Nuclear Data Newsletter
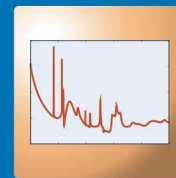
Contents

From the Section Head

Greetings from Vienna!

At the time of writing, the full lockdown in Austria has come to an end, and the Nuclear Data Section is trying to go back to the "normal" situation, although the COVID-19 pandemic has also changed our professional lives in many ways.

A very essential part of our work has always been to organize specialists' meetings in Vienna. The signs are that this will happen again, although it seems clear that virtual meetings are also here to stay. The coming time will show what new kind of equilibrium will set in.

Obviously, all meetings reported in this Newsletter were held virtually, usually between 2 and 6 pm Vienna time, which is of course very convenient for us and our participants from Europe.

Important network meetings were held, like Nuclear Reaction Data Centres (NRDC) Network for the collaborating data centres for EXFOR, International Nuclear Data Evaluation Network (INDEN) on Evaluation methods for light nuclides and the International Fusion Research Council (IFRC) Meeting to advise on our work on Atomic and Molecular Data.

In addition, technical meetings were held on Decay data for monitoring applications and on Collisional-radiative properties of tungsten in edge plasma for fusion devices.

At the end of March, we held the International Nuclear Data Committee (INDC) Meeting. The INDC came together, this time via video, to advise on our programme and to discuss whether we are on the right track.

It was a compact but efficient meeting, which gave rise to many new ideas for the coming years.

We will do our best to make that all visible on our new website (in preparation) and provide a larger variety of dissemination methods for our data.

We also did some tool development, there is a new viewer to compare nuclear reaction data from evaluated data libraries and EXFOR-C5 and a new web interface for anti-neutrino spectra and a new web interface for antineutrino spectra.

I hope nature will allow us to have some summer holidays!

A usual position of the Section Head in the past year

Computer Codes, Data Libraries and Web News

EMPIRE – nuclear reaction model code

Modular system of nuclear reaction codes for advanced modeling of nuclear reactions using various theoretical models. It consists of a number of FORTRAN codes, input parameter libraries, and experimental data library EXFOR; operated through the Graphic User Interface (Tcl/Tk).

New distribution of Empire package:
1. EMPIRE-3.2.3 Portable for Windows-64/32: https://nds.iaea.org/cdroms/#EMPIRE-3.2.3
2. EMPIRE-3.2.3src Linux and MacOSX https://nds.iaea.org/cdroms/#EMPIRE-3.2.3src

(both include EXFOR-XC4:2021-03-08)

New features:
a) Windows-version has latest EMPIRE codes, the rest is the same as in previous distributions
b) new in Linux: clear instructions for installation of additional components of Tcl/Tk (tested from scratch on Ubuntu-16)
c) new for MacOS: adapted for gfortran-10.2, tested on BigSur/x86_64
d) version for MacOS-BigSur/M1(arm64) with ZVView-4.3.2-M1 plotting-code and gfortran-11.0.0 (not yet supported by the compiler REAL*16 replaced by REAL*8 as a temporal solution, use with care)

Standard test passed on all available computer platforms. Full installation on various Unix-like platforms was a long - standing problem, which now is solved.

Reference Database for beta-delayed neutrons

A new Reference Database for beta-delayed neutrons is available
http://nds.iaea.org/beta-delayed-neutron/database.html.
The database includes recommended and compiled data on half-lives, beta-delayed neutron emission probabilities and spectra for all measured delayed-neutron emitters. It also comprises of a macroscopic data section with a comprehensive compilation of measured and recommended aggregate delayed neutron yields, spectra and time-dependent group constants in the 6- and 8-group models. The database is a product of the IAEA CRP (F41028) 'Reference Database for beta-delayed neutrons' (see published report in Nuclear Data Sheets 173 (2021) 144–238).

