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INDC International Nuclear Data Committee

Report of the IAEA Nuclear Data Section to the International Nuclear Data Committee for the period January 2012 – December 2013

Edited by

Roberto Capote Noy and Robin A. Forrest
IAEA Nuclear Data Section
Vienna, Austria

April 2014

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Abstract

This report contains details of the main activities of the IAEA Nuclear Data Section (NDS) during 2012 and 2013, 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.

April 2014

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Glossary of Abbreviations

A+M	Atomic and Molecular
ACE	A Compact ENDF library for MCNP Monte Carlo particle transport codes
ADLIST	Address List Database (IAEA Nuclear Data Section)
ADS	Accelerator Driven System
AMDC	Atomic Mass Data Centre
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
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
CM	Consultants' Meeting (of the IAEA)
CPND	Charged-particle nuclear data
CRP	Coordinated Research Project (of the IAEA (see also RCM))
CV	Consultancy Visit
DANIEL	Format of EXFOR Output Dictionaries
DBMS	Data Base Management System
DCN	Data Centre Network (IAEA)
DDP	Data Development Project
DMZ	De-Militarized Zone
EGAF	Evaluated Gamma-ray Activation File
EMPIRE	Nuclear reaction modelling code for calculating cross sections
ENDF	Evaluated Nuclear Data File
ENDVER	ENDF Verification software package
ENEA	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, Italy
ENSDF	Evaluated Nuclear Structure Data File
EU	European Union
EXFOR	Computer-based system for the compilation and international exchange of experimental nuclear reaction data (EXchange FORmat)
FENDL	Fusion Evaluated Nuclear Data Library
FTP	file transfer protocol
GENIE	General Internet Search Engine for atomic data
GUI	Graphics user interface
HINDAS	High and Intermediate energy Nuclear Data for Accelerator-driven Systems
HP	Hewlett Packard
IAEA	International Atomic Energy Agency, Vienna, Austria
IBA	Ion Beam Analysis
IBANDL	Ion Beam Analysis Nuclear Data Library
IBM	Interacting Boson Model
ICC	Internal Conversion Coefficient
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)
IPEN	Instituto de Pesquisas Energeticas e Nucleares
IPPE	Institute of Physics and Power Engineering, Russia
IRDF	International Reactor Dosimetry File (IAEA)
IRMM	Institute for Reference Materials and Measurements, Belgium
IT	Information Technology
ITER	International Thermonuclear Experimental Reactor

JEFF	Joint Evaluated Fission and Fusion Project (OECD/NEA-DB)
LANL	Los Alamos National Laboratory
MATXS	Material Cross Section Library
MCNP	Monte Carlo N-Particle code
MCNPX	Monte Carlo N-Particle eXtended code
MIRD	Medical Internal Radiation Dose format
MTIT	Division of Information Technology (IAEA)
n_TOF	neutron Time-Of-Flight (CERN experimental facility)
NAPC	Division of Physical and Chemical Sciences (IAEA)
NCDP	Nuclear Physics Data Center, Sarov, Russia
NDS	IAEA Nuclear Data Section, Vienna, Austria
NDS	IAEA Nuclear Data Services
NEA	Nuclear Energy Agency of the OECD, Paris, France
NEA-DB	Nuclear Energy Agency – Data Bank
NENP	Division of Nuclear Power (of the IAEA)
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
ORNL	Oak Ridge National Laboratory, Oak Ridge, USA
PC	Personal Computer
PDF	Portable Document Format
PGAA	Prompt Gamma Activation Analysis
POINT	Temperature Dependent Pointwise Cross Section Library series, based on ENDF/B
PREPRO	ENDF Pre-processing code
RAM	Random Access Memory
RCM	Research Coordination Meeting
RIPL	Reference Input Parameter Library
RNAL	Reference Neutron Activation Library
SAMMY	Resonance analysis code (ORNL, USA)
SMELS	Synthetic Multi-Element Standards
SSA	Special Service Agreement (IAEA)
SSH	Secure Shell
TAGS	Total Absorption Gamma-ray Spectroscopy
TECDOC	Technical Document series published by the IAEA
TM	Technical Meeting (IAEA)
TRANS	Collection of some EXFOR entries
UkrNDC	Ukrainian Nuclear Data Centre
VMS	Operating system of the Compaq Alpha Server
WIMS	Winfrith Improved Multigroup Scheme of reactor lattice codes
WINENDF	Package for storage/retrieval of ENDF files
WPEC	Working Party on international nuclear data Evaluation Cooperation (OECD)
WS	Workshop
XML	Extensible Mark-up Language
XnWlup	Graphical user interface to plot WIMS-D library multigroup cross sections

Preface

The IAEA Nuclear Data Section is one of four Sections within the Division of Physical and Chemical Sciences, 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 2012–2013. 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 A+M 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, while Appendix II summarizes all of the various publications during 2012–2013.

Fifty years of the IAEA Nuclear Data Programme: 1964-2014

Following recommendations to the Director General from the International Nuclear Data Scientific Working Group (INDSWG) under the Chairmanship of CH Westcott, the Nuclear Data Unit was set up in 1964. Its main objectives were to collect, compile and review nuclear data particularly those relevant for the worldwide fission reactor programs. INDSWG met four times with additional recommendations that NDU should organise international meetings, organise discussion between Nuclear Data producers in various countries and act as a Data Centre. INDSWG changed its name to INDC and has continued to review NDS' work and offer advice and recommendations.

NDU became the Nuclear Data Section in 1970 and has continued with its mission to provide accurate fundamental data to Member States and to act as a Coordination centre for Networks and as a stimulus for data work around the world. The ways of carrying out this mission have evolved and changed over the years becoming richer and more detailed with a much wider range of data considered, for example in 1977 the Atomic and Molecular (A+M) Data Unit was formed with the objective of providing fundamental data to advance fusion technology.

During the last fifty years the range of databases, tools, services and documents produced has been enormous and it is impossible to mention everything. A few examples are given to show how these have evolved to become the data products that are recognised worldwide today.

EXFOR - Experimental nuclear reaction data covering numerical (EXFOR) and bibliographic (CINDA) data have been a central concern of NDS since the earliest days and have evolved from punched cards to modern retrieval and visualization tools. In 1965 NDU began to contribute to the bibliographic index CINDA and in the following year the data storage and retrieval system DASTAR and the CINDA type index CINDU (Catalogue of the IAEA Nuclear Data Unit) were established. DASTAR records were later converted to EXFOR. In 2005 the merging of EXFOR libraries from NDS, NEA-DB, NNDC and the Kurchatov

Institute was done resulting in a centralized EXFOR maintenance system established at NDS (the global EXFOR Master file). In 2008 the EXFOR PDF collection started, in 2011 CINDA was produced essentially automatically and in 2013 the milestone of 20,000 experimental works was reached.

Standards - Starting in 1967, meetings on neutron cross section standards led to the Neutron Standards file released in 1982, continuing to a release in 2005 (STI/PUB/1291) and to the current work on a new evaluation.

X- and Gamma-ray standards resulting from a CRP started in 1986 generated the report IAEA-TECDOC-619, 1991. This was updated in 2007, in STI/PUB/1287.

Decay data studies started with a CRP in 1987, when decay data for actinides was generated. The most recent dataset resulting from a further CRP was published in 2013 (STI/PUB/1618).

Data for dosimetry was considered with a CM in 1973, a comprehensive review was written in 1978 (IAEA-208) and led to IRDF-2002 (STI/DOC/010/452) which is currently being updated and being validated as the IRDFF library in a CRP.

Medical - Starting with a CM on Nuclear Data for Medical Radioisotope Production in 1981 there were a series of meeting in the 1980s looking at data needs and a CRP starting in 1987 on neutron therapy. The latter resulted in a report (IAEA-TECDOC-992) giving the status. Monitor reactions play the role of 'standards' for charged particle reactions and a database was produced (IAEA-TECDOC-1211) covering these and the production of diagnostic radionuclides. Therapeutic radionuclides were also considered in a CRP from 2003-2006 resulting in a major report (STI/DOC/010/473). Accelerators used in treatments can be modelled with Monte Carlo codes, and require a detailed description of the source. Such data are available as a 'Phase-space' file, and these have been collected in a Phase-space database on the NDS medical portal (<https://www-nds.iaea.org/medportal/>).

FENDL - Nuclear data for fusion was a new area of work recognised in the early 1970s. A commitment to produce a data library suitable for fusion was made in 1989 with the FENDL CRP. The aim was to consider all data needs for fusion, general purpose, activation, decay and dosimetry. As well as producing the FENDL-1 library in 1995, the process of inter-comparison of the various regional libraries was very important and started a method of working that has continued to this day. FENDL-2 and 2.1 followed in 1997 and 2004, the latter was the reference data library for the ITER project. FENDL-3 (<https://www-nds.iaea.org/fendl30/>) was completed in 2013.

Analytical – A CM on Nuclear Data for Bore-hole and Bulk-media Assay Using Nuclear Techniques was held in 1982. Continued with meetings in 1984, 1986, in 1999 a CRP started on Prompt Gamma-ray Neutron Activation Analysis, completing in 2003 with a report (STI/PUB/1263) published in 2007. For Ion Beam Analysis existing databases were combined and IBANDL was created in 2003. A CRP initiated in 2005 and completing in 2009 improved the database (although the final report is still awaited). Since 2013 there has been closer link with EXFOR to add data. A CRP on PIGE started in 2011; data from this are also being stored in IBANDL.

RIPL - Starting with a CRP in 1994, the project of collecting the many input parameters required for theoretical model code calculations was began (IAEA-TECDOC-1034). This continued with a second (IAEA-TECDOC-1506) and third CRP ([Nuclear Data Sheets 110 \(2009\) 3107–3214](#)). Currently all data are available on a website (<https://www-nds.iaea.org/RIPL-3/>) and a fourth CRP to focus on fission aspects is proposed.

Many other nuclear and atomic data ‘brand names’ should be mentioned: ALADDIN, AMBDAS, CINDA, EMPIRE, ENDF, ENSDF, GANDR, GENIE, IBANDL, IRDF, IRDFF, LiveChart, MANREAD, NSR, PREPRO and ZVView. Some of these originate from NDS and for other we have made major contributions. A final example to show how far we have come is *Isotope Browser*, which is a freely distributed Android App containing summary information on over 4000 nuclides made available for mobile platforms in 2013.

These achievements have only been possible because of the many technical contributions of all the NDS staff, the guidance of the INDC, the collaborations with Data Centres, and the participants of the CRPs and data development projects. Nuclear data continues to be in great demand today and NDS has a role to play in the future as the community considers new formats, methods of collaboration, methods of distribution and takes advantage of the incredible computer power currently available.

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April 2014

Nuclear Data Section

Organization Chart

(April 2014)

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Nuclear Data Physicist
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(21710)

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

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 2012–2013 was effectively a total of 17.25, consisting of 12 professionals (P-staff) and 5.25 support staff (G-staff). However, due to Agency wide reductions in support staff, following the retirement of K. Sheikh at the end of 2013 the post will be abolished.

The Unit Heads have been:

- Bastiaan Braams, Atomic and Molecular Data Unit (AMDU);
- Stanislav Simakov, Nuclear Data Services Unit (NDSU);
- Daniel Abriola (retired March 2013), Nuclear Data Development Unit (NDDU);
- Roberto Capote Noy (started April 2013), Nuclear Data Development Unit (NDDU),

All of whom, except Daniel Abriola have contributed to this report.

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

- Janet Roberts retired January 2013.
- Mark Kellett left February 2012 at the end of his contract.
- Paraskevi (Vivian) Dimitriou started as Nuclear Physicist in the NDDU (June 2012).
- Lidija Vrapcenzak became Nuclear Data Services Assistant (started February 2013).
- Kyoto Viitaniemi was the temporary Section secretary (February - May 2013)
- Rosalinda Rangel Alvarez became Section secretary (July 2013)
- Kira Nathani took a temporary reassignment in Monaco (started October 2013).
- Ann Jensby took a temporary assignment in the NNDU (started December 2013).
- Andras Vasaros became IT Systems Engineer following a period of temporary assignment in the post (started August 2013).
- Strictly just outside the reporting period, A. Trkov started as Nuclear Physicist in January 2014.

The budget and costs of NDS are outlined in Table 1 in Euro. Data for 2011, 2012 and 2013 are in 2012 prices and are taken from PROBIS. Data for 2014 and 2015 are in 2014 prices and are taken from AIPS in 2014 prices, but note that the total is taken from Programme and Budget 2014-2015. It can be seen that the amount actually spent on the programme fell drastically in 2012 and while slightly recovering this year is still much less than in 2011.

Table 1. Staff and budget - summary for 2011–2015 (derived from PROBIS/AIPS).

	2011	2012	2013	2014	2015
Authorized Staff Level	17.25	17.25	17.25	16.25	16.25
Actual Staff Level	16.92	17.25	15.14	16.00*	15.50*
Salary + Agency O/H Support Costs(€)	2 031 348	2 217 955	2 217 936	1 921 671†	1 921 671†
Technical Programme(€)	829 302	626 299	630 654	673 637†	673 637†
Total (€)	2 860 650	2 844 254	2 848 590	2 685 712	2 685 712

*estimated figures † estimated figures from AIPS, but sum taken from P&B 2014-2015

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 report to INDC in May 2012, NDS staff have produced and distributed three regular transmissions of the EXFOR/CINDA dictionaries (TRANS 9104-9106) 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. Migration to Linux and Windows was done for several dictionary processing codes originally written for VMS, thus the dictionary update no longer requires the DEC Alpha server (ndsalpha) maintained by NDS for many years.

During 2012–2013 (03 Sept), NDS staff distributed: (i) 11 charged-particle TRANS files (D081–D089, S015 and S016) containing 163 new entries and 115 revised entries; (ii) 9 neutron TRANS files (3154–3160 and V030-V031) containing 51 new and 131 revised entries; (iii) 4 photonuclear TRANS files (G024–G027) containing 23 new and 28 revised entries. 61 new entries were compiled at NDS, 21 at UkrNDC, 32 at ATOMKI, 86 by NDPCI, 24 at CNDC, and 13 at KAERI. 48 entries with automatic corrections were included in TRANS.Y008.

92 TRANS files were received, checked (with feedback to the originating centres) and processed in 2012–2013 (03 Sept), 87 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 752 neutron entries (122 new, 630 revised), 1116 CPND entries (514 new, 642 revised) and 335 photonuclear entries (49 new, 286 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 missed in EXFOR. Several working documents (Memos), which summarise the lists of such data, were prepared.

Due to these efforts the following data were added to EXFOR during the reporting period:

- **MACS + Atlas.** NDS is maintaining a series of EXFOR entries specialized for evaluated data not included in data libraries in ENDF Format (EXFOR-VIEN file). The Maxwellian averaged cross sections (MACS) at $kT = 30$ keV recommended by the Karlsruhe group have been recognized as useful for validation of evaluated point-wise cross sections, and they were compiled in EXFOR V0102 by NDS. The thermal neutron cross sections and some other useful constants (e.g., resonance integrals) recommended by Mughabghab in his "Atlas of Neutron Resonances (2006)" are also frequently used, and they were compiled in EXFOR V1001 ($Z \leq 50$) and V1002 ($Z \geq 51$) by NNDC.
- **PFNS.** Prompt-fission neutron spectra (PFNS) are essential for fission energy applications and also for validation of dosimetry cross sections. Communication between

NRDC and PFNS EXFOR entry users was not well established in the past, and it was not very easy to extract and utilize all necessary data sets in EXFOR. In order to improve the situation, in collaboration with the currently ongoing CRP on PFNS, NDS made an effort to improve both completeness and quality of PFNS EXFOR entries with the help of other data centres (CJD, NEA DB and NNDC). For PFNS of neutron-induced or spontaneous fissions for Am and Cm isotopes, only one experimental work performed at Khlopin Radium Institute supported by an ISTC project is known, and all data were finally compiled by NDS and JAEA. Consistency of quantity indication (REACTION code) among existing EXFOR entries was also improved in order to make search of PFNS data sets easier.

