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INDC International Nuclear Data Committee

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

Summary Report of an IAEA Technical Meeting

St. Petersburg, Russian Federation

11 – 15 June 2007

Prepared by

A.L. Nichols and J.K. Tuli

September 2007

IAEA Nuclear Data Section, Wagramer Strasse 5, A-1400 Vienna, Austria

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Abstract

The IAEA Nuclear Data Section convened the 17th meeting of the International Network of Nuclear Structure and Decay Data Evaluators in St. Petersburg, Russian Federation, 11-15 June 2007. This meeting was attended by 27 scientists from 13 Member States concerned with the compilation, evaluation and dissemination of nuclear structure and decay data. A summary of the meeting, recommendations/conclusions, data centre reports, and various proposals considered, modified and agreed by the participants are contained within this document.

September 2007

ABBREVIATIONS

ALPHAD	ENSDF analysis program.
AME	Atomic Mass Evaluations.
ANL	Argonne National Laboratory, USA.
ANL NDP	ANL Nuclear Data Program.
ANSI	American National Standards Institute.
ANU	Australian National University, Canberra, Australia.
APS	American Physical Society.
ASCII	American Standard Code for Information Interchange.
BARC	Bhabha Atomic Research Centre.
BrICC	ENSDF analysis program.
BELW	Reduced electric transition probability in Weisskopf units (ENSDF).
BIPM	Bureau International des poids et Mesures (International Bureau of Weights and Measures).
BMLW	Reduced magnetic transition probability in Weisskopf units (ENSDF).
CEA	Commissariat à l'Energie Atomique (French Atomic Energy Commission).
CERN	Conseil Européen pour la Recherche Nucléaire (European Organization for Nuclear Research).
CD-ROM	Compact disk with read-only memory.
ComTrans	Nuclear structure evaluating tool for translating comments in ENSDF.
CNEA	Comisión Nacional de Energia Atómica (Argentina).
CNDC	China Nuclear Data Center, Institute of Atomic Energy (CIAE) Beijing.
CRP	Coordinated Research Project.
CSNSM	Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse.
DDEP	Decay Data Evaluation Project.
DNP	Division of Nuclear Physics (of APS).
DSAM	Döppler-Shift Attenuation Method.
DSIS	Distributed Statistical Information Service.
ENDF	Evaluated Nuclear Data File.
ENSDAT	Evaluated Nuclear Structure Drawings and Tables.
ENSDF	Evaluated Nuclear Structure Data File.
ERANET	European Research Area Network.
EU	European Union.
EUROATOM	European Atomic Energy Community.
EXFOR	Computer-based system for the compilation and international exchange of experimental nuclear reaction data.
FMTCHK	ENSDF format and syntax checking code.
FP	Overall Framework Programme within European Union funding procedure.
FSU	Florida State University.
FTE	Full Time Effort/Employment.
GABSPC	Computer code to calculate decay mode branching ratio, absolute γ-ray intensities, and the normalization factor (to convert relative to absolute intensities per 100 decays of the parent nuclide).
GAMUT	Computer code for gamma-ray energy and intensity analyses of data from ENSDF.
GSI	Gesellschaft für Schwerionenforschung mbH.
GTOL	ENSDF analysis program.

HSICC	ENSDF analysis program.
IAEA	International Atomic Energy Agency.
ICC	Internal Conversion Coefficients.
ICTP	International Centre for Theoretical Physics, Trieste, Italy.
IIT	Indian Institute of Technology.
INDC	International Nuclear Data Committee.
INL	Idaho National Laboratory, USA.
INR (Kiev)	Institute for Nuclear Research (Kiev).
IP	Isotopes Project at LBNL.
JAEA	Japan Atomic Energy Agency.
JAERI	Japan Atomic Energy Research Institute, Japan.
Janis	Java-based nuclear information software.
JENDL	Japanese Evaluated Nuclear Data Library.
JRA	Joint research activities.
LBNL	Lawrence Berkeley National Laboratory, USA.
LBNL LDRD	LBNL Laboratory Directed Research and Development Program.
LNHB	Laboratoire National Henri Becquerel.
LLNL	Lawrence Livermore National Laboratory.
LOGFT	ENSDF analysis program.
MIRD	Medical Internal Radiation Does (format from ENSDF).
MOME2T	Representation of Q_t values as measured by DSAM technique.
NA	Network activities.
NDP	Nuclear Data Project, Oak Ridge National Laboratory, USA.
NDS	Nuclear Data Sheets; journal devoted to ENSDF data.
NDS/IAEA	Nuclear Data Section, IAEA.
NIPNE (Bucharest)	National Institute of Physics and Nuclear Engineering (Bucharest).
NNDC/BNL	National Nuclear Data Center, Brookhaven National Laboratory, USA.
NSC	Nuclear Science Center (New Delhi).
NSDD	Nuclear Structure and Decay Data network.
NSDFLIB	Nuclear Structure Data File Library.
NSR	Nuclear Science References – bibliographic file.
NUBASE	Database of nuclear structure and decay data.
NUCWin	Windows code run in conjunction with nuclear databases (NUBASE) to draw chart of nuclides and display other information.
NuDAT	Interactive nuclear structure and decay database (predominantly from ENSDF).
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.
PrePro	PreProcessing code.
RADLIST	ENSDF analysis program.
RADWARE	Software package for interactive graphical analysis of gamma-ray coincidence data (developed at ORNL).
RDM	Recoil Distance Method.
RHIC	Relativistic Heavy Ion Collider.
RI-I3	European Union contracts nomenclature/system.
RIPL	Reference Input Parameter Library.

RotB	Rotational band code.
RUL	Recommended Upper Limit.
RULER	ENSDF analysis program.
TA	Translational access.
TAGS	Total Absorption Gamma-ray Spectroscopy.
TUNL	Triangle Universities Nuclear Laboratory, USA.
UNESCO	United Nations Educational, Scientific and Cultural Organization.
USDoE	US Department of Energy.
USNDP	US Nuclear Data Program.
VMI	Variable moments of inertia.
VMS	Virtual memory operating system.
WIDTHG	ENSDF code to calculate partial gamma width ($\Gamma\gamma$).
WPEC	NEA Working Party on International Evaluation Cooperation
XREF	Cross-reference symbol assignment(s) for experimental data sets (ENSDF).
XPQCHK	Checking code to determine the consistency of ENSDF ground and metastable levels and Q-values.
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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ANNEXES

Foreword

The International Network of Nuclear Structure and Decay Data (NSDD) Evaluators holds biennial meetings under the auspices of the IAEA, and consists of evaluation groups and data service centres in several countries. This network has the objective of providing up-to-date nuclear structure and decay data for all known nuclides by evaluating all existing experimental data. Data resulting from this international evaluation collaboration is 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 such media as the World Wide Web, CD-ROM, wall charts of the nuclides, nuclear wallet cards and others.

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 Center at the 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) coordinate the work of all centres and groups participating in the compilation, evaluation and dissemination of NSDD;
(b) maintain and improve the standards and rules governing NSDD evaluations;
(c) review the development and common use of the computerized systems and databases maintained specifically for this activity.

This work is undertaken over a 5-day period, and this document represents a summary of the network meeting held in St. Petersburg, Russian Federation, 11-15 June 2007. Twenty-seven nuclear data specialists attended this meeting to discuss work and problems of common interest, specifically with respect to the active membership of the mass chain evaluation team for ENSDF.

The first two days were dedicated to a combination of technical reviews and discussion papers, addressing particular topics in which progress has been made and problems have been experienced over the previous two years. Specific mass chain activities and administrative issues were debated over the final three days. Problems are being experienced in maintaining suitable numbers of mass chain evaluators (expressed as FTE – Full Time Effort), and these difficulties were extensively discussed during the course of the meeting (particularly with respect to European impacts). The list of participants is given in Annex 1, and the adopted agenda for the meeting is listed 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

1. Summary

The 17th meeting of the International Network of Nuclear Structure and Decay Data (NSDD) Evaluators was held in St. Petersburg, Russian Federation from 11 to 15 June 2007. This biennial meeting was hosted by the Petersburg Nuclear Physics Institute (PNPI), and their staff members made significant contributions towards the preparations. Twenty-seven participants from thirteen countries attended the meeting, representing the majority of data evaluation centres, new evaluation groups and data dissemination centres (Annex 1).

Drs. I. Mitropolsky (PNPI) and A.L. Nichols (IAEA) welcomed all delegates to the meeting. The Agenda was approved as listed in Annex 2. J.K. Tuli and A.L. Nichols were elected to co-chair the meeting at appropriate times. A list of all ENSDF evaluation centres and groups is given in Annex 3, along with their mass-chain evaluation responsibilities as assigned for 2005-2007, and all specific and continuous actions can be found in Annex 4.

Discussions over the first two days focused on specific technical issues either requiring resolution or for information; short summaries of the various presentations are given in Section 2. Work undertaken by the ENSDF evaluation and dissemination centres over the previous two years (Annex 5) was also considered, along with their planned activities for the forthcoming two years. Status reports on other activities were also presented (see Annex 6).

Participants discussed a wide range of technical matters, including recommendations to improve the quality of NSDD evaluations. A list of actions was also prepared for implementation during the course of the next two years (see Annex 4). NSDD members also prepared recommendations for implementation by the IAEA and the major evaluation centres, which are aimed at improving financial and technical support towards the network. These recommendations include: the development of stronger links and understanding between key financial organizations and research facilities; planning of IAEA and ICTP workshops designed to train new NSDD evaluators; support by the major NSDD centres of the evaluation work undertaken by new groups through mentoring; and maintenance of the list of horizontal evaluations required by users or covered by on-going activities.

The next Technical Meeting of the International Network of Nuclear Structure and Decay Data Evaluators will be held in April or May 2009, at IAEA Headquarters in Vienna, Austria.

2. Technical Discussions (Monday-Tuesday)

Extensive technical discussions took place the first two days of the meeting, as chaired by J.K. Tuli (NNDC, BNL, USA).

2.1. Cluster emissions in ENSDF (A. Sonzogni (NNDC, BNL))

Sonzogni proposed the assembly and full introduction of cluster emission decay data into ENSDF. This form of decay was first observed and reported in 1984 (Rose and Jones, *Nature* **307** (1984) 245), and possesses similar decay parameters to those of alpha radioactivity from the point of view of definition. Sonzogni proposed to account fully in ENSDF for cluster emissions, which are mainly observed for nuclei heavier than Ra that decay to Pb isotopes. He suggested the introduction of “K records” (standing for “cluster decay”, and avoiding confusion with the existing “C records”) to be located before and after the appropriate level entry. Horizontal evaluations would be carried out, checking for and eliminating possible conflicts in the format for such data. Any necessary changes would also be made to the relevant ENSDF codes and manuals before the next network meeting

ACTION: Sonzogni (NNDC/BNL) to assemble and distribute statistics to the Network that support the proposal for the modification of ENSDF format to include cluster emission data.

2.2. Nuclear Wallet Cards and ENSDF compatibility (A. Sonzogni (NNDC, BNL))

Major updates to the Nuclear Wallet Cards (NWC) occur every five years, with minor updates annually; while ENSDF updates are more variable – defined as “continuously”, but more regularly every six to ten years. Thus, there is a lack of synchronization between NWC and ENSDF with respect to half-life, J^{π}, isomer energy and specified decay modes (primary decay data to be found in NWC). Sonzogni proposed that the compatibility between NWC and ENSDF be assessed at regular interval throughout the year from the point of view of these parameters. If NWC data are more up to date than ENSF:

(i) communicate findings to evaluator/responsible data centre;
(ii) when no LOGFT/ALPHAD/RULER calculations are involved, NNDC staff will update with the consent of the responsible data centre;
(iii) more complex cases will require the more direct involvement of the original evaluator/responsible data centre.

Sonzogni provided examples of existing difficulties arising from changes in NWC that have yet to be reflected in ENSDF (e.g. existence of ^{147}Xe, and incomplete data for ^{146}Xe). After significant discussion of such problems and emerging inconsistencies, the following two actions were agreed:

ACTION: Sonzogni (NNDC/BNL) to provide the responsible NSDD evaluation centres with a list of radionuclides (and details) for which either half-life, J^{π} and/or decay modes differ between NWC and ENSDF.

ACTION: All network participants to consider any differences noted in the nuclear properties to be found in NWC and ENSDF, and adjust ENSDF files if deemed appropriate (after due consideration of evaluation effort to achieve the necessary changes).

2.3. Modernization of ENSDF (B. Singh (McMaster University) and J.K. Tuli (NNDC, BNL))

Tuli introduced changes that are being proposed for the layout of the decay scheme drawings and tables to be found in *Nuclear Data Sheets*. Zywina (ex-McMaster University) had written Java-based software that generated new layouts and colouring schemes under guidance from and discussions with Singh – his previous familiarity with ENSDF have proved particularly useful in this work. Multi-coloured decay schemes would only be a feature of the ENSDF Web pages (and not *Nuclear Data Sheets*). Extensive examples of the decay scheme layouts were presented and described by Singh. This work was still on-going, with estimated completion dates as follows:

full band drawings, July 2007;
general level schemes, August 2007;
compact drawings and tabulations, September 2007.

During subsequent discussions, Tuli noted that all new style drawings would not adhere to the same energy scale, but would vary from page to page (unlike current publication).

More detailed discussions took place with the principal mass chain evaluators in a separate side meeting at which the various improvements were approved, along with the proposed timetable. Further sample drawings/tables will be sent to network participants on completion of each stage of the agreed process.

ACTION: All network participants to provide Tuli/Singh with comments on the proposed improvements in level-scheme drawings and tables for *Nuclear Data Sheets* within 2 weeks of receipt of sample pages by e-mail.

2.4. Revision of rules #37, 38, 39 - proposed guidelines for configurations/labels of band assignments (B. Singh (McMaster University) and F.G. Kondev (ANL)) – see also Annex 6

Various people had become closely involved in this NSDD action (#34) of June 2005 – Baglin (LBNL), Burrows, Reich and Tuli (NNDC/BNL), along with Janssens (ANL), Riley (FSU) and Hartley (US Naval Academy). The primary aims were to define the proper quantity and symbol to represent the transition quadrupole moment for rotational bands, and propose an additional J^{π} rule for rotational and coupled bands. Singh described the new recommendations in detail.

2.4.1. Rule #37

For a deformed nucleus, a regular sequence of gamma-ray transitions can be assigned to $\Delta J=2$ or $\Delta J=1$ rotational-band structure with definite spin-parity assignments if:

a) the spin and parity of at least one level in this band is unambiguously determined;
b) for $\Delta J=2$ band structures, at least one of the in-band transitions has a well-established E2 multipolarity, *or*,

for $\Delta J=1$ band structures,

(i) at least one of the crossover ($\Delta J=2$) transitions has a well-established E2 multipolarity, *or,*
(ii) at least one of the stopover ($\Delta J=1$) transitions has a well-established M1 (or M1+E2) multipolarity or (for parity-doublet bands) E1 multipolarity; *and*

c) some other in-band transitions are stretched quadrupole for the $\Delta J=2$ band structures or stretched dipole (or dipole plus quadrupole) for $\Delta J=1$ band structures.

2.4.2. Rule #38

To be omitted - contained in Rule #37.

2.4.3. Rule #39

In the absence of angular distribution/correlation data or other supporting arguments, a regular sequence of gamma-ray transitions in high-spin data may be assigned to a common structure or a band with tentative spin-parity assignments if either the band head or some other low-lying member of this structure has reasonably well established spin and parity.
Move this rule to the section for "weak arguments" as rule #12.

2.4.4. Labelling of bands, configurations and cascades in ENSDF/NDS

The aim of this initiative was to promote uniformity and presentation in the labelling of bands and cascades. Various guidelines were proposed:

a) all level sequences or cascades of gamma rays which share some common mode of excitation should carry flags to mark them as bands or gamma-ray cascades;
b) first band/sequence-ID record – this information appears on the band drawing and space is limited, so wording should be kept as concise as possible; band/sequence ID should contain no more than ~ 25 characters – be very brief;
c) use the translated version (alternative character set) for configurations when they are listed on the first (band-ID) record (examples were provided);
d) all detailed statements, arguments, comments, 3- or greater quasiparticle configurations and source references concerning the band/sequence should be regulated to the records following the first band ID record (will appear in full in the tables, but will be omitted from the drawings);
e) when using the cranked-shell model notation for rotational bands, identify labels A, B, F, a, etc. by their respective orbitals;
f) labels were specified for cascades or sequences that could not be identified with any configuration or band structure;
g) band labels and configurations should be given in both the "adopted" dataset and individual reaction or decay data sets.

ACTION: All network participants to consider the proposals of Singh/Kondev for the labelling of bands, configurations and cascades – follow these established rules, and provide comments/criticisms.

2.5. Transition quadrupole moments (F.G. Kondev (ANL) and B. Singh (McMaster University)) – see also Annex 6

Kondev summarized the information required to define a transition quadrupole moment: level scheme, E_γ, P_γ and $t_{½}$. Lifetimes of excited nuclear levels less than 1 ns are generally measured by means of the Recoil-Distance Method (RDM) or the Döppler-Shift Attenuation Method (DSAM). The DSAM technique is most frequently applied when the lifetimes are less than ~ 1 ps, whereby the slowing-down time of a recoiling nucleus in the stopping medium is of the order of a few ps, and acts as a clock. Two different methods are used to analyse the DSAM data ("line shape" and "centroid shift"); and side feeding is treated as a rotational cascade with the same moment of inertia as the main band.

The transition quadrupole moment (Q_t) as deduced from the DSAM technique is dependent on the model used to represent the stopping powers of the recoiling nuclei, the model adopted for the side-feeding time distribution, and the validity of the rotational model at high angular momentum. Under these circumstances, Kondev and Singh argued that Q_t values determined by means of DSAM should be distinguished from directly measured spectroscopic quadrupole moments (Q). A new symbol should be introduced to represent Q_t values measured by means of the DSAM technique, i.e. MOME2T in units of barns:

- when MOME2T values are reported for individual levels, they should be given in a continuation record that follows the corresponding level record;
- if a single MOME2T value is assigned to the whole band, this value should be given in the comment records for the band ID label;
- consideration should also be given to the inclusion of additional information on the model and/or assumptions made concerning the stopping powers and the side-feeding patterns;
- would be useful to assign NSR key numbers to references that consider any of the various stopping power models.

Balabanski felt that such recommendations needed to be approached with some caution, although he noted that they were only associated with the Comments record and do acknowledge that Q_t is a derived quantity.

2.6. ENSDF Editor (A. Sonzogni (NNDC, BNL))

Sonzogni has developed a user-friendly Editor program for ENSDF, which he demonstrated to the meeting participants. A manual has also been prepared for use with this new software. This work was warmly welcomed as aiding considerably in the assembly of ENSDF data files. After some further debate the following actions were agreed.

ACTION: Sonzogni (NNDC/BNL) to provide the NSDD network with Java and Linux versions of ENSDF Editor by the end of 2008.

ACTION: All network participants to use the ENSDF Editor, and send their comments to Sonzogni.

2.7. Precise internal conversion coefficient measurements as tests of internal conversion theory (N. Nica (Texas A&M))

Nica reminded the meeting of the importance of internal conversion coefficients (ICCs) in the accurate analysis and development of consistent decay schemes. Various theoretical approaches had been adopted over the years to calculate and generate comprehensive sets of such data. The adoption of "hole" and "non-hole" models had been proposed in recent years based on the work of Band and Raman. Furthermore, extremely precise experimental techniques had been developed to explore and test the various alternative models.

An on-going experimental programme at Texas A&M involves highly accurate determinations of ICCs based on an exceptionally well-defined detector efficiency calibration (coaxial 28 cm^3 n-type Ge detector over an energy of 50 keV to 1.4 MeV), coupled with Monte-Carlo calculations. The measurements at Texas A&M have included the following: α_K for 80.236-keV M4 transition of $^{193}Ir^m$; $\alpha_K(^{193}Ir^m)/\alpha_K(^{191}Ir)$ ratio involving the 129.415-keV (M1 + E2) gamma transition of ^{191}Ir; $\alpha_K(^{134}Cs^m)/\alpha_K(^{137}Ba)$ ratio for the 127.502-keV E3 gamma transition of $^{134}Cs^m$ and the 661.657-keV M4 gamma transition of ^{137}Ba; and the 165.8575-keV M1 gamma transition of ^{139}La. All of these studies support the model defined as "with hole – frozen orbital". Further measurements are envisaged to add additional support to these findings.

2.8. Errors in ENSDF (G.I. Shulyak (PNPI))

Various errors and misprints have been detected in an automatic and systematic search of the existing ENSDF files. There are believed to be two sources of such problems:

- evaluators have not used the FMTCHK code to check the contents of their files for errors and inconsistencies;
- computer errors (e.g., non-ASCII symbols in the files).

ACTION: Shulyak (PNPI) to send the list of errors found in ENSDF to Tuli by the end of July 2007.

2.9. ENSDF evaluator's toolbox (G.I. Shulyak (PNPI))

Software has been developed by Shulyak to assist in the simplification of the evaluation processes for the formulation and preparation of ENSDF files. A working table is used by the evaluator to develop the desired nuclear structure database. Various operations can be implemented, including the following:

a). creation and editing of the data in ENSDF format;
b). introduction of data checking procedures;
c). selection of data under study (e.g., save to the main file);
d). selection and implementation of standard BNL programs for ENSDF analyses;
e). save all output data in ENSDF format.

Various other features were described, including "checking on the fly", creation of level schemes, and clarifying colour features.

ACTION: Shulyak (PNPI) to provide NNDC, BNL (Tuli) with a copy of the PNPI Editor program.

2.10. BrICC (T. Kibédi (ANU))

Kibédi reviewed the work undertaken within the NSDD network to develop a rapid means of deriving ICCs with confidence (undertaken in conjunction with PNPI and ORNL). The BrICC v2.0b program could be used to calculate Band-Raman internal conversion coefficients, electron-positron pair conversion coefficients, E0 electronic factors, and as an ENSDF tool to calculate ICCs for pure and mixed multipolarities. Kibédi noted that "the frozen orbital" approximation had been adopted by the NSDD network in 2005, a suitable Web interface had been formulated at ANU in February 2007, and the agreed methodology had been adopted for DDEP evaluations in April 2007. Future plans include extending the Z range to 110 (from $Z \leq 95$), update atomic electron binding energies and calculate average energies of L, M, ….. conversion electrons, develop a means of deriving mixing ratios from conversion electron data, and other issues.

Subsequent discussion centered on "how good are the internal conversion coefficients now?" and what relevant work has been undertaken to address this debate (see also Section 2.9). Approximately 185 experimentally-determined ICCs are known to be better than 5% (cut-off March 2007), and the "frozen orbital" approach was favoured by all K, all M4 and high precision ICCs ($\leq 1.5\%$), although there may be discrepancies between predicted and measured K/L ratios. Kibédi noted that he will be continuing his ICC studies, including detailed assessments of correlation effects in conjunction with Vanin (Universidade de São Paulo).

2.11. K-isomers (F. Kondev (ANL))

The evaluation and analysis of K-isomers in deformed nuclei offers the opportunity to probe nuclear structures at extreme conditions (limits of conservation of the K-quantum number) by means of radioactive beams and targets for applications that embrace astrophysics, activation analyses, nuclear medicine, detector calibration and nuclear energy. Kondev and Kibédi will evaluate the properties of all K-isomers in deformed nuclei, including such parameters as E_x, K, J^π, $t_{½}$, BR, ICCs, $B(X_L)$ and f_v. ENSDF does not explicitly include the K-quantum number:

$$f_v = (F)^{1/v}$$

where F is the hindrance factor, and v is the degree of forbiddenness. Consider M1 and E2 gamma transitions:

K-hindered decay is defined as $20 < f_v < 100$,
$f_v < 10$ implies anomalous decay, and
$f_v > 100$ suggests that something is wrong.

Specialised assessment codes have been developed, and the overall evaluation procedures have been agreed. Proposals for the resulting database include predictions of energies, J^π and half-lives. The evaluation process will be undertaken over a two-year period, and the database will be made available to all NSDD centres. ENSDF will be also updated, and the possibility of including other classes of isomer will be considered.

2.12. Enhanced reduced magnetic dipole transition probabilities (B. Singh (McMaster University)) – see also Annex 6

Enhanced reduced magnetic dipole transition probabilities (BM1(W.u.) > 0.4) in ENSDF (March 2007) have been reviewed following a query from the University of Notre Dame, USA. Values of RULs (RUL = Recommended Upper Limit) are used in ENSDF for spin-parity assignments and other parameters. ENSDF was scanned for BM1(W.u.) in different mass regions as classified by Endt - nuclide, level energy, gamma-ray energy, spin-parity, half-life and BM1(W.u.) value were tabulated for specific mass regions.