Release of nuclear reaction Data Explorer

A new web-tool has been released to plot nuclear reaction data, available at https://nds.iaea.org/dataexplorer.
Using a very minimal interface, experimental reaction data derived from EXFOR and evaluated reaction data derived from a variety of evaluated nuclear data (ENDF) libraries can be plotted.
The current version is restricted to cross sections and fission yields, and compares *raw* data from EXFOR with data from CENDL-3.2, ENDF/B-VIII.0, JEFF-3.3, JENDL-4.0, TENDL-2019, and the special purpose libraries IRDFF-2.0, IAEA/PD-2019, JENDL/AD-2017 and IAEA-medical isotope library, if available.
The tool is self-explanatory but there is a 'Tips' button which acts as a short tutorial. Three classes of reaction data can be chosen: exclusive channel cross sections, residual production cross sections and fission yields. Download of the data tables is also available.

The plotting package is based on the tabulated dataset (LIBRARIES-2021) by ENDFtables and EXFORtables tools available at https://nds.iaea.org/talys, which were announced in the previous Newsletter. Retrieving data from EXFOR and ENDF can be challenging. This means that the current graphical comparison can only be done for a restricted class of data, and errors cannot be completely excluded. For full flexibility of plotting and retrieval of data, including data normalization, we refer to EXFOR retrieval system at https://nds.iaea.org/exfor.
NDS will be very grateful for feedback that enables us to improve Data Explorer for LIBRARIES-2021.
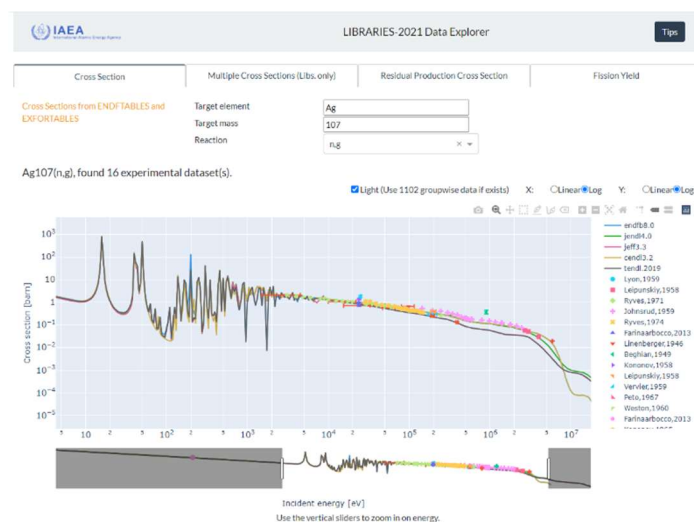
Antineutrino Spectra

New plots and data tables for antineutrino and neutrino energy distributions are available in Livechart. The plots and tables can be accessed by choosing a nuclide, then going to the "Decay radiations" tab.

The spectra are obtained using the Betashape code developed at LNHB (X. Mougeot, Physical Review C 91, 055504; Erratum Phys. Rev. C 92, 059902 (2015) DOI : https://doi.org/10.1103/PhysRevC.92.059902)
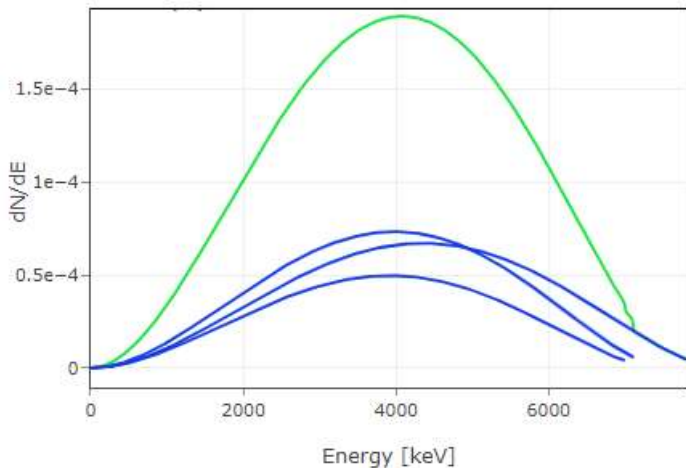
$^{120}_{47}Ag_{73}$ 100% β- 1.23 s $^{120}_{48}Cd_{72}$

Anti neutrino

Energy [keV]	dN/dE	unc
0	0.0000148432	0.0000000579341
23	0.000015884	0.0000000619305
46	0.0000170002	0.0000000661997

Data are provided for the total distribution, and for each transition as well. The plots are shown alongside the already existing plots for beta energy spectra also produced by Betashape; a warning message alerts the user in case the information on the decay is not complete (missing spins, intensities, etc..)