- For the needs of nuclear data for **medical applications**, comparison between the references cited in Volume 13 of Landolt-Börnstein (LB) New Series (Springer Verlag) and EXFOR was continued for light-charged particle (p,d,t,³He,α) induced reaction activation cross sections. In total 185 missing experimental works were newly identified, analysed, and proposed to other centres for compilation.
- The need for inclusion of **beta-delayed neutron data** (emission probabilities and neutron spectra) in a database was pointed out during the “Beta-delayed neutron emission evaluation” Consultants’ Meeting (INDC(NDS)-0599) and at the 1st RCM of the CRP on Beta-delayed Neutron Emission Data. The possibilities for compilation of delayed-neutron emission probabilities (P_n) and neutron energy spectra for individual precursors in EXFOR data library were assessed and discussed. The existing rules for compilation of delayed-neutron emission probabilities were revised. A new reaction coding for the beta-delayed neutron energy spectra from individual precursors, currently not compiled in EXFOR, was developed. A proposal for compilation of beta-delayed neutron energy spectra from individual precursors on a voluntary basis was prepared. The proposal will be presented at the next Technical Meeting of the International Network of Nuclear Reaction Data Centres in May 2014. Articles reporting experimental data were collected. The articles will be assigned for compilation of corresponding data centres after approval of the proposal.

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:

- Systematic checking of EXFOR data sets has been carried out for neutron-induced threshold reactions (n,2n), (n,p) and (n,α) in collaboration with NRG and the NEA Data Bank. NRG compared these EXFOR data sets with TALYS/TENDL and other libraries, and also checked **suspicious data sets** against the source articles. The list of errors was verified with the source articles once again at NDS. More than 30 erroneous EXFOR data sets were identified, and registered to the EXFOR Feedback system for correction by originating centres.
- Analysis of **duplicated information** in EXFOR entries has continued. NDS is currently working on three potential systematic duplications: (1) D-T neutron activation cross sections measured at OKTAVIAN (Osaka Univ.) by K. Kawade et al.; (2) high energy proton-induced activation cross sections measured at JINR by A.R. Balabekyan et al.; (3)

intermediate and high energy proton-induced activation cross sections measured at Uppsala, CERN, LANL, SATURNE and other facilities by R. Michel et al.. For all these cases, the compilation was done several times from preliminary and final publications. The analysis has been completed for the third item, resulting in the addition of superseded flags for about 450 data points, carried out by the originating data centre. The analysis is still continuing for the first and second items in collaboration with these authors (c.f. Recommendation 2.1 of the 29th INDC meeting Working Group 2).

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 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 36,000 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. The listing and collection of English translations has been done for Atomnaya Energiya (Atomic Energy), Yadernya Fizika (Soviet Journal of Nuclear Physics / Physics of Atomic Nuclei) and Yadernaya Konstany (Nuclear Constant). This project is continuing for Izvestiya Akademii Nauk SSSR, Seriya Fizicheskaya (Bulletin of Academy of Sciences Ser. Physics), Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki (JETP), Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki Pis'ma v Redaktsiyu (JETP Letters) and Doklady Akademii Nauk (Soviet Physics Doklady).

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 Entries in 2013: there are now more than 20,000 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 Consultants' Meeting on Benchmarking of Digitizing software was held from 12 to 14 November 2012 in Vienna to discuss the quality and consistency of digitized data in EXFOR. Prior to the meeting a benchmark exercise was initiated within the International Network of the Nuclear Reaction Data Centres (NRDC). The digitized datasets received from the compilers were compared with the original authors' data and the results were discussed during the meeting. The meeting was attended by software developers who presented the latest versions of the digitizing codes GSYS, InpGraph and GDgraph. Further developments based on feedback from compilers were discussed during the meeting. A list of recommendations to

software developers, EXFOR compilers and the NRDC coordinator was distributed after the meeting in order to improve the quality of the digitized data.

The Summary of Meeting was distributed as the report INDC(NDS)-0629.

A Consultants' Meeting on EXFOR Data in Resonance Region and Spectrometer's Response Function was organized from 8 to 12 October 2013 in Vienna. Regarding the neutron-induced reaction cross section data in the resonance region, typically only the resonance parameters have been compiled in EXFOR. In some cases the transmission or reaction yield is given, however, without the necessary information to analyse them properly. For example the time-of-flight bins are already transformed into energy bins without specifying the response function of the spectrometer. In addition, essential sample characteristics are missing. Therefore, to make optimum use of the results of such experiments for an evaluation of cross section data in the resonance region, it would be advisable to have the experimental observables available in a form that can be used to extract the required parameters. Scientists from different facilities providing data in the resonance range, such as GELINA (IRMM, Belgium), J-PARC (Japan), n_TOF (CERN), ORELA (Oak Ridge, USA) and RPI (NY, USA) took part in the meeting. Nuclear data measurements, analysis and EXFOR reporting were discussed. Recommendations for compilation of experimental data in the resonance region, including spectrometer response functions at the different TOF facilities were prepared.

The Summary of Meeting was distributed as the report INDC(NDS)-0647.

2.3. CINDA

The CINDA database was extended by information automatically imported from EXFOR (four updates) and from NSR (four updates). Manual compilation has stopped. An algorithm and software for importing data from NSR to CINDA were developed. All information, complete Master files and TRANS files in CINDA exchange format are available on the NDS web site. Full back up files (for MySQL database) were regularly produced and sent to NNDC, where they were loaded onto the database server and used for the Web retrieval system.

3. NUCLEAR DATA SERVICES

3.1. Web-based services and software

The main links to provide services are continuously updated on the NDS web server (<http://www-nds.iaea.org/>). An improved version of the NDS front page has been developed and implemented. 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 web retrieval interface has been extended to cover:
 - TENDL-2011, TENDL-2012: TALYS-based Evaluated Nuclear Data Library.
 - ENDF/B-VII.1: US Evaluated Nuclear Data Library, 2011-2012.

- JEFF-3.1.2: Joint Evaluated Fission and Fusion File, coordinated by NEA Data Bank, 2012.
- ENDF/B-V.2: General Purpose File and Standards (converted to ENDF-6 format), USA, 1994.
- IRDFF: International Reactor Dosimetry and Fusion File, IAEA-2012.
- New output formats for the EXFOR Web retrieval system (software was developed):
 - EXFOR in XML v3 with interpretation to HTML using XLS, schema and Web checking.
 - C5M computational format: C5 + automatically calculated correlation matrix.
- EXFOR data correction system was extended to include automatic re-normalization of old data to modern standard cross sections (available under Web retrieval system).
- NDS PDF collection of EXFOR papers was extended to have papers from NSR (available via EXFOR Web retrieval system for authorized users outside of the IAEA).
- Web interface to IBANDL and SigmaCalc data was redesigned from scratch according to requirements of IT security (it became part of the EXFOR-ENDF-CINDA package). Web-ZVView package was extended by several new functions (including the option of plotting ratios of evaluated data and distortion of the output picture to imitate the original picture during digitizing of bad quality data for EXFOR).
- EXFOR-CINDA dictionaries database has been prepared and regularly updated.
- Full EXFOR in C4 computational format was regularly produced and delivered to WPEC Subgroup 30. C5M for full EXFOR was generated for the GANDR project.
- 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:

- The set of web tools for EXFOR compilers was extended by “Coding and checking EXFOR references” allowing the editing of reference codes using Dictionaries and the ability to search existing references in CINDA and NSR.
- The set of web tools for ENDF evaluators was extended by PREPRO-2012 and “endf2gnd” converter to GND (XML) format (LLNL package Fudge).
- The set of web tools for ENSDF evaluators was extended by RADLIST.
- Web interface for Empire-3.1 package was created and connected to Web-ENDF uploading system.

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.
- It was extended to include structure and decay data from:
 - RIPL-3: Reference Input Parameter Library, Nuclear Levels Segment, 2012.
 - ENDF/B-VII.1: US Evaluated Nuclear Data Library, 2011-2012.

- JEFF-3.1.2: Joint Evaluated Fission and Fusion File, provided by the NEA Data Bank in 2012.
- The web-retrieval application was changed from Java-applet to HTML-javascript.
- A visualisation of nuclides decay-chain on the nuclide chart was implemented.
- An embedded plotting engine was implemented.
- The usability of the application was improved according to Section's staff advice, and users' feedback.
- An application for Android mobile devices, containing a reduced version of the relational database and a query interface, was made available on Google and Amazon app-distribution platforms.

As noted above, a major effort was put in changing the technology of the web-based applications to avoid the use of Java-applets, since this technology is becoming obsolete and its use means that the ability to use a wide range of platforms is difficult. This upgrade has made the services more browser friendly, resulting in an increase of user numbers.

The use of a relational database to store structure and decay data has made it possible to easily compare the basic nuclide properties across several different libraries, the results have fed into the preparation of a new release of the RIPL discrete levels segment.

Fulfilling the Section mission of “providing rapid access to reliable nuclear data” entails following users' preferences platforms, which in the recent years have shifted towards the use of mobile devices. To provide data to this new market, the section developed an application for mobile devices equipped with an Android operating system. The first working prototype was ready at the end of 2011, but its final release was delayed to focus on strengthening the security of the section IT infrastructure.

Called Isotope Browser, the app is based on a simpler version of the database underlying Livechart, and was released in July 2013. It has reached 5,000 users in the first 8 months, with many of them providing feedback which will be implemented in future releases. The plan is to prepare an updated version twice per year.

3.2. CD-ROM based services and Publications Management

CD-ROM and Document Services

During 2012-2013 in total 942 PC media (CD-ROMs and DVDs) were delivered as well as 193 hardcopy documents (INDC reports, Charts of Nuclides, Nuclear Wallet Cards, etc.).

The publications webpage (<https://www-nds.iaea.org/publications/>), started in 2011, is regularly updated with new documents, and now about 3,000 documents can be downloaded. The availability of documents on-line has also reduced the need for hardcopies to be sent to experts. Following that development, the ND Newsletters are also routinely sent electronically.

In 2012-2013 there were four Newsletter issues. They have been very well received and for many scientists they have proved to be a good way to stay informed about developments in the nuclear data field.

Some hardcopies of reports and newsletter have been sent upon request, the reduction in hardcopies means that we contribute to the greening of IAEA as well as to the overall savings policy.

Publications management

While finalizing the project of the scanning of all available INDC reports, and during the

search for many missing reports, the Nuclear Data Section Library has proved to be a valuable source of information. In order to make maximum use of the documents available, it was absolutely necessary to have a complete catalogue of the available items. Many of the reports that were requested through the IAEA Library were later discovered during a search for some other document in the NDS Library.

To improve accessibility, a project of cataloguing all the items in the NDS library was started in May 2013 in cooperation with staff from the main IAEA library. NDS will remain the primary custodian for all the documents, which will physically remain in the NDS library. However, the documents will be part of the main library catalogue, and will therefore be much easier to search and locate and can also be accessed by non-NDS staff. So far 1200 records have been catalogued, which covers approximately one third of all the documents available. In addition, this project will also include the cataloguing of all the Conference proceedings that NDS has available in hardcopy (330 books dating from 1957-present day).

Since the publications web page was made available for public use in 2011, it has become one of the most accessed sections of the www-nds web site.

CD-ROM Services

- CD-ROM “EXFOR-CINDA Database and Retrieval System for Windows” two issues;
- CD-ROM “EXFOR-CINDA for Applications with Endver/GUI” for Linux/Windows/Mac: six issues (available via Web).
- DVD-ROM with three CD-ROMs above and CD-ROM with collection of 29 ENDF libraries was prepared and issued. This single DVD-ROM will replace CD-ROMs distribution listed above.
- New DVD-ROM “Portable Empire-3.2.2 for Windows” was developed (available on Web)

3.3. Statistics

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

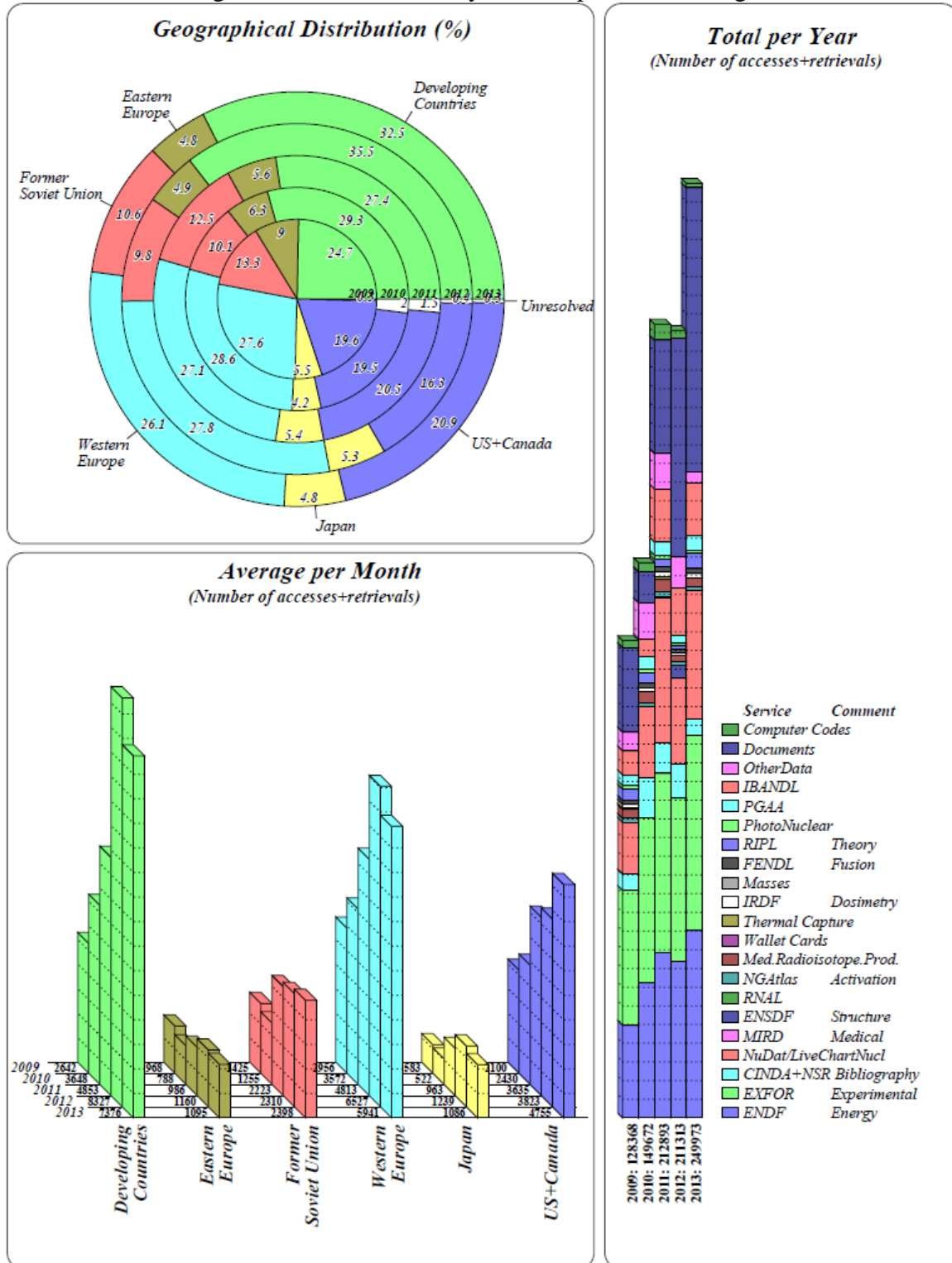


Fig. 1. Nuclear data access and retrievals from IAEA-NDS, 2009–2013.