Singh noted that Endt published six articles from 1974 to 1993 on the compilation and evaluation of BELW and BMLW values in different mass regions, and these particular categories were re-assessed in the new survey for M1 transitions:

(1)A = 6-20: Endt suggested RUL of 10, which is the same as in ENSDF. The highest value found in the new ENSDF study was 10.9(21), which occurs for the 1041-keV ground state transition in ^{18}F n- total of 340 BM1(W.u.) values in this region. **Perhaps the RUL should be changed from 10 to 12.**

(2)A = 21-44: Endt suggested RUL of 5 for this region, while ENSDF groups this region with the 6-20 region and gives them both an RUL of 10. Highest value of Endt was 4.3(5) in ^{40}Ca - however, this value is incorrect due to the use of a wrong branching ratio (correct value is 3.6(5)). There are a total of 753 values in this region. **RUL of 5 seems reasonable in this mass region (as before).**

(3)A = 45-90: Endt and ENSDF agree on RUL of 3. Highest value of Endt is 2.5(4) in ^{56}Fe, although this value is in error because of the use of an incorrect branching ratio (correct value is 0.6). The new search of ENSDF found the highest value to be 2.3(6) for the 54.5-keV ground state transition in ^{54}Mn. There are a total of 1245 BM1(W.u.) values in this region. **RUL of 3 is still appropriate (as before).**

(4)A = 91-150: Endt recommended RUL of 1, based on a value of 0.50(8) for the 30-keV ground state transition in ^{140}La. Of a total of 902 values to be found in ENSDF, seven were greater than 3. **RUL should be changed to 7 (instead of 1 recommended by Endt and 3 in ENSDF).**

(5)A > 150: There is no published compilation of BM1(W.u.) values in this region, and ENSDF RUL of 2 is based on a scan of the data by Martin (ORNL) in 1982. The latest scan of ENSDF found 921 values, with 20 greater than RUL of 2. Most of the transitions above RUL are in the region of $^{193\text{-}199}$Pb and are mainly due to magnetic-dipole rotational bands. **RUL should be changed to 8 (instead of the value of 2 recommended for ENSDF).**

Singh also reported that during the recent review of ENSDF, several values were found that were unrealistically high due to the misuse of the RULER code. When the full width Γ is given in a data set, RULER does not take particle branching into account when calculating the BM1(W.u.) values. The worst example was found to be 26.46 in ^{32}S - RULER will be updated and corrected by Burrows (NNDC, BNL) for release in August 2007 (see also Section 2.14).

ACTION: Singh (McMaster University) to continue his analysis of BM1W, and provide comprehensive recommendations to modify the Endt rules by the end of 2007.

2.13. Reminders of evaluation policies (J.K. Tuli (NNDC, BNL))

Tuli reminded participants of various facets of the agreed evaluation procedures that needed to be addressed by the reviewers in recent submissions:

a) Q-record is required, even if nothing is known (adopt value from AME);
b) XREF should be quoted even if only one data set with gammas;
c) BAND investigation should appear on the first record (needed for the drawings) – any further descriptions, qualifications, or explanation can continue on subsequent records;
d) levels – decay modes and moments of ground states and isomers must be provided on the Continuation records, if known - any comments on $t_{½}$ should give the DSID if measured, and not just the key number;
e) moments – check with Stone’s compilation;
f) an isomer is a level with $t_{½} \geq 0.1$ s (or if there is an IT data set);
g) data extraction – quote authors’ measured quantities, document and deviations, note authors’ assumptions, and check for missed references and quoted older values.

A wide range of other issues, needs and the inclusion of unnecessary entries were discussed, including the ordering of comments, avoidance of stating “from ENSDF”, ordering of gammas by increasing energy, and the adoption of an uncertainty limit of no more that 25 – this secondary list of reminders was extensive and covered presentation, systematics and style.

Special consideration was given to the adoption of absolute and relative gamma-ray intensities in ENSDF. The deduction of absolute intensities and their uncertainties from relative intensities by means of the decay scheme is not a trivial task. The GABSPC code has been modified to address this particular difficulty in a correct and systematic manner (Browne and Tuli).

Tuli also mentioned the continued need for reviewers of draft ENSDF data files. The mass chain evaluator should use PrePro, FMTCHK, XPQCHK and PANDORA at various stages in his/her evaluation prior to submission to the primary review process, and also take serious note of the reviewer’s comments.

2.14. RULER code (J.K. Tuli (NNDC, BNL))

Burrows (NNDC) will upgrade the RULER code because this program sometimes erroneously skips important calculations (see Section 2.12). Issues associated with WIDTHG were discussed in detail:

- WIDTHG given in the Gamma record is adopted in calculations, else WIDTHG given in Level record;
- if not given in any record, one of three options will be pursued –
  (i) treat gamma branch as 100%, and create a new Gamma continuation record (with output warning) prior to calculation;
  (ii) as above, but do not create new Gamma continuation record (PREFERRED);
  (iii) do not undertake any calculations, and register this fact.

The preferred procedure was agreed by the network participants.

2.15. Distribution of digits in errors of physical measurements (S.L. Sakharov (PNPI))

Analyses have been made of sets of distributions of experimental errors for level energies, half-lives and magnetic moments. The distributions of the first significant digits of the errors for each analysed data set were non-uniform (maxima at digit 3), and were found to follow the Newcomb-Benford law. Significant deviations of the distributions of errors from this law permit one to determine whether a given set of errors is correct. Thus, "non-statistical" regularities can be identified, and these data can be related to the systematic uncertainties when estimating uncertainties in the relevant nuclear parameter.

2.16. 3.5-eV state of ^{229}Th (S.L. Sakharov (PNPI))

Consideration has been taken of all relevant nuclear levels believed to populate the ground and low-energy states of ^{229}Th. The close level spacing between the two band heads raises difficulties in determining the correct intensities of the gamma transitions between these lower states. Studies by Helmer and Reich (1994), Barci *et al*. (2003), Guimaraes-Filho and Helene (2005), and Beck *et al*. (2007) have been assessed:

a) energy of the 3.5-eV nuclear level lies somewhere within the energy range from 0 to 15 eV (and may not even exist);
b) all efforts to measure the energy of the 3.5 eV transition are judged to have failed;
c) efforts should be made to measure the 42- and 97-keV transitions directly in order to calculate the energy of the 3.5-eV state with any confidence – double crystal spectrometer with a resolution of the order of 1 eV would be required.

2.17. ENSDF procedures manual and the web (T. Kibédi (ANU))

Kibédi believed that the material and facilities were available for the promulgation of extensive ENSDF information on the web. In particular, he urged that efforts be expended to ensure that the ENSDF procedures manuals be made more readily accessible in this manner. Links to the manual at the NSDD Evaluators' Corner should be established from a single web site on the NNDC and IAEA-NDS pages. Accessible material should include the following:

- NDS policies;
- Evaluated nuclear structure data file (BNL-NCS-51655-01/02-Rev.2001);
- NSDD evaluators' network (INDC(NDS)-421);

- NSR coding manual (24 May 2007);
- Procedures manual for the Evaluated Nuclear Structure Data File (BNL-NCS-40503);
- NSDD workshops, ICTP, Trieste, Italy;
  etc.

ACTION: NNDC, BNL staff to rationalize and create appropriate Web links for more convenient access to all available sources of information related to ENSDF (including procedures manuals and NSDD ICTP workshop material).

2.18. B(E2) and ββ decay (A. Sonzogni (NNDC, BNL))

Pritychenko (NNDC, BNL) is maintaining a B(E2) database that was originally established by Raman (ORNL). These data include experimental, theoretical and adopted B(E2) values, and can be found at http://www.nndc.bnl.gov/be2

A ββ-decay database of modest proportions has also been assembled, and will be maintained at NNDC, BNL (http://www.nndc.bnl.gov/bbdecay). There are over 300 best experimental limits and 14 adopted values that represent a reliable source of recommended data for ENSDF evaluators. This work is being undertaken by Pritychenko in collaboration with Tretyak (INR, Kiev).

ACTION: All network participants to provide Pritychenko with feedback/comments on the Web sites devoted to B(E2) and ββ-decay.

3. Technical Recommendations

1. Ensure that ENSDF entries are in-line with five-yearly updated nuclear parameters to be found within NWC ($t_{½}$, J^{π}, decay modes) – difficulties in implementation should be immediately reported back to NNDC.
2. Adopt agreed changes to ENSDF decay scheme drawings and tabulations based on McMaster initiative.
3. Recommendations concerning dynamic quadrupole moments and their nomenclature should be adopted (see revision of rules #37 and 39 for band assignments (latter to be re-defined as "weak argument" #12).
4. Ensure that RULER code is able to perform without failure all calculational checking functions – important for ensuring and maintaining the quality of ENSDF.
5. GAMUT code needs to be improved/updated with some urgency, as specified and agreed during 16th meeting of the NSDD network (June 2005).
6. Consider adding or updating basic information from NWC to ENSDF.
7. Consider the need and the method of adding cluster decay data into ENSDF.

4. Reports from Evaluation Centres – see also Annex 5

Representatives from the individual mass chain evaluation centres presented progress reports on their NSDD studies. These status reports are brought together within Annex 5.

5. Administrative and Related Matters

5.1. Actions from previous network meetings

All previous actions were reviewed in detail. Many of these actions are continuous, and are related to the monitoring of advances in NSDD to ensure that all evaluation centres are kept fully informed of various matters between biennial Network meetings. The list of actions and their current status (continuous, withdrawn and completed) can be found in Annex 4.

5.2. US Nuclear Data Programme (P. Obložinský (BNL)) – see also Annex 5

The mass chain responsibilities of the NNDC were described, along with details of the various evaluations, reviews and publications since June 2005. ENSDF is distributed twice per year to mass chain evaluators, while the IAEA Nuclear Data Section receives the full file every month. Both the NNDC computer system and Web-based services were also described. Obložinský noted that the number of NuDat retrievals has increased significantly over the previous 12 months from 374k to 631k, reflecting the growing popularity of the database, the attractiveness of the latest Java script web technologies, and the broad appeal of a Chart of the Nuclides system to less sophisticated users. More details of the NNDC programme can be found in Annex 5.

5.3. IAEA Nuclear Data Programme (A.L. Nichols (IAEA-NDS)) – see also Annex 5

5.3.1. ENSDF-related evaluations, 2005-07

Staff have been recruited into the IAEA Nuclear Data Section who possess the necessary background knowledge to undertake studies and evaluations of nuclear structure and decay data. Management’s aim is for two members of staff to spend about 30% of their time each carrying out NSR keywording and mass chain evaluations (Abriola and Kellett).

Nichols also listed the on-going Coordinated Research Projects (CRP), and placed particular emphasis on a CRP devoted to “Updated decay data library for actinides” (see INDC(NDS)-0479 and INDC(NDS)-0508). Mention was also made of a recently completed activity devoted to the production of “Handbook of Nuclear Data for Safeguards” (INDC(NDS)-0502, January 2007; also to be found at: http://www-nds.iaea.org/sgnucdat/). More details of the most relevant features of the IAEA-NDS programme can be found in Annex 5.

5.3.2. IAEA-ICTP NSDD workshops

Outline objectives and achievements were described for all NSDD workshops sponsored by the IAEA Nuclear Data Section:

(i) NSDD Evaluation, IAEA Vienna, 18-22 November 2002;
(ii) NSDD: Theory and Evaluation, ICTP Trieste, 17-28 November 2003;
(iii) NSDD: Theory and Evaluation, ICTP Trieste, 4-15 April 2005;
(iv) NSDD: Theory and Evaluation, ICTP Trieste, 20 February – 3 March 2006.

A summary was given of the countries of origin of past attendees at these four IAEA and ICTP workshops, and data presented concerning the number of students who have gone on to undertake mass chain evaluations though the network's mentoring system. All of these courses have been described and assessed in INDC(NDS) reports, and all materials and computer codes have been stored on file (see also: http://www-nds.iaea.org/workshops/ictp2006/).

Nichols announced that a further two-week course had been recently approved for 2008:

NSDD: Theory and Evaluation, ICTP, Trieste, 28 April – 9 May 2008.

The format would be similar to the previous three ICTP workshops. Funding would only be available to support participants from developing countries. He urged NSDD network participants to ensure that any suitable co-workers who would benefit from attendance apply, and that they should notify Tuli and himself of such intentions. Application forms and details of the contents of the course will become available on the ICTP web site at:
http://cdsagenda5.ictp.trieste.it/full_display.php?smr=0&ida=a07148

6. Mass Chain Evaluators: Problems and Opportunities

Nichols described the major problem being faced by the International Network of Nuclear Structure and Decay Data Evaluators as declining numbers of experienced mass chain evaluators, particularly from within Europe where the necessary expertise was known to exist. The advantages and beneficial impacts of ENSDF were defined, along with the definition of a significant number of derivative databases and publications (NuDat, Isotope Explorer, NUBASE, MIRD, RIPL, Janis, Nuclear Wallet Cards, Table of Isotopes and *Nuclear Data Sheets*).

Long-term contributors to ENSDF have included mass chain evaluators in Belgium, Canada, China, France, Japan, Kuwait, Russia and the USA, and emerging new contributors were to be found in Argentina, Australia, Brazil, Bulgaria and India. However, while the total FTE (Full Time Employment equivalent) for ENSDF in 2005 had been 9.5, only 2.2 came from outside North America; an overall figure of ~ 12 FTE was judged to be required to maintain all of the mass chain evaluated files in good order. Nichols pointed out that the main fall in mass chain evaluations was identifiable with the declining inputs from nuclear physics research institutes in Europe (involvement of six evaluation centres in 1985/86 falling to virtually zero in 2007 (two retirees only)). New mass chain evaluators are required now.

6.1. USA

Obložinský reported that the USDoE had expressed concern about the observed decline in non-USA contributions to ENSDF, particularly the steadily decreasing effort from within Europe. The Director of the Office of Nuclear Physics had requested background briefing material for possible debate at the Global Nuclear Physics Forum, and the resulting data formed the basis of this presentation to the NSDD network:

ENSDF contains nuclear structure and decay data for > 3000 known nuclides – best values for nuclear properties extracted from all known experimental data. These recommended files are used extensively in basic nuclear structure research, astrophysics studies, and a broad range of applications encompassing nuclear spectroscopic analyses, decay heat calculations in nuclear power reactors, homeland security and the determination of medical radiation dosages. ENSDF also provides the source data for various other important databases and publications (e.g., MIRD, NuDat, Nuclear Wallet Cards and *Nuclear Data Sheets*). The brief emphasised the requirement for strong international effort to sustain ENSDF as a vital resource for worldwide use, and that diminishing European support is of particular concern.

An increasingly large fraction of the evaluation effort comes from the USA and Canada, with a concomitant decline in the contribution of Europe over the previous 20 years from approximately 23% to 9% of the total effort. The net result has been the creation of a dramatic disparity between European contributions and usage of ENSDF (Table 1).

Table 1: ENSDF – Usage and contributions to ENSDF (2007).

	Usage (%)	Contribution to evaluations (%)
USA + Canada	44	78
Europe	26	9
Japan	6	5

There has been a major erosion of support within Europe since 1986: out of six European mass chain evaluation centres in existence in 1986, none are financially supported in 2007. Furthermore, the two remaining mass chain evaluators are retirees (in Belgium and France), and have no financial support (Table 2).

Table 2: European evaluation centres.

	Last published evaluation	Financial support in 2007?
France	2006	No
Belgium	2005	No
Netherlands	1998	No
Sweden	1992	No
Germany	1991	No
UK	1986	No

6.2. Europe

Balabanski (University of Sofia) discussed the funding opportunities within Framework Programme 7 (FP7) of the European Community, and on-going preparations for the RI-I3 call for proposal submissions. Three major types of research activities are envisaged:

TA (translational access);
JRA (joint research activities), and
NA (network activities),

as well as activities needed to strengthen European research activities. Other funding opportunities were the EUROATOM programme, ERANET action and e-libraries. Balabanski also provided details of the allocations and funding timetable:

Letters of Intent will be presented at the Helsinki Town Meeting (week of 17 September 2007);
RI-I3 call for proposals expected in November 2007;
FP7 projects to be approved and funded in 2008.

The imminent retirement of Georges Audi (CSNSM, Orsay) from atomic mass evaluations (AME) had induced significant discussion within Europe concerning the maintenance of AME. Litvinov (GSI) and Penttilä (University of Jyväskylä) described plans to continue this important work in Europe, and the preparation of a draft Letter of Intent with this aim in mind through FP7 funding.

Other possibilities mentioned by Balabanski included various types of horizontal evaluation at the University of Bucharest, GSI and the University of Sofia, and mass chain evaluations at specific research institutes (on condition that EU funding can be identified for post doctoral positions in the majority of cases). Possible partners in the proposed European NSDD network were defined as follows:

University of Sofia (2 or 3 people part-time);
University of Bucharest (1 person part-time);
others (e.g., University of Surrey), if EU funding available.

The Helsinki Town Meeting will take place during the week of 17 September 2007, and is particularly important in the formulation and agreement of the various joint European programmes for possible FP7 funding. Under these circumstances, the NSDD network was asked to consider how to ensure that the European nuclear physics community should be made aware of the emerging concern that nuclear physics research institutes within Europe were not contributing satisfactorily to the maintenance of ENSDF.

6.3. Russian Federation

Mitropolsky (PNPI) acknowledged that there was a need to expand the number of mass chain evaluators within Russia. Appeals were regularly made at the major nuclear physics conferences in Russia ("Interaction of Neutrons with Nuclei: Neutron Spectroscopy, Nuclear Structure, Related Topics", in particular), but the response over the years had been disappointing. He appealed for assistance from the NSDD network to publicise the problem, but also noted that a lack of funding would seriously inhibit such work.

6.4. Japan

Katakura (JAEA) said that budget cuts were in the process of being implemented across all nuclear research programmes in Japan. An overall reduction of staff numbers by 10% was envisaged in the next five years. These conditions were not conducive towards the desired increase in mass chain evaluators within Japan – rather the contrary was occurring, with an inevitable decline in numbers. Katakura would return to Japan with a clear message of network needs, and would discuss the growing problem with Prof. Arima in order to pursue the possibility of undertaking new evaluations through the basic nuclear physics research programme.

6.5. India

Ashok Jain (IIT) listed new and emerging nuclear physics research facilities in India. Despite the ambitious nuclear energy programme, there is a limited number of personnel available to undertake applications work. Thus, efforts were being made in a significant number of educational establishments to increase the number of relevant courses and students within the university system. Jain noted that funding was not seen as a major issue at the present time, but rather the rate of production of appropriately qualified nuclear scientists.

There are plans to introduce nuclear structure and decay data course work at IIT, Roorkee, and to identify more financial support for this area of expertise. BARC is in the process of establishing a dedicated Nuclear Data Committee within India to assist in national nuclear data communications, identify requirements, and instigate experimental and theoretical nuclear science projects to address these needs.

6.6. Subsequent discussion

Much discussion ensued, and the following specific thoughts and actions emerged. Kelley (TUNL) pointed out that very few young nuclear physicists are in permanent positions of employment within the USA. This unsatisfactory situation will almost certainly continue into the foreseeable future, and eventually the USA could be faced with a shortage of mass chain evaluation effort in a similar manner to Europe. Both Nica (Texas A&M) and Marti (CNEA) believed that the NSDD network merited more extensive publicity, including evidence of the citation record(s) of *Nuclear Data Sheets* and other modes of publication.

ACTION: Kondev (ANL) and Balabanski (University of Sofia) to coordinate the preparation of an informative article about nuclear data evaluations to be published in appropriate literature/journal (article to be prepared for publication by mid-2008).

ACTION: NNDC/BNL and IAEA-NDS to pursue initiatives to improve the non-USA/North America contributions to the ENSDF mass chain evaluations.

ACTION: Balabanski (University of Sofia) to explore methods of support for the establishment of ENSDF mass chain evaluations from within Europe.

ACTION: Tuli (NNDC, BNL) and Nichols (IAEA) to assist in the various national initiatives to improve non-North American contributions to the ENSDF mass chain evaluations – e.g., EU FP7 Town meeting at Helsinki, September 2007.

ACTION: All network participants to formulate and pursue methods of improving/expanding contributions towards mass chain evaluations within their own countries

7. Organisation of International Network of NSDD Evaluators - Review (J.K. Tuli (NNDC, BNL))

The current status and commitments of the mass chain evaluation centres were reviewed in detail:

		Mass chains	FTE
USA	NNDC	115	3.40
	ORNL (NDP)	9	0.25
	LBNL	43	1.95
	TUNL	19	0.60
	ANL	15	1.20
Non-USA	PNPI	6	0.25
	Beijing/Jilin	12	0.5
	Bruyères-le-Châtel	11	0.2
	JAEA	10	0.45
	Kuwait	7	0.2
	Ghent	6	0.2
	McMaster University	25	1.0
	ANU	4	0.2
	IIT, India	12	0.2
TOTAL		294	10.6

At least 12 FTEs per annum are needed to keep ENSDF in reasonably good shape.

Specific mass chain evaluations are being undertaken by some of the new evaluators in conjunction with their mentors:

Argentina; Marti, Achtenberg and Capurro, A = 178 (January 2006), 191 (July 2007), 193, (February 2008); A = 178, 191 shared with the Brazilian group (Browne (LBNL), mentor).

Austria, IAEA; Abriola, A = 96 (Sonzogni (BNL), mentor).

Brazil; Vanin and Castro (have left the programme), A = 178, 191 shared with the Argentine group (Browne (BNL), mentor).

Bulgaria; Balabanski and Lalkovski, A = 112, 200 (De Frenne (Ghent) and Kondev (ANL), mentors).

India; Gopal Mukherjee, A = 95 (Sonzogni (BNL), mentor);
Swapan Basu, A = 150 (Sonzogni (BNL), mentor);
Mohini Gupta, A = 266-294 update, 260-265 (Burrows (BNL), mentor).
USA; Nica, A = 140, 147 (Burrows (BNL), mentor).

The average time between evaluations of a particular mass chain is approximately 8 years. Specific Network contributions remain rather fragile; research institutes need to be convinced that the work is of basic importance, and is not a secondary "fall-back" job that can be outsourced. Institutional support continues to wane, and remains a serious cause for concern.

A nuclide priority list is distributed once per year (list of between 150 and 200 radionuclides) that is based on the number of 'new' experimental papers that have been registered in NSR. A mass chain evaluation is deemed necessary when more than three nuclides of the same mass appear on this list. Tuli asked Network participants to contact him at the NNDC if they wished to work on a mass chain not deemed to be in their mass region of responsibility.

8. Horizontal Evaluations

8.1. Atomic masses (J. Blachot (CEA, Bruyères-le-Châtel))

Blachot noted the publication of the most recent atomic mass evaluations and tabulations:

A.H. Wapstra *et al. Nucl. Phys.* **A729** (2003) 129-676,

and the corresponding release of NUBASE:

G. Audi *et al. Nucl. Phys.* **A729** (2003) 3-128.

The latter lists recommended nuclear and decay properties of all known ground and isomeric states, and can be used in conjunction with NUCWin to produce a chart of the nuclides and display other information. However, the future of both databases is uncertain because of Georges Audi's forthcoming retirement. Litvinov expressed a significant GSI interest in AME, and outlined plans that were being formulated to ensure the long-term survival of AME within Europe beyond 2008.

8.2. Nuclear data activities at Manipal University, June 2005 to June 2007 (A.L. Nichols (IAEA)) – see also Annex 6

Nuclear data studies at Manipal University embrace agreed super-heavy mass chain evaluations for ENSDF (see Annex 5), and the recent initiation of a research programme on the application of covariance error matrices to nuclear data assessments and evaluations (latter launched in conjunction with BARC).

Consideration is also being given to atomic and nuclear data/life science projects on radiation damage to DNA and nanodosimeters. Ideas for new atomic and nuclear data collaborations would be most welcome for discussion and development to project status.

8.3. Analyses of ENSDF (I. Mitropolsky (PNPI))

Statistical analyses have been carried out on the adopted levels and associated gamma transitions to be found in ENSDF (2005 version). There are 2931 sets of adopted levels, of which 1830 sets contain level schemes with allocated transitions; 138617 individual levels are contained within these 1830 sets of adopted levels; 40235 levels have no population/depopulation gamma transitions, and 17539 levels have only one such transition. ^{40}Ca contains the greatest number of levels with 578. Finally, the number of allocated gamma transitions is 204708; ^{53}Mn contains as many as 1319 gamma transitions, while ^{55}Mn contains 1130 gamma transitions.

8.4. Rotational bands in odd mass nuclei (K. Stroganova (PNPI))

Software has been developed to define and assess the rotational bands in odd mass nuclei ($K > ½$). The RotB code is based on parameterization by means of the Bohr-Mottelson polynomial formula and the variable moments of inertia model (VMI), and was demonstrated to the meeting.

9. NSDD – Other Topics and Issues

9.1. NSR (J.K. Tuli (NNDC, BNL))

From June 2005 to May 2007, 8581 new references have been added to the NSR database (giving a sum total of 189380 entries); NSR has received 305986 web queries in this same period of time. IAEA has taken over responsibility for the preparation of the keywords for the European journals *Nuclear Physics A*, *Eur. Phys. J. A* and *Physics Letters B*; preliminary files are prepared and e-mailed to the Nuclear Data Section (Kellett) for key wording.

ACTION: IAEA-NDS to bring NSR key-wording responsibilities in-line with NNDC key-wording timetable.

Changes have been made to the subject indexing program, including selector tags, reaction strings, multiple selectors and the calculation of daughter nuclides indexed on the basis of radioactivity keywords. Other modifications include author indexing with two initials (rather than only one), full listing of matching names, and more comprehensive search procedures. Winchell (NSR database manager) has taken leave of absence from BNL, and has been replaced by Manojeet Bhattacharya.

9.2. XUNDL (B. Singh (McMaster University)) – see also Annex 6

The XUNDL database provides a rapid form of internet access to recent publications and pre-prints of experimental nuclear structure data that are not yet available in the ENSDF database. Over 90% of the compilation work is undertaken at McMaster University, and a status report was presented by Singh (see also Annex 6):

> 2225 datasets (on 31 May 2007), data for 1345 nuclides spread over 253 A-chains; covers publications from 1995 to date, with much of the work carried out by undergraduate students (plus input from specific members of the NSDD network).

Compilers communicate with the authors of published papers to resolve misunderstandings, inconsistencies and errors, and to acquire additional data omitted due to space limitations in the original journal publications. Singh also noted that XUNDL datasets are regularly used by ENSDF mass chain evaluators to help speed up their evaluation efforts.

