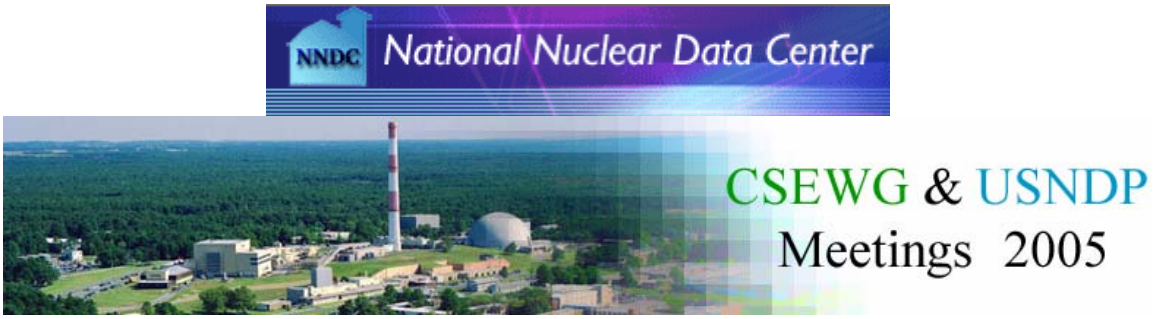

Summary of the

55th Cross Section Evaluation Working Group Meeting
November 8 - 10, 2005

and

8th U.S. Nuclear Data Program Meeting
November 9 - 11, 2005

Held at
Brookhaven National Laboratory
Upton, NY 11973

Edited by Pavel Oblozinsky
National Nuclear Data Center, BNL

www.nndc.bnl.gov/proceedings/2005csewgusndp

Preface

In 2005, for the 3rd time, the Cross Section Evaluation Working Group (CSEWG) and the U.S. Nuclear Data Program (USNDP) Annual Meetings were organized jointly. In the week of November 7 - 11, 2005, three nuclear data meetings were held at BNL:

- Nuclear Data Advisory Group of the DOE Criticality Safety Program (Nov 7),
- CSEWG Annual Meeting (Nov 8-10), and
- USNDP Annual Meeting (Nov 9-11), with a common CSEWG-USNDP session.

Participation in the CSEWG-USNDP meetings was even stronger than in the record year 2004. Altogether as many as 71 nuclear data developers and nuclear data users registered, including representatives of national laboratories, universities, nuclear industry from both the United States and Canada, and several foreign representatives of non-US nuclear data activities.

The present document contains the Summary of the CSEWG and USNDP Meetings. This Summary is produced both as a hardcopy and in electronic form but the presentations and the reports are available electronically only. An interested reader should go to www.nndc.bnl.gov/proceedings/2005csewgusndp for a full set of the CSEWG-USNDP 2005 meeting documents.

December 21, 2005

Pavel Oblozinsky
CSEWG chair
USNDP chair

Group Photo

55th Cross Section Evaluation Working Group Meeting, Nov 8 - 10, 2005

8th U.S. Nuclear Data Program Meeting, Nov 9 - 11, 2005

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The present document along with many presentations and reports given at both the CSEWG and USNDP meetings can be found at www.nndc.bnl.gov/proceedings/2005csewgusndp

Agenda

CSEWG & USNDP Annual Meetings, November 8-11, 2005

Underlined items are available at
www.nndc.bnl.gov/proceedings/2005csewgusndp

Nov 8, 2005, Tuesday, *Berkner B, Berkner C*

- 08:30-08:45 **CSEWG Opening**, Oblozinsky

- 08:45-10:45 **Formats and Processing** (Greene chair, parallel session)
  - Format and Related Issues
    - Formats for the near future (Larson)
    - Experiences and/or comments of extended Reich-Moore format (all)
    - Approval of post-fission beta-delayed photon format (Brown)
    - Discreate photon angular distribution (MacFarlane)
    - WPEC format interests (Trkov)
  - Processing Codes
    - Status of LANL code NJOY (MacFarlane)
    - Status of ORNL code AMPX (Dunn)
    - Status of LLNL code (Brown)
    - Status of ANL code VIM (McKnight)
  - Other Items
    - Status of ENDF-102 (Herman), 5'
    - Status of checking codes (Herman), 5'
    - Formats for consideration (Lubitz)
      - Explicit bound atom cross sections
      - Explicit dilute-average cross sections in URR
      - Explicit precision requirements for total cs and its components