Betashape code can be installed and run on a computer (http://www.lnhb.fr/rd-activities/spectrum-processing-software/).

Livechart is accessible at https://nds.iaea.org/livechart.

JENDL/DEU-2020:

JENDL Deuteron Reaction Data File 2020

Intensive fast neutron sources using deuteron accelerators have been proposed for various applications such as irradiation testing for fusion reactor materials, radioisotope production for medical purposes and others. In these accelerator-based neutron sources, (d,xn) reactions on Li, Be, or C are employed to generate neutron beams and thus deuteron reaction data for these isotopes are of importance to design such facilities.

JENDL Deuteron Reaction Data File 2020 (JENDL/DEU-2020) was released from Japan Atomic Energy Agency (JAEA). The new library stores evaluated deuteron reaction data up to 200 MeV for ^{6,7}Li, ^{9}Be, and ^{12,13}C. The evaluation have been made with particular attention to neutron production data. As illustrated in the figure below, the calculated results with the MCNP-6.2 code using the data of JENDL/DEU-2020 well reproduce the experimental thick target neutron yields. The details of JENDL/DEU-2020 were documented with some validation results in S. Nakayama et al. Journal of Nuclear Science and Technology 58 (2021) 805-821.

JENDL/DEU-2020 is now available from various sources.

The original release can be obtained from https://wwwndc.jaea.go.jp/ftpnd/jendl/jendl-deu-2020.html . In addition to the original ENDF-6 format files, application libraries including ACE format files are also available.

At NDS, JENDL/DEU-2020 is added to our ENDF database collection https://nds.iaea.org/endf/ and to our ENDF Archive:

https://nds.iaea.org/public/download-endf/JENDL-DEU-2020/. The data of JENDL/DEU-2020 are also included in the deuteron sublibrary of FENDL-3.2: https://nds.iaea.org/fendl/.
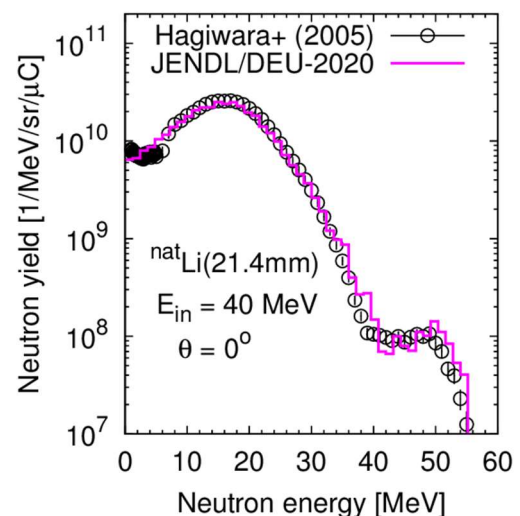
NDS Meeting Reports

(TM = Technical Meeting, RCM = Research Coordination Meeting, CM = Consultants' Meeting, WS = Workshop, CRP = Coordinated Research Project)

Technical Meeting of the International Fusion Research Council's Subcommittee on Atomic and Molecular Data for Fusion

14 – 15 June 2021, Vienna, Austria
Virtual event
Scientific Secretary: C. Hill
14 participants and IAEA staff

The International Fusion Research Council's (IFRC) Subcommittee on Atomic and Molecular Data is a standing committee which oversees and reviews the Atomic and Molecular Data (AMD) Unit's activities. It normally meets biennially in even years but met for only a short meeting during last year's COVID lockdown; this year's meeting was a more formal event, held virtually to assess ongoing projects and set priorities for the future.