Consider one or two papers per mass chain per year in the most active regions, and a full ENSDF evaluation every 10 to 12 years (rather than every 4 or 5 years). These statistics imply that XUNDL is a useful activity to maintain, and can be quickly used to identify new nuclides. Singh also pointed out that the maintenance of XUNDL within the next three years will require the participation of other nuclear data centres to replace McMaster University.

9.3. ENDF/B-VII.0 and ENSDF (P. Obložinský and A. Sonzogni (NNDC, BNL))

The US Evaluated Nuclear Data File has been assembled over the previous four years, and was released as ENDF/B-VII.0 in December 2006. All details of this nuclear applications library were published in an extensive paper (48 co-authors in *Nuclear Data Sheets*, **107**, 2006, 2931- 3060). The decay data library is based almost exclusively on the contents of ENSDF (adopted data for 3,838 nuclides) – these data have also been benchmarked for decay heat calculations and delayed neutron emissions.

Many of the cross-section evaluations are heavily based on nuclear model calculations, and such an approach does require a sound knowledge of the discrete energy levels and decay schemes of the various nuclides. ENDF/B-VII evaluators have taken these data most conveniently from RIPL (Reference Input Parameter Library, assembled by the IAEA through a series of coordinated research projects), as extracted or adequately estimated from ENSDF. Thus, realistic decay schemes are derived from ENSDF and used to calculate cross sections for the population of low-lying levels – important for both isomeric and gamma-production cross sections. Other data required in such calculations include Q-values, deformation parameters, collective levels and internal conversion coefficients.

10. ENSDF Customer Services

10.1. Analysis and utility codes (J.K. Tuli (NNDC, BNL)) – see also Annex 6

Burrows (NNDC, BNL) has continued to develop and improve an extensive set of NSDD analysis and utility codes. All of these codes have been converted to FORTRAN 95 (see Annex 6):

a) ALPHAD, ComTrans, FMTCHK, ENSDAT, GTOL, NSDFLIB, PANDORA and RULER have been distributed;
b) in-house testing continues with the remaining programs before distribution;
c) with the exception of RADLIST, all ANSI, Open-VMS, Linux and MS Windows version are current;
d) Compaq/Digital Visual FORTRAN used for Windows, and Lahey/Fujitsu FORTRAN 95 for Linux.

The development and modification of specific analysis codes were also defined as follows:

BrICC 2.0	– Band-Raman ICCs with "frozen orbital" hole approximation has been distributed;
ENSDAT	– updated;
FMTCHK	– various upgrades and corrections, including recognition of BrICC outputs;
GAMUT	– to be undertaken by LBNL (Action);
GTOL	– possible machine-dependent precision problem;
HSICC	– problem of creating new records when gamma energy is below subshell binding energy (further testing required);
LOGFT	– logic added for 3rd and higher order beta transitions;
PANDORA	– dimensions increased in GAMINT, and other modifications;
RADLIST	– updated to handle BrICC outputs;
RULER	– corrected initialization problem (sometimes caused program to skip calculations).

ACTION: Firestone to provide a new version of GAMUT – either update code within three months (by October 2007) and send to NNDC, or send unmodified code to NNDC.

10.2. Nuclear Wallet Cards (J.K. Tuli (NNDC, BNL))

Tuli reported that ~ 5000 of 10000 copies of Nuclear Wallet Cards, 7th Edition, have been distributed on request to APS, DNP and European Physics Societies. The 6th Edition of Nuclear Wallet Cards 2000, has been archived by NNDC because the recommended half-lives have been officially adopted as standards for USDoE nuclear materials inventory control.

Nuclear Wallet Cards for Radioactive Nuclides, March 2004, was also noted (stocks exhausted) – contains a limited number of radionuclides (half-lives > 1 hour), and was issued for applications involving US Homeland Security.

10.3. Nuclear Data Sheets (J.K. Tuli (NNDC, BNL))

Tuli noted that a new issuing structure had been adopted by Elsevier – only one volume per year consisting of 12 issues totalling approximately 2800 pages. One issue per year will be devoted to reaction data (issue that was originally *Recent References*). Elsevier had held a journal editors' workshop, and expressed their contentment with *Nuclear Data Sheets*. Tuli also stated that the previous backlog of completed mass chain evaluations had been fully cleared, and efforts would continue to modernize the presentational features of the journal (see also Section 2.3).

ACTION: Tuli to discuss with Elsevier whether they could make introductory material on NSDD available on their web site.

10.4. NuDat-2.3 (A. Sonzogni (NNDC, BNL))

Sonzogni described specific features of the most recently launched version of NuDat in March 2007 (NuDat-2.3):

handling and depiction of uncertainties;
introduction of a glossary;
suppression of upper/lower limit data;
triple-gamma coincidence data can be identified (any Z, A, N);
selection of individual data sets for retrieval;
3166 nuclides contained within NuDat-2.3.

Development studies will continue on ways of displaying the ENSDF data by means of NuDat and improve user accessibility. User requests would be most warmly welcomed.

ACTION: Sonzogni (NNDC, BNL) to introduce "±" symbol into the 'non-standard' layout of ENSDF data with respect to expressing uncertainties (e.g., ± 1.5).

ACTION: Sonzogni (NNDC, BNL) to acknowledge ENSDF as the main data source for NuDat in a suitable manner (e.g., at the bottom of the main web page).

11. Overall Recommendations and Conclusions

1. Groups will continue to be considered for inclusion in the Network based upon the development of their evaluation programmes and involvement in NSDD evaluation activities.
2. The Network strongly endorsed the sponsorship of NSDD evaluators' workshops at ICTP, Trieste, Italy, with a further 2-week workshop scheduled for 28 April – 9 May 2008.
3. Evaluation centres within NSDD are encouraged to invite and provide mentoring support to new ENSDF evaluators of mass chains.
4. Mass chain evaluations for ENSDF require reputable reviews by appropriate volunteers within the NSDD Evaluators' Network. More such reviewers are required from the Network to meet the current needs.
5. Acknowledgement of ENSDF as the main data source for NuDat should be appropriately cited (e.g., on the main NuDat we page).
6. IAEA NDS staff were asked to seek further support for mass chain evaluations:

   - continue to pursue initiatives to improve non-North American contributions to the ENSDF mass chain evaluations,
   - invite relevant specialists/managers to the next NSDD Evaluators' Network meeting (April/May 2009).
7. All Network participants should formulate and implement methods to improve/expand mass chain evaluations from within their own countries, including the identification of contributions from other research institutes.
8. Final points of note were that the next meeting of the International Network of NSDD Evaluators will be held in March/April 2009 at IAEA Headquarters, Vienna, Austria; and that Kibédi registered the strong interest of ANU to host the 2011 meeting in Canberra, Australia.

ANNEXES

ANNEX 1

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ANNEX 2

17^{th} Meeting of the Nuclear Structure and decay Data (NSDD) Network

Petersburg Nuclear Physics Institute, St. Petersburg, Russia 11-15 June 2007

AGENDA

Monday, 11 June 2007

08:30-09:00 Arrival

09:00-9:30 **Introduction**

- Welcome remarks
  - Ivan Mitropolsky (PNPI)
  - Alan Nichols (IAEA)
- Remarks by the organizer (Ivan Mitropolsky)
- Meeting Chairman
- Adoption of Agenda (Chairman)
- Apologies for absence – received from Daniel Abriola, Marie-Martine Bé, Ameenah Farhan, Mohini Gupta, Gopal Mukherjee, Charlie Reich, Nick Stone, John Wood, Huang Xiaolong

09:30-10:30 **Technical Discussions** (see list below)

10:30-11:00 *Coffee Break*

11:00-17:30 **Technical Discussions** (see list below)

12:30-14:00 *Lunch*

15:30-16:00 *Coffee Break*

19:00-21:00 *Reception*

Tuesday, 12 June 2007

09:00-17:30 **Technical Discussions, or until finish** (see list below)

10:30-11:00 *Coffee Break*

12:30-14:00 *Lunch*

15:30-16:00 *Coffee Break*

Technical Discussions - Monday 09:30-17:30, and Tuesday 09:00-17:30 (or until finish)

Discussion topics – leaders:

Cluster emissions in ENSDF, Alejandro Sonzogni (BNL)	15 mins
Nuclear Wallet Cards and ENSDF compatibility, Alejandro Sonzogni (BNL)	10 mins
Modernization of ENSDF, Balraj Singh (McMaster)	20 mins
Action 34 – revision of rules # 37, 38, 39 for spin-parity assignments, Balraj Singh (McMaster), Filip Kondev (ANL)	5 mins
Action 34 - Band labels and configurations in ENSDF, Balraj Singh (McMaster), Filip Kondev (ANL)	30 mins
Action 34 - Transition quadrupole moments, Filip Kondev (ANL), Balraj Singh (McMaster)	30 mins
ENSDF editor, Alejandro Sonzogni (BNL)	30 mins
Precise internal conversion measurements as tests of internal conversion theory, Ninel Nica (Texas A&M)	30 mins
Errors in ENSDF, G.I. Shulyak (PNPI)	15 mins
ENSDF evaluator's toolbox, G.I. Shulyak (PNPI)	20 mins
Internal conversion coefficients (BrIcc), Tibor Kibédi (ANU) program developments, high-precision ICCs, web interface future plans: E0 and mixed E0 + M1 + E2 transitions; X-ray and Auger energies and intensities; utility program for mixing ratios	40 mins
K-isomers, F. Kondev (ANL)	15 mins
Transition rates for magnetic dipole transitions, Balraj Singh (McMaster)	20 mins
ENSDF format and evaluation philosophy/policies - changes to format and reminders concerning evaluation procedures, Jagdish Tuli (BNL)	30 mins
RULER code, Jagdish Tuli (BNL)	10 mins
Distribution of digits in errors, S.L. Sakharov (PNPI)	20 mins
3.5-eV state of ^{229}Th, S.L. Sakharov (PNPI)	20 mins
ENSDF procedures manual(s): promulgation on the web, Tibor Kibédi (ANU)	10 mins
B(E2) and ββ decay, Alejandro Sonzogni (BNL)	30 mins
Other topics?	
General Discussions (all)	

Wednesday, 13 June 2007
(attendance of Drs. Y. Litvinov (GSI, Germany) and H. Penttilä (University of Jyväskylä, Finland))

09:00-9:30 **Actions from Previous Meetings**

09:30-10:30 **Reports by Evaluation Centres**
NSDD activities and ENSDF evaluators' reports (all centres – 5-10 mins each)
NNDC (including work of Nica, Reich and Browne)
IAEA-NDS
ORNL
LBNL
TUNL
ANL

10:30-11:00 *Coffee Break*

11:00-12:30 **Reports by Evaluation Centres** *(cont.)*
NSDD activities and ENSDF evaluators' reports (all centres – 5-10 mins each)
McMaster University
PNPI, St Petersburg
CEA Bruyères-le-Châtel
Gent University
JAEA
Institute of Atomic Energy, Beijing
Jilin University
IIT, Roorkee, India (and Manipal, India)

12:30-14:00 *Lunch*

14:00-15:00 **Reports by Evaluation Centres** *(cont.)*
NSDD activities and ENSDF evaluators' reports (all centres – 5-10 mins each)
Nuclear Data Project, Kuwait
ANU, Canberra
Others

15:00-15:30 *Coffee Break*

15:30-17:00 **Nuclear Data Programs**

- Report on the US Nuclear Data Program - P. Oblozinsky (BNL)
- Report on the IAEA Nuclear Data Program - A. Nichols, (IAEA)
  - ENASDF-realted evaluations, 2005-07
  - IAEA-ICTP NSDD workshops

Thursday, 14 June 2007
(attendance of Drs. Y. Litvinov (GSI, Germany) and H. Penttilä (University of Jyväskylä, Finland))

09:00-10:30 **Mass Chain Evaluators: Problems and Opportunities** (A. Nichols, leader)
USA - P. Oblozinsky (BNL)
Europe - D. Balabanski/Y. Litvinov/H. Penttilä
Russia - I. Mitropolsky (PNPI)
Japan – J. Katakura (JAEA)
India – A. Jain (IIT)
others (all)

10:30-11:00 *Coffee Break*

11:00-12:30 **Organisational Review** (J. Tuli, BNL):

- Activities, priorities and manpower
  - Summary of ENSDF evaluation status and activities in 2006-2007
  - Estimated manpower of each centre for future ENSDF evaluation
  - Future evaluations: priorities
- Responsibilities of current groups
- Due recognition of ENSDF inputs to other databases

12:30-13:30 *Lunch*

13:30-14:30 **Horizontal Evaluations, including Needs and Plans**

- Atomic masses – J. Blachot (CEA Bruyères-le-Châtel)
- Manipal University – A.L. Nichols (IAEA)
- Analyses of ENSDF – I. Mitropolsky (PNPI)
- Rotational bands in odd mass nuclei – K. Stroganova (PNPI)
- others

14:30-15:30 **NSDD – Other topics and issues**

- NSR – Jagdish Tuli (BNL)
- XUNDL – Balraj Singh (McMaster)
- ENDF/B-VII.0 and ENSDF – P. Oblozinsky and A. Sonzogni (BNL)
- others

15:30-16:00 *Coffee Break*

16:00-17:30 **ENSDF Customer Services**

- Analysis and utility codes - J. Tuli (BNL)
- Nuclear Wallet Cards - J. Tuli (BNL)
- *Nuclear Data Sheets* - J. Tuli (BNL)
- NuDat-2.3 - A. Sonzogni (BNL)

19:00-22:00 *Banquet* (bus)

Friday, 15 June 2007

09:00-10:30 **Conclusions and Recommendations**
Adoption of recommendations and actions

10:30-11:00 *Coffee Break*

11:00-12:30 **Conclusions and Recommendations** (cont.)
NSDD chairman
Next meeting

12:30 *Meeting adjournment*

12:30-14:00 *Lunch*

ANNEX 3

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A-Chain Evaluation Responsibility

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b. US/NDP	241-249
c. US/LBL	21-30,59,81,83,90-93,166-171, 180-193 (ex 188,190),210-217
d. US/TUNL	2-20
e. US/ANL	176-179,199-209
f. India	218-229

Center	Mass Chains
g. Russia/StP	130-135
h. PRC	51-56,62,63,195-198
i. France	101,104,107-109,111,113-117
j. Japan	120-129
k. Kuwait	74-80
l. Belgium	102,103,105,106,110,112
m. Canada	1,31-44,64,89,98,100,149, 151,164,188,190,194
n. Australia	172-175

ANNEX 4

List of Completed, Continuous and New Actions (15 June 2007)

No.	Responsible	Reason	Action
1	J. Tuli, BNL/NNDC	Quality assurance test.	Advise evaluators to run RADLIST, and comment on agreement of Q-value and sum of decay energies and X-ray intensities measured and calculated. **Continuous action**.
2	J. Tuli, BNL/NNDC	Priority list evaluations: has to be updated.	Send yearly priority list for nuclide and mass chain ENSDF evaluations. Add priority list of the NSDD TM and network document. **Continuous action**.
3	J. Tuli, BNL/NNDC	Format and consistency problems could arise for certain horizontal evaluations.	Co-ordinate horizontal and A-chain evaluators by means of procedures for inserting horizontal evaluations into ENSDF. **Continuous action**.
4	BNL/NNDC	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 action**.
5	All network participants	Results of significant horizontal evaluations are not always incorporated into ENSDF in a timely manner.	Keep abreast of activities in other areas where horizontal evaluations may be appropriate for incorporation into ENSDF. Inform J. Tuli (who will maintain a list of horizontal evaluations on NNDC-NDSDD Web site). **Continuous action**.
6	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 the NNDC in obtaining conference proceedings, meeting and laboratory reports for NSR. Copy of unpublished conference reports containing significant NSDD contribution should be sent to D. Winchell. **Continuous action**.
7	IAEA/NDS	Characteristics and parameters of NSDD network have to be regularly updated.	Update NSDD network document regularly as INDC(NDS) report - publish electronically according to the latest changes as defined at the network meeting. **Continuous action – but last updated, March 2004**.
8	BNL/NNDC	Publish versions of ENSDF are required.	Continue journal "publication" of the mass chain evaluations. **Continuous action.**

9	IAEA/NDS	Co-ordinate network activities in the lengthy period between NSDD meetings.	Nominate a chairman and deputy chairman for next NSDD meeting at the current NSDD meeting. **Continuous action**.
10	All network participants	Misprints and errors found in NSR and ENSDF.	Report all errors detected in NSR and ENSDF to NNDC as soon as they are found. **Continuous action**.
11	All ENSDF evaluators	Accelerate the review process.	Each ENSDF evaluator should be willing to do 2 mass-chains equivalent reviews per FTE-year. Reviewing process for one mass chain should not be longer than 3 months. **Continuous action**.
12	BNL/NNDC	Researchers are not familiar with ENSDF format.	Promote the concept that researchers should supply data to the network in complete, tabular form. **Continuous action**.
13	All network participants	Bring NSDD evaluation work to the attention of the nuclear community.	Present network activities at different conferences and meetings. **Continuous action**.
14	All network participants	Avoid duplication of work.	Participants should inform the network about any development of software related to NSDD. **Continuous action**.
15	J. Tuli, BNL/NNDC	Encourage specific new measurements.	Indicate in the abstract of an evaluation any critical problems in the data compared with the previous evaluation, gaps in the data, and discrepancies that could be resolved by new measurements. **WITHDRAWN (in ENSDF procedures manual)**.
16	Data centre managers	Attract young scientists to data evaluations.	Encourage evaluators to participate in research/evaluation of nuclear structure data. **Continuous action**.
17	All network participants	Improve NSR.	Send comments and suggestions on NSR improvements (indexing) to Manojeet Bhattacharya (NNDC). **Continuous action**.
18	BNL/NNDC	Increase the accuracy of Auger electron and continuum beta-spectra.	Improve ENSDF codes to provide more detailed presentations of Auger-electron and continuum beta spectra. **Progress to date by Kibedi/Burrows involves electron and X-ray spectra.**
19	All ENSDF evaluators	Check validity of the rules.	Inform NNDC when experimental results appear to contradict the rules. **Continuous action.**
20	All network participants	Improve quality of evaluations.	Solicit potential non-network evaluation reserves, and send names to ENSDF manager (NNDC). **Continuous action**.

21	McMaster University; BNL/NNDC; LBNL; and other evaluation centres	Support new ENSDF evaluators.	Provide local support and mentoring to new ENSDF evaluators of mass chain evaluations. **Continuous action**.
22	J. Tuli, BNL/NNDC	Network should be made aware of needs of NSDD users.	List of horizontal evaluation needs and on-going evaluation activities should be maintained through the NSDD network. **Continuous action**.
23	All network participants	Maintain up to date information on the Network.	Review, modify and correct the contents of INDC(NDS)-421. **Continuous action** **(see also Action 7)**.
24	Balraj Singh, McMaster; F. Kondev, ANL	Data definition.	Propose guidelines for appropriate configurations/labels of band assignments, define the proper quantity and symbol to represent the transition quadrupole moment for rotational bands, and propose an additional J^{π} rule for coupled bands, in addition to current rule #37 for other rotational bands (by 5 November 2005). **COMPLETED**.
25	T. Burrows, BNL/NNDC; T. Kibédi, ANU	Preparation of new agreed data set.	Provide BRICC program for ICC calculations, using the Band-Raman prescription with frozen orbital relativistic procedure (BNIT(2)), for network use (by 1 September 2005). [Sec. note: changed to 1 November 2005]. **COMPLETED**.
26	BNL/NNDC	Data definition/policy.	Ensure that discussions on the inclusion of data on hyper-nuclei in ENSDF occur at USNDP meeting in November 2005, and consider whether new NSDD policy is required. **WITHDRAWN**.
27	T. Burrows, BNL/NNDC	Improvements to codes.	Explore possible improvements to GTOL, following on from studies at Petersburg Nuclear Physics Institute. **COMPLETED**.
28	R. Firestone, LBNL	Data development.	Provide network with a new version of GAMUT by end of 2005. Update code (within 3 months, otherwise LBNL (Firestone) send code to NNDC.

29	IAEA/NDS; BNL/NNDC	Seek support for mass chain evaluations.	Invite relevant specialist/managers from most appropriate institutes to attend next NSDD meeting. **COMPLETED**.
30	IAEA/NDS	Seek support for mass chain evaluations.	Explore/organise 1-day *ad hoc* meeting of 3 or 4 Directors/Heads of appropriate institutes to discuss NSDD and develop a coherent approach to EU funding. **COMPLETED**.
31	J. Tuli, BNL/NNDC; A. Nichols, IAEA/NDS	Seek support for mass chain evaluations.	Following provision of information from N. Stone, write to interim Director of iThemba Labs, South Africa, to seek their involvement in NSDD. **COMPLETED**.
32	J. Tuli, BNL/NNDC	Evaluation responsibilities	Send network members copy of Responsibilities table (by July 2005). **COMPLETED**.
33	All network participants	Evaluation responsibilities	Correct Responsibilities table – send all changes to J. Tuli and A. Nichols (by mid-July 2005). **COMPLETED**.
34	I. Mitropolsky, PNPI	Possible venue for next NSDD meeting (May/June 2007).	Assess PNPI costs on the basis of Agency rules for external meetings. **COMPLETED**.
New			
35	A. Sonzogni, BNL/NNDC		Assemble and distribute statistics to support the proposal for the modification of ENSDF format to include cluster emission data.
36	A. Sonzogni, BNL/NNDC		Provide NSDD evaluation centres with a list of radionuclides/details for which either $t_{½}$, J^{π} and/or decay modes differ between ENSDF and NWC.
37	All network participants		Consider differences in nuclear properties between ENSDF and NWC, and adjust if deemed appropriate (after due consideration of evaluation effort for changes to ENSDF).
38	All network participants		Provide Tuli/Balraj Singh with comments on the proposed improvements in level-scheme drawings and tables for Nuclear Data Sheets publication within 2 weeks of receipt of sample pages by e-mail.
39	All network participants		Consider proposals of Singh/Kondev for the labelling of bands, configurations and cascades – follow established rules, and provide comments/criticisms.

40	A. Sonzogni, BNL/NNDC		Provide NSDD network with Java and Linux versions of ENSDF Editor by the end of 2008.
41	All network participants		Use and comment on ENSDF Editor to Sonzogni.
42	G. Shulyak, PNPI		Send list of errors found in ENSDF to Tuli by the end of July 2007.
43	G. Shulyak, PNPI		Provide copy of PNPI Editor program to NNDC, BNL.
44	B. Singh, McMaster University		Continue analysis of BM1W, and provide comprehensive recommendations to modify original Endt rules by the end of 2007.
45	BNL/NNDC		Rationalise and create appropriate Web links for more convenient access to all available sources of information (including manuals and NSDD workshop material).
46	All network participants		Provide Pritychenko with feedback/comments on Web sites devoted to B(E2) and ββ-decay.
47	F. Kondev, ANL; D. Balabanski, University of Sofia		Coordinate preparation of an informative article about nuclear data evaluations to be published in appropriate literature/journals (article to be prepared for publication by mid-2008).
48	BNL/NNDC; IAEA-NDS		Continue to pursue initiatives to improve the non-USA/North America contributions to the ENSDF mass chain evaluations.
49	D. Balabanski, University of Sofia		Explore methods of support for the establishment of ENSDF mass chain evaluations from within Europe.
50	J. Tuli, BNL/NNDC; A. Nichols, IAEA/NDS		Assist in the various national initiatives to improve non-North American contributions to the ENSDF mass chain evaluations – e.g. EU FP7 Town meeting in Helsinki, September 2007.
51	All network participants		Formulate and pursue methods to improve/expand mass chain contributions within their own countries.

52	A. Sonzogni, BNL/NNDC		NuDat: introduce ± symbol to the 'non-standard' layout of ENSDF data with respect to uncertainty (e.g. ± 1.5).
53	A. Sonzogni, BNL/NNDC		NuDat: acknowledge ENSDF as the data source for NuDat (e.g. at bottom of main Web page).
54	IAEA/NDS		Bring NSR key-wording responsibilities of NDS in-line with NNDC key-wording timetable.
55	J. Tuli, BNL/NNDC		Approach Elsevier to make introductory material on NSDD available on their Web site.

ANNEX 5

STATUS REPORTS OF EVALUATION CENTRES

Report of the National Nuclear Data Center

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National Nuclear Data Center
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June 2007

This report presents the status of nuclear structure, decay data, and related activities of the National Nuclear Data Center (NNDC) for the period June 2005 to May 2007, *i.e.,* since the 2005 NSDD meeting. The name of the NNDC staff member who has the lead responsibility for the part of the activity is given in parentheses.

ENSDF Evaluations Activity (J. Tuli)

NNDC responsibility consists of all mass chains not assigned to any other data center. Currently, it consists of the following 113 mass chains: A = 45-50, 57, 58, 60-73 (ex 62-64), 82-88 (ex 83), 94-99 (ex 98), 136-163 (ex 149, 151), 165, 230-240, >249.

The following mass-chains were evaluated/published since the last meeting (06/2005):

Mass	No. Of Nuclides	Evaluator(s)	Status
45	12	Burrows	Pre-review
47	12	Burrows	Published
48	13	Burrows	Published
67	13	Huo/Huang/Tuli	Published
88*	14	Sonzogni/Mukherjee	Published
94*	14	Abriola/Sonzogni	Published
137	15	Browne/Tuli	In review
140	16	Nica	Final
153	17	Helmer	Published
160	14	Reich	Published
162	15	Reich	Post-Review
221*	8	Jain/Kumar/Tuli	Published
232	9	Browne	Published
233*	9	B. Singh/Tuli	Published
234	10	Browne/Tuli	Published
236	9	Browne/Tuli	Published
251*	7	Jain/S. Singh/Tuli	Published
251No*	1	B. Singh/Tuli	In ENSDF

252	8	Nica	Published
253*	7	Jain/S. Singh/Tuli	Published
254*	13	Bhagwat/Thompon/Tuli	Published
255Rf*	1	B. Singh/Tuli	In ENSDF
266-294*	64	Gupta/Burrows	Published

The following mass chains are in progress:

A = 49, 95*, 96*,150*, 260*- 265*, 230, 247

(* indicates collaboration with other evaluators)

FTE: 3.40 including the NNDC staff (T. Burrows, J. Tuli and A. Sonzogni) and three subcontracted evaluators (E. Browne, N. Nica and C. Reich).