This figure and table present the external user access to the IAEA NDS web server and to the mirror servers in Brazil (until 2012), India and China (since 2013), including distribution over geographical area and technical topics. The total number of data and documents retrievals has

increased by 15-30% per year during the last five years (the drop during 2012 was a result of unavailability of NDS web services caused by the security threat). It can be seen that the increased demand arises mainly from customers for ENDF and EXFOR as well as for the NuDat and LiveChart databases. Noteworthy is that the number of queries from the USA, Canada, Western Europe and developing countries all show an increasing trend.

Table 2. Statistics of internet access to the main databases and documents for the period 2009-2013.

Database	2009	2010	2011	2012	2013
ENDF	24 812	36 170	44 279	43 0826	52 100
EXFOR	36 095	44 150	47 878	41 031	52 077
LiveChart	13 821	18 989	38 711	22 567	31 247
Documents	22 608	8 275	30 300	57 443	77 075
Others	53 640	42 088	51 725	46 446	37 474
Total	128 368	149 672	212 893	211 313	249 973

4. NETWORK COORDINATION

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

NDS assists the International Network of Nuclear Reaction Data Centres by organising its annual coordination meetings. This network consists of 14 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 OECD NEA, Issy-les-Moulineaux, France, from 16 to 19 April 2012 (see INDC(NDS)-0618). This combined meeting was attended by 20 participants and IAEA staff from 13 cooperating data centres of eight Member States and two international organizations. In total 43 working papers were presented at the meeting and the results of the discussions were summarized as 20 Conclusions and 74 Actions. Significantly improved format for uncertainty and covariance was discussed and approved.

The Technical Meeting of the International Network of Nuclear Reaction Data Centres was held at IAEA Headquarters in Vienna, Austria, from 23 to 25 April 2013 (see INDC(NDS)-0633). The meeting was attended by 16 participants and IAEA staff from 13 cooperating data centres of eight Member States and two international organizations. In total 36 working papers were presented at the meeting and the results of the discussions were summarized as 22 Conclusions and 75 Actions. The meeting participants agreed that an EXFOR entry should not be created from the data published in conference proceedings when the authors are reluctant to provide numerical data for EXFOR compilation within a five year period. (c.f. Recommendation 1.9 of the 28th INDC meeting Working Group 2).

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 (IAEA-NDS) to CNDC. Discussion on compilation of Chinese experimental nuclear reaction data published in Chinese journals. 29–31 October 2012.

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

Biennial meetings of the International Network of Nuclear Structure and Decay Data Evaluators (NSDD) are funded and organized under the auspices of NDS. The 20th meeting of the NSDD network was held in Kuwait City, Kuwait, 27-31 January 2013 (INDC(NDS)-0635). This meeting was hosted by KFAS and the Kuwait University Physics Department. It was attended by 36 scientists from 17 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. Specific mass chain activities, horizontal evaluations and technical issues were debated over the final three 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 updating and modernizing the ENSDF analysis codes, as well as providing re-fresher training to the existing less-experienced 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, three out of the six supported evaluators have successfully completed their mass-chain evaluations under their IAEA contracts. In addition, an updated table of Nuclear Magnetic Dipole and Electric Quadrupole Moments, and a table of Recommended Electric Quadrupole Moments have been published under the contractual services agreement of N.J. Stone (INDC(NDS)-0658, INDC(NDS)-0650, respectively).

NDS staff will continue to support and coordinate the efforts of the network, by focussing future activities on the two major issues raised at the 20th meeting, i.e. improving the ENSDF analysis codes and offering specialized training to less-experienced evaluators. 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 the years 2012-2013, the NDS paid 37 000 Euro for contracts with six NSDD evaluators to perform mass chain evaluations, and one evaluator to perform horizontal evaluation (Atomic Mass Evaluation 2012). In more detail:

Abusaleem (Jordan): 5000 Euro

Dhindsa (India): 6000 Euro

Erturk (Turkey): 7500 Euro

Lalkovski (Bulgaria): 4000 Euro

Negret (Romania): 6000 Euro-contract successfully closed in 2013

Timar (Hungary): 4500 Euro

Wang (China): 4000 Euro-contract successfully closed in 2013.

Two contracts were closed successfully in 2013 and 5 contracts remain active.

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 and meetings devoted to the development of XML standards for exchange of A+M and PMI data. Once every two to three years the Unit organizes a workshop addressed primarily to young researchers in the area of plasma modelling with use of A+M+PMI data, and at times the unit cooperates in more advanced workshops. In its work 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 Data Centre Network (DCN). The IFRC Subcommittee on Atomic and Molecular Data and the Data Centres Network 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 A+M Data Unit and are recommended data at the time of their compilation.

Several further numerical datasets that do not fit well into the ALADDIN framework are accessible through the A+M Data Unit 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).

In 2012-2013 a comprehensive collection of calculated data based on the Flexible Atomic Code (FAC) [Can. J. Phys. 86: 675-689 (2008)] was added 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). It is intended to integrate these FAC data with the FLYCHK code to support spectroscopic modelling of quasi-stationary multicomponent plasma.

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 2012-2013 the structure and spectra part of AMBDAS was updated with bibliographical data obtained from the NIST Atomic Spectra bibliographical databases.

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 A+M 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 2012-2013.

5.4. Coordinated Research Projects

The A+M Data Unit has an active programme of CRPs. One CRP had its final Research Coordination Meeting (RCM) in 2012-2013, two CRPs had their second RCM in 2012-2013 and will meet again in the next biennium and two new CRPs had their first RCM in 2012-2013.

The CRP on Light Element Atom, Molecule and Radical Behaviour in the Divertor and Edge Plasma Regions held its third and final meeting in March 2013. This CRP is 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. Hydrogen isotopes constitute the fuel of fusion reactors, helium is the product of the fusion reaction, lithium is used for beam diagnostics and also as a wall material, beryllium is a wall material for JET and ITER, boron is used as a coating material in fusion vessels, carbon is often used in divertor target plates, nitrogen is used as a buffer gas and oxygen is a ubiquitous impurity. A final report is being prepared for publication in the IOP Journal of Physics: Conference Series.

The CRP on Spectroscopic and Collisional Data for Tungsten from 1 eV to 20 keV had its second RCM in August 2012 and will meet again in 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 is to support the interpretation of spectroscopic measurements of tungsten in all regions of the plasma from the wall to the core.

The CRP on Atomic and Molecular Data for State-Resolved Modelling of Hydrogen and Helium and their Isotopes in Fusion Plasma held its second RCM in July 2013. This CRP is devoted to the development of data for collisional, photon-induced and radiative processes for species H, H⁺, H⁻, He, He⁺, He²⁺, He⁻, H₂, H₂⁺, H₃⁺, HeH⁺, He₂⁺ 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 first meeting in September 2012. 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 to be studied in the 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 will address 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 most recent CRP of the Unit is on Plasma-Wall Interaction with Irradiated Tungsten and Tungsten Alloys in Fusion Devices which had its first RCM in November 2013. 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 will be impacted the wrong way by the neutron fluence 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.

5.5. Data and Code Centre Networks and other meetings

The Data Centre Network (DCN) meets every two years to discuss data needs and coordinate activities. At their meeting in September 2013 at the IAEA in Vienna, participants discussed their activities on data development and data exchange, data evaluation and provision of recommended data, data exchange formats, bibliographical database maintenance, and priorities for new data development, evaluation and information exchange. These are all topics in which the data centres have a shared interest. Especially in the area of data evaluation there has been much new activity since the previous meeting of the DCN. The DCN meeting participants share a strong interest in systematic group evaluations of A+M collision data such as have been done recently in connection with the EU-funded EMOL project for electron scattering on several molecular targets and in meetings organized by NFRI specifically for electron-methane collisions.

The Code Centre Network (CCN) had its third meeting in May 2013 at the IAEA in Vienna. This meeting was coordinated with a meeting of the EMOL project, which met back-to-back with our CCN for their first evaluation, which was on electron-water molecule collision data. On one day participants of the EMOL group joined the CCN meeting to share the recommendations of the CCN meeting on uncertainty estimates of theoretical data and discuss data evaluation activities. The CCN meeting also benefited from interaction with nuclear data colleagues on the Unified Monte Carlo procedure for uncertainty assessment of nuclear cross section data. This CCN meeting made an inventory of many issues for provision of uncertainty estimates for calculated data, which vary between the type of target (atomic or molecular), the nature of the calculation (variety of computational methods) and the type of output that is considered (differential or integrated). The meeting is a part of an A+M Data Unit effort to develop community consensus on guidelines for uncertainty estimates for calculated scattering data. The CCN meeting also shared participants with the adjoining

Consultancy Meeting on “Auger electron emission from nuclear decay: Data needs for medical applications”, which is reported in Section 6.1.9.

Several other meetings were held on topics connected to data evaluation and uncertainty estimates. In February 2012 there was a Consultants’ Meeting held at the National Institute for Fusion Science (NIFS) in Japan on procedures for evaluation of atomic, molecular and plasma-material interaction data for fusion. This CM was organized at NIFS because of strong evaluation activities in Korea and Japan. Five scientists from Korea attended, one from China and five from Japan. A related consultancy meeting was held in Vienna in June 2012 with 7 participants from fusion research, A+M data centres and A+M physics.

The “Joint IAEA-NFRI Technical Meeting on Data Evaluation for Atomic, Molecular and Plasma-Material Interaction Processes in Fusion” was held in September 2012 in Daejeon, Korea in conjunction with the one-day “8th International Symposium on Standard Reference Data” organized by the Korean Research Institute of Standards and Science (KRISS). This Technical Meeting attracted 27 participants from 11 countries. In addition to the presentations there were extended discussion sessions on error propagation and sensitivity analysis, current status of evaluated databases, evaluation of theoretical and experimental data sets, evaluation methods and the role of semi-empirical fits. Invited papers from this TM have been published as a special issue of the journal Fusion Science and Technology.

The Unit cooperated with the Weizmann Institute of Science in the organization of the First Spectral Line Shapes in Plasmas (SLSP) code comparison workshop in April 2012 and, due to its success, the Second SLSP code comparison workshop in August 2013, both meetings held in Vienna. These workshops followed the model of the well-established Non-local Thermodynamic Equilibrium code comparison workshops. The nature of the workshop is that 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. Line shapes are used in plasma diagnostics, hence our interest. Each of these meetings attracted about 20 participants.

5.6. Other A+M activities

The “XML Schema for Atoms, Molecules and Solids” (XSAMS), developed under coordination by the A+M Data Unit, was adopted by the EU Framework-7 Virtual Atomic and Molecular Data Centre (VAMDC) project in 2010 and in the following years it became established for about 25 databases that participate in VAMDC. A Consultants Meeting on XSAMS was held in conjunction with a VAMDC project meeting on the Campus of the University of Vienna in February 2012. This meeting reviewed developments of XSAMS and agreed on a joint standard for the International and the VAMDC XSAMS version 1.0. At present, activities around XSAMS are concentrated on user tools and broader implementation. Further development of the Schema, for instance with respect to particle-surface interaction data, is not a priority.

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, Contractual 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;
- 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 (CRPs)

An extended historical perspective of CRPs within the NDS can be seen in Fig. 2 which covers the previous 9 years of such activities (2005–2013), and the planned activities for 2014 and beyond. As can be seen from this figure sufficient CRP commitments presently exist, and plans concerning future years are already being made on the basis of the envisaged completion dates of various on-going CRPs and previous recommendations of the INDC.

During the course of 2012–2013 there were six Nuclear Data (ND) CRPs at different stages of development, which are summarized in Table 3, along with other relevant CRPs, from where it can also be seen that six ND CRPs were completed over the 2010–2011 time period. Two new CRPs were approved in 2012 and another two in 2013 for which contracts/agreements were awarded, and their first RCMs convened.

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

No.	Short title	Duration	Participants (contracts)	Project Officer	Status	Section
1	Nuclear data for the production of therapeutic radionuclides	2003–2007	9 (4)	Capote Noy	Completed (2012) IAEA TRS 473 and webpage	6.1.1
2	Reference database for ion beam analysis	2005–2010	10 (4)	Abriola (Capote Noy)	Completed/ document in preparation	6.1.2
3	Reference database for neutron activation analysis	2005–2010	7 (4)	Kellett (Dimitriou/Trkov)	Completed/ document in preparation	6.1.3
4	Updated decay data library for actinides	2005–2010	7 (4)	Kellett (Capote Noy)	Completed (2013) Technical report STI/PUB/1618	6.1.4
5	Heavy charged-particle interaction data for radiotherapy	2007–2011	12 (2)	Capote Noy	Completed/ document in preparation	6.1.5
6	Minor actinide neutron reaction data (MANREAD)	2007–2011	12 (4)	Otsuka	Completed/ document in preparation	6.1.6
7	Nuclear data libraries for advanced systems: fusion devices (FENDL-3)	2007–2011	15 (3)	Forrest	Completed (2013) Webpage and reports INDC(NDS)-0645 INDC(NDS)-0628	6.1.7
8	Prompt fission neutron spectra for actinides	2009–2013	12 (6)	Capote Noy	On-going	6.1.8
9	Charged-Particle Monitor Reactions and Nuclear Data for Medical Isotope Production	2012–2016	13 (6) +1 CSA	Capote Noy	On-going	6.1.9
10	Development of a reference database for Particle Induced Gamma Ray Emission (PIGE)	2011–2015	10 (5)	Dimitriou (Abriola)	On-going	6.1.10
11	Testing and Improving the International Reactor Dosimetry and Fusion File (IRDF)	2013–2017	11 (4)	Simakov	On-going	6.1.11
12	Primary radiation damage cross sections	2013–2017	16 (0)	Simakov	On-going	6.1.12
13	Reference database for beta-delayed neutron emission	2013–2017	10 (2)	Dimitriou	On-going	6.1.13
14	RIPL for fission cross section calculations	2014–2018	--	Capote Noy	Planned	6.1.14
15	Reference database of compiled and evaluated gamma-ray data	2015–2019	--	Dimitriou	Planned	6.1.15

Fig. 2. Coordinated Research Projects - previous 11 years and the immediate future.

