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Summary Report of an IAEA Technical Meeting

Co-ordination of the International Network of Nuclear Structure and Decay Data Evaluators

IAEA Headquarters, Vienna, Austria

20 – 24 April 2015

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August 2015

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Abstract

The 21st meeting of the International Network of Nuclear Structure and Decay Data Evaluators was convened at the IAEA Headquarters, Vienna, from 20 to 24 April 2015 under the auspices of the IAEA Nuclear Data Section. This meeting was attended by 36 scientists from 15 Member States, plus IAEA staff, concerned with the compilation, evaluation and dissemination of nuclear structure and decay data. A summary of the meeting, data centre reports, various proposals considered, and actions agreed by the participants, as well as recommendations/conclusions are presented within this document.

August 2015

GLOSSARY

A	Mass Number
ADNDT	Atomic Data and Nuclear Data Tables
ALPHAD	ENSDF analysis program
AMDC	Atomic Mass Data Centre
AME	Atomic Mass Evaluations
ANL	Argonne National Laboratory, USA
ANU	Australian National University
ATOMKI	Institute of Nuclear Research of the Hungarian Academy of Sciences
A2, A4	Coefficients of Legendre expansion of γ-γ directional correlation
BIPM	Bureau International des Poids et Mesures, France
BMLW	Reduced magnetic transition probability in Weisskopf units (ENSDF)
BNL	Brookhaven National Laboratory, USA
BR	Branching Ratio
BrIcc	Program to calculate Band-Raman internal conversion coefficients
CD-ROM	Compact disk with read-only memory
CE	Conversion Electron
CEA	Commissariat à l'Energie Atomique (French Atomic Energy Commission)
CNDC	China Nuclear Data Centre, Institute of Atomic Energy (CIAE)
CRP	Coordinated Research Project (IAEA)
CSNSM	Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse, France
DDEP	Decay Data Evaluation Project
DDG-NA	Deputy Director General of the Department of Nuclear Sciences and Applications (IAEA)
DIR-NAPC	Director of the Division of Physical and Chemical Sciences of the Department of Nuclear Sciences and Applications (IAEA)
DELTA	ENSDF analysis program
DOE	U.S. Department of Energy
EADL	Evaluated Atomic Data Library
EC	European Commission
EC-Beta+	Electron capture-β^+ decay
EFG	Electric field gradient
EGAF	Evaluated Gamma-ray Activation File
EMPIRE	System of codes for nuclear reaction calculations
ENDF	Evaluated Nuclear Data File
ENSDAT	ENSDF analysis program
ENSDD	European Nuclear Structure and Decay Data Network of Evaluators
ENSDF	Evaluated Nuclear Structure Data File
EU	European Union
EURATOM	European Atomic Energy Community
EXFOR	EXchange FORmat: Computer-based system for the compilation and international exchange of experimental nuclear reaction data
Fm	Femtometer
FMTCHK	ENSDF analysis program
FO	Frozen Orbital
FP7 ENSAR	7th Framework Programme, European Nuclear Science and Applications Research (ENSAR)
FP7 ERA-NET	7th Framework Programme, European Research Area (ERA)
FTE	Full Time Employment
GABS	Gamma ABSolute: ENSDF analysis program
GAMUT	Computer code for gamma-ray energy and intensity analyses of data from ENSDF
GANIL	Grand Accélérateur National d'Ions Lourds, France

GND	General Nuclear Database
GSI	Gesellschaft für Schwerionenforschung mbH, Germany
GTOL	ENSDF analysis program
HF	Hindrance Factor
HSICC	Program to calculate Hager-Seltzer internal conversion coefficients
IAEA	International Atomic Energy Agency
IC	Internal Conversion
ICC	Internal Conversion Coefficients
ICRM	International Committee for Radionuclide Metrology
ICTP	International Centre for Theoretical Physics, Italy
IFIN-HH	Horia Hulubei Institute of Physics and Nuclear Engineering, Romania
IIT	Indian Institute of Technology
IMP	Institute of Modern Physics, Chinese Academy of Sciences, China
INDC	International Nuclear Data Committee
IP	Isotopes Project at LBNL
IPF	Internal Pair Formation
JAEA	Japan Atomic Energy Agency
$J\pi$/JPI	Spin and Parity
K	Angular momentum projection on the nuclear symmetry axis
LANL	Los Alamos National Laboratory, USA
LBNL	Lawrence Berkeley National Laboratory, USA
LiveChart	Interactive nuclear structure and decay database (predominantly from ENSDF)
LNHB	Laboratoire National Henri Becquerel, France
LLNL	Lawrence Livermore National Laboratory, USA
LOGFT	ENSDF analysis program
M, M$	Transition multipolarity
MR	Mixing ratio
MSU	Michigan State University, USA
MULT	Multipolarity
MySQL	Relational database engine
NAA	Neutron Activation Analysis
NDP	Nuclear Data Project, Oak Ridge National Laboratory, USA
NDS	Nuclear Data Sheets; journal devoted primarily to ENSDF data
NDS-IAEA	Nuclear Data Section, IAEA
NDSPUB	ENSDF code that produces PS/PDF for *Nuclear Data Sheets*
NIPNE	National Institute of Physics and Nuclear Engineering, Romania
NIST	National Institute of Standards and Technology, USA
ND	Nuclear Data
NNDC-BNL	National Nuclear Data Centre, Brookhaven National Laboratory, USA
NRM	Normalized Residual Method
NSCL	National Superconducting Cyclotron Laboratory, USA
NSDD	Nuclear Structure and Decay Data network
NSR	Nuclear Science References – bibliographic file
NUBASE	Experimental nuclear properties database
NuDAT	Interactive nuclear structure and decay database (predominantly from ENSDF)
NuPECC	Nuclear Physics European Collaboration Committee
NuPNET	Nuclear Physics Network
NWC	Nuclear Wallet Cards
OECD	Organization for Economic Co-operation and Development
ORNL	Oak Ridge National Laboratory, USA
PANDORA	ENSDF analysis program
PNPI	Petersburg Nuclear Physics Institute of the Russian Academy of Sciences
RADLST	ENSDF analysis code that calculates emitted radiation based on ENSDF
RIKEN	Japan’s largest research organization for basic and applied science
RIPL	Reference Input Parameter Library

RUL	Recommended Upper Limit
RULER	ENSDF analysis program
SHE	Super Heavy Elements
SQL	Structured Query Language
TJ^{π}	Proposed theoretical or recommended J^{π}
TUNL	Triangle Universities Nuclear Laboratory, USA
USNDP	US Nuclear Data Program
UCB	University of California at Berkeley
WPEC	NEA Working Party on International Evaluation Cooperation
XML	eXtensible Markup Language
XUNDL	Experimental Unevaluated Nuclear Data List

A-chain evaluation	Mass-chain evaluation: best data for the structure and decay of all nuclides with the same mass number.
Horizontal evaluation	Best values of one or a few selected nuclear parameters for many nuclides irrespective of their mass number.

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Foreword

Biennial meetings of the International Network of Nuclear Structure and Decay Data (NSDD) evaluators are held under the auspices of the IAEA. The network consists of evaluation groups and data service centres in several countries, and has the objective of providing up-to-date nuclear structure and decay data for all known nuclides by evaluating all relevant experimental measurements. Data resulting from this international evaluation collaboration are included in the Evaluated Nuclear Structure Data File (ENSDF) and published in the journals *Nuclear Physics A* and *Nuclear Data Sheets* (NDS). The results represent the recommended "best values" for the various nuclear structure and decay data parameters. These data and bibliographic details are also available through the World Wide Web, CD-ROM, wall charts of the nuclides, Nuclear Wallet Cards and other such media.

US efforts are coordinated by the Coordinating Committee of the US Nuclear Data Program. The ENSDF master database is maintained by the US National Nuclear Data Centre at Brookhaven National Laboratory, and these data are also available from other distribution centres including the IAEA Nuclear Data Section.

Biennial meetings of the network are sponsored by the IAEA Nuclear Data Section, and have the following objectives:

(a) coordination of the work of all centres and groups participating in the compilation, evaluation and dissemination of NSDD;

(b) maintenance of and improvements to the standards and rules governing NSDD evaluations;

(c) review of the development and common use of computerized systems and databases maintained specifically for this activity.

Detailed studies and discussions are undertaken over a five-day period. This document represents a summary of the network meeting held at the IAEA Headquarters, Vienna, Austria, from 20 to 24 April 2015. Thirty-six nuclear data specialists from fifteen countries along with IAEA staff attended this meeting to discuss their work as well as problems of common interest, particularly with respect to the active membership of the mass chain evaluation team responsible for ENSDF.

The first two days were dedicated to a combination of organisational, administrative and technical reviews of mass-chain activities and horizontal evaluations, and the progress made and problems encountered during the previous two years. A session on the new ENSDF processing procedure for submission of mass-chain evaluations was presented on the second day, while the remaining three days included the recently launched IAEA project on improved ENSDF analysis codes, and new proposals for application to ENSDF. Problems are still being experienced in maintaining a suitable number of mass chain evaluators (expressed as FTE – Full Time Employment). The uncertain future of the network, partly due to the ageing of the majority of existing evaluators and partly due to the fact that evaluators are overburdened with many other research activities and duties, was an important issue at the meeting, and alternative ways of organising ENSDF evaluations were discussed in this context. Difficulties have arisen in the maintenance of high quality evaluations achieved over the years by the meticulous work of network members. Under these circumstances, Member States are urged to support the continuing efforts of the network to train new evaluators by providing the proper working environment in their respective institutions. The adopted agenda for the meeting is listed in Annex 1, and a list of participants is given in Annex 2.

NSDD Meetings

Place	Date	Report
1. Vienna, Austria	29.04. – 03.05.1974	INDC(NDS)-60
2. Vienna, Austria	03 – 07.05.1976	INDC(NDS)-79
3. Oak Ridge, USA	14 – 18.11.1977	INDC(NDS)-92
4. Vienna, Austria	21 – 25.04.1980	INDC(NDS)-115
5. Zeist, Netherlands	11 – 14.05.1982	INDC(NDS)-133
6. Karlsruhe, Germany	03 – 06.04.1984	INDC(NDS)-157
7. Grenoble, France	02 – 05.06.1986	INDC(NDS)-182
8. Ghent, Belgium	16 – 20.05.1988	INDC(NDS)-206
9. Kuwait, Kuwait	10 – 14.03.1990	INDC(NDS)-250
10. Geel, Belgium	09 – 13.11.1992	INDC(NDS)-296
11. Berkeley, USA	16 – 20.05.1994	INDC(NDS)-307
12. Budapest, Hungary	14 – 18.10.1996	INDC(NDS)-363
13. Vienna, Austria	14 – 17.12.1998	INDC(NDS)-399
14. Vienna, Austria	04 – 07.12.2000	INDC(NDS)-422
15. Vienna, Austria	10 – 14.11.2003	INDC(NDS)-456
16. Hamilton, Canada	06 – 10.06.2005	INDC(NDS)-0476
17. St. Petersburg, Russia	11 – 15.06.2007	INDC(NDS)-0513
18. Vienna, Austria	23 – 27.03.2009	INDC(NDS)-0559
19. Vienna, Austria	04 – 08.04.2011	INDC(NDS)-0595
20. Kuwait City, Kuwait	27 – 31.01.2013	INDC(NDS)-0635
21. Vienna, Austria	20 – 24.04.2015	INDC(NDS)-0687

1. Introduction

The role of the NSDD Network is threefold: first, the compilation, evaluation and dissemination of nuclear structure and decay data; second, the maintenance and improvement of the standards and rules governing nuclear structure and decay data evaluations; and third, monitoring and reviewing the development and use of the computerized systems and databases maintained specifically for such activities. A primary aim of the network is that accurate and freely available data are provided to the user community so as to enhance the quality and reliability of their work. The IAEA Nuclear Data Section takes on the role of coordinator of the NSDD Network, and at the same time monitors and reviews the development and use of the computerized systems and databases maintained for such activities to ensure the smooth dissemination of nuclear structure and decay data

Meera Venkatesh (DIR-NAPC) welcomed delegates to this 21st meeting of the International NSDD Network, stressing the importance of the work and the coordinated effort. Roberto Capote (Deputy Section Head, NDS) emphasised and confirmed full NDS commitment to the support and coordination of the network activities.

The Agenda was approved as listed in Annex 1. A.L. Nichols (University of Surrey) and J.H. Kelley (TUNL) were elected to co-chair the meeting at appropriate times, and E. Ricard-McCutchan (BNL) was nominated rapporteur for the meeting. Thirty-six participants from fifteen countries, representing the majority of data evaluation centres, new evaluation groups and data dissemination centres, attended this meeting (Annex 2).

A list of all ENSDF evaluation centres and groups is given in Annex 3, along with their mass-chain evaluation responsibilities as assigned for 2013-2015. Representatives from the individual mass chain evaluation centres presented progress reports on their NSDD studies, and all of these status reports can be found in Annex 5. Apart from the status reports, other technical reports on horizontal evaluations, databases, and analysis codes are included in the main body of the report. Technical presentations made by participants are available on the IAEA NSDD website, and summaries are provided in Annex 6. Links to all the reports and presentations given during the meeting are listed in Annex 7.

The first two days were primarily devoted to administrative and organisational issues, in particular the discussion of actions from previous meetings, the proposals for two new Data Centres, the presentation of reports by evaluation centres, as well as reports on the USA and the IAEA Nuclear Data Programs, the network organisational review, and workshops, horizontal evaluations and databases. The final three days focussed on various technical matters including analysis codes and new proposals. Administrative and organizational items as well as workshops are summarized in Section 2. Activities related to databases and horizontal evaluations are presented in Section 3. ENSDF codes are discussed in Section 4, and new proposals for ENSDF are presented in Section 5. Summaries of round-table discussions are contained within Section 6, and recommendations and conclusions are given in Section 7.

Participants' discussions covered a wide range of topics, in the course of which recommendations were proposed to improve the quality of NSDD evaluations. A list of actions was prepared, indicating those responsible for implementation over the forthcoming two years (see Annex 4). An effort has been made during the preparation of this document to distinguish between meeting actions and recommended procedures that evaluators should continuously implement when performing their evaluations. As a result, the list of Continuous, Ongoing and Pending Actions was separated into two lists, one containing the continuous, ongoing and pending actions from this and previous meetings, and the other containing a list of recommended procedures that evaluators should follow when performing their evaluations. The latter was named Extensions to Procedures, and should eventually be incorporated into the general document on Procedures for ENSDF Evaluations which is available online at the NNDC and IAEA NDS websites.

The meeting concluded with the announcement that the next meeting will be held in the spring of 2017, the venue being the University of California at Berkeley, USA.

2. Administrative Matters and Reporting

2.1. New data centres

The following new data centres were introduced to the network:

- **IFIN-HH (A. Negret):** The evaluation effort at IFIN-HH started 7 years ago with one participant, and an IAEA contract was awarded to complete 3 mass chains. Two mass chains have already been published and now a second person (who attended the 2014 ICTP-IAEA training workshop) will join the evaluation work. Thus, the effort will be 0.2 FTE times two people (total of 0.4 FTE) devoted to evaluation work, and this new data centre could take full responsibility for about 6 mass chains. Both Directors of the Institute IFIN-HH and the Scientific Council have been consulted and approved the operation of an ENSDF Data Centre at IFIN-HH. The establishment of the Romanian Data Centre was endorsed by members of the network.
- M**SU (M. Thoennessen):** The new FRIB facility is currently under construction at NSCL/MSU, and will become one of the major facilities for the production of a wealth of nuclear data for exotic nuclides. NSCL/MSU has shown interest in contributing to the compilation and evaluation of such data, and the US Nuclear Data program has created a new position at MSU for this reason. J. Chen was recently hired to fill this position, and is already an active ENSDF evaluator and major contributor to XUNDL (he has compiled 122 XUNDL datasets (80 papers) in the last four months alone). MSU was endorsed by the network to become a recognised Data Centre.

2.2. Network membership

USA membership: Currently USA membership is composed of NNDC, NDP, LBNL, TUNL, and ANL. MSU will be added to this list, and LBNL will be retitled LBNL/UC Berkeley. A subset of mass chain responsibilities belonging to LBNL will be transferred to UC Berkeley at a later date. The definitive mass chain responsibilities of MSU will be agreed in consultation with McMaster and NNDC-BNL. From an administrative and budgetary point of view, B. Singh is now affiliated with NNDC-BNL.

Non-USA membership: Romania will be added to the non-USA list of Data Centres, defined in terms of both institute and country. The French Data Centre representative has retired (J. Blachot), and there are no plans to replace him – French membership is therefore withdrawn from the network, and their mass chain responsibilities (A = 113-117) are taken over by NNDC-BNL. [**Sec. Note:** following the meeting, Kuwait Data Centre representative A. Fahran informed the network that the Kuwait Data Centre will no longer be able to undertake ENSDF evaluations due to lack of suitable effort; thus, the Kuwait Data Centre has also been removed from the network list, with their mass chain responsibilities (A = 74-80) taken over by McMaster University.]

A proposal from RIKEN, Japan, to contribute to the compilation effort (XUNDL) and eventually to the evaluation of data produced by the facility was fully endorsed.

2.3. European effort

European contributions to the ENSDF evaluation effort remain low considering the number of large-scale experimental facilities producing significant amounts of nuclear structure and decay data throughout Europe. European research and applications groups are also among the greatest users of ENSDF (ENSDF database and *Nuclear Data Sheets*).

Currently, there are only two European Data Centres (ATOMKI, Hungary, and the newcomer IFIN-HH, Romania). One of the reasons is the lack of funding at both the overall European and national levels. All nuclear data activities in Europe are funded through individual grants which have limited duration and are non-renewable.

In spite of the significant efforts made in the past decade to organize and apply for European funding for mass chain evaluations (financial support from IAEA since 2006; IAEA meeting with potential European evaluators and EC laboratory directors, as well as contacts with EUROATOM, FP7 ENSAR committee, NuPECC and NuPNET project), there has been no success and little to no change in attitude from potential funding bodies.

Balabanski reported on the most recent attempt to establish nuclear data evaluation as an appropriately funded activity within European nuclear research. A proposal for a European network of data evaluators was submitted for inclusion in the ENSAR2 project to receive EU funding in the period of 2016-2020. This proposal was jointly prepared by several European laboratories and groups with the support of NDS IAEA. Unfortunately, the proposal was rejected, and the nuclear data evaluation package excluded from the ENSAR2 project.

Future activities involve submitting a recommendation to include nuclear data evaluation in the next update of the NuPECC long-range requirements.

2.4. NSDD Network status

INDC(NDS)-0421 is an IAEA document that contains descriptions of the structure, principal activities and products of the Nuclear Structure and Decay Data Evaluators' Network. This IAEA report constitutes a reference document one can use when referring to the status of the network. The last version was revised in 2004, and therefore an update is long overdue. Main items that need to be re-addressed and modified include

- data centres, and update of coordination responsibilities of ENSDF manager and IAEA;
- removal of Isotopes Project and Swedish Nuclear Data Centres from on-going activities;
- addition of LiveChart to libraries derived from ENSDF;
- update of data available on-line and off-line (mainly information from CRPs);
- update NSDD-related computer codes;
- mass chain responsibilities and horizontal evaluations;
- copyright issues.

This work will be undertaken by the NSDD Network Scientific Secretary (P. Dimitriou, IAEA) in consultation with the ENSDF Coordinator (J.K. Tuli, NNDC-BNL). A draft will be circulated to the network for comments and suggestions prior to publication.

M. Herman stated that greater efficiency would be achieved by writing a general description of the policies, and linking this material to webpages which would provide up-to-date information on specific topics on a continuously updated basis.

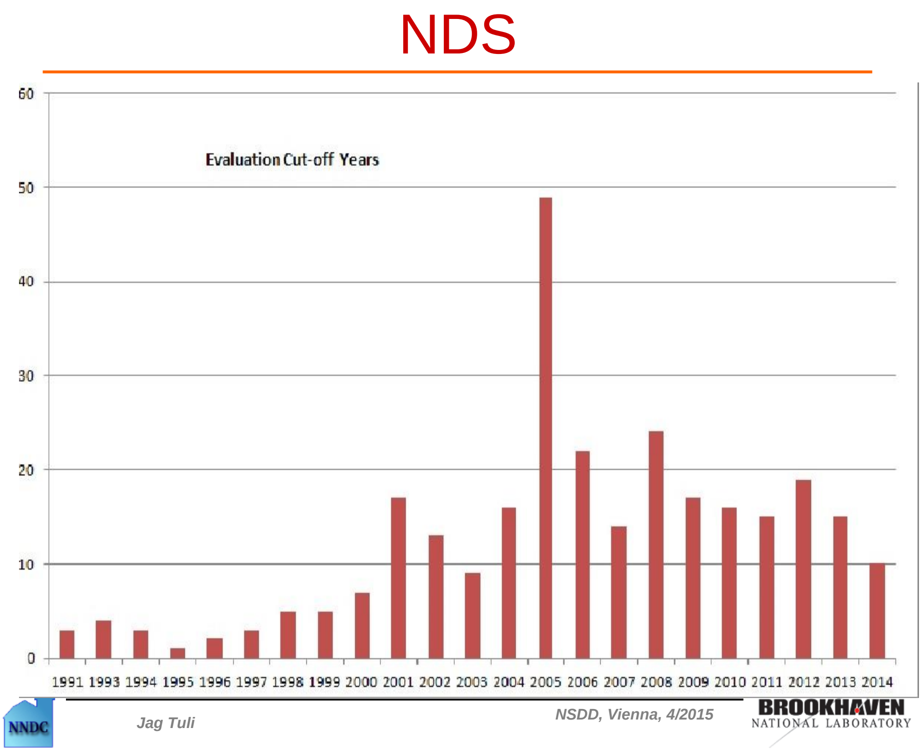
2.5. Organizational review

2.5.1. ENSDF statistics (J.K. Tuli, NNDC-BNL)

As co-ordinator of the ENSDF evaluation effort, J.K. Tuli (NNDC-BNL) provided a detailed overview of the current status of ENSDF. As of March 2015, the following are the important statistics for ENSDF:

- Datasets: 18261 (c.f. 17638 in 2013)
- Nuclides: 3261 (c.f. 3174 in 2013)
- Records: 2,668,002 (c.f. 2,522,559 in 2013), an increase of 5.8%
- Size: 213 Mega Bytes (202 MB)
- Adopted Datasets: 3261 (c.f. 3174 in 2013)
- Decay Datasets: 4245 (c.f. 4110 in 2013)
- Reactions: 9831 (c.f. 9503 in 2013)

ENSDF and XUNDL are both distributed electronically twice a year as updates, as well as in their entirety, to the network data centres and others who have requested them. A listing of the status of mass-chain processing is also issued to the network every month. On average, approximately 22 mass chains are undergoing review and processing at any one time. The inflow of mass chain evaluations for ENSDF has steadily decreased over recent years, threatening the ability to achieve the desired ten-year renewal rate. A bar chart was displayed that shows the approximate age of the various currently recommended mass chain data in NDS:



Tuli also maintains a priority list of 150 nuclides based on the number of experimental measurement papers in NSR that remain unevaluated. Network members should not hesitate to apply to evaluate a mass chain or **EVEN A NUCLIDE** of interest to them which does not fall within their particular areas of mass chain responsibility, and should contact NNDC (Tuli) to determine the feasibility of undertaking such evaluations.

2.5.2. Status of ENSDF evaluations and estimated manpower figures (J.K. Tuli, NNDC-BNL)

Tuli summarized the responsibilities of NSDD members, along with manpower commitments for the mass chain evaluators. There was a discussion on the usefulness of quantifying the FTE commitment for non-US participants. Some network members have experienced difficulties in quantifying the effort for institutions not directly funded to undertake ENSDF evaluations; however, according to the prevailing opinion, quantification of the total effort is essential in judging the overall output of the network. The ENSDF coordinator (J.K. Tuli) will supply the network with statistics defining the number of submitted mass chains/nuclides over the previous fiscal year.

Results of the discussions along with the statistics provided by Tuli are summarized in the following table:

Centre			No. mass chains responsible	FTE staff	FTE contract	No. mass chains submitted FY2014 Oct 2013 - Sept 2014
USA						
a	NNDC		118 *	1.2	1.8	7
b	ORNL		9	0.8	0.2	2
c	LBNL		33	1.0	0.5	1
d	TUNL		19	0.2		
e	ANL		23	0.4		
f	MSU		14	0.8		
Non-USA						
g	Russia		7	?		
h	China	Beijing	6	?		1
		Jilin	8	0.3		
i	India		15	0.7		1
j	Japan		10	0.2		
k	Canada		18	?	‡	
l	Australia		3	0.1		
m	Hungary		5	0.5		
n	Romania		6	0.4		
TOTAL				6.6	2.5	12

*118 = 294 – number of mass chains taken by all other Data Centres.

‡ FTE included in NNDC contract.

Specific mass chain responsibilities were also debated and agreed, including the following major changes:

- ANU gave up A = 175 and responsibility was transferred to ANL;
- McMaster University dropped A = 31-44 and this responsibility was transferred to MSU;
- France A = 113-117 responsibility was taken over by NNDC;
- Kuwait A = 74-80 responsibility was taken over by McMaster University (NNDC). [**Sec. note**: post meeting declaration.]

