-10 May 2013 in cooperation with the AMDU [3].
- The 2nd RCM was held in Vienna, Austria on 8–12 December 2014 [4].
- The 3rd RCM is scheduled to be held in Vienna, Austria on 30 May – 3 June 2016.

Evaluations of charged-particle induced reactions and associated decay data are on-going [1,2,4]. Measurements of new decay and cross section data and accurate integral yields for validation purposes are also under way [2,4].

The CRP is going very well and is close to conclusion. More than 100 reaction paths are being evaluated; uncertainty estimates are being included for all beam-monitor reactions (equivalent to charged-particle reaction standards). An extension of the CRP for one year (till 2017) was requested and granted considering the amount and quality of work undertaken.

References:

- [1] R. Capote Noy and F.M. Nortier, Summary Report of the Consultants' Meeting on Improvements in Charged-Particle Monitor Reactions and Nuclear Data for Medical Isotope Production, IAEA Vienna, Austria, 21–24 June 2011, **INDC(NDS)-0591**, September 2010.
- [2] A.L. Nichols, R. Capote Noy, Summary Report of the 1st Research Coordination Meeting on Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production, IAEA Vienna, Austria, 3–7 Dec. 2012, **INDC(NDS)-0630**, February 2013.
- [3] R. Capote Noy, H. Kyung Chung, K. Bartschat, Chenzhong Dong, P. Jonsson, T. Kibèdi, F.G. Kondev, H. Nikjoo, A. Pálffy, and F.M. Nortier, Summary Report of the Consultants' Meeting on Auger Electron Emission Data Needs for Medical Applications, IAEA Vienna, Austria, 9-10 May 2013, **INDC(NDS)-0638**, November 2013.
- [4] A.L. Nichols, F.M. Nortier, R. Capote Noy, Summary Report of the 2nd Research Coordination Meeting on Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production, IAEA Vienna, Austria, 8–12 Dec. 2014, **INDC(NDS)-0675**, April 2015.

6.1.3. Development of a reference database for Particle-Induced Gamma-ray Emission spectroscopy (PIGE)

Status: Completed, technical document in preparation

Overall objective:

To create a data library for Ion Beam Analysis that contains reliable and usable data on charged particle γ -ray emission cross sections that will be made freely available to the user community.

Specific research objectives:

- Identify the most important nuclear reactions for PIGE.
- Search the literature and electronic databases and convert relevant nuclear reaction data to a format suitable for use in PIGE simulation programs.
- Compare data from different sources and carry out measurements when there are no data available or unresolved discrepancies exist.
- Incorporate all measured data into the database, and make them available to the IBA community.

Activities:

- CM was held at the IAEA Vienna, Austria, 1–2 March 2010 [1].
- First RCM was held at the IAEA Vienna, Austria, 16–20 May 2011 [2].
- 2nd RCM was held at the IAEA, Vienna, Austria, 8–12 October 2012 [3].
- 3rd RCM was held at the IAEA, Vienna, Austria, 7–11 April 2014 [4].
- CM was held at the IAEA Vienna, Austria, 16-18 December 2015 to coordinate writing of the CRP technical report.

Outputs:

- New data files for uploading onto IBANDL (over 300 new PIGE data sets were uploaded in IBANDL by 2015)
- New evaluations of $^{27}\text{Al}(p,p'\gamma)$, $^{23}\text{Na}(p,p'\gamma)$, $^{52}\text{Cr}(p,\gamma)$ performed by CRP Consultants (**INDC(NDS)-0666**)
- Results of the CRP presented at International Symposium IBA 2015, 15-19 June 2015, Opatija [5]
- A joint article on the results of the Inter-laboratory exercise carried out within the CRP has been submitted for publication in Nuclear Instruments and Methods B
- Final Technical Document (in preparation)

References:

- [1] D. Abriola and A. Pedro de Jesus, Summary Report of Consultants' Meeting on Assessment of Nuclear Data Needs for Particle Induced Gamma Ray Emission (PIGE), IAEA Vienna, Austria, 1–2 March 2010, **INDC(NDS)-0568**, March 2010.
- [2] D. Abriola and A. Pedro de Jesus, Summary Report of the 1st Research Coordination Meeting Development of a Reference Database for Particle-Induced Gamma ray Emission (PIGE) Spectroscopy, IAEA Vienna, Austria, 16–20 May 2011, **INDC(NDS)-0589**, July 2011.
- [3] D. Abriola, P. Dimitriou and A. Pedro de Jesus, Summary Report of the 2nd Research Coordination Meeting Development of a Reference Database for Particle-Induced Gamma ray Emission (PIGE) Spectroscopy, IAEA Vienna, Austria, 8–12 October 2012, **INDC(NDS)-0625**, March 2013.
- [4] P. Dimitriou and A. Pedro de Jesus, Summary Report of the 3rd Research Coordination Meeting Development of a Reference Database for Particle-Induced Gamma ray Emission (PIGE) Spectroscopy, IAEA Vienna, Austria, 7–11 April 2014, **INDC(NDS)-0664**, May 2014.
- [5] P. Dimitriou et al, Development of a Reference Database for Particle-Induced Gamma-ray Emission spectroscopy, Nuclear Instruments and Methods B, 317, 33-36 (2016), 10.1016/j.nimb.2015.09.052
- [6] Web site: <http://www-nds.iaea.org/pige/>.

6.1.4. Testing and improving the International Reactor Dosimetry and Fusion File (IRDFF)

Status: on-going

Objectives:

- To stimulate new and use available measurements in the mono-energetic and broad energy neutron fields for validation of the IRDFF cross sections.
- To assess newly released high-fidelity evaluations with covariances in order to improve and extend IRDFF for fission, fusion and spallation applications.
- To use selected integral existing integral data (e.g. Kayzero, Kadonis, SINBAD, ISCBEP and others) to reduce the uncertainty in the existing evaluated cross sections and improve the consistency of the library.
- To identify and correct the possible deficiencies in the released library.
- To complete the documentation on the validation of the IRDFF as a tested reference library for various nuclear applications.

Activities:

- A related CM was held at IAEA Vienna, 5–7 May, 2010 to define the scope and recommend the need for a new CRP [1].
- Some format corrections to the IRDF-2002 library were discussed [2].
- A new dosimetry library for fission and fusion applications (IDRFF v1.02) has been developed and released in June 2012 [3], including ENDF-6 formatted files and spectra, an application library, and compilation of calculated SPA cross sections in selected neutron fields (<http://www-nds.iaea.org/IRDFF>). An updated version 1.05 of IDRFF has been released in Oct 2014 (<http://www-nds.iaea.org/IRDFF>, <https://www-nds.iaea.org/IRDFFtest/>). This release included 3 new reactions $^{28}\text{Si}(n,p)^{28}\text{Al}$, $^{29}\text{Si}(n,x)^{28}\text{Al}$, $^{113}\text{In}(n,g)^{114m}\text{In}$ and an update of $^{31}\text{P}(n,p)^{31}\text{Si}$ reaction [4]. IRDFF-1.05 contains 79 dosimetry and 3 absorption (cover materials) cross sections.
- Preliminary validation of the released library in selected neutron fields was performed and documented [5].
- First RCM was held at the IAEA HQ, Vienna, Austria, 16–20 May 2011 [6].
- Several new candidate evaluations for IRDFF were carried out by K. Zolotarev (IPPE, Russia) partially supported by IAEA NDS [7,8]. Those new evaluations have to be assessed for inclusion into the next release of IRDFF.
- IRDFF Reference Decay sub Library, which now contains data for 90 dosimetry reactions products, was regularly updated and processed in ENDF-6 format by the modified code SDF2NDF. Data are available online at www-nds.iaea.org/IRDFFtest/irdffnuclideslist.htm.
- Validation of IRDFF has been performed in standard and reference neutron fields ($^{252}\text{Cf}(s.f.)$, $^{235}\text{U}(n_{th},f)$, Sigma-Sigma, CFRMF, ISNF and YAYOI) using SPA cross sections available in EXFOR, Kaysero, Kadonis, Mughabghab' Atlas, SINBAD and other databases and compilations (see Refs.[9, 10] and papers in [List of Publications](#) of CRP Participants).
- Second RCM of CRP was held at the IAEA Vienna, Austria, 16–20 March 2015 [11].
- RCM-2 has recommended initiating a new neutron spectral adjustment exercise similar to [REAL-88 \(NMF-90\)](#). A set of representative exercises were selected, the numerical inputs are being collected on the corresponding NDS web site.
- Integral tests of the IRDFF reactions have been performed at pool-type and fast pulsed reactors in Sandia, at TRIGA in Ljubljana, at CALIBAN in Valduc, at OSIRIS/ISIS and EOLE in Saclay, at fusion neutron sources in FNG/Frascati and FNS/JAEA with bare D-T and within fusion reactors mock-ups.
- Measurements are planned at new critical assemblies at the NCERC facility by LANL and with new strong $^{252}\text{Cf}(sf)$ source in Rez.
- The trial extension of IRDFF from 60 up to 100 MeV has been done for the $^{209}\text{Bi}(n,3-10n)$ reactions using already available and new data measured at high neutron energies within this CRP.

Planned Outputs:

- Improved and validated Reference Database available online.
- Technical Document.

References:

- [1] M.A. Kellett, Summary Report of the Consultants' Meeting on Improvements and Extension to IRDF (International Reactor Dosimetry File), **INDC(NDS)-0575**, IAEA, Vienna, Austria, December 2010.
- [2] A. Trkov and M.K. Kellett, "IRDF-2002.1 Corrections to the IRDF-2002 Dosimetry Cross-Section Library (Covariance Processing Verification)", **INDC(NDS)-0576**, IAEA, Vienna, Austria, October 2012.
- [3] R. Capote, K.I. Zolotarev, V.G. Pronyaev, A. Trkov, "Updating and extending the IRDF-2002 Dosimetry Library", *J. of ASTM International* **9** (2012) *JAI104119*.
- [4] K.I. Zolotarev, "Evaluation excitation functions for $^{28}\text{Si}(n,p)^{28}\text{Al}$, $^{31}\text{P}(n,p)^{31}\text{Si}$, and $^{113}\text{In}(n,\gamma)^{114\text{m}}\text{In}$ reactions", Report [INDC\(NDS\)-0668](#), IAEA, Vienna, Austria, October 2014.
- [5] E.M. Zsolnay, R. Capote Noy, H.J. Nolthenius, and A. Trkov, R. Capote, K.I. Zolotarev, V.G. Pronyaev, A. Trkov, "Summary Description of the New International Reactor Dosimetry and Fusion File (IRDFF release 1.0), **INDC(NDS)-0616**, IAEA, Vienna, Austria, May 2012.
- [6] A. Trkov, L.R. Greenwood, and S.P. Simakov, Summary Report of the 1st Research Coordination Meeting of the CRP on Testing and Improving the International Reactor Dosimetry and Fusion File (IRDFF), IAEA Vienna, Austria, 1–5 July 2013, **INDC(NDS)-639**, IAEA, Vienna, Austria, September 2013.
- [7] K.I. Zolotarev, P.K. Zolotarev, "Evaluation of Some (n,n'), (n, γ), (n,p), (n,2n) and (n,3n) Reaction Excitation Functions for Fission and Fusion Reactor Dosimetry Application", **INDC(NDS)-0657**, IAEA, Vienna, Austria, December 2013.
- [8] K.I. Zolotarev, "Evaluation of $^{23}\text{Na}(n,\gamma)^{24}\text{Na}$, $^{23}\text{Na}(n,2n)^{22}\text{Na}$, and $^{27}\text{Al}(n,2n)^{26}\text{Al}$ reaction cross sections for the IRDFF library", Report **INDC(NDS)-0705**, Vienna, February 2016.
- [9] S. Simakov, R. Capote, L. Greenwood, P. Griffin, A. Kahler, V. Pronyaev, A. Trkov and K. Zolotarev, "Validation of IRDFF in ^{252}Cf standard and IRDF-2002 reference neutron fields", Proc. of 15th Symposium on Reactor Dosimetry, 18-23 May 2014, Aix en Provence, France [EPJ Web of Conferences 106, 04011 \(2016\)](#).
- [10] I. Kodeli, "Validation of IRDFF-v1.04 (and v.1.05) Dosimetry Library using SINBAD Shielding Benchmark Experiments", Report [INDC\(SLO\)-0002](#), IAEA, February 2015.
- [11] P. Griffin, L.R. Greenwood, and S.P. Simakov, Summary Report of the 2nd Research Coordination Meeting of the CRP on Testing and Improving the International Reactor Dosimetry and Fusion File (IRDFF), IAEA Vienna, Austria, 1–5 July 2015, Report [INDC\(NDS\)-682](#), IAEA, Vienna, Austria, June 2015.
- [12] CRP web page: <https://www-nds.iaea.org/IRDFFtest/>

6.1.5. Primary radiation damage cross sections

Status: on-going

Overall Objective:

- In accordance with the recommendations of the International Nuclear Data Committee in May 2012, the Nuclear Data Section has held in 2012 a dedicated Technical Meeting [1] and then initiated in 2013 a new Coordinated Research Project with the main goal of reviewing and recommending primary damage response functions for neutron and ion irradiations of materials.

Specific Objectives:

- To revisit the *NRT* standard for the atom displacement cross section (dpa), inspect evaluated recoil spectra and other quantities impacting on the Damage Energy, dpa and KERMA.
- To step beyond the *NRT* standard, i.e. to generate an athermal recombination-corrected (*arc*) displacement and replacements-per-atom (*rpa*) cross sections employing the results of primary radiation defect modelling which captures the effect of the primary defects annealing in the recoils cascade.
- To demonstrate a performance of *arc*-dpa as correlation parameter for microstructural material damage, using proper experimental test data accumulated at reactors and accelerators.
- To inspect the status of evaluated gas production cross sections, verify them against existing experimental data, stimulate new measurements and eventually recommend the reference data.
- To develop the methods and propagate uncertainties or covariances of cross sections, ion stopping powers and defect surviving efficiencies to the uncertainties for damage energy, dpa, KERMA and gas production.

Activities:

- Technical Meeting “Primary Radiation Damage: from nuclear reaction to point defects” was held at the IAEA, Vienna, Austria, 1–4 October 2012 [1].
- First RCM was held at the IAEA, Vienna, Austria, 4–8 November 2013 [2].
- The Damage Cross Sections database DXS (which includes the *NRT*-, *arc*-dpa and gas production cross sections in the ENDF-6 format) was made available on the CRP webpage: www-nds.iaea.org/public/download-endf/DXS/.
- Last year DXS was extended by the data for the “real” structural materials: austenitic SS-316 and martensitic Eurofer steels.
- The *arc*-dpa cross sections for the ionic ceramic breeder materials (Li_2O , Li_2TiO_3 and Li_4SiO_4) with different ^6Li enrichments and at several ambient temperatures made available at: www-nds.iaea.org/CRPdpa/Li_ceramics/.
- The representative [neutron spectra](#) for the leading material test facilities (HFIR, HBR-2, BOR-60, EPRI, EBR-II, OWR, FFTF, RTNS-II, ITER, DEMO, IFMIF, ESS ...) were collected and distributed among CRP participants for the assessment of radiation damage.
- The 2nd RCM of CRP was held at the IAEA Headquarters from 29 June to 2 July 2015. For detailed information see 2nd RCM Summary Report **INDC(NDS)-0691** [3] and original participants’ publications in the following [link](#).

- CRP participants have found rather large discrepancies for atom recoils spectra present in main evaluated libraries (ENDF, JEFF, JENDL, TENDL) as well as several drawbacks during calculation of radiation damage cross sections by the NJOY code.
- To resolve these issues a dedicated Technical Meeting “Nuclear Reaction Data and Uncertainties for Radiation Damage” will be held at the IAEA in Vienna from 13 to 16 June 2016.
- Due to the strong relation between Nuclear Data and Radiation Material Physics, the CRP activities and results were regularly reported at the Meetings coordinated by WP on Multiscale Modelling of NEA, Physics Section of NA/IAEA and Nuclear Fuel Cycles and Materials Section of NE/IAEA.

Planned Outputs:

The output of this CRP will be a database of recommended damage response functions for selected materials with corresponding documentation. It will serve the needs of the fission, fusion and accelerator neutron source communities.

References:

- [1] R. Stoller, K. Nordlund, S.P. Simakov, Summary Report of the Technical Meeting on Primary Radiation Damage: from nuclear reaction to point defects, **INDC(NDS)-0624**, November 2012.
- [2] R. Stoller, L.R. Greenwood, S.P. Simakov, Summary Report of the First Research Coordination Meeting on Primary Radiation Damage Cross Sections, **INDC(NDS)-0648**, December 2013.
- [3] R. Stoller, L.R. Greenwood, S.P. Simakov, Summary Report of the Second Research Coordination Meeting on Primary Radiation Damage Cross Sections, **INDC(NDS)-0691**, 29 June - 2 July 2015, IAEA, Vienna, December 2015.
- [4] CRP web site: www-nds.iaea.org/CRPdpa/

6.1.6. Reference database for beta-delayed neutron emission

Status: On-going.

At a related CM held at the IAEA, Vienna, from 10–12 October, 2011 [1], the consultants pointed out the need for a CRP on the topic. The CRP proposal was subsequently endorsed at the INDC TM in May 2012. The proposal was submitted to the IAEA CCRA/NE in August 2012 and was approved. The first RCM was held at the IAEA, Vienna, from 26–30 August 2013.

Objectives:

- To create a reference database of evaluated data for beta-delayed neutron emission.
- The database should contain evaluated half-lives, emission probabilities and neutron spectra for individual precursors.
- The evaluation methodology should be described and documented.
- The database should also contain a separate section for macroscopic data, measured and derived from individual precursor data using the summations method.
- Aggregate quantities like group constants should be re-evaluated and stored in the database.

- The CRP should produce a priority list for evaluations and new experiments and improvements in the theoretical predictions.

Activities:

- Compilation and Evaluation of nuclides in $Z=2-28$ region has been completed and published [4].
- Preliminary database for $Z=2-28$ including systematics has been prepared.
- bDN: the CRP joined the IAEA networks on the IAEA CONNECT Platform.[5]. The CONNECT Sharepoint site is used for document repository and as discussion forum.
- Measurements of macroscopic properties have been performed for inclusion in the database [6,7].
- New theoretical calculations of beta-decay and beta-delayed neutron properties have been published [8].
- New measurements of beta-delayed neutron emission probabilities are continuously published and uploaded on the CRP website.