CRPs - Technical reports	10 2005	10 2006	12 2007	11 2008	12 2009	11 2010	8 2011	(8) 2012	(8) 2013	(6) 2014	(6) 2015	(3) 2016
STI/PUB/1291 (2007) (Pronyaev) & Nuclear Data Sheets 110 (2009) (Carlson) International evaluation of neutron cross section standards			STI/PUB		PAPER				New DDP			
STI/PUB/1435 (2010) (Trkov/Capote Noy/Nichols) Evaluated nuclear data for nuclides within Thorium Uranium fuel cycle						STI/PUB						
Nuclear Data Sheets 110 (2009) (Capote Noy) RIPL-3					PAPER							
Technical Report Series 473 (2011) (Capote Noy) Nuclear data for production of therapeutic radionuclides								TRS				
Technical report (Abriola/Capote Noy) Reference database for ion beam analysis (IBA)										Planned		
Technical report (Trkov/Kellet/Dimitriou) Reference database for neutron activation analysis										Planned		
Technical report (Kellett) Updated decay data library for actinides									STI/PUB			
Technical report (Capote Noy) Heavy charged-particle interaction data for radiotherapy (CHARPAR)											Planned	
Technical report (Otsuka) Minor actinide neutron reaction data (MANREAD)											Planned	
Technical report (Forrest) ND libraries for advanced systems: fusion devices (FENDL-3)									2 INDC			
Technical report (Capote Noy) Prompt fission neutron spectra of actinides												Planned
Technical report (Dimitriou) Reference database of Particle-Induced Gamma-ray Emission (PIGE)												
Technical report (Capote Noy) Nuclear data for charged-particle monitor reactions & med. 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) Primary Radiation Damage Cross Sections												
Technical Report (Capote Noy) RIPL for fission cross section calculations												
Technical Report (Dimitriou) Reference Database of Compiled and Evaluated Gamma-Ray Data												

6.1.1. Nuclear Data for the Production of Therapeutic Radionuclides

Status: completed – database assembled.

Document published as IAEA **Technical Report Series No.473** (2012).

Objectives:

For reactor-produced radioisotopes:

- Compile and evaluate cross sections as a function of energy in the range 0–20 MeV.
- Deduce spectrum-averaged data in the conventional way for thermal, epithermal and fast neutrons and compare with measurements.

For accelerator-produced radioisotopes:

- Compile and evaluate cross sections as a function of energy up to 40 MeV (or 100 MeV, when necessary).
- 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.

Activity:

- Technical Report finalized and published.
- Maintenance activities through expert contracts.

Outputs:

- Final versions of evaluated data files are available on web page <http://www-nds.iaea.org/radionuclides/>, together with documentation; these data and associated documents are also accessible through a Medical Portal <http://www-nds.iaea.org/medportal/>.
- Produced nuclear data are also available in ENDF-6 format for [neutrons](#), [protons](#), [deuterons](#) and [alpha](#) particles.

Remarks/Outcomes:

Resulting recommended data are particularly important in ensuring that the optimum yields of the desired radioisotopes are achieved with the minimum of contamination from other radioactivity – adoption of these reaction data in the preparation of the specified radionuclides will maximise their desired dose rate and medical impact, while minimising and even eliminating the impact of undesirable radionuclide impurities.

Monitor reactions webpage www-nds.iaea.org/medical/monitor_reactions.html has become a reference for cross sections of charged-particle reaction measurements. They will be updated within the on-going CRP (see Section 6.1.9).

6.1.2. Development of a Reference Database for Ion Beam Analysis

Status: completed – database assembled.

Document was prepared and is undergoing review.

Objectives:

- Identify the most important nuclear reactions for Ion Beam Analysis (IBA).
- Compare data and perform measurements, apply model calculations, and incorporate all measured and evaluated data into the IBANDL database.

Activity:

- Technical Report finalized and submitted for publication.
- Maintenance activities through expert contracts.

Outputs:

- New data assessments of nuclear reactions for several target-projectile combinations of interest to the IBA community have been uploaded to the web page: <http://www-nds.iaea.org/iba/>.
- The IBANDL interface was modernized, a CD-ROM version was prepared.
- Updated IBANDL is available at and available at <http://www-nds.iaea.org/ibandl>.
- New evaluations are available in IBANDL through the SigmaCalc software.
- The final technical report was submitted for publication.

References:

- [1] I.C. Vickridge and O. Schwerer (Eds.), Summary Report of the 1st RCM on Development of a Reference Database for Ion Beam Analysis, Vienna, 21-23 November 2005, IAEA Vienna, Austria, **INDC(NDS)-0481** (2006).
- [2] I.C. Vickridge and O. Schwerer (Eds.), Summary Report of the 1st RCM on Development of a Reference Database for Ion Beam Analysis, Vienna, 18-21 June 2007, IAEA Vienna, Austria, **INDC(NDS)-0511** (2007).
- [3] D. Abriola and I.C. Vickridge (Eds.), Summary Report of the 1st RCM on Development of a Reference Database for Ion Beam Analysis, Vienna, 27-30 April 2009, IAEA Vienna, Austria, **INDC(NDS)-0555** (2009).

6.1.3. Reference Database for Neutron Activation Analysis

Status: completed – document in preparation.

Objectives:

- Improve the database of integral nuclear constants for neutron activation analysis.
- Improve consistency between energy-dependent cross sections and integral constants.
- Contribute to the nuclear structure database.

Activities:

- Correction of the database of integral constants, e.g. k_0 , σ_0 , Q_0 , etc.
- Compilation and comparison of available differential cross section data to produce a library consistent with integral k_0 -values.
- Comparison and update of γ -ray transition probabilities in EGAF.
- Technical Report is being prepared.

Outputs:

- Recommended database of integral constants relevant to the k_0 neutron activation analysis technique.
- Validation of the k_0 -IAEA spectrum analysis software and associated updates.
- Analysis and comparison of SMELS reference material neutron activation.

References:

- [1] R.B. Firestone and A. Trkov (Eds.), Summary Report of the 1st RCM on Reference Database for Neutron Activation Analysis, IAEA Vienna, Austria, 3–5 October 2005, **INDC(NDS)-0477**, October 2005.
- [2] R.B. Firestone and M.A. Kellett (Eds.), Summary Report of the 2nd RCM on Reference Database for Neutron Activation Analysis, IAEA Vienna, Austria, 7–9 May 2007, **INDC(NDS)-0514**, March 2008.
- [3] M.A. Kellett (Ed.), Summary Report of the 3rd RCM on Reference Database for Neutron Activation Analysis, IAEA Vienna, Austria, 17–19 November 2008, **INDC(NDS)-0542**, December 2009.
- [4] <http://www-nds.iaea.org/naa/>.

6.1.4. Updated Decay Data Library for Actinides

Status: completed – database assembled and available as a CD/webpage.

Document published as IAEA **Technical Report STI/PUB/1618** (2013).

Objectives:

- Measure specific actinide decay data judged to be inadequate, assuming suitable sources are available.
- Evaluate half-lives, and α -particle and γ -ray emission probabilities.
- Assemble a database that constitutes improved/recommended decay data files for actinides of direct application in nuclear facilities, and for waste management.

Outputs:

- New measurements undertaken and published by participants through this CRP.
- Specific evaluations undertaken and published by participants.
- Final data library in various user-relevant formats, i.e. simple tabulations, ENSDF and ENDF.

References:

- [1] M.A. Kellett (Ed.), Summary Report First Research Coordination Meeting on Updated Decay Data Library for Actinides, IAEA Vienna, Austria, 17–19 October 2005, **INDC(NDS)-0479**, January 2006.
- [2] M.A. Kellett (Ed.), Summary Report of the Second Research Coordination Meeting on Updated Decay Data Library for Actinides, IAEA Vienna, Austria, 28–30 March 2007, **INDC(NDS)-0508**, December 2007.
- [3] M.A. Kellett (Ed.), Summary Report of the Third Research Coordination Meeting on Updated Decay Data Library for Actinides, IAEA Vienna, Austria, 8–10 October 2008, **INDC(NDS)-0539**, July 2009.
- [4] http://www-nds.iaea.org/act_ddl/.

6.1.5. Heavy Charged-particle Interaction Data for Radiotherapy

Status: completed – document in preparation

Objective:

- Primary aim is to improve the quality of the heavy charged-particle interaction data for patient dose delivery calculations in radiotherapy.

Activities:

- Second RCM was held at the LNS, Catania, Italy, 8–12 June 2009 [1]; third and final RCM was held at the Heavy Ion Therapy Center (HIT), Heidelberg, Germany on November 22 – 26, 2010.
- Major evaluated nuclear data libraries have been processed and made available for their use in the general-purpose Monte Carlo transport code Geant-4 (<http://www-nds.iaea.org/geant4> [2]).
- Benchmark of spallation reaction models and subsequent analysis concluded, see <http://www-nds.iaea.org/spallations/>

Remarks / Outcomes:

- Emphasis on nuclear data needs for proton and carbon therapies.
- The benchmark exercise is complementary to the CRP activities.
- Experimental data for Carbon fragmentation experiments in water have been measured, and compiled into EXFOR (Haettner et al, EXFOR D0589; De Napoli et al, O2089)

References:

- [1] H. Palmans and R. Capote Noy, Summary Report of Second Research Coordination Meeting on Heavy Charged-Particle Interaction Data For Radiotherapy, Catania, Italy, 8–12 June 2009, **INDC(NDS)-0567**, December 2009.
- [2] E. Mendoza, D. Cano-Ott, C. Guerrero, R. Capote, New Evaluated Neutron Cross Section Libraries for the GEANT4 Code, **INDC(NDS)-0612** (2012).

6.1.6. Minor Actinide Neutron Reaction Data (MANREAD)

Status: completed – document in preparation

Objective:

- To assess experimental capabilities to undertake measurements of neutron reaction cross sections for the important isotopes of the minor actinide elements.
- To report measurements of neutron-induced reaction cross sections on minor actinides just completed or planned in the period of activity of the CRP at research laboratories worldwide.
- To assess uncertainty of available experimental information on minor actinide neutron cross section data.
- To assess quality and uncertainties of minor actinide data present in the evaluated nuclear data libraries.

Activities:

- CM was held at IAEA Vienna, Austria, 23–24 November 2006 [1].
- First RCM was held at IAEA, Vienna, Austria, 19–23 November 2007 [2].
- Second RCM was held at IAEA, Vienna, Austria, 31 March–3 April 2009 [3].
- Third RCM was held at IAEA, Vienna, Austria, 19–22 October 2010 [4].

- CRP participants Meeting in Brussels, 17-21 October 2011, and continuous mail exchange to draft the Final Report.

References:

- [1] A. Plompen and A. Mengoni, Summary Report of Consultants Meeting on Minor Actinide Nuclear Reaction Data (MANREAD), IAEA Vienna, Austria, 23-24 November 2006, **INDC(NDS)-0512**, October 2007.
- [2] F. Käppeler and A. Mengoni (ed.), Summary Report of First RCM on MANREAD, IAEA Vienna, Austria, **INDC(NDS)-0528**, September 2008.
- [3] Y. Nagai and A. Mengoni (ed.), Summary Report of Second RCM on MANREAD, IAEA Vienna, Austria, **INDC(NDS)-0557**, July 2009.
- [4] F. Gunsing and N. Otsuka (ed.), Summary Report of Third RCM on MANREAD, IAEA Vienna, Austria, **INDC(NDS)-0585**, December 2010.
- [5] Web site: <http://www-nds.iaea.org/manread/public.html>.

6.1.7. Nuclear Data Libraries for Advanced Systems: Fusion Devices (FENDL-3)

Status: completed - documentation published in INDC(NDS) reports [5,6,7]

Objective:

- Primary objective is to provide an evaluated nuclear data library which is a substantial extension of the FENDL-2.1 library toward higher energies, with inclusion of incident charged particles and the evaluation of related uncertainties (to be called FENDL-3.0).

Activities:

- Technical Meeting was held at the IAEA, Vienna, Austria, 31 Oct. - 2 Nov. 2007 [1].
- First RCM was held at the IAEA, Vienna, Austria, 2–5 December 2008 [2].
- Second RCM was held at the IAEA, Vienna, Austria, 23–26 March 2010 [3].
- Third RCM was held at the IAEA, Vienna, Austria, 6–9 December 2011 [4].

Outputs:

- Summary reports of the Technical Meeting, 1st, 2nd and 3rd RCMs available [1-4].
- Final FENDL-3 library in ENDF-6 format and processed multi-group and ACE files available on web site: <http://www-nds.iaea.org/fendl30/>.
- Report on processing of the FENDL-3 library to produce application libraries [5].
- Summary documentation of the FENDL-3 database [6].
- Final Report of the Coordinated Research Project on Nuclear Data Libraries for Advanced Systems: Fusion Devices [7].

References:

- [1] R. Forrest and A. Mengoni, Technical Meeting on Nuclear Data Libraries for Advanced Systems: Fusion Devices, **INDC(NDS)-0525**, April 2008.
- [2] A. Trkov, R. Forrest and A. Mengoni, Summary Report of the First RCM on Nuclear Data Libraries for Advance Systems - Fusion Devices (FENDL-3), IAEA Vienna, Austria, 2–5 December 2008, **INDC(NDS)-0547**, March 2009.
- [3] M.E. Sawan, Summary report from the Second Research Coordination Meeting on Nuclear Data Libraries for Advanced Systems- Fusion Devices (FENDL-3), IAEA Vienna, Austria, 23–26 March 2010, **INDC(NDS)-0567**, June 2010.

- [4] M.E. Sawan, Summary report from the Third Research Coordination Meeting on Nuclear Data Libraries for Advanced Systems- Fusion Devices (FENDL-3), IAEA Vienna, Austria, 6-9 December 2011, **INDC(NDS)-0602**, March 2012.
- [5] D. Lopez Aldama and R. Capote Noy, FENDL-3.0: Processing the Evaluated Nuclear Data Library for Fusion Applications, **INDC(NDS)-0611**, December 2011.
- [6] R. Forrest, R. Capote, N. Otsuka, T. Kawano et al., FENDL-3 Library – Summary documentation, **INDC(NDS)-0628**, December 2012.
- [7] R. Forrest et al, Final report of the Coordinated Research Project on Nuclear Data Libraries for Advanced Systems: Fusion Devices (FENDL-3), **INDC(NDS)-0645**, December 2013.

6.1.8. Prompt Fission Neutron Spectra for Actinides

Status: on-going

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.

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 CRP webpage containing new evaluations is available <http://www-nds.iaea.org/pfns>

The CRP is going well and is close to conclusion. An extension of the CRP for one year (2013) was requested and granted considering new experimental and theoretical results in the field that will significantly impact the quality of undertaken evaluations. A final technical document is in preparation.

The following new PFNS evaluations have been delivered:

1	P. Talou LANL, USA	$^{230-241}\text{U}$ and $^{236-246}\text{Pu}$	Los Alamos method incl. covariances	Files
2	B. Morillon CEA DAM France	^{235}U , ^{238}U , ^{239}Pu , ^{240}Pu	Los Alamos method	Files
3	R. Vogt LLNL, USA	^{235}U , ^{239}Pu	Monte Carlo including covariances	Files
4	N. Kornilov Ohio Univ., USA	^{235}U thermal	Scale method	U235th-SCALE
5	N. Shu CIAE, China	^{235}U (thermal to 5 MeV)	Semi-empirical	Files

6	A. Tudora Univ. Bucharest,Romania	^{232}Th , $^{233,234}\text{U}$, ^{237}Np	PbP Los Alamos method	Files
7	V.M. Maslov JIENR, Belorussia	^{232}Th , $^{232-235,238}\text{U}$, ^{237}Np , $^{241,243}\text{Am}$	Maslov/Kornilov (Minsk Actinide Library @ IAEA)	Files

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** (in preparation).

6.1.9. Charged-Particle Monitor Reactions and Nuclear Data for 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 A+M Data Unit [3].
- The 2nd RCM is scheduled to be held in Vienna, Austria on 8–12 December, 2014.