- 08:45-10:45 **Measurements and Basic Physics** (D. Smith chair, parallel session)
  - Laboratory measurement programs
    - Argonne (Kondev), 10'
    - Los Alamos (Haight), 20'
    - NIST (Carlson), 10'
    - RPI (Danon), 10'
    - Idaho (Cole), 10'
    - Oak Ridge (Leal), 10'
  - Reports on meetings
    - 12th Int. Conf. on Emerging Nucl. Energy Systems (Cheng), 10'
    - IAEA TC Meeting on Nuclear Data for IFMIF (Smith, Cheng, Haight), 15'
  - Special topics
    - LANL actinide nuclear data measurements (Reifarth), 15'
    - Experiments at Yalina sub-critical assembly in Belarus (Kondev), 10'
    - Status of CSISRS compilation (Rochman), 10'

- 10:45-11:00 **Coffee Break**

- 11:00-12:30 **ENDF/B-VII Evaluation & Validation** (Chadwick chair)

  Status of ENDF/B-VII
  - Overview Comments, Chadwick, 15'
  - Status of ENDF/B-VII (beta1, known deficiencies), Herman, 25'
    - Phase1 testing, Zajac, 5'
  - Status of ENDF/B-VII Validation, MacFarlane, 20'
  - Benchmarking ENDF/B-VII beta1, Van der Marck, presented by McKnight, 20'

- 12:30-14:00 **Lunch Break**

  - ***CSEWG Executive Committee Working Lunch**, Berkner A*
    - *ENDF/B-VII Release*
    - *ENDF/B-VII Paper*
    - *WPEC Matters*
    - *Next Meeting*

- 14:00-18:00 **ENDF/B-VII Evaluation & Validation**, continues (Chadwick chair)

  Specific Improvements in beta1 Library
  - Actions from July'05 Meeting, Chadwick & Oblozinsky, 15'
  - LANL Evaluations for ENDF/B-VII, Chadwick, 30'
    - ^{240}Am, Brown, 5'
  - ^{232}Th Evaluation, Trkov, 15'
  - S(α,β) Changes, MacFarlane, 20'
  - H-1 Evaluation from Hale, MacFarlane, 10'
  - Fission Products, Oblozinsky, 25'
    - ^{74,75}As, Brown, 5'
  - Gd Isotopes and Covariances in Fast Region, Rochman, 10'
  - Covariance Data in the Resonance Region, Leal & Kawano, 30'
  - Neutron Cross Section Standards, Carlson, 30'

Nov 9, 2005, Wednesday, *Berkner B, Berkner C*

- 08:30-08:45 **USNDP Opening**, Oblozinsky, *Berkner B*

- 08:45-12:30 **ENDF/B-VII Evaluation & Validation**, continues (Chadwick chair)

  Data Testing

  - Testing of ENDF/B-VII b0, Lubitz, 20'
  - Testing at LANL, MacFarlane, 30'
  - Data Testing, Kahler, 20'
  - ^{233}U Testing, Heinrichs, 20'
  - Testing at ANL, McKnight, 20'
  - Testing at INL, Schaefer, 20'
  - Testing at LLNL, Brown, 10'
  - Comparison of B-VI and initial B-VII results for MCNP criticality validation suite, Mosteller/Little, 15'
  - Problems with nuclear data for D-U systems, Kozier, 15'

- 08:45-12:30 **USNDP Structure WG** (Baglin chair)