Planned Outputs:

- Reference Database containing microscopic and macroscopic data will be available online.
- Technical Document.

References:

- [1] D. Abriola, B. Singh and I. Dillmann, Summary Report of Consultants' Meeting on Beta-delayed neutron emission evaluation, IAEA, Vienna, Austria, 10–12 October 2011, **INDC(NDS)-0599**, December 2011.
- [2] I. Dillmann, P. Dimitriou, B. Singh, Summary Report of the 1st Research Coordination Meeting of the CRP on Beta-Delayed Neutron Emission, IAEA, Vienna, 26–30 August 2013. **INDC(NDS)-0643**, March 2014.
- [3] I. Dillmann, P. Dimitriou, B. Singh, Summary Report of the 2nd Research Coordination Meeting of the CRP on Beta-Delayed Neutron Emission, IAEA, Vienna, 26–30 August 2013. **INDC(NDS)-0683**, July 2015.
- [4] M. Birch et al, Nuclear Data Sheets **128**, 131 (2015).
- [5] IAEA CONNECT Website: nucleus.iaea.org/sites/connect-members/Pages/
- [6] V.M. Piksaikin et al, Absolute total delayed neutron yields, relative abundances and half-lives of neutron groups for neutron-induced fission of ²³²Th, ²³³U, ²³⁶U, ²³⁹Pu and ²⁴¹Am. **INDC(NDS)-0646**, October 2013.
- [7] V.M. Piksaikin et al, High resolution measurements of aggregate delayed neutron spectra in different time intervals from thermal neutron induced fission of ²³⁵U. **INDC(NDS)-0689**, September 2015.
- [8] T. Marketin et al, Phys. Rev. C **92**, 025805 (2016).
- [9] bDN preliminary results presented at Nuclear Structure 2014, Vancouver BC, 2014.
- [10] Web site: <http://www-nds.iaea.org/beta-delayed-neutron/>.

6.1.7. RIPL for fission cross section calculations

Status: Started.

A follow-up project to maintain and extend the RIPL database was discussed in a previous INDC and endorsed. A technical document documenting the update of the RIPL discrete level database was published [1].

A CM on “Recommended Input Parameters for fission cross section calculations” was held at the IAEA, Vienna, 17–18 December 2013 [2].

Consultants agreed that RIPL input parameters for fission have not been comprehensively validated against available experimental data, and therefore do not guarantee a reproducible and/or accurate calculation of fission cross sections. A large variability in calculated fission cross sections is observed due to the use of different fission formalisms, implementation in the codes, and/or combination of parameters.

Due to the increasing importance of modelling in nuclear data evaluation to improve fission input parameters is considered a high priority. The consultants pointed out the need for a CRP on the topic.

Scope

- Recommend a comprehensive set of input parameters with estimates of uncertainties needed for modelling of fission cross sections based on microscopic and phenomenological approaches.
- Priorities will be given to the modelling of photon and nucleon induced reactions on actinides and a description of relevant reaction channels with emphasis on incident energies below 30 MeV.

Model input parameters to be considered

- Compilation of input parameters according to the following three descriptions of the fission path: fission barriers (parabolic), barrier and wells (parabolic), full 1D fission path (as in RIPL-3) including sets of transition and class II/III states.
- Compilation of available sets of optical model potentials for actinides.
- Compilation of available sets of gamma-ray strength functions for actinides.
- Compilation of available sets of theoretical masses and ground state deformations.
- Update of sets of discrete levels and decay properties from ENSDF, NUBASE-2012.
- Update of average resonance properties for actinides (e.g. average spacing, strength function, ρ if new evaluations are available).

Planned Outputs

- A technical document describing both the nuclear reaction formalism and model parameters included in the database.
- A reference database will be made available for online distribution.

References

- [1] M. Verpelli and R. Capote Noy, Update of RIPL Nuclear Levels Segment, IAEA, Nuclear Data Section, **INDC(NDS)-0702** (December 2015)
- [2] R. Capote, S. Goriely, O. Iwamoto, T. Kawano, A. Koning, S. Hilaire, and S.P. Simakov, Summary Report of the Consultants' Meeting on "Recommended input parameters for fission cross-section calculations", IAEA, Vienna, 17–18 December 2013, **INDC(NDS)-0654** (December 2014)

6.1.8. Updating the photonuclear data library and generating a reference database for photon strength functions

Status: Started.

Gamma-ray data from nuclear reactions are important for a wide range of applications, as well as for basic sciences.

There has been an explosion of γ -ray data related to PSFs and photonuclear reactions in recent years that needs to be compiled and evaluated, and made available to researchers worldwide. These data are important sources of information for experimental data files such as EXFOR and evaluated data files such as RIPL, ENDF, EGAF, ENSDF etc. supported by the IAEA. However, there is currently no comprehensive database that includes all these data, which are also of use in the development and improvement of theoretical models describing the electromagnetic response of the nucleus.

The reaction γ -ray community, at the 4th Level Density and Photon Strength Workshop in Oslo, May 2013, expressed a strong interest to have a reaction γ -ray database under the auspices of the IAEA.

A Consultants' Meeting [1] was held from 4–6 November 2013 to review the state-of-affairs regarding experimental techniques, new measurements, and new evaluation methods. The meeting concluded that there is urgent need for updating the IAEA Photonuclear Data Library of 1999, and generating a Reference Database for Photon Strengths.

The CRP proposal was approved by the NA CCRA session in July 2015. It will run from 2016-2020 and will include 15 participants (6 agreements and 9 contracts) from Belgium, Czech Rep., Germany, Japan, Hungary, Norway, Rep. China, Rep. S. Korea, Russian Fed., S. Africa, USA.

Objectives:

- Update the IAEA Photonuclear Data Library (1999).
- Create a reference database of photon strength functions.
- Evaluate the compiled data and make recommendations.

Activities:

- 1st RCM, 4-8 April 2016, IAEA, Vienna.

Outputs:

- Updated Photonuclear Data Library
- Reference Database of Photon Strength Functions.
- Technical Report.

References:

- [1] P. Dimitriou, R. Firestone and S. Siem, Summary Report of the Consultants' Meeting on Compilation and Evaluation of γ -ray Data, Vienna, 4–6 November 2013, **INDC(NDS)-0649**.
- [2] P. Dimitriou et al, Updated Photonuclear Data Library and Database for Photon Strength Functions, EPS Web of Conferences, Vol. 93, 06004 (2015); <http://dx.doi.org/10.1051/epjconf/20159306004>
- [3] <http://www-nds.iaea.org/CRP-photonuclear>.

6.2. Data Development Projects (DDP)

Several DDPs were completed through consultancy visits, service agreements, and work undertaken directly by NDS staff.

6.2.1. Maintain the international neutron cross section standards file and evaluation techniques

One TM was organized to review the status of the international cross section standards released in 2006 [1,2], and to consider the possibility of releasing new standards in 2016 with extended energy ranges and including selected new reactions that could be considered for adoption as reference cross sections. The summary report was published in July 2013 [3]. This was a continuation of the Data Development Project started in 2009 to monitor and review the status of cross section standards [4].

The TM endorsed the proposed schedule toward the release of new standards in summer 2016 as requested within the international evaluation project CIELO (see 6.2.2).

On-going work is coordinated through contracts issued to V. Pronyaev (2012, 2013) and consultancy visits (2014, 2015, 2016), and work undertaken directly by NDS staff. A follow-up TM was held in Vienna on December 2014 [5]. Invited talks by A.D. Carlson were delivered at the NDST 2013 [6] and Santa Fe Covariance workshop CW2014 [7].

The neutron fission cross sections were evaluated for ^{209}Bi and $^{\text{nat}}\text{Pb}$ and extended for ^{235}U , ^{238}U and ^{239}Pu up to 1 GeV [8]. Corresponding data files in ENDF-6 format were made available from the NDS Standards web-page as reference cross sections in June 2015.

References:

- [1] S.A. Badikov, Chen Zhenpeng, A.D. Carlson, E.V. Gai, G.M. Hale, F.-J. Hambsch, H.M. Hofmann, T. Kawano, N.M. Larson, V.G. Pronyaev, D.L. Smith, Soo-Youl Oh, S. Tagesen, and H. Vonach, International Evaluation of Neutron Cross-Section Standards, Technical report **STI/PUB/1291** (Vienna, International Atomic Energy Agency, 2007).
- [2] A.D. Carlson, V.G. Pronyaev, D.L. Smith, N.M. Larson, Chen Zhenpeng, G.M. Hale, F.-J. Hambsch, E.V. Gai, Soo-Youl Oh, S.A. Badikov, T. Kawano, H.M. Hofmann, H. Vonach and S. Tagesen, International Evaluation of Neutron Cross Section Standards, *Nucl. Data Sheets* **110** (2009) 3215–3324.
- [3] V.G. Pronyaev, A.D. Carlson, and R. Capote Noy, Summary Report Technical Meeting “Toward a new evaluation of neutron standards”, IAEA Vienna, Austria, 8-12 July 2013, **INDC(NDS)-0641**.
- [4] V.G. Pronyaev, A.D. Carlson, R. Capote Noy, and A. Wallner, Summary Report Consultants' Meeting on International Neutron Cross Section Standards: Extending

and Updating, IAEA Vienna, Austria, 13–15 October 2010, **INDC(NDS)-0583**.

- [5] V.G. Pronyaev, A.D. Carlson, and R. Capote Noy, Summary Report Technical Meeting “Current status of neutron standards”, IAEA Vienna, Austria, 1-5 December 2014, **INDC(NDS)-0677**.
- [6] A.D. Carlson, V.G. Pronyaev, R. Capote, F.-J. Hambsch, F. Käppeler, C. Lederer, W. Mannhart, A. Mengoni, R.O. Nelson, P. Schillebeeckx, S. Simakov, P. Talou, S. Tagesen, H. Vonach, A. Vorobyev, and A. Wallner, “Improvements and Extensions of the Neutron Cross Section and Fluence Standards”, Presented at ND2013, 4-8 March 2013, New York, USA, *Nucl. Data Sheets* **118** (2014) 126–131.
- [7] A.D. Carlson, V.G. Pronyaev, R. Capote, G.M. Hale, F.-J. Hambsch, T. Kawano, S. Kunieda, W. Mannhart, R.O. Nelson, D. Neudecker, P. Schillebeeckx, S. Simakov, D.L. Smith, P. Talou, X. Tao, A. Wallner, and W. Wang, “Recent Work Leading Towards a New Evaluation of the Neutron Standards”, *Nucl. Data Sheets* **123** (2015) 27–35.
- [8] B. Marcinkevicius, S. Simakov and V. Pronyaev, “ ^{209}Bi and $^{\text{nat}}\text{Pb}$ neutron fission cross sections as new references and extensions of the ^{235}U , ^{238}U and ^{239}Pu (n,f) standards up to 1 GeV”, Report [INDC\(NDS\)-0681](#), IAEA, May 2015.

6.2.2. CIELO collaboration: coordination and technical work

The OECD’s Nuclear Energy Agency WPEC (Working Party on International Nuclear Data Evaluation Co-operation) during a meeting held in May 2012 accepted a new WPEC working group SG40 with the name CIELO [1]. CIELO is a pilot project of the OECD-NEA, coordinated by Los Alamos National Laboratory (United States), and it provides a new working paradigm to facilitate evaluated nuclear reaction data advances. It brings together experts from across the international nuclear reaction data community to identify and document discrepancies among existing evaluated data libraries, measured data, and model calculation interpretations, and aims to make progress in reconciling these discrepancies to create more accurate ENDF-formatted files. CIELO pilot isotopes ^1H , ^{16}O , ^{56}Fe , ^{235}U , ^{238}U , ^{239}Pu will be addressed as highest priority nuclides [2].

The IAEA NDS plays an important dual role in the new collaboration. On one side it contributes to the coordination, R. Capote is a coordinator (jointly with O. Iwamoto from JAEA, Japan) of the U-238 evaluation in the fast neutron range. Additionally, evaluation work is being supported through IAEA projects (e.g. the Neutron standards), the NDS staff technical work, and IAEA consultancy visits and meetings. The Neutron standard group will contribute with evaluations of selected neutron induced reactions on ^1H , ^{235}U , ^{238}U , and ^{239}Pu [3,4]. IAEA staff has been contributing technically to solve the discrepancies between different evaluated nuclear data libraries in the elastic/inelastic scattering, to the evaluation of the actinide nuclei in the fast neutron region [5-8], and to the evaluation of the thermal-neutron-induced prompt fission spectrum of ^{235}U [9-12]. Additionally, IAEA is coordinating evaluation changes in the U-238 and U-235 resonance regions, the former in collaboration with EC IRMM, the later in collaboration with CEA Cadarache, ISRN, and ORNL.

References:

- [1] Collaborative International Evaluated Library Organisation Pilot Project, WPEC Subgroup 40 (SG40) - CIELO Pilot Project. Online at <https://www.oecd-nea.org/science/wpec/sg40-cielo/>.
- [2] M.B. Chadwick, E. Dupont, E. Bauge et al., “The CIELO Collaboration: Neutron

Reactions on ^1H , ^{16}O , ^{56}Fe , ^{235}U , ^{238}U , ^{239}Pu ”, Presented at ND2013, 4–8 March 2013, New York, USA, *Nucl. Data Sheets* **118** (2014) 1–25.

- [3] V.G. Pronyaev, A.D. Carlson, and R. Capote Noy, Summary Report Technical Meeting “Toward a new evaluation of neutron standards”, IAEA Vienna, Austria, 8-12 July 2013, **INDC(NDS)-0641**.
- [4] A.D. Carlson, V.G. Pronyaev, R. Capote, F.-J. Hambsch, F. Käppeler, C. Lederer, W. Mannhart, A. Mengoni, R.O. Nelson, P. Schillebeeckx, S. Simakov, P. Talou, S. Tagesen, H. Vonach, A. Vorobyev, and A. Wallner, “Improvements and Extensions of the Neutron Cross Section and Fluence Standards”, Presented at ND2013, 4-8 March 2013, New York, USA, *Nucl. Data Sheets* **118** (2014) 126–131.
- [5] R. Capote, A. Trkov, M. Sin, M.W. Herman, and E.Sh. Soukhovitskii, “Elastic and inelastic scattering of neutrons on ^{238}U nucleus”, Presented at CNR*13 workshop, 7-11 October, 2013, *EPJ Web of Conferences* **69** (2014) 00008.
- [6] R. Capote, A. Trkov, M. Sin, M.W. Herman, A. Daskalakis, Y. Danon, “Physics of neutron interaction with ^{238}U nucleus: New developments and challenges”, Presented at ND2013, 4–8 March 2013, New York, USA, *Nucl. Data Sheets* **118** (2014) 26–31.
- [7] R. Capote, M. Sin, A. Trkov, M.W. Herman, D. Bernard, G. Noguere, A. Daskalakis, Y. Danon, “Evaluation of neutron induced reactions on ^{238}U nucleus”, Presented at NEMEA-7/CIELO workshop, 5–8 November 2013, JRC, EU, Geel, Belgium, Technical Report NEA/NSC/DOC(2014)13, Geel, EC IRMM, pp.113-118 (see <https://www.oecd-neo.org/science/wpec/nemea7/>)
- [8] A.M. Daskalakis et al, *Ann. Nucl. Energy* **73** (2014) 455-464.
- [9] A. Trkov, R. Capote, V.G. Pronyaev, “Current issues in nuclear data evaluation methodology: ^{235}U prompt fission neutron spectra and multiplicity for thermal neutrons”, *Nuclear Data Sheets* **123** (2015) p.p. 8-15.
- [10] D. Neudecker, P. Talou, T.N. Taddeucci, R.C. Haight, T. Kawano, H.Y. Lee, D.L. Smith, R. Capote, M.E. Rising, M.C. White, “Preliminary Evaluation and Uncertainty Quantification of the Prompt Fission Neutron Spectrum of ^{239}Pu ”, *Nuclear Data Sheets* **123** (2015) 146-152.
- [11] A. Trkov, R. Capote, “Evaluation of the Prompt Fission Neutron Spectrum of Thermal-neutron Induced Fission in U-235”, Scientific Workshop on Nuclear Fission dynamics and the Emission of Prompt Neutrons and Gamma Rays, *Physics Procedia* **64** (2015) 48-54.
- [12] D. Neudecker, R. Capote, D.L. Smith, T. Burr, P. Talou, “Impact of the Normalization Condition and Model Information on Evaluated Prompt Fission Neutron Spectra and Associated Uncertainties”, *Nucl. Sc. Eng.* **179** (2015) 381-397.

6.2.3. Neutron data evaluation work up to 150 MeV: ^{55}Mn nucleus

Neutron data evaluation work is being supported through NDS staff, consultancy visits and service agreements. Such work is important as a testing ground of developed methodologies for nuclear data evaluation and for validation of public nuclear reaction evaluation tools (e.g. EMPIRE and GANDR code systems). Evaluation of ^{55}Mn nucleus was concluded in 2013 [1]. Minor modifications of this evaluation were recently undertaken; evaluation was adopted by the EU JEFF-3.2 library (March 2014). An earlier version of the evaluation was adopted by the US ENDF/B-VII.1 library (December 2011). The earlier evaluation is fully documented in refs. [2,3].

References:

- [1] A. Trkov, R. Capote, L. Leal, D.W. Muir, and E.Sh. Soukhovitskii, “Fluctuations Above the Resonance Range in Evaluated Data of ^{55}Mn “, Presented at ND2013, 4-8 March 2013, New York, USA”, *Nuclear Data Sheets* **118** (2014) 161–164.
- [2] M.B. Chadwick, M. Herman, P. Oblozinsky, M.E. Dunn, Y. Danon, A.C. Kahler, D.L. Smith, B. Pritychenko, G. Arbanas, R. Arcilla, R. Brewer, D.A. Brown, R. Capote, *et al.*, “ENDF/B-VII.1 Nuclear Data for Science and Technology: Cross Sections, Covariances, Fission Product Yields and Decay Data”, *Nucl. Data Sheets* **112** (2011) 2887–2996.
- [3] A. Trkov, R. Capote, *et al.*, “Covariances of Evaluated Nuclear Cross Section Data for ^{232}Th , $^{180,182,183,184,186}\text{W}$ and ^{55}Mn ”, *Nucl. Data Sheets* **112** (2011) 3098–3119.