The agreed responsibilities are listed in the following table:

Data Centre	**Mass Chains**
NNDC-BNL	45-50, 60-73 (ex 62-64, 67), 82, 84-88, 94-97, 99, 113-116, 136-148 (ex 146), 150, 152-165 (ex 164), 180-183, 189, 230-240, >249
NDP	241-249
LBNL	21-30, 81, 83, 90-93, 166-171, 184-193 (ex 185, 188-190), 210-214
TUNL	2-20
ANL	106-112, 175-179, 199-209
MSU	31-44
Russia – St. Petersburg	130-135, 146
PRC – Beijing	51, 62, 195-198
PRC – Jilin	52-56, 63, 67, 73
India	215-229
Japan	120-129
Canada	1, 64, 74-80, 89, 98, 100, 149, 151, 164, 188, 190, 194
Australia	172-174
Hungary	101-105
Romania	57-59, 117-119

2.5.3. ENSDF processing using MyEnsdf (V. Zerkin, NDS-IAEA)

MyEnsdf is a web-tool application developed by V. Zerkin (NDS, IAEA) that allows the user to upload an ENSDF file and run the following Fortran programs remotely:

- ENSDF analysis/utility codes,
  NDSPUB2: produces PS/PDF for *Nuclear Data Sheets*
  (connected to ENSDF and NSR relational databases).

Due to limited resources available to assist in the preparation and editing of manuscripts submitted and accepted for publication in *Nuclear Data Sheets*, MyEnsdf has been further enhanced to allow evaluators to perform the following actions:

1. Upload mass-chain evaluation into an ENSDF database.
2. Run all analysis codes at one location.
3. Run production program NDSPUB to obtain an NDS-style output.
4. Be able to modify drawings and tables generated by step (3).

All the ENSDF analysis codes ALPHAD, GTOL, RULER, GABS, LOGFT, BrICC, BrICCmixing, PANDORA, RADLST, and the FMTCHK checking code are now available on

MyEnsdf. An additional feature has also been added that allows the user to adopt the output file of one code as input to another.

The main advantages of such an enhanced web-tool is that

1. User does not need software installation (only Web browser).
2. Central maintenance of utilities (only one platform)
3. Convenient Web interface to old legacy codes (automatic connection input-output of programs).

The disadvantage is that the user needs to have access to the Internet with all the problems that may entail (limited access, low connection speed, etc.). V. Zerkin gave a step-by-step demonstration of how MyEnsdf works, and evaluators agreed to try out this new web-tool and provide feedback to him.

2.6. Workshops

2.6.1. Joint ICTP-IAEA workshop (J.K. Tuli, NNDC-BNL; P. Dimitriou, NDS-IAEA)

A joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Theory and Evaluation, was held from 24-28 March 2014, at ICTP, Trieste, Italy, and was organized in collaboration with NNDC-BNL. Twenty-one participants from 15 countries attended the workshop. Six lecturers were invited: P. Van Isacker (GANIL), who covered aspects of nuclear structure theory; F.G. Kondev (ANL) and E. McCutchan (NNDC-BNL) who presented selected topics on experimental nuclear physics; and J.K. Tuli (NNDC-BNL) and B. Singh (McMaster University) who gave a general introduction to ENSDF, including formats and procedures. Hands-on exercises consisted of the evaluation of four isotopes of mass chain A = 227 (^{227}Th, ^{227}Ac, ^{227}Ra, and ^{227}Fr) – the remaining members of this mass chain had been updated by B. Singh before the workshop. Work on the mass chain evaluation continued after the workshop, and is in the final stages of preparation prior to submission to *Nuclear Data Sheets* for review and publication.

Contrary to previous such initiatives, this workshop was limited to only a one week event. As such, five days proved to be too short to serve as a comprehensive and effective introduction to nuclear structure and decay data evaluation. Therefore, the directors decided to modify the content to an advanced workshop and encouraged the existing less-experienced ENSDF evaluators to attend. The process of participant selection was strict, with emphasis on the nuclear physics background of the applicants and their previous experience in nuclear data evaluation. As a result, five of the workshop attendees had already been involved in mass chain evaluations prior to the workshop, while eight participants from India had attended previous ENSDF workshops and contributed to group mass-chain evaluations before. Thus, all participants were not only motivated and keen to learn, but able to engage actively in the hands-on exercise and discussions. Overall, a very good group assembled, and the re-shaped event proved to be a rewarding experience for both lecturers and students.

A questionnaire about the structure and effectiveness of the workshop and hands-on exercise was circulated at the end of the workshop. Summarizing the participants' response to the questions, one can safely conclude that a one-week workshop is too short, and more emphasis should be placed on hands-on exercises, demonstrations with specific examples, joint discussions, and how to use the analysis codes.

Some thoughts on the future of these workshops were considered by the NSDD Network, particularly whether they should be seen as either an outreach activity, or a means of attracting potential new evaluators. An additional issue of debate involved what actions need to be taken to make them as effective as possible (mass-chain or nuclide evaluation; exercise on analysis codes and smart editors; regular discussion sessions). The following feedback was given during the discussion that ensued:

Nichols believed strongly that a one week as opposed to two weeks workshop impacts and alters the practical nature of such ICTP-based NSDD workshops away from attempting to identify new blood for mass-chain evaluations towards the development of a simple educational tool. Herman suggested that the offer of this form of training to potential European-based evaluators made little sense for an environment in which no appropriate funding existed to continue the effort beyond the workshop. Martin stressed that mass-chain evaluations are becoming much more complex than previous, and require too much effort – better to choose a well-thought out nuclide that covers several different ENSDF datasets.

Stone suggested tailoring NSDD training workshops towards recent retirees as a group who could more easily pick-up data evaluation in their area of expertise and be productive for 5-10 years, instead of selecting "younger" people who are in the process of developing an existing and possibly divergent career. While this might prove feasible by means of an IAEA-based workshop, Nichols doubted that retiree attendees at technical workshops would be welcomed within the ICTP education and training system. Bernstein supported Stone's line of argument which he believed would also work well by focussing on necessary horizontal evaluations targeted towards retirees' expertise.

2.6.2. Other workshops (P. Dimitriou, NDS-IAEA)

Following the conclusions of the previous NSDD meeting (see IAEA report INDC(NDS)-0635) that maintaining the quality of ENSDF is an utmost priority of the NSDD network, NDS-IAEA decided to hold a Specialized IAEA workshop for active ENSDF evaluators. The aim of the workshop is to bring together experienced and relatively new ENSDF evaluators and give them the opportunity to discuss common problems they encounter in their mass evaluations, to get informed on evaluation policies and their implementation, and to be updated about analysis codes. The outcome of the workshop would be to re-fresh evaluators skills.

A Specialized Workshop for NSDD Evaluators will take place the week after the on-going NSDD meeting, from 27 to 29 April 2015. Depending on the recommendations and conclusions from this workshop, NDS-IAEA staff will decide on whether there will be a future sequel.

Firestone believed that a summer school on nuclear data evaluation needed to be organised in the foreseeable future designed to develop evaluators' abilities further.

3. Technical Reports

3.1. Databases

3.1.1. XUNDL (B. Singh, McMaster University)

Balraj Singh announced his decision to retire as coordinator of the XUNDL compilation effort. Under such circumstances, he gave a detailed history and comprehensive status report of the XUNDL effort and database covering the period from 1 February 2013 to 17 April 2015.

Following observations made by a US-DOE panel that high-spin structure data in ENSDF database were outdated and subsequent consultations with nuclear structure physicists at universities and major laboratories in the USA and Canada, compilation work started at

McMaster University in October 1998 for mainly high-spin publications. From these early beginnings, the involvement of McMaster undergraduate students was an important element in the work. Participants at the December 1998 IAEA-NSDD meeting in Vienna formally approved this initiative, and the project was named XUNDL (eXperimental Unevaluated Nuclear Data List).

Critical compilations are undertaken (in ENSDF format) of recently published experimental nuclear structure and decay data articles in PRC, PRL, NP-A, EPJ-A, PL-B, JP-G, and several others. The information in a given XUNDL dataset comes normally from either a single article or set of closely related articles from the same experimental group. Supplementary material sent by researchers in support of their published papers is also compiled and archived. Active and timely communications between data compilers and original authors of publications are encouraged. All contributed datasets are reviewed and edited, as needed, by the XUNDL coordinator and editor. Papers that are not generally covered in XUNDL: (1) papers reporting the discovery of new nuclides and/or first observation of excited states – such papers are included in the ENSDF database by updating nuclides; (2) mass measurement papers are compiled separately at McMaster and this data file is annually sent to Michael Smith (ORNL) to be made available on the *nuclearmasses.org* web site; (3) papers on continuum gamma-ray spectroscopy in high-spin, gamma-strength functions, TAS measurements, and structure data for hypernuclei.

Since 1999, long data tables in papers have been automatically converted to ENSDF format by means of optical scanning of pdf files, followed by a text-to-ENSDF translation code. Consistency checks, decay-scheme normalizations, and other quantities are deduced/added by making full use of the suite of ENSDF computer codes. Frequent communications are held with authors of articles with respect to data-related inconsistencies, and the transfer of additional details concerning the data.

Participants:

McMaster (from 1998):	B. Singh, and McMaster undergraduate students
ANL (from 2008):	F.G. Kondev, J. Chen (April 2012 – Nov 2014)
NSCL (from Dec 2014):	J. Chen
TUNL (from 2009):	J.H. Kelley, G. Sheu, J. Purcell: A = 2-20 mass region
ORNL (from Oct 2013):	C. Nesaraja, C. Smith, J. Batchelder
LBNL (from Nov 2013):	S. Basunia, A.M. Hurst
LLNL (from April 2014):	L. Bernstein, M.A. Trudel
BNL (from July 2014):	E.A. McCutchan
2013-2015:	S. Lalkovski (Sofia), S. Kumar (Delhi), A. Chakraborti (Vishva Bharati)

Database management at NNDC, BNL: D.F. Winchell (1998-2008), J.K.Tuli (2008 onwards)

Current contents of XUNDL (as of 17 April 2015): 6190 datasets compiled from 3740 papers (1993-2015) for 2317 nuclides spread over 288 mass chains, with about 900 communications with authors to resolve data inconsistencies and obtain additional details.

Work accomplished from 1 Feb 2013 – 17 April 2015:
1136 datasets compiled from 492 publications +78 updated datasets for new papers.
McMaster: 685 from 192 papers + 451 from other centres reviewed and edited, if needed. 70 datasets updated as a consequence of new papers or additional data received. 30 mass measurement papers compiled.
ANL + NSCL: 30 (ANL) from 13 papers + 130+1 update from 85 papers (14 with McMaster).
TUNL: 138 from 116 papers.

ORNL : 68 datasets from 33 papers (4 with McMaster).
LBNL +LLNL: 53+2 updates from 30 papers (11 with McMaster).
BNL: 33+5 updates datasets from 23 papers.

Compilation of TAGS data on a trial basis:
*Total absorption study of the β decay of $^{102, 104, 105}$Tc, D. Jordan, A. Algora, J.L. Tain, et al., PRC **87** (2013) 044318*: Dataset for ^{104}Tc to ^{104}Ru decay has been prepared, and is now available as "104TC B-DECAY: TAGS:XUNDL" in XUNDL; comments are welcome concerning the inclusion of such data from recent papers on TAGS measurements.

XUNDL schedule for Coordinator and Editor:

- Scan journal webpages: PR-C, PRL, PL-B, EPJ-A, NP-A, JP-G. Also Nature, ARI, NIM-A, NIM-B, CPL, CP-C, IJMP-E, PAN, BRAS, APP-B, arXiv.
- Select papers for XUNDL or ENSDF. Assess whether author needs to be contacted.
- Compile papers as time permits.
- Suggest papers to data centres, and obtain their agreement for compiling.
- Review datasets received from compilers, run FMTCHK, SPELLCHECK, and edit as needed. If any major changes are made, send edited data file to compiler for comments.
- Check if all transmitted datasets to NNDC are in XUNDL database.
- Twice a year, replace temporary key-numbers with NSR assigned key-numbers.

Next generation XUNDL Coordinator and Editor profile:

- Interested in the compilation activity.
- Active, unhesitating communication with authors of papers.
- Consistent work schedule – papers keep coming every week.
- Keep up-to-data with new literature, independent of NSR.
- Be willing to coordinate this activity for several years to come.

Effective from 1 October 2015, Libby McCutchan (NNDC, BNL) has agreed to be the next XUNDL Coordinator and Editor. For the first few months B. Singh will assist, if needed, for a smooth transfer of this effort.

3.1.2. NSR (B. Pritychenko, NNDC-BNL)

Nuclear Science References (NSR) database, together with an associated Web interface, is the world's only comprehensive source of easily accessible low- and intermediate-energy nuclear physics bibliographic information, covering 216,696 articles since the beginning of nuclear science. Updated weekly, the NSR database provides essential support for nuclear data evaluations, compilations and research activities. The complete NSR database is freely available on the websites of the National Nuclear Data Centre http://www.nndc.bnl.gov/nsr/ and the International Atomic Energy Agency https://www-nds.iaea.org/nsr/.

Fiscal Year 2014: 3130 new articles were added, 1898 were assigned keywords, and 220 additional modifications were introduced. The NSR database was updated 102 times, and the total number of Web retrievals was 232,107. NSR content and dictionary updates serve as an indicator of nuclear physics research worldwide – 1488 new authors, 7 new journals, 257 new nuclides, 141 new reactions, and 20 new decays have been added.

NSR scope is very broad, and provides an essential gateway to new data for ENSDF evaluations and XUNDL compilations. The content is an invaluable resource for horizontal nuclear structure evaluations. Staff work in close cooperation with the NSDD network, and are presently investigating the possibility of creating a joint NSR/EXFOR electronic library that would provide access to BNL/IAEA bibliographical resources.

3.1.3. Nudat: recycling NuDat programs (A.A. Sonzogni, NNDC-BNL)

Although most of the programs that make NuDat possible were written in Java around 2004, important upgrades have been produced every year. Due to the flexibility of object-oriented programming, these codes have been used in different situations where large amounts of nuclear data need to be searched under different criteria for further use in calculations.

One such application is the calculation of antineutrino spectra following the fission of an actinide nuclide in equilibrium. Data needed for such calculation are the fission yields and the beta-minus intensities, with respect to effective Q-values and degree of forbiddenness, for all relevant fission fragments. We have learned that (a) energy integrated antineutrino spectra follow (3Z - A) systematic behaviour similar to that of delayed nu-bar (b) light fission fragment group contributes more than the heavy fission group, and (c) odd-Z, odd-N nuclides contribute more than nuclides with different degrees of Z and N evenness.

Another somewhat related application is the calculation of the decay heat of previously irradiated fuel as a function of cooling time. A network of inter-related differential decay equations need to be solved in which the population values at zero time are the independent fission yields. Half-lives and branching ratios are required to calculate the evolution of the network while mean decay energies are needed to determine the decay heat. Studies of beta-minus decay heat have shown that the main peak in the time x decay-heat plot at approximately 10 seconds arises predominantly from the decay of odd-Z, odd-N nuclides within the light fission fragment group. A closer examination to understand which individual nuclides are the significant contributors reveals a list that is similar to the main nuclides that contribute most in the region of the antineutrino ‘bump’ at around 5.5 MeV.

3.1.4. LiveChart (M. Verpelli, NDS-IAEA)

Recent developments and improvements in LiveChart applications include the following

- JAVA-NDS code developed at McMaster University is used to parse the ENSDF files.
- New features in the display include the nuclear chart and individual nuclei.
- Atomic masses and Q-values are taken from AME2012.
- Extensive plotting features with many new criteria.
- New mobile application called Isotope Browser available for Android and iphone applications.
- New medical portal – data on the production modes (including reaction cross sections) and decay modes of nuclei – click on a specific nuclide to obtain particular reaction excitation function and decay data.

A compilation of the most frequently asked questions and popular requests made by users of LiveChart was also presented:

- Why are level and γ radiation properties different in the Adopted and Decay datasets in ENSDF?
- Why not provide absolute intensities in addition to relative intensities?
- Why not provide all the decay radiation from a single nuclide in one table?
- Why not give the branching ratio for individual decay modes of EC and Beta+ instead of (EC-Beta+)?
- Place ENSDF under version control.
- Make ENSDF database relational.

The following comments were made after the LiveChart presentation:

Sonzogni stated that customer support at NNDC has become increasingly time consuming, and provision of a relational ENSDF database will only add to this problem of ensuring a satisfactory customer service.
Tuli pointed out that as far as version control is concerned, copies of the ENDSF database from bi-annual dumps are now available on the website effectively to inform the user on changes in the traceability of recommended ENSDF data. However, Capote was not confident that this approach would be sufficient to address the need for version control – all data modifications and updating need to be fully and rapidly traceable.

Action on NNDC-BNL: to explore the implementation of ENSDF tracking, and report their findings and recommendations at the next USNDP meeting (November 2015).
Action on NNDC-BNL: insert AME2012 Q-values as an additional Q-record in the ENSDF Adopted datasets.

3.1.5. RIPL: discrete levels (M. Verpelli, NDS-IAEA)

The new release of RIPL – Discrete Levels segment has the following features:

- Adoption of NUBASE2012 data to define isomer excitation energies resulted in 30% of the undefined ("+X") energies in ENSDF being assigned.
- Interpolation of Hager-Seltzer ICC tables replaced by BrIcc – Interpolation of Band ICC tables + Frozen Orbital approximation.
- Total internal conversion factors include the internal-pair formation channel.
- Assignment of a level to a band is reported.
- ENSDF-parsing bugs and other user-identified problems have been corrected.

Subsequent discussions focussed on whether and how to use NUBASE2012 data to assign unknown isomer energies in ENSDF, and appropriate actions were agreed.

3.2. Horizontal evaluations

3.2.1. Atomic masses evaluation (coordinated by M. Wang (IMP-Lanzhou); presented by G. Audi, CSNSM)

A number of new experimental activities devoted to atomic masses have been carried out in recent years. Two experimental approaches contribute to mass measurements at high precision and permit access to nuclei far from stability, improving accuracy and reaching more exotic frontiers. While the first approach is based on energy measurements by means of nuclear reactions and decays, the second relies on the inertial mass of a moving atom. Across the full chart of the nuclides accuracies have been increasing, and the area occupied by known nuclei has extended considerably. The published Atomic Mass Evaluation (AME) in 2012 contained 8534 reactions and decays, and 5275 mass spectrometry data, establishing relations between 2416 ground state masses and 232 isomers, with the addition of 1063 still unknown masses for which estimates were given.

Precision and accuracy have now reached levels well below one electron-volt (or one nano-u), thus rendering ionisation and molecular energy corrections absolutely necessary. An example was given for the HD+ ion in a Penning trap, which differs from the sum of the masses of one atom of hydrogen plus one atom of deuterium by 4.85 nano-u for their molecular binding energy and 16.58 nano-u for their ionisation energy. Molecular binding energies are calculated from the standard heat of formation of the species, and for the purpose of AME they are extracted from: http://webbook.nist.gov/chemistry/ while the molecular ionization energy can be obtained from:
http://physics.nist.gov/PhysRefData/ASD/ionEnergy.html

New techniques are entering the world of mass measurements, with the most spectacular example being the "multi-reflection time-of-flight mass spectrometry (MR-TOF)" which has now been implemented at both the ISOLDE and RIKEN facilities.

NUBASE EVALUATION:

NUBASE was created in 1993 because the contents were urgently needed and essential for the AME. The primary goal was to determine as accurately as possible which isomers were associated with a specific mass measurement.

NUBASE has now reached a high degree of reliability and recognition from the broader physics community. Therefore, this information needs to be exploited by ENSDF evaluators or at least not ignored when they are building a new mass-chain evaluation. An example of a series of ground state and isomeric alpha decays in the chain of nuclides from ^{179}Tl to ^{155}Tm illustrated the large quantity of information that is still missing in ENSDF.

3.2.2. DDEP (M.A. Kellett, LNHB, CEA-Saclay)

The Fundamental Data Unit of the Laboratoire National Henri Becquerel (LNHB) – the French national standards laboratory – continues to perform a number of full decay scheme evaluations as part of the Decay Data Evaluation Project (DDEP), which includes conversion- and Auger-electron data as well as X-rays. Current members of the DDEP are: M.-M. Bé, V.P. Chechev, Ch. Dulieu, X. Huang, M.A. Kellett, A. Luca, X. Mougeot, and A.L. Nichols.

Means to access these data include the currently available seven volumes of the Monographie-5 series published by the Bureau International de Poids et Mesures (BIPM), that can be downloaded free of charge from www.bipm.org/fr/publications/monographie-ri-5.html, with volume 8 planned for publication in 2015. Data are also available from the dedicated DDEP website (http://www.nucleide.org/DDEP_WG/DDEPdata.htm) where detailed evaluator comments are also stored. A tool for alpha-particle and gamma-ray spectroscopists has been developed at the LNHB that provides a user interface allowing searches of the DDEP database to be made, available at http://laraweb.free.fr. LNHB staff are also developing a code to precisely calculate the shape of beta spectra for all transition types, in conjunction with an experimental programme to validate the code. Further details were given in the “Computer Codes” session of the meeting (see Section 4.7. in this report).

Kellett stated that there is a shortage of decay data evaluators which other metrology institutes would hopefully help to address. Under this unsatisfactory situation, manpower issues remain a major concern for the future.

3.2.3. EGAF (R.B. Firestone, LBNL)

Analyses of 16 thermal neutron capture decay schemes, total radiative capture cross sections, and neutron separation energies were published from 2013-2015 [1-8] – see Table 1. Neutron separation energies for ^{181}W, ^{238}Np, ^{242}Am and ^{243}Pu were discrepant from AME values [9]. Also found in ^{42}K β^- decay that P_γ(1524.7 keV) = 0.164(4) differs from 0.1808(9) in ENSDF [10], and in ^{187}W β^- decay that P_γ(686 keV) = 0.352(9) is slightly higher than the value of 0.332(5) in ENSDF. The –26.6 eV bound resonance of ^{184}W given as $(0,1)^-$ in ENSDF was determined as 1^-. Additional (n,γ) data for ^{2}H, ^{16,17,18}O, ^{54,56,57,58}Fe, ^{90}Y, ^{94}Nb, ^{140}La and ^{186}Re are currently being evaluated.

Recent work has also focused on the evaluation of primary γ-ray photon strengths. A >99% complete decay scheme for ^{56}Fe(n,γ)^{57}Fe has been constructed based on γ-ray singles spectra from the Budapest Reactor and γγ-coincidence data from the Rez Reactor, Prague. Gamma-ray strengths have been determined for 90 primary transitions in ^{57}Fe. The high-energy γ-ray strengths are consistent with Brink-Axel predictions, whereas the low-energy γ-ray strengths greatly exceed Brink-Axel predictions, consistent with observations from the $^{57}Fe(^{3}He,^{3}He\gamma)$ reaction at the Oslo cyclotron [11]. These low-energy γ rays are proposed to possess M1 multipolarity, with photon strength increasing for transitions between states of the same seniority.

The distributions of primary and secondary γ-ray transition probabilities have also been compared to Porter-Thomas (PT) predictions. Only E1 γ rays appear to follow this predicted form of distribution. Weak E2 γ rays exceed PT expectations, while both weak primary and secondary M1 γ rays have lower probabilities than predicted by PT. Correspondence of the two low-energy M1 groups supports the M1 assignment to low-energy primary γ rays.

Table 1. Results of recent EGAF (n,γ) measurements.

	σ_0 (this work) b	**σ_0 (Atlas [12]) b**	**S_n (this work) keV**	**S_n (AME [9]) keV**
$^{23}Na(n,\gamma)^{24}Na$	0.541(3)	0.517(4)	6959.352(18)	6959.42(4)
$^{39}K(n,\gamma)^{40}K$	2.28(4)	2.1(2)	7799.57(12)	7799.62(6)
$^{40}K(n,\gamma)^{41}K$	90(7)	30(8)	10095.243(15)	10095.37(6)
$^{41}K(n,\gamma)^{42}K$	1.62(3)	1.46(3)	7533.829(10)	7533.80(11)
$^{152}Eu(n,\gamma)^{153}Eu$	7060(400)	5900(200)	6307.11(6)*	6306.71(10)
$^{152}Eu(n,\gamma)^{153}Eu^{m1}$	2345(220)	3300(200)		
$^{154}Eu(n,\gamma)^{155}Eu$	9405(460)	9200(100)	6442.0(3)*	6442.17(24)
$^{154}Eu(n,\gamma)^{155}Eu^{m}$	335(10)	310(7)		
$^{155}Gd(n,\gamma)^{156}Gd$	56,700(2100)	60,900(500)	8536.39(12)*	8536.35(7)
$^{157}Gd(n,\gamma)^{158}Gd$	239,000(6000)	254,000(815)	7937.50(4)*	7937.39(6)
$^{180}W(n,\gamma)^{181}W$	24.7(8)	<150	6668.79(20)	6686(5)†
$^{180}W(n,\gamma)^{181}W^{m}$	6.8(9)			
$^{182}W(n,\gamma)^{183}W$	20.5(14)	19.9(3)	6190.88(6)	6190.81(5)
$^{182}W(n,\gamma)^{183}W^{m}$	0.177(18)			
$^{183}W(n,\gamma)^{184}W$	9.4(4)	10.4(2)	7411.11(13)	7411.66(25)
$^{183}W(n,\gamma)^{184}W^{m}$	0.025(6)			
$^{184}W(n,\gamma)^{185}W$	1.43(10)	1.7(1)	5753.74(5)	5753.71(30)
$^{184}W(n,\gamma)^{185}W^{m}$	0.0062(16)			
$^{186}W(n,\gamma)^{187}W$	33.3(6)	38.1(5)	5466.62(7)	5466.79(5)
$^{186}W(n,\gamma)^{187}W^{m}$	0.400(16)			
$^{237}Np(n,\gamma)^{238}Np$	170(7)	175.9(29)	5039.0(4)	5033.9(26)†
$^{241}Am(n,\gamma)^{242}Am^{g}$	663(29) 650(28)	533(13)	5534.87(15)	5537.64(10)†
$^{241}Am(n,\gamma)^{242}Am^{g+m}$	725(34) 711(34)	587(12)		
$^{242}Pu(n,\gamma)^{243}Pu$	20(4)	18.5(5)	5490.44(5)	5488.32(20)†

* Preliminary unpublished value. † Discrepant neutron separation energy.