ENSDF Evaluation Reviews (J. Tuli)

The following evaluations were reviewed:

Browne	196
Burrows	131, 140
Reich	52, 64, 94, 200
Sonzogni	54, 135
Tuli	101, 109, 112, 213, 216, 218, 232, 233, 237
Winchell	74

ENSDF Evaluation Processing and Nuclear Data Sheets (J. Tuli)

On an average there were ~22 mass chains in the production pipeline at various stages of production. Evaluations received are checked for their consistency, format and physics content. The manuscripts prepared are returned to evaluators for their approval before they are sent for review. After review, and with corrections and changes made post-review by the evaluator, the final checks are made and the manuscripts prepared for publication.

Every month processing status report is sent to the network.

One issue of **Nuclear Data Sheets** (NDS) was prepared and sent every month to Elsevier. There is a change as to the number of volumes per year. Although the number of issues per year continues to be twelve there is only one volume per calendar year since 2006, it used to be three.

Nineteen mass chains were published in 2005 (A > 265 counted as one), and nineteen in first eleven issues in 2006. The December 2006 was a special issue of Nuclear Data Sheets with non-ENSDF based (new ENDF/B-VII.0 library) content. Although this new evaluated nuclear data library is dominated by the reaction data, one of its sublibraries (Decay Data Sublibrary) is fully based on ENSDF.

The published page count in NDS was 2930 in calendar year 2005 and 3118 in 2006.

ENSDF Evaluation Priority and Maintenance (J. Tuli)

A list of nuclides for priority evaluation is prepared and distributed once a year. The last distribution was on August 23, 2006.

NNDC continues to maintain, update, and distribute ENSDF. ENSDF statistics (as of June 1, 2006):

Nuclides	3,016
Datasets	16,003
Records	2,065,096
Size	165 MB
Comments Datasets	409
Adopted Datasets	3,018
Decay Datasets	3,788
Reaction Datasets	8,497
Reference Datasets	291

ENSDF is updated continuously. Two different versions are maintained. One in its original form as sent by the evaluators and the other after it is translated using COMTRANS. The former version is available only via the NNDC web site www.nndc.bnl.gov/nndc/evalcorner.

ENSDF is distributed twice a year. The last distribution was on March 6, 2007. The distribution is in two modes, an update to the file as well as the full ENSDF. The IAEA Nuclear Data Section receives the full file every month.

Nuclear Wallet Cards (J. Tuli)

All copies of Nuclear Wallet Cards for Radioactive Nuclides published in March 2004 have been distributed.

The seventh edition, April 2005, of Nuclear Wallet Cards was produced in July 2005 with 10000 copies printed. About 6000 copies have been distributed. The Nuclear Wallet Cards data file is updated twice a year following ENSDF distribution and is available online.

Nuclear Science References (D. Winchell)

NSR highlights for the period June-2005 to May-2007:

- 8,581 references added

- 189,380 total entries (as of May 24, 2007)
- 305,986 web queries
- Changes to database and website
- "Recent References" added to website
- Added DOI field to exchange format

Keyword preparation by the Nuclear Data Section, IAEA Vienna:

- Since late 2005, IAEA Vienna took responsibility for preparing keywords for three European journals, *viz*., Nucl. Phys. A, Eur. Phys. J. A, and Phys. Lett. B.
- If covered as planned, this should represent about 20-25% of the keywording effort.
- Files are prepared at NNDC and sent to Vienna for keywording.

Changes to subject indexing:

- NSR "selector" field is generated from keyword field, and used to create indexed Searches on nuclide, subject etc.
- New "prep" program was written to generate selectors.
- Selectors for all entries were re-generated and made publicly available on web in May 2007.
- Complete exchange-format file with new selectors was made available to collaborators.
- Daughter nuclides are now calculated and indexed in "Radioactivity" keywords where possible.
- New selector tags: "P" for parent and "G" for daughter.
- Specific subjects generated by reaction strings (i.e., "CHARGEX", "POLARIZED"…).
- Multiple selectors are generated for some keyword phrases.
- "MASS" selector generated for "Atomic Masses" articles.
- Added new selectors ("HALO", "HYPERFINE", …).

Other changes to database and web:

- Authors are now indexed by two initials, rather than one. This required rebuilding author and alias dictionaries.
- If author is entered as a search parameter, and more than one author/alias matches, then a list of matching names will be given at the bottom of the search results.
- Searching on "Nuclide" will look for entries with "N", "P" and "G" selectors.
- "List analyze" feature added to website.

Change in Database Manager

- Dr. Winchell has been the database manager for NSR for the last decade, and decided to leave NNDC on May 31st 2007 to pursue his other interests.
- Dr. Manojeet Bhattacharya has taken over as the NSR database manager from June 1, 2007.

Training and Mentoring (J. Tuli)

Jagdish K. Tuli helped organize, and served as co-director, for three IAEA sponsored Nuclear Structure Evaluation and Theory workshops held at ICTP, Trieste, Italy. The first workshop was sponsored by the IAEA, but hosted by the ICTP, and was held during Nov 17-28, 2003. The second and third workshops were jointly sponsored by the IAEA and ICTP, and hosted by the ICTP, and were held during April 4-15, 2005 and Feb 20-March 3, 2006, respectively. Jagdish Tuli and Thomas Burrows, from NNDC, lectured at these workshops and conducted hands-on training for the participants. The materials were prepared, presented and published as the IAEA reports.

Thomas Burrows continues to mentor and collaborate with Dr. Mohini Gupta of India (a Trieste-03 trainee) in the evaluation of A=260-265 and is mentoring Dr. Ninel Nica of Texas A&M (a Trieste-05 trainee).

Dr. Mohini Gupta from India visited the NNDC in 2005 to collaborate with Thomas Burrows on the evaluation of A=266-294.

Alejandro Sonzogni mentored and collaborated with Dr. S. Basu of India in evaluation of A=150. Dr. Basu visited NNDC during summer of 2006. Alejandro also mentored and collaborated with Dr. Daniel Abriola of Argentina (a Trieste-05 evaluators' workshop trainee) in evaluation of A=94.

ENSDF Analysis and Checking Codes (T.W. Burrows)

The ENSDF analysis and checking codes continue to be maintained and improved; recent improvements and their current status are given a separate report accompanying these distributions. In addition to NSDFLIB and RULER, FORTRAN 95 versions of ALPHAD, ComTrans, FMTCHK, ENSDAT, GTOL, and PANDORA have been distributed and the FORTRAN 95 versions of the remaining programs are undergoing in-house testing. BrIcc 1.3 ("No hole" approximation) and BrIcc 2.0 ("Frozen orbitals" approximation) have been released since the last network meeting; this is a result of collaboration between the Australian National University, National Nuclear Data Center, Petersburg Nuclear Physics Institute, and University of Tennessee. FMTCHK has implemented several new checks based on an error report from PNPI. GTOL was converted to double precision to solve platform-dependent problems and additional tables were added to its report.

NuDat (A. Sonzogni)

Versions 2.2 and 2.3 of NuDat were released since the 2005 meeting. The last version was made available to the public in March 2007. The following are the main upgrades to NuDat:

a) Tool-tips to navigate the chart of nuclides.

b) Triple gamma coincidence search.
c) Glossary of the many terms used in NuDat.
c) Uncertainties are given in the traditional Nuclear Data Sheets style as well as in a standard style.

A succinct summary of NuDat contents as of June 2007 is given in the table below:

Number of nuclides	3,166
Number of levels	146,313
Number of levels with known half-life	21,076
Number of gamma rays	216,368
Number of alpha transitions	2,344
Number of gamma-gamma coincidences	2,622,671

NuDat contains highly processed ENSDF data that allows for complex queries, which facilitates data mining and illustrate the richness of the database. As an example, shown in Fig.1, the first 2+ level energy for even-even nuclides was looked for as a function of Z and A for Z larger than or equal to 50 (Sn), and then, the quadrupole deformation parameter was deduced using Grodzin's formula. Results are shown in the following figure, where experimentally known nuclides with no quadrupole deformation data are plotted as a grey cell. The high-deformation regions at mid-shell are clearly seen.

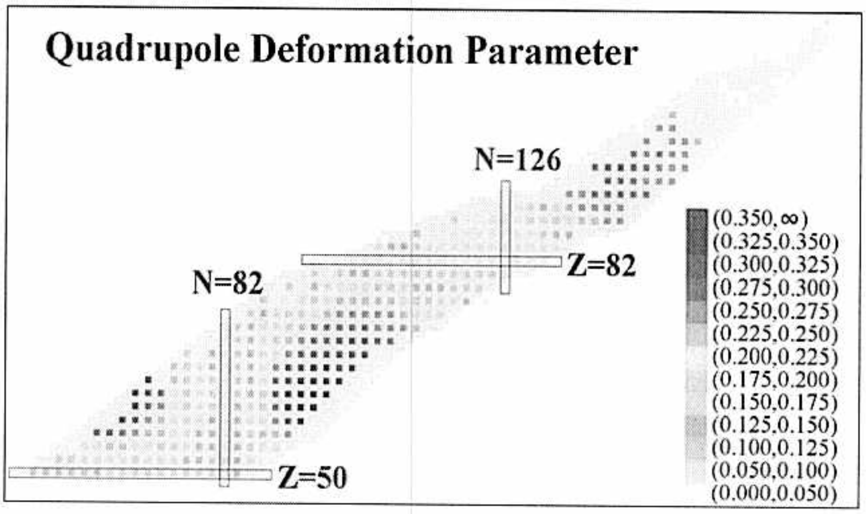


Fig.1. NuDat - Quadrupole deformation parameters.

Finally, 1.1 million retrievals were performed from NuDat from a very diverse body of web addresses in the last two years, and on average, about 10 monthly emails are received from NuDat users.

NNDC Computer System (R. Arcilla)

To improve the availability, reliability and security of its Web-based data services, NNDC performed the following computer infrastructure upgrades and reconfiguration during the reporting period:

1) Purchased and installed a second Web server in the second half of 2005. Automatic failover was then configured between the first Web server and the second Web server. If the first Web server stops working, all Web traffic will be automatically redirected to the second Web server and vice versa.

2) Upgraded the operating system (Linux), DBMS software (Sybase) and the storage capacity (by another 132 GB) on the master and the slave database servers. The slave database server was then relocated from the NNDC Computer Room to the BNL Central Computing facility. The master database server is still housed in the NNDC Computer Room. This configuration would provide the minimum redundancy to enable NNDC to quickly recover from any disaster that may befall to either site.

Web-based Services (B. Pritychenko)

NNDC is continuing to improve its services, accessible at www.nndc.bnl.gov, by upgrading its computer infrastructure as described above and improving web retrieval capabilities. The following software upgrades were done in the last 2 years:

- Web servers were migrated to Enterprise version of Red Hat Linux operating system and Tomcat5 web server software. The current nuclear data retrieval system is highly reliable and tightly integrated with nuclear structure evaluations and compilation efforts.

New and/or improved nuclear structure data services introduced in the last two years:

- Chart of Nuclides
- Qcalc (Java version of Q-value calculator)
- BrIcc, B(E2) and ββ-decay
- Logft and HSIcc upgrades
- NuDat and NSR improvements.

The new services and upgrades significantly improved capabilities and user friendliness for ENSDF, NSR and NuDat databases and increased the value of the NNDC web services.

In fiscal year 2006, total number of nuclear data retrievals from USNDP databases exceeded one million. This milestone was recognized by nuclear physics community and Brookhaven National Laboratory, see http://www.bnl.gov/bnlweb/pubaf/bulletin/2006/bb102006.pdf.

NNDC web retrievals as a function of time are shown in Fig. 2.

Total number of data retrievals in the calendar year 2006 increased to 1,206K versus 850K in 2005. In the same period, ENSDF data retrievals grew from 147K to 151K and NuDat & Chart of Nuclides data retrievals increased from 374K to 631K. The remarkable increase in NuDat data retrievals reflects the growing popularity of the database and the powerful software using latest Java and Java script web technologies as well as a broad appeal of Chart of Nuclides to less sophisticated users.

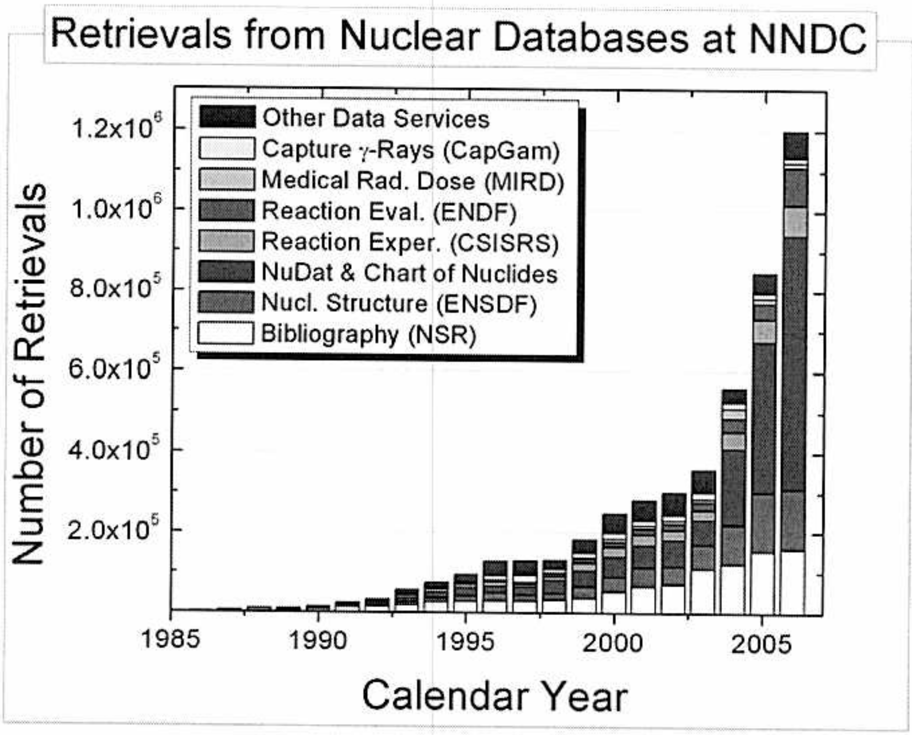


Fig.2. Retrievals from the nuclear database at the NNDC.

Selected NNDC Publications (6/2005-5/2007)

On the NNDC webpage, http://www.nndc.bnl.gov/articles/jsp/references/formrefs.jsp, a complete list of recent papers and reports by the NNDC staff can be found. A selected list of ENSDF-related papers, published in refereed journals, by the NNDC staff and its subcontracted evaluators is as follows:

1. Next-generation Nuclear Data Web Services, **A. A. Sonzogni**, **Nucl. Phys. A758,** 178c (2005)

2. "Particle-core coupling in the transitional proton emitters 145,146,147Tm", D. Seweryniak, C.N. Davids, A. Robinson, P.J. Woods, B. Blank, M.P. Carpenter, T. Davinson, S.J. Freeman, N. Hammond, N. Hoteling, R.V.F. Janssens, T.L. Khoo, Z. Liu, G. Mukherjee, J. Shergur, S. Sinha, **A.A. Sonzogni**, W.B. Walters and A. Woehr, **Eur. Phys. Jour. A25,** s01 159 (2005)

3. "Recoil decay tagging study of 146Tm", A. Robinson, C.N. Davids, D. Seweryniak, P.J. Woods, B. Blank, M.P. Carpenter, T. Davinson, S.J. Freeman, N. Hammond, N. Hoteling, R.V.F. Janssens, T. L. Khoo, Z. Liu, G.

Mukherjee, C. Scholey, J. Shergur, S. Sinha, **A.A. Sonzogni**, W.B. Walters and A. Woehr, **Eur. Phys. Jour. A25,** s01, 155 (2005)

4. "Nuclear Data Sheets for A = 88", G. Mukherjee and **A. A. Sonzogni**, **Nucl. Data Sheets 105,** 419 (2005)

5. "Nuclear Data Sheets for A = 254", A. Bhagwat, N. J. Thompson and **J. K. Tuli**, **Nucl. Data Sheets 105,** 959 (2005)

6. "Nuclear Data Sheets for A = 67", Huo Junde, Huang Xiaolong and **J. K. Tuli**, **Nucl. Data Sheets 106,** 159 (2005)

7. "Nuclear Data Sheets for A = 233", Balraj Singh and **Jagdish K. Tuli**, **Nucl. Data Sheets 105,** 109 (2005)

8. "Nuclear Data Sheets for A = 160", **C. W. Reich**, **Nucl. Data Sheets 105,** 557 (2005)

9. "Nuclear Data Sheets for A = 266-294", M. Gupta and **Thomas W. Burrows**, **Nucl. Data Sheets 106,** 251 (2005)

10. "Nuclear Data Sheets for A = 252", **N. Nica**, **Nucl. Data Sheets 106,** 813 (2005)

11. "Structure of the Odd-A, Shell-Stabilized Nucleus 253 102No" , P. Reiter, T. L. Khoo, I. Ahmad, A. V. Afanasjev, A. Heinz, T. Lauritsen, C. J. Lister, D. Seweryniak, P. Bhattacharyya, P. A. Butler, M. P. Carpenter, A. J. Chewter, J. A. Cizewski, C.N. Davids, J. P. Greene, P.T. Greenlees, K. Helariutta, R.-D. Herzberg, R.V.F. Janssens, G. D. Jones, R. Julin, H. Kankaanpaa, H. Kettunen, F. G. Kondev, P. Kuusiniemi, M. Leino, S. Siem, **A.A. Sonzogni**, J. Uusitalo, and I. Wiedenhover, **Phys. Rev. Lett. 95,** 032501 (2005)

12. "Nuclear Data Sheets for A = 153", **R.G. Helmer**, **Nucl. Data Sheets 107,** 507 (2006)

13. "Nuclear Data Sheets for A = 48", **T.W. Burrows**, **Nucl. Data Sheets 107,** 1747 (2006)

14. "Nuclear Data Sheets for A = 253", Ashok K. Jain, Sukhjeet Singh and **Jagdish K. Tuli**, **Nucl. Data Sheets 107,** 2103 (2006)

15. "Nuclear Reaction and Structure Data Services of the National Nuclear Data Center", **B. Pritychenko, A. A. Sonzogni, D. F. Winchell, V. V. Zerkin, R. Arcilla, T. W. Burrows, C. L. Dunford, M. W. Herman, V. McLane, P. Oblozinsky, Y. Sanborn, J. K. Tuli, Ann. Nucl. Energy 33,** 390 (2006)

16. "Nuclear Data Sheets for A = 94", D. Abriola and **A. A. Sonzogni, Nucl. Data Sheets 107,** 2423 (2006)

17. "Nuclear Data Sheets for A = 236", **E. Browne and J. K. Tuli, Nucl. Data Sheets 107,** 2649 (2006)

18. "Nuclear Data Sheets for A = 251", **J. K. Tuli**, Sukhjeet Singh and Ashok K. Jain, **Nucl. Data Sheets 107**, 21347 (2006)

19. "Direct evidence for the onset of intruder configurations in neutron-rich Ne isotopes", J.R. Terry, D. Bazin B.A. Brown, C.M. Campbell, J.A. Church, J.M. Cook, A.D. Davies, D.-C. Dinca, J. Enders, A. Gade, T. Glasmacher, P.G. Hansen, J.L. Lecouey, T. Otsuka, **B. Pritychenko**, B.M. Sherrill, J.A. Tostevin, Y. Utsuno, K. Yoneda and H. Zwahlen, **Phys. Lett. B640,** 86 (2006)

20. "ENDF/B-VII.0: Next Generation Evaluated Nuclear Data Library for Nuclear Science and Technology", M.B. Chadwick, **P. Oblozinsky, M. Herman,** N.M. Greene, R.D. McKnight, D.L. Smith, P.G. Young, R.E. MacFarlane, G.M. Hale, S.C. Frankle, A.C. Kahler, T. Kawano, R.C. Little, D.G. Madland, P. Moller, R.D. Mosteller, P.R. Page, P. Talou, H. Trellue, M.C. White, W.B. Wilson, **R. Arcilla, C.L. Dunford, S.F. Mughabghab, B. Pritychenko, D. Rochman, A.A. Sonzogni,** C.R. Lubitz, T.H. Trumbull, J.P. Weinman, D.A. Brown, D.E. Cullen, D.P. Heinrichs, D.P. McNabb, H. Derrien, M.E. Dunn, N.M. Larson, L.C. Leal, A.D. Carlson, R.C. Block, J.B. Briggs, E.T. Cheng[10] H.C. Huria, M.L. Zerkle, K.S. Kozier,A.Courcelle, V. Pronyaev and S.C. van der Marck, **Nucl. Data Sheets 107,** 2931 (2006)

21. "Nuclear Data Sheets for A = 47", **T.W. Burrows, Nucl. Data Sheets 108,** 923 (2007)

22. "Nuclear Data Sheets for A = 234", **E. Browne, J. K. Tuli, Nucl. Data Sheets 108,** 681 (2007)

23. "Nuclear Data Sheets for A = 2221" A.K. Jain, S. Singh, S. Kumar, **J. K. Tuli, Nucl. Data Sheets 108,** 883 (2007)

Report of the IAEA Nuclear Data Section to the International Network of Nuclear Structure and Decay Data Evaluators for the period May 2005 – June 2007

Alan Nichols
IAEA Nuclear Data Section
Vienna, Austria

1. ENSDF AND NSR

Staff have been recruited into the IAEA Nuclear Data Section who possess the necessary background knowledge to undertake specific tasks involving the study of nuclear structure and decay data, more specifically with respect to ENSDF and NSR.

1.1. ENSDF

Daniel Abriola (ex-Physics Department, TANDAR Laboratory, CNEA, Buenos Aires, Argentina) joined the Nuclear Data Section in January 2007. He has previously worked for short periods of time at the Brookhaven National Laboratory with Alejandro Sonzogni (NNDC) on the mass chain evaluation for A = 94 (*NDS* **107** (2006) 2423). Daniel will continue to undertake mass chain evaluations in conjunction with NNDC staff; evaluation of A = 96 is currently underway.

1.2. NSR

Mark Kellett (ex-NEA Data Bank, Paris, France) joined the Nuclear Data Section in 2005. Primarily though his efforts, the Nuclear Data Section is now responsible for maintaining the NSR entries for *Nuclear Physics A*, *European Physics Journal A*, and *Physics Letters B*.

2. WEB-BASED SERVICES

The migration of all the Web-services from VMS to Linux-based systems has been completed, and has operated reliably from implementation in 2004-2005. Further improvements have been made to the EXFOR/CINDA/ENDF retrieval systems with direct links to Web-journals and NSR, and inclusion of the data retrieval in the new computational format (T4). The ENDF retrieval system has been extended to include the IRDF-2002, JEFF-3.1 and ENDF/B-VII.0 libraries. Further developments of the system have been based on analyses of retrieval statistics, user feed back and regular discussions within NDS and with NNDC staff.

3. DATA DEVELOPMENT PROJECTS

IAEA nuclear data development activities are primarily aimed at improving the quality and quantity of nuclear data accessible by all Member States through the following functions:

- coordinated research projects,
- individual research contracts, contractual and special service agreements with experts in specific fields,

- specialised technical meetings,
- work undertaken directly by NDS staff.

Immediate outputs of these data development projects include:

- creation of new data bases designed and dedicated to various energy and non-energy based applications,
- new contributions or improvements to existing databases,
- documents related to the database description, verification and validation,
- software tools for data manipulation including visualisation and verification,
- users' manuals when appropriate.

3.1. Coordinated Research Projects (CRP)

Four coordinated research projects on nuclear reaction data were active and continued during 2005; four CRPs on "Prompt-gamma activation analysis", "Cross section standards", "Nuclear data for Th-U fuel cycle" and "Nuclear data for the production of therapeutic radionuclides" were completed during the course of 2004-07. Three new CRPs were approved during 2004 for which contracts/agreements were awarded, and their first RCMs were convened in 2005. The status of the various on-going nuclear data CRPs is summarised in Table 1. The total number of currently active CRPs in NDS is 10, including those identified with the A+M Data Unit (but not listed in Table 1).

Table 1. Status of Coordinated Research Projects Dedicated to Nuclear Data.

Short title	Duration	Participants (contracts)	Status
Prompt gamma-rays from slow neutron capture	1999-2004	7 (3)	Completed – database assembled, and report published
Cross-section standards	2002-2006	9 (4)	Completed – database assembled, and document in preparation
Nuclear data for Th-U fuel cycle	2002-2006	10 (6)	Completed – database completed, and document in preparation
Nuclear data for the production of therapeutic radionuclides	2003-2007	9 (4)	Completed – database/document in preparation
RIPL-III	2003-2008	11 (5)	On-going
Reference database for ion beam analysis	2005-2009	9 (4)	Approved and on-going
Reference database for neutron activation analysis	2005-2009	6 (4)	Approved and on-going
Updated decay data library for actinides	2005-2009	7 (4)	Approved and on-going
Heavy charged-particle interaction data for radiotherapy	2007-2010	?	Approved, and about to begin
Minor actinide neutron reaction data	2007-2011	?	Approved, and about to begin

Most relevant to NSDD network:

(a) CRP on "Updated Decay Data Library for Actinides"

Objectives:

- Measure specific actinide decay data judged to be inadequate, assuming suitable sources are available.
- Evaluate half-lives, and α-particle and γ-ray emission probabilities (see Table 2).
- Assemble database that constitutes improved/recommended decay data files for actinides of direct application in nuclear facilities, and for waste management.