6.2.4. Ion Beam Analysis Nuclear Data Library (IBANDL)

The Ion Beam Analysis community has repeatedly shown deep appreciation for the continuous updating of IBANDL as well as for the theoretical evaluations provided through IBANDL. The NDS (V. Semkova, P. Dimitriou, V. Zerkin) has continued to provide this service to the user community.

A new feature that was made available in 2015, is the ability to convert cross-section data available in forward kinematics, to cross sections in inverse kinematics, by a simple click of a button (V. Zerkin). This feature was implemented upon several requests of members of the IBA user community, as it is particularly useful in IBA applications using heavier projectile beams which are now becoming all the more available at Radioactive Beam facilities. Furthermore, during the course of the PIGE CRP, over 300 new data sets have been uploaded. With the advice of IBA consultants [1,2], IBANDL is continuously checked for errors, missing data, and consistency.

In addition to the updating, maintenance and development of IBANDL, a Technical Meeting was held from 26 to 29 May 2015, at the IAEA Headquarters in Vienna, on Benchmarking Experiments for IBA applications.

Objective:

- to address the need for validation/benchmarking of nuclear cross sections for the various IBA techniques by
- assessing the current status of experimental and evaluated data
- outlining the methodology for performing benchmarking experiments
- proposing guidelines for validation of nuclear cross sections using benchmark data
- producing a list of priority benchmark experiments

Output:

- Detailed guidelines for planning and performing benchmark measurements were proposed for each of the widely used IBA techniques (EBS, NRA, PIGE)
- Lists of reactions cross sections that need to be validated
- Recommendation of targets to be used

Data compilation and dissemination was also discussed.

The summary report **INDC(NDS)-0690** is in preparation. Presentations are available on the meeting web page: <https://www-nds.iaea.org/index-meeting-crp/TM-IBA-2015/>

Reference:

- [1] Developments in the Ion Beam Analysis Nuclear Data Library (IBANDL), Report of services delivered under CSA (A. Gurbich), Ed. P. Dimitriou, **INDC(NDS)-0660** (June 2014).
- [2] Consultant A. Lagoyannis (Greece), 27 October 2015; 16-18 December 2015.

6.2.5. Development of evaluation methodology and nuclear reaction modelling systems

Further development of the EMPIRE and GANDR codes is being supported through NDS staff, consultancy visits and service agreements. Several technical papers have been published at major nuclear data conferences and in peer-reviewed journals; these activities support the extension of nuclear data evaluation capabilities including covariance generation relevant for other projects. These activities are the backbone of evaluation activities for neutron induced reactions on actinides undertaken by IAEA staff.

6.2.6. Evaluation of charged-particle-induced reaction data in the resolved-resonance region for applications

Evaluated cross section data are considered to be more reliable and more practical for implementing in the IBA simulation codes than the actual measured data themselves. For this reason, the IBA community has strongly supported the evaluation efforts undertaken within the relevant CRPs or under individual contracts, but has also raised concerns about the fact that these evaluations are performed by a single scientist.

In view of these concerns, the NDS has decided to investigate other possibilities and tools for evaluating low-energy charged-particle-induced reactions in the resolved-resonance region.

The first step in this direction was the Consultant's Meeting on R-matrix Codes for Charged-particle Reactions in the Resolved Resonance Region, which was held from 7-9 December 2015, in Vienna [1].

Four experts from the international community who are developing R-matrix codes, met to discuss the main capabilities of the existing R-matrix codes, the implementation of R-matrix theory in the codes, and establishing the translatability of the R-matrix fits produced by these codes. The latter would allow the conversion of the R-matrix fits between the codes and into appropriate data formats that could then be used by processing codes for broader applications.

The meeting was the first in a series of meetings aiming at outlining the methodology and tools to be used for the (i) evaluation of charged-particle cross sections in the resolved resonance region, (ii) producing evaluated nuclear data files for further processing and finally (iii) disseminating these data through the general purpose evaluated nuclear data libraries, in an effort coordinated by the IAEA NDS.

The presentations are available on www-nds.iaea.org/index-meeting-crp/CM-R-matrix/.

References:

- [1] deBoer, Kunieda, Thompson, Paris and Dimitriou, Summary Report of the CM on R-matrix Codes for Charged-particle Reactions in the Resolved Resonance Region, 7-9 December 2015. **INDC(NDS)-0703**.

6.2.7. Improvement of analysis codes for nuclear structure and decay data evaluations

The ENSDF Analysis and Utility codes are essential tools for evaluators' work and for that reason it is important that they are maintained, i.e. that they are continuously checked for bugs, kept up-to-date with developments in physics models, statistical methods and error analysis, and evaluation methods/policies in general. To make sure 'maintenance' of these codes is kept up by future generations of programmers and evaluators, these codes need to be reviewed and most likely re-written using modern programming tools.

Objective:

The Nuclear Data Section has begun a Data Development Project to address all the problems that are encountered in the utilization of the existing ENSDF codes in view of the overall need to re-structure and/or re-write them using modern programming tools. The kick-off Technical Meeting was held at IAEA headquarters in Vienna, from 10 to 13 June 2014. The output of this meeting was a priority list of codes that need to be improved and a list of assignments/tasks to be delivered within a given period [1].

A follow-up meeting was held from 5 to 8 October 2015 at IAEA, Vienna. The aim was to monitor progress made in the tasks assigned at the previous meeting, discuss and validate the new codes, assess the current status and emerging needs, and revise the list of priorities and assignments accordingly [2].

Output:

Nearly all the existing ENSDF analysis codes will be reviewed by this project, with some being re-written in modern programming languages and other codes undergoing serious improvements. So far, two new codes have been delivered to the evaluator's community:

- JGAMUT: a Java code to produce adopted levels and gammas from the decay and reaction data sets using appropriate algorithms [3].
- RadD: deduces r_0 parameters for odd-A and odd-odd nuclides from Alkovali's tables. The manual and guidelines are available on www-nds.iaea.org/public/ensdf_pgm/.

In addition, a code to calculate improved beta spectra produced from beta (EC) decay processes is in preparation and will soon be disseminated to the NSDD network.

Other outputs of the project will be improved, user-friendly editors providing an interface between the evaluator and the ENSDF format. These smart editors will also integrate the analysis and checking codes and will thus be similar to a compact evaluation toolkit for evaluators to use without concerns about learning the ENSDF format or installing, compiling and debugging the various analysis and checking codes.

An important achievement of the codes project, apart from delivering improved codes and editors, is that it has recommended the proper way of preparing a software package for dissemination, which will include source code, auxiliary libraries and codes, make files to compile the codes in all available platforms using widely used compilers, as well as standard input/output files for checking.

References:

[1] P. Dimitriou and T. Kibedi, Summary Report of Technical Meeting on Improvement of Analysis Codes for Nuclear Structure and Decay Data Evaluations, 10-13 June 2014, IAEA, Vienna; **INDC(NDS)-0665**.

[2] P. Dimitriou and T. Kibedi, Summary Report of 2nd Technical Meeting on Improvement of Analysis Codes for Nuclear Structure and Decay Data Evaluations, 5-8 October 2015, IAEA, Vienna; **INDC(NDS)-0696**.

[3] M. Birch, Development of Java GAMUT (JGAMUT) – Adopted Levels, Gammas Evaluator Assistant Code, **IAEA-NDS-222**, January 2016.

[4] https://www-nds.iaea.org/public/ensdf_pgm/index.htm

6.2.8. Stopping power database

The compilation of experimental electronic stopping powers that was created and maintained for decades by Prof. Helmut Paul, Univ. Linz, has been passed over by Prof. Paul to IAEA NDS in December 2015.

The database and online retrieval interface have been updated and installed on the NDS web server and are now available at www-nds.iaea.org/stopping/.

The NDS plans to maintain the compilation and further develop the database to meet the needs of the user community, in collaboration with external consultants.

6.2.9. Total Absorption Gamma-ray Spectroscopy (TAGS) decay data for decay heat calculations and other applications

A consultant's meeting was held from 17-19 December 2014, at the IAEA, Vienna. The objective of the meeting was to review the current status of TAGS measurements and reassess the data needs for decay heat calculations, beta-delayed neutrons and anti-neutrino spectra [1].

The output of the meeting included updated tables of nuclides that merit to be measured using Total Absorption Gamma-ray Spectroscopy methods because of their importance in decay heat and anti-neutrino calculations, and because they are candidates for the Pandemonium effect.

The meeting concluded with two important recommendations: (i) extensive inventory calculations should be performed for the standard U/Th fuel cycle but also for other innovative fuel cycles to identify the major contributors to decay heat, (ii) an online repository of the most important measurements of decay heat should become available on the IAEA web server to ensure traceability, and preservation of data and knowledge. The former work has been completed and published [2], while work is in progress to address the latter.

Reference:

[1] Total Absorption Gamma-ray Spectroscopy for Decay Heat Calculations and Other Applications, Summary Report of Consultants' Meeting, 15-17 December 2014, IAEA. P. Dimitriou and A.L. Nichols, **INDC(NDS)-0676**, February 2015.

[2] M. Fleming and J.-C. Sublet, in -Validation of FISPACT-II Decay Heat and Inventory Predictions for Fission Events CCFE-R(15)28; Decay Data Comparisons for Decay Heat and Inventory Simulations of Fission Events CCFE-R(15)28 S1; Fission Yield Comparisons for Decay Heat and Inventory Simulations of Fission Events CCFE-R(15)28 S2.

6.2.10. Data for safeguards

In 2008 a set of recommended nuclear data for safeguards applications has been assembled by NDS and represented as “Handbook of Nuclear Data for Safeguards” [1] and databases at the NDS Safeguards Data portal <https://www-nds.iaea.org/sgnucdat/>.

Responding to the request from the IAEA Safeguards Department, neutron emission yields from reactor fuels (oxides and fluorides of U and Pu) [2] and from spontaneous fission of actinides (isotopes of Th, U, Np, Pu, Am, Cm Bk and Cf) [3] were assessed employing the latest evaluated decay and (α ,xn) cross section data.

These updated physical quantities used in Non Destructive Assay systems for SG verification are now available at the NDS Safeguards Data portal <https://www-nds.iaea.org/sgnucdat/> and submitted to SG/IAEA.

References:

- [1] A.L. Nichols, D.L. Aldama, M. Verpelli, “Handbook of Nuclear Data for Safeguards: Database Extensions, August 2008”, Report [INDC\(NDS\)-0534](#), IAEA, August 2008.
- [2] Q. van den Berg and S. Simakov, “Updating of data for the neutron yields in reactor fuels for the interest of Nuclear Safeguards, Report [INDC\(SEC\)-0111](#), IAEA, October 2015.
- [3] S. Simakov, M. Verpelli and N. Otsuka, “Update of the nuclear data for the neutron emissions for actinides of interest in safeguards”, see https://www-nds.iaea.org/sgnucdat/SF_n-Yield_20150313.pdf , IAEA, March 2015.

6.2.11. Nuclear data libraries for advanced systems: fusion devices (FENDL-3)

This DDP is devoted to maintenance and update of the CRP released FENDL-3 library.

Activities:

- A number of problems were reported by Chikara Konno from JAEA, mainly related to problems originating in the NJOY code system.
- Some of the problems originated in the evaluated data files taken from the TENDL-2010 library. Those nuclides were replaced with data from TENDL-2014.
- Updates to the library were reported in informal notes that are available from the updated FENDL web site <https://www-nds.iaea.org/fendl/> .
- The current version of the FENDL library is FENDL-3.1b (15 October 2015).

6.2.12. Thermal scattering law data

The activity on the evaluation of the thermal scattering law data is conducted within the OECD/NEA Subgroup-42. The IAEA was supporting a participant from Argentina, who is an expert in this field, to participate in the Meeting of the Subgroup. IAEA staff are involved in benchmark validation and integration of this new data within the CIELO activities. TSL data are important for solutions and lattices.

7. TECHNOLOGY TRANSFER

Technology transfer activities during 2014-2015 include maintenance of mirror site facilities and provision of training workshops. In addition to the workshops described below two others on EXFOR compilation are described in Section 4.1. As noted in Section 4.2 NDS staff continues to be active in providing support to new ENSDF evaluators.

7.1. Technical cooperation: regional centres for nuclear data services

The system of Mirror sites is successfully functioning in BARC (India) and CNDC (China) with regular (approximately monthly) updates of EXFOR, CINDA, ENDF databases and Web retrieval system. Updates are prepared on NDS site in compact form; link to the update with instructions is sent to the Mirror-sites' staff, and they perform all needed operations locally having consultancies only when and if necessary.

The full NDS system of EXFOR, ENDF, CINDA databases with software for independent database management and Web retrieval system is regularly deployed to NNDC (BNL, USA). Software updates are done once a year during visits (with discussing, testing and planning), and then database updates are performed by the local staff.

Bilateral visits:

- V. Zerkin (NDS) to NNDC. Deployment and development of software for the management and the web retrieval of ENDF, EXFOR and CINDA databases; common work on development of XML for EXFOR and ENDF data formats and on MyEnsdf project. 18 August-5 September 2014; 7-25 September 2015.

7.2. Workshops

NDS partially sponsored and organised thirteen workshops in 2014–2015, of which one was hosted by ICTP and organized by the IAEA (7.2.1) , three were jointly organized by IAEA/ICTP (7.2.2, 7.2.9, 7.2.13), one was held at IAEA premises (7.2.10) and eight were sponsored by the IAEA and held in Member States (7.2.3, 7.2.4, 7.2.5, 7.2.6, 7.2.7, 7.2.8, 7.2.11, 7.2.12). These workshops are described below.

7.2.1. IAEA workshop on nuclear structure and decay data: theory and evaluation

(Hosted at ICTP Trieste, Italy, 24-28 March 2014)

Workshop Directors: P. Dimitriou (NDS), J.K. Tuli (NNDC).

The eighth workshop in this field was a one week event organized by the NDS in collaboration with NNDC, USA. The programme was based on the previous seven successful workshops (November 2002, one-week trial, IAEA Vienna, Austria; November 2003, April 2005, February–March 2006 and April–May 2008 two weeks each, October 2010, August 2012-two weeks, ICTP, Trieste, Italy).

Objectives:

- Familiarize students with new experimental data that characterize the nucleus, and with modern nuclear models.
- Train participants in methodology of NSDD evaluations and in production of evaluated nuclear structure and decay data (as ENSDF mass-chain evaluations).

Topics:

- ENSDF evaluation philosophy, policies and analysis programs.
- NSDD network, relevant IAEA activities, web retrieval systems.
- Nuclear Structure Theory.
- Nuclear Experiments Radioactive Decays.
- Adopted Levels/ XUNDL.
- Databases and Web resources.
- Reaction Data.

Actions:

- Workshop material was presented as lectures (mainly mornings) and exercises (afternoons), with hands-on introduction of participants to mass chain evaluations through group and individual PC/computing activities.
- As part of the Workshop activities (organized by B. Singh) four student groups were formed under the leadership of one mentor, and the evaluation of mass chain $A=227$ was undertaken collectively by the six groups. The evaluation has been published in *Nuclear Data Sheets* **132** (2016) 257.
- Students were given the opportunity to review the workshop through a written questionnaire and direct discussions.

Remarks/Outcomes:

- 21 trainees from 10 countries received training from 4 lecturers.
- The evaluation work undertaken within Workshop activities was later completed, included into the ENSDF database, and published in Nuclear Data Sheets.
- Several participants expressed strong interest in undertaking NSDD evaluation work.

These NSDD workshops have been particularly successful in achieving significant technology transfer and the identification and motivation of new potential ENSDF evaluators.

7.2.2. Joint IAEA/ICTP workshop on nuclear reaction data for nuclear power applications

(ICTP Trieste, Italy, 22-26 September 2014)

Workshop Director: R. Capote Noy (NDS)

Local Organizer: C. Tuniz

A one-week workshop was organized by the NDS in collaboration with ICTP, Italy. The Workshop continued the longest series of “Nuclear Data for Science and Technology” workshops initiated in the early seventies, almost from the start of ICTP. The Workshop represents a unique forum where nuclear scientists and engineers can get extensive and up-to-date information on the whole 'know-how' of nuclear data, from the physics of nuclear reactions to the production and validation of evaluated nuclear data files. In the era of vanishing expertise and infrastructure due to low support for nuclear reactor activities, this type of training is important, particularly in view of challenges posed by emerging innovative fuel cycle concepts, enhanced safety requirements and radioactive waste incineration.

Objectives:

The purpose of the Workshop is to train scientists and engineers from both developing and developed countries in modern nuclear reaction theory, nuclear

data production and validation, and data use, with particular emphasis on applications in nuclear reactor physics, design and safety. Participants will gain an overview of modern computer codes relevant to these topics. Furthermore, they will be introduced to the online retrieval of nuclear data.

Topics:

- Facilities and instrumentation for nuclear reaction data measurements.
- Experimental techniques for measurements of nuclear reaction data.
- Modern theoretical nuclear structure and reaction models.
- Evaluation of nuclear data and creation of evaluated nuclear reaction data libraries.
- Overview of the status of the research and technology and of strategies for advanced nuclear technologies deployment (ADS, Gen-IV reactors, fusion reactor).
- On-line retrieval of nuclear data.
- Presentations of participants' own work.

Actions:

- The Workshop was organised on a week basis with morning and afternoon sessions. Both of them consisted of two 90 minutes lectures (or exercises) followed by discussion.
- Hands-on introduction of workshop participants to nuclear data retrieval and advanced functions available at the IAEA NDS server (e.g. data plotting, retrieval, corrections, etc.); use of the mobile retrieval tools (apps), introduction to nuclear reaction modelling.

Remarks/Outcomes:

- 22 participants from 12 countries received training from 6 lecturers. Two students from Greece attended the workshop supported by their institute.
- Workshop feedback was obtained by an email survey distributed after the workshop. The students had thoroughly enjoyed the workshop, and made useful new contacts with the IAEA staff, lecturers and other students, and learnt much about nuclear data for energy applications.

The joint IAEA/ICTP workshops serve as an excellent training opportunity for students coming from all over the world, but particularly to those coming from developing countries, as they have the opportunity to meet top level researchers in the field. This particular workshop was not an exception, lively discussion followed each lecture and a healthy exchange of information was observed. All of the objectives of the workshop were successfully achieved.