Over two days, the AMD Unit's Technical Meetings, Consultancies, Coordinated Research Projects (CRPs), Workshops and database activities were described and discussed. Plans for a new CRP in the Unit concerning the atomic data relating to the impurities injected into fusion plasmas for diagnostic and disruption mitigation purposes were given the support of the Subcommittee and work begins on this later in the year.

More details about the IFRC A+M Data Subcommittee can be found at the URL https://amdis.iaea.org/IFRC/.

Technical Meeting of the International Network of Nuclear Reaction Data Centres

4 – 8 May 2021, Vienna, Austria
Virtual event
Scientific Secretary: N. Otsuka
26 participants and IAEA staff

Twenty-nine participants representing thirteen cooperative Centres from eight Member States (China, Hungary, India,

Japan, Korea, Russia, Ukraine and USA) and two International Organizations (NEA, IAEA) as well as a participant from Kazakhstan were represented at the meeting. Main topics were the EXFOR transmission statistics, EXFOR coverage and quality control, revision of coding rules and manuals, EXFOR/CINDA dictionaries as well as improved tools for compilation and dissemination.

NRDC is intensively working on improvement of the fission product yield (FPY) data coverage in EXFOR. FPY data published in around 600 articles were missing in EXFOR, and the Network arranged their compilation at the NRDC 2019 meeting. It was confirmed at this year's meeting that around 57% of them have been compiled in EXFOR since the previous meeting in 2019.

It was agreed that NEA Data Bank will revise the EXFOR entries compiling the quasi-Maxwellian spectrum averaged neutron capture activation cross sections measured at Karlsruhe and renormalized with the new gold standard cross section (See INDC(GER)-0053 for the renormalized cross section values).

NDS demonstrated the EXFOR-CINDA-ENDF-IBANDL web database retrieval system as well as other online and offline data services emphasizing new directions for data dissemination such as JSON, SQLite and API.

NRDC started data exchange with the EXFOR Format on 1 July 1970, and we originally planned to organize a special session to celebrate 50th Anniversary of the EXFOR collaboration in 2020. We decided to postpone it to next year due to COVID-19 pandemic.

A summary report of the meeting is available as INDC(NDS)-0829. All progress reports, working papers and slides are available on the meeting web page (http://nds.iaea.org/nrdc/nrdc_2021/).

Technical Meeting of the International Nuclear Data Committee (INDC)

29 March – 1 April 2021, Vienna, Austria
Virtual event
Scientific Secretary: A. Koning
participants and IAEA staff
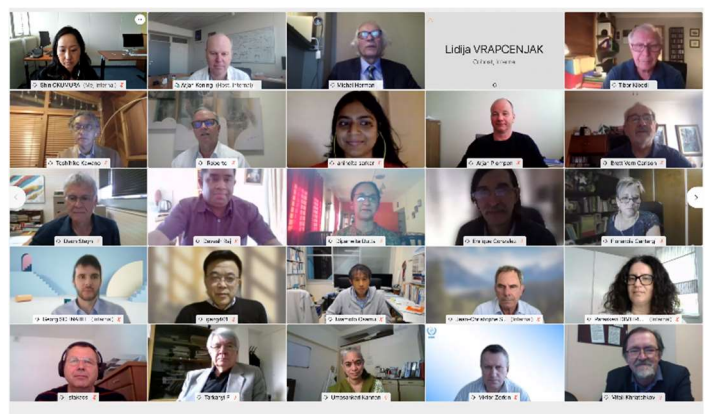
Every two years, the International Nuclear Data Committee meets in Vienna to advise the Nuclear Data Section (NDS) on their programme. The traditional moment for this is in June of the even years, but due to COVID-19, the INDC was eventually held 9 months later.

After two days of presentations by staff from NDS, delegates of 15 Member States discussed the Section's work for the remaining two days of the meeting. This resulted in a list of recommendations for NDS to use as guidelines in the coming two years.