Activities:

- Project was approved on 7 December 2004, and initiated in 2005.
- First Research Coordination Meeting was held at IAEA Vienna, Austria, 17-19 October 2005.
- Second Research Coordination Meeting was held at IAEA Vienna, Austria, 28-30 March 2007.

References:

M.A. Kellett (Ed.), Summary Report of the First RCM on Update of Decay Data Library for Actinides, IAEA Vienna, Austria, 17-19 October 2005, INDC(NDS)-0479, January 2006.

M.A. Kellett (Ed.), Summary Report of the Second RCM on Update of Decay Data Library for Actinides, IAEA Vienna, Austria, 28-30 March 2007, INDC(NDS)-0508, to be published 2007.

Table 2. Radionuclides selected for extensive re-evaluation.

Responsible evaluator	Actinides	Natural decay products
M.-M. Bé	^{234,238}U, ^{243}Am, ^{252}Cf	^{210}Tl, ^{210,214}Pb, ^{210,214}Bi, ^{210,214,218}Po, ^{218}At, ^{218,222}Rn, ^{226}Ra
V.P. Chechev	^{233}Th, ^{233}Pa, ^{237,239}U, ^{236,236m,237,238,239}Np, ^{238,239,240,241,242}Pu, ^{241}Am, ^{242,244}Cm	^{227}Ac
Huang Xiaolong	^{231}Th, ^{235}U	^{213}Bi, ^{213}Po, ^{217}At, ^{217}Rn, ^{221,223}Fr, ^{225}Ra, ^{225}Ac
F.G. Kondev	^{243,245,246}Cm	^{206}Hg, ^{206,207,209}Tl, ^{209,211}Pb
A. Luca	^{234}Th, ^{236}U	^{228}Ra
G. Mukherjee	^{229}Th, ^{233}U	-
A.L. Nichols	^{228}Th, ^{242,242m,244,244m}Am	^{208}Tl, ^{212}Pb, ^{212,215}Bi, ^{212,216}Po, ^{211,219}At, ^{219,220}Rn, ^{224}Ra
A.K. Pearce	^{232}Th, ^{231}Pa, ^{232}U	^{223}Ra, ^{228}Ac
Unallocated, April 2007	-	^{211}Bi, ^{211,215}Po, ^{215}At

3.2. Additional activity: Handbook of Nuclear Data for Safeguards (INDC(NDS)-0502, January 2007)

A set of recommended nuclear data have been assembled that are judged to be suitable for application with respect to nuclear materials accounting techniques. These revised data supersede the tabulations to be found within IAEA report INDC(NDS)-376, December 1997. The update is based on available evaluated nuclear databases and recently published files, books and technical reports (CRP (*"Updated X-ray and Gamma-ray Decay Data Standards"*), BIPM-5, LNHB, ENSDF, JEFF-3.1, Mughabghab (2006) and ENDF/B-VII). Every effort has been made to ensure that the recommended data are credible and correct with respect to their original sources:

> Section A contains decay data, thermal neutron capture cross section data, resonance integrals and neutron emission yields per fission for relevant actinides and their natural decay products;
>
> Section B includes decay data and thermal neutron capture cross section data for important fission products;
>
> Section C presents fission product yield data for selected actinides.

The recommended data sets can be inspected as tables in the INDC (NDS) report, or through the adoption and use of appropriate software associated with a Web site located at *http://www-nds.iaea.org/sgnucdat/*

4. ICTP-IAEA WORKSHOPS ON NUCLEAR STRUCTURE AND DECAY DATA

The Abdus Salam International Centre for Theoretical Physics (ICTP, Trieste, Italy) in cooperation with the International Atomic Energy Agency has organised workshops on *Nuclear Structure and Decay Data: Theory and Evaluation* on a regular basis since November 2003:

(1) 17 to 28 November 2003, ICTP, Trieste, Italy; 24 participants and 11 lecturers/demonstrators – see IAEA report INDC(NDS)-452, January 2004; also available on *www-nds.iaea.org/reports-new/indc-reports/indc-nds/.*

(2) 4 to 15 April 2005, ICTP, Trieste, Italy; 27 participants and 11 lecturers/demonstrators – see IAEA report INDC(NDS)-0473, July 2005; also available on *www-nds.iaea.org/reports-new/indc-reports/indc-nds/.*

(3) 20 February to 3 March 2006, ICTP Trieste, Italy; 23 participants and 11 lecturers/demonstrators – see IAEA report INDC(NDS)-0496, June 2006; also available on *www-nds.iaea.org/reports-new/indc-reports/indc-nds/.*

Following on from a one-week trial workshop at the IAEA, Vienna, in November 2002, these workshops have been held at the Abdus Salam ICTP, and constitute a unique opportunity for scientists to gain extensive and up-to-date training on the evaluation of nuclear structure and decay data as developed for the preparation of ENSDF files. Nuclear physicists from all countries that are members of the United

Nations, UNESCO or the IAEA may attend such workshops. While the main purpose of such ICTP initiatives is to assist scientists from developing nations through a programme of training activities, applicants from developed countries are also welcome to attend.

Extensive presentations of the most pertinent scientific material are given by invited lecturers, along with the introduction of computer-based exercises and workshop tasks. Participants are also invited to contribute their own thoughts and presentations of direct relevance to the workshop. The computer-based laboratory facilities at ICTP are superior to those available at IAEA Headquarters, and were admirably suited to the implementation of individual exercises by approximately 30 students under a central control system as required for the ENSDF model exercises. Students are given the opportunity to review the contents of the programme through a written questionnaire and direct discussions close to the end of the two weeks of work.

Significant quantities of written material and various Powerpoint presentations have been prepared. Therefore, a relatively large fraction of this knowledge has been assembled in the form of working manuals for distribution and use at future workshops (see also Web page *www-nds.iaea.org/workshops/ictp2006/*). A summary of the country origins of past attendees at the IAEA and ICTP workshops is given in Table 3. Such events have a strong educational function, but may also serve to identify those students who may have sufficient personal interest to consider undertaking their own mass chain evaluations in the future. Efforts will continue to develop the contents of further workshops to the benefit of the participants and the International Network of Nuclear Structure and Decay Data Evaluators. Hopefully, a two-week workshop of this type can be held at Abdus Salam International Centre for Theoretical Physics on a regular basis every two or three years.

Table 3. Attendance at IAEA and ICTP NSDD workshops.

Country	*No.*	*Country*	*No.*
Algeria	3	Mongolia	2
Argentina	3 (3)	Nigeria	1
Australia	1 (1)	Pakistan	1
Bangladesh	3	Romania	4 (1)
Brazil	4 (2)	Russian Federation	5 (2)
Bulgaria	3 (2)	Spain	1
Cameroon	3	Sudan	2
China	8 (2)	Syria	1
Egypt	3	Turkey	1
France	2	UK	2
Hungary	1	USA	2 (2)
India	15 (6)	Ukraine	1
Iran	5	Uzbekistan	1
Iraq	1	Vietnam	1
Republic of Korea	2		

() denotes number of subsequent mass chain evaluators, albeit sometimes only temporary.

5. CONCLUDING REMARKS

The survival and maintenance of the quality of ENSDF depends on the recruitment of new data evaluators to replace the ageing nuclear physicists undertaking this work. Unless new blood can be introduced soon, there is a serious danger that the current loose confederation of dedicated participants will fade away – there is an urgent need for younger scientists to join the NSDD evaluation network. An initiative was launched by the IAEA in 2002/03 to establish regular workshops at ICTP, Trieste, Italy, for the training of new nuclear structure evaluators. The IAEA also provides seed-funding to ensure that the most promising students are able to contribute to the mass chain evaluations beyond the workshops by means of an agreed mentoring process that involves individual members of the NSDD network. There can be no doubt that the assistance of the worldwide nuclear physics research community is urgently required to ensure the survival of ENSDF at the necessary level of credibility, reliability and quality.

Isotopes Project

LAWRENCE BERKELEY NATIONAL LABORATORY

R.M. Clark (Project Leader), **C.M. Baglin*, M.S. Basunia*, R.B. Firestone*,**
Guests: Y. Ben-Dov, E. Browne, S.-C. Wu*
*Structure/decay data evaluators supported at LBNL by US Department of Energy

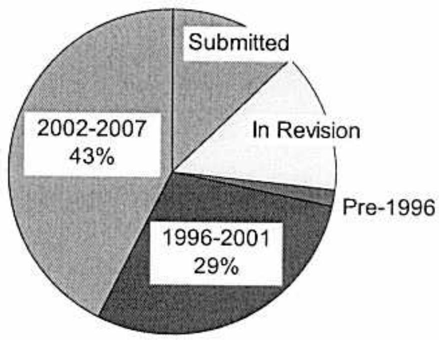
Report prepared by C.M. Baglin for the 11-15 June 2007 IAEA Advisory Group Meeting at Hotel Russ, St. Petersburg, Russia on *Coordination of the International Network of Nuclear Structure and Decay Data Evaluators*. This report covers the period from June 2005 through May 2007.

Mass Chain Responsibility:
A = 21-30, 59, 81, 83, 90-93, 166-171, 180-193 (ex. 188,190), 210-217 (~480 nuclides).

Current Levels of Effort (Structure/Decay Data):

Mass Chains/Nuclides:	1.75 FTE (staff)
	0.20 FTE (guest)
(n,γ) data Evaluation:	0.35 FTE
Data Dissemination:	0.10 FTE
Total:	**2.40 FTE**

Literature Cutoff Dates for LBNL Nuclides



Collaborations with:
- Institute of Isotope and Surface Chemistry and Budapest Reactor, Hungary
- Lawrence Livermore National Laboratory
- Decay Data Evaluation Project (DDEP) participants
- IAEA CRP participants

A. NUCLEAR STRUCTURE AND DECAY DATA EVALUATION

- **Mass Chain and Nuclide Evaluations (1.95 FTE):**
  Submitted: A=23, 24, 166, 184, 213, 216, 232, 237, ^{173}Pt, ^{187}Po, ^{192}At (83 nuclides).
  Published: A=22, 23, 176, 181, 185, 213, 216, 232, 237 (90 nuclides).
  Reviews Performed: A=48, 51, 191.

- **Decay Data Evaluation Project (DDEP) Participation:**
  Coordination of program and general editorial oversight for collaboration continues at LBNL, but without financial support.

- **Neutron Capture Data Evaluation (0.35 FTE)**
  a) **Collaboration with LLNL**:
  Continued collaboration with LLNL on statistical-model calculations of photon quasi-continuum information needed for a complete description of (n,γ) reactions at thermal energy. A paper describing calculations for Pd isotopes is in preparation.

b) **Participation in IAEA CRP on *Reference Database for Neutron Activation Analysis***
Continued participation in the above IAEA CRP; its objective is to provide recommended sets of evaluated k_0 and cross section data for use by this applied community. Initial intercomparison of data from three sources has been completed.

B. NUCLEAR STRUCTURE DATA DISSEMINATION (0.10 FTE)

Web Page Maintenance (0.10 FTE)

- **Installed** revised versions ENSDF, XUNDL and NSR databases (needed by our numerous web pages) as they became available.
- **Served** 255K distinct hosts who downloaded ~152 Gb data last fiscal year.

C. OTHER NUCLEAR PHYSICS ACTIVITIES INVOLVING LBNL STRUCTURE DATA EVALUATORS

a. **Collaboration with Chemical Research Centre, Budapest, Hungary:**
Measured (n,γ) cross sections for ^{6,7}Li, ^{10,11}B, ^{13}C, ^{15}N.

b. **Measurements of Cross Sections for Advanced Fuel Cycles:**
Completed analysis of ^{238}U(^{3}He,tf) cross section data measured in collaboration with LLNL. This reaction serves as a surrogate for the ^{237}Np(n,f) reaction which is of relevance to Advanced Fuel Cycle data needs, a current LBNL research priority. The work serves to benchmark the experimental procedure using the Liberace array at LBNL for a previously-measured reaction, with a view to employing the surrogate technique to obtain vital (n,f) cross section data for cases where direct experimental measurements are not possible. It has also extended data to equivalent neutron energies somewhat beyond those covered by the earlier ^{238}U(^{3}He,tf) measurement. LBNL LDRD funding for this project provides partial support for one of our structure evaluators, enabling retention of evaluation capability while addressing laboratory research priorities.

c. **Low-energy (α,γ) Cross Section Measurements**
Measured alpha-induced cross sections for ^{197}Au and thick-target yields for ^{64}Zn and ^{63}Cu; published in Phys. Rev. C 75, 015802 (2007).

d. **IAEA CRP on *New Applications of Prompt Gamma-ray Neutron Activation Analysis***
Completed participation in this CRP; presented invited talk on *LBNL Neutron Generator Activities* to final CRP Meeting in Bariloche, Argentina in December 2005 and contributed to final CRP report.

D. STRUCTURE DATA PUBLICATIONS, REPORTS and INVITED TALKS

Mass Chain or Nuclide Evaluation Publications

- *Nuclear Data Sheets for A=22*, R. Firestone, Nuclear Data Sheets **106**, 1 (2005).
- *Nuclear Data Sheets for A=181*, S.-C. Wu, Nuclear Data Sheets **106**, 367 (2005).
- *Nuclear Data Sheets for A=185*, S.-C. Wu, Nuclear Data Sheets **106**, 619 (2005).
- *Nuclear Data Sheets for A=176*, M.S. Basunia, Nuclear Data Sheets **107**, 791 (2006).
- *Nuclear Data Sheets for A=237*, M.S. Basunia, Nuclear Data Sheets **107**, 2323 (2006).
- *Nuclear Data Sheets for A=232*, E. Browne, Nuclear Data Sheets **107**, 2579 (2006).
- *Nuclear Data Sheets for A=23*, R. B. Firestone, Nuclear Data Sheets **108**, 1 (2007).
- *Nuclear Data Sheets for A=213*, M.S. Basunia, Nuclear Data Sheets **108**, 633 (2007).
- *Nuclear Data Sheets for A=216*, S.-C. Wu, Nuclear Data Sheets **108**, 1057 (2007).

E. Browne coauthored two additional mass chain evaluations under subcontract to BNL.

Other Nuclear Data Related Publications and Reports

The Evaluation of Gamma Ray Emission Probabilities in the Decay of ^{56}Co, Desmond MacMahon and Coral Baglin, National Physical Laboratory Report DQL-RN 010 (May 2005).

Radioactivity, in *Encyclopedia of Physics*, Third Edition, Bernard G. Harvey and Edgardo Browne; Rita G. Lerner (Editor), George L. Trigg (Editor), Wiley-VCH Verlag, December 2005.

Revisiting the U-238 Thermal Neutron Capture Cross Section and Gamma-emission Probabilities from Np-239 Decay, A.Trkov, G.L. Molnár, Z.S. Révay, S.F. Mughabghab, R.B. Firestone, V.G. Pronyaev, A.L. Nichols, M.C. Moxon, Nucl. Sci. Eng. B150B, 336 (2005).

Radioisotopes, Coral M. Baglin, in Kirk-Othmer Encyclopedia of Chemical Technology, John Wiley & Sons, NY, posted online 17 March 2006;
Summary of this article in Kirk-Othmer Concise Encyclopedia of Chemical Technology, John Wiley & Sons, NY (2007).

Table of Radionuclides, M.-M. Bé, V. Chiste, C. Dulieu, E. Browne, C. Baglin, V. Chechev, N. Kuzmenco, R. Helmer, F. Kondev, D. MacMahon, K.B. Lee, Bureau International des Poids et Mesures Monographie BIPM-5, Vol. 3 (2006).

Summary Report: First Research Coordination Meeting on Reference Database for Neutron Activation Analysis, R.B. Firestone and A. Trkov, INDC(NDS)-0477 920050.

Contributions from R.B. Firestone to *Database of Prompt Gamma Rays from Slow Neutron Capture for Elemental Analysis,* IAEA Scientific and Technical Information Publication 1263 issued 16 March 2007.

Invited Talks

- *Extension of the Evaluated Gamma-Ray Activation File (EGAF) to Include Data for Neutron Activation Analysis,* R.B. Firestone, First Co-ordination Meeting on Reference Database for Neutron Activation Analysis, IAEA, Vienna, Austria, 3 October 2005.
- *ENSDF – Reaction Data,* Coral M. Baglin, two 90-minute lectures at the IAEA/ICTP *Workshop on Nuclear Structure and Decay Data: Theory and Evaluation* held in Trieste, Feb. 2006.
- *ENSDF – Adopted Levels and Gammas,* Coral M. Baglin, two 90-minute lectures at the IAEA/ICTP *Workshop on Nuclear Structure and Decay Data: Theory and Evaluation* held in Trieste, Feb. 2006.
- *ENSDF – Decay Data,* Edgardo Browne, two 90-minute lectures at the IAEA/ICTP Workshop on *Nuclear Structure and Decay Data: Theory and Evaluation,* held in Trieste, Italy, Feb. 2006.
- *DDEP – Statistical Analysis of Data, Decay Scheme Normalization, Gamma-Ray Properties, and Alpha Hindrance Factors*, Edgardo Browne, four lectures at the CEA Workshop on Decay Data Evaluation, held in Saclay, France, March 6 – 10, 2006.
- *For the Best Nuclear Data Who Do You Call?*, Edgardo Browne, Colloquium – Spring 2007, Nuclear Engineering Department, University of California, Berkeley, California, April 2, 2007.

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REPORT

To IAEA Advisory Group Meeting on

NUCLEAR STRUCTURE AND DECAY DATA EVALUATORS' NETWORK

TUNL NUCLEAR DATA EVALUATION PROJECT

June 2007

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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 2005 reviews of A = 3 and A = 11, 12 are under way.

Recent Publications from the TUNL Data Evaluation Group

Nuclear Mass	Publication/Status
A = 8,9,10 [a]	Nucl. Phys. A745 (2004) 155
A = 3, 11, 12, 13	Evaluation activities in progress

[a] With D.J. Millener (BNL).

II. ENSDF

We have published a review of Energy Levels of Light Nuclei, A = 8-10 in 2004; the corresponding ENSDF files are completed and were added into ENSDF A=8 (2005), A=9 (2006), A=10 (2007).

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 make extensive use of the NSR link manager. We have also begun a new effort to organize and provide information on Thermal Neutron Capture evaluated data and Beta Decay data.

IV. Related Activities

TUNL continuously maintains a substantial reference database. We make extensive use of the Nuclear Science References services at NNDC and Monthly Updates from NNDC.

Supported by the U.S. Department of Energy Director of Energy Research, Office of High Energy and Nuclear Physics, Contract Nos. DEFG02-97-ER41042 (North Carolina State University); DEFG02-97-ER41033 (Duke University).

Progress Report on Nuclear Structure and Decay Data Activities at Argonne National Laboratory*

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Prepared for the 17th meeting of the *Nuclear Structure and Decay Data* Network
St. Petersburg, Russia, June 9-16, 2007

Period covered: May 2005 –June 2007

I. Program overview

The Argonne Nuclear Data Program (ANL NDP) includes in 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 nuclear reaction data, and the development of nuclear data measurement, 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. Program activities

II.1 Nuclear Structure and Decay Data Evaluations for ENSDF

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 NDP has responsibilities for evaluating nuclei within the A=176-179 and 199-209 mass chains whose up-to-date status is presented in Table 1. During the period of time covered by this report, evaluations of the A=201 and 203 mass chains were completed, reviewed and published in *Nuclear Data Sheets*. Work on the A=200 mass chain was also completed in collaboration with Dr. S. Lalkovski (University of Sofia, Bulgaria). This evaluation was submitted to NNDC, reviewed and is currently in press. Evaluations of A=202 and 206 mass chains are ongoing and these will be completed by the end of September 2007. Near

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* This work is supported by the Office of Nuclear Physics, U.S. Department of Energy under Contract No. DE-AC02-06CH11357.

Table 1. Evaluation status of mass chains assigned to the ANL NDP group

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/to be updated
178	NDS **72** (1994) 221	E. Browne	being evaluated/Argentina
179	NDS **72** (1994) 617	C.M. Baglin	being evaluated/LBNL
199	NDS **108** (2007) 79	B. Singh	completed/McMaster
200	NDS **75** (1994) 297	F.G. Kondev & S. Lalkovski	completed/in press*
201	NDS **108** (2007) 365	F.G. Kondev	completed
202	NDS **80** (1997) 647	S. Zhu & F.G. Kondev	being evaluated/FY2007
203	NDS **105** (2005) 1	F.G. Kondev	completed
204	NDS **72** (1994) 409	M.R. Schmorak	to be evaluated/FY2008
205	NDS **101** (2004) 521	F.G. Kondev	completed
206	NDS **88** (1999) 29	E. Browne	being evaluated/FY2007
207	NDS **70** (1993) 315	M. Martin	to be evaluated/FY2008**
208	NDS **47** (1986) 797	M. Martin	completed/ORNL
209	NDS **63** (1991) 723	M. Martin	to be evaluated/

* In collaboration with the group at the University of Sofia, Bulgaria
** In collaboration with Dr. G. Mukharjee, India

future plans for mass chain evaluations by the ANL NDP group are also indicated in Table 1. The ultimate goal is to complete evaluations of all mass-chains within the ANL NDP region of responsibilities in the next 2-3 years. ANL NDP is also involved in reviewing evaluations completed by other members of the NSDD network. Following on requests from the Editor of *Nuclear Data Sheets,* reviews of A=176 and 208 mass chains were completed during the period of time covered by this report.

II.2 Specialized Decay Data Evaluations for the DDEP collaboration and for the IAEA-CRP on "Updated Decay Data Library for Actinides"

ANL NDP is contributing to the activities of the Decay Data Evaluation Project (DDEP) collaboration. Decay data for three nuclides were evaluated, including ^{177}Lu, ^{206}Tl and ^{246}Cm. Several nuclides were reviewed following requests from the DDEP coordinator.

Since October 2005, ANL NDP staff has been participating in the activities of the IAEA-CRP on "Updated Decay Data Library for Actinides". Evaluations on ^{243,245,246}Cm, ^{206}Hg, ^{206,207,209}Tl and ^{209,211}Pb were assigned to our program. Following recommendations made at the first IAEA-CRP meeting, measurements on half-lives, and γ-ray and α-particle emission probabilities for selected nuclides of interest (^{233}Pa, ^{240}Pu, $^{243\text{-}246}$Cm and ^{249,250}Cf) were also initiated at Argonne National Laboratory. Work on

^{240}Pu, ^{244,246}Cm and ^{250}Cf was completed and the results were published in two journal articles.

II.3 Other Activities

ANL NDP staff attended the IAEA/ICTP organized workshop on "Nuclear Structure and Decay Data: Theory and Evaluation" that took place in Trieste, Italy in February 2006. Two lectures entitled "Experimental Nuclear Structure Methods and Techniques" and "Contemporary Nuclear Structure Physics at the Extreme" were presented at this meeting. ANL NDP staff also participated in the DDEP training workshop that was organized by LNHB, Saclay in March 2006. Two lectures entitled "Log *ft* values in β decay" and "Example of Evaluation – ^{177}Lu nuclide" were presented.

In collaboration with scientists from the Australian National University, ANL NDP staff is involved in a horizontal evaluation (topical review) of properties of K-isomers in deformed nuclei. Data are compiled in ENSDF format, evaluated and processed using codes developed by the collaboration. The evaluation activities are near completion and a review journal article is envisioned to be published.

Our program is also involved in complementary experimental nuclear structure and decay data activities in collaboration with scientists from several U.S. national laboratories and universities, and leading nuclear physics institutes overseas. The main emphasis was on studies of properties of K-isomers in a wide range of nuclei, properties of nuclei far from the line of stability and spectroscopy of heavy nuclei. Some of the results from this effort have been already published and the relevant data were submitted to the appropriate data centers for inclusion into the ENSDF and XUNDL databases.

III. Personnel & Effort

ANL NDP is a member of the U.S. Nuclear Data Program that is sponsored by the Office of Nuclear Physics, Office of Science, U.S. DOE. One ANL full-time staff (0.85 FTE) was involved in nuclear structure and decay data activities during FY06. One ANL full-time staff (1.0 FTE) and a part-time post-doc (~0.5 FTE) have been contributing to the program activities during FY07.