7.2.3. 5th workshop on Asian nuclear reaction database development

(Hosted at Bhabha Atomic Research Centre, Mumbai, India, 22-24 September 2014)

IAEA officer: Naohiko Otsuka.

The workshop was organized by Nuclear Data Physics Centre of India in cooperation with the International Atomic Energy Agency and the Board of Research in Nuclear Sciences, Department of Atomic Energy (DAE-BRNS). Asian Nuclear Reaction Database Development Workshops (AASPP) are held every year in different countries for discussing current status and possible future collaborations in Asian nuclear data activities. The first AASPP was organized in Japan in 2010 followed by China (2011),

Korea (2012) and Kazakhstan (2013).

Objectives:

- Present nuclear data activities in Asian countries, including nuclear data measurements, compilations, evaluations and applications.
- Discuss collaborations involving participants from different countries.

Topics:

- Nuclear data activities in Asian Nuclear Data Centres.
- Progress in EXFOR compilation
- Development of the Asian Nuclear Reaction Database Network.
- Nuclear data measurement and experimental facilities.
- Computational nuclear reaction and nuclear data evaluation.

Actions:

- The talks presented by the participants of the Workshop covered the topics related to experiments performed using various facilities, the upcoming and existing accelerators and experimental facilities, EXFOR compilation activities, reactor sensitivity studies to nuclear data, criticality benchmarking studies, nuclear data requirement of nuclear power reactors, theoretical calculations using various codes, and covariances in nuclear data.
- The Workshop Proceedings was published as INDC report **INDC(IND)-0048**.
- Various possibilities for future collaborations were discussed at the concluding session.

Remarks/Outcomes:

- 80 participants from 8 countries attended the Workshop.
- More than 40 talks were presented during the Workshop and the summary of the presentations is included in the **INDC(IND)-0048** report.
- Special attention was given to the application of EXFOR database in different area of research.
- Progresses in the EXFOR compilation activities and software developments were presented by participants from Asian Nuclear Data Centres.

The 5th AASPP workshop has been particularly successful. The talks covered a broad area of topics related to nuclear research. Many young scientists attended the workshop and had the opportunity to present and discuss their work.

7.2.4. 33rd Joliot-Curie school on neutrons and nuclei

(La Villa Clythia, Frejus, Cote d' Azur, France, 29 September - 3 October 2014)

School director: E. Khan, *IAEA Officer:* S.P. Simakov.

The Joliot Curie School trains since 1982 the PhD students, post-doctorates and researchers on scientific breakthroughs performed in a broad range of nuclear physics, first being a high-standard French speaking school, it became international since 2009. The school is mainly funded by IN2P3/CNRS. 33rd School was co-sponsored by NDS of IAEA.

The topics addressed by the School-2014 “Neutrons and Nuclei”:

- properties of the neutrons
- production of neutron beams, collimation, neutron guides
- interaction of neutrons with nuclei (theory and experiments)
- detection of neutrons
- nuclear astrophysics and structure of neutron-rich nuclei
- nuclear reactors, evaluations and library development

Actions:

- 10 lectures were presented
- 2 mini-workshops (one of them entitled “IAEA activities and available services related to nuclear data” was presented by S. Simakov)
- discussions after lectures and during mini-workshops
- 17 students posters were exhibited during Poster session

Remarks/Outcomes:

- around 50 Students were trained
- among them the participation of 5 students from India, Romania and Spain were supported by IAEA
- lectures and other presented materials are made available on line <http://ejc2014.sciencesconf.org/>

The Joliot-Curie School covers every year a specific nuclear physics’ topic inviting the world leading experts as lecturers. Since it is mainly funded by France authorities the most students are selected from France and other EU countries. Participation of IAEA as a sponsor and lecturer extends the range of participants and topics.

7.2.5. 16th international workshop on Radiative Properties of Hot Dense Matter (RPHDM)

(Held at Park hotel Schönbrunn, Vienna, Austria, 29 September - 3 October 2014)

Contact Person: R. W. Lee

IAEA officer: Hyun-Kyung Chung

International Workshops on Radiative Properties of Hot Dense Matter are held alternatively in USA and Europe every two years. In 2014, IAEA cooperated with the international organizing committee to host the 16th event in Vienna and Ms. Chung was the local organizer to provide organizational and programmatic support.

Objectives:

The purpose of the meeting is to bring together a relatively small, international group of leading researchers in the field of radiative properties of hot dense matter to identify current problems and directions for future research.

Topics:

- Radiative transfer
- Spectral Line shapes,
- Dense plasma spectroscopy
- Non-LTE population kinetics
- Opacity studies
- Warm-dense matter research

Actions:

- One oral session and poster sessions are arranged.
- Discussions on the development and planning of future efforts were conducted.

Remarks/Outcomes:

- 105 participants attended the Workshop.
- 54 oral presentations and 38 posters were presented.
- Proceeding papers were published in the High Energy Density Physics journal.

The 16th RPHDM workshop was particularly successful with 20 % more attendants than usual. Exceptionally good organization of both program and venue was highly appreciated by participants. The next workshop will be held in Santa Barbara, USA in December 2016.

7.2.6 5th workshop of the Decay Data Evaluation Project (DDEP)

(Organised by IFIN-HH, Romania and IAEA NDS; held at IFIN-HH, Bucharest-Magurele, Romania, from 6-8 October 2014)

Local Organisers: Aurelian Luca, Viktor Zamfir, IFIN-HH, Romania

IAEA officer: Paraskevi Dimitriou

Objectives:

- Discuss technical issues and progress related to DDEP evaluations, computer tools and dissemination
- Review current status and perspectives of DDEP effort worldwide

Topics:

- Nuclear decay data: determination, evaluation and applications;
- Nuclear decay data and radionuclide metrology: results of the IFA Romania - CEA France joint research project no. C2-05/2012;
- International collaborations in the field of nuclear decay data: IAEA, DDEP, NSDD Network and BIPM;
- Nuclear decay data evaluations: principles, procedures and tools.
- Training and exercises organized by DDEP;

Actions:

- 13 presentations were given
- Discussions were held during dedicated discussions and round-table sessions
- Visit to IFIN-HH, Radioisotopes and Radiation Metrology Department: Radionuclide Metrology Laboratory, Radiopharmaceuticals Research Centre and other laboratories

Remarks:

- 24 participants, among which 11 from outside Romania, 4 of which were supported by the IAEA
- A Workshop CD-ROM including all presentations is available free of charge
- Workshop web site: <http://ddep14.nipne.ro/>

7.2.7. 3rd school for neutron resonance analysis

(Hosted at EC-JRC-IRMM, Geel, Belgium, 15-19 December 2014)

IAEA officer: Naohiko Otsuka.

The 3rd Neutron Resonance Analysis School was hosted at the EC-JRC-IRMM in Geel, Belgium from 15 to 19 December 2014. The school was organized within the FP7 project CHANDA (Solving Challenges in Nuclear Data for the Safety of European Nuclear Facilities), and in collaboration with the University of Manchester, IAEA, OECD/NEA and CEA. A number of 31 students from over 15 different countries (Austria, Italy, France, Greece, Poland, Spain, UK, Republic of Korea, China, Cuba, Chili, Japan, India) were selected to participate in the school.

Objectives:

The objective of the School was to provide an introduction to the neutron induced reaction measurements employing time-of-flight technique, analysis of experimental data in the resolved resonance energy range, data processing, EXFOR compilation and data evaluations.

Topics:

- Neutron-induced reaction measurement techniques.
- Neutron time-of-flight measurements.
- R-matrix theory and neutron resonance analysis.
- Uncertainty and covariance assessment.
- Compilation of TOF data.

Actions:

- The School material was presented as lectures.
- Hands-on computer exercises of the experimental data processing.
- Resonance analysis of the time-of-flight spectra using REFIT.
- Visit to 150 MeV linear electron accelerator GELINA.

Remarks/Outcomes:

The measurements and analysis in the resolved resonance range are particularly challenging and require in-depth knowledge in order to provide high quality results. The training provided by the EC-JRC-IRMM, University of Manchester, IAEA, OECD/NEA and CEA was an excellent opportunity for the young scientists to obtain comprehensive information on all aspects of the neutron-induced cross section measurements in the resolved resonance range as well as perform resonance analysis of the time-of flight spectra.

7.2.8. 3rd Spectral Line Shapes in Plasmas (SLSP) code comparison workshop

(Held at Aix University Marseille, France, 2-6 March 2015)

Contact person: Annette Calisti

IAEA Officer: Hyun-Kyung Chung

The SLSP workshop was initiated in cooperation with IAEA Atomic and Molecular Data Unit and the 1st and 2nd workshops were held in Vienna in 2012 and 2013. The 2015 workshop was the 3rd in the series and held in France.

Objectives:

- Line-shape analysis is one of the most important tools for diagnostics of both laboratory and space plasmas. Evidently, its reliable implementation requires sufficiently accurate calculations.
- The purpose of the meeting is to bring code developers of line-shape calculations to compare different computational analysis and to pinpoint sources of disagreements, infer limits of applicability, and assess accuracy.

Topics:

- Ion dynamics
- Ionization potential depressions and line shapes
- Large-scale line-shape calculations
- Stark broadening in the presence of external electric and magnetic fields
- Stability and convergence of line-shape calculations

Actions:

- Except for limiting cases, line-shape calculations imply a usage of computer codes of varying complexity and requirements of computational resources. However, studies comparing different computational and analytical methods are almost nonexistent. This workshop purports to fill this gap. By detailed comparison of results for a selected set of case problems, it becomes possible to pinpoint sources of disagreements, infer limits of applicability, and assess accuracy.
- One oral session and poster sessions are arranged.
- Discussions on the development and planning of future efforts were conducted.

Remarks/Outcomes:

- 11 cases of line shape problems were reviewed.
- 23 participants contributed cases with 16 different codes for inter-code comparisons.
- The review of the workshop will be reported in the 17th International Workshop on Radiative Properties of Hot Dense Matter (RPHDM) in December 2016.

7.2.9. Joint IAEA/ICTP workshop on nuclear data for neutron dosimetry and analytical methods by applying research reactors

(ICTP – Miramare, Trieste, Italy, 20-24 April 2015)

Workshop Directors: A. Trkov and D. Ridikas

Local organizer: C. Tuniz

The Workshop was part of the series that addresses the use of nuclear data in practical applications of nuclear techniques in various fields of scientific research, medical and industrial applications, including nuclear energy. It represents a unique forum where scientists and engineers can get extensive and up-to-date information on the whole 'know-how', from the theoretical models and experiments to the practical details of the applications.

Objectives

The objective of the Workshop was to present the theoretical background of neutron dosimetry and activation analysis and the current status of nuclear data for different variants of the techniques, identify open issues and lay foundations for possible activities carried out under the auspices of the Agency to remedy the deficiencies.

Actions

In the process, scientists and engineers from both developing and developed countries received introductory training on the use of the method through practical exercises.

Remarks/Outcomes

In total, out of 73 applicants, 30 from 21 different countries attended the workshop. Considering the relatively large number of applicants it was possible to select a fairly homogeneous group of participants, who showed great interest in the subject, reflected in numerous questions to the lecturers. An opportunity was also given to a few volunteers to prepare seminars about their work. The workshop was highly effective and reached the objectives.

7.2.10. Specialized workshop on nuclear structure and decay data evaluations

(Hosted at IAEA, 27-29 April 2015)

Workshop Directors: P. Dimitriou (NDS), Co-ordinators: F. Kondev (ANL), E. McCutchan (NNDC).

The first workshop of this kind, this three-day event was organized by the NDS following the recommendations of the 20th NSDD meeting for continuous training and refreshing of evaluators skills to maintain the good quality of ENSDF evaluations.

Objectives for evaluators:

- discuss frequently encountered problems in their evaluation work,
- be informed on evaluation policies and their implementation,
- be updated about analysis codes,
- refresh their evaluation skills.

Topics:

- ENSDF evaluation policies and procedures
- Formats and codes
- Evaluators guidelines
- Feedback from evaluators

Actions:

- Workshop material was presented as informal lectures
- Discussions around the presentations
- Update of Evaluators Guidelines (coordinator: Murray Martin)
- Update of General Policies (coordinator: Jagdish Tuli)

Remarks/Outcomes:

- 18 participants from 11 countries
- The updated Evaluators Guidelines and General Policies will become available on the IAEA and NNDC webpages
- Summary Report: Nichols, Dimitriou, Kondev, McCutchan, **INDC(NDS)-0688**

Discussions during the closing session of the workshop indicated that all had benefitted immensely from the in-depth discussions of the contents of the re-drafted guidelines, along with the recommended evaluation policies, procedures and rules. A majority of participants believed that this form of specialized workshops would benefit from the

inclusion of the following forms of focussed session:

- dedicated hands-on exercises to demonstrate ‘best practices’
- treatment of exceptional cases,
- how to run and use the various analysis and utility codes

This more practical approach to refresher training will be considered in any future form of this workshop.

7.2.11. International workshop on models and data for plasma-material interaction in fusion devices

(Held at Aix-Marseille University, Marseille, France, 25-27 May 2015)

IAEA Officer: Bastiaan Braams.

The 2015 International Workshop on Models and Data for Plasma-Material Interaction in Fusion Devices (MoD-PMI 2015) was organized by the Physics Laboratory Ionic and Molecular Interactions (PIIM) of CNRS and Aix-Marseille University in cooperation with IAEA. The workshop was intended to provide a bridge between fundamental computations and interpretation of experimental data for processes such as erosion, hydrogen trapping and radiation damage, all in the context of nuclear fusion research.

Topics:

- Electronic structure calculations for materials microstructure, trapping and transport;
- Molecular Dynamics and (Object) Kinetic Monte Carlo studies of plasma-material interaction, radiation damage processes and material and surface evolution;
- Mean-field rate theory and phase field method;
- Multi-method and multi-scale simulations;
- Optimization of parameters in semi-empirical codes, parameterization of interaction potentials;
- Diagnostics of material microstructure, radiation damage, hydrogen and helium in fusion materials and plasma-material interaction.

Remarks/Outcomes:

The meeting had 24 oral and 19 poster contributions in 2 days that provided a good cross section of computational work on plasma-material interaction with fusion materials, especially tungsten and steel. The Agency provided partial support for participation of 3 researchers from eligible countries. Meeting highlights for the IAEA Officer were presentations on treatment of electronic excitation, on quantum effects on the nuclear motion, and on developments with tight-binding DFT. Interests of ITER received special attention; they judge that the key issue for tritium retention in ITER is codeposition with beryllium, and ITER is also very interested in interaction of possible deliberate impurities neon and nitrogen with tungsten, and in multiscale multiphysics modeling of Edge Localized Modes (ELMs).

7.2.12. 6th workshop on Asian nuclear reaction database development

(Hosted at Hokkaido University, Sapporo, Japan, 15-17 September 2015)

IAEA officer: Naohiko Otsuka

The workshop was organized by Hokkaido University Nuclear Reaction Data Centre (JCPRG) and supported by the International Atomic Energy Agency. The purpose of the Workshop was to share information on activities of the nuclear data centres, EXFOR compilation, nuclear data evaluations, computational simulations and other related topics.

Objectives:

- Review the progress in the Nuclear Reaction Data Centres activities.
- Discuss new software developments related to the EXFOR compilation.
- Present results from some recent nuclear data measurements and evaluations.

Topics:

- Nuclear data activities in Asian Nuclear Data Centres.
- Progress in EXFOR compilation
- Development of the Asian Nuclear Reaction Database Network.
- Nuclear data measurement and experimental facilities.
- Computational nuclear reaction and nuclear data evaluation.

Actions:

- Topics related to the compilation activities such as: collection of data for different applications; updates in EXFOR compilation scope and rules; software developments etc. were presented by the participants.
- The Workshop Proceedings was published as **INDC(JPN)-0200** report.

Remarks/Outcomes:

- Participants from 8 countries attended the Workshop.
- The summary of the talks presented during the Workshop is included in the **INDC(JPN)-0200** report.

The 6th AASPP workshop continues the tradition to provide a forum for discussions and closer cooperation between Asian countries in the field of nuclear data measurements, compilations and evaluations.

7.2.13. Joint IAEA/ICTP nuclear data measurements for science and applications

(ICTP Trieste, Italy, 19–30 October 2015)

School Directors: S.P. Simakov (NDS/IAEA), D. Ridikas (Physics Section/IAEA), J. Niemela (ICTP)

A two-weeks School was organized by NDS and Physics Section of IAEA in collaboration with ICTP (Italy), n_TOF/CERN (Switzerland) and University of Sevilla (Spain). This event followed the recommendation of the IAEA Technical Meeting (Dec 2012, Budapest, Summary Report [IAEA-TECDOC-1743](#)): “Organization of periodic technical meetings, education and training workshops/schools is necessary to ensure knowledge transfer and preservation”. The program was aimed at delivering up-to-date knowledge on nuclear reaction physics and precise data measurements for both fundamental research and applications.

Objectives:

To introduce and deliver concise and updated information on nuclear reaction physics and nuclear data measurements required for both fundamental research and various applications for young physicists and engineers.

Topics:

- Needs and justifications for the high precision nuclear data measurements, actual status;
- Neutron sources, beam characteristics and instrumentations based on reactors and accelerators;
- Fundamentals and advances in nuclear data measurements of (n,tot), (n,el), (n,g), (n,f), (n,xn), (n,chp), neutron and gamma multiplicities, fission fragments, (g,xn), neutrinos, ... ;
- Data acquisition, normalization, correction and preliminary analysis; associated software;
- Determination of experimental errors and uncertainties;
- Introduction to covariance data and correlations associated with experimental data;
- Case-studies and procedures on measurements: hands-on-virtual experiments and data taking in small groups;
- Introduction to data evaluations and evaluated data files;
- Presentations of participants' own work.

Actions:

- The School was organised on 2 weeks basis with morning and afternoon sessions. All of them consisted of two 90 minutes lectures (or exercises) followed by questions and discussions;
- 25 lectures were presented by 22 Lecturers - the leading experts in these fields;
- 8 hands-on virtual experiments and trainings were held to teach students on the data acquisition and reduction in the specific experiments as well as on the retrieving the EXFOR and ENDF data from the NDS/IAEA server;
- 2 poster sessions were organized with eventual selection of the best posters and awarding with prizes sponsored by University of Sevilla (EU NeutAndalus project).