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

Following advice at the 1st RCM [1], a CM was organized in cooperation with the A+M Data Unit on 9-10 May 2013 at IAEA Headquarters to discuss “Auger Electron Emission Data Needs for Medical Applications” [3]. The main goal was to establish collaborations between Auger (nuclear) data users and (atomic) data producers and stimulate long-due developments in Auger electron emission calculations. Low energy Auger data are needed in internal-therapy applications, and clear deficiencies in existing data have been identified. Participants assessed and reviewed detailed atomic and nuclear data needs for a number of Auger emitters deemed as potentially suitable for applications in nuclear medicine and radiotherapy.

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.

6.1.10. Nuclear data for Particle Induced Gamma Ray Emission (PIGE) analysis

Status: On-going

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 scheduled for 7–11 April 2014.

Outputs:

- New data files for uploading onto IBANDL
- New evaluations performed by CRP Consultants and NDS staff
- Final Technical Document

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] Web site: <http://www-nds.iaea.org/pige/>.

6.1.11. Testing and Improving the International Reactor Dosimetry and Fusion File (IRDF)

Status: Started

Objectives:

- To create reference neutron fields and corresponding experimental database of integral measurements for fission and fusion applications.
- To assess newly released high-fidelity evaluations with covariances in order to improve the existing dosimetry library for fission and fusion applications.
- To use selected integral data (e.g. kayzero), in order to reduce the uncertainty in existing evaluated cross sections and improve the consistency of the library (for many reactions in the low energy region uncertainties are still too large - capture and inelastic).
- To identify and correct possible deficiencies in the released library.
- To complete the documentation of the validation of the IRDF library for fission and fusion 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, 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/IRDF>).

- A summary description of the IRDF library was published as a technical paper [3].
- Preliminary validation of the released library in selected neutron fields was performed and documented [4].
- First RCM was held at the IAEA Vienna, Austria, 16–20 May 2011 [5].
- Several new candidate evaluations for IRDF were carried out by K. Zolotarev (IPPE, Russia) partially supported by IAEA NDS [6].

Planned Outputs:

- 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) *JAIOAD*
- [4] 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 (IRDF release 1.0)", **INDC(NDS)-0616**, IAEA, Vienna, Austria, May 2012
- [5] 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 (IRDF), IAEA Vienna, Austria, 1–5 July 2013, **INDC(NDS)-639**, IAEA, Vienna, Austria, September 2013.
- [6] 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 Reactors Dosimetry Application", **INDC(NDS)-0657**, IAEA, Vienna, Austria, December 2013.
- [7] CRP web page: <https://www-nds.iaea.org/IRDFtest/>

6.1.12. Primary Radiation Damage Cross Sections

Status: on-going

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. 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.

Activities:

- Technical Meeting “Primary Radiation Damage: from nuclear reaction to point defects” was held at the IAEA, Vienna, Austria, 1–4 Oct 2012 [1].
- First RCM was held at the IAEA, Vienna, Austria, 4–8 Nov 2013 [2].
- Second RCM is planned to be held at the IAEA, Vienna, Austria in beginning of 2015.

Outputs:

- Summary report of the first RCM available (see reference 2).
- Starter damage and gas production files are available on the CRP web site: <https://www-nds.iaea.org/CRPdpa/>.
- Relevant documents, codes and input files are available on the CRP web site.

Reference:

- [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.

6.1.13. Reference Database for Beta-delayed Neutron Emission

Status: Started.

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 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.

Planned Outputs:

- Reference Database available online.
- Technical Document.

References:

- [1] D. Abriola, B. Singh and I. Dillman, Summary Report of Consultants’ Meeting on Beta-delayed neutron emission evaluation, IAEA, Vienna, Austria, 10–12 October 2011, **INDC(NDS)-0599**, December 2011.

- [2] Summary Report of the 1st Research Coordination Meeting of the CRP on Beta-Delayed Neutron Emission, IAEA, Vienna, 26–30 August 2013. **INDC(NDS)-0649**, in preparation.
- [3] Web site: <http://www-nds.iaea.org/beta-delayed-neutron/>.

6.1.14 RIPL for fission cross section calculations

Status: Planned.

A follow-up project to maintain and extend the RIPL database was discussed in a previous INDC and endorsed. A CM on “Recommended Input Parameters for fission cross section calculations” was held at the IAEA, Vienna, 17–18 December 2013 [1].

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, Γ_γ) 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] 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** (in preparation).

6.1.15 CRP on Reference Database of Compiled and Evaluated Gamma-Ray Data

Status: Planned

Gamma-ray data from nuclear reactions are important for a wide range of applications, as well as for basic sciences. A Consultants' Meeting was held on 4–6 November 2013 [1] to review the state-of-affairs regarding experimental techniques, new measurements, and new evaluation methods. The meeting concluded that there is urgent need for a Reference Database that would contain a compilation and evaluation of the available reaction γ -ray data and recommended that the IAEA initiate a Coordinated Research Project.

Suggested Objectives:

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

Suggested Outputs:

- Reference Database of compiled and evaluated reaction γ -ray.
- 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**.

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 and 2013), and work undertaken directly by NDS staff. A follow-up TM is being organized for December 2014. Invited talks by A.D. Carlson were delivered at the Fourteenth International Symposium on Reactor Dosimetry held in May 22–27, 2011, at Bretton Woods, New Hampshire, USA [5], and at the NDST 2013 [6].

References:

- [1] S.A. Badikov, Chen Zhenpeng, A.D. Carlson, E.V. Gai, G.M. Hale, F.-J. Hamsch, 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. Hamsch, 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] A.D. Carlson, V.G. Pronyaev, R. Capote, F.-J. Hamsch, F. Käppeler, C. Lederer, W. Mannhart, A. Mengoni, R.O. Nelson, P. Schillebeeckx, P. Talou, S. Tagesen, H. Vonach, A. Vorobyev, and A. Wallner, “New Work on Updating and Extending the Nuclear Data Standards”, ASTM Special Technical Publication 1550 STP, (2012) 141-160; doi:[10.1520/STP155020120012](https://doi.org/10.1520/STP155020120012).
- [6] A.D. Carlson, V.G. Pronyaev, R. Capote, F.-J. Hamsch, 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 Nuclear Data Standards”, Presented at ND2013, 4-8 March 2013, New York, USA (to be published in Nucl. Data Sheets 2014).

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.A. Forrest is one of the SG monitors while 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, 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 have been contributing technically to solve the discrepancies between different evaluated nuclear data libraries in the elastic/inelastic

scattering, and to the evaluation of the actinide nuclei in the fast neutron region [5-7].

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 (to be published in Nucl. Data Sheets 2014).
- [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 Nuclear Data Standards”, Presented at ND2013, 4–8 March 2013, New York, USA (to be published in Nucl. Data Sheets 2014).
- [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 (to be published as EPJ Web of Conferences in 2014).
- [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 (to be published in Nucl. Data Sheets 2014).
- [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 on International Collaboration on Nuclear Data, 5–8 November 2013, JRC, EU, Geel, Belgium
(see <https://www.oecd-nea.org/science/wpec/nemea7/>)

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 evaluations 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 (to be published in Nucl. Data Sheets 2014).
- [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. To continue providing this service to the user community, a one-year CSA was awarded to A. Gurbich, IPPE, from 2012-2013, to maintain and update IBANDL, to perform new evaluations, and to maintain and update the SigmaCalc calculator available on the IAEA server. Evaluated data was delivered and the report received.

As of April 2013, the data and web management of IBANDL was completely passed over to the NDS due the enforcement of stringent IT security requirements. The IBANDL webpage has been re-engineered, and many additional features and options are now available (see <https://www-nds.iaea.org/exfor/ibandl.htm>). An example is that one can now obtain a complete listing of similar or relevant data available in EXFOR by a simple click of a button. The user is thus able to find new data, if available in EXFOR, and also access experimental information that is not included in IBANDL.

Apart from the effort under CSA (Gurbich), additional efforts to update IBANDL with data relevant to the CRP on Particle-Induced Gamma-ray Emission has been made by CRP participants and currently became the responsibility of the IAEA staff (V. Semkova). A new CD-ROM has been prepared with the updated IBANDL data library.

6.2.5. Development of evaluation methodology and nuclear reaction modelling systems

1. 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.

A major release of the GANDR system (GANDR v.5.1) was undertaken in November 2013 (see <http://www-nds.iaea.org/gandr>). A new major version of the EMPIRE system (version 3.2) was also released in summer 2013.

2. A national Indian workshop on the use of the EMPIRE and GANDR systems for nuclear data evaluation was held in Mumbai, India in February 2012 (see Section 7.2.5); a follow-up one-day workshop was held in Mumbai, India in February 2013.

3. The reference publication for the EMPIRE system [1] has been cited 220 times (Google scholar) as of January 2014, a 100% citation increase in the last two years. An updated Users' manual was published in August 2013 [2].

References:

- [1] M. Herman, R. Capote, B.V. Carlson, P. Oblozinsky, M. Sin, A. Trkov, H. Wienke, and V. Zerkin, EMPIRE: Nuclear Reaction Model Code System for Data Evaluation, *Nucl. Data Sheets* **108** (2007) 2655-2715.
- [2] M. Herman, R. Capote, M. Sin, *et. al.*, “EMPIRE-3.2 Malta - Modular system for nuclear reaction calculations and nuclear data evaluation”, Technical report **IAEA(NDS)-0603**, IAEA, Vienna, 2013.

6.2.6. Input to JEFF project

The on-going collaboration between the OECD/NEA Databank and NDS continues, in part, through contributions made to the JEFF Project. A number of cross section evaluations produced through data development projects and/or in collaboration with NDS staff, have been adopted for the JEFF-3.2 library (released in March 2014). In particular, IAEA evaluations for ^{232}Th and $^{231,233}\text{Pa}$ [1-3], the evaluation of ^{180}W isotope [2,3], and the recent evaluation of ^{55}Mn [4] (see Section 6.2.3) were adopted for JEFF-3.2 library.

References:

- [1] R. Capote, L. Leal, Liu Ping, Liu Tingjin, P. Schillebeeckx, M. Sin, I. Sirakov, A.L. Nichols, and A. Trkov, “Evaluated Nuclear Data for Nuclides within the Thorium-Uranium Fuel Cycle”, IAEA Technical report **STI/PUB/1435** (IAEA, May 2010).
- [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.
- [4] 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 (to be published in *Nucl. Data Sheets* 2014).

6.2.7. 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. One possible, powerful and versatile tool that has the potential to meet these evaluation needs is the R-matrix computer code SAMMY. Although it has been extensively used in analyses of neutron-induced cross section data, it has far less often been employed for incident charged particles. To explore and implement all the capabilities available in SAMMY to the analyses of charged-particle-induced cross section data directly related to IBA applications, including the PIGE CRP, collaboration

with Dr. Luiz C. Leal (Oak Ridge National Laboratory) has been initiated at the Nuclear Data Section/IAEA. Dr. Leal is a widely acknowledged expert on nuclear data evaluation using computer tools such as the SAMMY code, and with the aid of his expertise we have begun to investigate the various tools incorporated in the code for calculations of charged-particle-induced cross sections and their related uncertainties in the resolved-resonance region. We have already used SAMMY to reproduce the resonances in the elastic, different inelastic and α -particle outgoing channels for ^{27}Al . Work is in progress to evaluate all channels simultaneously and produce uncertainties and covariance matrices.

This project is not only limited to providing recommended nuclear data for IBA applications, but it also aims at incorporating the relevant information resulting from the evaluation (resonance parameters plus covariances) in suitable formats (ENDF-6) that can be accessed and processed by a wider user community through the ENDF/B databases for an extended range of applications including accelerator, medical, environmental, and fusion applications.

6.2.8. Accuracy of Nuclear Reaction Cross Sections for IBA and Benchmarking

The issue of uncertainties of evaluated differential cross section data is a very important one and has to be addressed by the IBA community in conjunction with the need to incorporate and propagate them in the analysis of the measured spectra. The various statistical approaches need to be investigated in parallel with an effort to extend the existing simulation codes to treat the uncertainties in the cross section data.

On the other hand, benchmarking is a valuable tool in validating nuclear cross section data. Integral measurements can provide valuable insight in the uncertainties associated with experimental and evaluated cross sections, and may also contribute to the improvement of the simulation codes.

Although there is significant activity currently going on in this field, it lacks the necessary coordination. The IAEA could play an important role as a coordinator of a broader effort to validate IBA cross section data through benchmark experiments.

The Consultants' Meeting [1] recommended that the IAEA addresses the above-mentioned data needs of the IBA community, by the means it deems most appropriate.

References

- [1] D. Abriola, P. Dimitriou, and A. Gurbich, Summary Report of the Consultants Meeting on Accuracy of Nuclear Reaction Cross Sections for IBA and Benchmarking, IAEA, Vienna, 11–13 March 2013, **INDC(NDS)-0634**.

6.2.9. Compilation and Evaluation of Gamma-Ray Data

Gamma-ray data from nuclear reactions are important for a large range of applications, as well as for basic sciences. In particular, γ -ray data to extract Photon Strength Functions (PSF) and photonuclear cross sections are necessary for energy, safety and medical applications as well as for nuclear physics and astrophysics.

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 a Reference Database that would contain a compilation and evaluation of the available reaction γ -ray data. To achieve that it was recommended that the IAEA initiates a Coordinated Research Project.

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**.

7. TECHNOLOGY TRANSFER

Technology transfer activities during 2012-2013 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 continue to be active in providing support to new ENSDF evaluators.

7.1. Technical cooperation: regional centres for nuclear data services

Mirror servers help to fulfil the needs of developing countries to provide data services to their users. The mirror server at the Bhabha Atomic Research Centre (BARC), Mumbai, India has been extensively used and a new legal agreement was signed to continue to support it. The server at PIEN, São Paulo, Brazil has ceased to be updated and was closed down in 2012. A request for a new mirror server at the China Nuclear Data Centre has been followed up and a legal agreement has been recently signed. The new service started during 2013. The opportunity was taken to streamline the updating method and now both sites are updated on a monthly cycle.

Web mirror-site in BARC (India) was re-installed in 2011. Since 2012 it is based on a new concept where the full product having all encapsulated data is prepared on NDS site and made available for mirror site staff together with updating instructions; all updating procedures are performed locally by staff on mirror site without involvement of NDS staff. It has major nuclear reaction databases (EXFOR, ENDF, CINDA) with Web retrieval system. Regular updating of this mirror-site was provided (approximately monthly). New web mirror-site was created at CNDC (China) in 2013; it is maintained and regularly updated using the same concept. Since 2013, both mirror sites have new web IBANDL interface and EXFOR, ENDF, ENSDF uploading systems.

7.2. Workshops

NDS partially sponsored and organised nine workshops in 2012–2013, of which four were supported by ICTP (7.2.1 - 7.2.4), two (7.2.5 and 7.2.6) were related to EXFOR and one to Nuclear Data Evaluation (7.6.7) and were held outside of Vienna, and two were held at IAEA premises (7.6.8 and 7.6.9). These workshops are described below.

7.2.1. Joint ICTP-IAEA Workshop on Fusion Plasma Modelling Using Atomic and Molecular Data

23–27 January 2012, ICTP - Miramare, Trieste, Italy

Workshop Directors: B.J. Braams and H.-K. Chung (IAEA, Vienna, Austria)

Local Organizer: J. Niemela (ICTP, Trieste, Italy)

The “ICTP-IAEA Joint Workshop on Fusion Plasma Modelling Using Atomic and Molecular Data” was held the week 23–27 January 2012 at the International Centre for Theoretical Physics (ICTP) in Miramare, Trieste, Italy. Earlier similar workshops were held in 2003 (1 week), 2006 (2 weeks) and 2009 (2 weeks). The 2012 workshop had 10 invited lecturers, 21 other participants, plus the director and the local organizer. The following countries and international organizations were represented (in brackets the total number if more than one): Algeria, Burundi, Cameroon, China (2), Finland, France (2), Germany (6), India (6), Italy (2), Japan, Kazakhstan, Pakistan, Tunisia (3), USA (2); IAEA (2), ICTP.