IV. Publications & Presentations (2005-2007)

- **31** articles in peer reviewed scientific journals
- **14** articles in refereed conference proceedings & books
- **45** contributed abstract in conference proceedings & meetings
- **5** technical reports & preprints
- **18** presentations at scientific conferences & professional meetings
- **3** invited seminars & colloquia

Nuclear Data Project at McMaster University

Status Report: May 21, 2005 to May 31, 2007

B. Singh

Department of Physics and Astronomy, McMaster University, Hamilton, ON, Canada

IAEA-NSDD-07 meeting St. Petersburg, Russia, June 11-15, 2007

ENSDF Work:

Permanent Responsibility:
A= **1** (2005), **31-36** (1998), **37** (1998,w), **38** (1998,s), **39** (2006), **40** (2004), **41** (2001), **42** (2000), **43** (2001), **44** (1999), **64** (2007), **89** (1998), **98** (2003), **100** (1997,s), **149** (2004), **151** (1997,w), **164** (2001), **188** (2002), **190** (2003), **194** (2006)

- w: work in progress
- s: revision submitted
- The number in parentheses gives the year of last revision in ENSDF database

During 2005-07, work was also done on many other (priority) A-chains and nuclides, which are outside McMaster's A-chain responsibility

Mass-chain Evaluations Published/submitted Since May 21, 2005:

- **A=38,** J.A. Cameron and B. Singh, NDS (submitted 2006, review stage)
- **A=100,** B. Singh, NDS (submitted 2006, post-review stage)
- **A=135,** B. Singh, Yu. Khazov and A.A. Rodionov, NDS (submitted 2006, post-review stage)
- **A=64**, B. Singh, NDS **108**, 197-364 (2007)
- **A=199**, B. Singh, NDS **108**, 79-195 (2007)
- **A=74**, B. Singh and A.R. Farhan, NDS **107**, 1923-2102 (2006)
- **A=194**, B. Singh, NDS **107**, 1531-1746 (2006)
- **A=165**, A.K. Jain, A. Ghosh and B. Singh, NDS **107**, 1075-1346 (2006)
- **A=218**, A.K. Jain and B. Singh, NDS, **107**, 1027-1074 (2006)
- **A=39**, B. Singh and J. Cameron, NDS **107**, 225-354 (2006)
- **A=1,** B. Singh, NDS **106**, 601-618 (2005)
- **A=80**, B. Singh, NDS **105**, 223-418 (2005)
- **A=233**, B. Singh and J.K. Tuli, NDS **105**, 109-221 (2005)

Nuclide Updates (by B. Singh):

- **55 nuclides, many were either new nuclides in ENSDF or for which excited-state data became available for the first time**

SD Updates (by B. Singh):

- **For 21 nuclides, three are included in nuclide update category.**
- As of May 31, 2007, the ENSDF database is current on the coverage of all the published and known SD structures in nuclei, except data from three recent papers that are being evaluated.

Review of A Chains for ENSDF and nuclides for DDEP (by B. Singh):

- **A=122 and 153 for ENSDF. The A=153 submitted in Oct 2004 by R.G. Helmer was reviewed, updated for new papers and edited.**
  7 nuclides reviewed for DDEP

XUNDL work: Compilation of Data from Recent Literature (May 21, 2005 to May 31, 2007):
Initiated in December 1998, XUNDL project is continuing. Since 2003 both the low- and high-spin papers have been compiled. Since May 21, 2005, 715 compiled (but checked for level-scheme consistency) new datasets and about 47 updated datasets from about 300 recent (from May 2005 onwards) publications have been prepared at McMaster and included in XUNDL database. Five datasets received from other centers were checked, edited and sent to NNDC. Up-to-date on the coverage of data from experimental structure papers, 10 low-spin papers published in the last few weeks have been compiled but remain to be checked. Compiled datasets in XUNDL are being used by mass-chain evaluators, which should potentially help in the evaluation process. Details of this work can be found in the XUNDL status report.

Work in Progress:
A=38, 100, 135: At review or post-review stage, will be updated and completed for final publication in NDS.
A=78: Full update in collaboration with the data group in Kuwait. The mass chain is expected to be submitted to NNDC probably by Sept 2007.
A=37, 85, 151, 182: Full mass-chain updates.
A=58: Full mass-chain update in collaboration with Caroline Nesaraja at ORNL
Superdeformed Bands: Continuous update of SD band data for all nuclides from current publications.
Compilation of recent data for XUNDL: Continued work on compilation of current experimental nuclear structure publications.
New nuclides and nuclides for which excited state data become available: Such nuclides will be evaluated for ENSDF.
Review of BMLW and BELW values in ENSDF: This project is expected to continue in the coming year. All relevant multipolarities will be considered.

Collaborative Work as a Part of Training/Mentoring of ENSDF Evaluators

- **Collaboration with PNPI, Russia:**
  Since March 2003, McMaster group has worked closely with the team of evaluators (Yu. Khazov, A.A. Rodionov, S. Sakharov) at PNPI in evaluations of **A=132** and **135** nuclides.
  Also some consultation on A=**131** and **133** nuclides.
  Dr. Alexander Rodionov visited McMaster for 3 weeks in June 2006 for consultations and work on **A=135** mass chain. All his travel-related expenses were covered by McMaster. This mass chain is now at post-review stage.

- **Collaboration with Indian Institute of Technology (I.I.T.), Roorkee, India:**
  Since March 2004, McMaster group has worked closely with the team at Department of Physics, I.I.T., Roorkee, evaluating **A=165** and **218** nuclides and some other A chains. Both A=165 and 218 are now published in NDS.
  Dr. A.K. Jain visited our group for 3 weeks in June 2005 to work on A=218 mass chain. His local expenses were covered by McMaster group.

- **Collaboration with ORNL group:**
  Dr. C.D. Nesaraja visited our group for 3 weeks in May 2007 to work on A=58 mass chain. Her local expenses were covered by McMaster group. The work on this mass chain will continue for another few months through exchange of data files and comments.

- **Possible Collaboration with Panjab University, Chandigarh, India: ??**
  In January 2007 we approached Professor Ashok Bhati at Panjab to consider participation in the evaluation work. This university has been involved in nuclear research (experimental and theoretical) since 1960. Dr. Bhati's research interests are in both nuclear physics (at NSC in New Delhi) and in particle physics (at CERN and RHIC). About a month ago we started work on A=71 mass chain. Still preliminary!

Magnetic-dipole rotational bands:
Compilation of magnetic-dipole rotational structures is continuing in collaboration with Nuclear Theory group (and data group) at I.I.T., Roorkee, India. Subsequent to first publication of a table of such structures by Amita, A.K. Jain and B. Singh in Atomic Data and Nuclear Data Tables **74**, 283-331 (2000), an updated table in December 2006 has been posted on NNDC website. The update represents about 50% addition to the table of 2000. A publication is under preparation for submission to the Atomic Data and Nuclear Data Tables.

Personnel and Funding

- Alan Chen: Asst. Professor, Head of the Project
- Jim Waddington: Emeritus Professor: Co-PI of the project
- John Cameron: Emeritus Professor
- Balraj Singh: Research Scientist, Nuclear Data Evaluator

- Undergraduate Students (part-time):
- Joel Roediger: since Feb. 2004
- Max Mitchell: March 2006-April 2007
- Scott Geraedts: since March 2007

- One FTE support for evaluation + partial support for undergraduate students (from NSERC, Canada + DOE, USA)

Petersburg Nuclear Physics Institute Data Centre - Status Report, 2005 – 2007

I.A. Mitropolsky
Petersburg Nuclear Physics Institute
St. Petersburg, Gatchina, Russian Federation

The PNPI data centre consists of five nuclear physicist, one mathematician and two programmers based in the Nuclear Spectroscopy Laboratory of the Reactor Department.

Staff at the data centre assess, evaluate and referee Russian publications devoted to nuclear physics, and found in NSR. Examples include the following:

> abstracts of reports presented at the Russian Annual Conferences on Nuclear Spectroscopy and Structure of Atomic Nuclei,
> preprints of Joint Institute for Nuclear Research (Dubna), and Petersburg Nuclear Physics Institute (Gatchina).

This activity could be extended, if the Centre received additional publications from other Russian institutes. A local bibliographical system has also been constructed on the basis of the NSR - contains full text references, with keyword searching capabilities.

ENSDF evaluations

PNPI area of responsibility: A = 130 to 135 inclusive. The data centre has continued collaborating with Dr. B. Singh (McMaster University, Hamilton, Canada). Staff will be able to dedicate more effort in the future to new mass chain evaluations than previously able.

Mass number (A)	Last publication	Comments
130	*NDS*, **93** (2001)	by B. Singh (McMaster University)
131	*NDS*, **107** (2006)	-
132	*NDS*, **104** (2005)	-
133	*NDS*, **75** (1995)	in preparation (publish in 2008?)
134	*NDS*, **103** (2004)	by A. Sonzogni (NNDC, BNL)
135	*NDS*, **84** (1998)	In post review (to be published in 2007)

Searches continue to be made to discover any mistakes in the ENSDF files. A suite of programs has been developed to undertake regular searches for physical and formal errors. Refinements have been made to the GTOL code that are believed to assist in improving the quality of ENSDF mass chain evaluations.

Horizontal evaluations

A database of nuclear rotational bands has been constructed from the contents of ENSDF. The energies of the rotational states are defined, along with the variable moments of inertia. These data have been published in "Atlas of rotational bands in odd-mass nuclei" (in Russian (2003), and in English (2004)). A similar database has been recently assembled for odd-odd and even-even nuclei.

Various possibilities that fundamental regularities exist in nuclear data are being explored (e.g., significant digit distributions) for possible adoption in the future testing of ENSDF.

France Group Status Report

Jean Blachot
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F-91680 Bruyères-le-Chatel, France

We have since the beginning of the network the responsibility for 11 Mass chains. All the work now is now done as a consultant for the laboratory of Bruyères le Chatel CEA France

1. Status of publications in NDS:

101	NDS 83, 1 (2006) Put in ENSDF
104	NDS 64, 1 (1991),evaluated and put in ENSDF (Feb 2000)
107	NDS 89, 213 (2000) sent for publication March 2007
108	NDS 91, 135 (2000)
109	NDS 107, 355 (2006)
111	NDS 100, 179 (2003)
113	NDS 104 , 791(2005)
114	NDS 97, 593 (2002)
115	NDS 104,967 (2005)
116	NDS 92, 455 (2001)
117	NDS 95, 679 (2002)

2. Status of XUNDL.

Many files of XUNDL have been used for our evaluation in ENSDF.
The following files are available to update ENSDF but not evaluated for ENSDF.
The XUNDL files already in ENSDF are not listed below.

108

108**Rh**;	176YB(28SI,XG);	2002Po11
	64NI(48CA,4NG);	2002Go03
	173YB(24MG,XG)	2003FO09
108**IN**;	EC DECAY;	2002Ga35
	76GE(37CL,5NG);	2001Ch71
108**MO**	238U(A,FG):	2004HU02
108**RU**	252CF SF DECAY	2004CH54
	176YB(28SI,XG):	2000DE33
108**PD**	176YB(31P,XG):	2003LA23
108**CD**	96ZR(16O,4NG):	2000KE01
	108CD(G,G')	2003GA06

111

111**TC**	248CM SF DECAY:	2005URAA
111**RU**	248CM SF DECAY	2004UR05
111**RH**	252CF SF DECAY:	2004LU03

114

114**PD**	114RH B- DECAY:	2003LH01
	114RH B- DECAY:	2003LH01
114**AG**	208PB(16O,XG):	2003PO11
114**CD**	114CD(N,N'G):	2003BA57
114**IN**	113IN(N,G):	2002SAZO
	113IN(D,P):	2002SAZO
	115IN(D,T):	2002SAZO

116

116**PD**	238U(A,FG):	2003HU05
116**AG**	208PB(16O,XG):	2003PO11
116**CD**	116AG B- DECAY (8.6 S)	2001WA42
	116CD(N,N'G):	2003KA45
116**I**	103RH(16O,3NG):	2004MO02

117

117**Ag**	;252CF SFDECAY;	2002Hw06
117**PD**	248CM SF DECAY:	2004UR04
117**IN**	238U(12C,XG):	2002LU15

Status Report of Belgian Group

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Retired 1 October 2007 from all research and teaching activities of the University of Ghent. However, I hope to continue the mass evaluation work for the NSDD Network for at least another two years.

Since 2005:
we have finished the evaluation of A=106 which was sent to NNDC last May.
I was assisted for a couple of nuclides by one of my PhD students, Alexandru Negret, who is from NIPNE Institute, Bucharest , Romania (finished his PhD last year). He has the intention, when he goes back to Romania next spring, to become an NSDD evaluator. Dr. Bucurescu will be his supervisor in Bucharest (very experienced experimental nuclear spectroscopist), and he is willing to help in this evaluation work.

I plan for mid 2007-mid 2008 the evaluation of A=102, and from mid 2008-mid 2009 the evaluation of A=110.

D. De Frenne
June 2007

Status Report of Japanese Activities for Nuclear Structure and Decay Data Evaluation

J. Katakura
Nuclear Data Center
Nuclear Science and Engineering Directorate
Japan Atomic Energy Agency

1 Members

The present members of Japanese group for the evaluation of Nuclear Structure and Decay Data are following: H. Iimura, J. Katakura, M. Kanbe and S. Ohya. Most of them are part time evaluators. K. Kitao, Y. Tendow and A. Hashizume are voluntary evaluators, but not official members of Japanese group. T. Tamura has retired after A=122 evaluation.

New members are not foreseen. It is rather difficult in the present JAEA situation to recruit new members.

2 Mass-chain evaluation

The mass chain evaluation on which Japanese group has the responsibility is for A=118-129. The last publication of the mass chain and the status are listed in Table 1.

Table 1: Status of Mass Chain Evaluation

Mass	Last NDS publications	Evaluators	Status
118	NDS 75, 99 (1995)	Kitao	Evaluating (Kanbe, Kitao)
119	NDS 89, 345 (2000)	Ohya, Kitao	
120	NDS 96, 241 (2002)	Kitao	
121	NDS 90, 107 (2000)	Tamura	
122	NDS 108, 455 (2007)	Tamura	
123	NDS 102, 547 (2004)	Ohya	
124	NDS 80, 895 (1997)	Iimura, Katakura, Tamura, Kitao	New evaluation (by Katakura and Wu) is being reviewed.
125	NDS 86, 955 (1999)	Katakura	Evaluating (Katakura)
126	NDS 97, 765 (2002)	Katakura, Kitao	
127	NDS 77, 1 (1996)	Kitao, Oshima	New evaluation (by Hashizume) is being reviewed.
128	NDS 94, 227 (2001)	Kitao, Kanbe	
129	NDS 77, 631 (1996)	Tendow	Evaluating (Tendow)

The NDS publication after the previous meeting is A=122 and A=123. The evaluation of A=124 and A=127 have been sent to BNL and being reviewed. Other evaluations are being continued. But the manpower is decreasing. It becomes difficult to maintain the covered mass region. If possible, we would like to reduce the mass numbers in charge.

3 Other related activities on nuclear structure and decay data evaluation

3.1 Decay data evaluation for reactor decay heat prediction

For the application purpose to nuclear technology such as nuclear reactor and fuel cycle, we are compiling the JENDL (Japanese Evaluated Nuclear Data Library) . Although most of the data in JENDL are neutron induced reaction data, the decay data of fission product (FP) nuclides are needed for reactor decay heat prediction and inventory analysis in spent fuel. The number of FP nuclides amounts to nearly 1000, half of which have measured data. The measured data, however, occasionally suffer from so-called "Pandemonium Effect", in which high energy levels of daughter nuclides are missing in β-decays with high Q-values. In such a case the decay energy values derived from the measured decay scheme are not adequate for application purpose. There are roughly 100 such nuclides. Recently TAGS (Total Absorption Gamma-ray Spectroscopy) measurement has been planed in order to avoid "pandemonium Effect". WPEC (Working Party on International Evaluation Cooperation) in OECD/NEA NSC (Nuclear Science Committee) in cooperation with IAEA organized a subgroup to identify the nuclides, whose measured data by TAGS may improve the average decay energy values for decay heat application. The activity of the group is helpful for improving the decay energy values used for reactor decay heat prediction. We are now trying to use the TAGS data for decay heat application and incorporate them into the JENDL.

Status Report of the Nuclear Structure and Decay Data Evaluation in CNDC

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1. Mass Chain Evaluation

The nuclear structure and decay data evaluation group in China Nuclear Data Center (CNDC) has permanent responsibility for evaluating and updating NSDD for A=51,195-198; temporary for A= 67. The status is as follows:

Table 1 Status of Mass Chain Evaluation in CNDC

Mass chain A	Status	Evaluators
51	NDS,107,2131(2006)	Huang Xiaolong
195	Updated, not published	Huang Xiaolong
196	Being evaluated	Huang Xiaolong
197	NDS,104,283(2005)	Huang Xiaolong, Zhou Chunmei
198	NDS,95,59(2002)	Zhou Chunmei
67	NDS,106,159(2005)	Huo Junde,Huang Xiaolong,J.K.Tuli

2. Decay Data Measurement and Evaluation

The half-lives, relative γ ray emission probabilities of 36 γ ray and absolute γ ray emission probability for 191.9keV γ ray of ^{101}Mo were measured. The radioactive source of ^{101}Mo were obtained from the ^{100}Mo(n,γ)^{101}Mo reaction. A total of 27 sources were prepared. Single γ ray spectra were recorded by HPGe detector.

Half-lives were extracted from the decay curves of 191.9keV γ ray. Results from the decay over 11 half-lives of 12 separate sources were subjected to analysis by the method of least squares. The results gave a weighted average of 14.84±0.02 minutes where the error quoted is the probable error of the mean.

About 36 γ rays transitions to the ground state and the first two excited states of ^{101}Tc, which used to deduce the absolute γ ray emission probabilities by scheme balance method were determined. To improve the statistics, 15 sources were used. The results are listed in Table2.

Table 2 Relative γ ray emission probabilities of ^{101}Mo

Energy/keV	relative γ ray emission probabilities	
	Present work	NDS
191.92	100	100
378.99	1.72 2	1.69 8
491.5	0.32 2	0.37 3
499.65	7.63 38	7.66 24
505.05	64.4 7	2.0 2

505.92		63.8 14
523.83	1.08 4	0.87 6
533.57	2.34 10	2.18 10
590.10	104.8 49	105.5 46
606.8	0.11 10	0.4 1
660.64	1.14 4	1.23 6
695.56	37.2 6	36.6 8
701.80	1.86 6	1.96 11
732.98	1.67 13	1.47 8
871.08	9.25 14	9.4 4
877.39	18.8 4	17.7 10
887.0	0.70 7	1.03 7
1012.47	77.0 42	71.5 37
1018.58	3.38 22	4.0 2
1304.00	14.7 3	14.9 4
1583.1	0.43 3	0.45 4
1589.67	1.57 7	1.49 6
1594.8	0.12 3	0.12 3
1599.26	9.52 28	9.6 4
1605.3	0.29 8	0.23 3
1615.0	0.21 4	0.31 3
1662.49	3.80 7	3.84 7
1759.72	5.12 15	5.52 24
1882.26	0.67 7	0.47 3
1888.3	0.13 5	0.24 4
1946.54	0.30 4	0.44 3
2032.10	37.6 7	36.2 10
2038.40 2041.24	11.6 3	1.14 15 11.8 4
2047.31	0.29 8	0.49 4
2114.34	2.95 18	3.16 14

To check the decay scheme and the relative γ ray emission probabilities of ^{101}Mo, the affiliation method was adopted to determine the absolute γ ray emission probability for 191.9keV γ ray. The results is P_γ(191.9keV)=17.20±0.18. This value is different from the NDS value 18.21±0.21, which deduced by scheme balance method.

3. Other Related Activities- Chart of the Nuclides

The Chart of the Nuclides was developed taking into account the data obtained in 1998-2006. Unlike widespread nuclide charts the present Chart of Nuclides contains evaluated values of the main characteristics such as mass excess, nuclide percent abundance, thermal neutron capture cross sections for stable and natural long-lived nuclides; half-life, decay energy and spin, parity of ground/isomeric state for radioactive nuclides. These values are supplied with the standard deviations and taken from the evaluated data of China Nuclear Data Center, Nuclide Guide-3, International Chart of Nuclides-2003, Nuclear Wallet Cards, evaluated thermal neutron capture cross sections and evaluated atomic data. The presented data are applicable in medicine, agriculture, environmental protection etc.

IAEA's Technical Meeting on the Coordination of the International Network of Nuclear Structure and Decay Data Evaluators
Nuclear Physics Institute St. Petersburg, Russia, June 11-15, 2007

Status Report of Mass Chain Evaluation

Huo Junde
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Jilin University
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This report covers the mass chain evaluation activities of Nuclear Structure and Decay Data from June 2005 to May 2007..

1. Mass Chain Responsibility:
   A=52, 53, 54, 55, 56, 62, 63

2. Mass Chain Evaluation:
   Submitted to NNDC: A=53, 55
   Published in NDS: A=52, 54

3. Status of publication in NDS:
   52 NDS 108, 773 (2007)
   53 NDS 87, 517 (1999)
   54 NDS 107, 1393 (2006)
   55 NDS 64,723 (1991)
   ENSDF Updated Jan., 2001
   56 NDS 86, 315 (1999)
   62 NDS 91, 317 (2000)
   Joint with Dr. B. Singh (McMaster)
   63 NDS 92, 147 (2001)

   Other Mass Chains:
   67 NDS 106, 159 (2005)
   Joint with Drs. X. Huang (CNDC) and J. K. Tuli (NNDC)
   174 NDS 87, 15 (2000)
   Joint with Dr. E. Browne (LBL)
   176 NDS 84, 377 (2000)
   Joint with Dr. E. Browne (LBL)

Indian Institute of Technology Data Centre, Roorkee, India - Status Report, 2005 – 2007

Ashok K. Jain
Department of Physics
Indian Institute of Technology
Roorkee-247667, India

Staff: Prof. Ashok Kumar Jain
Sukhjeet Singh (Senior Research Fellow)
Suresh Kumar (Senior Research Fellow)

Trained at IAEA-ICTP workshops:
Sukhjeet Singh
Suresh Kumar

Publications:
Nuclear Data Sheets for A=165, A.K. Jain, Anwesha Ghosh, B. Singh, *NDS* **107** (2006) 1075-1346.
Nuclear Data Sheets for A=218, A.K. Jain, B. Singh, *NDS* **107** (2006) 1027-1074.
Nuclear Data Sheets for A=251, J.K. Tuli, S. Singh, A.K. Jain, *NDS* **107** (2006) 1347-1392
Nuclear Data Sheets for A=253, A.K. Jain, S. Singh, J.K. Tuli, *NDS* **107** (2006) 2103-2129.
Nuclear Data Sheets for A=221, A.K. Jain, S. Singh, S. Kumar, J.K. Tuli, *NDS* **108** (2007) 883-921.

Horizontal evaluations:
Table of Three-Quasiparticle Rotational Bands in Deformed Nuclei 153 ≤ A ≤ 187
S. Singh, S.S. Malik, A.K. Jain, B. Singh, *At. Data Nucl. Data Tables* **92** (2006) 1-46.

Table of Magnetic Dipole Rotational Bands
Amita Rastogi, A.K. Jain, B. Singh (2006).
http://www.nndc.bnl.gov/publications/preprints/mag-dip-rot-bands.pdf

Evaluations in progress:

Mass chains A=225 and 229 are in progress.
M.Sc. project was recently completed by two students.

Mass chain A=76 in collaboration with the Kuwait data centre.

Invited talk: A.K. Jain and Mohini Gupta - *"ENSDF – Purpose, Philosophy and Usage"*, at DAE-BRNS National Workshop on Nuclear Data for Reactor Technology and Fuel Cycle, 7-10 March 2005, BARC, Mumbai.

Acknowledgements:
Mentors: Balraj Singh (McMaster University) and Jagdish Tuli (NNDC, BNL).
Financial and logistic support: IAEA, Alan Nichols and NNDC staff.

Mass Chain Evaluations at Manipal University

Status Report: 21 May 2005 to 31 May 2007

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Manipal University, Manipal, Karnataka, India

in collaboration with
T.W. Burrows
National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY, USA

A = 266-294

Evaluated data for the superheavy mass region was published in "Nuclear Data Sheets for A = 266-294", Nuclear Data Sheets **106**, 261, 2005 (2005Gu33). Taking into account the peculiarities of experimentation in the super heavy region, an internally consistent evaluation methodology was adopted and applied. Systematics of the region based on the *best* available data has become possible. The evaluation method was based on 1992Ba77 and applied individually to 63 nuclides, comprising 14 elements, 29 experimentally observed mass chains and over 260 α-decay chains. Additional evaluation tools included using the approximations of 1984Sc13 for estimates of half-lives and an updated parameter set for the Viola-Seaborg phenomenology (1966Vi04).

A = 260-265

The above methods are currently being applied to the mass region A = 260-265. Some of the α-decay mass chains from heavier nuclei (A ≥ 266) end in this region and an update is due since new data are available. These nuclides were covered in 1999Ar21, 1999Ak02, and 2001Ak11 and 2000Fi12 (in the case of ^{265}Rf). The same evaluation methodology adopted for (distant) ancestors was judged to be appropriate for extension to descendants within an α-decay chain, and would also maintain consistency and uniformity of treatment.

A re-evaluation of existing data within the new framework in instances where no new data are available yields useful information. For instance, in the case of the even-even nucleus ^{264}Hs, no new data have appeared since 1999Ak02. When re-visiting the data using the above evaluation methods, a revision of the adopted Q-value and half-life is achieved. The revised value is seen to be closer to the systematics of expected half-lives for this nucleus. However, due to existing ambiguities in the measurements, the set of physical properties adopted for this nuclide are taken as "tentative".

The current evaluation spans about nine elements comprising ≈ 32 nuclides. It is possible that updates for specific nuclides with A < 260 may have to be considered concurrently.

Future Plans

Future plans for ENSDF data evaluations include the possibility of selectively updating data on some of the nuclides with A < 260.

Also, updates for A = 266-294 may become necessary over the next two years, depending on the pace at which new experimental data become available.

Data evaluations for the mass region 260 ≤ A ≤ 294 will be continued.

References

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1984Sc13: Z. Phys. **A316**, 19 (1984); K.-H. Schmidt, C.-C. Sahm, K. Pielenz, H.-G. Clerc; Some Remarks on the Error Analysis in the Case of Poor Statistics.