Among the INDC-endorsed developments are a new NDS website, a further modernization of our methods for data dissemination, continuation of the CRPs on fission product yields and evaluation of nuclear data related to the INDEN project and the back-end of the fuel cycle, and modelling method developments, like R-matrix codes.
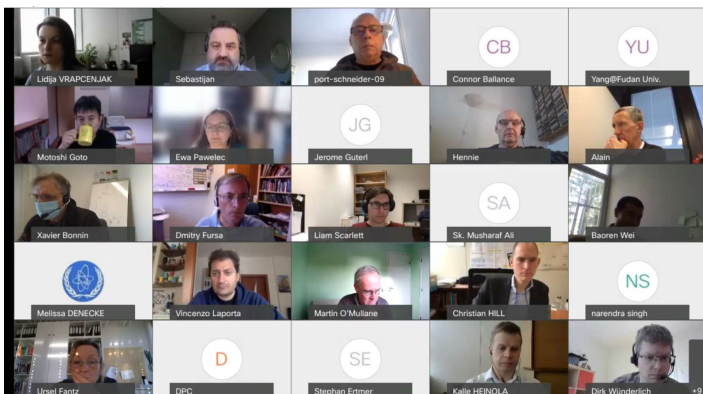
Technical Meeting on the Collisional and Radiative Properties of Tungsten and Hydrogen in Edge Plasma of Fusion Devices
29 March – 1 April 2021, Vienna, Austria
Virtual event
Scientific Secretary: K. Heinola
45 participants and IAEA staff

40 participants presenting 13 Member States and one international research institute, ITER, joined with IAEA staff for an online Technical Meeting to discuss data status of the collisional-radiative processes of tungsten and hydrogen ions and atoms in nuclear fusion reactors. These data are needed for simulations of fusion plasma collisions in the edge region and scrape-off layer of a plasma. An additional data requirement emerges from the interaction processes between plasma particles and the reactor vessel inner surface, i.e. through plasma-wall interactions. The meeting reviewed current needs of the simulations community and experimentalists performing laboratory and fusion reactor plasma experiments. Scientific reports were given by the data providers, such as research groups performing fundamental atomic and molecular data calculations and experimentalists performing fundamental atomic research. The event provided a fruitful forum for discussions, information exchange and building various

collaborations in the future between data providers and data users. It was concluded by all the participants that there is a requirement for a continuation of the meeting topic. The AMD Unit will be pursuing for a meeting series or similar regular activity. For building future collaboration activities, meeting participants were encouraged to join the AMD Unit's Global Network for the Atomic and Molecular Physics of Plasmas (GNAMPP) (https://amdis.iaea.org/GNAMPP/). The near-future follow-up meeting for tungsten and hydrogen in edge plasmas is planned to be held in conjunction with the next GNAMPP meeting in Dec 2021. The present meeting report will be made available as a publication in the journal Nuclear Fusion. More details can be found at the meeting web page https://amdis.iaea.org/meetings/tm-tungsten-hydrogen/.

Technical Meeting on Decay Data for Monitoring Applications
24-26 March 2021, Vienna, Austria
Virtual event
Scientific Secretary: P. Dimitriou
10 participants and IAEA staff

The 2nd IAEA Technical Meeting of the project on Decay Data for Monitoring Applications was held from 24 to 26 March 2021. The meeting was virtual and included eight participants from four Member States, as well as two IAEA staff. Participants reported on the status of their evaluation and review work, discussed technical aspects of the evaluation and updated their work program. The summaries of the presentations and technical discussions are published in INDC(NDS)-0828.

Consultants' Meeting on INDEN for Light Elements
15 – 19 March 2021, Vienna, Austria
Virtual event
Scientific Secretary: P. Dimitriou
30 participants and IAEA staff

A Consultant's Meeting of the INDEN-Light Elements working group was held from 15 to 19 March 2021 to review progress in the evaluation of light nuclear systems relevant to fission reactors, waste management, and nuclear astrophysics applications. The meeting was virtual and consisted of three parts:

Part 1: R-matrix codes for charged-particle reactions in the resolved resonance region (6) (15-16 March 2021).
The sixth IAEA meeting of the working group on R-matrix codes and analysis for charged-particle reactions in the resolved-resonance region was held from 15 to 16 March 2021. This project is now part of the INDEN-LE collaboration and henceforth the reports of the two meetings will be published jointly. Twenty participants from six Member States, one international organization (JRC-EU)

and two IAEA staff were in attendance. Participants discussed the results of the exercise on comparison of covariances produced by the R-matrix codes AZURE2, CONRAD, EDA, SFRESCOX, and SAMMY, as well as the results of the evaluation of ^{7}Be with the RAC code. A new approach to solving the three-body break-up channels and a Bayesian analysis of the ^{7}Be system were presented. The impact of relativistic kinematics and the implementation of the reduced R-matrix theory were also discussed in the context of the full evaluation of the ^{7}Be system.