Objectives

The aim of the workshop was to bring together plasma modellers that use atomic, molecular and plasma-material interaction (A+M+PMI) data in their work with researchers in the field of atomic, molecular or plasma-material interaction physics that produce relevant data. The workshop was addressed to early-career researchers, generally beyond the level of a Ph.D. that wanted to broaden their outlook with respect to plasma modelling and relevant A+ M+ PMI processes.

Main topics

In principle four broad topics are in the domain of the workshop: plasma modelling, atomic processes and spectroscopy, molecular processes, and plasma-material interaction. Within the one-week slot it was not possible to do justice to all four topics and molecular processes received less coverage.

Actions

Lecturers D. Reiter, K. Ohya and B. Ziája-Motyka presented plasma modelling, Yu. Ralchenko and H.-K. Chung presented computational procedures for atomic processes and spectroscopy, Yaming Zou/R. Hutton and J. Clementson described EBIT atomic data experiments, M. Telmini spoke on electron-molecule collisions and K. Nordlund, A. Allouche and P. Giannozzi presented plasma-material interaction processes. A poster session provided all participants the opportunity to present their research. The poster session was preceded by a session of 3-minute mini-talks for each participant to introduce his or her poster.

Remarks/Outcomes

The workshop was successful and was much appreciated by lecturers and participants alike. A few issues are worth noting with a view to a future workshop on fusion plasma modelling and related atomic, molecular and plasma-material interaction data.

1. The workshop has a unique character in bringing together young and established researchers from several communities including both users (plasma modellers) and producers of atomic, molecular and plasma-material interaction data. This character should be preserved in future similar events.
2. The workshop is most valuable for researchers beyond the Ph.D. and that is also the audience through which the workshop has the most impact on fusion plasma modelling and the production of A+M+PMI data. We should emphasize the scientific workshop aspect in all our advertising.
3. The duration of one week is acceptable, but really 2 weeks is to be preferred especially if it can be in a timeslot somewhat later in the year to have more time to advertise the event. We have four broad topics that call for some coverage: plasma modelling, atomic processes and spectroscopy, molecular processes, and plasma-material interaction. All these topics cannot be adequately covered in one week.
4. We aim to attract experts in any of the main topics of the workshop, but the focus of the workshop is on the interaction between lecturers and participants from neighbouring fields. An expert in one of main topics (plasma modelling, atomic data, molecular data, plasma-material interaction) attends the workshop primarily to learn about the other fields and their interrelation and to develop contacts with experts in these other fields.

7.2.2. Nuclear Structure and Decay Data: Theory and Evaluation

(Hosted at ICTP Trieste, Italy, 6–17 August 2012)

Workshop Directors: D.H. Abriola (NDS), J.K. Tuli (NNDC).

The seventh workshop in this field was organized by the NDS in collaboration with NNDC, USA. The programme was based on the previous six 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, 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) six student groups were formed under the leadership of one or two mentors, and the evaluation of mass chain A=211 was undertaken collectively by the six groups. The evaluation has been published in NDS 114 (2013) 661.
- Students were given the opportunity to review the workshop through a written questionnaire and direct discussions.

Remarks/Outcomes:

- 24 participants received training from 10 lecturers and demonstrators.
- The evaluation work undertaken within Workshop activities was later completed, included into the ENSDF database, and published in Nuclear Data Sheets.
- Some participants expressed a strong interest in undertaking NSDD evaluation work.

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

7.2.3. Nuclear Data for Science and Technology: Medical Applications

(ICTP Trieste, Italy, 30 September–4 October 2013)

Workshop Directors: S.M. Qaim (FZK Julich) and R. Capote Noy (NDS)

A one-week workshop was organized by the NDS in collaboration with ICTP, Italy. The Workshop continued the series of “Nuclear Data for Science and Technology: Medical applications” workshops initiated in 1999 (SMR1148) and continued in 2007 (SMR1868) and 2011 (SMR H270). The programme was organised to cover the physics and nuclear data for medical applications including relevant experimental techniques, diagnostic and therapeutic applications of radionuclides, medical radioisotope production, overview of the nuclear reaction modelling, along with improvement of their awareness of support materials and most relevant CRPs available through the IAEA Nuclear Data Section and network of international nuclear data centres.

Objectives:

To facilitate the application of modern nuclear technology in therapy and diagnostics by training scientists, medical physicists and engineers, particularly from Developing countries, in the use and understanding of those nuclear data of relevance to medical applications.

Topics:

- Overview of nuclear techniques used in medicine (cancer therapy using radioisotopes, gamma rays, neutrons, protons and heavy ions; diagnostics with SPECT and PET).

- Nuclear data for medical applications (e.g., cross sections for interaction of neutrons and charged particles with tissue elements, cross sections for radioisotope production, spectroscopic data and calibration standards, decay data).
- Use of nuclear data for monitoring beam parameters.
- Theoretical methods for nuclear data production (nuclear reaction models and relevant codes).
- 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.); emphasis on data distributed at the IAEA/NDS medical portal.

Remarks/Outcomes:

- 23 participants from 15 countries received training from 7 lecturers and/or demonstrators. Two students from Germany attended the workshop supported by their institutes.
- A face-to-face short review session produced constructive feedback. Students committed to the course 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 medical 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.

7.2.4. Nuclear Data for Science and Technology: Analytical Applications

(ICTP Trieste, Italy, 21–25 October 2013)

Workshop Directors: A. Gurbich (IPPE) and P. Dimitriou (NDS)

A one-week workshop was organized by the NDS in collaboration with ICTP, Italy. The programme was organised to cover the physics and nuclear data behind ion beam analysis (IBA) with special emphasis on the PIGE technique, which for their efficient use require appropriately trained physicists.

Objectives:

- Brief the participants on the nuclear data and experimental methodologies of the IBA analytical techniques, with emphasis on their practical applications.
- Train participants in the use of associated software analysis tools.

Topics:

- Nuclear data and on-line retrieval systems.
- Fundamentals of energetic particle interaction with matter, atoms and nuclei.
- Overview of IBA techniques (RBS, ERDA, EBS, NRA, PIGE).
- Nuclear data for IBA – IBANDL data library.
- Nuclear data for Particle Induced Gamma ray Emission (PIGE).
- Applications of IBA and in particular PIGE.
- Presentations of participants' own work.

Actions:

- Workshop material was presented as lectures each morning and computer-based exercises each afternoon.
- Hands-on introduction of participants to the online services of the NDS, including EXFOR, ENDF and IBANDL databases, the SRIM software for stopping powers, the SIMNRA software for NRA spectral analysis, and the RadView software for PIGE spectral analysis.

Remarks/Outcomes:

- 21 participants from 15 countries received training from 5 lecturers and/or demonstrators.
- The workshop facilitated participating physicists to better understand and appreciate the full potential and weaknesses of these techniques and to improve their knowledge and ability to fully utilize them.

The overall opinion of the participants was that they had thoroughly enjoyed the workshop and learnt much about IBA and PIGE in particular.

**7.2.5. DAE-BRNS Theme Meeting on Nuclear Reaction Data Evaluation
(13 to 17 February 2012, Mumbai, India)**

Workshop Scientific Officer: R. Capote (NDS)

This workshop was sponsored by BRNS (India) and hosted by the Homi Bhabha National Institute (BARC, Mumbai). NDS staff aided by A. Trkov (JSI, Slovenia) provided training in 1) installation and use of the nuclear reaction model code EMPIRE developed by an international collaboration and supported by NDS; 2) installation and use of the nuclear data evaluation code GANDR; 3) Monte Carlo generation of model covariance information using the EMPIRE code and its subsequent use in the GANDR evaluation package.

The theme meeting was attended by participants from various Indian Universities, Indian National laboratories and BARC. In all, 19 participants from various universities, 16 from BARC and 4 from other units of DAE were present. The source codes were distributed to the participants. The participants could acquire a working knowledge of the computer simulations to be carried out for generating and evaluating nuclear reaction data.

7.2.6. 5th DAE-BRNS Theme Meeting on EXFOR Compilation of Nuclear Data (18– 22 February 2013, Varanasi, India)

Workshop Scientific Officer: N. Otsuka (NDS)

This workshop was organized by the Nuclear Data Physics Centre of India (NDPCI) and hosted by Banaras Hindu University. NDS staff provided training in 1) access to the EXFOR database maintained by NDS and 2) compilation of experimental reaction data measured in India for the EXFOR library. The participants from various universities and institutions of India compiled 42 new articles published in 2010–2013 during the workshop.

7.2.7. Workshop on EXFOR search and compilation (28 - 30 October, 2013, Almaty, Kazakhstan)

Workshop Scientific Officer: N. Otsuka (NDS)

This small workshop was organized by the Physical-Technical Department of al-Farabi Kazakh National University. NDS staff provided training in 1) access to the various web interfaces provided by NDS (e.g., EXFOR, ENDF, LiveChart of Nuclides) and 2) compilation of experimental reaction data measured in Kazakhstan and Uzbekistan for the EXFOR library. The participants from Kazakhstan and Uzbekistan started compilation of old and new articles published in Kazakh and Uzbek journals after the training, and NDS has received 5 new entries by the end of 2013.

7.2.8. IAEA Workshop on Modelling and Evaluating Nuclear Reaction Data for Energy and Non-energy Applications (2-6 December 2013, IAEA, Vienna, Austria).

Workshop Director: R. Capote Noy (NDS).

Objective:

The Workshop objective was to provide extensive and up-to-date training on the use and understanding of the [EMPIRE code](#) for nuclear reaction modelling and nuclear data evaluations. Both neutron and charged-particle induced reactions will be covered addressing data needs for energy and non-energy applications (e.g. theoretical modelling of medical isotope production cross sections).

Lecturers: Core developers of the EMPIRE system were lecturing including M. W. Herman and S. Hoblit (Brookhaven National Laboratory, USA), M. Sin (University of Bucharest, Romania), B.V. Carlson (ITA, Brazil), A. Trkov (Jozef Stefan Institute, Slovenia), V. Zerkin (IAEA), and R. Capote (IAEA).

The workshop was attended by 15 participants from China (2), India (3), Malaysia, Pakistan (2), Nigeria, Indonesia, Slovenia, Germany, Hungary, Ukraine, and Brazil. The EMPIRE Linux setup was distributed to the participants. The participants could acquire a working knowledge of the computer simulations to be carried out for generating and evaluating nuclear reaction data.

7.2.9. EXFOR Compilation Workshop (27-30 August, 2013, IAEA, Vienna, Austria)

Workshop Scientific Officer: N. Otsuka (NDS)

The workshop was attended by 14 participants and IAEA staff. The main topic of this workshop was uncertainty and covariance of experimental nuclear reaction data. In order to ensure that enough information from experimentalists is compiled for future use, the participants learned basic concepts and evaluation methodologies as well as specific types of measurements and evaluations. The participants were also introduced to a new digitizer developed by CNDC as well as updated digitizers and editors developed by CNPD and JCPRG.

8. COMPUTER SUPPORT

The main concerns during the reporting period were the various security issues and the temporary closure of the NDS website. A summary is provided for the record, but only limited details are provided as more could be improperly used by people wishing to improperly use Agency facilities.

On 29 April 2012 the NDS website was closed down because of security issues. These were addressed and the site was reopened on 11 May 2012. Although the immediate issues were corrected there remained some deep seated ones that were exploited later in the year as part of a wider, well publicised ‘hacking’ attack on several IAEA sites. As a result of this, a decision was made at the highest levels of the IAEA to make fundamental changes, particularly as the NDS site was responsible for a major part of the total IAEA web usage. The site was consequently shut down from 30 November 2012 – 28 January 2013 and during that time the site was moved to the ‘Cloud’ and security improved by rewriting many of the applications. The meaning of the ‘Cloud’ is that the website and all supporting software are managed by the IAEA, but these services are run on physical servers which are rented from a provider. The reopened site was still missing a part of the required functionality; restoring this took most of the remaining year. The lesson learned is that in the modern world web security is extremely important, and while the closure meant that we could not provide data to users, these changes have ensured that NDS can now operate a safe and useful web site for the benefit of Member States.

The highlights in IT services and systems development during 2012–2013 can be summarised as follows:

- The separation of NDS and AMDIS servers was successfully done. The two websites **www-nds.iaea.org** and **www-amdis.iaea.org** now run on physically different hardware.
- Decision was made to move NDS web services to the ‘Cloud’. The Web Servers **www-nds.iaea.org** and **www-amdis.iaea.org** were migrated to an external datacentre and service provider. The physical servers 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 a compatible operating system and enabled to be able to run application tests and perform preliminary and final security scans. These machines are also used as the source for deployment to the cloud-based web servers. Location: IAEA Data Centre.
- The two servers **int-nds.iaea.org** and **int-amdis.iaea.org** are used by NDS staff members to provide data-, code- and application development. Location: IAEA Data Centre.
- Implementation of security scans on all objects of NDS web content.

- 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'):

- **www-nds.iaea.org** and **www-amdis.iaea.org**, the primary Nuclear Data Section and Atomic and Molecular data units servers.

The following NDS computers are located in the 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 available internally).
- **nds121.iaea.org**, the NDS test and development server for older Linux distributions (only available internally).
- **castor.iaea.org**, a Dell Precision, Linux-based computer hosting the GANDR project was decommissioned during 2013.
- **nds120.iaea.org**; a 64-bit Linux computer used for Monte Carlo and other calculations was decommissioned in 2012.

X Terminal access by NDS staff to development 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 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. 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** and **nds121.iaea.org** is granted.

The Phase Space CRP has resulted in the acquisition of large amounts of new data, by the end of 2011 this amounted to almost 0.8 TB, and approximately a further 2.3TB is expected over the course of the project. This, plus the addition of almost 450GB of new or updated data (i.e. POINT, TENDL, NSR, EXFOR ENDF, CINDA), has highlighted the need for considerable additional disk storage and powerful hardware on the main server. The servers with 4.5TB disk array each were implemented in the IAEA Data Centre in 2011; these were used to separate NDS and AMDU web servers and migrate them to the target hardware. This was done in 2012.

8.2.2. 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 IAEA Intranet. 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.

The Compaq ML350 server located within the NDS is being used by the NDSU for storing and sharing work related to EXFOR (compilations, scanned documents, etc.).

8.2.3. VMS systems

The Alpha server running Open VMS was decommissioned and is no longer used.

8.3. Software development

NDS staff have continued to collaborate with MTIT staff on the development of the IAEA Nuclear Information and Knowledge Portal (NUCLEUS). This allows public access to scientific, technical and regulatory data; in the case of content from NDS this is mostly via a set of convenient links to our own pages. The NUCLEUS portal can be accessed at <http://nucleus.iaea.org/>.

The ADLIST application was improved according to users' feedback, but during 2013 it has been made essentially obsolete by transfer of data and functionality to the IAEA-wide Contact Management System and other AIPS modules.

8.4. Hardware overview

Table 4 lists the main computer hardware during the reporting period of 2012–2013.

Table 4. NDS computer hardware for 2012–2013.