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Report of Mass Chain Evaluations: TANDAR Laboratory, Argentina

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TANDAR Laboratory
CNEA, Buenos Aires, Argentina

First year, 2003: A = 193 *(under IAEA contract ARG-12480-R0, March 2003)*
Evaluators:
TANDAR Laboratory, CNEA, Argentina - E. Achterberg, O.A. Capurro, G.V. Marti
^{193}At, ^{193}Po, ^{193}Bi, ^{193}Pb, ^{193}Tl, ^{193}Hg
Instituto de Fisica, Universidade de Sao Paulo, Brazil - V.R. Vanin, R.M. Castro
^{193}Au, ^{193}Pt, ^{193}Ir, ^{193}Os, ^{193}Re

April 2004 – complete evaluated mass chain uploaded to NNDC
August 2004 – evaluation received by reviewer for processing
November 2004 – received reviewer's report from NNDC
April 2005 – TANDAR part of the mass chain revised according to the reviewer's report, and re-sent to NNDC
October 2005 – complete revised mass chain uploaded to NNDC
January 2006 – publication as *NDS* 107 (2006) 1

Second Year, 2004: A = 191 *(under IAEA contract ARG-12480-R1, April 2004)*
Evaluators:
TANDAR Laboratory, CNEA, Argentina - E. Achterberg, O.A. Capurro, G.V. Marti
^{191}At, ^{191}Po, ^{191}Bi, ^{191}Pb, ^{191}Tl, ^{191}Hg
Instituto de Fisica, Universidade de Sao Paulo, Brazil - V.R. Vanin, N.I. Maidana, R.M. Castro
^{191}Au, ^{191}Pt, ^{191}Ir, ^{191}Os, ^{191}Re

July 2005 – TANDAR part of re-evaluated mass chain sent to NNDC
January 2007 – complete mass chain uploaded to NNDC for review
May 2007 – received reviewer's report in Buenos Aires
June 2007 – reviewer's report received I Sao Paulo (Vanin)

Third year, 2005: A = 178 *(under IAEA contract ARG-12480-R2, April 2005)*
Evaluators:
TANDAR Laboratory, CNEA, Argentina - E. Achterberg, O.A. Capurro, G.V. Marti
^{178}Re, ^{178}Os, ^{178}Ir, ^{178}Pt, ^{178}Au, ^{178}Hg, ^{178}Tl, ^{178}Pb

March 2006 – first half of re-evaluated mass chain sent to NNDC

Fourth year, 2007: A = 178 *(under IAEA contract ARG-14244-R0, March 2007)*
Evaluators:
TANDAR Laboratory, CNEA, Argentina - E. Achterberg, O.A. Capurro, G.V. Marti
^{178}Yb, ^{178}Lu, ^{178}Hf, ^{178}Ta, ^{178}W

March 2007 – second half of A = 178 mass chain re-evaluation began
June 2007 – first drafts ready of ^{178}Yb and ^{178}Lu ENSDF files
February 2008 – expected date to finish re-evaluations for A = 178

STATUS REPORTS OF OTHER PROJECTS AND ACTIVITIES

<u>Action item #34 from NSDD-2005</u>

B. Singh (McMaster) and F. G. Kondev (ANL)

C. M. Baglin (LBNL), T.W. Burrows (BNL), C. W. Reich (Idaho) and J. K. Tuli (BNL) were active participants in the preparation of this draft document.

For revision of rules #37-39, research community was approached and very useful comments and suggestions were received from Robert Janssens (ANL), Mark Riley (FSU) and Daryl Hartley (US Naval Academy).

IAEA-NSDD-07 meeting St. Petersburg, Russia. June11-15, 2007

"Propose guidelines for appropriate configurations/labels of band assignments; define the proper quantity and symbol to represent the transition quadrupole moment for rotational bands; propose an additional J^{π} rule for coupled bands, in addition to current rule #37 for other rotational bands (by November 5, 2005)."

1. Revision of Rule #37 (also #38 and #39): presenter: B. Singh
2. Labeling of Bands, Configurations and Cascades in ENSDF/NDS: presenter: B. Singh
3. Transition Quadrupole Moments for rotational bands: presenter: F. G. Kondev

1. **<u>Revision of Rule #37 (also #38 and #39)</u>: first presented at USNDP-2006: November 7-9, 2006; circulated to the NSDD network in Nov 2006.**

Rule 37:

Previous:

For a well-deformed nucleus when a regular sequence of $\Delta J=2$ (stretched quadrupole) transitions is observed at high spins as a cascade, the sequence may be assigned to a common band with E2 multipolarity for all the transitions in the cascade. A similar but somewhat weaker argument holds for less deformed nuclei where a common sequence of levels is connected by a regular sequence of $\Delta J=2$ (stretched quadrupole) transitions in a cascade.

Revised:

For a deformed nucleus, a regular sequence of gamma-ray transitions can be assigned to a $\Delta J=2$ or a $\Delta J=1$ rotational-band structure with definite spin-parity assignments if:

a) **the spin and parity of at least one level in this band is unambiguously determined; *and***

b) for $\Delta J=2$ band structures, at least one of the in-band transitions has a well established E2 multipolarity, *or*, for $\Delta J=1$ band structures,

i) at least one of the crossover ($\Delta J=2$) transitions has a well established E2 multipolarity, *or,*
ii) at least one of the stopover ($\Delta J=1$) transitions has a well established M1 (or M1+E2) multipolarity or (for parity-doublet bands) E1 multipolarity; *and*

c) some other in-band transitions are stretched quadrupole for the $\Delta J=2$ band structures or stretched dipole (or dipole plus quadrupole) for $\Delta J=1$ band structures.

Rule 38:

Previous:

For near-spherical nuclei, when a regular sequence of $\Delta J=1$ (stretched dipole) transitions is observed at high spins as a cascade, then the sequence may be assigned to a common band with (M1) multipolarity for all the transitions in the cascade. (Cascades of $\Delta J=1$, E1 transitions occur in rare cases of nuclides which show alternating-parity bands or reflection asymmetry.)

Revised:

To be omitted: contained in rule 37.

Rule 39:

Previous:

In the absence of angular distribution/correlation data, a regular sequence of transitions in a cascade may be assigned to a common structure or a band if (a) the low-lying levels of this structure have well established spin and parity assignments and (b) there is good evidence that, at higher energies and spins, the band has not changed in its internal structure due to band crossings or other perturbations.

Revised:

In the absence of angular distribution/correlation data or other supporting arguments, a regular sequence of gamma-ray transitions in high-spin data may be assigned to a common structure or a band with tentative spin-parity assignments if either the bandhead or some other low-lying member of this structure has reasonably well established spin and parity.
(Move this rule to section of "weak arguments" as rule #12

2. Labeling of Bands, Configurations and Cascades in ENSDF/NDS

Motivation: 1. To promote uniformity in labeling of bands and cascades.
2. To improve presentation in drawings and tables in ENSDF/NDS.
3. Possible search and retrieval capabilities for band structures or configurations.

(Currently no recommendations exist in ENSDF manual or policies.)

Proposed guidelines:

1. All level sequences (or cascades of gamma rays) which share (or appear to share) some common mode of excitation should carry flags to mark them as bands or gamma-ray cascades, e.g. BAND(A), BAND(B), etc.

   (Note: word "BAND" above is used as a dummy label in ENSDF; in the tables and drawings, only the flags such as "A", "B", etc. appear, not the word "BAND". The label (band/sequence ID) is given on the first record and detailed description on the next records.)

   (Possibly a new descriptor such as "CASCADE" could be introduced for structures that do not fit the category of conventional bands. This would require modification of several computer codes. Exact classification in terms of "BAND" and "CASCADE" may also become difficult in some cases e.g. in transitional nuclei.)

2. First (band/sequence-ID) record:
   The information on this record appears on the band drawing and space is limited there, so keep wording as concise as possible, avoiding redundancy. Band/sequence ID should contain no more than ~25 (printable) characters. For the sake of brevity, avoid using "CONF=....", "rotational", "collective", 'negative-parity', etc. Also avoid the use of uncommon, undefined or ambiguous labels such as "twin band", "t-band", "s-band", etc., on this record.

3. For configurations, use the translated version (i.e., use the alternate character set) as given in some examples below, when they are listed on the first (band-ID) record.

   Only the 1- or at the most 2-quasiparticle configurations (in the translated version) will fit on the first record.

   Specify "K|p=.." on the ID record for bands whenever possible.

   For rotational bands, when possible, use separate flags (e.g. BAND(A) and BAND(a)) for signature partners of a band.

Some Examples of First (band ID) record:

CL BAND(A)$ **K|p=1- g.s. band.**

CL BAND(B)$ **K|p=2+, |g-vib. band.**

CL BAND(C)$ **K|p=0+, |b-vib. band.**

CL BAND(A)$ **SD-1 band.**

CL BAND(A)$ **Dipole MR-1 band.**

CL BAND(D)$ **|n1/2[521] band.**

CL BAND(E)$ **|n5/2[512] band, |a=+1/2.**
CL BAND(e)$ **|n5/2[512] band, |a=-1/2.**

CL BAND(F)$ **|p7/2[523]~#|n3/2[521], |a=0.**
CL BAND(f)$ **|p7/2[523]~#|n3/2[521], |a=1.**

CL BAND(G)$ **3-qp, K|p=19/2+ band.**

4. Band/sequence continuation records:
All the detailed statements, arguments, comments, 3- or greater quasiparticle configurations, and source references concerning the band/sequence should be relegated to the records following the first band ID record. This information will appear in full in the tables but will be omitted from the drawings.
Some Examples of continuation records:

CL BAND(A)$ ....band.
2CL **Possible CONF=(|n 9/2[624])(|n 1/2[521]). No connection**
3CL **observed to K=0 bands. J values are adopted from (28SI,4NG)**
4CL **and are one unit lower than those from (36S,4NG)**

CL BAND(B)$ ....band.
2CL **This band originates from p{-3/2} orbital.**
3CL **Configuration proposed by 2005XXAA. Band crossing**
4CL **observed at ~h|w |? 0.4 MeV, ...**

CL BAND(C)$ ....band.
2CL **Configuration=(|p 1/2[411])+(|n 1/2[521]).**
3CL **Rotational parameters: A=11.4 (for J odd), 10.3**
4CL **(for J even).**

CL BAND(D)$ ………band, |a=+1/2.
2CL **This band originates from h{-9/2} orbital.**
3CL **Alignment at higher angular frequencies. Band**
4CL **intensity=…….. Measured ^Q(transition)=3.4, ………..**

CL BAND(E)$ Band built on 31/2+ isomer.
2CL **Multi-quasiparticle state with configuration=……..**

5. When using Cranked-shell model (CSM) notation for rotational bands, identify labels "A", 'B", "F", "a", etc. by their respective orbitals:

CL $ CSM labeling scheme: **A=|n7/2[633], a=|p1/2[660],**
2CL **F=|n5/2[503], f=|p1/2[541],** ………..

CL BAND(A)$ **AF (oblate) band, |a=1**

CL BAND(B)$ **af (prolate) band, |a=1**

6. For cascades or sequences which cannot be identified with any Configuration or band structure, the following labels may be used:

CL BAND(A)$ **|DJ=2, |g cascade.**

CL BAND(B)$ **|g cascade based on 1834,(14).**

7. Band labels and configurations should be given in both the "adopted" dataset and individual reaction or decay datasets.

3. Transition Quadrupole Moments for Rotational Bands

I. Introduction

Lifetimes of short-lived (less than 1 ns) excited nuclear levels are generally measured using the Recoil-Distance Method (RDM) or the Doppler-Shift Attenuation Method (DSAM). While the RDM method is used when the lifetimes are longer than a few picoseconds, the DSAM technique is frequently applied when the lifetimes are relatively short (less than ~1 ps). In a case of the DSAM technique, the slowing-down time of a recoiling nucleus in the stopping medium (usually Pt, Au or Pb backed targets) is typically fast enough (less than a few ps), so that it acts as a clock in this technique. Two different methods, known as "line-shape" and "centroid-shift", are used in the analysis of the DSAM data. For a rotational cascade consisting of $\Delta J=2$ transitions, one can then determine the reduced transition probability as:

$$B(E2, J \rightarrow J-2) = \frac{0.08156 \times P_\gamma(J \rightarrow J-2)}{\tau \times E_\gamma^5(J \rightarrow J-2)} [e^2 b^2] \tag{1}$$

where τ is mean lifetime of a level in ps, E_γ is γ–ray transition energy in MeV connecting states J and J-2, and $P_\gamma(J \rightarrow J-2) = I_\gamma / \sum_i I_{\gamma_i} \times (1+\alpha_i^T)$ is the branching ratio.

Using the rotational model, one can write the reduced transition probability for the γ–ray transition connecting states J and J-2 within a rotational band that has a quantum number K (projection of the angular momentum on the symmetry axis) as:

$$B(E2, KJ \rightarrow KJ-2) = \frac{5}{16\pi} e^2 Q_t^2 (J \rightarrow J-2) < JK20 \mid J-2K >^2 [e^2 b^2] \tag{2}$$

where $Q_t(J \rightarrow J-2)$ is called the **transition quadrupole moment** that is related to the level lifetime by the equation:

$$eQ_t(J \rightarrow J-2) = 0.906 \frac{\sqrt{P_\gamma(J \rightarrow J-2)}}{\sqrt{\left(\tau \times E_\gamma^5 (J \rightarrow J-2)\right)} \times < JK20 \mid J-2K >} [eb] \tag{3}$$

In the "line-shape" DSAM data analysis, equation (3) is directly used to deduce Q_t for individual levels. In the "centroid-shift" DSAM data analysis, a single Q_t value is usually extracted for the whole cascade by performing a least-square fit to the measured fractional Doppler shifts, $F(\tau)=v/v_0$, where v is the average velocity of the recoiling nucleus when a particular γ–ray was emitted and v_0 is the initial recoil velocity, as a function of the gamma-ray energies. It should be pointed out that the sign of Q_t is not determined by these methods.

The **transition quadrupole moment** (Q_t) deduced from the DSAM technique is dependent on:

1) the model used for the stopping powers of the recoiling nuclei, which act as a clock in the DSAM technique
2) the model used for the side-feeding time distribution. Usually, a rotational cascade consisting of three or more transitions is used, which has a different Q_t value than that for the main cascade
3) the validity of the rotational model at high-angular momentum, e.g. (2) and (3).

Therefore, the **transition quadrupole moment** (Q_t) deduced using the DSAM technique should be distinguished from the directly measured (for a list of methods see 2005St24) spectroscopic (static) quadrupole moment (Q).

II. Recommendations

1. In ENSDF, a new symbol MOME2T is introduced to represent the **transition quadrupole moment** in units of barns, deduced using the DSAM technique.

2. When MOME2T values are reported for individual levels ("line-shape" DSAM), these should be given in a continuation record that follows the corresponding level record (see Example 1). When a single MOME2T value is assigned to the whole band ("centroid-shift" DSAM), it should be given in the comment records for band ID label (see Example 2).

Example 1:

```
  L  1000.0        12+          3.2    PS    3
2 L  $ MOME2T=4.7 2 (2010YYxx)
  L  1200.0        14+          1.2    PS    1
2 L  $ MOME2T=4.5 5 (2010YYxx)
```

Example 2:

```
 CL BAND(A)$ BAND LABEL or BAND ID.
2CL MOME2T=4.7 2 (2010YYxx)

  L 1800         14+                                   A
```

3. It would be useful to include additional information about the model(s) or/and the assumptions used for the stopping powers and the side-feeding patterns (see Example 3).

Example 3:

CL BAND(A)$ BAND LABEL or BAND ID.
2CL MOME2T=4.7 2 (2010YYxx). Deduced using the centroid-shift DSAM. The stopping powers of Ziegler et al. (^TRIM computer code) were used. The side feeding was modeled as a cascade of three transitions with MOME2T(side feeding)=2.5 3.

4. It would be useful that corresponding NSR key-numbers be assigned to references that deal with various stopping powers models, for example J.F. Ziegler, J.P. Biersack and U. Littmark, The Stopping and Range of Ions in Solids (Pergamon, New York, 1985); http://www.srim.org/ and L. C. Northcliffe and R. F. Schilling, Nuclear Data Tables, **7**, 233 (1970).

Review of Enhanced Reduced Magnetic Dipole Transition Probabilities (BM1(W.u.)>0.4) in ENSDF (March 2007 version)

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IAEA-NSDD-07 meeting St. Petersburg, Russia, June 11-15, 2007

Abstract. All BM1(W.u.) values were extracted from ENSDF and sorted into the following groups: 6-20, 21-44, 45-90, 91-150, and 150+. The results were graphed by mass and by the number of occurrences per value. The group assignments are the same as those in Ref [1].

Introduction: From 1974 to 1993 P.M. Endt published 6 articles [1-6] on the compilation and evaluation of BELW and BMLW values in different mass regions. Values of RULs (RUL=Recommended Upper Limit) based on 5 publications (1974-1981) have been used in ENSDF for spin-parity assignments and other parameters.

In March 2007, we were approached by a physicist from Notre Dame about some recent compilation of (very) fast M1 transitions e.g. BM1(W.u.)>0.4 or so. Through a code written at McMaster, complete ENSDF was scanned for BM1(W.u.) in different mass regions as classified by Endt. Nuclide, level energy, gamma-ray energy, spin-parity, half-life and BM1(W.u.) value are tabulated for each region.

The survey is presented in this work. It reveals possible need for reassessment of the RUL values for M1 transitions.

A=6-20: Endt [1] suggests a RUL of 10, which is the same as in ENSDF. This is based in the highest value found by Endt, which is 8.6(2) in the 3560γ g.s. transition in ^{6}Li. The highest value we found was 10.9(21), which occurs for the 1041γ g.s. transition in ^{18}F. Our search in ENSDF found 340 BM1(W.u.) values in this region. **The RUL should perhaps be changed to 12 from the current value of 10.**

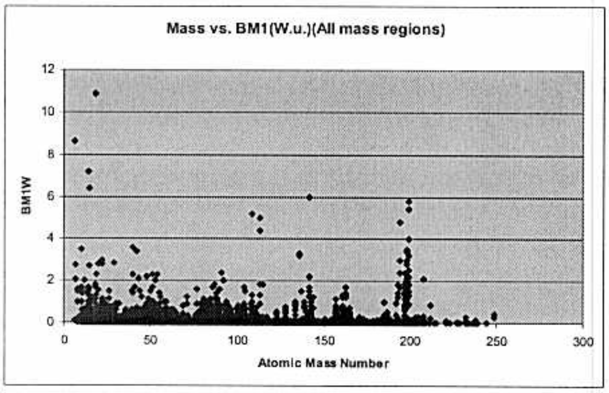
A=21-44: Endt [1] suggests a RUL of 5 for this region, while ENSDF groups this region with the 6-20 region and gives them both an RUL of 10. Endt's highest value was 4.3(5) in ^{40}Ca. This value, however, is incorrect due to the use of wrong branching ratio, the correct value should be 3.6(5). We found 753 values in this region. **In this mass region RUL=5 as before seems reasonable.**

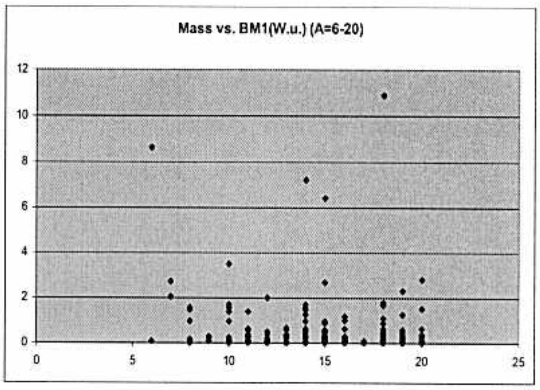
A=45-90: Endt [1] and ENSDF agree on an RUL of 3. Endt's highest value is 2.5(4) in ^{56}Fe. However, this value is in error, because of the use of incorrect branching ratio. Correct value should be 0.6, and the next highest value is 1.6(5) in ^{50}V. Our search on ENSDF found the highest value to be 2.3(6) for the 54.5γ g.s. transition in ^{54}Mn. Based on this value, **the RUL of 3 is still appropriate.** We found 1245 BM1(W.u.) values in this region.

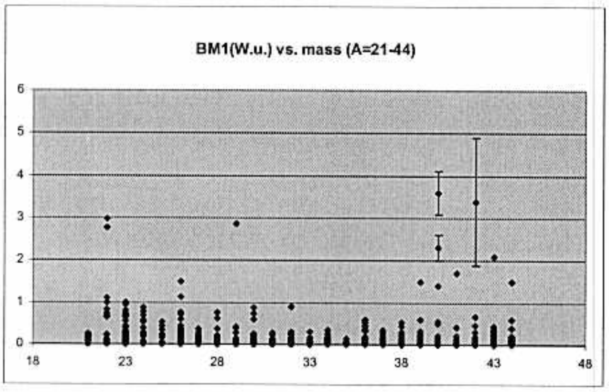
A=91-150: Endt [1] recommended RUL=1 based on a value of 0.50(8) in the 30γ g.s. transition in ^{140}La. ENSDF has a RUL of 3. We found seven values greater than three in ENSDF, the highest being 6(3) for the 359γ transition from the 2540 level in ^{142}Ce, and 5.2(19) for the 208γ transition from the 3410 level in ^{109}In. We found a total of 902 values in this region in ENSDF. **The RUL should be changed to 7 instead of the current value of 1 recommended by Endt and 3 for ENSDF.**

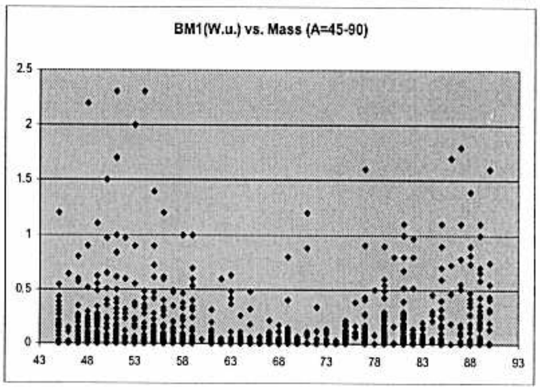
A>150: There is no published compilation of BM1(W.u.) values in this region, and ENSDF's RUL of two is based on a scan of the data by M. Martin in 1982. Our scan of ENSDF found 921 values, and 20 of these values are greater than the RUL. The highest value is 5.8(21) in the 273.8γ transition from the 6804.2 level in ^{199}Pb. Most of the transitions above the RUL are in the region $^{193-199}$Pb. These are mainly due to magnetic-dipole rotational bands. **The RUL should be changed to 8 instead of the current value of 2 recommended for ENSDF.**

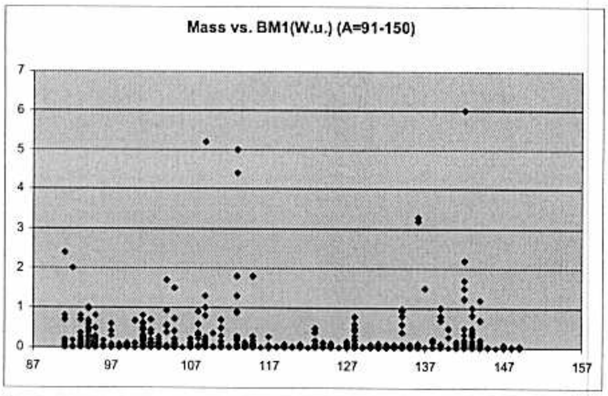
Errors in ENSDF: During out scan of ENSDF, several values were found that were unrealistically high. The worst example is 26.46 in ^{32}S. These errors were found to be due to misuse of the RULER code. When the full width Γ is given in a dataset, RULER does not take particle branching into account when it calculates the BM1(W.u.) values. Values affecting the RUL in this report were recalculated, and therefore should be reliable. This misuse of the RULER code may have affected many BM1(W.u.) values, as well as other BELW and BMLW values. The program will be updated by Tom Burrows at NNDC, BNL to correct this problem by August 2007.