  - 8:45-9:20 Status Reports (5' - 10' each)
    - ENSDF (J. Tuli)
    - NSR (D. Winchell)
    - XUNDL (J. Cameron or B. Singh)
    - ENSDF Analysis and Utility Codes (T. Burrows)
  - 9:20-9:45 BRICC: Newly-released Band/Raman conversion-coefficient calculation utility (T. Burrows), 20'
  - 9:45-10:00 Report on new evaluator recruitment, training and assimilation efforts (J. Tuli), 10'
    - April 2005 and February 2006 evaluator training workshops (ICTP, Trieste)
    - Mentoring/collaboration with newly-trained evaluators
  - 10:00-10:15 Report on IAEA-CRP "Updated Decay Library for Actinides" and its potential implications for ENSDF (F. Kondev), 15'

- 10:15-10:30 **Coffee Break**

- 10:30-12:30 **USNDP Structure WG, continues** (Baglin chair)

  - 10:30-11:00 Update on ENSDF Editor software (A. Sonzogni), 30'
  - 11:00-12:30 Formats/Procedures /Jπ rules, *etc.*
    - Revision of notation for B(σL) entries in ENSDF.
    - Jπ values in reaction-γ data sets.
    - Update on rotational band nomenclature and new strongly-coupled band Jπ rule (F. Kondev), 5'.
    - Quality/legibility of level scheme and band drawings in Nuclear Data Sheets and ENSDF retrievals.
    - Interactions between ENSDF evaluators, reviewers and editor - are new procedures working?
    - Possible need for program to extract MR from ce data.

- 12:30-14:00 **Lunch Break**

- 14:00-18:00 **ENDF/B-VII Evaluation & Validation**, continues (McKnight chair)

Data Testing, continues

  - Photofission testing, White, 15'
  - Testing at BNL, Zajac & Aronson, 10'
  - Fission products testing, Trkov, 10'
  - Anomalies with Reflected Assemblies, Briggs, 15'
  - ICSBEP Handbook 2005 Edition, Briggs, 5'

Other Topics

  - New ENDF/B-VII decay data sublibrary, Sonzogni, 10'
  - ENDF/B-VI with EGAF data, Sleaford, 15'
  - Minor actinide evaluations, Wright/Dunn, 10'
  - Others

- 14:00-15:30 **User Community-USNDP Discussion Forum** (Winchell chair)
  - Overview of USNDP Products and Services (D. Winchell,A. Sonzogni,B. Pritychenko), 30'
  - Physics opportunities of gamma-ray tracking detectors (I.Y. Lee), 30'
  - The Study of Proton-Rich Nuclei in the Pb Region (M. Carpenter), 30'

- 15:30-15:45 **Coffee Break**

- 15:45-18:15 **User Community-USNDP Discussion Forum, continues** (Winchell chair)
  - Small, medium and big ideas for NNDC and nuclear data (P. Cottle), 30'
  - Hypernuclear Gamma-Ray Spectroscopy (J. Millener), 30'
  - Discussion, 90'
    - How are current services utilized
    - How can current services be improved
    - How research community can contribute
    - Would a USNDP user group be worthwhile
    - Other?

Nov 10, 2005, Thursday, *Berkner B, Berkner C*

- 08:30-10:30 **ENDF/B-VII Evaluation & Validation**, continues (McKnight chair)

  Concluding Discussion
  - What to do with covariances from ENDF/B-VI.8?
  - ENDF/B-VII Release
  - ENDF/B-VII Paper
  - Other topics
  - Next meeting
  - Minutes

- 08:30-10:45 **USNDP Structure WG** (Baglin chair)
  - 8:30-8:45 New web interface for evaluated B(E2) data (B. Pritychenko), 10'.
  - 8:45-9:20 Nuclear Data Sheets
    - Impact factors (A. Sonzogni; 20').
    - Content
    - Accessibility (as libraries cut subscriptions).
  - 9:20-10:00 Possible development of an electronic Table of Isotopes type of product (J. Tuli).
  - 10:00-10:30 Next year's Working Group meeting schedule. Other items?