Item	Quantity
Servers (HP DL380 G7 Rack Mount Servers)	2
Servers (HP DL380 G5 Rack Mount Servers)	2
Compaq ML350 servers	2
IAEA Standard Desktop PCs	16
Laptops (HP Notebooks)	9
HP LaserJet M3027 MFP Scanner/Printer	1
Linux PC's for calculations	5
Tablets for testing applications iPad & Galaxy Tab	2
External Hard Drives (Backup)	12

9. CONCLUDING REMARKS

The outcome of supporting of Member States by the provision of high quality atomic and nuclear data has been achieved by many outputs during 2012–2013. These include:

- Following a regrettable extended period of shutdown in December 2012- January 2013 the NDS website was transferred to the cloud and during 2013 regained functionality.
- Several applications have been rewritten or significantly updated to improve security and standardise technologies, including IBANDL, LiveChart, GANDR, ALADDIN and AMBDAS.
- The FENDL-3 web site has been produced giving access to all databases and documentation arising from the FENDL-3 CRP.
- A new version of the EMPIRE modelling code has been produced and a package enabling the code and user interface to be easily run on a Windows PC has been made available.
- The EXFOR database has reached the milestone of 20,000 experimental works. Further improvements to searching, plotting and conversion to new user formats have been achieved.
- The comprehensive phase space database has been updated on the Medical Portal website.
- Evaluated files from various data development projects (JENDL-4.0u2, TENDL-2012) have been made available.
- The preliminary dosimetry file, IRDFF which replaces IRDF-2002 has been released and is undergoing validation in a CRP.
- Maintenance of the neutron cross section standards is continuing.
- Maintenance of the RIPL-3 database of parameters to aid in model calculations and data evaluations has been done, and following a Consultants' Meeting it is planned to develop it further, particularly the fission parameters, in a new CRP.
- 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.
- The web page providing access to all NDS publications has been updated with additional publications and searching facilities.
- New datasets generated by the FAC code have been made available for Atomic and Molecular data for fusion.
- A mirror site located in China has been opened. Together with the site in India these provide local versions of a subset of important NDS data.
- An Android app, Isotope Browser, has been produced and freely distributed for mobile platforms. This provides summary data on more than 4,000 nuclides taken from ENSDF.
- 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, medical and analytical techniques.

A significant number of important technical reports were published to a high presentational style and editorial standard: Library of Recommended Actinide Decay Data, 2011, STI/PUB/1618, December 2013; International Bulletin on Atomic and Molecular Data for Fusion, Number 69, January 2013; Experimental nuclear reaction data uncertainties: Basic concepts and documentation, D.L. Smith, N. Otuka, *Nucl. Data*

Sheets, **113** (2012) 3006-3053; Nuclear Data Sheets for A=215, B. Singh, G. Mukherjee, D. Abriola, S. Basu, P. Demetriou *et al.*, *Nucl. Data Sheets*, **114** (2013) 2023–2078; Nuclear Data Sheets for A=211, B. Singh, D. Abriola, C. Baglin, P. Demetriou *et al.*, *Nucl. Data Sheets*, **114** (2013) 661–749; Determination of resonance parameters and their covariances from neutron induced reaction cross section data, P. Schillebeeckx, B. Becker, Y. Danon, K. Guber, H. Harada, J. Heyse, A.R. Junghans, S. Kopecky, C. Massimi, M.C. Moxon, N. Otuka, I. Sirakov, K. Volev, *Nucl. Data Sheets*, **113** (2012) 3054-3100. A wide range of papers in peer-reviewed journals continue to be produced by staff, including one in *Nature*: “Creation and diagnosis of a solid-density plasma with an X-ray free-electron laser”, S.M. Vinko, O. Ciricosta, B.I. Cho, K. Engelhorn, H.-K. Chung *et al.*, *Nature* **482** (2012) 59-62.

Much 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 most important was the ND-2013 Conference in New York, USA at which three IAEA staff attended and where Section staff contributed to 24 papers. Others include in 2012: Int. Conf. on Advances in Reactor Physics (PHYSOR 2012), Knoxville, USA; 20th International Seminar on Interaction of Neutrons with Nuclei (ISINN-20), Alushta, Ukraine; 20th International Conference on Plasma Surface Interactions, Aachen, Germany; 11th International Workshop on Hydrogen Isotopes in Fusion Reactor Materials, Munich, Germany; 13th International Conference on Nuclear Reaction Mechanisms, Varenna, Italy; 17th Topical Meeting of Radiation Protection (RPSD-12), Nara, Japan; 12th International Conference on Radiation Shielding (ICRS-12), Nara, Japan; 4th International Conference on Current Problems in Nuclear Physics and Atomic Energy, Kiev, Ukraine; International Workshop on Elastic and Inelastic Neutron Scattering (WINS-2012), Boston, USA; 3rd International Symposium on Frontiers in Nuclear Physics, Beijing, China.

In 2013: 14th International Conference on Plasma-Facing Materials and Components for Fusion Applications, (PFMC-14), Juelich, Germany; 4th International Workshop on Level Density and Gamma Strength, Oslo, Norway; 25th International Nuclear Physics Conference (INPC2013), Firenze, Italy; 4th International Conference on High Energy Density Physics (ICHED), Saint-Malo, France; 7th International Workshop on Warm Dense Matter (WDM), Saint-Malo, France; 9th International Conference on Dissociative Recombination: Theory, Experiment and Applications (DR2013), Paris, France; 18th International Conference on Atomic Processes in Plasmas (APiP), Auburn, USA; 6th International k_0 -Users Workshop, Budapest, Hungary; 66th Annual Gaseous Electronics Conference, Princeton, USA; 4th International Workshop on Compound-Nuclear Reactions (CNR*13), Sao Paulo, Brazil; 8th NLTE (Non-local thermodynamic equilibrium) Code Comparison Workshop, Santa Fe, USA.

The impressive technical outputs and positive impacts 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.

MEETINGS AND SCIENTIFIC VISITS IN 2012

Month/ Duration	Responsible Officer	Type	Meeting Title/Type of Visit	Home Institute	Location
<u>February</u>					
06 – 10	Capote Noy	CV	M. Sin: validate fission cross section calculations in the EMPIRE 3.1 version	Physics Department, Bucharest University, Romania	Vienna
07 – 09	Chung	CM	Consultants' Meeting: Procedures for Evaluation of Atomic, Molecular and Plasma Material		Toki, Japan
20 – 22	Braams	CM	Consultants' Meeting: XML Schema for Atoms, Molecules and Solids	University of Vienna	Vienna
<u>March</u>					
06 – 09	Simakov	CM	Consultants' Meeting: Further Development of EXFOR		Vienna
12 - 16	Capote Noy	CV	V. Pronyaev: develop and validate interfaces from EXFOR to GMA formats	Centr Jadernykh Dannykh, Fiziko-Energeticheskij Institut, Obninsk, Russia	Vienna
19 - 20	Verpelli	CV	F. Kondev: discuss possible developments of services related to nuclear structure and decay data	Argonne National Laboratory, USA	Vienna
26 - 28	Forrest	CV	J. Kopecky: review neutron-induced activation data with particular reference to FENDL-3/A and EAF-2010	JUKO, Alkmaar, The Netherlands	Vienna
26 - 30	Verpelli	CV	A. Sonzogni: install on the NDS server applications NuDat and ENSDF web retrieval	Brookhaven National Laboratory, USA	Vienna
<u>April</u>					
16 - 19	Otsuka	TM	Technical Meeting: International Network of Nuclear Reaction Data Centers (NRDC)		Paris, France
26 – 27	Braams	TM	Technical Meeting: 18 th Meeting of the IFRC Sub-Committee on Atomic and Molecular Data for Fusion		Vienna

30 April – 4 May	Capote Noy	CV	C. Ozen: advise on the extension of RIPL and discuss collective enhancement of level densities and possible parameterizations	Kadir Has University, Istanbul	Vienna
<u>May</u>					
08 – 11	Forrest	TM	Technical Meeting: 29 th Meeting of the International Nuclear Data Committee (INDC)		Vienna
14 – 21	Forrest	CV	T. Valentine: advise on collaboration between Radiation Safety Information Computational Center (RSICC) and NDS/IAEA.	Oak Ridge National Laboratory, USA	Vienna
<u>June</u>					
01 June – 31 August	Chung	SSA	Y.J. Kim: produce new numerical data by using an existing atomic physics code and compile new data sets from the literature and design a free-form data query interface for atomic data.	Seoul, Korea	Vienna
20 – 22	Braams	CM	Consultants' Meeting: Development of a Recommended Library for Atomic, Molecular and Plasma-material Interaction Processes in Fusion		Vienna
25 – 29	Capote Noy	CV	E. Soukhovitskii: prepare publication on results of new optical model potential describing nucleon induced reactions on ²³⁸ U nucleus and discuss further development of OPTMAN code	Joint Institute of Energy and Nuclear Research Sosny, Minsk, Belarus	Vienna
<u>July</u>					
31 July – 03 Aug	Capote Noy	CV	M. Sin: define input parameters for modelling of neutron induced reactions on ²³⁸ U, calculate cross sections and start covariance calculations	Physics Department, Bucharest University, Romania	Vienna
<u>August</u>					
21 - 24	Abriola	CV	M. Kokkoris: knowledge transfer for nuclear reaction evaluation procedures	Technical University of Athens, Greece	Vienna

21 – 31	Abriola	CV	A. Gurbich: knowledge transfer for nuclear reaction evaluation procedures	Institut for Physics and Power Engineering, Obninsk, Russia	Vienna
29 - 31	Braams	RCM	2. RCM: Spectroscopic and Collisional Data for Tungsten from 1 eV to 20 keV		Heidelberg, Germany
29 - 31	Braams	CV	P. Beiersdorfer: advisory capacity at 2nd RCM on Spectroscopic and Collisional Data for Tungsten from 1 eV to 20 keV as a leader of group at LLNL who pioneered electron beam ion trap research.	Lawrence Livermore National Laboratory, USA	Heidelberg, Germany
<u>September</u>					
04 – 07	Chung	TM	Joint IAEA-NFRI Technical Meeting: Evaluation of Atomic, Molecular and Interaction Data for Fusion		Daejeon, Korea
26 – 28	Braams	RCM	1. RCM: Erosion and Tritium Retention for Beryllium Plasma Facing Materials		Vienna
26 – 28	Braams	CV	S. Lisgo: advise on plasma-material interaction with beryllium tiles and beryllium wall in ITER	ITER, Saint Paul Lez Durance, France	Vienna
26 - 28	Braams	CV	P. Coad: advise on plasma-material interaction with beryllium tiles and beryllium wall in the JET tokamak	EURATOM-TEKESW, Espoo, Finland	Vienna
<u>October</u>					
01 – 04	Simakov	TM	Technical Meeting: Primary Radiation Damage: from Nuclear Reaction to Point Defects		Vienna
01 – 05	Capote Noy	CV	N. Carjan: advise on calculation of neutron emission during the fission processes	Centre d'Etudes Nucleaires, Gradignan, France	Vienna
08 – 12	Abriola	RCM	2. RCM: Reference Database of Cross Sections for Particle-induced Gamma-ray Emission (PIGE) Spectroscopy		Vienna
08 – 17	Abriola	CV	A. Gurbich: advise on ion beam analysis experimental techniques and methods of data collection and input new PIGE data into IBANDL and perform software update.	Institut for Physics and Power Engineering, Obninsk, Russia	Vienna

November

12 – 14 Semkova CM Consultants' Meeting: Benchmarking of Digitizing Software Vienna

26 Nov – Zerkin CV K. Zolotarev: advise on development of the EXFOR data Institut for Physics and Power Vienna
07 Dec corrections system Engineering, Obninsk, Russia

December

03 - 07 Capote Noy RCM 1. RCM: Nuclear Data for Charge-particle Monitor Vienna
Reactions and Medical Isotope Production

MEETINGS AND SCIENTIFIC VISITS IN 2013

Month/ Duration	Responsible Officer	Type	Meeting Title/Type of Visit	Home Institute	Location
<u>January</u>					
21 - 25	Capote Noy	CV	A. Trkov: advise on implementation of advanced nuclear data processing capabilities and benchmark calculations at IAEA/NDS computers	Jozef Stefan Institute, Ljubljana, Slovenia	Vienna
27 - 31	Abriola	TM	Technical Meeting: 20 th Meeting of the International Network of Nuclear Structure and Decay Data Evaluators		Safat, Kuwait
27 - 31	Abriola	CV	M. Gupta: advise at 20 th Meeting of the International Network of Nuclear Structure and Decay Data Evaluators	Manipal University, Karnataka, India	Safat, Kuwait
27 - 31	Abriola	CV	M. Wang: advise at 20 th Meeting of the International Network of Nuclear Structure and Decay Data Evaluators	Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou, China	Safat, Kuwait
28 Jan – 1 Feb	Capote Noy	CV	N. Carjan: advise on scission neutron emission of actinide nuclei from mass asymmetric fragments	Centre d'Etudes Nucleaires, Gradingan, France	Vienna
<u>February</u>					
04 - 08	Capote Noy	CV	M. Sin: advise the IAEA/NDS on consideration of direct reaction mechanisms in He-3 and deuteron induced reactions	Bucharest University, Bucharest-Magurele, Romania	Vienna
<u>March</u>					
11 – 13	Abriola	CM	Consultants' Meeting: Accuracy of Experimental and theoretical Nuclear Cross Sections for Ion Beam Analysis and Benchmarking		Vienna
20 - 22	Braams	RCM	3. RCM: Light Element Atom, Molecule and Radical Behavior in the Divertor and Edge Plasma Regions		Vienna
20 - 22	Braams	CV	J. Reader: advise on light element atom, molecule and	National Institute of Standards and Technology (NIST),	Vienna

radical behaviour in the divertor and edge plasma regions Gaithersburg, USA

April

08 - 12	Dimitriou	CV	L. Leal: advise on SAMMY reaction code	Oak Ridge National Laboratory, Oak Ridge, USA	Vienna
08 - 12	Chung	CV	C. Hill: advise on improvement of the XML output of our ALADDIN numerical database and addition of CHIANTI database to GENIE search engine	Department of Physics and Astronomy, University College London, United Kingdom	Vienna
15 - 26	Capote Noy	CV	E. Soukhovitskii: advise on OPTMAN code for optical model calculations	Energy and Nuclear Research Institute Sosny, Minsk, Belarus	Vienna
23 - 25	Otsuka	TM	Technical Meeting: International Network of Nuclear Reaction Data Centres		Vienna

May

06 - 08	Chung	TM	Technical Meeting: International code Centre Network		Vienna
09 - 10	Capote Noy	CM	Consultants' Meeting: Auger Electron Emission from Nuclear Decay: Data Needs for Medical Applications		

July

01 - 05	Semkova	CV	K. Zolotarev: advise on evaluation methods for reactor dosimetry reactions above 15 MeV	Institut for Physics and Power Engineering, Obninsk, Russia	Vienna
01 - 05	Simakov	RCM	1. RCM: Testing and Improving the IAEA International Reactor Dosimetry File (IRDF)		Vienna
01 - 05	Capote Noy	CV	P. Griffin: advise on review of measured (n,2n) SPA cross sections in U-235 neutron field	Sandia National Laboratories, Albuquerque, USA	Vienna
01 - 26	Capote Noy	SSA	V. Pronyaev: discuss relevant issues for possible inclusion of Cf-252 and U-235(n,f) PFNS as reference neutron spectra	Institut for Physics and Power Engineering, Obninsk, Russia	Vienna
03 - 05	Braams	RCM	2. RCM: Atomic and Molecular Data for State-resolved Modelling Hydrogen and Helium		Vienna