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3.2.4. Semi-magic seniority isomers and the effective interaction (A.K. Jain, ITT-Roorkee)

Experimental data have been collected on more than 2450 nuclear isomers in the *Atlas of Nuclear Isomers* [1], with a half-life cut-off at 10 ns. Several of their properties have been found to exhibit novel systematics. Nuclear isomers in different semi-magic chains possess almost identical experimental excitation energy and half-life systematics. Large-scale shell model calculations have been carried out to decipher their configurations and seniorities, which are able to reproduce the observed systematics quite well. Therefore, they are concluded to be seniority isomers, which show similar features due to the same seniorities, even though different orbitals up to J = 11/2 or 13/2 are involved. These systematic studies also constitute a powerful tool to predict some unknown isomers at the nuclear extremes.

Seniority v = 2, 6^+ nuclear isomers have been studied in neutron-rich Sn-isotopes beyond magic number N = 82 as shown in Fig. 1 [2], as a consequence of new experimental data becoming available [3]. Large-scale shell model calculations are able to explain the isomeric excitation energies as well as their BE2 values reasonably well. However, the original RCDB effective interaction [4] has to be modified by reducing 25 keV from the diagonal and non-diagonal $\upsilon f_{7/2}^2$ two-body matrix elements (TBME) in order to explain the discrepancy of a large non-zero BE2 value at the mid-shell of $f_{7/2}$ orbital, i.e. ^{136}Sn. This small change in TBME leads to an incremental change in the seniority mixing, and a non-zero BE2 value at the mid-shell, which comes closer to the experimental data. These studies have shown that one can check the scope of the realistic effective interactions, particularly in the neutron/proton-rich nuclei, by exploring the role of seniority in semi-magic nuclei.

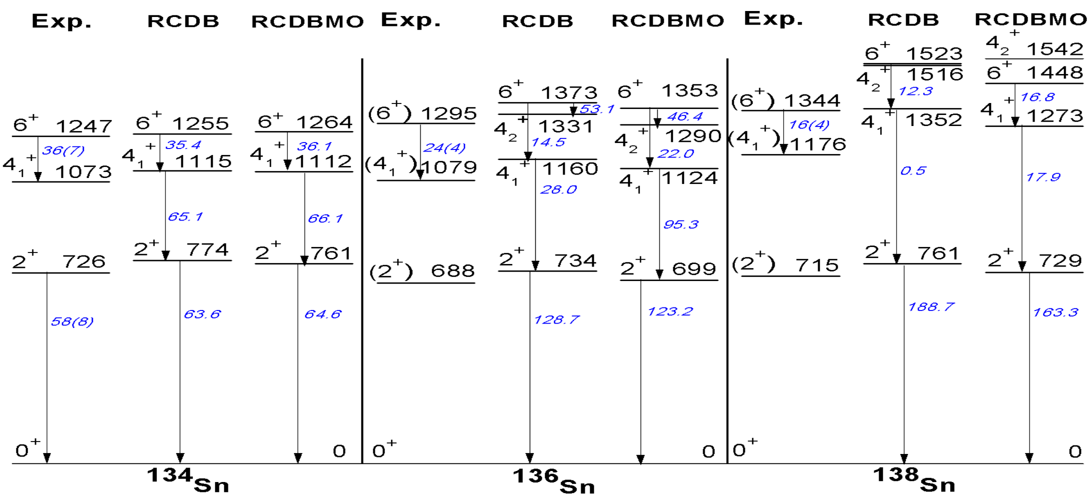

FIG 1: Energy level schemes for $^{134\text{-}138}$Sn. All the energies are in keV; BE2 values in e^2fm^4 units, shown in italics, are rounded off (see [2] for details).

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3.2.5. K-isomers in deformed nuclei A > 100 (F.G. Kondev, ANL)

A topical review and horizontal evaluation of the properties of K-isomers in deformed and transitional nuclei has been completed and published in *Atomic Data and Nuclear Data Tables* [1]. Assigned multi-quasiparticle configurations were included together with the factors that control the transitions strengths, such as various contributions to K mixing. The systematics of K-forbidden transitions for different multipolarities were discussed for selected cases in terms of the hindrances (FW) and reduced hindrance factor per degree of K forbiddenness (f_ν), where $\nu = \Delta K - \lambda$ in which ΔK is the K-value difference between the initial and final state, and λ is the transition multipole order. With the improved statistics for E1, M1 and E2 transitions, a factorization into the product of the underlying multipolarity-dependent transition strength and a ν-dependence due to K forbiddenness (f_0) was proposed. This suggests a weaker dependence on K forbiddenness than is commonly assumed.

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3.2.6. Isobaric analogue states in NUBASE (M. MacCormick, IPNO-Orsay)

Recent studies of isospin symmetry in light to medium mass nuclei have led to a detailed evaluation of experimentally observed isobaric analogue states (IAS) with isospin, T = 1 to 4 [1]. Focus in this presentation was set on the new notation introduced in NUBASE2012 [2] to identify and label these ground state analogues.

The basic hypotheses of the Isobaric Multiplet Mass Equation (IMME) as used to extract the theoretical Coulomb energy components from experimentally determined masses is that the spatial distribution and spin-parity of each member in a given isospin multiplet is the same; only the isospin projection changes. In turn, if an IAS is unambiguously identified within a given nuclide, this observation can be used to define the spin-parity of the state.

Overall, there are three nuclides in 109 evaluated multiplets that are both isomer states as well as IAS for which the isomer notation m,n is used; furthermore, the well-known isospin inversions in six $N = Z$ ground state nuclei of the *fp*-shell make the excited state notation unnecessary since the ground states are $T_Z = 0$ components in these cases. Experimentally observed fragmented IAS are labelled *frg*, and the strongest contribution is given as the principal mass. The other fragment positions are given in comments relative to the strongest, and every effort is made to communicate the complete original experimental information. Finally, out of over 180 different nuclides, 52 are determined by means of horizontal relations including 17 reaction threshold measurements, two (p,γ) measurements and 33 single or double proton-decay channels. The dataset continues to evolve: some IAS have been recently repositioned or observed with greater precision, and future NUBASE publications will continue to be updated to include new results.

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[1] M. MacCormick, G. Audi, *Nucl. Phys*. A **925** (2014) 61–95.
[2] G. Audi, F.G. Kondev, M. Wang, B. Pfeiffer, X. Sun, J. Blachot, M. MacCormick, *Chin. Phys*. C **36** (2012) 1157–1286.

3.2.7. Magnetic moments

Compilation and Evaluation (N.J. Stone, ORNL)

2013-2015 has seen the completion and publication of the Table of Nuclear Electric Quadrupole Moments [1]. This table constitutes a list of recommended values of more than 1000 measured nuclear electric quadrupole moments, with detailed reference to the type of measurement and the electric field gradient (*efg*) adopted to extract the moment from experiment. The efg is a calculated quantity and the marked improvement in the quantity and quality of efg calculations in multi-electron atoms, ions and molecules over the past decade or so has encouraged this timely review and update of all published quadrupole moments and relate them to the best available efgs. Selection of efgs was based on the tabulation of Pyykko [2], supplemented by further standards for additional elements not included in these 2001/2008 listings and for the analysis of measurements which cannot be directly related to the adopted standards of Pyykko. The compilation Table of Nuclear Magnetic Dipole and Electric Quadrupole Moments was also maintained, and an updated version has been issued which includes the recommended quadrupole moment values [3].

Future plans include the need to produce a companion table with recommended values of nuclear magnetic dipole moments. Hence, the presentation considered several problem areas which will need to be tackled to achieve a uniform treatment. These include the possible application of corrections to experiment for diamagnetism and for the common neglect of hyperfine anomaly effects. As for the transient field method applied to very short-lived states, the use by different experimenters of their own empirical calibrations will require attention. The value of moving to a database form of tabulation in the future is presented in the following section.

References

[1] N.J. Stone, Table of Nuclear Electric Quadrupole Moments, IAEA report INDC(NDS)-0650, December 2013.

[2] P. Pyykko, *Molecular Physics* **99** (2001) 1617, and *Molecular Physics* **106** (2008) 1965.

[3] N.J. Stone, Table of Nuclear Magnetic Dipole and Electric Quadrupole Moments, IAEA report INDC(NDS)-0658, February 2014.

Dissemination (T. Mertzimekis, National University of Athens)

A web-based database for nuclear EM moments has been created at the University of Athens [1]. This database was built with the support of earlier published tabular compilations, but also incorporates older and recent data that were not available previously to constitute a data file comprised of more than 1100 levels and 5300 entries of individual measurements. While the front end of the database is built with HTML, the back end is MySQL and the operational engine is PHP. Elementary particle data are also included that have been taken directly from the Particle Data Group site. The data can be retrieved either by first selecting an element, then a particular isotope, or by providing (Z,A). Information for a particular level is shown as: isotope, energy, half-life, spin and parity, magnetic moment in μ_N, electric quadrupole moment in *barns*, reference nucleus (if any), experimental technique, NSR keynumber(s) and the Digital Object Identifier (DOI). The latter two are provided with direct url links, whereby the DOI is a major innovation of the database with regards to the published compilations, as the process allows for immediate access to the original work.

Another advantage of the web-based database is the frequency of updates. Since 2007, the database has incorporated non-evaluated data directly from publications, conference proceedings, preprints, abstracts, and existing compilations and evaluations from a large number of sources (~30). The average amount of published data requires an updating exercise every 2-3 months. Despite the database being a stand-alone application, the technology allows for easy integration into other databases, such as the IAEA LiveChart. This electromagnetic moments database will be made available on the NDS IAEA web server as a stand-alone application and also through LiveChart by the end of 2015.

Future plans involve provision of more reliable data, adding data plotting capabilities to reveal and present systematic trends, and collaboration with experts to incorporate evaluated data. Finally, an existing associated blog will be upgraded to serve as an online forum for researchers to provide feedback on the database in order to improve performance and data quality. This work is being partially supported by NDS IAEA.

References

[1] http://magneticmoments.info
[2] The Particle Data Group http://pdg.lbl.gov

As a consequence of what had been said and recognising the growing number of such data and the complexity of the various measurements, Martin believed there to be a definite need for a comprehensive evaluation of nuclear moments. Both Stone and Dimitriou pointed out that a table of recommended electric quadrupole moments already exists (IAEA report INDC(NDS)-0650), although the situation for magnetic dipole moments is not so simple or satisfactory. Different measurement techniques require different methods of extracting the 'bare' nuclear dipole moment from the measured data. NDS IAEA staff plan to coordinate an international effort involving experts familiar with all the different measurement techniques to evaluate and recommend dipole magnetic moments for use in various applications.

4. ENSDF Computer Codes

4.1. Overview (P. Dimitriou, NDS-IAEA)

The first meeting of the IAEA data development project to improve the ENSDF analysis codes was held in June 2014. Participants reviewed the existing codes and discussed emerging needs for improved physics models, uncertainty treatment, physics and format checking, and modernisation of the programming tools, along with the development and use of online web-tools and a user-friendly evaluation toolkit to facilitate evaluators' work. A list of priorities was produced that was expressed in terms of the codes and the modifications that need to be made, along with the assignment of tasks to individual participants (see IAEA report INDC(NDS)-0665). As also agreed, a common platform will be used for the development and dissemination of the codes. Reports on the progress made since the June 2014 meeting were given separately in this session by the responsible persons (see below). The second Technical Meeting of the project will be held from 5 to 8 October 2015 to monitor progress and revise the work plan.

Significant debate ensued, and a number of key questions were posed and statements made that need to be satisfactorily addressed during and at the conclusion of the project:

- Who will remain responsible for the codes?
- Who should users contact about bugs in these emerging and modified codes?
- How will people outside the network gain access to the codes?
- We need to retain transparency so that outside users can easily find and implement stable versions of these codes. Thus, the webpage from which these codes are downloaded needs to contain clear messages to the user and, without any ambiguity, point to the stable versions.

- Codes on the IAEA and NNDC websites are not always the same. What will be the procedure for ensuring that both sites carry the most recent and identical versions of the codes?

All of the codes undergoing development will be uploaded on the GFORGE server at NNDC-BNL. Bugs and requests can be easily logged through the tracker in GFORGE. However, for broader dissemination to users from different disciplines and fields of applications, the dedicated websites for downloading the codes should be maintained, and these websites should most emphatically point to the most recent stable versions of the codes.

Action on NDS IAEA and NNDC-BNL: ensure that both web sites are synchronized with respect to the versions of the codes made available.

4.2. RULER (T. Kibedi)

A new version of RULER (v.4.1c) has been written to deal with values given as upper or lower limits and propagation of uncertainties. Careful investigation of the v. 3.2 of the RULER code (T.W. Burrows) revealed the following difficulties:

- complicated logic,
- related parameters stored at different places,
- uncertainty propagation – analytical approach and *ad hoc* nested branches based on numerical values.

Therefore, the following changes were implemented:

- ENSDF type – value, uncertainties (numerical and character) stored together,
- simplified logic,
- added functionality
    - ICC calculated for mixed and pure multipolarities to deduce B(tL) and B(t'L'),
    - LaTex output for *ADNDT*.

A probability distribution function was introduced to treat the propagation of asymmetric uncertainties by means of a Monte-Carlo approach. The results obtained with a normal probability function (symmetric uncertainties), skewed (asymmetric uncertainties) and square probability function (limits) were discussed. Work is underway to finalize the new program.

4.3. GAMUT code and V. averaging library (B. Singh)

A necessary and important feature in ENSDF evaluations is to produce a set of recommended values of gamma-ray energies and intensities (or relative branching ratios) for a nuclide. This process involves consideration of gamma-ray data from different experiments involving radioactive decays and nuclear reactions. The current approach in the evaluation of data for Adopted datasets is described as "Gamma-by-gamma approach": manually take the weighted average of selected set of measurements for each gamma ray that has been observed, which is labour intensive, and does not account for inconsistencies in energy and efficiency calibrations between experiments and possible non-uniformity in the handling of data by different evaluators.

Plan of the new GAMUT-like code in Java:
Step 1: "gamma-by-gamma" averaging approach that includes user-entered systematic shifts for calibration differences between experiments.
Step 2: add algorithms in the original Firestone code as an alternative method to the "gamma-by-gamma" approach

Current status of V.AveLib (JAVA) and J-GAMUT:

- all averaging and outlier methods in JAVA are functional,
- graphical interface is fully functional except for the data plotting (work in progress),
- work on "gamma-by-gamma" automated averaging routine is on-going,
- methods to parse ENSDF file for gamma and level data, and match gamma rays in different datasets,
- averaging code and intermediate file was demonstrated at the meeting – comments on this file welcome.

Following are in progress:

- methods to output data into an editable intermediate text file for evaluators,
- methods to use the edited data in an intermediate file to obtain adopted values by means of "gamma-by-gamma" averaging, and output result in ENSDF format to include in the Adopted data set,
- methods to use the edited data in an intermediate file to obtain adopted values by means of the original GAMUT algorithms, and output result in ENSDF format to include in the Adopted data set.

4.4. RadD – R0 tables (S. Singh)

The RadD.FOR code deduces the radius parameter (r_0) for odd-odd and odd-A nuclei through adoption of the radius parameter for even-even radii as input parameters [1]. These deduced radius parameters can be used in the calculation of alpha hindrance factors [2] by assuming that the radius parameter (r_0(Z,N)) for odd-Z and odd-N nuclides lies midway between the radius parameters of adjacent even-even neighbours. The main program segment is written in Microsoft FORTRAN 77 (version V3.31 August 1985) and is compatible with MS WINDOWS, LINUX and MAC Operating systems; source code is available at

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

Input files:

(1) 98AK04.IN contains the radii of 153 even-even nuclei listed in Akovali [1], but one alpha daughter radius corresponding to Z = 74 and N = 92 is given without any uncertainty [1], and has been omitted in this input file.

(2) ELE.IN contains nuclide symbols along with their atomic numbers.

During execution of this program, a message will appear:

"ENTER ATOMIC NUMBER (Z) and NEUTRON NUMBER (N) FOR ALPHA DAUGHTER NUCLEUS"

Enter Z and N values for the nuclide whose radius parameter is required. The corresponding alpha daughter radius will be displayed on the screen with the appropriate nomenclature for alpha parent and alpha daughter nuclides. Future plans are to incorporate this code in ALPHAD so as to deduce hindrance factors in one step. This work was partly supported by an IAEA contract (No. RC-17642-R0).

References

[1] Y.A. Akovali, *Nucl. Data Sheets* **84** (1998) 1.
[2] M.J. Martin, Calculation of radius parameter (r_0) for odd-A and odd-odd nuclides (2007).

4.5. JAVA-NDS code (B. Singh)

Development of a new code in JAVA to generate *Nuclear Data Sheets* started in 2007 with a contract from NNDC, BNL to Roy Zywina in collaboration with Balraj Singh. A code supplied by Zywina in January 2008 was not operational, and work was halted without completing the contract. However, work on the code was continued in 2008-2011 by Scott

Geraedts and Jeremie Choquette, and a workable version was presented at the 2009 and 2011 NSDD meetings. Furthermore, a complete A = 182 chain was prepared in Nuclear Data Sheets style in 2011, and this output was reviewed by several people in the USNDP. A copy of A = 75 was also produced and sent to a reviewer. The code was subsequently turned over to NNDC in 2011 for further improvement and smooth working. Marion Blennau (NNDC) has used this JAVA-NDS code to generate band drawings, and M. Verpelli at IAEA-NDS also adopted the code for level-scheme drawings in LiveChart.

Both the workings and merits of the code were discussed at this NSDD Network meeting, as well as many recent comments (pros and cons) from J. Chen (NSCL-MSU). The control file used in this code needs to be improved with the specific aim of achieving a better layout of the data tables. An overall running of the code was demonstrated for a complete A = 43 mass chain, of which a copy is available on the NSDD meeting web page (see also Annex 6)

Balraj Singh estimated that the program still requires 2-3 months of full-time development effort. However, if such programming effort was to be expended, Firestone strongly urged that such an initiative include improvements to the layout of *NDS* rather than simply copy the current version. Kondev suggested that J. Chen should work on the development of this program within the IAEA codes development project.

4.6. GABS (T. Kibedi)

The GABS code has been modified and updated as follows:

- source codes for the Windows and Linux were different, and the program only accepted capital letters in column 79 → corrected;
- user interface has been simplified to allow the input file to be read from the command line;
- GABS updated to FORTRAN 90 and some basic format checking was added to detect problems with the ENSDF cards and user input → report file has been enhanced and the user manual updated to reflect these changes;
- several bugs have been corrected.

4.7. Beta-spectra (M.A. Kellett)

The Fundamental Data Unit of the Laboratoire National Henri Becquerel (LNHB) – the French national standards laboratory – is developing a code named *BetaShape* to precisely calculate the shape of beta spectra for all transitions types, in conjunction with an experimental programme to validate the code. Details were presented of the current status of the code development and how some common assumptions are incorrect. The *BetaShape* code uses the formalism of Behrens and Bühring (H. Behrens, W. Bühring, *Radial Wave Functions and Nuclear Beta Decay*, Oxford Science Publications, 1982) to calculate the beta spectrum in the first instance, with additional corrections for atomic screening and radiative processes. Under these circumstances, the nucleus is no longer considered as a point charge.

A systematic comparison with the 130 experimental shape factors reveals that the $\lambda_k = 1$ approximation is a poor approximation [1]: ξ approximation is correct for only ≈ 50% of the 1st forbidden non-unique transitions and incorrect for higher order non-unique transitions; atomic exchange and screening effects have a great influence on the spectrum shape of low energy [2]; and new measurements are required to test the theoretical predictions.

Code compatible with ENSDF-formatted files is envisaged in liaison with the IAEA for the codes data development project, and a dedicated electron-capture code is in the process of being prepared. A longer-term goal within the next 2–3 years, in collaboration with nuclear theoreticians from IPHC Strasbourg, is to evaluate the influence of the nuclear matrix elements in order to calculate specifically the forbidden non-unique transitions, with the aim to account consistently for atomic and nuclear structure effects.

References
[1] X. Mougeot, *Phys. Rev*. C **91** (2015) 055504.
[2] X. Mougeot, C. Bisch, *Phys. Rev*. A **90** (2014) 012501.

4.8. BrIccEmis (T. Kibedi)

A new program (BrIccEmis) is being developed in an ANU-ANL collaboration (with F.G. Kondev) to evaluate the complete spectrum of atomic radiations, including X-rays and Auger electrons from radioactive decay, and eventually to replace RADLIST. Initial vacancies can be created in the electron capture decay and internal conversion processes, and the subsequent atomic relaxation process is treated stochastically. These improved atomic data will be inserted into ENSDF after a suitable format has been agreed and adopted (see relevant proposal in Section 5.3).

4.9. All ENSDF codes (P. Dimitriou)

Efforts should be made to re-structure all existing codes with the aim to separate the reading/writing input/output subroutines from the main part of the code that performs the core operations to produce the desired output values. Also, care should be taken to ensure that nuclear parameters and/or constants that may vary in time are not hard-wired in the main part of the code, but instead are stored in a Common Block or a separate library module. These corrective procedures would ensure that keeping the codes up-to-date with the most recent changes in the values of nuclear properties and modifying the format of input files would be relatively straightforward and expend considerably less effort. The NDS IAEA will undertake this task with the help of an intern who will be hired with the task of assisting with the ENSDF-codes development project.

4.10. Evaluation toolkit (P. Dimitriou)

An all-inclusive evaluation toolkit that integrates a smart user-friendly editor with the analysis and checking codes to give an output in ENSDF format and in PDF with the standard Nuclear Data Sheets style was suggested as necessary, especially for new evaluators. Such an evaluation toolkit would provide a simple interface between the evaluator and the ENSDF file, allowing the evaluator to insert the experimental and/or evaluated values in well-defined fields without having to worry about the format. Furthermore, this approach would allow the evaluator to run the analysis and checking codes directly from the interface without having to prepare the input file or run the code from a separate command-line window, and would also insert the results of the code directly into the appropriate fields and provide detailed error messages when appropriate. A compact toolkit would include the latest versions of the codes in one package, and will have the facility to check the already installed versions and update them if necessary.

A suitable software package already exists (EVP Editor developed by A.A. Sonzogni), and efforts will be made to further enhance the capabilities of this code, ensure maintenance and make available to all evaluators. An intern will be hired by NDS IAEA to work together with A.A. Sonzogni and NDS staff to update and extend the EVP editor.

5. New Proposals for ENSDF

Summaries are given below of proposals for new evaluation procedures and the inclusion of additional data in ENSDF. Discussions led to actions which are noted here, and are also contained in a complete list of new actions to be found in Annex 5.

5.1. Reconsideration of proposal on guidelines for ground-state and isomer half-life evaluation (A.L. Nichols and B. Singh)

The proposal was originally submitted for discussion at the NSDD meeting of 2011 (see IAEA summary report INDC(NDS)-0595). Subsequently, the wording was revised and circulated to the network for further comments. After further revisions and referral to an auxiliary paper [1], the guidelines were re-submitted for discussion and adoption at this meeting. The following points summarize the highlights of the discussion:

- Important half-life references are missing from NSR. Evaluators should consider searching less well-monitored journals identified with Health Physics, Radiochemistry and Geochemistry articles for references. Sometimes even Google can be useful.
- An article by Pommé *et al*. [1] which discusses half-life measurements and uncertainty budgets should be read and considered by evaluators.
- If statistical and systematic uncertainties are separated, the evaluated uncertainty can be lower than the lowest quoted statistical experimental uncertainty [comment by M.J. Martin].
- NIST has recalled and corrected a number of their previous half-life measurements; therefore, evaluators should check their analyses and recommended half-lives against these revisions of previously published NIST values.
- The policy that the uncertainty should never be lower than 0.01% should be included in the guidelines.
- When a new half-life measurement comes to an evaluator's attention, they should consider the impact of that measurement on their currently recommended value in ENSDF, and accordingly proceed with updating ENSDF.