- 10:30-10:45 **Coffee Break**

- 10:45-12:45 **Common Session CSEWG + USNDP**
  - Homeland Security (McNabb chair, 1 hour)
    - $^{13}C(p,\gamma)^{14}N$ as source reaction for interrogation and $^{10}B(p,\alpha)^{7}Be$ reaction (Page), 10'
    - Monte-Carlo simulation of fission fragments evaporation (Talou), 10'
    - Update in Nuclear Wallet Cards for Homeland Security (Tuli), 10'
    - Motivation for adding (γ,γ') resonances to photonuclear sublibrary (McNabb), 10'
    - Discussions of data needs (McNabb), 10'
  - Modeling & Astrophysics (Kawano chair, 1 hour), 10' each
    - Code PRECO (Kalbach)
    - Code EMPIRE (Herman)
    - Code McGNASH (Talou)
    - JAERI code (Fukahori)
    - Astrophysics online computer system (Nesaraja)
    - s-process modeling (Reifarth)
  - CSEWG adjourns

- 12:45-14:00 **Lunch Break**
  - ***USNDP Coordinating Committee Working Lunch***, *Berkner A*
    - *Report FY05*
    - *Workplan FY07*
    - *Budget Briefing FY08*
    - *Next Meeting*

- 14:00-15:00 **USNDP Modeling & Astrophysics**, continues (Kawano chair), *Berkner B*
  - Covariance Methodology, 15' each
    - Resonance region (Leal/Larson/Arbanas)
    - EMPIRE+KALMAN (Herman)
    - Covariance work at LLNL (McNabb/Brown)

- 15:00-16:00 **USNDP Dissemination** (Burrows chair)
  - Recent Developments in NNDC Web Service, Pritychenko, 15'
  - USNDP Database Computer System Upgrade, Arcilla, 10'
  - Nuclear Astrophysics Data Dissemination, Nesaraja, 10'
  - Discussion: New services, products, improvements

- 16:00-18:00 **USNDP Reports (TF Reports, Lab Reports)** (Oblozinsky chair)
  - TF Nuclear Data for Astrophysics, C. Nesaraja
  - TF Nuclear Data for/from RIA, Kawano
  - TF Nuclear Data for Homeland Security, McNabb
  - NNDC Report, Oblozinsky
  - ANL Report, Kondev
  - LANL Report, Kawano

Nov 11, 2005, Friday, *Berkner B*

- 08:30-10:00 **USNDP Reports (Lab Reports)**, continues (Oblozinsky chair)
  - LBNL Report, Baglin
  - LLNL Report, McNabb
  - MacMaster Report, Cameron
  - NIST Report, Carlson
  - ORNL Report, C. Nesaraja
  - TUNL Report, Kelly

- 10:00-11:30 **USNDP Reporting, Coordination, Planning** (Oblozinsky chair)
  - Annual Report FY05
  - Budget FY06, update from Congress, Haight
  - Workplan FY07
  - Budget Briefing FY08

- 11:30-12:00 **Next Meeting, Minutes, AOB**

- Lunchtime: **USNDP adjourns**

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USNDP Annual Meeting, November 9-11, 2005
Criticality Safety (Nuclear Data Advisory Group) Meeting, November 7, 2005

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Summary of the 55th Cross Section Evaluation Working Group Meeting

Held at
Brookhaven National Laboratory
November 8 - 10, 2005

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Cross Section Evaluation Working Group

Chairman's Summary

Pavel Oblozinsky
National Nuclear Data Center, BNL

CSEWG Annual Meeting

The 55th CSEWG meeting was held on November 8-10, 2005 and attended by the record number of 56 participants. Among them were representatives of national laboratories, academia as well as nuclear industry of U.S. and Canada (Knolls Atomic Power Laboratory, Bechtel Bettis, Westinghouse, and Atomic Energy of Canada).

Central topic of the meeting was validation of the beta1 version of the ENDF/B-VII library.