Remarks/Outcomes:

- 35 participants from 15 countries received training from lecturers and demonstrators. A few students from USA, Germany, and UK attended the workshop with support from their institutes.
- A face-to-face session produced constructive feedback. Students have learnt much about nuclear data and applications, made new contacts with lecturers, IAEA staff and other students.
- The lectures and exercises materials including video recordings are available from the School (smr 2741) web-page: <http://indico.ictp.it/event/a14288/>.

The joint IAEA/ICTP school served as a an opportunity for training and direct contacts with the top level researchers in this field for students coming from all over the world, in particularly from developing countries. The vital discussions and exchange of information have followed each lecture as well as two poster sessions. All of the objectives of the Scholl were successfully achieved.

8. COMPUTER SUPPORT

The highlights in IT services and systems development during 2014–2015 can be summarised as follows:

- Two high-end Dell Precision™ R7610 rack workstation, with 16 high-speed CPUs, were purchased and put into operation in 2014. These devices **calc1-nds.iaea.org** and **calc2-nds.iaea.org** are mostly used for scientific computing including Monte Carlo benchmark calculations (e.g., by using MCNP), nuclear reaction modelling and nuclear data evaluation. All Linux based PCs for calculations were decommissioned.
- Decision was made to introduce a failover load balancing technique for NDS web services on the ‘Cloud’. The Web Servers **www-nds.iaea.org** and **www-amdis.iaea.org** became two endpoints (nodes) each. The physical servers, representing the nodes are located in different datacentres across the globe. The physical load-balancer and their environment are under full control of the IAEA but are located outside the VIC.
- The two Staging servers **dev-nds.iaea.org** and **dev-amdis.iaea.org** were updated to the most recent operating system release and are used to run application tests and perform preliminary and final security scans. These machines are also used as the source for manual and automatic deployment to the cloud-based nodes. Location: IAEA Data Centre.
- The two servers **int-nds.iaea.org** and **int-amdis.iaea.org** were updated to the most recent operating system release and are used by NDS staff members to provide data-, code- and application development. Location: IAEA Data Centre.
- **nds121.iaea.org** was migrated from the unsupported Compaq ML350 server to Virtual Server located in the IAEA datacentre.
- The Microsoft based **Compaq ML350** server located within the NDS and being used by the NDSU for storing and sharing work related to EXFOR (compilations, scanned documents, etc.) was migrated to the IAEA internal storage area network and the unsupported server was decommissioned.
- Regular updates of NDS and partner databases, applications and provided services.

8.1. Computer networks

The following computers are located in the external Data Centre (‘Cloud’):

- 2 endpoints (nodes) of **www-nds.iaea.org** and 2 endpoints (nodes) of **www-amdis.iaea.org**, the primary Nuclear Data Section and Atomic and Molecular data units servers.
- Multiple (2x8) **traffic manager** (load balancer) around the globe.

The following NDS computers are located in the IAEA Data Centre on floor C-01:

- **dev-nds.iaea.org** and **dev-amdis.iaea.org**, the mirrors of primary Nuclear Data Section and Atomic and Molecular data units servers (only available internally).
- **int-nds.iaea.org** and **int-amdis.iaea.org**, the Nuclear Data Section and Atomic and Molecular data units data and code development servers (only accessible from the IAEA internal network).
- **calc1-nds.iaea.org** and **calc2-nds.iaea.org**, used for scientific computing (only accessible from the IAEA internal network).

- **nds121.iaea.org**, the NDS test and development server (only accessible from the IAEA internal network).

X Terminal access by NDS staff to development/computing servers is carried out through X-Win32 over SSH on their standard PCs or Laptops. This approach works from node to node on the NDS Ethernet and from nodes on the IAEA Intranet (OASIS) to the NDS network over secure firewall tunnels. SSH and Secure Copy are used for terminal emulation and file transfer, in compliance with IAEA IT security policy.

8.2. Data servers

8.2.1. Load balancing technique

In order to load balance two – NDS and AMDU – pairs of endpoints that are located in different datacentres across the globe, the incoming traffic will be directed to the closest endpoint, in terms of the lowest latency between the requesting client and the endpoint. Usually, the “closest” endpoint directly corresponds to the shortest geographic distance. The performance load balancing method allows distributing, basing on location and latency, but cannot taking into account real-time changes in network configuration or loading.

The used performance load balancing method locates the requesting client and refers it to the closest endpoint. “Closeness” is determined by an internet latency table showing the round trip time between various IP addresses and each cloud datacentre. This table is updated at periodic intervals and is not meant to be a real time reflection of performance across the Internet. It does not take into account the load on a given service, although the load balancer monitors NDS and AMDU endpoints based on the performance method and will not include them in DNS query responses if they are unavailable due to any crash or maintenance. In other words, the used performance load balancing method also incorporates the failover load balancing method.

The following steps are performed, assuming that the user is located in Western Europe:

1. Load Balancer builds the Internet Latency Table periodically. The Load Balancer infrastructure runs tests to determine the round trip times between different points in the world and the cloud datacentres that host endpoints.
2. Load Balancer receives an incoming request from a client through its local DNS server and locates the profile.
3. Load Balancer locates the row in the Internet Latency Table for the IP address of the incoming DNS request. Because the user's local DNS server is performing an iterative DNS query to find the authoritative DNS server for the Load Balancer profile name, the DNS query is sent from the IP address of the client's local DNS server.
4. Load Balancer locates the datacentre with the shortest time for the datacentres that host the endpoints defined in the profile. In our example, that is the West-Europe Datacentre.
5. Load Balancer returns West-Europe Datacentre's domain name to the client's local DNS server, which resolves the domain name to an IP address and sends it to the client.
6. The client initiates traffic to Western Europe Data centre.

8.2.2. Linux systems

The major nuclear and atomic and molecular data services are located in the cloud and are connected to the Internet from two web addresses: <http://www-nds.iaea.org/> and <http://www-amdis.iaea.org/> respectively. A second set of similar machines (**dev-nds.iaea.org** and **dev-amdis.iaea.org**) act as a test and deployment server where modifications, new applications etc. are tested before being moved to the main server. A third set of machines (**int-nds.iaea.org** and **int-amdis.iaea.org**) act as development servers where modifications, new applications etc. are developed before being tested and moved to the staging server. As mentioned earlier these four machines are logically located in the IAEA DMZ and located physically in the main computer room on C-01. No external access to **dev-nds.iaea.org**, **dev-amdis.iaea.org**, **int-nds.iaea.org**, **int-amdis.iaea.org**, **nds121.iaea.org**, **calc1-nds.iaea.org** and **calc2-nds.iaea.org** is granted.

8.2.3. Microsoft systems

NDS has been able to acquire enhanced access for certain members of staff to allow the installation of non-IAEA standard applications (e.g. FORTRAN compilers, X-windows, PDF manipulation etc.). NDS maintains a dedicated Microsoft Windows file server located inside the OASIS. This server is equipped with CD-ROM and DVD writers, and is used to store master copies of all data libraries and services distributable on CD-ROM, diskette and other media.

8.3. Software maintenance

NDS staff have continued to maintain the NDS relevant content in the IAEA Nuclear Information and Knowledge Portal (NUCLEUS), which allows public access to scientific, technical and regulatory data. The NUCLEUS portal can be accessed at <http://nucleus.iaea.org/>.

8.4. Hardware overview

Table 4 lists the main computer hardware during the reporting period of 2013–2014.

Table 4. NDS computer hardware for 2014–2015.

| Item | Quantity |
|--|----------|
| Servers (HP DL380 G7 Rack Mount Servers) | 2 |
| Servers (HP DL380 G5 Rack Mount Servers) | 2 |
| Dell Precision™ R7610 rack workstation | 2 |
| IAEA Standard Desktop PCs | 22 |
| Laptops (HP Notebooks) | 10 |
| HP LaserJet M3027 MFP Scanner/Printer | 1 |
| Tablets for testing applications iPad & Galaxy Tab | 2 |
| External Hard Drives (Backup) | 9 |

9. CONCLUDING REMARKS

The primary objective of the Nuclear Data Section is the provision of high quality atomic and nuclear data to the Member States. This has resulted in many outputs during 2014-2015. These include:

- Provision of workshops enabling a wide range of people to be trained in the use of atomic and nuclear data for applications as diverse as energy production, nuclear reaction modelling, analytical techniques, and EXFOR compilation.
- The EXFOR database has reached the milestone of 22,000 experimental works. Further improvements to searching, plotting and conversion to new user formats have been achieved.
- Evaluated files from various data development projects (JENDL-4.0u2, JEFF-3.2, TENDL-2014) have been made available.
- The Isotope Browser, an Android and Iphone app, has been further developed and is freely distributed for mobile platforms. This provides a summary data on more than 4,000 nuclides taken mainly from ENSDF. The number of downloads now exceeds 20,000.
- The web page providing access to all NDS publications has been updated with additional publications, improved structure, and searching facilities.
- Maintenance of ENSDF decay and structure data by the International Network of Nuclear Structure and Decay Data Evaluators under the coordination of the NDS. The range of data that can be displayed in the LiveChart web-based application has been extended.
- An extensive evaluation effort for U-235 and U-238 in the framework of the CIELO project, leading to new nuclear data libraries that are now being tested by the CIELO community. Related to this is a large publication in Nuclear Data Sheets on Prompt Fission Neutron Spectra presenting the IAEA CRP results.
- The dosimetry file, IRDFF, has been improved and has now reached version 1.05
- Development of a new version of Neutron Standards is continuing.
- Connection to other IAEA working areas has been established through nuclear data for radiation damage and nuclear data for safeguards.

NDS web services have now been transferred to the cloud and the physical servers are now located in different data centres across the globe. Meanwhile, more processors have become available, a total of about 80, for scientific calculations at NDS. A significant number of important technical reports were produced and in most cases ended up as scientific publications. Appendix III gives an overview. The same holds for conferences and workshops: A lot of important technical information and related material has been generated over the previous two years by NDS staff, and they have been able to demonstrate the high quality of these efforts through an impressive array of key papers and conference presentations.

The staff of the Nuclear Data Section also visited various conferences, workshops and other meetings in 2014-2015. The list is given below:

| | |
|---------------|---|
| R. Capote Noy | WS on Experimental and theoretical problems around actinides for future reactors, Paris, France, 17-28 March 2014 |
| P. Dimitriou | ICTP/IAEA WS on Nuclear Structure and Decay Data: Theory and Evaluation (Co-Director), Trieste, Italy, 24-28 March 2014 |
| S. Simakov | WS on Novel Measurements Techniques for Safety, Security and Safeguards, Oxford, United Kingdom, 27-28 March 2014 |
| A. Trkov | Joint Evaluated Fission and Fusion File (JEFF) project, NEA Headquarter, Paris, France, 21-26 April 2014 |
| R. Capote Noy | International WS on Nuclear Data Covariances, Los Alamos National Lab., New Mexico, USA, 28 April-5 May 2014 |
| A. Trkov | Meeting of the Collaborative Int. Evaluated Library Organization (CIELO) pilot project, NEA Headquarter, Paris, France, 12-14 May 2014 |
| S. Simakov | 15 th International Symposium on Reactor Dosimetry and Validation of IRDFF in the standard and IRDF-2002 Reference Neutron Fields, Aix en Provence, France, 18-23 May 2014 |
| V. Semkova | 22 nd International Seminar on Interaction of Neutrons with Nuclei (ISINN22), Dubna, Russia, 27-30 May 2014 |
| V. Semkova | 15 th International Symposium on Capture Gamma - Ray Spectroscopy and Related Topics (CGS15), Dresden, Germany, 24-30 August 2014 |
| V. Semkova | 5 th Asian WS on Nuclear Reaction Database Development, Mumbai, India, 20-25 September 2014 |
| S. Simakov | Joliot Curie School 2014 Neutrons and Nuclei, Frejus, France, 27 September-4 October 2014 |
| P. Dimitriou | Nuclear Structure 2014 and the 3 rd N. American WS on Beta-delayed Neutron Emission, Vancouver, Canada, 21-28 July 2014 |
| R. Capote Noy | THEORY-3 Scientific WS on Nuclear Fission Dynamics and the Emission of Prompt Neutrons and Gamma Rays, Opatija, Croatia, 16-18 September 2014 |
| P. Dimitriou | 15 th International Symposium on Capture Gamma-Ray Spectroscopy and related topics (CGS15), Dresden, Germany, 24-29 August 2014 |
| R. Capote Noy | Project Advisory Committee (PAC) meeting for the EU CHANDA project, Brussels, Belgium, 3-4 July 2014 |
| H-K. Chung | Joint IAEA-ITAMP Technical Meeting on Uncertainty Assessment for Theoretical Atomic and Molecular Scattering Data, Cambridge, MA, USA, 7-10 July 2014 |
| R.A. Forrest | PHYSOR International Conference 2014, Tokyo, Japan, 27 September-4 October 2014 |

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|---------------|--|
| B. Braams | 9 th International Conference on Atomic and Molecular Data and their Applications (ICAMDATA) and Annual Atomic Data and Analysis Structure (ADAS), Jena, Germany, 22-25 September 2014, and Warsaw, Poland, 29 September - 1 October 2014 |
| V. Zerkin | Joint IAEA/ICTP WS on Nuclear Reaction Data for Nuclear Power Applications, Trieste, Italy, 24-26 September 2014 |
| A. Trkov | WPEC SG-38 (GND) Meeting, BNL, 29-31 October 2014, CSEWG meeting, BNL, 3-7 November 2014; Scientific visit to NNDC, BNL, Upton, NY, USA, 10-14 November 2014 |
| A. Trkov | WINS 2014: WS on Elastic and Inelastic Neutron Scattering, Dresden, Germany, 3-5 December 2014 |
| P. Dimitriou | 5 th WS of the Decay Data Evaluation Project (DDEP), Bucharest-Magurele, Romani, 6-8 October 2014 |
| R. Capote Noy | WS on Nuclear Reaction Code –EMPIRE, Kochi, IND, 8-13 November 2014 |
| R. Capote Noy | Joint Evaluated Fission and Fusion File (JEFF) project 24-25 November 2014, Paris, France, 20-25 November 2014 |
| H-K. Chung | Joint ICTP-IAEA Conference on Models and Data for Plasma-Material Interaction in Fusion Devices, Trieste, Italy, 3-7 November 2014 |
| B. Braams | Joint ICTP-IAEA Conference on Models and Data for Plasma-Material Interaction in Fusion Devices, Trieste, Italy, 3-7 November 2014 |
| B. Braams | Joint ICTP-IAEA Advanced School and WS on Modern Methods in Plasma Spectroscopy, Trieste, Italy, 16-27 March 2015 |
| H-K. Chung | Joint ICTP-IAEA Advanced School and WS on Modern Methods in Plasma Spectroscopy, Trieste, Italy, 16-27 March 2015 |
| H-K. Chung | International Conference on Plasma Facing Materials and Components for Fusion Applications (PFMC 2015), Aix en Provence, France, 18-22 May 2015 |
| B. Braams | International WS on Models and Data for Plasma-Material Interaction in Fusion Devices (MoD-PMI), Marseille, France, 25-27 May 2015 |
| B. Braams | WS on Measurement Uncertainty at the BIPM, Sevres, France, 15-17 June 2015 |
| V. Semkova | 2 nd NAUSICAA WS at Institute Laue-Langevin (ILL), Grenoble, France, 29-30 June 2015 |
| A. Trkov | ICTP-IAEA WS on Nuclear Data for Neutron Dosimetry and Analytical Methods by Applying Research Reactors, Trieste, Italy, 20-24 April 2015 |
| A. Trkov | WPEC meeting SG-42, SG-40, NEA Data Bank, Paris, France, 18-22 May 2015 |
| V. Zerkin | Working Party on International Nuclear Data Evaluation Co-operation (WPEC) Subgroup 38, Issy-Les-Moulineaux, France, 20-22 May 2015 |
| R. Capote Noy | Varenna Nuclear Reaction Conference, Varenna, Italy, 15-19 June 2015 |

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|---------------|---|
| P. Dimitriou | 22 nd International Conference on Ion Beam Analysis, Opatija, Croatia, 15-19 June 2015 |
| B. Braams | 24 th International Symposium on Ion Atom Collisions (ISIAC), Barcelona, Spain, 19-21 July 2015 |
| H-K. Chung | XXIX International Conference on Photonic, Electronic and Atomic Collisions (ICPEAC), Toledo, Spain, 21-28 July 2015 |
| V. Semkova | 6 th Asian WS on Nuclear Reaction Database Development, Sapporo, Japan, 15-17 September 2015 |
| R. Capote Noy | WONDER 2015, NEA, France, 5-13 October 2015 |
| R. Capote Noy | CNR*15, Tokyo, Japan, 19-23 October 2015 |
| S. Simakov | ICTP-IAEA School Nuclear Data School for Science and Applications (Co-Director), Trieste, Italy, 19-23 October 2015 |
| V. Zerkov | Joint ICTP-IAEA School on Nuclear Data Measurements for Science and Applications in Collaboration with n_TOF/CERN, Trieste, Italy, 27-30 October 2015 |
| A. Koning | JEFF Nuclear Data Week, NEA, France, 30 November - 4 December 2015 |
| R. Capote Noy | CHANDA Program Advisory Committee, GRS Garching, Germany, 27 November 2015 |
| R. Capote Noy | US Nuclear Data Advisory Committee (US NDAC), BNL, USA, 2-6 November 2015 |
| A. Trkov | CSEWG at Nuclear Data Week, BNL, USA, 2-6 November 2015 |
| H-K. Chung | 9 th NLTE code comparison WS at Pierre and Marie Curie University, Paris, France, 1-4 December 2015 |

The impressive technical output and positive impact of the work of the Nuclear Data Section (NDS) illustrated above and in more detail throughout this report are indicative of the contributions made to Member States by the IAEA as a whole, and should be a source of pride and satisfaction to the Department of Nuclear Sciences and Applications and the IAEA.