The above points were taken into consideration in the final revision of the guidelines on half-life evaluation, and the proposal was adopted. The complete set of guidelines can be found in Appendix A and can also be downloaded from http://www-nds.iaea.org/nsdd/

Reference

[1] S. Pommé, *et al*., *J. Radioanal. Nucl. Chem.* **276** (2008) 335-339.

5.2. Proposal to include absolute γ-ray emission probabilities in decay data sets (F.G. Kondev)

The current procedure of applying error propagation on the formula used to derive the absolute γ–ray intensities may result in an overestimation of the uncertainties for those gammas used in an earlier procedure to determine the normalization factor:

$$absolute\ I_\gamma = NR \times I_\gamma^{rel}$$

where NR is the normalization factor and I_γ^{rel} is the relative intensity of the γ ray. Under such circumstances, one should implement the procedure described by Browne [1]. Given that this procedure is rather complex and requires a sound understanding of the decay scheme in ENSDF, evaluators should undertake this analysis rather than the ENSDF users.

Kondev proposed that the absolute intensity should be given explicitly by the evaluators in the following two alternative ways:

- As in the current version of GABS: deduce $\%I_\gamma$ from above formula and place in the Comment record. A major disadvantage is that the value is not immediately obvious to the user, and would prove difficult to extract by means of a computer program. The main advantage is that no additional work is required, although the user needs to be aware of the existence of these data in the Comment record in order to note their values.
- Extend ENSDF beyond the 80 column format, and insert the absolute γ intensity $\%I_\gamma$ and absolute transition intensity %TI in columns 22-29 and 65-74, respectively, with the relative γ intensity RI and relative transition intensity IT placed in 82-89 and 92-99, respectively. The major advantage is that the absolute values become obvious and easy to extract, while the disadvantage is that a number of analysis and checking codes would have to be modified.

The consensus of the meeting was that absolute intensities should be provided in a clear and computer-readable manner within ENSDF, and therefore the proposal was approved. Details of the implementation are incorporated in the following actions:

Action on Kibedi: modify GABS to generate %Igamma, and include on the continuation record.
Action on Tuli: run GABS on ENSDF file.
Action on NNDC-BNL: modify Webtrend so that %Igamma field is displayed on the web in the decay data sets.

Reference

[1] E. Browne, in ENSDF Procedures Manual, http://www.nndc.bnl.gov/nndc/evalcorner/ENSDF-Procedures.pdf

5.3. Proposal to include absolute atomic radiation energies and emission probabilities in decay data sets (T. Kibedi)

Atomic data in ENSDF should (1) contain energy and intensity information, (2) be readable by a computer program, and (3) possess standard notation. A proposal was made for a new type of continuation record: "A" for Auger electrons and "X" for x-rays followed by "D" to store Auger and X-ray energies and emission probabilities, respectively, to be located in columns 7 and 8, respectively. The cut-off intensity would be set at 0.0001 per decay, with the full list and figure of the detailed spectra to be stored on the ENSDF server. During the discussions, there was an additional proposal to modify the continuation S G records for conversion coefficients in order to include conversion-electron energy along with intensity and uncertainty in intensity.

There was overall agreement and support of the proposal by Kibedi. Sonzogni suggested including the uncertainties in the x-ray energies, and independently labelling the intensities instead of inserting them in brackets. He also thought that the record containing the internal conversion coefficients should be expanded to include individual sub-shell data. Audi also added that full sets of uncertainties should always be included, if at all feasible. Kibedi responded to both of the above statements by pointing out the significant increase in data storage that would be required to accommodate ENSDF files containing the resulting sets of Auger-electron and X-ray data – he believed that a suitable compromise would be a summary form of the Auger-electron and x-ray data as he suggested, and storing more extensive details of the calculations and full data sets in a separate file. Nichols remained of the opinion that the potentially important and efficacious development of microdosimetry in nuclear medicine would benefit considerably from the assembly of complete and comprehensive decay data sets that also included detailed descriptions of the Auger-electron and x-ray emissions.

Action on Tuli, Kibedi and Sonzogni: to work out the practical details in order to implement this proposal for Auger electrons and X-rays.

5.4. Proposal to include horizontal evaluations in adopted data sets (P. Dimitriou and B. Singh)

IAEA-NDS CRPs result in the production of specialized databases that contain evaluated data (invariably in the form of "horizontal evaluations") which are up-to-date but never get fed back into ENSDF. An acceptable mechanism needs to be found to incorporate these evaluated data into ENSDF. Horizontal evaluations to be considered include beta-delayed neutron emitter half-lives and emission probabilities ($T_{1/2}$ and P_n) produced by the IAEA CRP on beta-delayed neutron emission, B(E2) from 1st 2+ states, and Electric Quadrupole Moments to name but three such evaluated and recommended data sets.

Several actions were agreed upon during the discussion of this proposal:
Action on Tuli: all horizontal evaluations to be available to evaluators in a single location.
Action on Balraj Singh: to incorporate the delayed-neutron emitter half-lives and emission probabilities ($T_{1/2}$ and P_n), and B(E2) into relevant ENSDF Adopted data sets.
Action on all evaluators: consult NUBASE for isomer energies.
Action on Tuli: add all new Q values to ENSDF; however, for all files that recommended the older values, these superseded values will be moved within a Comment that also states "values adopted in this particular evaluation were derived in conjunction with the older mass evaluation".

As pointed out by A. Negret, in doing such large systematic updates, one can no longer point to *NDS* publications as being the definitive last sources of "traceable" information.

5.5. Proposal to include particle decays from nuclear levels (J.H. Kelley)

A proposal was made to identify particle emission data from nuclear levels, and include these data in ENSDF. However, particle decay leads to a final state within a different isotope which creates an issue of compatibility towards the nature of the underlying formulation and format of ENSDF.

Action on Kelley: develop an example dataset of particle decay from nuclear levels for further discussion.

6. Round-table Discussions

6.1. New formats

Considerable effort has been devoted in recent years to develop a General Nuclear Database (GND) to include ENDF, ENSDF and other data based on the eXtensive Markup Language (XML). These studies were coordinated by WPEC Sub-group 38 of the NEA/OECD. Under these advancing circumstances, the NSDD Network should address the benefits of moving away from the 80-column card-image format of ENSDF to new formats such as XML that would ensure future continuity of the ENSDF project under a broader scheme such as GND.

The following points summarize the NSDD Network discussions on new formats:

- Any new format should be "backwards compatible", and should maintain the nuclear physics content in the form of categories, quantities and operations used.
- XML format is the most obvious choice at the present time, having already been developed for ENDF:

- easily translated to and from any other language;
- can accommodate more data in an explicit manner;
- easier to edit;
- since XML belongs to the same family of languages as HTML, an XML file can be directly incorporated into HTML for web display.

- Important to identify what improvements can be achieved in the nuclear structure and decay data file in moving to XML format – make a definite list of proposals on how to include such data in XML, and collaborate with other working groups to implement these proposals.
- Since the LBNL group has already gained some experience in XML format, LBNL staff should liaise with the LLNL group responsible for the GND project in order to develop an appropriate schema for the inclusion of nuclear structure and decay data in the XML file.
- Given that conversion to a new format will take considerable effort and time, if small modifications in ENSDF format are not too time consuming, they should be rapidly implemented.

The consensus was that the NSDD Network should become involved in the effort of designing a new XML data file for nuclear structure and decay data as a future replacement for the existing ENSDF format.

Action on LBNL (Firestone): work on the development of the new XML format for nuclear structure and decay data in collaboration with LLNL.

6.2. New content (adopted decay data sets, adopted (n,γ))

A proposal for new ENSDF arrangements was presented by R.B. Firestone: evaluation effort to be split into three independent and parallel evaluation exercises per isotope – (1) decay data evaluation, (2) neutron data evaluation, and (3) XUNDL compilation. These three separated activities would result in three datasets: adopted decay dataset, adopted neutron dataset, and supporting datasets, respectively. The final step in the full evaluation process would involve merging these datasets into a single adopted levels and gammas dataset, with the advantage that decay data experts and neutron data experts would be encouraged to complete their corresponding evaluations, while a different set of evaluators would be responsible for producing the combined adopted levels and gammas dataset. This same division would apply to reviewers of the different adopted datasets. Furthermore, authorship of the published evaluations would be separately provided to Decay, Neutron, and Adopted Level and Gammas data evaluators.

Significant discussion followed to clarify various aspects of the proposal. Tuli, Firestone and Martin agreed that placing all evaluated decay data and related information in a dedicated decay dataset was worth further consideration. However, how best and who would implement such suggestions remained unclear. This matter clearly requires further thought and discussion.

6.3. Radiative strength function data

After almost a decade of measurements of radiative strength functions, many different techniques have emerged and a wealth of data has become available. There is clearly a need to compile, assess and evaluate the measured radiative strength functions and level densities. Therefore, an IAEA CRP has been approved with the aim of creating a reference database for all these data (see IAEA consultants' meeting summary report INDC(NDS)-0643).

A clear connection exists between radiative strength function data and ENSDF: former describe radiation emissions from the continuum phase space, while the latter involves radiation emitted from discrete states. Therefore, experienced usage of the ENSDF evaluation procedures would be extremely useful in the evaluation of radiative strength functions.

During the course of subsequent discussions, Nichols recommended that interested parties should ensure they become involved in the IAEA CRP, and results be reported to the NSDD Network.

6.4. Miscellaneous

Discussions revealed that the definition of the multiplier evaluated and used to convert per hundred delayed transitions to per hundred precursor decays in delayed-particle emission (NP) is unclear, and depends on whether the delayed-transition data are given as relative or absolute intensities. Recommended that Action 15 (or 45 from INDC(NDS)-0635) should be further discussed and modified accordingly.

6.5. Budgets, manpower, and mentoring

R.B. Firestone presented a few slides in which he advocated that the time had arrived to move away from traditional sources of funding, and pursue other possibilities of support within both energy and non-energy applications. The increasing shortage of evaluators is of serious concern, such that further thought needs to be given with respect to the involvement of greater numbers of students in nuclear data compilation and evaluation.

UC Berkeley is willing to create mentoring schemes for new evaluators interested in training and working side-by-side with an experienced senior evaluator. Funding for travel to UC Berkeley would be provided.

No other institution is able to host new evaluators, but mentoring could be offered provided those interested are able to travel at their own or home institute's expense.

6.6. Future of ENSDF

The future of ENSDF discussions focussed on the key issue of keeping the datasets up-to-date. Balraj Singh expressed concern that evaluators do not make any effort to keep ENSDF up-to-date with respect to new developments in nuclear physics, i.e., identification of first excited level, discovery of new nuclides, among others.

Another worrying issue is that fewer and fewer mass chains were being submitted for review and publication in *Nuclear Data Sheets*. As a result, the number of issues per annum of *Nuclear Data Sheets* has fallen, and further reductions may be necessary because of a lack of timely mass-chain submissions. The main implication of the above is that ENSDF cannot be kept up-to-date at the current rate of production of mass-chain evaluations:

- aim of updating all mass chains every ten years is not being achieved – reality is about every 14 years, with about 15 mass chains even longer and therefore older;
- more difficult to find qualified referees – an adequate review of a mass chain constitutes a significant amount of work, and there are only a few referees available to ensure such quality control.

These troubling facts form a worrying background to a timely review of the advantages and disadvantages of the 'mass-chain' evaluation system, and consideration of other ways to be potentially more effective.

The advantages of undertaking 'mass-chain' evaluations can be summarized as follows:

- beta decay is the predominant decay mode connecting nuclides along a mass chain, and represents a logical means of evaluating decay chains of parents and daughters together;

- complete mass chains are a practical unit for publication in *Nuclear Data Sheets*;
- evaluators need the publication of *Nuclear Data Sheets* in order to document and demonstrate their scientific productivity to their home institutions.

Adopting a different approach based on 'individual nuclide' evaluations would benefit ENSDF as follows:

- priority system based on XUNDL would allow the most relevant nuclides (and thus all of ENSDF) to be more up-to-date;
- evaluators who work on such evaluations for only a relatively small fraction of their time will be able to complete their obligations within the deadlines (furthermore, the not-so daunting prospect of evaluating individual nuclides may attract new evaluators).

The overall evaluation workload in both approaches is the same whether one evaluates 5 mass chains or 60 nuclides. Encouraging and enabling a new approach makes sense only if a larger number of evaluators and/or increase in the productivity of individual evaluators occurs. Such an impact would have to outweigh the increased administrative overhead required to organize the submission of smaller packages of evaluations (e.g., centrally managed web-based system to coordinate and manage the more fragmented effort of the evaluators).

Although in principle version-controlled updates of ENSDF (already implemented every six months by NNDC staff) should be sufficient for researchers to quote in their cited work database, publications in *Nuclear Data Sheets* remain of some importance to evaluators. Already mentioned that the current system of continuously updating individual nuclides in ENSDF causes citation-index problems for mass chain evaluators – this process supersedes the information in *Nuclear Data Sheets*, so researchers do not cite the original mass-chain publication anymore. The publication of individual nuclide evaluations by the NSDD Network would not be satisfactory. However, one might think of a way to publish a group of nuclides that are thematically connected other than by mass chain.

Action on ENSDF coordinator (J.K. Tuli): re-distribute a high-priority list of nuclides that need to be evaluated.
Action on ENSDF coordinator and NNDC-BNL: assess the impact of switching from mass-chain evaluations to individual nuclide evaluations, covering all aspects of the evaluation process.

7. Recommendations and Conclusions

The 21st meeting of the IAEA Network of Nuclear Structure and Decay Data evaluators was held in Vienna, and attended by 36 participants from 15 countries. A wide range of administrative and technical issues were addressed, representatives from the various data centres presented their biennial progress reports, and active members of the network reported on their activities related to ENSDF. A few additional attendees who are not part of the NSDD network presented information related to their research interests of relevance to NSDD activities.

Proposals were made and accepted to recognize the Institute of Physics and Nuclear Engineering-Horia Holubei, Romania, and Michigan State University, USA, as new ENSDF Data Evaluation Centres. A proposal from RIKEN, Japan, to contribute to the compilation in XUNDL and eventually to the evaluation for ENSDF of data produced by their facilities was also endorsed. Further steps to assure the quality and completeness of the databases were taken, and a detailed set of actions was produced covering the time up to the next network meeting in 2017. Technical improvements to facilitate the work of evaluators were discussed, with special emphasis placed on improvements to and maintenance of the analysis codes. An on-going IAEA project which is in the process of undertaking this task was reviewed, and suggestions for improvement were made. New guidelines for the evaluation of the half-lives of ground states and isomers were adopted, as well as proposals for incorporating into ENSDF new evaluations produced as horizontal evaluations and by IAEA CRPs.

Ensuring that ENSDF is up to date was re-emphasized as the main task and the top priority for the NSDD network. The ENSDF database and derivatives can only serve users to the level of reliability they desire if all files are kept reasonably close to being current. A recycling time of up to ten years for each set of nuclides remains recommendable. At the very least, about 25 mass-chain evaluations need be renewed per a year to achieve this estimate, requiring a minimum of approximately twelve FTE evaluators. Given that this is not achievable in the foreseeable future, alternative ways of organizing evaluations per nuclide instead of by mass chains were agreed, and need to be explored and reported to the next USNDP meeting in November 2015.

The dedicated biennial IAEA/ICTP workshops held at ICTP, Trieste, Italy, were acknowledged to be useful. Requests for more specialized refresher workshops to improve the expertise and skills of existing evaluators have been answered by the organisation of such a workshop to take place at the IAEA in the week immediately after this on-going NSDD Network meeting.

The 22nd Technical Meeting of the International Network of Nuclear Structure and Decay Data Evaluators will be held at the University of California, at Berkeley, USA, in the spring of 2017.

GUIDELINES FOR ENSDF HALF-LIFE EVALUATIONS (GROUND STATES AND LONG-LIVED ISOMERS)

ACTION 44, 20th NSDD Meeting, Kuwait, January 2013, IAEA report INDC(NDS)-0635

A.L. Nichols (University of Surrey, UK), B. Singh (McMaster University, Canada)

April 2, 2011: edited Dec 10, 2013 by B. Singh, Feb 20, 2014 by A.L. Nichols;

March 18, 2015 by B. Singh; April 16, 2015 by A.L. Nichols and B. Singh; April 29, 2015 by A.L. Nichols and B. Singh.

<u>Final Document adopted at the 21st NSDD Meeting, 20-24 April 2015, IAEA, Vienna.</u>

(1) Identify and accumulate ALL published measurements of the half-life of the specified nuclear level(s)

(2) Ensure that all of the above identified half-life data and origins (NSR key-numbers) are listed systematically (chronologically reverse) in the *Comments* area, or as a footnote in **Adopted Levels, Gammas data set.**

(3) Consider any other features of each specific measurement for either rejection or increased preference, based on your own experience and subjective judgements. Examples include the following:

- acceptance or rejection of *grey* references (publications that have not been fully peer reviewed: laboratory reports; conference proceedings; sometimes the journal issue of a set of conference papers),
- measurement technique (compared with others, the technique is judged/known to be more appropriate for the half-life being addressed),
- recognised difficulties and complications (e.g. impact of impurities, detector limitations, background subtraction, dead-time losses, relative to “standards”),
- known reliability or improvements in a particular measurement technique (improvements might make the date of the measurements important),
- regular and lengthy measurement programme of specific half-lives for important applications (normally a policy instigated by national standards laboratories, but also observed to be undertaken by others) can result in rejecting all but the most recently reported value; complications can also arise when the laboratory changes equipment/technique,
- if the same author(s) determine a particular half-life based on the same measurement technique/apparatus, only consider the most recent value in deducing the recommended value,

and various other imponderables.

An important issue of procedure is faced by any evaluator commissioned to derive a recommend half-life with an uncertainty (for example) at the 1σ level from a set of data varying widely with measurement techniques, data handling procedures by the measurers, and problems with the detail (or lack thereof) provided in a publication. Unrealistically low uncertainties are known to be reported in the field of half-life measurements (particularly obvious when systematic uncertainties are ignored by the experimenters), such that various subjective decisions may need to be taken by the evaluator:

- reject measurements that do not quantify the uncertainty (budgets) at all;
- reject or be cautious of measurements with uncertainties that are judged to be totally unrealistic and/or incorrect;
- reject or be cautious of half-life studies that suffer from insufficient measurement time when determining activity decay as a function of time in order to quantify the slope of such a plot, and which do not provide details of counting losses;
- increase the uncertainty in a particular measurement on the basis of known limitations in the measurement technique, hopefully described adequately in the paper;
- increase specific uncertainties during the course of the process of weighted-mean calculation, and subsequently recycle until the weighting of any particular half-life measurement does not exceed a prescribed level (one common practice is “no more than 50% weighting”).

All actions of above type which involve some form of subjective judgement require full explanation of what was done and why, and should be included in the *Comments* area.

(4) Identify outliers, document and discard, based on the criteria adopted in least-squares analysis codes. Numerous averaging techniques have been proposed and developed (see VISUAL AVERAGING LIBRARY or AVETOOLS on NNDC webpage). Examples include:

- weighted mean (WM);
- limitation of the relative statistical weight (LRSW or LWM);
- normalised residuals (NR);
- Rajeval Technique (RT) (M.U. Rajput, T.D. MacMahon, Nucl. Instrum. Methods Phys. Res. **A312** (1992) 289-295);
- BootStrap (BS) (O. Helene, V.R. Vanin, Nucl. Instrum. Methods Phys. Res. **A481** (2002) 626-631); etc.

These disparate techniques use different methods to handle the uncertainties, identify outliers, and derive the mean value and uncertainty. LRSW, NR and RT use the uncertainties and occasionally inflate them to accommodate discrepant data; all three of these methods should be used simultaneously to identify outliers (i.e. defined as such if at least two of the methods identify a data point as an outlier). BS method ignores uncertainties, and therefore does not identify outliers. Software codes are available to run these methods of analysis simultaneously/together for direct and speedy comparison. There are eight different averaging methods in the Visual Averaging Library code (V-AVELIB) developed by Michael Birch at McMaster, and available through NNDC. This code also handles asymmetric uncertainties. Note that AVETOOLS does not handle asymmetric uncertainties.

(5) All acceptable half-life data to be analysed by means of these techniques

- may need to define which method is the most appropriate – WM, LRSW, NRM, RT, BMR, BootStrap, others, and so adhere to consistency in the selection of the recommended half-life value and uncertainty,

- role of reduced χ^2 in such analyses needs to be better defined, implemented and used to develop a more rigorous understanding of the data set adopted for full analysis.

- when a new half-life measurement for a ground state or long-lived isomer comes to the evaluator's attention, the impact of that measurement on the currently recommended ENSDF value should be assessed, and suitable adjustments made in ENSDF, if deemed necessary.

- as an overall guide:

adopt WM value and uncertainty when measured half-life data are not discrepant;

adopt value from LRSW or other procedures when measured half-life data exhibit discrepancies;

the recommended uncertainty should generally be no lower than the lowest uncertainty to be found in sets of experimental half-life data that are not individually defined in terms of various types of separated component uncertainties (also see below);

if the statistical and systematic components of the half-life uncertainty have been quantified as separate entities in the various measurements, the recommended overall uncertainty in the half-life should be the sum of the lowest systematic uncertainty to be found in the data set and the weighted mean of the statistical uncertainty;

the final uncertainty should not be lower than 0.01%;

the adopted analytical route should be clearly described in the *Comments* area (data accepted; data rejected; numerical method adopted/applied).

(6) **Literature coverage**: some half-life articles are published in non-nuclear physics or non-radioactivity journals, and can consequently be missed by NSR. Examples of such omissions can be found in journals that include Health Physics, Geochronology and Geochemistry, and Planetary and Earth Sciences. The DDEP group generally undertakes a more complete literature search than ENSDF for their selected set of nuclides, but they do not always register and request NSR key-numbers, when they make use of a reference not found in NSR. Examples of previously missing important articles on half-life measurements that were added to NSR about two months ago on request of one of the authors of this report: 1991Ma68 (*Health Physics* **61**, 511) for ^{214}Pb, ^{214}Bi; 1989Ma67 (*Health Physics* **57**, 121) for ^{218}Po; 2001Po32 (*Radiochemistry* **43**, 549) for ^{175}Hf, ^{181}Hf; and also several other references.

(7) **Useful article**: there is an interesting article by S. Pomme *et al.* from IRMM, Geel, published in *Journal of Radioanalytical and Nuclear Chemistry* **276** (2008) 335-339, which constitutes a useful document for evaluators of half-lives. Pomme and co-workers have also published significant articles on half-life measurements, mostly in *Applied Radiation and Isotopes*. A search of NSR can retrieve a list of some of these papers published during 2011-2014, where methodology and uncertainty budgets are discussed in good detail.

Examples (2010/11):

Co-62 half-life

Reference	Half-life (min)	Comments
1949Pa01	1.6 (2)	β-decay curves followed over six half-lives; decay curve shown
1960Pr05	1.9 (3)	β-decay curve not shown – only lists half-life
1962Va23	1.5 (1)*	β-decay curve followed over four half-lives; no discussion of impurities
1969Wa16	1.50 (4)#	γ-γ coincidence and high energy β; decay curves not shown – only lists half-life
1970Jo12	1.4 (2)	1129-keV γ decay followed for more than five half-lives; decay curves shown for several γ rays
	1.54(10)	Recommended value (LRSW – Limitation of Relative Statistical Weights)

* Uncertainty increased to ± 0.2 to reduce weighting to below 50%.
# Uncertainty increased initially to ± 0.20 to reduce weighting to below 50%.

Co-62m half-life

Reference	Half-life (min)	Comments
1949Pa01	13.9 (2)	β-decay curves followed over six half-lives; decay curve shown
1957Ga15	13.91 (5)*	γ decay measured in well-type scintillation detector; minor Cu-64 and Ni-65 impurities present; no decay curves shown – only lists half-life
1960Pr05	13.8 (2)	β-decay curve not shown – only lists half-life
1962Va23	13.9 (2)	β-decay curve followed over about two half-lives; no discussion of impurities
1969Wa16	14.00 (24)	High energy β and γ decay; decay curves not shown - only lists half-life
1969Mo04	13.8 (5)	1163-, 1172-, 2003- and 2103-keV γ decay followed for about six half-lives; decay curves shown for several γ rays
1970Jo12	13.5 (3)	1163- and 1173-keV γ decay followed for more than two half-lives; decay curves shown for several γ rays
	13.86 (9)	Recommended value (LRSW)

*Uncertainty increased to ± 0.20 to reduce weighting to below 50%.