ENDF/B-VII beta1 validation was extensively discussed during several sessions of the combined Evaluation Committee & Data Validation Committee, focusing on 387 materials in neutron sub-library. Although general feeling was that the library is in a good shape, a list of actions with 59 items, to be completed before final release, is still appreciable.

Standards will be incorporated into full evaluations as much as possible and a new ENDF/B-VII.0 standards sub-library will be created (NSUB=13).

Covariances are currently taken from ENDF/B-VI.8 (4 materials with mf32 and 36 with mf33) that are often old and contain limited information. Only covariances of good quality should be adopted for ENDF/B-VII. It is anticipated that only a few covariances now in ENDF/B-VI.8 will make it to ENDF/B-VII.0.

ENDF/B-VII.0 paper should be completed in March 2006 in draft form, followed by final review and submittal either to NSE or to PRC.

ENDF/B-VII.0 release schedule is as follows:

- February 28, 2006 All updated and new files sent to the NNDC.
- March 15, 2006 Beta2 released by the NNDC for final testing.
- June 27, 2006 CSEWG validation meeting at BNL to approve the library.
- July 15, 2006 Official release of the library by the NNDC.

Next CSEWG annual meeting will be held at BNL on Nov 6 - 8, 2006 (Mon – Wed), while USNDP meeting will be held on Nov 7 - 9 (Tue – Thu), 2006. The NDAG Criticality Safety meeting will be held on Nov 9, 2005 (Thu).

CSEWG Executive Committee Meeting

The Executive Committee met during lunchtime on November 8, 2005, with all 10 members present. This included chair (P. Oblozinsky), four committee chairs (M. Chadwick, M. Greene, R. McKnight, D. Smith) as well as R. Block, A. Carlson, E. Cheng, L. Leal and D. McNabb.

Agenda

- ENDF/B-VII.0 release: See above.
- ENDF/B-VII.0 paper: See above.
- WPEC matters: The US delegation should be the same as in 2005 (P. Oblozinsky - head, R. McKnight, M. Greene and Mark Chadwick - members). Several other U.S. participants should attend in their capacity of Subgroup Chairs. P. Oblozinsky will approach WPEC coordinator, C. Nordborg to arrange for participation of one representative of the U.S. measurement activities (Don Smith/B. Haight/L. Leal). The next WPEC meeting should be held on May 3-5, 2006 in Paris, France.
- Next Meeting: See above.

Cross Section Evaluation Working Group

Measurements and Basic Physics Committee Report

Donald L. Smith, ANL
Committee Chairman

The Measurements and Basic Physics session was held from 08:45 to 10:45 on November 8, 2005, as scheduled, in a parallel session during CSEWG-2005. This meeting was attended by approximately 20 individuals. There were 14 presentations that were organized into three categories as follows:

Laboratory Measurement Programs

- Argonne National Laboratory (Filip Kondev)

This presentation focused on three basic areas: Gamma-ray spectroscopic studies including those associated with the formation of exotic nuclei by heavy-ion reactions, development of a new generation of Ge tracking detectors, and neutron measurements at the sub-critical facility YALINA in Belarus.

The spectroscopic studies discussed in this presentation addressed properties of nuclear K-isomers in neutron rich nuclei near A = 180, shell-model isomers near 132Sn, properties of 237U, 239U, 171-175Hf, and 170,171 Ta. These studies are interesting from a basic physics point of view and they also figure in certain applications such as astrophysics, detector calibration, "gamma-ray" lasers, and the transmutation of nuclear waste.

Development of Ge strip detectors has been pursued with the idea this this technology might eventually be used to create new multiple-detector systems for applications in basic nuclear physics research.

Argonne recently participated in sub-critical measurements at the YALINA facility in Belarus in collaboration with scientists from several European countries as well as Belarus (more below).

- Los Alamos National Laboratory (Robert Haight)

An overview was provided of nuclear data experiments performed at five major facilities associated with LANSCE at Los Alamos. These facilities are: GEANIE (for n,x-gamma measurements), FIGARO (for n,xn+gamma measurements), DANCE (for n,gamma measurements), N-Z Spectrometer (for n,charged-particle measurements), and LSDS (for fission measurements).