APPENDICES

MEETINGS, SCIENTIFIC VISITS AND SPECIAL SERVICE AGREEMENTS IN 2014

| Month/ Duration | Responsible Officer | Type | Meeting Title/Type of Visit | Home Institute | Location |
|--------------------|------------------------|------|--|--|----------------|
| <u>January</u> | | | | | |
| 13 – 17 | Chung | CV | Christian Hill: advice on developing further the XSAMS interface to the ALADDIN database | Department of Physics & Astronomy, University College London | United Kingdom |
| <u>April</u> | | | | | |
| 07 – 11 | Dimitriou | RCM | 3. RCM: Development of a Reference Database for Particle-induced Gamma Ray Emission (PIGE) Spectroscopy | | Vienna |
| 07 – 11 | Dimitriou | CV | Iva Bogdanovich: advice at 3. RCM on Development of a Reference Database for Particle-induced Gamma Ray Emission (PIGE) Spectroscopy | Rudjer Boskovic, | Croatia |
| 07 – 11 | Braams | CV | Ane Lasa Esquisabel: work with the AMDU on classification and indexing of recent literature on plasma-material interaction in fusion devices | University of Helsinki | Finland |
| 10 – 11 | Braams | CV | Michael Bussmann: discuss the applications of FLYCHK and its extended versions to recent laser driven experiment | Helmholtzzentrum | Germany |
| 10 – 11 | Braams | CV | Iingen Huang: discuss the applications of FLYCHK and its extended versions to recent laser driven experiment | Helmholtzzentrum | Germany |
| 28 – 29 | Braams | TM | Technical Meeting: 19 th Meeting of the IFRC Sub-Committee on Atomic and Molecular Data for Fusion | | Vienna |

May

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|---------|---------|----|---|-----------------------------------|------------------------|
| 06 – 09 | Otsuka | TM | Technical Meeting: International Nuclear Reaction Data Centres (NRDC) | | Smolenice, Slovakia |
| 12 – 16 | Capote | CV | Mihaela Sin: advise on theoretical modelling of fission cross sections | Bucharest University | Romania |
| 15 – 16 | Forrest | CV | Zhigang Ge: to participate in the WPEC meeting | NEA, Headquarters | France |
| 26 – 27 | Simakov | CV | Albert C. Kahler: updates of the NJOY Code and fixing bugs found during the IRDFF database processing in ACE format | Los Alamos National Laboratory | USA |

June

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|---------|-----------|----|---|---|---------|
| 02 - 06 | Forrest | TM | Technical Meeting: 30th International Nuclear Data Committee (INDC) Meeting | | Vienna |
| 10 - 13 | Dimitriou | TM | Technical Meeting: Improvement of Analysis Codes for NSDD Evaluations | | Vienna |
| 10 - 13 | Capote | CV | Jagdish Tuli: to work on the review of the new discrete levels file for the Reference Input Parameter Library (RIPL) | Brookhaven National Laboratory | USA |
| 10 – 23 | Capote | CV | Efrem Soukhovitskii: work on parallelization of the optical model code OPTMAN | Energy and Nuclear Research Institute, | Belarus |
| 30 | Chung | CV | Vladimir Bernshtam: discuss application of IAEA Atomic and Molecular Databases for fusion and plasma applications. (NDS/AMDU) | Weizmann Institute of Science | Israel |

July

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|---------|-------|----|--|--|-------------------|
| 07 – 09 | Chung | TM | Technical Meeting: Joint IAEA-ITAMP Technical Meeting on Uncertainty Assessment and Theoretical Atomic and Molecular Scattering Data and Molecular Data Uncertainty Propagation for Calculated Atomic and Molecular Data | | Cambridge, USA |
|---------|-------|----|--|--|-------------------|

August

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|---------|--------|-----|---|---|---------|
| 04 – 08 | Braams | CV | Ane Lasa Esquisabel: advise on articles for inclusion in the A+M Bibliographic Data System (AMBDAS) | University of Helsinki | Finland |
| 18 – 19 | Braams | RCM | 2. RCM: Erosion and Tritium Retention for Beryllium Plasma-facing Materials | | Vienna |
| 18 – 19 | Braams | CV | Martin Koeppen: advise on and discuss data for plasma interaction with beryllium in particular about recent work at IPP Garching and planned work in the Tri-regio collaboration of Belgium, Netherlands and Germany. | Institute für Energie und Klimaforschung– Plasmaphysik | Germany |
| 20 | Braams | CM | Consultants’ Meeting: Plasma-material Interaction with Steel Surfaces | | Vienna |
| 25 - 26 | Capote | CV | Ludovi Bonneau: work on implementation of the Talmi transformation into the CASSINI computer code | Centre d’Etudes Nucleaires de Bordeaux | France |

September

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|------------------------------|-----------|-----|--|---|--------|
| 1 Sept.2014 – 31 Aug 2015 | Dimitriou | CSA | Michael Birch: write and deliver a platform-independent program to automatize the evaluation work involved in determining the adopted gamma-ray energy and intensity data and to re-writte the existing Visual Averaging Library code in Java. | McMaster University | Canada |
| 29 Sept.–2 Oct. | Capote | CV | Brett Vern Carlson: undertake DWBA calculations of deuteron reduced reactions and validate results vs existing experimental data for implementation into the EMPIRE code | Instituto Tecnológico de Aeronáutica (ITA) | Brazil |

October

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|---------|--------|-----|---|--|--------|
| 06 – 08 | Braams | RCM | 3. RCM: Spectroscopic and Collisional Data for Tungsten from 1 eV to 20 keV | | Vienna |
|---------|--------|-----|---|--|--------|

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|-----------------|---------|-----|--|--|---------|
| 06 – 08 | Braams | CV | Peter Beiersdorfer: give advice at the 3rd RCM on Precision Spectroscopic Data for Tungsten in Fusion Plasma and on X-ray Spectroscopy for ITER and other Fusion Experiments | Lawrence Livermore National Laboratory | USA |
| 06 – 08 | Braams | CV | Vladimir V. Nikulin: provide advisory capacity at the 3rd RCM on Spectroscopic and Collisional Data for Tungsten from 1eV to 20 keV | Ioffe Physical Technical Institute | Russia |
| 06 – 08 | Braams | CV | Jean-Francoise Wyart: provide advisory capacity at the 3. RCM on Spectroscopic and Collisional Data for Tungsten from 1eV to 20 keV | Centre Universitaire Paris-Sud 11 | France |
| 06 – 10 | Semkova | WS | Workshop: Experimental Nuclear Reaction Database | | Vienna |
| 06 – 10 | Capote | CV | Donald Smith: advise on evaluation methodology of prompt fission neutron spectra | Argonne National Laboratory | USA |
| 13 – 24 | Simakov | CV | Konstantin Zolotarev: Further development of the EXFOR Data Correction System and International Reactor Dosimetry and Fusion File (IRDFF) | | Russia |
| 20 – 24 | Simakov | CV | Valentin Sinita: advise on specific technical details and possible usage of GRUCON package for evaluated nuclear data processing including an oral presentation | Institute of Atomic Power Stations | Russia |
| 28 Oct.–28 Nov. | Capote | SSA | Daniel Lopez Aldama: to prepare a WIMS-D library based on ENDF/B-VII.1 data | | Cuba |
| <u>November</u> | | | | | |
| 03 – 07 | Capote | CV | Mihaela Sin: advise on improving the U-238 nuclear data evaluation | Bucharest University | Romania |
| 17 – 21 | Braams | CV | Evgeny Stambulchik: work on development of an SQL database of atomic data for use with the FLYFAC code for plasma spectroscopy | Weizmann Institute of Science | Israel |

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|---------------------------|-----------|-----|---|--|---------|
| 24 - 28 | Capote | CV | Efrem Soukhovitskii: advise on dispersive optical model potential with multiple band coupling for Pu-239 nucleus | Energy and Nuclear Research Institute | Belarus |
| <u>December</u> | | | | | |
| 01 Dec 2014 – 31 May 2015 | Trkov | CSA | Red Cullen: maintenance of the Pre-Pro codes which requires updates due to the extensions of the ENDF formats or due to specific requirements by the users. | | USA |
| 01 Dec 2014 – 30 Nov 2015 | Dimitriou | CSA | Theodoros J. Mertzimekis: expanding and upgrading an online database of available EM moments data to fill a lack of corresponding online presence that is updated on a continuous basis. To ensure wider visibility and accessibility by all Member States the database will be installed on the IAEA Nuclear Data Server, and will be made available as a stand-alone database and also through LiveChart. | University of Athens | Greece |
| 01 – 05 | Capote | TM | Technical Meeting: Current Status of Neutron Standards | | Vienna |
| 01 – 19 | Capote | SSA | Vladimir Pronyaev: finalize the document reporting on the outcomes of the Technical Meeting on Neutron Standards | | Russia |
| 08 – 12 | Capote | RCM | 2. RCM: Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production | | Vienna |
| 08 – 12 | Capote | CV | Jonathan Ward Engle: advise at 2 nd RCM on Nuclear data for charged-particle monitor reactions and medical isotope production | Los Alamos National Laboratory | USA |
| 08 – 12 | Capote | CV | Anatoly Ignatyuk: advise at 2 nd RCM on Nuclear data for charged-particle monitor reactions and medical isotope production | Institute of Physics and Power Engineering | Russia |
| 08 – 12 | Capote | CV | Filip Kondev: advise at 2 nd RCM on Nuclear data for charged-particle monitor reactions and medical isotope | Argonne National Laboratory | USA |

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|------------------------------|-----------|-----|---|----------------------|-------------------|
| | | | production | | |
| 08 – 17 | Capote | CV | Alan Nichols: advise at 2nd RCM on Nuclear data for charged-particle monitor reactions and medical isotope production | | United Kingdom |
| 10 Dec 2014 – 09 Jun 2015 | Otsuka | CSA | Svetlana Dunaeva: submission of updated EXFOR entries to remove errors recorded in the EXFOR Feedback System and to provide more experimental and numerical information; submission of electronic copies of articles published in proceedings of the Conference Series ‘Nuclear Spectroscopy and Nuclear Structure’ compiled in the EXFOR library | | Russia |
| 12 – 14 | Dimitriou | CV | Theodoros J. Mertzimekis: advise on online database of nuclear electromagnetic moments | University of Athens | Greece |
| 15 – 17 | Dimitriou | CM | Consultants’ Meeting: Status of Total Absorption Gamma-ray Spectroscopy Measurements for Decay Data Calculation | | Vienna |
| 15 – 19 | Capote | CV | Nicolae Carjan: advise on energy spectra calculations of scission neutrons emitted in thermal neutron induced fission of U-235 | | Daejeon, Korea |
| 15 – 19 | Braams | TM | Technical Meeting: IAEA-NFRI Meeting on Atomic and Plasma-Material Interaction Data for Fusion Science and Technology | | Daejeon, Korea |

MEETINGS, SCIENTIFIC VISITS AND SPECIAL SERVICE AGREEMENTS IN 2015

| Month/ Duration | Responsible Officer | Type | Meeting Title/Type of Visit | Home Institute | Location |
|------------------------------|------------------------|------|---|--------------------------------|----------|
| <u>February</u> | | | | | |
| 02 Feb – 30 Jun | Simakov | CSA | Nikolay Kornilov: Evaluation of the corrections and important functions for application of dynamic threshold method for investigation of the ^{252}Cf spontaneous fission spectrum in the energy range 2-20 MeV. | | USA |
| 16 Feb 2015 – 22 Feb 2016 | Naohiko | CSA | Anatoly Filatenkov: to publish all the KRI data, revise them with the latest reference parameters and bring the form of data presentation into accordance with the modern requirements of EXFOR format. | | Russia |
| <u>March</u> | | | | | |
| 02 – 13 | Capote | CV | Donald Smith: Discussion of PFNS evaluation methodology and drafting of the PFNS technical paper | Argonne National Laboratory | USA |
| 16 – 20 | Simakov | RCM | 2. RCM: Testing and Improving the International Reactor Dosimetry and Fusion File (IRDFF) | | Vienna |
| 16 – 20 | Simakov | CV | Konstantin Zolotarev: advise on evaluation of $^{238}\text{U}(\text{n},\text{g})$ and $^{238}\text{U}(\text{n},2\text{n})$ reactions cross sections, including analysis of microscopic and integral experimental data. | | Russia |
| 16 – 23 | Dimitriou | CV | Alejandro Sonzogni: advise on aggregate beta-delayed neutron data and to advise at the 2nd RCM on Reference Database for Beta-delayed Neutron Emission Evaluation | Brookhaven National Laboratory | USA |

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|---------|-----------|-----|---|--|----------------|
| 16 – 27 | Simakov | CV | Vladimir Pronyaev: advise and report on evaluation of $^{209}\text{Bi}(\text{n},\text{xn})$ reaction cross sections and prompt fission spectra for ^{239}Pu and ^{233}U | | Russia |
| 19 – 20 | Dimitriou | CV | Vladimir Piksaikin: advise on experimental data for delayed neutron decay curves and group parameters on the Reference Database of beta-delayed neutron emission | Institute of Physics and Power Engineering | Russia |
| 23 – 27 | Dimitriou | RCM | 2. RCM: Reference Database for Beta-delayed Neutron Emission Evaluation | | Vienna |
| 23 – 27 | Dimitriou | CV | Ivan Borzov: advise on the 2nd RCM on Reference Database for Beta-delayed Neutron Emission Evaluation | Institute of Physics and Power Engineering | Russia |
| 23 – 27 | Dimitriou | CV | Stephane Ciccone: advise on the 2nd RCM on Reference Database for Beta-delayed Neutron Emission Evaluation | TRIUMPF | Canada |
| 23 – 27 | Dimitriou | CV | Iris Dillmann: advise on the 2nd RCM on Reference Database for Beta-delayed Neutron Emission Evaluation | Justus Liebig University | Germany |
| 23 – 27 | Dimitriou | CV | Robert Grzywacz: advise on the 2nd RCM on Reference Database for Beta-delayed Neutron Emission Evaluation | Department of Physics and Astronomy | USA |
| 23 – 27 | Dimitriou | CV | David Mountford: advise on the 2nd RCM on Reference Database for Beta-delayed Neutron Emission Evaluation | National Nuclear Laboratory Ltd. | United Kingdom |
| 23 – 27 | Capote | CV | Balraj Singh: advise on the 2nd RCM on Reference Database for Beta-delayed Neutron Emission Evaluation | McMaster University | Canada |

April

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|-----------------|-----------|----|---|--|--------|
| 20 – 24 | Dimitriou | CV | Nicholas Stone: advise on the evaluation of nuclear moments and a transfer-of-knowledge project on evaluated nuclear moments data | Oak Ridge National Laboratory | USA |
| 20 – 29 | Dimitriou | CV | Filip Kondev: consult on NSDD issues and to advise on the validation of the Live Chart application | Argonne National Laboratory | USA |
| 20 – 24 | Dimitriou | TM | 21 st Technical Meeting: Nuclear Structure and Decay Data Network (NSDD) | | Vienna |
| 21 – 23 | Otsuka | TM | Technical Meeting: International Nuclear Reaction Data Centres (NRDC) | | Vienna |
| 27 – 29 | Dimitriou | WS | Specialized Workshop on Nuclear Structure and Decay Data Evaluation | | Vienna |
| 27 Apr – 01 May | Capote | CV | Ramona Vogt: advice on Monte Carlo calculations of prompt fission neutrons for neutron induced fission of actinides and assembly and review a proposed publication on the subject | Lawrence Livermore National Laboratory | USA |

May

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|---------|-----------|----|---|------------------------|-------------|
| 26 – 29 | Dimitriou | TM | Technical Meeting: Benchmarking Experiments for Ion Beam Analysis (IBA) | | Vienna |
| 26 – 29 | Dimitriou | CV | Adelaide Pedro de Jesus: advisory capacity at the Technical Meeting on Benchmarking Experiments for Ion Beam Analysis | Universidade de Lisboa | Portugal |
| 27 – 28 | Forrest | CV | Jiri Kopecky: discuss activation data suitable for additional validation of the FENDL-3 library | JUKO Research | Netherlands |

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|-----------------|---------|-----|--|---------------------------------------|--|----------------|
| <u>June</u> | | | | | | |
| 01 – 30 | | SSA | Daniel Lopez Aldama: implementation of the GRUCON code for nuclear data processing and demonstrates the operability of the system on selected practical benchmark problems; review of identified deficiencies in the FENDL-3.0 library and take corrective action. | | | Cuba |
| 01 – 12 | Capote | CV | Vladimir Pronyaev: advise on GMA fit of thermal Prompt Fission Spectra and prepare a draft of the PFNS paper | | | Russia |
| 08 – 19 | Simakov | CV | Valentin Sinitsa: deploy the computer code package GRUCON-D for nuclear cross section data processing: Installation, testing, planning of further development and cooperation | Institute of Atomic Power Stations | | Russia |
| 22 – 23 | Braams | CM | Consultants' Meeting: Uncertainty Assessment of Atomic and Molecular Data | | | Vienna |
| 22 – 23 | Capote | CM | Consultants' Meeting: Inelastic Scattering Data for Major Actinides | | | Vienna |
| 22 - 26 | Capote | CV | Efrem Soukhovitskii: undertake optical model cross section calculations for Pu-240 and Np-237 using extended coupling | Energy and Nuclear Research Institute | | Belarus |
| 25 June | Capote | CM | Consultant's Meeting: CHANDA Project Advisory Committee | | | Vienna |
| 29 Jun – 02 Jul | Simakov | RCM | 2. RCM: Primary Radiation Damage Cross Section | | | Vienna |
| 29 Jun – 02 Jul | Simakov | CV | Sergej Dudarev: provide advisory capacity to the 2nd RCM on Primary Radiation Damage Cross-Section | Culham Centre for Fusion Energy | | United Kingdom |
| 29 Jun – 02 Jul | Simakov | CV | Ulrich Fischer: provide advisory capacity to the 2nd RCM on Primary Radiation Damage Cross-Section | Karlsruher Institute for Technology | | Germany |