Cu-62 half-life

Reference	Half-life (min)	Comments
1954Nu27	10.1 (2)[#]	Cu-62 milked from parent Zn-62
1965Eb01	9.76 (2)	Decay of positron annihilation radiation; Cu-64 impurity considered constant - no decay curves, only lists measured half-life
1965Li11	9.79 (6)	Decay of positron annihilation radiation corrected for Cu-64 activity, and fitting of excitation functions for Co-63(n,2n)Cu-62 reaction at E_n=12.6-19.6 MeV – lists half-life derived from these fittings
1969Bo11	9.7 (1)	Decay of positron annihilation radiation and fitting of excitation functions for Co-63(n,2n)Cu-62 reaction at E_n=13-18 MeV – lists half-life derived from these fittings
1969Jo07	9.73 (2)	Decay of positron annihilation radiation - no decay curves, only lists measured half-life
1975Ca40	9.80 (2)	γ-ray decay – no decay curves, only lists measured value
1997Zi06	9.68 (4)	4πβ liquid scintillation spectrometry, twelve independent measurements spanning two to four half-lives
	9.673 (26)	4πγ ionization chamber, two independent measurements spanning two to four half-lives
2002Un02	9.673 (8)*	Quote 1997Zi06, see above, but uncertainty is statistical only.
	9.74 (6)	LRSW: weighted average of the above with uncertainty expanded so that range includes the most precise value (9.673 min); data set exhibits significant inconsistencies that mitigate against LSWM approach
1997Zi06	9.68 (4)	4πβ liquid scintillation spectrometry, twelve independent measurements spanning two to four half-lives
	9.673 (26)	4πγ ionization chamber, two independent measurements spanning two to four half-lives
2002Un02	9.673 (8)*	Quote 1997Zi06, see above, but uncertainty is statistical only.
	9.675 (22)	Recommended value: from weighted average of two values in 1997Zi06. Uncertainty should be increased to 0.026.

[#] Rejected as outlier, and not included in the data sets for LRSW analyses.
[*]Not included in averaging.

Further comments:

2012Fi12 (NIST correction to 2002Un02 half-life data (see also footnote above for [*])) – adjusted value of 9.672(8) min has no impact on the analysis of the data published up to and including 2002.

2014Un01 report a half-life of 9.673(8) min, which is identical to their previous value and therefore has no impact on the analysis of the data published up to and including 2002.

<u>Half-life of Bi-207: review of ENSDF evaluation, 2010</u> (A.L. Nichols)

Each relevant paper considered in reasonable detail below. Comments are given in order of year of publication of each of the highly-relevant papers. Earlier half-life measurements are significantly less accurately characterised, and have not been assessed in this exercise.

<u>1978Ya04: Yanokura et al., Nucl. Phys. A229 (1978) 92-98</u>

Three different approaches were taken to measure the half-life of Bi-207.

(1) The absolute disintegration rate of At-211 in a purified sample was measured by means of a liquid scintillation counter, and a large volume of the same solution was used to study the gamma-ray decay of daughter Po-211 and Bi-207 with a heavily-shielded Ge(Li) detector, calibrated against IAEA standard γ-sources of Na-22, Mn-54, Co-57, Co-60, Ba-133 and Cs-137. The prominent 569.7-keV gamma ray was used to calculate the decay rate of Bi-207 (emission probability of 99.85% was used from Parsa and Markowitz, *J. Inorg. Nucl. Chem.* **36** (1974) 1429-1431), with a theoretical total internal conversion coefficient of 0.0221 adopted for this E2 transition). Thus, the half-life value for Bi-207 was “evaluated” to be 32.2 ± 1.3 years.

(2) A Bi-207 half-life of 31.7 ± 3.7 years was determined from a source prepared for liquid scintillation counting, but after complete decay of At-211, whereby the large uncertainty was attributed to the poor detection efficiency when gamma counting this particular liquid sample (?).

(3) And finally, the half-life of Bi-207 was also determined from the EC/α branching ratio, the emission probability of the 6868-keV α transition from Po-211 to the 569.7-keV nuclear level in Pb-207, the half-life of At-211, and the decay probability of Bi-207 feeding the 5769.7-keV nuclear level in Pb-207. A half-life value of 33.4 ± 0.8 years was calculated via this method. The authors assigned the small uncertainty to the counting statistics involving the 569.7-keV gamma ray – this value was adopted as the definitive recommended half-life through rather nebulous reasoning (simply because the value was deemed to be the most accurate?).

Systematic uncertainties are ignored in this set of studies, and are difficult to extract from the contents of the paper. Furthermore, such issues as the data sources for the direct 569.7-keV gamma-ray study need to be re-assessed (emission probability and ICC(total)) to derive a new half-life value, rather than simply adopt the original value of 32.2 ± 1.3 years. The half-life derived from the liquid sample should simply be discarded as seriously inaccurate. Finally, the half-life calculated from the EC/α branching ratio and other derived nuclear data needs to be re-assessed (and discard if deemed inappropriate).

<u>1990Al11: Alburger and Harbottle, *Phys Rev.* C41 (1990) 2320-2324</u>

An end-window gas-flow proportional counter was used to determine the decay of β^- radiation from two samples of Ti-44 and one sample of Bi-207. Consideration of the detailed and overall performance of this system can be found in Alburger *et al*. *Earth Planetary Sci. Letts.* **78** (1986) 168-176. Long-term drift in counter voltage was deemed to be of the order of less than 0.5 V (c.f. 25 V to achieve the equivalent of 1σ statistical uncertainty); box pressure would have to vary by 0.15″ compared with monitored changes of better than 0.03″. Changes in temperature of 2°F would result in 1σ standard deviation change in activity ratios, while a variation from 30% to 80% in the relative humidity would also cause a variance of 1σ standard deviation. These latter parameters were only monitored close to the end of the earlier studies on Si-32/Cl-36 with the following observations: temperature fluctuated from 72.4 to 74.7°F, and average relative humidity varied between 35% to 76% - judged as unfortunate and important variations in any attempt to define SYSTEMATIC uncertainties. Fluctuations of the data points from a smooth exponential decay were observed that are approximately THREE times the statistical uncertainty, and the authors assigned this unusual behaviour to variations in the temperature and relative humidity. Uncertainties were also identified with the operating pressure for the system – judged by the authors as operational under somewhat lower conditions than optimum. Other considerations involved studies of restoration of operational stability (system required a week to re-stabilize of any power shut-down), and change to a new gas supply (no observable effect). One might judge an overall SYSTEMATIC uncertainty of the order of ± 1.5 for a value of 34.9 years, without consideration of source preparation, radionuclidic purity and stability.

Clearly, the uncertainties quantified in this paper are only the STATISTICAL uncertainties from the relative activity measurements for Cl-36, Ti-44 and Bi-207 (Figs. 1, 2, 3, 4). A recommended value of 34.9(4) years is derived by the authors for the half-life of Bi-207.

Consideration of a combination of systematic and statistical uncertainties could result in a significant adjustment to 34.9 ± 2.0 years. However, there are a number of imponderables in this analysis that can be seen to justify the rejection of the half-life value from this particular study by the original 207 mass chain evaluators.

<u>1991Li10: Lin and Harbottle, *J. Radioanal. Nucl. Chem.* 153 (1991) 51-55</u>

Note same common author for 1990 and 1991 publications (Harbottle).

An inadequate paper, with insufficient detail and lack of clear traceability. Used gamma-ray spectroscopy to monitor the disintegration rates of individual gamma rays, and calculated half-life data from a combination of these disintegrations rates, "known" gamma abundances and the detector efficiency curve. Measured gamma-ray abundances are compared with equivalent data from the NBS certification of the Bi-207 source, and recommendations to be found in *Nucl. Data Sheets* **43** (1984) 383.

Interestingly, three half-live values are quoted in this paper:

(1) 31.6 ± 0.7 years from "only" the major 569-keV gamma line;

(2) 32.7 ± 0.7 years from the 569- and 1063-keV gamma lines;

(3) 32.7 ± 0.8 years from the 569-, 1063- and 1770-keV gamma lines.

There is an argument to be made for just adopting the half-life value of 31.6 ± 0.7 years, although a reasonable understanding of the recommended uncertainty is required (and is judged to be unrealizable).

1992Un01: Unterweger *et al., Nucl. Instrum. Methods Phys. Res.* A312 (1992) 349-352

2002Un02: Unterweger, *Appl. Radiat. Isot.* 56 (2002) 125-130

Represent a small part of a long-term NBS/NIST exercise to monitor, characterise and revise the decay half-lives of an extensive list of radionuclides maintained and stored within NIST. These studies have been ongoing for approximately five decades, based on measurements by means of 4πγ pressurized ionization chambers and (more recently) high-resolution HPGe detectors.

Both of these papers lack sufficient detail, but refer to detailed descriptions and equipment and techniques to be found in NBS Special Publication 626 (1982) 85 and NBS Special Publication 250-10 (1987). However, specific systematic uncertainties are noted, such as the lower response of the ionization chambers that was believed to arise from instabilities in the old battery pack, and improvements noted after the vibrating reed electrometer and capacitor bank were replaced with a multi-range electrometer. Other unexplained changes also occurred periodically in the response of the ionization chamber to radium references sources prior to 1973.

The 1992 publication contains a recommended half-life for Bi-207 of 11523 ± 19 days which is equivalent to 31.55 ± 0.05 years (1 year (mean tropical year) ≡ 365.2422 days), which had only been followed for 0.6 half-lives (~ 19 years). Uncertainties are quantified in terms of Statistical Uncertainty (10.0) and Other Uncertainty (16.0), although I am uncertain as to what these numbers really mean.

The 2002 publication contains a recommended half-life for Bi-207 of 11523.0 ± 15.0 days which is equivalent to 31.55 ± 0.04 years (1 year ≡ 365.2422 days), which had been followed for 0.9 half-lives (~ 28 years). Uncertainties are also quantified in terms of Statistical Uncertainty (9) and Other Uncertainty (12), although I remain uncertain as to what these numbers mean.

Concluding Remarks

I would recommend discarding:

half-life (2) from Yanokura et al;

half-life of Alburger and Harbottle;

half-lives (2) and (3) of Lin and Harbottle;

ignore 1992 half-life of Unterweger *et al*. (replaced by recommended 2002 value).

Rework and accept half-lives (1) and (3) from Yanokura et al (however, may still discard re-worked half-life (3));

accept half-life (1) of Lin and Harbottle;

accept 2002 half-life of Unterweger.

Bi-207 half-life: 2011Ko04 – F.G. Kondev, S. Lalkovski, NDS 112 (2011) 707-853

Recommended $T_{1/2}$: 31.55 y *4*

$T_{1/2}$: From 2002Un02, using 4πγ pressurized ionization chamber at NIST; statistical uncertainty 0.025 y and systematic uncertainty 0.033 y. No impurities in the sources were observed using HPGe; decay has been followed over a period of t ≈ 28 y. The value agrees with that of 31.55 y 5 reported by the same group (1992Un01), when decay was followed over a period of t ≈19 y. **Value superior to others described below.**

Others (not used in the NDS evaluation):

32.7 y *8* (1991Li10) by measuring the activity of a calibrated ^{207}Bi source (t ≈ 17 y after the source was calibrated) with a HPGe detector; value determined by averaging activities for 569γ, (I_γ = 97.75%), 1063γ (I_γ = 76.0% 14) and 1770γ (I_γ = 6.95% 13); $T_{1/2}$ = 31.6 y *7*, when the activity was deduced using 569γ only. The quoted uncertainty is statistical only. A sizable systematic uncertainty can be expected, given the uncertainties in the nuclear data parameters used in the calibration of the source.

34.9 y *4* (1990Al11) using a gas-flow proportional counter system; the uncertainty is statistical only and quoted at 2σ level; the source was produced by bombarding a Pb target with 22-MeV deuterons following chemical separation; the measurements were followed over a period of t = 3.4 y. A break in the singles rates were observed around t = 1.7 y after the beginning of the measurements. So the data were analyzed in two separate parts yielding $T_{1/2}$ = 34.88 y 21 from the first 27 points (up to t = 1.7 y) and 35.2 y *9* from the next eight points; the quoted $T_{1/2}$ is higher than the adopted one. The quoted uncertainty is statistical only, although a large systematic uncertainty should be expected owing to sensitivity of the measurements to temperature and humidity changes. It is worth noting that $T_{1/2}$ = 66.6 y *16* was reported by this group (1990Al11) for ^{44}Ti, which is higher than other precise measurements of 58.9 y *3* (2006Ah10) and 60.7 y *13* (1999Wi01).

33.4 y *8* (1978Ya04) deduced indirectly using the decay of a ^{211}At source and knowledge of the ε/α branching ratio of ^{211}At (0.583/0.417), the emission probability of 6568-MeV α to the 569.7-keV level of ^{207}Pb (0.58% 1), the half-life of ^{211}At (7.23 h *2*) and the total emission probability of 569.7γ fed in ^{207}Bi ε decay (99.85%). The quoted uncertainty is statistical only, but a large systematic uncertainty can be expected. The authors also quote a value of 32.2 y 13 using the disintegration rate of ^{211}At in a purified sample measured by the means of a liquid scintillation counter and by adopting the 569.7γ to determine the decay rate of ^{207}Bi. A measurement performed after a complete decay of ^{211}At yielded $T_{1/2}$ = 32.2 y *37*, whereby the large uncertainty was attributed to the poor detection efficiency when gamma counting this particular sample.

38 y *4* (1972Ru10) using a ^{207}Bi source by counting the 569.7-keV gamma ray, using a NaI(Tl) scintillation spectrometer over a period of t = 0.5 y.

38 y *3* (1961Ap01) deduced indirectly using the decay of ^{211}At source and knowledge of the α branching ratio of ^{211}At (40.9%), the half-life of ^{211}At (7.214 h *35*) and the total emission probability of 569.7γ that is fed in ^{207}Bi ε decay (assumed 100% gamma-ray emission probability and 2.2% total α).

28 y *3* (1959So12) using the parent-daughter activity of ^{207}Po and ^{207}Bi.

Concluding Remarks

On balance, we sympathise with the rejection of much of the existing half-life data (2010/11), with the emphasis placed solely on the NIST measurements of 2002Un02 to the exclusion of all other studies.

Further comments, February 2014:

Amongst other publications since 2010, 2012Fi12 and 2014Un01 from NIST provides strong evidence that some of their reported half-life measurements over many years are systematically incorrect because of previously undetected physical movements of the source holder within the ionization chamber used to perform the work. The impact on the measured half-life of ^{207}Bi shows a change from (11523 ± 15) d to (11403 ± 61) d. which represents a decrease in the half-life of ≈ 1%. An adjusted half-life value of 31.22 y *17* constitutes a significant correction to the originally recommended half-life and uncertainty of 31.55 y *4* reported by 2002Un02 and adopted in ENSDF – the uncertainty at the 1σ confidence level has increased by a factor of 4.25.

21st Technical Meeting of the
Nuclear Structure and Decay Data Network

IAEA Headquarters, Vienna, Austria
20 – 24 April 2015
Meeting Room M4

ADOPTED AGENDA

Monday, 20 April

08:30 – 9:30	**Registration at Gate 1**
09:30 – 10:00	**Opening address**
	Chairman and Rapporteur
	Adoption of Agenda
10:00 – 11:00	**Actions from Previous NSDD Meetings**
	List of Actions (carry over from NSDD-2013) Others
11:00 – 12:30	**Reports by Evaluation Centres about NSDD activities** (all centres – 10-mins each)
	ORNL, USA LBNL, USA TUNL, USA ANL, USA McMaster, Canada *(20 min)* JAEA, Japan Jilin University, China IIT, Roorkee, India
12:30 – 14:00	***LUNCH***
14:00 – 15:30	**Reports cont'd**
	ANU, Australia Nuclear Data Project, Kuwait Nuclear Physics Institute, Hungary CEN, France PNPI, Russia NNDC, USA IAEA-NDS

15:30 – 16:00 **Coffee Break**
16:00 – 18:00 **Reporting cont'd**
New Data Centres (IFIN-HH, *Negret;* MSU, *Thoennessen***) -** *10 min*
Report on Workshops and Other Activities:
European effort- *Balabanski (5 min)*
ICTP Workshops, *Tuli, Dimitriou*
Organizational review, *Tuli*
incl. revision of NSDD Network Status (INDC(NDS)-0421)

Tuesday, 21 April

09:00 – 10:00 **Databases** (15 min)
ENSDF, *Tuli*
XUNDL, *Singh*
NSR, *Pritychenko*
RIPL-levels, *Verpelli*

10:00 – 10:30 **Coffee Break**
10:30 – 12:30 **Horizontal Evaluations** (15 min)
AME/NUBASE, *Audi*
DDEP, *Kellett*
EGAF, *Firestone*
New systematics of semi-magic seniority isomers, *Jain*
K-isomers in deformed nuclei (A>100), *Kondev*
Nuclear Moments Tables, *Stone*
Isobaric Analogue States in NUBASE, *MacCormick*

12:30 – 14:00 ***LUNCH***
14:00 – 15:00 **ENSDF Processing,** *Tuli*

15:00 – 15:30 **Coffee Break**

15:30 – 17:30 **MyEnsdf,** *Zerkin*

19:00 ***Dinner at Restaurant***

Wednesday, 22 April

09:00 – 11:00 **Computer Codes**

IAEA Project/Techn.Meeting June 2014
Assignments/Progress, *Dimitriou*

New Codes: (10-15 min each)
RULER, *Kibedi*
BriccEmis, *Kibedi (25 min)*
RADD, *Sukhjeet Singh*
Beta-spectra, *Kellett*
JAVA Averaging Library-GAMUT, *Singh*
JAVA-NDS code, *Singh*

Discussion on computer codes needs

11:00 - 11:30 **Coffee Break**

11:30-12:30 **Dissemination (15 min)**

Nudat, *Sonzogni*
LiveChart, *Verpelli*
Nuclear Moments database, *Mertzimekis*

12:30 – 14:00 ***LUNCH***

14:00 – 15:30 **Technical presentations (15 min)**

1. Inelastic neutron scattering and Bagdad Atlas compilation, *Bernstein*
2. Evaluation of atomic radiations for medical radioisotopes, *Kibedi*
3. High-precision decay data for medical isotopes, *McCutchan*
4. Update of Internal Conversion Coefficient Measurements, *Nica*
5. ^{105}Ru – data evaluation and experimentation, *Lalkovski*
6. Particle decay from levels, *Kelley*

15:30 – 16:00 **Coffee Break**

16:00 - 18:00 **Technical pres. cont'd**

7. Nuclear Structure and Decay Programs at RIKEN, *Sakurai*
8. Status report of nuclear data activities at TANDAR laboratory-Argentina, *Abriola*
9. ELI-NP @ IFIN-HH, *Balabanski*
10. Research Activities for Evaluations of Nuclear Structure and Decay Data in Korea, *Gil*
11. ENSDF-translation efforts at LBNL, *Hurst*
12. Report on evaluation for A~173:^{173}Tm and ^{173}Er, *Erturk*

Thursday, 23 April

09:00 – 10:30 **New Proposals for ENSDF (for discussion and adoption)**

Re-consideration of Proposal on Guidelines for g.s. and isomer $T_{1/2}$ evaluation - Missing important g.s. half-life papers (Nichols, Singh)
Proposal to include absolute γ-ray emission prob. in decay data sets (Kondev)
Proposal to include absolute atomic radiation energies and emission probabilities in decay data sets (Kibedi)
Proposal to include AME12 Q-values in adopted data sets (Kondev)
Proposal to include horizontal evaluations such as $T_{1/2}$+Pn for β–n emitters; B(E2) to 1st 2+, and others, in adopted data sets (IAEA-NDS, Kondev, Singh)

10:30 – 11:00 **Coffee Break**
11:00 – 12:30 **Round Table Discussion**

Incorporation of other evaluations (incl. CRP products) into ENSDF (NDS-IAEA, Kondev)
New formats (Kondev)
Future for ENSDF: quality, currency (keeping in synch with new exp. data and user needs), usage, dissemination (Kondev, Singh)
Budgets, Manpower, Mentoring (Firestone)
New Content (adopted decay data sets, adopted (n,γ) data) (Firestone)
Radiative Strength Function Data (Bernstein)
Relevance, New Physics (All)

12:30 – 14:00 ***LUNCH***

14:00 – 15:00 **Round Table Discussion cont'd**
15:00 – 15:30 **Coffee Break**

15:30 – 18:00 **Round Table Discussion cont'd**
List of Actions - drafting

Friday, 24 April

09:00 – 13:00 **List of Actions – adoption**
Drafting of Summary report
Next meeting
Adjournment *Coffee break as needed*

21st Meeting of the *International Network of Nuclear Structure and Decay Data Evaluators*

20 – 24 April 2015
International Atomic Energy Agency,
Vienna, Austria

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A-Chain Evaluation Responsibility

Centre	Mass Chains
a. US/NNDC	45-50,60-73(ex 62-64,67),82, 84-88,94-97,99,113-116,136-148(ex 146),150, 152-165 (ex 164),180-183,189,230-240,>249
b. US/NDP	241-249
c. US/LBL	21-30,81,83,90-93,166-171, 184-193 (ex 185,188-190),210-214
d. US/TUNL	2-20
e. US/ANL	106-112,175-179,199-209
f. US/MSU	31-44
g. Russia/StP	130-135,146
h. PRC-Beijing	51,62,195-198
PRC-Jilin	52-56,63,67,73
i. India	215-229
j. Japan	120-129
k. Canada	1,64, 74-80,89,98,100, 149,151,164,188,190,194
l. Australia	172-174
m. Hungary	101-105
n. Romania	57-59,117-119

Annex 3

List of Continuous, New and Competed Actions

As of 24/04/2015

CONTINUOUS / ON-GOING / PENDING			
No.	**Responsible**	**Reason**	**Action**
1 (1)	Tuli (ENSDF coordinator) NNDC-BNL All network participants	Keeping ENSDF up-to-date.	Maintain a list of horizontal evaluations in separate repository accessible to evaluators. Keep Tuli informed about horizontal evaluations. **Continuous**
2 (2)	NNDC-BNL	ENSDF analysis and checking codes need to remain up-to-date with respect to formats, physics requirements, and the needs of the community.	Update codes for approved format changes. **Continuous**
3 (4)	NDS-IAEA	Maintain up-to-date information on the network.	Review, modify and correct the contents of INDC(NDS)-421. **Continuous – update planned by mid/late 2015**
4 (19)	Tuli, NNDC-BNL	Facilitate evaluators' work.	Analyze Nica proposal to modify PANDORA. **Still to be undertaken**
5 (21)	NSR manager	Assignment of key numbers.	Evaluators should be able to create NSR keynumbers remotely: evaluators to send relevant references/articles immediately to NNDC for keynumber assignments. **Continuous**
6 (22)	NSR manager	Assignment of key numbers.	Keyword requirement for evaluators should be optional; however, keywords should be encouraged as they constitute valuable information. **Continuous**
7 (23)	NNDC-BNL	Obscure references.	Investigate access to electronic copies of secondary references which are difficult to track down and acquire. **Continuous**
8 (24+57)	Firestone	ENSDF into XML.	Work with LLNL on proposed format, liaise with IAEA and report to network. **In progress** First draft format will be presented at November 2015 USNDP meeting.
9 (25)	Kibedi	Mixing ratios for E0, E2, M1.	Suggest changes to format in order to define mixing ratios. **In progress**
10 (27)	Kibedi	Quantification of Auger electrons.	Develop and recommend analysis codes to provide more detailed presentations of Auger-electron data. **In progress**

First column: number in brackets indicates the action number from the previous meeting (INDC(NDS)-0635).

CONTINUOUS / ON-GOING / PENDING (continued)			
No.	**Responsible**	**Reason**	**Action**
11 (17)	IAEA-NDS	Maintain links with horizontal evaluations	Invite representatives of atomic mass and other horizontal evaluations to the next meeting. **Continuous**
12 (33)	NDS-IAEA	Training of evaluators.	Explore need for additional training workshops. **Continuous**
13 (34)	NDS-IAEA/ NNDC-BNL	Information relevant to all ENSDF network members.	Regularly update network website - ensure all relevant talks are made available on website. **Continuous**
14 (35)	NDS-IAEA/ NNDC-BNL	Newly evaluated nuclear moments to be made available to evaluators.	Update evaluated nuclear moments file on network website when required. **Continuous**
15 (36)	NNDC	Maintain up-to-date information on network.	Update website with new group responsibilities. **Continuous**
16 (39)	NNDC-BNL	Maintain analysis codes.	Update all analysis codes that use atomic masses to include AME 2012. **Partially completed/on-going**
17 (43)	NNDC-BNL/ Johnson	Policy implementation in FMTCHK.	Modify FMTCHK to read continuation record containing Jπ estimates. Relates to completed Action #(42). **On-going**
18 (45)	NNDC-BNL/ Johnson	Policy implementation.	Modify FMTCHK to take into account new policy that BR=NP is not needed. **Requires further discussion**
19 (46)	NNDC-BNL/ Johnson	Format.	Update list of element names. **Continuous**
20 (47)	Kondev, Herman, Tuli. NDS-IAEA	Maintain and update codes.	Assess status of analysis codes and determine priorities as to which codes should be re-written or corrected. **Continuous**
21 (48)	NNDC-BNL	Format.	Look into modifying NDSPUB/HTML translator for cases with >26 XREF symbols. **Still to be done**
22 (49)	Singh, Kondev, Tuli	Policy.	Revisit Rule 37. **On-going**
23 (56)	Firestone	ENSDF.	Suggest way of introducing parent-daughter isomeric feeding into ENSDF decay data. **On-going**

First column: number in brackets indicates the action number from the previous meeting (INDC(NDS)-0635).