08 – 12	Capote Noy	TM	Technical Meeting: Toward a New Evaluation of Neutron Standards		Vienna
08 – 19	Capote Noy	CV	D.L. Smith: advise on the Unified Monte Carlo method applied to the evaluation of prompt fission neutron spectra (PFNS)	Argonne National Laboratory, Coronado, USA	Vienna
15 – 19	Capote Noy	CV	Xi Tao and Wenming Wang: advise on standards evaluation	China Institute of Atomic Energy, Beijing, China	Vienna
22 – 26	Capote Noy	CV	M. Sin: advise on nuclear data evaluation of U-238 neutron induced reactions	Bucharest University, Bucharest-Magurele, Romania	Vienna
<u>August</u>					
26 – 29	Chung	CV	E. Stambulchik: advise on constructing a CR model using FAC data	Weizmann Institute of Science, Rehovot, Israel	Vienna
26 – 30	Dimitriou	RCM	1. RCM: Reference Database for Beta-delayed Neutron Emission Evaluation		Vienna
26 – 30	Capote Noy	CV	B. Singh: advise on methods applied to the evaluation of nuclear structure and decay data	McMaster University, Hamilton, Canada	Vienna
26 Aug– 06 Sept	Semkova	CV	V. Piksaikin: advise on completeness of the delayed neutron data measured at the Institute of Physics and Power Engineering (IPPE), Obninsk, Russia in EXFOR Data Library	Institut for Physics and Power Engineering, Obninsk, Russia	Vienna
27 – 30	Otsuka	WS	Workshop: Compilation of EXFOR		Vienna
27 – 30	Semkova	CV	V. Varlamov: check the expression of incident energies given in the EXFOR entries for Bremsstrahlung photon spectrum averaged data against the original publications, make suggestions of necessary corrections for relevant EXFOR entry	Lomonosov Moscow State University, Moscow, Russia	Vienna
<u>September</u>					
02 – 06	Chung	CV	C. Hill: advise on implementation of XSAMS for atomic	Department of Physics and	Vienna

			and molecular databases maintained by International Data Centre Network	Astronomy, University College London, United Kingdom	
04 – 06	Chung	TM	Technical Meeting: Technical Aspects of Atomic and Molecular Data Processing Exchange (22 nd Meeting of International Network of A+M Data Centres-DCN)		Vienna
04 – 06	Chung	CV	H. Sadeghpour: advise on uncertainty estimates of theoretical atomic and molecular data	Harvard Smithsonian Center for Astrophysics, Cambridge, USA	Vienna
23	Capote Noy	CV	Shan-Gui Zhou: advise on impact of triaxiality on fission barriers of actinide nuclei	Institute of Theoretical Physics, Chinese academy of Sciences, Beijing, China	Vienna
<u>October</u>					
08 – 10	Semkova	CM	Consultants' Meeting: EXFOR Data in Resonance Region and Spectrometer's Response Function		Vienna
21 – 24	Capote Noy	RCM	3. RCM: Prompt Fission Neutron Spectra of Actinides		Vienna
21 – 24	Capote Noy	CV	O. Serrot: advise at 3rd RCM on Prompt Fission Neutron Spectra of Actinides	Centre d'Etudes de Cadarache, Saint-Paul-lez-Durance, France	Vienna
<u>November</u>					
04 – 06	Dimitriou	CM	Consultants' Meeting: Compilation and Evaluation of Gamma-Ray Data		Vienna
04 – 08	Simakov	RCM	1. RCM: Primary Radiation Damage Cross Section		Vienna
04 - 15	Otsuka	CV	L. Greenwood: advise on the present and perspective status of STAYSL and SPECTER codes used for radiation damage calculation and energy differential flux adjustment.	Pacific Northwest Laboratory, Richland, USA	Vienna
11 – 22	Capote noy	CV	N. Carjan: advise on calculations of scission neutron multiplicity of U-236 compound nucleus	Centre d'Etudes Nucleaires, Gradignan, France	Vienna
26 – 28	Braams	RCM	1. RCM: Plasma-wall Interaction of Irradiated Tungsten and Tungsten Alloys in Fusion Devices		Vienna

December

05 – 06	Braams	CM	Consultants' Meeting: Data Evaluation for electron Collisions with Nitrogen		Vienna
02 – 06	Capote Noy	WS	Training Meeting: Modelling and Evaluating Nuclear Reaction Data for Energy and Non-energy Applications		Vienna
09 – 13	Chung	CV	U. Von Toussaint: advise on maintenance and development of PMI/PSI data in our bibliographical database AMBDAS	Max-Planck Institut fuer Plasmaphysik, Garching, Germany	Vienna
17 – 18	Capote Noy	CM	Consultants' Meeting: Recommended Input Parameters for Fission Cross-section Calculation		Vienna

Scientific Papers and Publications 2012 and 2013

Activation Cross Sections of Deuteron Induced Nuclear Reactions on Natural Titanium up to 24 MeV

M.U. Khandaker, H. Abu Kassim, H. Haba, J. Kanaya, N. Otuka, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

A Regional Coupled-channel Dispersive Optical Potential for Fe Isotopes

Weili Sun, Rui Li, E. Soukhovitskii, J.M. Quesada, R. Capote, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

CIELO, A Future Collaborative International Evaluated Library

M.B. Chadwick, T. Kawano, M.W. Herman, B. Pritychenko, E. Bauge, R. Capote, R. Forrest, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

Current Status of Evaluated Nuclear Data of Mn-55

A. Trkov, R. Capote, L. Leal, D.W. Muir, E.Sh. Sukhovitskii, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

Developments of the EXFOR Database: Possible New Formats

R.A. Forrest, V. Zerkin, N. Otsuka, S. Simakov, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

Documentation of Uncertainties in Experimental Neutron Cross Sections for EXFOR

N. Otuka, D.L. Smith, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

EMPIRE: A Reaction Model Code for Nuclear Astrophysics

A. Palumbo, M. Herman, R. Capote, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

Exclusive Multiple Emission Cross Sections in the Hybrid Monte Carlo Pre-Equilibrium Model

B.V. Carlson, L. Brito, D.F. Mega, R. Capote, M. Herman, M.E. Rego, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

Fitting Prompt Fission Neutron Spectra Using Kalman Filter Integrated with Empire Code

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Investigations of the $^{nat}\text{Fe}(d,x)^{55,56,57,58}\text{Co}$, $^{52,54}\text{Mn}$ Nuclear Reactions

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Measurement of the Thulium Stellar Cross Section at $kT=30$ keV by Activation with an Innovative Method

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Neutron-Induced Reactions on U and Th - New Cross-Section Measurements via AMS

A. Wallner, R. Capote, M. Christl, L.K. Fifield, M. Srncik, S. Tims, F. Käppeler, A. Krása, A. Plompen, J. Lippold, P. Steier, S. Winkler, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

Nuclear Data Measurements at VERA for Fusion, ADS and Environmental Applications

A. Wallner, K. Buczak, O. Forstner, R. Golser, W. Kutschera, C. Lederer, A. Priller, P. Steier, A. Klix, A. Krasa, A. Plompen, D. Schumann, V. Semkova, *Int. Conf. Nucl. Data Sci. Tech. (ND2013)*, in Press, 2013.

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Experimental and theoretical study of the (n,2n) reaction on $^{174,176}\text{Hf}$ isotopes

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Dispersive coupled-channels optical-model potential with soft-rotator couplings for Cr, Fe, and Ni isotopes

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NDS Publications in 2012 and 2013

Series and Number	Titles
Newsletter	Nuclear data newsletter N ^{os} 53, 54, 55, 56.
Technical Reports:	Atomic and Plasma-Material Interaction Data for Fusion, Tritium Inventory in Fusion Reactors, Vol. 15, IAEA, Vienna, Austria, 2012 Atomic and Plasma-Material Interaction Data for Fusion, Tritium Inventory in Fusion Reactors, Vol. 16, IAEA, Vienna, Austria, <i>in press</i> . Library of Recommended Actinide Decay Data, 2011, STI/PUB/1618, December 2013
IAEA(NDS)-82	PROGRAM PLOTTAB (Version 2013-1) Continuous and/or Discrete Physical Data, Parts A and B (Revision 1)
INDC(NDS)-572	Summary Report of the 17 th Meeting of the IFRC Subcommittee on Atomic and Molecular Data for Fusion
INDC(NDS)-576	IRDF-2002.1 Corrections to the IRDF-2002, Data Needs for Neutron Activation Analysis (2009)
INDC(NDS)-597	Summary Report of the Technical Meeting on Inelastic Scattering and Capture Cross Sections
INDC(NDS)-601	Summary Report of the Technical Meeting on Long-term Needs for Nuclear Data Development
INDC(NDS)-602	Summary Report of the Third Research Coordination Meeting on (RCM) on Nuclear Data Libraries for Advanced Systems - Fusion Devices (FENDL 3)
INDC(NDS)-603	EMPIRE-3.2 Malta – Modular System for Nuclear Reaction Calculations and Nuclear Data Evaluation – User’s Manual
INDC(NDS)-604	Summary Report of the Second Research Coordination Meeting on (RCM) on Light Element Atom, Molecule and Radical Behaviour
INDC(NDS)-605	Summary Report of the First Research Coordination Meeting on (RCM) on Atomic and Molecular Data for the State-Resolved Modelling of Hydrogen and Helium and Their Isotopes in Fusion Plasma
INDC(NDS)-606	Summary Report of the Consultants’ Meeting on XML Schema for Atoms, Molecules and Solids (XSAMS)
INDC(NDS)-607	Summary Report of the Third Research Coordination Meeting on

	(RCM) on Characterization of Size, Composition and Origins of Dust
INDC(NDS)-608	Summary Report of the Second Research Coordination Meeting on Prompt Fission Neutron Spectra of Major Actinides
INDC(NDS)-609	Summary Report of the Technical Meeting on Improving Database for Physical and Chemical Sputtering
INDC(NDS)-611	FENDL-3.0: Processing the Evaluated Nuclear Data Library for Fusion Applications
INDC(NDS)-612	New Evaluated Neutron Cross Sections
INDC(NDS)-613	Summary Report of the IAEA-ICTP Workshop on Atomic, Molecular and Plasma-material Interaction Data and Codes for Fusion Plasma Modelling
INDC(NDS)-614	Summary Report of the Consultants' Meeting on Further Development of EXFOR
INDC(NDS)-615	Evaluation and Compilation of Neutron/Proton-induced Fission Cross-sections for Hg, Pb, Bi, Th and U at 20 MeV to 1 GeV
INDC(NDS)-616	Summary Description of the New International Reactor Dosimetry and Fusion File (IRDF release 1.0)
INDC(NDS)-617	Summary Report of the Consultants' Meeting on Procedures for Evaluation of Atomic, Molecular and Plasma-material Interaction Data for Fusion
INDC(NDS)-618	Summary Report of the Technical Meeting of International Nuclear Reaction Data Centres
INDC(NDS)-619	Report of the IAEA Nuclear Data Section to the International Nuclear Data Committee for the period January 2010 – December 2011
INDC(NDS)-620	Summary Report of the First Research Coordination Meeting (RCM) on Spectroscopic and Collisional Data for Tungsten from 1 eV to 20 keV
INDC(NDS)-621	Summary Report of the 18 th Meeting of the IFRC Subcommittee on Atomic and Molecular Data for Fusion
INDC(NDS)-622	Summary Report of the Consultants' Meeting on Development of a Recommended Library for Atomic, Molecular and Plasma-material Interaction Processes in Fusion
INDC(NDS)-624	Summary Report of the Technical Meeting on Primary Radiation Damage
INDC(NDS)-625	Summary Report of the Second Research Coordination Meeting (RCM) on Development of a Reference Database for Particle-induced Gamma-ray Emission (PIGE)

INDC(NDS)-626	RIPL-2012 Discrete Levels
INDC(NDS)-627	Summary Report of the Joint IAEA-NFRI Technical Meeting on Data Evaluation for Atomic, Molecular and Plasma Material Interaction Processes in Fusion
INDC(NDS)-628	FENDL-3 Library – Summary Documentation
INDC(NDS)-629	Summary Report of the Consultants’ Meeting on Benchmarking of Digitizing Software
INDC(NDS)-630	Summary Report of the First Research Coordination Meeting (RCM) on Nuclear Data for Charged-particle Monitor Reactions
INDC(NDS)-632	Summary Report of the First Research Coordination Meeting (RCM) on Data for Erosion and Tritium Retention in Beryllium Plasma-facing Materials
INDC(NDS)-633	Summary Report of the Technical Meeting of International Nuclear Reaction Data Centres
INDC(NDS)-634	Summary Report of the Consultants’ Meeting on Accuracy of Experimental and Theoretical Nuclear Cross Sections for IBA and Benchmarking
INDC(NDS)-635	Summary Report of the Technical Meeting of Nuclear Structure and Decay Data (NSDD) Network
INDC(NDS)-636	Summary Report of the Third Research Coordination Meeting (RCM) on Light Element Atom, Molecule and Radical Behaviour
INDC(NDS)-637	Summary Report of the Technical Meeting of International Codes Centres Network (CCN)
INDC(NDS)-638	Summary Report of the Consultants’ Meeting on Auger Electron Emission from Nuclear Decay Data Needs for Medical Applications
INDC(NDS)-639	Summary Report of the First Research Coordination Meeting (RCM) on Testing and Improving the IAEA International Dosimetry Library for Fission and Fusion (IRDF)
INDC(NDS)-641	Summary Report of the Technical Meeting “Toward a New Evaluation of Neutron Standards”
INDC(NDS)-642	Program OPTMAN Version 14 (213), User’s Guide
INDC(NDS)-644	Summary Report of the Technical Meeting of International Network of Atomic and Molecular Data Centres (DCN)
INDC(NDS)-645	Summary Report of the Coordinated Research Project (CRP) on FENDL-3 Library
INDC(NDS)-646	The Absolute Total Delayed Neutron Yields, Relative Abundances

and Half-lives of Delayed Neutron Groups

INDC(NDS)-647	Summary Report of the Consultants' Meeting on EXFOR Data in Resonance Region and Spectrometer's Response Function
INDC(NDS)-648	Summary Report of the First Research Coordination Meeting on Primary Radiation Damage Cross Section
INDC(NDS)-649	Summary Report of the Consultants' Meeting on Compilation and Evaluation of Gamma-ray Data
INDC(NDS)-650	Table of Nuclear Electric Quadrupole Moments
INDC(NDS)-651	Summary Report of the Consultants' Meeting on XML Schema for Atoms, Molecules and Solids (XSAMS)
INDC(NDS)-656	ADS-HE: Evaluated Nuclear Data Library up to 1 GeV for ^{202}Hg , ^{208}Pb , ^{209}Bi , ^{232}Th , ^{235}U , ^{238}U , ^{237}Np , ^{239}Pu , ^{242}Am and ^{245}Cm
INDC(NDS)-657	Evaluation of Some (n,n'), (n, γ), (n,p), (n,2n) and (n,3n) Reaction Excitation Functions for Fission and Fusion Reactors Dosimetry Application

<u>Report</u>	<u>Country of Origin</u>	<u>Numbers of Reports</u>	<u>Total Reports</u>
INDC(HUN)	Hungary	0037	1
INDC(JPN)	Japan	197	1
INDC(NED)	Netherlands	0011	1
INDC(CCP)	Russian Federation	0454	1

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