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|-----------------|---------|-----|---|---------------------------------|----------------|
| 29 Jun – 02 Jul | Simakov | CV | Mark Gilbert: provide advisory capacity to the 2nd RCM on Primary Radiation Damage Cross-Section | Culham Centre for Fusion Energy | United Kingdom |
| 29 Jun – 02 Jul | Simakov | CV | Dieter Leichtle: provide advisory capacity to the 2nd RCM on Primary Radiation Damage Cross-Section | ITER, Fusion for Energy | Spain |
| 29 Jun – 02 Jul | Simakov | CV | Laurence Luneville: provide advisory capacity to the 2nd RCM on Primary Radiation Damage Cross-Section | CEA CEN Saclay | France |
| 29 Jun – 02 Jul | Simakov | CV | Liu Ping: provide advisory capacity to the 2nd RCM on Primary Radiation Damage Cross-Section | China Nuclear Data Center | China |
| 29 Jun – 02 Jul | Simakov | CV | Qiujuan Zhao: provide advisory capacity to the 2nd RCM on Primary Radiation Damage Cross-Section | China Institute Atomic Energy | China |
| 29 Jun – 02 Jul | Simakov | CV | Petter Helgesson: provide advisory capacity to the 2nd RCM on Primary Radiation Damage Cross-Section | Uppsala University | Sweden |
| 29 Jun – 02 Jul | Simakov | CV | Rafael Vila: provide advisory capacity to the 2nd RCM on Primary Radiation Damage Cross-Section | CIEMAT | Spain |
| <u>July</u> | | | | | |
| 01 Jul – 31 Dec | Simakov | SSA | Konstantin Zolotarev: Evaluation of the Na23(n,g)Na24, Na23(n,2n)Na22 and Al27(n,2n)Al26 reaction cross sections for the IRDFF library; submission of new files in the ENDF format and Summary Report to NDS. | | Russia |
| 06 - 10 | Braams | CV | Evgeny Stambulchik: cooperate on development of Flexible Atomic Code (FAC) and its documentation, as well as use of FAC for spectroscopy | Weizmann Institute of Science | Israel |
| 06 - 10 | Braams | CV | Ming-Feng Gu: cooperate on development of Flexible Atomic Code (FAC) and its documentation, as well as use of FAC for spectroscopy | State College | PA, USA |
| 13 – 15 | Chung | CM | Consultants' Meeting: Evaluation and Uncertainty Assessment of Be, C and Ne Data | | Vienna |

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|-------------------|--------|-----|--|-------------------------------|--------------|
| 29 – 31 | Braams | TM | Technical Meeting: International Atomic and Molecular Code Centres Network on Simulation of Plasma-material Interaction Experiments | | Vienna |
| <u>September</u> | | | | | |
| 08 – 11 | Braams | CV | Shishir Deshpande: provide advisory capacity at the 2nd RCM on Plasma-Wall Interaction with Irradiated Tungsten and Tungsten Alloys in Fusion Devices | Institute for Plasma Research | India |
| 08 – 11 | Braams | CV | Gon Ho Kim: provide advisory capacity at the 2nd RCM on Plasma-Wall Interaction with Irradiated Tungsten and Tungsten Alloys in Fusion Devices | Seoul National University | Korea |
| 08 – 11 | Braams | CV | Heun Tae Lee: provide advisory capacity at the 2nd RCM on Plasma-Wall Interaction with Irradiated Tungsten and Tungsten Alloys in Fusion Devices | Osaka University | Japan |
| 08 – 11 | Braams | CV | Takuji Oda: provide advisory capacity at the 2nd RCM on Plasma-Wall Interaction with Irradiated Tungsten and Tungsten Alloys in Fusion Devices | Seoul National University | Korea |
| 08 – 11 | Braams | RCM | 2. RCM: Plasma-wall Interaction with irradiated Tungsten and Tungsten Alloys in fusion Devices | | Seoul, Korea |
| 14 – 16 | Braams | CM | Consultants' Meeting: Recommended Data for Atomic Processes of Tungsten Ions | | Seoul, Korea |
| 28 Sept. – 1 Oct. | Capote | CM | Consultants' Meeting: Compensating Effects due to Nuclear Reaction and Material Cross Correlations Related to CIELO Project | | Vienna |
| <u>October</u> | | | | | |
| 01 Oct – 31 Dec | Trkov | CSA | Dermott Edward Cullen: Develop a software module to extend the GROUPIE code of the PREPRO package to calculate Doppler-broadened self-shielded cross section in the unresolved resonance region and the corresponding multi-band parameters. | | USA |

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|---------|-----------|----|---|---|--------|
| 05 – 08 | Dimitriou | TM | 2 nd TM on Improvement of Analysis Codes for Nuclear Structure and Decay Data Evaluations | | Vienna |
| 05 – 08 | Zerkin | CV | Jagdish Tuli: advise on the further development and implementation of the IAEA MyEnsdf Webtools for the processing of ENSDF files and preparations of manuscripts for publication in Nuclear Data Sheets | Brookhaven National Laboratory | USA |
| 05 – 09 | Trkov | CM | Consultants' Meeting: New Evaluated Nuclear Data file Processing Capabilities Dates | | Vienna |
| 05 – 09 | Trkov | CV | Jeremy Conlin: to explain the LANL Position on the new format development and the current status on the development work on the new format, which will help the IAEA to plan its activities in the future | Los Alamos National Laboratory | USA |
| 05 – 09 | Trkov | CV | Caleb Mattoon: to explain the LANL Position on the new format development and the current status on the development work on the new format, which will help the IAEA to plan its activities in the future | Lawrence Livermore National Laboratory | USA |
| 05 – 09 | Trkov | CV | Bett Beck: to explain the LANL Position on the new format development and the current status on the development work on the new format, which will help the IAEA to plan its activities in the future | Lawrence Livermore National Laboratory | USA |
| 05 – 09 | Trkov | CV | Wim Haeck: to explain the LANL Position on the new format development and the current status on the development work on the new format, which will help the IAEA to plan its activities in the future | Institut de Radioprotection et de Surete Nucleaire (IRSN) | France |
| 12 – 16 | Otsuka | CV | Yosuke Iwamoto: advise on Application of Particle and Heavy-Ion Transport Code System (PHITS) to Corrections of Activation Cross-Sections | Japan Atomic Energy Agency | Japan |

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|-----------------|-----------|-----|---|--------------------------------------|----------------|
| 27 – 30 | Braams | CV | Stephen Buckman: advise about a proposed network of experimental physicists in the field of electron-molecule collision data and about best practices for evaluating electron-molecule collision data | Australian National University | Australia |
| 27 | Dimitriou | CV | Anastasios Lagoyannis: advise NDS on the maintenance and update of the Ion Beam Analysis Nuclear Data Library (IBANDL) | NCSR Demokritos | Greece |
| 27 – 28 | Braams | CV | Jonathan Tennyson: advise about guidelines for uncertainty quantification for calculated electron-molecule collision data | Department of Physics and Astronomy | United Kingdom |
| 29 – 30 | Braams | CV | Alfred Mueller: advise on a proposed network of experimental physicists who can provide electron-atom and electron-molecule collision data for fusion applications | Institut für Atom- und Molekulphysik | Germany |
| <u>November</u> | | | | | |
| 02 – 04 | Semkova | CM | Consultants' Meeting: EXFOR Compilation of Thermal Neutron Scattering Data | | Vienna |
| 02 – 04 | Semkova | CV | Florencia Cantargi: attend the ICTP Workshop in Trieste and to advise on EXFOR compilation of total cross section below thermal neutron energy | Centro Atómico Bariloche | Argentina |
| 02 – 04 | Braams | TM | Technical Meeting: International Atomic and Molecular Data Centre Network | | Vienna |
| 02 – 06 | Braams | CV | Peter Young: collaboration towards an evaluated and recommended data library for fusion applications | NASA Godard Space Flight Center | USA |
| 20 Nov – 18 Dec | Dimitriou | SSA | Michail Axiotis: work on alpha optical potential | | Greece |

December

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|---------|-----------|-----|--|---|-----------|
| 07 – 09 | Dimitriou | CM | Consultants' Meeting: R-matrix Codes for charged-particle Reactions in the Resolved-Resonance Region | | Vienna |
| 07 – 11 | Braams | CV | Martin Balden: review the database on properties of dust in fusion devices and populate it with data from NFRI and IPP Garching | Division of Plasma Edge and Wall | Germany |
| 07 – 11 | Braams | CV | Suk-ho Hong: review the database on properties of dust in fusion devices and populate it with data from NFRI and IPP Garching | National Fusion Research Institute | Korea |
| 07 – 18 | Chung | CV | Wonwook Lee: review and compile bibliographical data published in the field of electron-molecule and heavy particle collision processes in a fusion plasma environment | Nuclear Data Center, KAERI | Korea |
| 09 – 11 | Braams | RCM | 1. RCM: Plasma-wall Interaction with Low-activation Steel Surfaces in Fusion Devices | | Vienna |
| 14 – 16 | Dimitriou | CV | Claudia Montanari: advise on further development of the IAEA database on stopping powers | Instituto de Astronomía y Física del Espacio, CONICET | Argentina |
| 14 – 18 | Chung | CV | Makoto Imai: advise the IAEA about numerical and bibliographical data for heavy particle collision processes in a fusion plasma environment | | Japan |
| 16 – 18 | Dimitriou | CM | Consultants' Meeting: Assessment of the measurements of PIGE differential cross section data | | Vienna |

IAEA Contribution for Workshops and Meetings in 2014

| Name | Location | Dates |
|---|---|-----------------|
| 33 rd Joliot-Curie School on Neutrons and Nuclei <i>Contact person: Mr Khan</i> <i>IAEA officer: Stanislav</i> | La Villa Clythia, Frejus, Cote d' Azur FRANCE | 29 Sept - 3 Oct |
| 5 th AASPP workshop <i>Contact person: Mr Saxena</i> <i>IAEA officer: Naohiko</i> | Mumbai INDIA | 22-24 Sept |
| 16 th International Workshop on Radiative Properties of Hot Dense Matter (RPHDM) <i>IAEA officer: Hyun</i> | Park hotel Schönbrunn, Vienna, AUSTRIA | 29 Sept - 3 Oct |
| 5 th Workshop of the Decay Data Evaluation Project (DDEP-2014) <i>Contact person: Mr Zamfir</i> <i>IAEA officer: Vivian</i> | Bucharest-Magurele ROMANIA | 6-8 Oct |
| 3 rd School for Neutron Resonance Analysis <i>Contact person: Jon Billowes</i> <i>IAEA officer: Naohiko</i> | Geel, BELGIUM | 15-19 Dec |

IAEA Contribution for Workshops and Meetings in 2015

| Name | Location | Dates |
|---|---|--------------|
| 3 rd Spectral Line Shapes in Plasmas (SLSP) Code Comparison Workshop <i>Contact person: Annette Calisti</i> <i>IAEA Officer: Hyun Chung</i> | Aix University Marseille, FRANCE | 2-6 Mar |
| International Workshop on Models and Data for Plasma-Material in Fusion Devices <i>Contact person: Mr Ferro</i> <i>IAEA officer: Braams</i> | Campus of Aix- Marseille University in Marseille, FRANCE | 25-27 May |
| 6 th Workshop on Asian Nuclear Reaction Database Development <i>Contact Person: Prof. Dr. Masayuki Aikawa</i> <i>IAEA officer: Naohiko Otsuka</i> | Hokkaido University, Sapporo, JAPAN | 15-17 Sept |

Scientific Papers and Publications 2014 and 2015

Updated Photonuclear Data Library and Database for Photon Strength Functions

P. Dimitriou, R.B. Firestone, S. Siem, F. Becvar, M. Krticka, V.V. Varlamov, M. Wiedeking, *EPJ Web of Conferences* **93** (2015) 06004.

Excitation functions of deuteron-induced nuclear reactions on natural platinum up to 24 MeV

M.U. Khandaker, H. Haba, M. Murakami, N. Otsuka, H.A. Kassim, *Nucl. Instrum. Meth. B* **362** (2015) pp. 151-162.

Investigation of femtosecond collisional ionization rates in a solid-density aluminium plasma

S. M. Vinko, O. Ciricosta, T. R. Preston, D. S. Rackstraw, C.R.D. Brown, T. Burian, J. Chalupský, B. I. Cho, H.-K. Chung, K. Engelhorn, R. W. Falcone, R. Fiokovinini, V. Hájková, P. A. Heimann, L. Juha, H. J. Lee, R. W. Lee, M. Messerschmidt, B. Nagler, W. Schlotter et al. *Nature Communications* **6**. (2015) pp. 6397

High-accuracy determination of the $^{238}\text{U}/^{235}\text{U}$ fission cross section ratio up to ≈ 1 GeV at n_TOF at CERN

C. Paradela, M. Calviani, D. Tarrío, E. Leal-Cidoncha, L. S. Leong, L. Tassan-Got, C. Le Naour, I. Duran, N. Colonna, L. Audouin, M. Mastromarco, S. Lo Meo, A. Ventura, G. Aerts, S. Altstadt, H. Alvarez, F. Alvarez-Velarde, S. Andriamonje, J. Andrzejewski, G. Badurek, M. Barbagallo, P. Baumann, V. Bećares, F. Becvar, F. Belloni, B. Berthier, E. Berthoumieux, J. Billowes, V. Boccone, D. Bosnar, M. Brugger, F. Calvino, D. Cano-Ott, R. Capote, et al. (n_TOF Collaboration), *Phys. Rev. C* **91** 024602

TANGRA-Setup for the Investigation of Nuclear Fission induced by 14.1 MeV neutrons

I.N. Ruskov, Yu.N. Kopatch, V.M. Bystritsky, V.R. Skoy, V.N. Shvetsov, F.-J. Hambsch, S. Oberstedt, R. Capote Noy, P.V. Sedyshev, D.N. Grozdanov, I.Zh. Ivanov, V.Yu. Aleksakhin, E.P. Bogolubov, Yu.N. Barmakov, S.V. Khabarov, A.V. Krasnoperov, A.R. Krylov, J. Obhodaš, L.B. Pikelner, V.L. Rapatskiy, A.V. Rogachev, Yu.N. Rogov, V.I. Ryzhkov, A.B. Sadovsky, R.A. Salmin, M.G. Sapozhnikov, V.M. Slepnev, D. Sudac, O.G. Tarasov, V. Valkovic, D.I. Yurkov, N.I. Zamyatin, Sh.S. Zeynalov, A.O. Zontikov, E.V. Zubarev, *Physics Procedia* **64** (2015) pp. 163-170.

Evaluation of the Prompt Fission Neutron Spectrum of Thermal-neutron Induced Fission in U-235

A. Trkov, R. Capote, *Physics Procedia* **64** (2015) pp. 48-54.

Impact of the Normalization Condition and Model Information on Evaluated Prompt Fission Neutron Spectra and Associated Uncertainties

D. Neudecker, R. Capote, D.L. Smith, T. Burr, P. Talou, *Nucl. Sci. Engineering* **179** (2015) pp. 381-397.

Evaluation of the ^{239}Pu prompt fission neutron spectrum induced by neutrons of 500 keV and associated covariances

D. Neudecker, P. Talou, T. Kawanoa, D.L. Smith, R. Capote, M.E. Rising, A.C. Kahler, *Nucl. Instrum. Meth. A* **791** (2015) pp. 80-92.

Random Sampling of Correlated Parameters - a Consistent Solution for Unfavourable Conditions

G. Zerovnik, A. Trkov, I.A. Kodeli, R. Capote, D.L. Smith, *Nucl. Data Sheets* **123** (2015) pp. 185-190.

Preliminary Evaluation and Uncertainty Quantification of the Prompt Fission Neutron Spectrum of ^{239}Pu

D. Neudecker, P. Talou, T.N. Taddeucci, R.C. Haight, T. Kawano, H.Y. Lee, D.L. Smith, R. Capote, M.E. Rising, and M.C. White, *Nucl. Data Sheets* **123** (2015) pp. 146-152.

Recent Work Leading Towards a New Evaluation of the Neutron Standards

A.D. Carlson, V.G. Pronyaev, R. Capote, G.M. Hale, F.-J. Hambsch, T. Kawano, S. Kunieda, W. Mannhart, R.O. Nelson, D. Neudecker, P. Schillebeeckx, S. Simakov, D.L. Smith, P. Talou, X. Tao, A. Wallner, W. Wang, *Nucl. Data Sheets* **123** (2015) pp. 27-35.

Current Issues in Nuclear Data Evaluation Methodology: ^{235}U Prompt Fission Neutron Spectra and Multiplicity for Thermal Neutrons

A. Trkov, R. Capote, V.G. Pronyaev, *Nucl. Data Sheets* **123** (2015) pp. 8-15.

Production cross-sections of long-lived radionuclides in deuteron-induced reactions on natural zinc up to 23 MeV

M.U. Khandaker, H. Haba, M. Murakami, N. Otsuka, *Nucl. Instrum. Meth. B* **346** (2015) pp. 8-16.