NEW ACTIONS			
No.	**Responsible**	**Reason**	**Action**
24	NNDC-BNL	Keep NSR up-to-date.	Ensure that references provided by Kondev are incorporated into NSR (relates to completed Action #(38)).
25	Martin	Modify *Guidelines for Evaluators*.	Implement in *Guidelines for Evaluators* – relates to completed Action #(42) – list spins in order of preference.
26	Martin	Modify *Guidelines for Evaluators*.	Implement in *Guidelines for Evaluators* – relates to completed Action #(65) – unique gamma transitions should be assigned intensities of 100.
27	Tuli	NSDD Data Centre status.	Compose a statement which defines the requirements for the recognition and creation of a new NSDD Data Centre.
28	Tuli	ENSDF processing.	Generate one page summary of what is required for submission of ENSDF mass chain for publication in NDS by means of myENSDF.
29	All network participants	Maintain and update codes.	Utilize the GFORGE server to report bugs in codes and requested enhancements.
30	NDS-IAEA / NNDC-BNL	Dissemination of codes.	Coordinate the distribution of ENSDF codes on both web sites.
31	Kibedi, Tuli, Sonzogni	Implementation of new policy for atomic radiation.	Develop a means of introducing atomic radiations into ENSDF file.
32	Audi Tuli/NNDC-BNL	Keep ENSDF up-to-date.	Send table of published AME2012 values to Tuli/NNDC. Replace Q values in ENSDF (taken from on-line AME2012 mass files) with published AME2012 values.
33	Audi, Kondev Tuli/NNDC-BNL	Keep ENSDF up-to-date.	Provide Tuli/NNDC with isomer information from NUBASE. Distribute this information to all evaluators.
34	All ENSDF evaluators	ENSDF evaluations.	Consult NUBASE when dealing with excitation energies of isomers - adopt isomer energies that are confirmed by Penning trap mass measurements.
35	Singh	Keep ENSDF up-to-date.	Incorporate delayed-neutron $T_{1/2}$, P_n, B(E2) and quadrupole moment into ENSDF files.
36	NNDC-BNL	Keep ENSDF up-to-date.	Add AME2012 Q-values as Q-records in the Adopted Levels and P records.
37	Kelley	Particle decay in ENSDF.	Create an example dataset for particle decay from excited levels.
38	Tuli	Keep ENSDF up-to-date and prioritize.	Re-distribute a high-priority list of nuclides.

NEW ACTIONS cont'd			
No.	**Responsible**	**Reason**	**Action**
39	NNDC-BNL	Keep ENSDF up-to-date and prioritize.	Covering all aspects of the evaluation process, assess the impact of switching from mass-chain evaluations to individual nuclide evaluations and report at next USNDP meeting (November 2015).
40	Tuli	ENSDF coordination.	Add name of responsible person and starting date of mass-chain evaluation in the record of monthly update.
41	Kibedi	Policy implementation.	Modify GABS to generate %Igamma, and include on the continuation record.
42	Tuli	Policy implementation.	Run GABS on ENSDF file.
43	NNDC-BNL	Policy implementation.	Modify Webtrend so that %Igamma field displays on the web in the decay data sets.
44	Heads of all NSDD Data Centres	ENSDF coordination.	Convey following information to Tuli by the end of May 2015: (1) permanent and temporary FTEs, (2) mass-chain assignments, and (3) work projection(s) covering the next 12 months.
45	NNDC-BNL	Keep ENSDF traceable	Explore the implementation of ENSDF tracking, and report their findings and recommendations at the next USNDP meeting (November 2015).

COMPLETED ACTIONS			
No.	**Responsible**	**Reason**	**Action**
(26)	Sonzogni	Improve data that quantify continuum beta spectra.	Develop and recommend analysis codes to provide more detailed presentations of continuum beta spectra. **Completed**
(28)	Singh, Baglin, Browne, Kondev, Timor, Sonzogni, Tuli, Abriola	*Guidelines for Evaluator*s.	Revise *Guidelines for Evaluators*. **Completed - undertaken by Martin**
(32)	Firestone	Thermal-neutron capture gammas.	Suggest procedure for inclusion of capture gamma intensities in adopted levels. **Completed**
(37)	Sonzogni	Update codes.	Incorporate AME 2012 into QCALC. **Completed**
(38)	Kondev	Update NSR with missing decay-data references.	Contact M.-M. Bé for list of references included in DDEP database that are not in NSR. **Completed**
(40)	All ENSDF evaluators/ Kibedi	Determination of mixing ratios from available experimental information/Improve calculations of mixing ratios.	1). If significant penetration effects observed: re-calculate mixing ratios from experimental information rather than BrIcc conversion coefficients. 2). If mixing ratios based on HSICC: re-calculate using BrIcc. A new version of BrIcc for mixing ratio calculations is being prepared by Kibedi who will also look into how penetration effects can be incorporated when relevant. **Completed**
(41)	NDS-IAEA	Reports from Russian and Chinese Data Centres.	Abriola contact NSDD representatives of Russian and the Chinese Nuclear Data Centres to clarify status of evaluation effort, and their participation at next meeting. **Completed**
(42)	All ENSDF evaluators	Assignment of spin.	Uncertain Jπ: evaluators should assign up to three alternative values in order of preference, or should insert best-guess or theoretical spin value in 2L record. **Completed - also include in *Guidelines for Evaluators***
(44)	Singh, Nichols	Evaluation of half-lives.	Revise and distribute the final version of guidelines for the evaluation of half-lives of ground states and long-lived isomers. **Completed**
(50)	NNDC-BNL/ Tuli, McCutchan	*Guidelines for Evaluators*.	Include separate section on multipolarity assignment in *Guidelines for Evaluators*. **Completed by Martin**

First column: number in brackets is the action number from the previous network meeting (INDC(NDS)-0635).

COMPLETED ACTIONS cont'd			
No.	**Responsible**	**Reason**	**Action**
(51)	Kelley, Tuli	Prompt particle decays from short-lived excited states.	Explore method and format to include particle decays from excited states in ENSDF. **Completed by Kelley**
(52)	Network	Ensure sustainability of XUNDL effort.	Network participants with direct access to undergraduate students should explore possible ways of becoming involved in XUNDL effort, and contact Balraj Singh. **Completed**
(53)	Singh	Facilitate conversion of published data tables to ENSDF format.	Provide NNDC with procedure and computer code to translate tabular text to ENSDF format. **Completed by Chen**
(54)	Kibedi, Nichols, Kondev	Emerging need for X-ray and other atomic data in decay data sets.	Suggest possible ways to include atomic radiation data in ENSDF so that they are easily retrievable. **Completed**
(55)	NNDC-BNL /Tuli	Absolute intensities.	Consider absolute intensity program of Browne, and possible ways of incorporating into ENSDF. **Completed by Kondev, Kibedi, Browne**
(58)	Balabanski/ NDS-IAEA	European ENSDF evaluators.	Explore ways to acquire funding from the EU with assistance of NDS-IAEA. **Completed - unsuccessful**
(59)	NNDC-BNL /NDS-IAEA	Applied users/researchers interested in retrieving decay data sets only.	Consider making decay-only retrieval mode more user friendly. **Completed**
(60)	Firestone, University of Oslo, NDS-IAEA	Database of γ-ray data.	Hold IAEA Consultants' Meeting to explore need for database of photon strength functions, and report in two years. **Completed**
(61)	NNDC-BNL/ Tuli	Status of updates in mass-chain evaluations.	Request Elsevier and NNDC to include a copy of *Nuclear Data Sheets* index page on their website every month. **Completed**
(62)	NDS-IAEA	Improve tools.	Consider the possibility of displaying full parent-daughter isomeric relationships in tabular form in LiveChart. Continue to improve LiveChart. **Completed**

First column: number in brackets is the action number from the previous network meeting (INDC(NDS)-0635).

COMPLETED ACTIONS cont'd			
No.	**Responsible**	**Reason**	**Action**
(64)	All ENSDF evaluators	ENSDF evaluations.	Rule 25 should be optionally used. **Completed**
(65)	All ENSDF evaluators	Avoidance of blank records for unique gamma transition intensity records, which is particularly problematic for ENSDF users.	Unique γ transitions to be assigned intensity of 100%. **Sec. note**: Following discussions held after the meeting, participants felt that the above wording was too general to be practical, and suggested the following action to supersede the original proposal: A low-lying and generally low-spin level depopulated by a single definite gamma transition to be assigned 100 for relative photon branching ratio (in RI field of Gamma record) within ENSDF Adopted dataset; total conversion coefficient for such a transition should be given if expected to be significant, together with known or assumed multipolarity and mixing ratio - typically, first 30 or so low-lying levels for even-even, and first 15 or so low-lying levels for odd-even and odd-odd nuclei. Exceptions to this rule must be clearly noted and explained. **Completed – also to be implemented in *Guidelines for Evaluators***
(66)	NSR manager	To ensure consistency of keynumber assignments in NSR database.	Keynumber for AME 2012 publication is 2012Wa38. DOI numbers should be provided in NSR database. **Completed**

First column: number in brackets is the action number from the previous network meeting (INDC(NDS)-0635).

Extensions to ENSDF Procedures

ENSDF PROCEDURES			
No.	**Responsible**	**Reason**	**Extension**
1	All network participants	Highly relevant information and data from some conferences, meetings and laboratory reports are not always available to NSR compilers in NNDC.	Assist NNDC in obtaining conference proceedings, meeting and laboratory reports for NSR. Copy of unpublished conference reports containing significant NSDD contribution should be sent to NNDC.
2	NNDC-BNL	Publication of ENSDF.	Continue journal publication of the mass chain evaluations in *Nuclear Data Sheets.*
3	All network participants	Misprints and errors found in NSR and ENSDF.	Report misprints and errors detected in NSR, XUNDL and ENSDF to NNDC.
4	All ENSDF evaluators	Accelerate review process.	Each ENSDF evaluator should be willing to review two mass-chain equivalents per FTE-year; reviewing process for one mass chain should take no longer than three months.
5	All network participants	Bring NSDD evaluation work to the attention of the nuclear community.	Present network activities at a wide range of appropriate conferences and meetings.
6	All network participants	Avoid duplication of work.	Participants should inform the NNDC and NDS-IAEA about any development of software related to NSDD.
7	All network participants	Young scientists to evaluate mass chains.	Encourage participation in research/evaluation of nuclear structure data.
8	All network participants	Improve NSR.	Send comments and suggestions on NSR improvements (indexing) to NNDC.
9	All network participants	Support new ENSDF evaluators.	Provide local support and mentoring to new ENSDF evaluators of mass chain evaluations.
10	All ENSDF evaluators	Check continued validity of the rules.	Inform NNDC when experimental results appear to contradict accepted rules.
11	All network participants	Improve quality of evaluations.	Solicit potential non-network evaluation reviewers, and send names to ENSDF coordinator at NNDC.
12	NNDC-BNL/ NDS-IAEA	Outreach.	Continue to pursue initiatives to improve the international contributions to the ENSDF mass chain evaluations.
13	All network participants	Outreach.	Formulate and expand contributions to mass chain evaluations within their own countries.

ENSDF PROCEDURES cont'd			
No.	**Responsible**	**Reason**	**Extension**
14	All ENSDF evaluators	Quality assurance.	Consider updating the evaluation cut-off date when no or little experimentally significant new data are available.
15	All ENSDF evaluators	Evaluations in progress.	Inform ENSDF coordinator at NNDC (Jag Tuli) about mass chain and individual radionuclide evaluations in progress to ensure their inclusion in monthly evaluation processing report.
16	All network participants	Policies.	Inform NNDC of discrepancies in the current policies, and propose changes and additions.
17	NNDC-BNL	Analysis codes.	Notify network of new versions of analysis codes.
18	NNDC-BNL	General policy pages in NDS.	Modify policy pages, as needed.
19	All ENSDF evaluators	Keep ENSDF up-to-date.	Check NNDC monthly report for nuclides added by others to ENSDF that are in your mass-chain responsibility.

STATUS REPORTS OF NSDD DATA CENTRES

NNDC/USNDP REPORT FY2013-2014, M. Herman

There have been considerable personnel changes in the US Nuclear Data Program over the previous two years. Three structure evaluators (two at LBNL and one at McMaster) have retired, but continue to contribute under contracts with UCB and BNL. Postdoc at ANL moved to MSU in September 2014 with the intention of becoming a permanent staff member involved in structure evaluations. Retirement of technical staff at NNDC in December 2014 created some concerns regarding preparation of the papers for *Nuclear Data Sheets* that fortunately seem to have been satisfactorily resolved. Over the broader picture, it is worth noting a consolidation of the Bay Area nuclear data group involving LBNL and UCB, as well as the entrance of Michigan State University into the USNDP.

USNDP funding increased by 5% in FY2014 and remained essentially constant in FY2015, whereas a flat budget scenario is most likely to occur over forthcoming years. The increasing cost and depletion of the reserves reduced the permanent scientific staff at the USNDP by 2 FTE in FY2015, and further decline is expected in FY2016 and FY2017. This will inevitably result in a decrease of evaluation activities unless additional funding can be secured. Therefore, strengthening of the non-US component of the NSDD is of primary importance.

In view of the potential shortage in resources, it is vital to set up priorities that in the long range will minimize possible adverse effects. Archiving of nuclear data for basic nuclear science and technologies as well as dissemination of nuclear physics data through Web-based services are relatively inexpensive and have to be fully maintained. Next priority has been assigned to the compilation of nuclear structure and reaction data into the NSR, XUNDL and EXFOR databases. These activities require continuity in order to be useful to users and especially to nuclear data evaluators. Under these regrettable circumstances, evaluation work is most likely to suffer eventual cuts.

NNDC nuclear data services have been moved to newer and more powerful hardware, and have undergone a complete reorganization with the GFORGE server playing a key role in data distribution. Practically all servers and the cluster moved to a dedicated, ITD-operated building which ensures a more reliable operational environment. On the other hand, upgrade of the file system resulted in sluggish performance of Webtrend (because of the outdated Perl coding that requires rewriting of the Webtrend program). Although providing for better utilization of resources, round-robin load balancing between the two Web servers has caused some problems in prolonged Web sessions. Cyber security became recently an onerous task and it is expected to demand even more resources in the future to maintain the USNDP servers up to DOE standards. Retrievals from the NNDC Web portal stabilized on the 3.3 million level, although there was a 6% dip in FY12.

USNDP went through an extensive external review in July 2014, as mandated by the DOE-SC - the first one of this type in about 20 years. The essential part of the effort related to this review was carried through by the NNDC, which provided local organization, prepared a substantial part of the USNDP presentations, and developed ideas for the future. Overall, the results of the review were very positive indicating that "the NNDC and participating institutions have done a remarkable job trying to define the purpose of the USNDP and coordinate the overall effort" and that "NNDC operates very well as a Data Center; this is an essential national resource." The Review Panel made several recommendations including:

- Create an external USNDP Advisory Panel to critically assess current efforts and proposed activities.
- DOE NP and USNDP should jointly develop an updated Mission Statement for USNDP that takes into account stakeholder interests and input.

- A comprehensive document should be prepared that summarizes and prioritizes the possible future developments in the nuclear data program proposed by all USNDP participants.
- DOE NP should be cognizant of the need for adequately funded career paths for sufficient new evaluators, recruited and trained by USNDP to carry out the USNDP program.
- USNDP should devise effective and transparent mechanisms to solicit input and feedback from all stakeholders on nuclear data needs and priorities.
- Pursue a potential collaboration between the USNDP and Brookhaven Linac Isotope Producer (BLIP) with the aim to expand this to collaborations with other DOE NP funded isotope production facilities such as at LANL and ORNL.

In addition to the usual dissemination, compilation and evaluation activities, the USNDP structure and decay data network will have to face a number of challenges, such as:

1. Substantial changes in the USNDP structure and organization (new centers at LBNL/UCB and MSU).
2. Reorganization of XUNDL compilation.
3. Need to increase of non-US contribution to ENSDF.
4. Developing new nuclear data structure to replace ancient formats.
5. Transition to the new mode of *Nuclear Data Sheets* production.
6. Continue upgrading codes for ENSDF (replacement of Webtrend being most urgent).
7. Continue collaboration with BLIP targeting data needs for isotope production.
8. Major modernization of the NNDC Web services.

Some of these challenges will have to be addressed independently of the funding scenario. For example, implementation of points 1, 2 and 5 are already a reality. There are also clear intentions by the sponsor to support activities under points 4 and 7, which in the case of the latter includes targeted experimental activities. In general, USNDP will have to be more responsive to user needs, seek advice from stakeholders, and prioritize activities accordingly.

NDS-IAEA STATUS REPORT 2013-2014, P. Dimitriou

Coordination:
The 20th meeting of the NSDD network organized by NDS-IAEA was held in Kuwait City, Kuwait, 27-31 January 2013. This meeting was hosted by KFAS and the Kuwait University Physics Department, and was attended by 36 scientists from 17 Member States involved in the compilation, evaluation and dissemination of nuclear structure and decay data. The summary report of the meeting was published as IAEA report INDC(NDS)-0635.

Based on the conclusions and recommendations of that meeting, a series of actions were taken by NDS-IAEA in support of the network activities. These actions are briefly outlined below.

Financial support:
NDS-IAEA has continued to provide financial support to mass-chain evaluators. Over the course of 2014, three out of the six supported evaluators (J. Timar, A. Negret, S. Lalkovski) successfully completed their mass-chain evaluations under their IAEA contracts.
Horizontal evaluations/compilations: NDS-IAEA has also supported the AME 2012 effort by providing a contract to M. Wang (2011-2013).

An updated table of Nuclear Magnetic Dipole and Electric Quadrupole Moments, and a table of Recommended Electric Quadrupole Moments have been published under contractual services agreements placed with N.J. Stone (INDC(NDS)-0658 and INDC(NDS)-0650, respectively). Improved and continuously up-to-date data on magnetic dipole and electric quadrupole magnetic moments have been provided as an online database made available on the IAEA Web server. The database provides direct access to the above-mentioned tables as well as to the latest published data, and was developed by T. Mertzimekis (University of Athens) and installed on the IAEA web server under an IAEA contract. Future plans include upgrading the database to provide recommended values as well as plotting capabilities.

Training:
A joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Theory and Evaluation, was held from 24-28 March 2014, at ICTP, Trieste, Italy, and was organized in collaboration with NNDC-BNL. Twenty-one participants from 15 countries and six lecturers attended the workshop. Hands-on exercises consisted of the evaluation of four isotopes of mass chain A = 227 (^{227}Th, ^{227}Ac, ^{227}Ra, and ^{227}Fr) – the remaining members of this mass chain had been updated by B. Singh before the workshop. Work on the mass chain evaluation continued after the workshop, and has been submitted for review and publication in *Nuclear Data Sheets*.

A proposal to organize a Specialized Workshop for active ENSDF evaluators was approved and the workshop will take place the week after the NSDD meeting, from 27 to 29 April 2015 at the IAEA Headquarters. The purpose of the workshop was to gather active but less-experienced evaluators together with more experienced evaluators in order to discuss frequently encountered problems in their evaluation work, achieve greater clarity in existing evaluation policies and their implementation, obtain updates concerning on-going and planned improvements to analysis codes, and refresh their evaluation skills. Coordinators of this workshop were F.G. Kondev (ANL) and E. McCutchan-Ricard (NNDC, BNL).

A proposal for the next joint ICTP-IAEA Workshop on NSDD in 2016 has been submitted and approved for a two-week event from 22 August to 2 September 2016.

Codes:
Following the concerns vividly expressed throughout the network about the current status and future maintenance of the ENSDF Analysis codes, NDS-IAEA initiated a Data Development Project to improve the analysis codes and ensure their timely dissemination among the network. The first meeting of this project was held from 10 to 13 June 2014. Participants reviewed the existing codes and discussed emerging needs for improved physics models, uncertainty treatment, physics and format checking, and modernisation of the programming tools, along with the development and use of online web-tools and a user-friendly evaluation toolkit to facilitate evaluators' work. A list of priorities of the codes and the modifications that need to be made was produced, and specific tasks were assigned to individual participants (see IAEA report INDC(NDS)-0665). The second meeting to monitor progress in this work will be held from 5 to 8 October 2015.

MyEnsdf Web Tool (V. Zerkin) has been updated with all the ENSDF Analysis, Checking and Utility codes. Recent developments allow evaluators to upload their ENSDF files and produce pdf/ps printouts ready for publication in *Nuclear Data Sheets*. Hence, this web tool is being used partly for processing and editing ENSDF files for publication.

Dissemination:
Live Chart (M. Verpelli) is continuously being developed and improved to take into consideration the feedback from and needs of the members of the network and the broader nuclear data and nuclear physics communities.

NDS-IAEA staff have always ensured that all newly evaluated data produced by their CRPs are readily available to evaluators and users at large (see also the presentation by P. Dimitriou). A common web site that will accommodate all CRP-evaluated data is under construction in furtherance of this aim, and will soon become available online.

Other:
Along with the specific activities mentioned above, NDS-IAEA has also supported the most recent European attempt to establish nuclear data evaluation as an appropriately funded activity within European nuclear research. A proposal for a European network of data evaluators was jointly prepared by several European laboratories and groups with the support of NDS IAEA and was submitted for inclusion in the ENSAR2 project to receive EU funding in the period of 2016-2020. Unfortunately, this proposal was rejected.

NDS-IAEA provided financial assistance to the 5th DDEP Workshop, which was held from 6-8 October 2014 in Bucharest, Romania.

All network participants should note that the IAEA NSDD web site is fully maintained and kept up-to-date with the latest information about nuclear data publications and events.

STATUS REPORT OF NUCLEAR DATA ACTIVITIES AT OAK RIDGE NATIONAL LABORATORY (ORNL), C.D. Nesaraja

1. Members

The Nuclear Data Group consists of Michael Smith (Group Leader for Experimental Astrophysics & Nuclear Data Program), Caroline Nesaraja (ENSDF evaluator and XUNDL compiler), Murray Martin (ENSDF evaluator and consultant), Eric Lingerfelt (Software Developer), Chris Smith (XUNDL compiler and Computational Astrophysics Programmer), and Jon Batchelder (XUNDL compiler and Horizontal Structure evaluator. Contract: October 2014 - April 2015)

2. Activities

i) Nuclear Structure Data

This activity consists of the mass chain evaluations, and our responsibility is in the actinide region A = 241-249. Current literature cut-off dates for mass chain A = 241-249 are listed below:

Mass chain and literature cut-off dates from ENSDF database	
241	M.J. Martin NDS 106, 89 (2005) (Lit. cut-off June 2005)
242	Y. A. Akovali NDS 96, 177 (2002) (Lit. cut-off Sept 2001)
243	C.D. Nesaraja and E.A. McCutchan NDS 121, 695 (2014) (Lit. cut-off Sept 2013)
244	Y. A. Akovali NDS 99, 197 (2003) (Lit. cut-off June 2002)
245	E. Browne and J.K. Tuli NDS 112,447 (2011) (Lit. cut-off June 2011)
246	E. Browne and J.K. Tuli NDS 112,447 (2011) (Lit. cut off Jan 2011)
247	C.D. Nesaraja NDS 125, 395 (2015) (Lit. cut-off March 2014)
248	M.J. Martin NDS 122, 377 (2014) (Lit. cut-off Sept 2014)
249	K. Abusaleem NDS 112, 2129 (2011) (Lit. cut-off Dec 2010)

Since the last NSDD meeting in 2013, several mass chains are being evaluated and are in their various stage of evaluation process as shown below.

Mass Chain	Evaluator	#Nuclides	Status
41	McCutchan and Nesaraja	11	Under evaluation
241	Nesaraja	8	In review
242	Martin	12	Under evaluation
243	Nesaraja and McCutchan	8	Published
247	Nesaraja	8	Published
248	Martin	7	Published
69	Nesaraja	2	Updated ^{69}Br, ^{69}Kr

Both Murray Martin and Caroline Nesaraja are also reviewing mass chains as requested by the National Nuclear Data Centre (A = 54, A = 87, A = 209). Murray Martin had prepared a draft version of the "**Guideline for Evaluators**" which was discussed in detail at the Specialized Workshop on NSDD Evaluations, 27-29 April 2015, IAEA, Vienna.

ii) Nuclear Astrophysics Data

The astrophysics data research is closely coupled with our program of measurements of reactions with unstable and stable nuclei. One recent example of such work, Shisheng Zhang as a guest visitor from Beihang University in Beijing collaborated with Michael Smith and others to calculate the direct capture of neutrons on ^{132}Sn with the FRESCO code using information from recent ^{132}Sn(d,p) measurements at ORNL. This project first developed a technique to provide the necessary structure input for the FRESCO code, using a combination of experimental information and (when not available) information from a RMF-based structure code. The robustness of this approach was tested on three nuclei for which direct capture data is available -- ^{16}O, ^{36}S, and ^{48}Ca. Then the capture on the unstable ^{132}Sn nucleus was calculated and was found to agree well with a recent study using a totally different approach. The advantage of the approach in the current work is use of a global structure model that can provide input for all nuclei with just 11 parameters. This work is published in "Exploration of direct neutron capture with covariant density functional theory inputs", Shi-Sheng Zhang, Jin-Peng Peng, M.S. Smith, G. Arbanas, R.L. Kozub, Phys. Rev. C **91** (2015) 045802. Another project involves the conversion of two recent collections of point-wise thermonuclear reaction rates into analytical functions that can be used with a wide variety of astrophysical simulation codes. This conversion required fitting the point-wise rates with functions that range over 30 orders of magnitude to a precision of approximately 2%. Approximately 90 different rates were fit and are now available for use in nucleosynthesis codes. A paper describing this work is in preparation.

iii) Online Software Systems

Our nuclear astrophysics data activity also includes software work to improve and expand the functionality of the Computational Infrastructure for Nuclear Astrophysics (CINA). This suite enables users to make the connection between laboratory nuclear physics results -- and USNDP data bases -- and astrophysical simulations with just a few mouse clicks. Researchers from over 150 institutions in 35 countries use this software system for their research. A related tool at nuclearmasses.org is also periodically updated with the latest mass measurements as compiled by McMaster University, as well as with the latest theoretical mass models. These systems provide platform-independent, user friendly mechanisms to utilize nuclear data sets for research in nuclear physics and astrophysics.