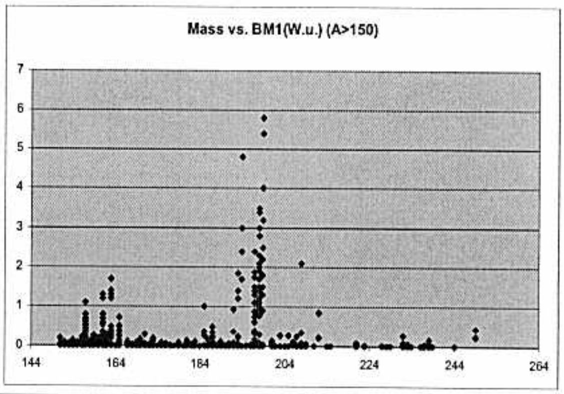


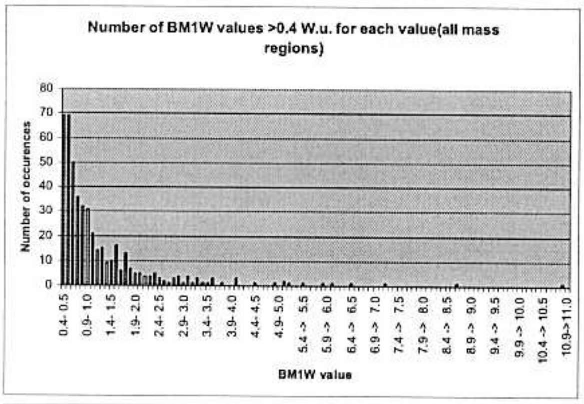


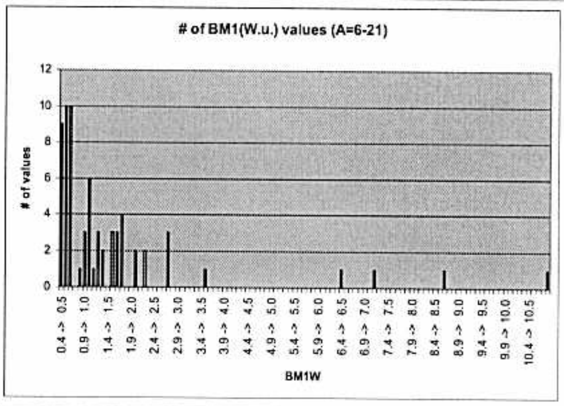


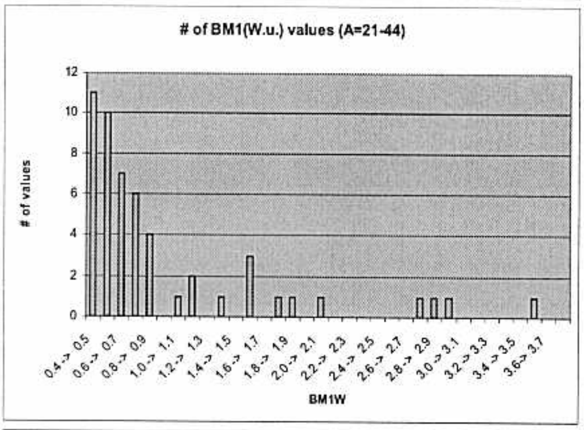



Mass vs. BM1(W.u.) (A=91-150)


Mass vs. BM1(W.u.) (A>150)


Number of BM1W values >0.4 W.u. for each value(all mass regions)
Number of occurences
BM1W value


# of BM1(W.u.) values (A=6-21)
# of values
BM1W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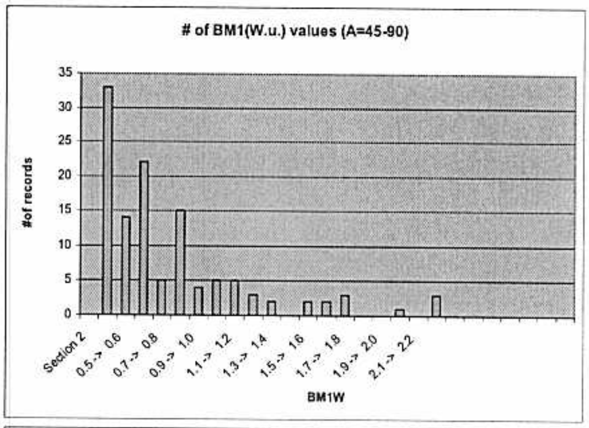
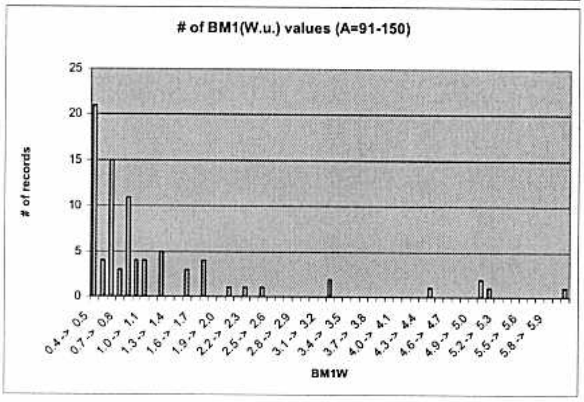
# of values
BM1W


# of BM1(W.u.) values (A=45-90)
#of records
BM1W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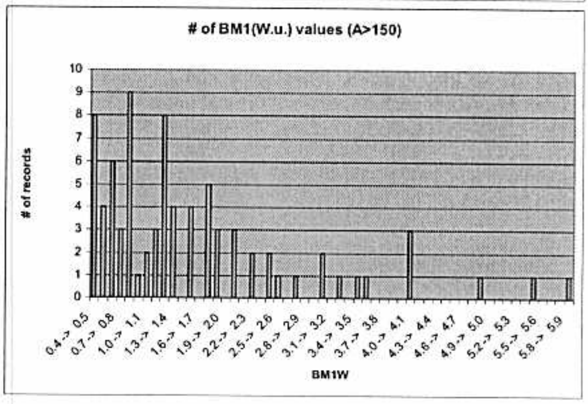
# of records
BM1W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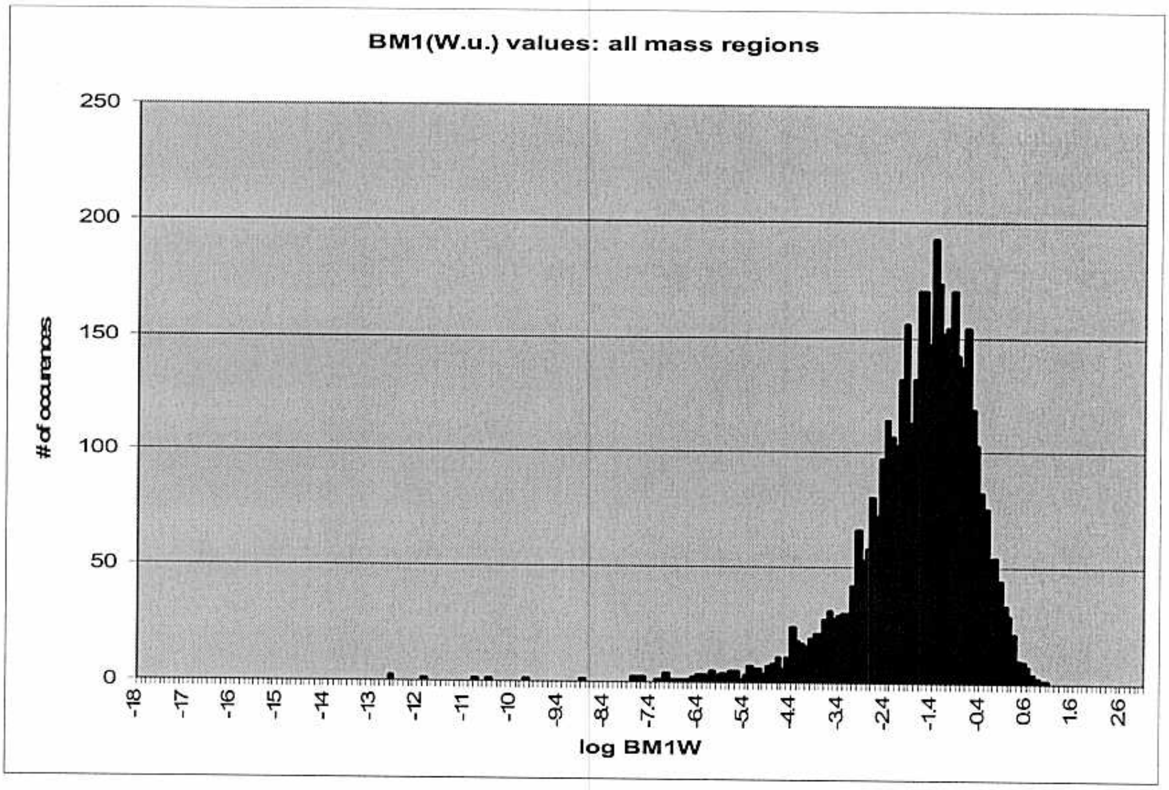
# of records
BM1W



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Nuclear Data Activities at Manipal University, June 2005 to June 2007

M. Gupta
on behalf of
The Manipal Advanced Research Group (MARG),
Manipal University, Manipal, Karnataka, India

Nuclear data work commenced at Manipal University (MU) in 2003 with ENSDF evaluations of superheavy elements. The formation of the Manipal Advanced Research Group (MARG) was announced in 2006 with the primary aim of promoting collaborative and/or inter-disciplinary research in the basic sciences and through their interface with medicine. Atomic and nuclear data was suggested as one of the areas where collaborative work could be pursued.

A Meeting on "Atomic and Nuclear Data for Next Generation Medicine and Technologies", 12-13 November 2006, was hosted by MARG at Manipal. Dr. Alan Nichols (representing the IAEA-NDS) presided as the Chief Guest. Two new data proposals emerged as a result of the Meeting along with many ideas for future work.

The details of on-going data activities as of June 2007 are given below.

1. ENSDF evaluations in collaboration with T.W. Burrows (NNDC-BNL):
   - ◊ A=266-294 (completed)
   - ◊ A=260-265 (in progress)
   - ◊ Updates for A=266-294 (on-going)

2. Multi-disciplinary work in statistics and reactor physics:
   A project on Covariance error matrices in nuclear data has been established as a result of the November 2006 meeting. MU proposed the project (Dr. N. Sreekumaran Nair, Department of Statistics as the Principle Investigator in

collaboration with Dr S. Ganesan, Reactor Physics Division, Bhabha Atomic Research Centre (BARC), and others from MU). The project has been funded and two full time students are expected to obtain their PhDs through these studies. A Workshop is planned at Manipal in February 2008 with a few international participants.

3. Multi-disciplinary project under the Life Sciences Centre:
   A project on DNA damage and nano-dosimetry is currently under consideration. The proposal includes the training of two post graduate students who are expected to be awarded PhDs in these topics.

4. Future projects of interest:
   Other research interests include the construction and performance evaluation of a nano-dosimeter, and the use of Monte Carlo methods in radiation biology and statistical correlations to quantify DNA damage.

Manipal University remains committed to promoting and maintaining robust inter-disciplinary and collaborative programs in contemporary fields of research including atomic and nuclear data. Confidence that such programmes will be successful arises from the strong student strength and "will-do" culture, together with the variety of disciplines and expertise within MU. The availability of the existing excellent infrastructure will ensure growth and sustainability. Ideas and collaborations for new data projects are also welcome.

XUNDL Status Report: (May 21, 2005 – May 31, 2007)

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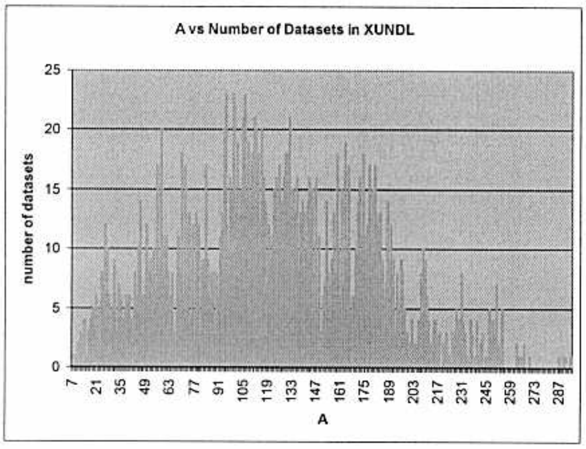
IAEA-NSDD-07 meeting St. Petersburg, Russia, June 11-15, 2007

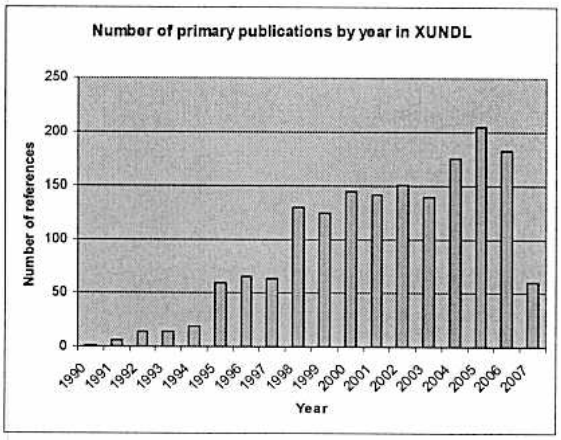
Purpose and Overview:
The purpose of XUNDL is to provide prompt and convenient web access to current publications in experimental nuclear-structure data (level-scheme information) through on-line retrieval at BNL; RADWARE at ORNL and Isotope-Explorer at LBNL. XUNDL consists of ENSDF-formatted datasets compiled from one paper, or a set of related papers from the same group. The database covers high- and low-spin reaction and decay papers, and is created based on daily perusal of web pages of primary nuclear physics journals (PR-C, EPJ-A, PRL, NP-A, PL-B, JP-G, IJMP-E). Compilation work done primarily at McMaster. Database management is done at NNDC. Also involves keeping up-to-date with the published literature, communication with original authors, and training of undergraduate students in basic nuclear physics, familiarity with ENSDF, XUNDL and NSR databases; and computer codes: PDF to TEXT to ENSDF; FMTCHK; PANDORA: ENSDAT; Isotope-Explorer; GTOL; BrIcc; LOGFT. Various steps of compilation procedures have been described at earlier USNDP and NSDD meetings. Although the datasets are called as "unevaluated", each dataset is sort of internally evaluated through consistency checks and communication with the authors about data-related problems and unpublished data.

Current Contents:
Since the start in December 1998, 2225 datasets added up to May 31, 2007; over 300K lines of data. The database covers mainly high-spin structures; but since 2003, most low-spin papers have also been compiled. In total, there are 1345 nuclides: 7Li to 288115, spread over ~253 A-chains; there are a few datasets for hypernuclides also. Data from taken over ~1700 primary references published mainly during 1995 – 2007: year-wise distribution: 2007-1995: 50, 185; 205; 175; 140; 151; 142; 145; 125; 130; 64; 66; 59.

Work during May 21, 2005-May 31, 2007:
715 datasets have been compiled since May 21, 2005; which include data from about 300 publications, ~55 in 2007 alone. 47 existing datasets have been revised/updated based on new papers from previous authors/groups McMaster undergraduate students Max Mitchell and Joel Roediger participated in XUNDL work from May 21, 2005 to April 2007. A new undergraduate student, Scott Geraedts started in February 2007 and has undergone training in the XUNDL compilation procedures and basic knowledge of nuclear physics and spectroscopy. Except for about 12 papers published in journal web pages in the last few weeks, we are current on the compilation of high- and low-spin primary publications. These papers have been compiled but not yet checked.

Communication with authors:
Authors of original papers are frequently contacted to resolve data-related errors (inconsistencies) and/or to request additional details of data which are often lacking in publications due to space limitations or other reasons. Generally, prompt and useful responses are received from the authors In cases where we received preprints, data-related errors pointed out to authors were corrected prior to actual publications of paper. In other cases, authors have published errata based on our communications with them about data-related problems. Since June 2005, compilation of ~70 e-mail communications containing additional information (data) and/or clarifications was sent to BNL (for archival purposes) in Sept 2006, as a composite computer file and in print version. Some difficulties occur when no details of data are available, either in the paper or in private communication with the authors. (Ex. ^{161}Lu and ^{170}Hf, in PR-C). Also, level diagrams are often illegible and/or not given enough space. For example, ^{58}Ni, the most complex level scheme, was given on less than half a page.

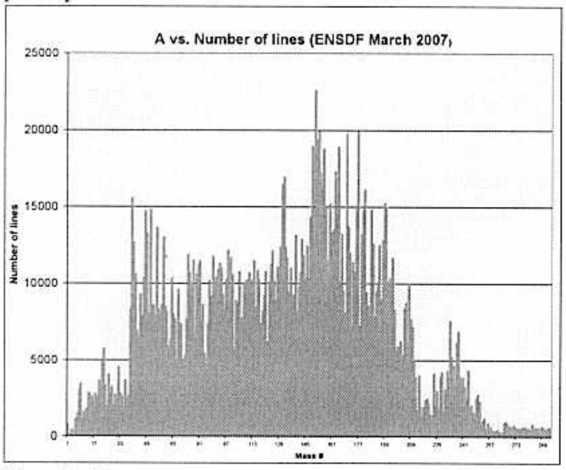


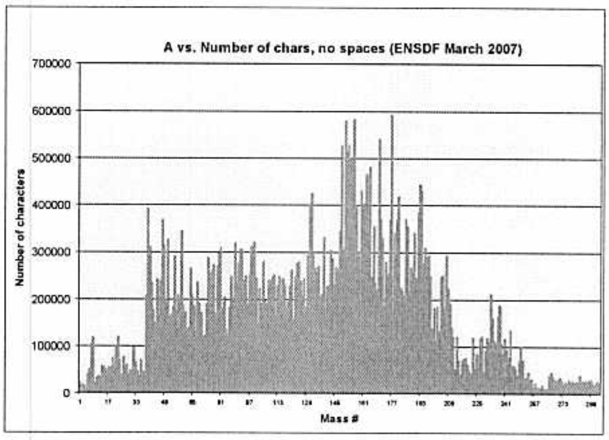


ENSDF coverage of Nuclei at the Limits of Stability:

First primary papers covered on new Nuclides at the limits of Stability: bound and unbound. First primary papers about excited states in nuclides at the limits of stability are also included in ENSDF. As part of XUNDL activity, we routinely compile papers containing types of discoveries stated above. With some extra work, we can prepare datasets for inclusion in ENSDF. The advantage of this is prompt inclusion of such important data in ENSDF, NUDAT and other related databases. If necessary, the datasets can first be sent to the center responsible for that mass region for the purpose of approval of a dataset prior to entry in ENSDF. This point was discussed at US-NDP-06 meeting in November 2006. There was a general agreement.

We estimate average of ~180 primary (and detailed) papers/year relevant to ENSDF for all mass chains. These are the type of papers which we compile for XUNDL This suggests an average of about 1-2 paper per mass chain/year in the active regions. This may suggest that a mass chain needs to be published in NDS every 10-12 years or so, not earlier. Earlier proposed cycle times of 4-5 years were never met and perhaps not recommendable either.





Conclusions:

Compiled datasets in XUNDL are being used by ENSDF evaluators in their A-chain/nuclide evaluation work, which may be helping the ENSDF evaluation process. Based on our XUNDL compilations, we have undertaken to prepare ENSDF datasets when either first (primary) papers appear on the identification of new nuclides (bound or unbound) or first published reports of excited states (mainly) for nuclei at the limits of stability.

Future of XUNDL ?: If this database is useful and is to continue on a long-term basis, it is perhaps time to consider participation by other data centers in compilations. For 2-3 years we will continue the activity at McMaster, but it may get scaled down after that.

Status of ENSDF Analysis and Utility Codes
(May 15, 2005 to May 15, 2007)

T.W. Burrows

NNDC, BNL, USA

Report Prepared for the 2007 Meeting of the IAEA-sponsored Nuclear Structure and Decay Data (NSDD) Network

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Previous Status Reports

Sept. 30, 2003:	Status report for the 2003 USNDP Annual Meeting
Sept. 30, 2003:	Status report for the 2003 meeting of the IAEA-sponsored Nuclear Structure and Decay Data (NSDD) Network
Oct. 28, 2004:	Status report for the 2004 USNDP Annual Meeting
May 15, 2005:	Status report for the 2005 meeting of the IAEA-sponsored Nuclear Structure and Decay Data (NSDD) Network
Oct. 24, 2005:	Status report for the 2005 USNDP Annual Meeting
Oct. 25, 2006:	Status report for the 2006 USNDP Annual Meeting

Links to status reports from 1998 through 2002 are contained in the above reports

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Current Status

A. With the exception of RadList all ANSI, Open-VMS, Linux, and MS Windows versions are current with those maintained in-house at the NNDC.

B. All analysis and utility codes have been converted to FORTRAN 95 (C.L. Dunford)
   1. ALPHAD, ComTrans, FMTCHK, ENSDAT, GTOL, NSDFLIB, PANDORA, and RULER distributed
   2. Further in-house testing before distribution of remaining programs
   3. Compaq/Digital Visual FORTRAN for Windows and Lahey/Fujitsu FORTRAN 95 for Linux.

C. Code Revisions (See the relevant "Read Me's" for additional details):

BrIcc
1. BrIcc 2.0 (Band-Raman Internal Conversion Coefficients using the "frozen orbitals" hole approximation) distributed.
2. Corrected problem in merging new records into original file

ComTrans ENSDF translation dictionary files (ensdf_dic.dat and ra_ensdf_dic.dat) updated to May 4, 2007

ENSDAT
1. Program updated to correspond to the current version (May 4, 2007) of the Nuclear Data Sheets publication program
2. ENSDF translation dictionary files (ensdf_dic.dat and ra_ensdf_dic.dat) updated to May 4, 2007

FMTCHK
1. Added coding to recognize new quantities output by BrIcc
2. Corrected problems caused by different ways of ordering multiple PARENT and NORMALIZATION records
3. Relaxed criteria for comparing final level to calculated final level
4. Implemented several checks based on an error report from PNPI in May 2005. This included checking the residual calculated from the target and reaction against the NUCID
5. Corrected several problems associated with parsing reactions
6. Corrected problem in assigning numeric value for current level introduced in the conversion from F77 to F95
7. Added check to see if FL= was identical to current level energy
8. Added check for embedded "+" or "-" in outgoing reactions.
9. Allow "XREF=A(123?)" and "XREF=A(?)"

GTOL
1. Converted to double precision to address platform-dependent precision problems
2. Table comparing input level energies to calculated energies added.
3. Table comparing input transition energies to calculated energies with χ^2's added.
4. Compare normalized χ^2 to critical χ^2 and output warning to terminal and report file if exceeded.
5. FORTRAN 95 version released
6. Changed logic for processing FL=? so that RI and TI would be included in RI(OUT) and TI(OUT)
7. Added query to allow user to specify theoretical DCC to be assumed (HSICC, BrIcc, or Other)
8. Added some checks in attempt to determine if level should be held fixed in the least-squares fit
9. Added option to place "G" in level energy field. Similar to "F" option but uncertainty will be added in quadrature with that derived from the least-squares adjustment
10. Reworked logic so matrix would be recalculated if "FL=" gamma had not been placed within ±10 keV

PANDORA 1. Increased dimensions in GAMINT from 150 to 500 to handle primary capture gammas
2. Modified dimensions of adopted level parameters to be consistent with MAXLEV parameter.
3. Added check for existence of source datasets before trying to create file with new XREF's.

RULER Corrected initialization problem caused in porting from F77 to F95 (null character in F95 instead of " " in F77 if string not initialized). This caused the program to sometimes skip calculations

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In Progress and Future Plans

A. **BrIcc:**
   1. Extend Z range to 110
   2. Update atomic electron binding energies
   3. Correct problem in overestimating shell ratio uncertainties
   4. Attempt to solve problems in estimating the uncertainty when $|\delta \pm \Delta\delta|$ overlaps zero or there is a significant tail in the probability distribution overlapping zero.
   5. Attempt to reduce size of report file

B. **GAMUT:** To be done by LBNL (December 2005)

C. **HSICC:** Problem in creating new records when a gamma energy lay below a subshell binding energy corrected. Needs testing before distribution.

D. **RadList:** Update to handle new quantities generated by BrIcc. This will include expanding the atomic data tables to include the O through R atomic electron shells.

Note: OpenVMS versions are no longer maintained or upgraded.

Analysis Codes								
Code	Function	Version No./Date	FORTRAN ANS[a]	DVF[b]	VMS[c]	UNX[d] Linux	UNIX	Documentation
ALPHAD	Calculates α R_0's, HF's and theoretical $T_{½}(\alpha)$'s	2.0a 20061106	X	X		X		No (See "Read Me" file)
BrIcc	Calculates internal conversion coefficients, internal electron-positron pair formation coefficients, and E0 electronic form factors.	2.0b 20070112		X[e]		X[ef]	X[eg]	Yes
DELTA	Analyzes angular correlation data.	1.01 19930415	X	X	X	X[h]		LUNFD/(NFFR-3048) 1-27
GABS	Calculates absolute ΔI_γ's.	9.2 20010207	X	X	X	X[h]		Yes
GTOL	Determines level energies from a least-squares fit to E_γ's & feedings.	7.2d 20060515	X	X		X		BNL-NCS-23375/R LUNFD/(NFFR-3049) 1-27
HSICC	Interpolates internal conversion coefficients	11.13f 20011009	X	X	X	X[h]		Nucl. Data **A4**, 1 Nucl. Data Tables **A6**, 235 Nucl. Data Tables **A9**, 119 BNL-NCS-23375/R (1977)
LOGFT	Calculates log *ft*.	7.2a 20010220	X	X	X	X[h]		Nucl. Data Tables **A10**, 206 BNL-NCS-23375/R (1977)
NSDFLIB	Support subprograms for many codes: FORTRAN77	1.5d 19990628	X[i]					Yes
	Support subprograms for many codes: FORTRAN95	1.6g 20051114	X	X		X		Yes
PANDORA	Physics check of ENSDF data sets. Aids with adopted gammas & XREF.	7.0b 20070501	X	X		X		Yes
RadList	Calculates atomic & nuclear radiations. Checks energy balance.	5.5 19881005	X	X	X			BNL-NCS-52142
RULER	Calculates reduced transition probabilities.	3.1c 20061030	X	X		X		Yes

a ANSI-standard FORTRAN 95, except as noted
b Compaq/Digital Visual Fortran (Win9x/ME/NT/2000/XP)
c OpenVMS Fortran, except as noted
d Lahey/Fujitsu FORTRAN 95, except as noted
e Only executables are available
f INTEL FORTRAN 90
g Digital FORTRAN 90
h Linux GNU f77 Fortran
i ANSI-standard FORTRAN 77

Utility Codes

Code	Function	Version No./Date	FORTRAN				Documentation
			ANS[a]	DVF[b]	VMS[c]	UNX[d]	
ADDGAM	Adds gammas to adopted data set.	1.4 20010207	X[e]	X	X	X<SUPf	No (See "Read Me" file)
COMTRANS	Converts the text comments of an ENSDF dataset to a "rich text format"	7.1 20031124		X[g]		X[g]	No (See "Read Me" file)
ENSDAT	Produces tables and drawings	12.19 20070501		X[g]		X[g]	No (See "Read Me" file)
FMTCHK	ENSDF format checking	10.2 20070503	X	X		X	No (See "Read Me" PDF or "Read Me" in HTML)
NSDFLIB	Support subprograms for many codes	See above					
TREND	Tabular display of ENSDF data.	8.3 20010207	X[e]	X	X	X<SUPf	No (See "Read Me" file)

a ANSI-standard FORTRAN 95, except as noted
b Compaq/Digital Visual Fortran (Win9x/ME/NT/2000/XP)
c OpenVMS Fortran
d Lahey/Fujitsu FORTRAN 95, except as noted
e ANSI-standard FORTRAN 77
f Linux GNU f77 Fortran
g Only the executables are available

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