Screenshot from one of the meeting sessions

Part 2: INDEN for Light Elements (3) (17,19 March 2021): The third Consultants' meeting on the Evaluation of Light Elements within the International Nuclear Data Evaluation Network (INDEN) was held on 17 and 19 May 2021, to review the status of the evaluations of the light elements ^{9}Be, ^{14,15}N, ^{16}O and ^{23}Na. Attendance varied from 18 to 30 participants from six Member States, one international organization (JRC-EU) and the IAEA. Updated evaluations of the mentioned light systems, the implementation of the reduced R-matrix theory using the Reich-Moore approach and the treatment of experimental outliers were among the subjects that were discussed.

Part 3: (α,n) reaction data for applications (18 March 2021): A dedicated session was held on 18 March 2021 on (α,n) reactions for a wide range of applications in basic and applied sciences. Twenty-nine participants from six Member States, one international organization (JRC-EU) and the IAEA were in attendance. Presentations covered new emerging data needs for (α,n) cross sections on light and medium-light elements at energies up to 10 MeV, new experimental campaigns in the USA and Europe, as well as new measurements of the ^{13}C(α,n) reaction at Notre-Dame and Ohio University, and of the ^{16}O(n,α) reaction at LANL. Summaries of the presentations and discussions can be found in INDC(NDS)-0827.

The presentations are available on the meeting website [5th Consultant's Meeting on R-matrix Calculations for Charged-particle Reactions in the Resolved-Resonance Region and INDEN on Light Elements (iaea.org)].

Consultants' Meeting on Model Code Output &Application of Nuclear Data Form Structure

15 – 17 March 2021, Vienna, Austria
Virtual event
Scientific Secretary: J.-Ch. Sublet
22 participants and IAEA staff

The purpose of this fully virtual event was to assess the actual capabilities, successfully deployed methods, tools and protocols, future needs in terms of model code output and application nuclear data form structure. The main aim of testing/prototyping/developing and deploying cutting-edge nuclear data form structure is to support high-fidelity multiphysics simulation efforts as a partnership between fundamental sciences and applications, along the lines of PREPRO, CRECTJ6, FUDGE, TAGNDS, TARES, DeCE, TEFAL, GIDI, MCGIDI. With 24 participants and 19 presentations the meeting has been great success.
https://conferences.iaea.org/event/253/overview
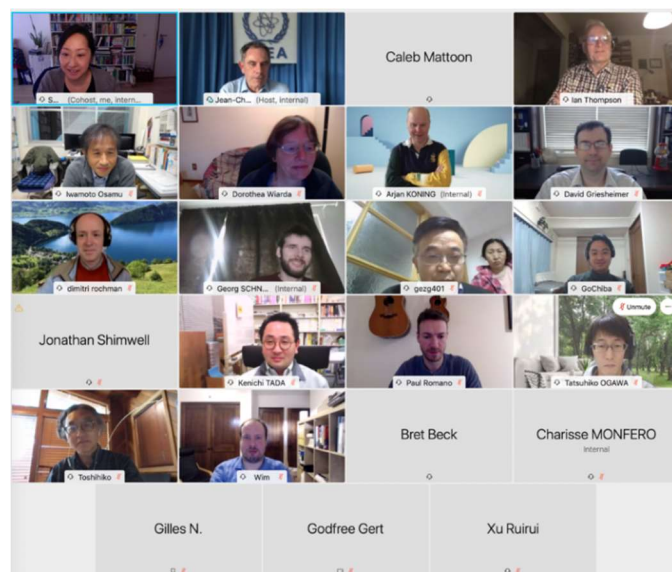
Selected Charts, Reports and Documents

IAEA-NDS-0223 Rev. 2 ACEMAKER-2017: A code package to produce ACE-formatted files for MCNP calculations, prepared by D. Lopez Aldama and A. Trkov, May 2021.