3. Future Activities

Future mass chains will be evaluated within the range A = 241-249 assigned to NDP/ORNL, as well as others assigned by USNDP/NNDC.

LBNL/UCB REPORT (May 2013 - April 2015), S. Basunia

Nuclear Data activities under the Isotopes Project at LBNL cover nuclear structure data evaluation, experiments and evaluation of neutron capture gamma ray data for Evaluated Gamma ray Activation File (EGAF), and nuclear reaction studies for applied applications using neutrons from local facilities, like deuteron breakup reaction at 88-Inch Cyclotron at LBNL and DD neutron generator at the University of California at Berkeley (UCB) and other facilities like, Nuclear research reactors at Budapest, Hungary and FRM, Germany, and Cyclotron facility at the University of Oslo through an international collaboration.

In this reporting period – mass chains A=28, A=91, A=92, A=192, A=210, A=211 were published in the *Nuclear Data Sheets* and A=22 in ENSDF. Mass chains A=22, A=170, A=171, A=183 are in the production process for publication. Also four nuclides, ^{93}(Br, Kr, Rb), ^{186}Po were updated in ENSDF. Compilation of nuclear structure data for XUNDL has been started at LBNL since November 2013 and 53 data sets from 28 papers were compiled.

Neutron capture studies of ^{93}Nb, ^{139}La, ^{185}Re, and ^{242}Pu targets related to EGAF were carried out by four students (Danyal Turkoglu – Ohio State University, Adriana Ureche – University of California at Berkeley, Andrew Lerch – US Army, and Christoph Genreith – Jülich GmbH). Recently, a new NA-22 (non-proliferation) initiative has been funded at LBNL that is aligned with Correlated Fission Data Project at Lawrence Livermore National Laboratory and Los Alamos National Laboratory.

An experiment on ^{56}Fe(n,n'γ) reaction studies has been performed by Leo Kirsch and Lee Bernstein at the 88-Inch Cyclotron facility. This research work will address the nuclear data need for the CIELO (Collaboration International Evaluated Library Organization) project. Data analyses are in progress. Compilation of (n,n'γ) data from Baghdad Atlas into a SQL database has been completed. Evaluation of these data is in progress.

In total twenty three journal papers/conference proceedings/meeting reports related to experimental activities have been published, authored/co-authored by nuclear data group members, in this reporting period.

Future plan of Isotopes Project at LBNL will continue activities for ENSDF, XUNDL, and EGAF databases. Specific interest will be devoted to address nuclear data needs for applied applications combining local facilities and personnel at LBNL, UCB, and LLNL. A workshop titled 'Nuclear Data Needs and Capabilities for Applications' will be held at LBNL on May 27-29, 2015 focusing mainly in four major areas, like Energy, National Security, Isotope Production, and Industrial Applications for future funding application and experimental activities.

At present group members at LBNL and UCB-NE include M. S. Basunia, Aaron M. Hurst, Eddie Browne (affiliate) at LBNL; Lee A. Bernstein, Richard B. Firestone (affiliate), Coral M. Baglin (affiliate) along with students Mark A. Trudel, Adriana Ureche, Leo Kirsch, and Ivana Abramovic represent the UCB component of the Nuclear Data Group.

TUNL NUCLEAR DATA EVALUATION PROJECT, J.H. Kelley

I. Status of A = 3–20 data evaluation

TUNL is responsible for data evaluations in the mass range A = 3-20. Since the last NSDD/IAEA meeting in 2013 reviews of A = 2 and A = 12 are underway.

Recent Publications from the TUNL Data Evaluation Group

Nuclear Mass	Publication/Status
A = 3	*Nucl. Phys*. **A848** (2010) 1
A = 11	*Nucl. Phys*. **A880** (2012) 88

II. ENSDF

We anticipate publication of *A*=2 and *A*=12 in 2015, the corresponding ENSDF files will quickly be added to the database. In addition, we plan to publish a condensed and updated version of the *A* = 3 review in *Nuclear Data Sheets* (NDS). Future reviews will be published exclusively in NDS.

In addition to these A-chain reviews, we have added reviews of ^{6,7}B, ^{14}F, ^{15,16,18}Be, ^{15}Ne and ^{18,19,20}Mg to the ENSDF, and we have added an extensive list of delayed particle emission datasets to ENSDF.

We also contribute compilation effort that covers the A=2-20 region for XUNDL.

III. World Wide Web Services

TUNL continues to develop new WWW services for the nuclear science and applications communities. PDF and HTML documents are online for TUNL and Fay Ajzenberg-Selove reviews. Energy Level Diagrams are provided in GIF, PDF and EPS/PS formats. Information on the TUNL web pages makes extensive use of the NSR link manager. We also provide information on Thermal Neutron Capture evaluated data and Beta Decay data, and we have begun providing information on excitation functions for light-particle reactions relevant to the *A*=3-20 nuclides.

Related Activities

Grace Sheu has become involved in the effort of producing print ready and review drafts of articles in connection with the preparation of manuscripts for *Nuclear Data Sheets*.

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PROGRESS REPORT ON NUCLEAR STRUCTURE AND DECAY DATA ACTIVITIES AT ARGONNE NATIONAL LABORATORY (ANL)

Filip G. Kondev

Period covered: March 2013 – April 2015

I. Program overview

The Argonne National Laboratory (ANL) Nuclear Data Program (NDP) is involved is a variety of scientific activities carried out within the broader framework of the Coordinated Work Plan of the U.S. Nuclear Data Program that is sponsored by the Office of Nuclear Physics, Office of Science, U.S. Department of Energy. Among these are the compilation and evaluation of nuclear structure and decay data, and the development of nuclear data measurements, analysis, modeling, and evaluation methodologies for use in basic science and technology applications. Contributions are also made to various specialized databases serving specific needs in the fields of nuclear structure, nuclear astrophysics, and applied nuclear physics.

II. Nuclear Structure and Decay Data Evaluations Activities

The main emphasis of the nuclear data activities at Argonne National Laboratory is on nuclear structure and decay data evaluations for the ENSDF database. ANL data centre has responsibilities for evaluating nuclei within the A=106-112, 176-179 and 199-209 mass chains. The up-to-date status of the evaluations under the ANL responsibility is presented in Table 1. During the period of time covered by this report, evaluations of the A=112 (with S. Lalkovski, University of Sofia) and 209 (with Jun Chen, ANL) mass chains were completed, reviewed and published in the journal *Nuclear Data Sheets*. Work is continuing on A=188 (with Prof. S. Juutinen, Jyvaskyla University and Prof. D. Hartley, US Naval Academy), 177 and 109 (with S. Kumar, University of Delhi and Jun Chen, ANL). Compilations for the XUNDL database were also carried out. ANL staff interacted with the leading authors on several occasions in order to collect additional data and to resolve data ambiguities.

Table 1. Status of mass chain evaluations assigned to the ANL data centre

Mass Chain	NDS publication	Evaluator	Current Status
176	NDS **107** (2006) 791	M.S. Basunia	completed/LBNL
177	NDS **98** (2003) 801	F.G. Kondev	completed/under revision
178	NDS **110** (2009) 1473	E. Browne	completed/Argentina
179	NDS **110** (2009) 265	C.M. Baglin	completed/LBNL
199	NDS **108** (2007) 79	B. Singh	completed/McMaster
200	NDS **108** (2007) 1471	F.G. Kondev & S. Lalkovski	completed
201	NDS **108** (2007) 365	F.G. Kondev	completed

Mass Chain	NDS publication	Evaluator	Current Status
203	NDS **105** (2005) 1	F.G. Kondev	completed
204	NDS **111** (2010) 141	C.J. Chiara & F.G. Kondev	completed
205	NDS **101** (2004) 521	F.G. Kondev	completed
206	NDS **109** (2008) 1527	F.G. Kondev	completed
207	NDS **112** (2011) 707	F.G. Kondev & S. Lalkovski	completed
208	NDS **108** (2007) 1583	M.J. Martin	completed/ORNL
209	NDS **126** (2015) 373	J. Chen & F.G. Kondev	completed

Mass Chain	NDS publication	Evaluator	Current Status
106	NDS **109** (2008) 943	D. De Frenne & A. Negret	completed
107	NDS **109** (2008) 1383	J. Blachot	completed
108	updated online 2008,	J. Blachot	completed
109	NDS **107** (2006) 355	J. Blachot	being evaluated/**
110	NDS **113** (2012) 1315	G. Gurdal & F.G. Kondev	completed
111	NDS **110** (2009) 1239	J. Blachot	completed
112	NDS **124** (2015) 157	S. Lalkovski & F.G. Kondev	completed

** In collaboration with S. Kumar (University of Delhi) and J. Chen (NSCL).

STATUS REPORT OF McMASTER UNIVERSITY (1 February 2013 to 17 April 2015), Balraj Singh

Main data evaluation and compilation activity at McMaster University is centred around the ENSDF database which includes nuclide and mass-chain evaluations, compilations of current papers for XUNDL database, writing keyword abstracts for NSR database, and selected horizontal evaluations of certain nuclear structure quantities. For several years we have had permanent responsibility for evaluating 25 mass chains (A=1, 31-44, 64, 89, 98, 100, 149, 151, 164, 188, 190, 194) for the ENSDF database; 16 of these are less than 10 years old in ENSDF, other 8 mass chains are in progress and expected to be completed within about 2 years. The oldest mass chain in this group is A=149 from 2004, which is not being evaluated at present, but there is limited new data for nuclides of this mass chain.

ENSDF evaluations: During 2013-2015, eight mass chains (A=31, 61, 85, 86, 129, 211, 215) were published in NDS issues of 2013-15, most of these publications have shared authorship, as part of training and mentoring. Complete evaluations of A=76, 139 and 224 were submitted in 2014. Apart from the listed mass chains, a total of 148 nuclides were updated in ENSDF, which were either new entries in ENSDF or for which very limited information existed. Two mass chains from other evaluators were reviewed. Currently, evaluation work is in progress for A=40, 57, 79, 98, 130, 165, 189, 190 and 227, most of these are being done in collaboration with other centres, some as part of training process. In this connection, Drs. Anagha Chakraborti and Sukhjeet Singh from India visited McMaster during 2013 and 2014. For work on A=130 mass chain, Dr. Alexander Rodionov from St. Petersburg, Russia visited McMaster in summer 2013.

ENSDF training workshop: B. Singh lectured and coordinated the exercises sessions at the IAEA-ICTP NSDD workshop in Trieste, Italy in March 2014. Work on the A=227 nuclides was taken up at this workshop as part of practical exercises in ENSDF work. Under the coordination of B. Singh, this mass chain will soon be submitted for publication in *Nuclear Data Sheets*.

ENSDF codes meeting: B. Singh attended a meeting organized by the IAEA-NDS in August 2014 to evaluate the current status of computer codes for ENSDF evaluations and to assess the need for improvements in existing codes and for possible new codes. B. Singh presented a talk on the need to write a code to deduce recommended gamma-ray energies and intensities (or branching ratios) by two approaches, gamma-by-gamma as most evaluators do now manually, and a revived GAMUT-type code which may consider normalizations of different datasets. Based on discussion at this meeting, Michael Birch at McMaster University, with a contract from the IAEA-NDS and in consultation with B. Singh, is writing a code to deduce recommended values, which should help automatize the process of creating Adopted Datasets in the ENSDF database.

XUNDL compilations: A total of 485 datasets were compiled and another 70 were updated based on a total of 192 journal publications. Another 30 papers on mass measurements were compiled separately and data made available on nuclearmasses.org webpage. As part of coordination of XUNDL project, 451 datasets received from other data centres were reviewed and edited when needed.

NSR keyword abstracts: 1550 keyword abstracts were written from a total of 2450 papers in 27 months of *Physical Review C* issues from October 2012 to December 2014.

Horizontal Compilations/Evaluations

B(E2) values for first 2+ states in all the even-even nuclei: A comprehensive compilation and evaluation of B(E2) values has been prepared, and a paper has been submitted and is currently under review for publication in *Atomic Data and Nuclear Data Tables*. A recent version of this paper is available on the arXiv preprint site. A report on this work was presented at the ND2013 conference.

Beta-delayed neutron probabilities and half-lives: As part of the IAEA-CRP to create a reference database for beta-delayed neutron emitters, compilation of the evaluation of half-life and Pn data for Z=2-28 nuclides (219 nuclides, 107 P_{1n}, 20 P_{2n} and 5 P_{3n} were involved in this work) has been completed, and a paper for publication in *Nuclear Data Sheets* has been submitted and is currently under review. The following data files in EXCEL and pdf formats have been submitted to IAEA-NDS for creation and testing of a database at the IAEA dedicated to beta-delayed neutron precursors:

a) Table of recommended half-life and Pn data file with complete bibliography (list of references hyperlinked to NSR database).
b) Table of nuclides and Q-values for possible P_{1n}, P_{2n}, P_{3n} precursors (based on AME2012).
c) Table of compiled data for P_{1n}, P_{2n}, P_{3n} and half-lives with all available references, including some secondary publications.
d) Supplementary table of comments for Pn and half-life measurements (this file will be made available, but not published).

Work is in progress for Z>28 region, in collaboration with five other data centres.

B. Singh attended the 2nd RCM of this CRP in March 2015 at the IAEA, Vienna, and presented a report of the work accomplished for Z=2-28 region, and a plan of future evaluation work.

Compilation of directly measured nuclear spins of ground states and isomers: This work was prepared in 2012-13 by B. Singh and his students at McMaster, and published in *Nuclear Data Sheets* **114**, 397 (2013).

Atlas of Nuclear Isomers: We have collaborated with Prof. Jain's group at IIT, Roorkee, India to compile a list of all isomers of half-life 10 ns or higher, together with their decay modes and other characteristics. This work has been submitted for publication in *Nuclear Data Sheets*, has passed through the review process, and should soon appear in the journal.

Collaborative experimental research: B. Singh participated in two experiments at TRIUMF one to investigate shape coexistence in Zr-94 through the study of Y-94 decay to Zr-94 which has produced a paper in PRL **110,** 022504 (2013); and second a related experiment on structure of Zr-98 through the decay of Y-98 to Zr-98, for which the data are still being analysed. As a by-product of a nuclear astrophysics experiment on S-30 carried out at University of Tsukuba Tandem Accelerator by Prof. Chen's research group at McMaster, extensive structure data for N = Z = 15, P-30 nucleus were analysed, presented at ND2013 conference, and finally published in *Nuclear Data Sheets* **120**, 88 (2014). During 2013-2015, there were 9 journal publications dealing with research topics and evaluations, five of these were related to presentations at the ND2013 conference in New York city.

B. Singh's work was partly supported by a contract (1 October 2013 onwards) from Brookhaven National Laboratory, Upton, NY, USA, while infrastructure support was provided by McMaster University.

PROGRESS REPORT OF CEN, J. Blachot

Blachot noted that he has been Member of the NSDD Network since the beginning in 1978 (35 years), as a member of CEA Grenoble , then CEA Bruyères le Chatel, and finally CNRS Orsay, with more than 45 publications in *Nuclear Data Sheets*.

Status since the last meeting of 2013:

Mass	NDS	Dat--ENSDF	Comments
113	NDS **111**, 1471(2010)	201006	
114	NDS **113**, 515 (2012)	201203	
115	NDS **113**,2391 (2012)	201210	
116	NDS **111**, 717 (2010)	201004	Mo (10)
117	NDS **95**, 679 (2002)	201101	
	ENSDF (2011)		

The new data that have appeared since the previous meeting are as follows:

113Cs	ENSDF	2015	(BS)
113In	XUNDL	2013	58NI(58NI,3PG):RDM
113In	XUNDL	2011	113CD B- DECAY:8E15 Y
		2013	110PD(7LI,4NG):
		2014	100MO(18O,P4NG)
		2015	113SN EC DECAY:115.09 D
113Mo	XUNDL	2011	BE(238U,F):T1/2
113Pd	XUNDL	2015	113RH B-DECAY:2.80 S
		2015	252CF,248CM SF DECAY
113Sb	XUNDL	2013	100MO(19F,6NG)
		2014	112SN(A,T),(3HE,D)
113Tc	XUNDL	2011	9BE(238U,X):ISOM
		2013	BE(238U,FG):ISOMER
113Xe	XUNDL	2013	58NI(58NI,2PNG)
114Pd	XUNDL	2012	248CM SF DECAY
		2014	252CF SF DECAY
115Ag	XUNDL	2013	115PD B- DECAY
115Cd	XUNDL	2013	U(N,F):J,MOMENTS
115Pd	XUNDL	2014	252CF SF DECAY
115Sb	XUNDL	2014	114SN(A,T),(3HE,D)

115In	XUNDL	2015	114CD(7LI,A2NG)
116Cd	XUNDL	2011	COULOMB EXCITATION:G
		2015	116IN EC DECAY:14.1 S
116Pd	XUNDL	2012	248CM SF DECAY:T,DSA
		2014	252CF SF DECAY
116Sb	XUNDL	2013	114CD(7LI,5NG)
116Sn	XUNDL	2011	COULOMB EXCITATION
		2015	116SN(D,D'):ISGMR,GQR
116Tc	ENSDF	2013	(BS)
116Mo	ENSDF	2013	
116Ru	ENSDF	2013	
117Cd	XUNDL	2012	252CF SF DECAY
		2013	U(N,F):J,MOMENTS
117La	XUNDL	2011	64ZN(58NI,P4NG)
117Mo	ENSDF	2012	(BS)
117Pd	XUNDL	2014	252CF SF DECAY
117Rh	XUNDL	2014	9BE(238U,FG)
117Ru	XUNDL	2012	9BE(238U,FG)
		2013	BE(238U,FG):ISOMER

NSDD DATA CENTRE PETERSBURG NUCLEAR PHYSICS INSTITUTE (PNPI): STATUS REPORT 2013-2015, I.A. Mitropolsky

General

The Data Centre is a part of the Nuclear Spectroscopy Laboratory in the Neutron Research Department of the Petersburg Nuclear Physics Institute, consisting of three physicists, one mathematician and one programmer. Our main activity is connected with information support of fundamental research and nuclear technologies for the WWR reactor.

Evaluations in ENSDF format

PNPI area of responsibility in the evaluation process includes nuclides with A = 130 – 135:

Mass number	Last publication	Comments
130	*NDS*, **93** (2001)	will be updated with Balraj Singh
131	*NDS*, **107** (2006)	
132	*NDS*, **104** (2005)	
133	*NDS*, **112** (2011)	
134	*NDS*, **103** (2004)	
135	*NDS*, **109** (2008)	

Yu. Khazov, A. Rodionov and G. Shulyak have re-evaluated mass chain A = 146 (*NDS*, **82** (1997)). After global revision in 2013, the evaluation will be finished this year.

Extraction of the ENSDF errors

G. Shulyak created a suite of codes to search for errors in ENSDF. The codes are located on the Web site of the Data Centre. There is an actual list of the errors found in ENSDF (http://georg.pnpi.spb.ru/). We proposed to include error checking in the revised procedures manual for ENSDF.

Horizontal evaluation and data systematics

L.Kabina, I. Mitropolsky and S. Lisin have created special problem-oriented databases that are needed for the application of ENSDF nuclear data in physics and technology. The ROTAN database is oriented towards the analysis of nuclear rotational states, and contains a relational database of nuclear rotational bands, codes for model analysis of energy levels, and a useful interface.

STATUS REPORT OF THE JAPANESE NSDD DATA CENTRE, JAEA, H. Iimura

1. Members

Present members of the Japanese group are A. Hashizume (former affiliation: RIKEN), M. Kanbe (Tokyo City University), J. Katakura (Nagaoka University of Technology), K. Kitao (former affiliation: National Institute of Radiological Science), S. Ohya (former affiliation: Niigata University), and H. Iimura (JAEA), who serves as group leader. Recently, H. Koura (JAEA) has newly joined the group. Group meetings are held once a year to exchange information on each member's progress in their evaluations. This Japanese group is a sub-group of the JENDL committee, which supports the travel costs for group meetings.

2. Mass chain evaluation

The Japanese group is responsible for mass chain evaluations A = 120-129. Evaluation of this mass chain A = 118 has been continued by Kitao, although the NSDD Network has accepted that the responsibility for A = 118 will be transferred to another group after we finish the present revision. As for A = 128 and 129, these mass chains were temporally evaluated by the Hungarian group for the present revision, although we will re-adopt responsibility for A = 128 and 129 in the next revision. We are now evaluating A = 120 (Hashizume) and 126 (Iimura, Katakura, Ohya), and their first drafts will be sent to NNDC within this year. Mass chain A = 126 is especially close to completion. Also, the evaluation of A = 123 (Kanbe) has recently started with the collection of references.

Status of Mass Chain Evaluations.

Mass	Last NDS publication		Status
	Year	Evaluators	
118	1995	Kitao	Being evaluated (Kitao)
120	2002	Kitao, Tendow, Hashizume	Being evaluated (Hashizume)
121	2010	Ohya	
122	2007	Tamura	
123	2004	Ohya	
124	2008	Katakura, Wu	
125	2011	Katakura	
126	2002	Katakura, Kitao	Being evaluated (Iimura, Katakura, Ohya)
127	2011	Hashizume	
128	2001	Kanbe, Kitao	Post review (Timar, Elekes)
129	2014	Timar, Elekes, Singh	

3. Chart of the nuclides

10th edition of JAEA Chart of the Nuclides was published in 2014, four years after the previous revision. Compilers of this edition are Koura, Katakura, Minato and Tachibana. Total number of nuclides included is 2916. In the light mass region, 32 nuclides with extremely short half-lives (< 10^{-20} s) for proton or neutron emission have been newly adopted. A particular property of this chart is that theoretical half-lives for α-decay, β-decay, spontaneous fission and proton emission are given for unmeasured radionuclides.

STATUS REPORT OF THE CNDC NSDD DATA CENTRE, Huang Xiaolong

1. Members

Current members of the CNDC group for the evaluation of Nuclear Structure and Decay Data are Huang Xiaolong and Kang Mengxiao. Kang Mengxiao is a graduate student who participates in some of the evaluation work.

2. Mass Chain Evaluations

The NSDD group at the China Nuclear Data Centre (CNDC) has permanent responsibility for evaluating and updating NSDD for A=51, 62, 195-198, and is temporarily participating in A=174. Over the previous 2 years, mass chain A=195 has been revised using available experimental decay and reaction data, A=198 was submitted for review, and A=51 is in the process of being updated. A=62 was assigned to CNDC from Jilin University (JLU, China) group at the 2011 NSDD meeting, and A=62 was evaluated by Balraj Singh *et al*., 2012.

Table 1. Status of Mass Chain Evaluations in CNDC.

Mass chain A	Status	Evaluators
51	*NDS*, **107**, 2131 (2006)	Huang Xiaolong, being updated
62	*NDS*, **113**, 973 (2012)	Balraj Singh, *et al*.
195	*NDS*, **121**, 395 (2014)	Huang Xiaolong, Kang Mengxiao
196	*NDS*, **108**, 1093 (2007)	Huang Xiaolong
197	*NDS*, **104**, 283 (2005)	Huang Xiaolong, Zhou Chunmei
198	*NDS*, **110**, 2533 (2009)	Huang Xiaolong, post review
174	Being updated	F.G. Kondev, T. Kibedi, Huang Xiaolong

3. Decay Data Evaluations

Over the previous two years, the recommended decay data for ^{68}Ga, ^{125}Sb, ^{227}Th, ^{229}Th and ^{233}U have been updated through studies of the available experimental data. Recommended data and evaluation comments for ^{227}Th, ^{229}Th and ^{233}U will be published on the DDEP website.

CNDC staff have also updated the main relative γ-ray intensities for ^{56}Co and ^{66}Ga, as adopted in high-energy calibrations of Ge detectors prior to their use in Chinese experimental studies.

Evaluations of the half-lives and delayed-neutron emission probabilities of ^{139}I, ^{140}I, ^{141}I, ^{141}Xe, ^{142}Xe, ^{145}Xe and ^{147}Xe were undertaken in 2014.

STATUS REPORT OF JILIN UNIVERSITY, Yang Dong

At present, members of Jilin University (JLU) group are Huo Junde and Yang Dong, along with a number of Masters students who are also involved in the evaluation work. Jilin University group is responsible for the nuclear structure and decay data evaluation of mass chains: A = 52, 53, 54, 55, 56, 63 and 73.