The GEANIE experiments involved cross setion measurements for various isotopes of Ir,

Au, Cr, V, Ti, Sm, Mo, Te, F, Ge, Sn, Ba, Tm, W, Tl, and U. The resulting data, often for partial cross sections, are being used in conjunction with nuclear model calculations to produce reliable total reaction cross sections of specific interest for various applications. The acquired data are also useful for understanding the decay schemes of excited nuclei.

FIGARO has been used for neutron-emission spectrum and nu-bar measurements on isotopes of U, Np, Tc, Pb, and Ba. Measurements at the N-Z Spectrometer have provided valuable new data on neutron-induced H and He production from Fe, Ta, and Cr. Measurements on Zr and Mo are also planned.

The N-Z Spectrometer has been used for H and He production cross-section measurements on Fe, Ta, and Cr from 1 to 100 MeV. These data have been very valuable for improving the cross-section evaluations related to these processes since in most cases they provide unique information in the energy range above 20 MeV.

DANCE is used for neutron capture measurements using very small sample target (including radioactive targets). Measurements have been performed on isotopes of Au, La, Sc, Mn, Co, Cu, V, Rb, Sr, Pd, Ni, Se, Fe, Mo, Gd, Eu, U, Pu, and Sm.

The LSDS (Lead Slowing Down Spectrometer) has been used for fission measurements on 235mU and 239Pu. Again, this facility can be used for measurements with very small samples.

A program of neutron fission cross section measurements in support of the Advanced Fuel Cycle Initiative (AFCI) is being undertaken. Among the materials to be studied are isotopes of Np and Pu. The focus will be on extending the existing databases by high precision measurements over a wide energy range.

Two new initiatives were mentioned. One initiative is a plan to provide a neutron spectrum with enhanced yield in the energy region applicable to fast reactor systems. The second initiative is the development of an intense neutron source for materials testing, i.e., for the production of significant dpa and He production, again in support of advanced reactor development.

Finally, this presentation discussed briefly some of the challenges facing LANCSE as well as many positive developments at this facility. One of the most encouraging points is the fact that there is that many collaborators from other U.S. laboratories and abroad who are involved in the nuclear data experiments at Los Alamos.

- National Institute of Standards and Technology (Alan Carlson)

A new standards evaluation produced for ENDF/B-VII, with significant contributions from foreign scientists, is nearly a reality. This project, carried out under IAEA and NEA auspices, stimulated many new measurements. This measurement activity will continue following release of the current version of the standards. Data obtained in the later years will be used to improve the standards even further in future releases. This presentation

described some of the experimental work that is now in progress and that will continue in the years ahead. Among these areas are continuing measurements on the H(n,n) standard, 6Li(n,t)alpha, 10B(n,alpha)7Li, 235,238U fission, and 239Pu fission.

- Rensselaer Polytechnic Institute (Yaron Danon)

Work on neutron transmission and capture in the resonance region continues at the RPI Linac facility. Fission measurements are also being carried out using the RPI lead slowing down spectrometer. A new initiative is the development of a capability to perform measurements at higher energy. This is being accomplished by establishing a 100 m flight path that is equipped with a new multi-detector neutron spectrometer. A program of maintenance and upgrade of the Linac accelerator continues including the development of a new injector module.

- Idaho Nuclear Laboratory (Jerald Cole)

A new program is under development at INL to measure differential cross sections and resonance parameters for heavy actinide nuclei. This work is being carried out in collaboration with Argonne National Laboratory at the Argonne Intense Pulsed Neutron Source facility (IPNS). The apparatus used incorporates multi-detector arrays as well as coincidence methods that have been applied to other areas of nuclear physics study but not to cross section measurements. Preliminary measurements have been carried out at IPNS to test the validity of the method. INL has access to target materials from Russia that will prove valuable for this work in the future. This presentation focused on the experimental apparatus and procedures and provided an example of some cross-section data taken for 239Pu.