IAEA-NDS-0237 POINT2021: ENDF/B-VIII.0 Temperature Dependent Cross Section Library, prepared by Dermott E. Cullen, May 2021.

INDC(EUR)-0038 Results of time-of-flight transmission measurements for ^{142}Ce at a 50m station of GELINA, prepared by D.H. Moon, et al., March 2021.

INDC(GER)-0053 Activation Data from Karlsruhe Revisited, prepared by F. Kaeppeler and R. Reifarth, February 2021.

INDC(NDS)-0801 Summary Report of the Technical Meeting on Technical Aspects of Atomic and Molecular Data Processing and Exchange (25th Meeting of the A+M Data Centres Network), prepared by K. Heinola, June 2021.

INDC(NDS)-0817 Summary Report of the First Research Coordination Meeting on Updating Fission Yield Data for Applications, prepared by B. Pritychenko, et al., April 2021.

INDC(NDS)-0818 Summary Report of the Consultants' Meeting of International Nuclear Data Evaluation Network (INDEN) on Actinide Evaluation in the Resonance Region (3) prepared by G. Noguere, R. Capote, July 2021.

INDC(NDS)-0820 Summary Report of the Consultants' Meeting on Neutron Data Standards, prepared by A. Carlson, et al., June 2021.

INDC(NDS)-0826 Summary Report of the Second Research Coordination Meeting on Atomic Data for Vapour Shielding, prepared by K. Heinola, February 2021.

INDC(NDS)-0828 Summary Report of the Technical Meeting on Improved Decay Data for Monitoring Applications, prepared by Jun Chen, F. Kondev and P. Dimitriou, July 2021.

INDC(NDS)-0829 Summary Report of the Technical Meeting of International Network of Nuclear Reaction Data Centres, prepared by N. Otuka and B. Pritychenko, June 2021.
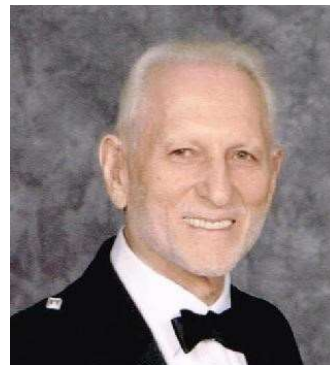
Available cost-free on request only for **teachers and scientists from developing countries:**

Chart of the Nuclides 2014 JAEA Nuclear Data Centre.

Karlsruher Nuklidkarte *Wall chart of the nuclides and folding chart with booklet, 10th edition (2018).*

In Memoriam

Cecil Lubitz

Dr Cecil Robert Lubitz passed away on 5 March 2021. Cecil had great impact within and on the nuclear data community. He contributed to the early development of the ENDF project and remained to be a contributor to the development of ENDF evaluations in particular U-235. He was one of the first members of the Cross Section Evaluation Working Group (CSEWG) and within was involved in formats and processing code, evaluation and validation. Cecil developed a nuclear data system for KAPL. He was a member of the several subgroups of the NEA/OECD Working Party on International Evaluation Cooperation (WPEC), among others in the pilot project of the SG40 Collaborative International Evaluated Library Organisation (CIELO). His contributions shaped and improved the quality of the nuclear data libraries used. For all of his achievements he will be remembered and greatly missed.

Efrem Sh. Soukhovitskii

Dr. Efrem Sholomovich Soukhovitskii passed away peacefully in Minsk, Belarus, on 16 March 2021 at the age of 73 years. Efrem studied Nuclear Physics at the Novosibirsk State University in Russia, did post-doctoral studies in Kiev, Ukraine, and joined the Joint Institute for Power and Nuclear Research (Sosny) near Minsk, Belarus, in 1971 where he had been working since.