Current status of mass-chain evaluation:

A	Last NDS Publication	Status
52	2007	evaluated and reviewed
53	2009	
54	2014	published in 2014
55	2008	
56	2011	
63	2001	evaluation underway, ENSDF revised in 2009
73	2004	evaluation underway

Other activities of the group

- Yang Dong has taken part in a collective evaluation of mass chain A = 227, and specifically he worked on updating nuclide ^{227}Ac with other participants at the joint ICTP-IAEA NSDD workshop in 2014 under the guidance of Balraj Singh.
- Some experiments on the nuclear structure of odd-odd nucleus, such as ^{138}Pm, have been performed at the tandem accelerator, using the heavy-ion, fusion-evaporation reaction and γγ coincidence measurements. These data are being analyzed.

ENSDF AND OTHER EVALUATION ACTIVITIES IN INDIA, A.K. Jain

Mass Chains Under Review

A=224: Sukhjeet Singh, M.M. University Mullana visited Balraj Singh during June 2014 and completed the evaluation of A=224 mass chain. The peer review version of this chain has been received, and a final submission will be made within one month.
A=227: Sushil Kumar, M.M. University Mullana attended NSDD-2014 workshop held at ICTP, Italy, and carried out part of the evaluation work for the A=227 mass chain. This mass chain will be submitted within a month. The other participants from India who participated in this evaluation work were Anagh Chakravarty, Sudeb Bhattacharya, and the SSSIHL group.
A=139: This mass chain has been completed in collaboration with P.K. Joshi, Balraj Singh, Sukhjeet Singh and A.K. Jain. The peer review of this mass chain has been received, and a revised file is being finalized by Balraj Singh.

Mass Chains Being Evaluated

A=219: Evaluation Team: Balraj Singh, McMaster University (Principal Coordinator) and other evaluators involved in this mass chain are from IIT Roorkee, VECC Kolkata, SINP, Kolkata, SSSIHL and Bayres Institute Mangalore, M.M.U. Mullana, Barasat Government College, Kolkata, and Girls' College, Kolkata. This mass chain evaluation has been completed and a discussion meeting has been planned for June-2015.
A=226: Sukhjeet Singh, Ashok Kumar Jain, Balraj Singh; this mass chain is being evaluated, and will be completed in the next 4-6 months.
A=90: This mass chain has been completed and submitted by S.K. Basu; the referee's comments are being addressed.
A=98: This mass chain is being evaluated by S.K. Basu and Anagha Chakrabarti.

New Code: (RadD) (https://www-nds.iaea.org/public/ensdf_pgm/index.htm)

An interactive code to deduce the radius parameter of Odd-Odd and Odd-A nuclei has been written and submitted to the IAEA-NDS by Sukhjeet Singh.

Horizontal Evaluations

- "Atlas of Isomers" has been completed by A.K. Jain, Bhoomika, Swati, Monika Patial and Balraj Singh, and accepted for publication in *Nuclear Data Sheets*.
- Table of MR bands is currently being updated by Sukhjeet Singh, A.K. Jain and Balraj Singh.

Future Plans

- Update of Akovali table (1998Ak04) will be undertaken. This project will be completed by means of an IIT Roorkee, MM University Mullana and McMaster University collaboration.
- A proposal has been submitted to undertake total absorption spectroscopy measurements on neutron rich ^{43}K by means of the TAS setup at VECC (with BaF_2 detectors). Total absorption spectroscopic studies of other nuclei are also being planned.
- 2nd NSDD-India network workshop is being planned for November, 2015, at the Homi Bhabha Centre for Science Education (TIFR), Mumbai.
- Gopal Mukherjee and Kaushik Banerjee are involved in the IAEA-CRP on a reference database for beta delayed-neutron emissions.

Active Evaluators

- Prof. A.K. Jain, Bhoomika Maheshwari, Swati Garg, IIT Roorkee,
- Dr. Sukhjeet Singh and Sushil Kumar, M. M. University, Ambala,
- Dr. Paresh Joshi, HBCSE, TIFR, Mumbai,
- Dr. Gopal Mukherjee, VECC, Kolkata,
- Dr. S.K. Basu, VECC, Kolkata,
- Dr. Anagh Chakravarty, Visva Bharti University,
- SSSIHL Group, Prashanti Nilayam.

PROGRESS REPORT ON NUCLEAR STRUCTURE AND DECAY DATA ACTIVITIES AT MTA ATOMKI, J. Timár

Period covered: 2013-2014

The data centre at the Institute for Nuclear Research (MTA Atomki) consists of two evaluators: János Timár and Zoltán Elekes, who devote altogether 0.5 FTE to mass-chain evaluation work. We have been working on mass-chain evaluations since 2009. Our permanent responsibilities are the A = 101-105 mass chains. This evaluation work is funded mainly by the MTA Atomki, but we have also received partial financial support from IAEA-NDS through Research Contract No. 15902/R0.

Status of our permanent responsibilities

Mass	Last NDS	ENSDF update
101	1998	2006-10
102	2009	2009-08
103	2009	2009-10
104	2007	2007-09
105	2005	2005-11

Mass-chain evaluations and other activities in 2013-2014

In order to maintain the desired 10-year period between evaluations, we have been working on the A = 105 mass chain, which consists of 15 nuclides. We have already evaluated 13, and are still working on ^{105}Pd and ^{105}Cd, with the aim of finishing the whole mass chain in 2015. These evaluations are being undertaken together with Stefan Lalkovski from the University of Sofia. We have also started an evaluation of the A = 101 mass chain.

Out studies have extended to evaluations of the temporarily assigned 128, 129 and 46 mass chains. These evaluations started in the previous two-year period, and we have completed the evaluations for 128 and 129. The evaluated A = 129 mass chain was undertaken in conjunction with Balraj Singh, and was published in *NDS* in 2014. A = 128 has reached the stage of galley preparation, whereas we are still working on one nuclide of the A = 46 mass chain.

Besides the above evaluations, we have also reviewed one mass-chain evaluation.

Plans for the next period

Over the next two-year period, we plan to finish and publish the A = 46 and A = 105 mass chains, as well as complete the evaluation of the A = 101 mass chain and start work on the A = 104 mass chain. Furthermore, we are planning to host a one-day workshop for European NSDD evaluators in 2015.

KUWAIT DATA CENTRE STATUS REPORT, A. Fahran

The Kuwait Nuclear Data Project has responsibility for the evaluation and updating of mass chains A = 74-80. The status of these mass chains is as follows:

- A = 74 (2006) – McMaster University and Kuwait University
- A = 75 (1999) – 2013, IFIN-HH and McMaster University
- A = 76 (1995) – McMaster University and Kuwait University
- A = 77 (2012) – 2012, McMaster University and Texas A&M University
- A = 78 (2009) – Kuwait University and McMaster University
- A = 79 (2002) – McMaster University and Kuwait University
- A = 80 (2005) – McMaster University and Kuwait University

A major issue for the Kuwait Data Centre these past few years has been the lack of manpower, and serious doubts have emerged as to whether we will be able to continue contributing to the network under the present circumstances. The possibility of hiring a nuclear scientist to work partly on mass-chain evaluations will be investigated after the end of this meeting. Kuwait University's involvement in the NSDD network will depend on the results of this exploratory investigation.

Status Report of the Nuclear Structure and Decay Data evaluation activities at the Australian National University (ANU), 2013-2015, T. Kibédi

Mass chain evaluations. The ANU has primary responsibilities for A = 172-175. Over the previous two years the A = 174 mass chain has been evaluated. This work is in collaboration with J.K. Tuli and E. Browne, and is expected to be completed in 2015.

Horizontal evaluation: Configurations and hindered decays of K isomers in deformed nuclei with A > 100 (with F.K. Kondev (ANL) and G.D. Dracoulis (ANU)) has been published in *At. Data Nucl. Data Tables* **103-104** (2015) 50. Spectroscopic information on the decay properties of high-K isomers in deformed and transitional nuclei has been evaluated and collated. Assigned multi-quasiparticle configurations are included. Factors that control the transitions strengths, such as various contributions to K mixing, are outlined. The systematics of K-forbidden transitions for different multipolarities are discussed for selected cases in terms of the hindrances (F_W) and the reduced hindrance factor per degree of K forbiddenness (f_ν), where $\nu = |\Delta K - \lambda|$ and ΔK is the K-value difference between the initial and final state and λ is the transition multipole order. With the improved statistics for E1, M1 and E2 transitions, a factorization into the product of the underlying multipolarity-dependent transition strength and a ν-dependence due to K forbiddenness (f_0) is possible. This suggests a weaker dependence on K forbiddenness than is commonly assumed.

Atomic radiations in nuclear decay (with B.Q. Lee (ANU), A.E. Stuchbery (ANU), F.G. Kondev (ANL), and A.L. Nichols (University of Surrey))

- Completed nuclear structure evaluations for ^{103}Pd/^{103}Rh^{m} and ^{111}In/^{111}Cd^{m}, and on-going for ^{99}Mo/^{99}Tc^{m} and ^{131}Cs.
- Monte Carlo calculations of Auger electron and X-ray yields.
- Collaborations with
  - Theory: University of Malmo and University of Lisbon,
  - Experiments: Dubna, ILL, PSI.
- Participation in IAEA CRP on Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production (December 2014).
- Participation in CM on Auger-Electron Emission Data Needs for Medical Applications (May 2013).

Publications:

- Inoyatov *et al*., Influence of host matrices on krypton electron binding energies and KLL Auger transition energies, *J. Elect. Spect. Rel. Phenomena* **197** (2014) 64-71.
- Inoyatov *et al*., Search for environmental effects on the KLL Auger spectrum of rubidium generated in radioactive decay, *Phys. Scripta* **90** (2015) 025402.
- B.Q. Lee, T. Kibédi, A.E. Stuchbery, Auger yield calculations for medical radioisotopes, *EPJ Web of Conferences* **91** (2015) 01002.

BrIcc and other evaluation tool developments: The ANU has primary responsibility to maintain the BrIcc and BrIccMixing programs for the NSDD network. We are also responsible for maintaining the BrIcc web interface at http://bricc.anu.edu.au/. Furthermore, ANU also maintains the AveTools, RULER and GABS programs. Several new versions of these codes have been released in the reporting period. ANU is also participating in the IAEA Data Development Project on Improvement of Analysis Codes for NSDD Evaluations (1st TM 10-13 June 2014).

TECHNICAL PRESENTATIONS

COMPILATION OF THE "BAGHDAD ATLAS" (1978De41)
L. Bernstein (UCB/LLNL)

Recently, inelastic neutron scattering has been identified as being important to a number of applied nuclear science areas ranging from neutron transport and criticality safety to counter-proliferation and the design of advanced Generation-IV reactors [1-3]. In response to such requirements, the data group at LBNL and the University of California – Berkeley Department of Nuclear Engineering (UCB-NE) has initiated an effort to compile data from the "Atlas of Gamma-Ray Spectra from the Inelastic Scattering of Reactor Fast Neutrons" by Demidov *et al.* (1978De41). This "Baghdad Atlas" contains γ-ray yields for more than 7090 γ emissions from more than 105 elemental and isotopically-enriched targets measured largely at the IRT-5000 reactor of the Al-Tuwaitha Nuclear Research Facility outside Baghdad, Iraq. Since the areal density and target irradiation time were included in the atlas, the γ-ray yields can be converted to (n,n'γ) cross sections relative to the yield of the ^{56}Fe yrast $2 \rightarrow 0$. A search of the literature shows that only a small fraction of the data in the atlas was ever published in any other form, making this document a uniquely valuable nuclear data resource for the applied nuclear science community.

While the IRT-5000 reactor was destroyed in the first Gulf War of 1991, a printed copy of the atlas was in the possession of the IAEA, which forwarded the report to the nuclear data group at LBNL. The atlas was scanned in electronic format, and optical character recognition was used to convert the tabulated γ-ray yields into an Excel spreadsheet by staff at Lawrence Livermore National Laboratory. The LBNL group also took the lead in further converting the atlas into an SQL database that is now available for public dissemination. In addition, the data from the atlas is also being converted to ENSDF format, and will form the basis for a planned horizontal evaluation of (n,n'γ). Lastly, the UCB-NE group has started modelling the energy dependence of the neutron spectrum used for the measurements at Al-Tuwaitha in order to better quantify the spectrum over which the data were taken.

In addition to the importance of the data with respect to neutron transport and nuclear reactor design, the (n,n'γ) cross sections offer a powerful tool to aid in the evaluation of low-lying off-yrast nuclear structure. Inelastic neutron scattering at fast neutron energies ($1 \leq E_n$ (MeV) ≤ 10) is an extremely non-selective reaction channel that should in principle populate all low-lying transitions in limited angular momentum range regardless of the detailed configuration. This feature of (n,n'γ) was pointed out by Demidov in a later publication, and was used to call into question the existence of 130 transitions in 34 stable nuclei [4], most notably the first 3^- transition in ^{56}Fe whose non-existence was later confirmed by Fotiades *et al.* [5].

In addition to their compilation and evaluation efforts, the LBNL/UCB-NE nuclear data group is also performing select inelastic neutron scattering measurements using an intense thick target deuteron breakup neutron source at the LBNL 88-inch cyclotron which was recently used to measure the properties of a novel inorganic scintillator-based neutron detector [6].

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HIGH PRECISION DECAY DATA FOR MEDICAL ISOTOPES
E.A. McCutchan (NNDC-BNL)

Precise knowledge of the radiation emitted by medical isotopes is needed to determine the total dose received by the patient, the specific dose to targeted tissue, the cost of infrastructure in production facilities (i.e. shielding requirements) and the background in imaging technologies. A beta-decay level scheme is usually determined by measuring the gamma-ray transitions which are emitted from the daughter nucleus, then balancing the gamma-ray intensity at each excited level to determine the beta-decay feeding to each level. If the detection system is not sensitive to weak gamma rays, not only will the total gamma-ray radiation be underestimated, but also the deduced beta feedings will not be properly determined.

Many important medical isotopes were last studied decades ago with low-sensitivity detection systems. Given the increasing use and importance of radionuclides in medical procedures, we have begun a campaign to provide superior knowledge of the radiation emitted by key medical isotopes using state-of-the-art gamma-ray spectroscopy. Sources are produced at the Brookhaven Linear Isotope Producer (BLIP), and then shipped to Argonne National Laboratory where high-precision gamma-ray spectroscopy is performed with the 100 HPGe detector array of Gammasphere. Our first experiment was to study the ^{82}Sr/^{82}Rb system, a common PET isotope used for cardiac imaging procedures. In a subsequent study, we have measured the decay of ^{72}As, a non-conventional PET isotope used for imaging slow metabolic processes. We have also performed a number of cross-section measurements for protons on natural metallic foils (including Pt, Ni, and Zn). The high sensitivity and efficiency of Gammasphere allows us to perform simultaneous cross-section and decay data measurements, thus yielding rich datasets where improvements in the decay data of a number of medical isotopes can be made. Following analysis, the new decay data resulting from these studies will be incorporated into ENSDF.

TESTS OF INTERNAL-CONVERSION THEORY WITH PRECISE γ- AND X-RAY SPECTROSCOPY: THE CASE OF ^{111m}Cd

N. Nica (Texas A&M University)

Calculated Internal Conversion Coefficients (ICCs) make critical contributions to the majority of nuclear decay schemes. However, values of ICCs depend on the theoretical treatment of the electron vacancy used in their calculation, and the 2002 survey of experimental data by Raman *et al*. [1] demonstrated that the discrepancy between theories could not be resolved with the data available at that time which included only five ICCs measured to ±2% precision or better. At Texas A&M University, with our very precisely efficiency-calibrated HPGe detector [2], we were in a position to increase the number of high-precision ICC measurements. So far, we have more than doubled their number, with all our results supporting only those calculations that include the atomic vacancy [3]. We report a new measurement on the 150.8-keV E3 transition from the 48.5-min isomer in ^{111}Cd.

The total intensity of a nuclear electromagnetic transition is split between γ-ray emission and electron conversion, which can take place in several atomic shells and subshells, and is followed by the corresponding x-rays. If only *K*-shell conversion is considered, one can use the following formula to determine the *K*-shell conversion coefficient (α_K):

:
$$\alpha_K \omega_K = \frac{N_K}{N_\gamma} \cdot \frac{\varepsilon_\gamma}{\varepsilon_K} \qquad (1)$$

where ω_K is the fluorescence yield taken from Ref. [4]; N_K and N_γ are the respective peak areas of the *K* x-rays and the transition γ ray; and ε_K and ε_γ are the corresponding detector efficiencies.

Two samples were prepared by electro-deposition of 1 mg of 96%-enriched ^{110}Cd oxide on 10-μm pure Al backing, and activated by thermal neutrons at the Nuclear Science Centre TRIGA reactor of Texas A&M University to produce ^{111m}Cd. Our preliminary reported result of α_K(150.8 keV) = 1.454(20) agrees well with the theoretical calculation that includes the atomic electron vacancy (α_K = 1.450), and is more than one standard deviation away from the value calculated without the vacancy (α_K = 1.425). This observation conforms with all of our previous results [3]. The 150.8-keV transition is in cascade with an *E*2 245.4-keV transition, therefore as a byproduct we also obtained the total conversion coefficient of the former transition by measuring the intensity of the latter. Using the calculated total ICC value of the E2 transition, which is insensitive to the treatment of the vacancy, we obtained a preliminary result of α_{total}(150.8 keV) = 2.241(30), which can be compared with the calculated values of 2.28 with hole and 2.26 without hole. Both of our results disagree with less-precise previous measurements [5] of α_K(150.8 keV) = 1.29(11) and α_{total}(150.8 keV) = 1.98(5), which were significantly lower than both types of calculations.

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ENSDF-TRANSLATION EFFORTS AT LBNL

A.M. Hurst (Lawrence Berkeley National Laboratory)

A technical presentation covering four projects that I have developed at the Lawrence Berkeley National Laboratory (LBNL) was presented to the 21st Technical Meeting of the Nuclear Structure and Decay Data Network at the International Atomic Energy Agency in Vienna. All projects involve interpretation of the Evaluated Nuclear Structure Data File (ENSDF), and are briefly described below.

(1) A Python-coded translator to translate the ENSDF format to Reference Input Parameter Library (RIPL) format.
This capability was necessitated through our non-proliferation work supported by NA-22, where reaction calculations provide a useful test for our (n,γ) measurements (compiled in ENSDF format for the Evaluated Gamma-ray Activation File (EGAF)) and simulations. Our RIPL-translated files now include primary γ rays and a more extensive range of particle-decay modes. Representative input and output were demonstrated in the presentation.

(2) A Python-coded translator to translate the ENSDF format to an eXtensible Markup Language (XML) format.
Representative XML-translated output was presented. Advantages of migrating to this format were demonstrated, for example, by providing additional and useful explicit information, such as final energy levels for depopulating γ rays that is only implicit in the current format.

(3) PABS-I and PABS-II.
A new capability was presented to calculate renormalized particle-decay probabilities and their associated correlated uncertainties using direct (PABS-I) and indirect (PABS-II) methods. Both programs were developed in Python to read ENSDF files directly.

(4) A Structured Query Language (SQL) database format for the atlas of (n,n'γ) spectroscopic data from inelastic scattering of fast reactor neutrons (SQL format for the "Baghdad Atlas").
A proposed SQL schema was presented. The database comprises 3 relational tables and is populated with 105 complete data sets from 76 natural-sample and 29 enriched-sample measurements. Visualization of the data and methods for querying the database were illustrated.

^{105}Ru – EXPERIMENTS AND DATA EVALUATION
S. Lalkovski (University of Surrey/University of Sofia)

^{105}Ru is the lightest neutron-rich ruthenium isotope, placed between the heaviest stable ^{104}Ru and the neutron-rich Ru isotopes, produced mainly in fission reactions. Such nuclei are located at the edge of the line of beta stability, and therefore are scarcely studied because of the few methods available for population of their excited states and often those methods give access only to some of the excited states because of the specific selection rules.

In the past, ^{105}Ru was studied by means of ^{105}Tc beta-decay, neutron capture and (d,p) reactions. The most recent experimental study of this nucleus was almost two decades ago when the intruder band based on a long-lived isomer was observed from ^{173}Yb(^{24}Mg,Xg)-induced fission reactions. Data evaluations, performed recently at the University of Sofia, have triggered new experiments on the structure of ^{105}Ru which has led to re-evaluations of some of the “known” properties. Details of these studies were presented.

POSSIBLE CONTRIBUTION OF RIKEN TO THE NUCLEAR STRUCTURE DATABASE

H. Sakurai (RIKEN Nishina Center for Accelerator-Based Science)

The world premier heavy-ion accelerator facility "Radioactive Isotope Beam Factory (RIBF)" at RIKEN started operation in 2007, and significant amounts of nuclear structure data have subsequently been generated. More than 100 isotopes have been newly produced and identified, and half-lives for neutron-rich nuclei have been determined along the r-process path. Low-lying excited states have been observed via decay spectroscopy and in-beam gamma-ray spectroscopy to investigate shell evolution. Particle unbound nuclei and unbound states have been studies via invariant mass spectroscopy. Mass measurements are starting at a storage ring with a multi-reflection device. Electromagnetic moments are also being measured with polarized and aligned beams, as well as very slow beams coupled with laser spectroscopy.

Concerning the nuclear reaction database, Hokkaido University and RIKEN have established a collaborative MOU whereby charged-particle nuclear reaction data produced at RIKEN are compiled at Hokkaido University. Every spokesperson for each experimental programme must ensure that all their numerical reaction data are catalogued and published.

ENSDF activities in Japan are organized on the basis of a collaborative framework of researchers in several institutes and universities, with JAEA as coordinator. Up to 2000, a few researchers at RIKEN worked on ENSDF as well as XUNDL and NSR. However, because of individual retirements, there are currently no official nuclear structure database activities underway at RIKEN. Nevertheless, nuclear structure studies at RIKEN have largely benefited from the availability of ENSDF, XUNDL and NSR. Thus, RIKEN would like to agree, evolve and develop a future role in these nuclear structure database activities. As a first step, some permanent staff members would assign 10-20% of their effort towards the compilation of RIKEN data for XUNDL (and NSR). A medium- and long-term plan for RIKEN would need to involve discussions in terms of ENSDF collaboration in Japan, and possible ENSDF activities at RIKEN should be one major possibility in terms of an organized and collaborative plan of action.

RIKEN would welcome international recognition and endorsement for their proposed involvement in nuclear structure database studies, as outlined above.

NUCLEAR DATA ACTIVITIES AT TANDAR LABORATORY, ARGENTINA
D.H. Abriola (Tandar Laboratory)

The TANDAR Laboratory is part of the CNEA (Atomic Energy Commission of Argentina). Located just outside of the northern border of the city of Buenos Aires, the Tandar Laboratory constitutes a union of the Accelerator, Experimental and Theoretical Physics Departments. I am part of the Experimental Physics department, which has 15 staff members and a variable number of post-docs (currently two) and students (about 15). My involvement in nuclear data evaluation activities is of the order of 0.1 FTE.

A recent collaborative effort was the collective evaluation of A = 215 published in December 2013 [1], and the horizontal evaluation of beta-delayed neutron emissions [2, 3, 4]. Work in progress: mass-chain A = 144, evaluation of beta delayed-neutron emissions for Z > 28 and the study of their systematics.

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NUCLEAR DATA ACTIVITIES AT KAERI
C.S. Gil and J.H. Lee (KAERI)

Understanding nuclear structure/decay data and fission product yield data in terms of how to evaluate the data, what are the data uncertainties, etc. is needed from the viewpoint of nuclear safety across the whole of the nuclear industry. Several experimental facilities in Korea have been used to undertake nuclear data measurements, and were briefly described. Nuclear data will continue to be measured by means of various Korean facilities, especially after completion of the RAON accelerator, and KAERI will continue to support ENSDF evaluation work.

A project dedicated to both nuclear structure/decay data and fission yield evaluations began at KAERI in 2012. More specifically, evaluations of nuclear structure and decay data for ENSDF have been performed at KAERI with the help and guidance of NNDC-BNL staff. ^{211}Po and ^{215}Po data were evaluated by JY Lee at IBS (Institute for Basic Science), who initiated and undertook the first structure and decay data evaluation in Korea. During a two-week stay at BNL, JH Lee (KAERI) evaluated several isotopes within A = 72 and 144, under the welcome mentorship of A.A. Sonzogni.

JH Lee presented his evaluations of ^{72}Mn, ^{72}Fe, ^{72}Ni, ^{72}Co, ^{72}Ge, ^{144}Cs, ^{144}Xe and ^{144}Ba in detail. Efforts are also being made to introduce ENSDF to the Korean nuclear physics community which is unfamiliar with and has rarely used the database. ENSDF and the various analysis programs have been presented at national conferences and workshops. Furthermore, nuclear reactions and decay processes are being studied with simulation programs that contain nuclear structure data. As ENSDF is updated, our nuclear data library should also be changed appropriately as well. Comparing simulation results with experiments or related evaluated values, we are able to check whether our simulation programs exploit our adoption of nuclear data in the correct manner.

Links to Presentations

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Data Centre Reports			
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2	M. Herman	NNDC/USNDP Report	PDF
3	C. Nesaraja	ORNL Report	PDF
4	S. Basunia	LBNL Report	PPT
5	J. Kelley	TUNL Report	PPT
6	F. Kondev	ANL Report	PDF
7	B. Singh	McMaster Univ. Report	PPT
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58	R. Firestone	Budgets, Manpower, Mentoring	PPT

Group Photo

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