Saturable Absorption of an X-Ray Free-Electron-Laser Heated Solid-Density Aluminum Plasma

D. S. Rackstraw, O. Ciricosta, S. M. Vinko, B. Barbrel, T. Burian, J. Chalupský B. I. Cho, H.-K. Chung, G. L. Dakovski, K. Engelhorn, V. Hájková, P. Heimann, M. Holmes, L. Juha, J. Krzywinski, R.W. Lee, S. Toleikis, J. J. Turner U. Zastra and J. S. Wark, *Phys. Rev. Lett.* **114** (2015) 015003

Definitions of radioisotope thick target yields

N. Otsuka and S. Takács, *Radiochim. Acta* **103** (2015) pp. 1-6.

Recent Work Leading Towards a New Evaluation of the Neutron Standards

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Opacity effects in a solid-density aluminium plasma created by photo-excitation with an X-ray laser

D. S., Rackstraw, S. M. Vinko, O. Ciricosta, B. I. Cho, K. Engelhorn, H.-K. Chung, & J. Wark, *High Energy Density Physics*, **11** (2014) pp. 59-69

Measurement and analysis of the ^{243}Am neutron capture cross section at the n_TOF facility at CERN

E. Mendoza, R. Capote, *et al.*, (n_TOF Collaboration) *Phys. Rev. C* **90** (2014) 034608

Uncertainties of mass extrapolations in Hartree-Fock-Bogoliubov mass models

S. Goriely, R. Capote, *Phys. Rev. C* **89** (2014) 054318

Neutron-induced fission cross section of ^{234}U measured at the CERN n_TOF facility

R. Sarmiento, P. Dimitriou, R. Capote, *et al.*, (n_TOF Collaboration), *Phys. Rev. C* **89** (2014) 044606

Evaluation of neutron-induced reactions on ^{238}U nucleus

R. Capote, M. Sin, A. Trkov, M.W. Herman, D. Bernard, G. Noguère, A. Daskalakis, Y. Danon, Procs. Workshop "Nuclear Measurements, Evaluations and Applications (NEMEA-7) Collaborative International Evaluated Library Organisation (CIELO)", 5-8 November 2013, Geel, Belgium, NEA/NSC/DOC(2014)13, OECD 2014, pp. 113-118

Neutron-induced reactions on U and Th – A new approach via AMS

A. Wallner, R. Capote, M. Christl, L.K. Fifield, M. Hotchkis, A. Krasa, J. Lachner, J. Lippold, A. Plompen, V. Semkova, M. Srncik, P. Steier, S. Tims, S. Winkler, Procs. Workshop "Nuclear Measurements, Evaluations and Applications (NEMEA-7) Collaborative International Evaluated Library Organisation (CIELO)", 5-8 November 2013, Geel, Belgium, NEA/NSC/DOC(2014)13, OECD 2014, pp. 159-167

Nuclear data for medical applications – Recent developments and future requirements

A.L. Nichols, R. Capote, *Nucl. Data Sheets* **120** (2014) pp. 239–241

Measurement of the MACS of $^{159}\text{Tb}(n,\gamma)$ at $kT = 30$ keV by activation

J. Praena, P.F. Mastinu, M. Pignatari, J.M. Quesada, R. Capote, Y. Morilla, *Nucl. Data Sheets* **120** (2014) pp. 205–207

EMPIRE: A reaction model code for nuclear astrophysics

A. Palumbo, M. Herman, R. Capote, *Nucl. Data Sheets* **120** (2014) pp. 180–183

Evaluation of neutron resonance cross section data at GELINA

P. Schillebeeckx, B. Becker, R. Capote, F. Emiliani, K. Guber, J. Heyse, K. Kauwenberghs, S. Kopecky, C. Lampoudis, C. Massimi, W. Mondelaers, M. Moxon, G. Noguere, A.J.M. Plompen, V. Pronyaev, P. Siegler, I. Sirakov, A. Trkov, K. Volev, G. Zerovnik, *Nucl. Data Sheets* **119** (2014) pp. 94–97

Study of $^{234}\text{U}(n,f)$ resonances measured at the CERN n_TOF facility

E. Leal-Cidoncha, R. Capote, *et al.*, *Nucl. Data Sheets* **119** (2014) pp. 42–44

Evaluation of the covariance matrix of estimated resonance parameters

B. Becker, R. Capote, S. Kopecky, C. Massimi, P. Schillebeeckx, I. Sirakov, K. Volev, *Nucl. Data Sheets* **118** (2014) pp. 381–383

Exclusive multiple emission cross sections in the hybrid Monte Carlo pre-equilibrium model and in EMPIRE-3.1

B.V. Carlson, L. Brito, D.F. Mega, R. Capote, M. Herman, M.E. Rego, *Nucl. Data Sheets* **118** (2014) pp. 276–279

Rotational-vibrational description of nucleon scattering on actinide nuclei using a dispersive coupled-channel optical model

J.M. Quesada, R. Capote, E.Sh. Soukhovitskiĭ, S. Chiba, *Nucl. Data Sheets* **118** (2014) pp. 270-272

Fitting prompt fission neutron spectra using Kalman filter integrated with Empire code

G.P.A. Nobre, M. Herman, S. Hoblit, A. Palumbo, R. Capote, A. Trkov, *Nucl. Data Sheets* **118** (2014) pp. 224-226

A fully Lane-consistent dispersive optical model potential for even Fe isotopes based on a soft-rotator model

W. Sun, R. Li, E.Sh. Soukhovitskiĭ, J.M. Quesada, R. Capote, *Nucl. Data Sheets* **118** (2014) pp. 191-194

Fluctuations above the resonance range in evaluated data of ^{55}Mn

A. Trkov, R. Capote, L.C. Leal, D.W. Muir, E.Sh. Soukhovitskiĭ, *Nucl. Data Sheets* **118** (2014) pp. 161-164

Zirconium evaluations for ENDF/B-VII.2 for the fast region

D.A. Brown, R. Arcilla, R. Capote, S.F. Mughabghab, M.W. Herman, A. Trkov, H.I. Kim, *Nucl. Data Sheets* **118** (2014) pp. 144–146

Physics of neutron interactions with ^{238}U : New developments and challenges

R. Capote, A. Trkov, M. Sin, M. Herman, A. Daskalakis, Y. Danon, *Nucl. Data Sheets* **118** (2014) pp. 26-31

Elastic and inelastic scattering of neutrons on ^{238}U nucleus

R. Capote, A. Trkov, M. Sin, M.W. Herman, E.Sh. Soukhovitskiĭ, *EPJ Web of Conferences* **69** 00008 (2014)

Quasi-differential neutron scattering from ^{238}U from 0.5 to 20 MeV

A.M. Daskalakis, R.M. Bahran, E.J. Blain, B.J. McDermott, S. Piela, Y. Danon, D.P. Barry, G. Leinweber, R.C. Block, M.J. Rapp, R. Capote, A. Trkov, *Ann. Nucl. Energy* **73** (2014) pp. 455-464

Recent Developments in the Experimental Nuclear Reaction Data Library EXFOR

V. Semkova, N. Otsuka, S. Simakov, V. Zerkov, *EPJ Web of Conferences* **66** 03078 (2014)

Measurement of Neutron Activation Cross Sections on Mo isotopes in the Energy Range from 7 MeV to 15 MeV

V. Semkova, Ralf Nolte, *EPJ Web of Conferences* **66** 03077 (2014)

Quality Assurance of the Cross-sections Measured on p+Li/C Source

M. Majerle, P. Bém, J. Novák, E. Šimečková, M. Štefánik, S. Simakov, and U. Fischer, *Nucl. Data Sheets* **119** (2014) 425-428

The Neutrons for Science Facility at SPIRAL-2

X. Ledoux, M. Aïche, M. Avrigeanu, V. Avrigeanu, L. Audouin, E. Balanzat, B. Ban-détat, G. Ban, G. Barreau, E. Bauge, G. Bélier, P. Bem, V. Blideanu, C. Borcea, S. Bouffard, T. Caillaud, A. Chatillon, S. Czajkowski, P. Dessagne, D. Doré, M. Fallot, F. Farget, U. Fischer, L. Giot, T. Granier, S. Guillous, F. Gunsing, C. Gustavsson, B. Jacquot, K. Jansson, B. Jurado, M. Kerveno, A. Klix, O. Landoas, F.R. Lecolley, J.L. Lecouey, M. Majerle, N. Marie, T. Materna, J. Mrazek, F. Negoita, J. Novak, S. Oberstedt, A. Oberstedt, S. Panebianco, L. Perrot, A.J.M. Plompen, S. Pomp, J.M. Ramillon, D. Ridikas, B. Rossé, G. Rudolf, O. Serot, S.P. Simakov, E. Simeckova, A.G. Smith, J.C. Sublet, J. Taieb, L. Tassan-Got, D. Tarrío, A. Takibayev, I. Thfoin, I. Tsekhanovich, and C. Varignon, *Nucl. Data Sheets* **119** (2014) 353-356

The CIELO Collaboration: Neutron Reactions on ^1H , ^{16}O , ^{56}Fe , $^{235,238}\text{U}$, and ^{239}Pu

M.B. Chadwick, E. Dupont, E. Bauge, A. Blokhin, O. Bouland, D.A. Brown, R. Capote, A. Carlson, Y. Danon, C. De Saint Jean, M. Dunn, U. Fischer, R.A. Forrest, S.C. Frankle, T. Fukahori, Z. Ge, S.M. Grimes, G.M. Hale, M. Herman, A. Ignatyuk, M. Ishikawa, N. Iwamoto, O. Iwamoto, M. Jandel, R. Jacqmin, T. Kawano, S. Kunieda, A. Kahler, B. Kiedrowski, I. Kodeli, A.J. Koning, L. Leal, Y.O. Lee, J.P. Lestone, C. Lubitz, M. MacInnes, D. McNabb, R. McKnight, M. Moxon, S.

Mughabghab, G. Noguere, G. Palmiotti, A. Plompen, B. Pritychenko, V. Pronyaev, D. Rochman, P. Romain, D. Roubtsov, P. Schillebeeckx, M. Salvatores, S. Simakov, E.Sh. Soukhovitskiĭ, J.C. Sublet, P. Talou, I. Thompson, A. Trkov, R. Vogt, and S. van der Marck, *Nucl. Data Sheets* **118** (2014) pp. 1-25

Working Party on International Nuclear Data Evaluation Cooperation (WPEC)

E. Dupont, M.B. Chadwick, Y. Danon, C. De Saint Jean, M. Dunn, U. Fischer, R.A. Forrest, T. Fukahori, Z. Ge, H. Harada, M. Herman, M. Igashira, A. Ignatyuk, M. Ishikawa, O. Iwamoto, R. Jacqmin, A.C. Kahler, T. Kawano, A.J. Koning, L. Leal, Y.O. Lee, R. McKnight, D. McNabb, R.W. Mills, G. Palmiotti, A. Plompen, M. Salvatores, and P. Schillebeeckx, *Nucl. Data Sheets* **118** (2014) 264-267

Deuteron-induced activation cross-sections on natural copper up to 24 MeV

M.U. Khandaker, H. Haba, M. Murakami, N. Otsuka, H.A. Kassim, and J. Radioanal. Nucl. Chem. **302** (2014) pp. 759-764.

Activation cross-sections of deuteron-induced nuclear reactions on natural titanium

M.U. Khandaker, H. Haba, J. Kanaya, N. Otsuka, H.A. Kassim, *Nucl. Data Sheets* **119** (2014) pp. 252-254.

Documentation of uncertainties in experimental cross sections for EXFOR

N. Otsuka, D.L. Smith, *Nucl. Data Sheets* **120** (2014) pp. 281-284.

First Compilation and Evaluation of Beta-Delayed Neutron Emission Probabilities and Associated Half-Lives for $A \leq 72$ Nuclei

M. Birch, B. Singh, D. Abriola, I. Dillmann, T.D. Johnson, E.A. McCutchan, and A.A. Sonzogni, *Nucl. Data Sheets* **120** (2014) 66–69

A New Approach to Estimating the Probability for β -delayed Neutron Emission

E.A. McCutchan, A.A. Sonzogni, T.D. Johnson, D. Abriola, M. Birch, and B. Singh, *Nucl. Data Sheets* **120** (2014) 62–65

Towards a More Complete and Accurate Experimental Nuclear Reaction Data Library (EXFOR): International Collaboration Between Nuclear Reaction Data Centres (NRDC)

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| Series and Number | Titles |
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| Newsletter | Nuclear data newsletter N ^{os} 57, 58, 59 and 60. |
| Technical Reports: | Atomic and Plasma-Material Interaction Data for Fusion, Tritium Inventory in Fusion Reactors, Vol. 16, IAEA, Vienna, Austria, 2014. |
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| IAEA-NDS-215 | NRDC Protocol (Protocol Cooperation between Nuclear Reaction Data Centres) |
| IAEA-NDS-217 | Program ENDF2C: Convert ENDF Data to Standard FORTRAN, C and C++ Format |
| IAEA-NDS-218 | EPICS2014: Electron Photon Interaction Cross Sections (Version 2014) |
| IAEA-NDS-219 | IBA-EVAL Charged-particle Cross-Section Library in ENDF-6 Format |
| IAEA-NDS-221 | POINT 2015: ENDF/B.VII.1 Final Temperature Dependent Cross Section Library |
| INDC-(NDS)-605 | Summary Report of the First Research Coordination Meeting (RCM) on Atomic and Molecular Data for the Resolved Modelling of Hydrogen and Helium |
| INDC-(NDS)-611 | FENDL-3.0 – Processing of Evaluated Nuclear Data |
| INDC-(NDS)-623 | Summary Report of the Second Research Coordination Meeting (RCM) on Spectroscopic and Collisional Data for Tungsten |
| INDC-(NDS)-631 | FENDL-3 Benchmarking Report |
| INDC-(NDS)-643 | Summary Report of the First Research Coordination Meeting (RCM) on Reference Database for Beta-delayed Neutron Emission Evaluation |
| INDC-(NDS)-653 | Summary Report of the Consultants' Meeting on Data Evaluation for Electron Collisions with Nitrogen |

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| INDC-(NDS)-654 | Summary Report of the Consultants' Meeting on Recommended Input Parameters for Fission Cross Section Calculation |
| INDC-(NDS)-655 | Summary Report of the Third Research Coordination Meeting (RCM) on Prompt Fission Neutron Spectra for Major Actinides |
| INDC-(NDS)-658 | Table of Nuclear Magnetic Dipole and Electric Quadrupole Moments |
| INDC-(NDS)-659 | ENDF/X: An Extended ENDF Format (Evolution, not Revolution) |
| INDC-(NDS)-660 | Development in the Ion Beam Analysis Nuclear Data Library |
| INDC-(NDS)-661 | Summary Report of the Technical Meeting of International Nuclear Reaction Data Centres |
| INDC-(NDS)-662 | Report of the IAEA Nuclear Data Section to the International Nuclear Data Committee for the Period January 2014 – December 2015 |
| INDC-(NDS)-663 | Standard Procedures for the IAEA Dust Database |
| INDC-(NDS)-664 | Summary Report of the Third Research Coordination Meeting (RCM) on Development of a Reference Database for Particle-Induced Gamma-Ray Emission (PIGE) Spectroscopy |
| INDC-(NDS)-665 | Summary Report of the Technical Meeting on Improvement of Analysis Code for Nuclear Structure and Decay Data (NSDD) Evaluations |
| INDC-(NDS)-666 | How Accurate are our Processed ENDF Cross Sections? |
| INDC-(NDS)-667 | Summary Report of the 19th Meeting of the IFRC Subcommittee on Atomic and Molecular Data for Fusion |
| INDC-(NDS)-668 | Evaluation Excitation Functions for $^{28}\text{Si}(n,p)^{28}\text{Al}$, $^{31}\text{P}(n,p)^{31}\text{Si}$ and $^{113}\text{In}(n,\gamma)^{114\text{m}}\text{In}$ |
| INDC-(NDS)-669 | Summary Report of the IAEA-ITAMP Technical Meeting on Uncertainty Assessment for Theoretical Atomic and Molecular Scattering Data |
| INDC-(NDS)-671 | Summary Report of the Consultants' Meeting on Plasma-material Interaction with Steel Surfaces |
| INDC-(NDS)-672 | Summary Report of the Workshop of the Experimental Nuclear Reaction Database |
| INDC-(NDS)-673 | Summary Report of the Third Research Coordination Meeting (RCM) on Spectroscopic and Collisional Data for Tungsten from 1eV to 20 keV |
| INDC-(NDS)-674 | Documentation for WIMSD-formatted libraries based on ENDF/B-VII.1 evaluated nuclear data files with extended actinide burn-up chains and cross section data up to 2000 K for fuel materials |

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| INDC-(NDS)-675 | Summary Report of the Second Research Coordination Meeting (RCM) on Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production |
| INDC-(NDS)-676 | Summary Report of the Consultants' Meeting on Total Absorption Gamma-ray Spectroscopy for Decay Heat Calculations and Other Applications |
| INDC-(NDS)-677 | Summary Report of the Technical Meeting on Current Status of Neutron Standards |
| INDC-(NDS)-678 | Prompt Fission Neutron Spectrum Evaluation Techniques |
| INDC-(NDS)-679 | Summary Report of the IAEA Technical Meeting on Atomic, Molecular and Plasma-Material Interaction Data for Fusion Science and Technology |
| INDC-(NDS)-680 | Summary Report of the Joint ICTP-IAEA Conference on Models and Data for Plasma-Material Interaction in Fusion Devices |
| INDC-(NDS)-681 | $^{209}\text{Bi}(\text{n},\text{f})$ and $^{\text{nat}}\text{Pb}(\text{n},\text{f})$ Cross Sections as a New Reference and Extension of the ^{235}U , ^{238}U and $^{239}\text{Pu}(\text{n},\text{f})$ Standards up to 1 GeV |
| INDC-(NDS)-682 | Summary Report of the Second Research Coordination Meeting (RCM) on Testing and Improving of the International Reactor Dosimetry and Fusion File (IRDFF) |
| INDC-(NDS)-683 | Summary Report of the Second Research Coordination Meeting (RCM) on Beta-delayed Neutron Emission Evaluation |
| INDC-(NDS)-684 | ENDF/B-VII.1 versus ENDF/B-VII.0 Comparison |
| INDC-(NDS)-685 | Summary Report of the Joint ICTP-IAEA Advanced School and Workshop on Modern Methods in Plasma Spectroscopy |
| INDC-(NDS)-686 | Summary Report of the Technical Meeting of International Network of Nuclear Reaction Data Centres (NRDC) |
| INDC-(NDS)-687 | Summary Report of the 21st Technical Meeting of International Network of Nuclear Structure and Decay Data (NSDD) Evaluators |
| INDC-(NDS)-688 | Summary Report of the Specialized Workshop on Nuclear Structure and Decay Data (NSDD) Evaluations |
| INDC-(NDS)-689 | High Resolution Measurements of Aggregate Delayed Neutron Spectra in Different Time Intervals from Thermal Neutron Induced Fission of ^{235}U |
| INDC-(NDS)-691 | Summary Report of the Second Research Coordination Meeting on Primary Radiation Damage Cross Section |
| INDC-(NDS)-693 | Supplementary Data for Neutron Activation Analysis |

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| INDC-(NDS)-696 | Summary Report of the Second Technical Meeting on Improvement of Analysis Codes for NSDD Evaluations |
| INDC-(NDS)-698 | Summary Report from the Consultants' Meeting on Uncertainty Assessment for Atomic and Molecular Data |
| INDC-(NDS)-699 | Summary Report from the Consultants' Meeting on Evaluation and Uncertainty Assessment for Be, C and Ne Atomic Data |
| INDC-(NDS)-701 | An Alternative Approach to Creating ACE Data Files for Use in Monte Carlo Codes |
| INDC-(NDS)-702 | Update of RIPL Nuclear Levels Segment |

| <u>Report</u> | <u>Country of Origin</u> | <u>Numbers of Reports</u> | <u>Total Reports</u> |
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| INDC(AUS) | Austria | 0019 | 1 |
| INDC(CCP) | Russian Federation | 0455, 0456, 0457, 0458, 0459 | 5 |
| INDC(EUR) | European Commission | 0032 | 1 |
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| INDC(KAS) | Kazakhstan | 0001 | 1 |
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| INDC(UK) | United Kingdom | 0094 | 1 |
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