Efrem was an extremely knowdledgeable nuclear physicist specializing in optical model studies. He was the lead author of the OPTMAN code dedicated to generalized optical model fits and optical model calculations based on sophisticated nuclear structure models, in particular, the soft rotator model. Efrem's work on evaluations undertaken and coordinated by the IAEA Nuclear Data Section has had a huge and lasting impact. He derived custom dispersive coupled-channel optical model potentials used in all the evaluations carried out by the IAEA/NDS and international collaborators, including seminal contributions to evaluations of Mn-55, Zr, Cr, Fe, and W isotopes, Au-197, Th-232, U-235 and U-238. Many of those evaluations built on the basis of jointly developed optical model potentials have been accepted by national and international nuclear data libraries. For all his knowdledge, Efrem was a very modest person, who fruitfully and intensively cooperated with an international team of researchers throughout the world, from Japan, Korea, China, Spain, the United States, Russia, and of course with our IAEA staff. His work will continue to be used and the OPTMAN code is part of his enduring legacy. Our colleague and friend, Efrem, will be deeply missed.

Nuclear Data Services – Contact Points

<u>For services to customers in USA and Canada</u>:
US National Nuclear Data Center, Bldg. 197D, Brookhaven National Laboratory, P.O. Box 5000,
Upton, NY 11973-5000, USA.
Tel. +1 631-344-2902; Fax +1 631-344-2806;
Website: http://www.nndc.bnl.gov/
Email: nndc@bnl.gov
For information regarding on-line services, contact: B. Pritychenko: pritychenko@bnl.gov
For information regarding general NNDC services, contact: Letty Krejci: lkrejci@bnl.gov

<u>For services to customers in OECD/NEA Data Bank member countries</u>:
NEA Data Bank, OECD Nuclear Energy Agency, 46, quai Alphonse Le Gallo
F-92100 Boulogne-Billancourt, France.
Tel. +33 1 7321 (plus extension);
Website: http://www.oecd-nea.org/databank/
Contact: F. Michel-Sendis, Tel.: +33 1 73 21 28 23, Email: franco.michel-sendis@oecd-nea.org;.

<u>For services to the customers from the former USSR</u>:
<u>Neutron data</u>: Russia Nuclear Data Center, Centr Jadernykh Dannykh (CJD), Fiziko-Energeticheskij Institut, Ploschad Bondarenko,1,
249033 Obninsk, Kaluga Region, Russian Federation.
Tel. +7 08439-9-5803; Fax +7 08439-68235;
<u>Photonuclear data</u>: Centre for Photonuclear Experiments Data, Centr Dannykh Fotoyadernykh Eksperimentov (CDFE),
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Tel. +7 495-939-3483; Fax +7 495-939-0896;
Website: http://cdfe.sinp.msu.ru/
Contact: V.V. Varlamov, Email: varlamov@depni.sinp.msu.ru;.

<u>For services to customers in China</u>:
China Nuclear Data Center, China Institute of Atomic Energy, P.O. Box 275(41), Beijing 102413, China.
Tel. +86 10-6935-7275; Fax +86 10-6935-8119
Contact: Ge Zhigang, Email: gezg@ciae.ac.cn;

<u>Computer codes of US origin to all countries</u> (there are charges and release restrictions):
Radiation Safety Information Computational Center (RSICC), Oak Ridge National Laboratory,
P.O. Box 2008, Oak Ridge, TN 37831-6003, USA.
Tel. +1 865-574-6176; Fax +1 865-241-4046;
Email: pdc@ornl.gov

<u>Computer codes of non-US origin to all countries</u> (there may be release restrictions):
NEA Data Bank (see above)
Contact: A. Dufresne, Email: Alice.DUFRESNE@oecd.org, Tel.: +33 1 73 21 28 30

IAEA-NDS on-line services at Website https://nds.iaea.org/
Users in India, China, Russia and neighbouring countries may use
IAEA-NDS mirror websites:
http://www-nds.org.in (India); http://www-nds.ciae.ac.cn/ (China); http://www-nds.atomstandard.ru/ (Russia).