- Oak Ridge National Laboratory (Luis Leal)

The principal facility at Oak Ridge, ORELA, is currently inoperable for measurements, but some progress is being made to bring it back on line as a viable research facility. In the meantime, scientists from ORNL have been involved in collaborative studies at LANSCE (Los Alamos) and GELINA (Geel, Belgium). Measurements have been performed on isotopes of Rh, Cs, Nd, Sm, Gd, F, and Mn with a strong focus on interests of the U.S. Criticality Safety Program (CSP).

Reports on Meetings

- 12-th International Conference on Emerging Nuclear Energy Systems (Edward Cheng)

This meeting was held on August 21-26, 2005, in Brussels, Belgium. An overview of this meeting was provided in this presentation. The main objective of ICENES 2005 was to provide an international scientific and technical forum for scientists, engineers, industry leaders, policy makers, decision makers and young professionals who will shape future requirements, for a broad review and discussion, at world level, of various

advanced, innovative and non-conventional nuclear energy production systems. The proposed systems should contribute to a sustainable development of future energy production. Earlier editions were held in Graz (Austria), Lausanne (Switzerland), Helsinki (Finland), Madrid (Spain), Karlsruhe (Germany), Monterey (USA), Chiba (Japan), Obninsk (Russia), Tel-Aviv (Israel), Petten (The Netherlands) and Albuquerque (USA) respectively. Further information on this meeting can be found at the official website:

http://www.sckcen.be/sckcen_en/activities/conf/conferences/Icenes2005/objectives.shtml

- IAEA Technical Committee Meeting on Nuclear Data for IFMIF (Donald Smith, Edward Cheng, Robert Haight)

The selection of a site for ITER (Cadarache, France) and long-term planning concerning technology needs for the DEMO fusion plant has led the fusion community to consider construction of a facility for the testing of materials for radiation damage. This facility would be called IFMIF (International Fusion Materials Irradiation Facility). The main technological concern is damage due to dpa and He production. There has been an on-going design and data development activity for IFMIF involving mainly laboratories in Europe, Japan, and Russia. The present meeting was sponsored by the IAEA to explore specific nuclear data needs for the development of this facility. Three of the attendees were from the U.S. A website will eventually be posted by the IAEA Nuclear Data Section where one can view all the presentations and other submitted technical documents related to this meeting:

http://www-nds.iaea.org/.

- Twelfth International Symposium on Reactor Dosimetry (Alan Carlson)

This meeting was held on May 8-13, 2005, in Gatlinburg, TN, USA. Details were discussed only briefly by Carlson who attended the meeting. This Symposium is held approximately every three years to provide a forum for the interchange of state-of-the-art techniques, data bases and standardization of radiation metrology. The content from this Symposium should be of value to those involved in reactor dosimetry, including researchers, manufacturers and representatives from industry, utilities and regulatory agencies. This Symposium was jointly sponsored by ASTM International, the European Working Group on Reactor Dosimetry (EWGRD), and the Atomic Energy Society of Japan (AESJ). It was organized by ASTM Committee E10 on Nuclear Technology and Applications and EWGRD. The Symposium theme was dosimetry for the assessment of irradiated reactor materials and reactor experiments, featuring radiation metrology techniques, databases and standardization.

Special Topics

- Actinide Nuclear Data Measurements at Los Alamos (Rene Reifarth)

This presentation focused on three specific areas mentioned briefly in the overview presentation by Haight on LANSCE (above). These included (n,gamma) measurements at

DANCE, capture-to-fission ratio measurements at DANCE, and fission measurements at WNR and the Lujan Center.

The DANCE facility was described briefly. Some details were then provided on measurements of capture for sub-milligram quantities of 237Np and 242Pu. Analysis is in progress for data on capture measurements for 234,235,236,238U and new measurements are planned this year on 240Pu. The apparatus and methodology to be used for capture-to-fission ratio measurements was described. A successful proof of principle experiment has been carried out for 235U and new measurements are planned for this year 241-243Am.

Conventional fission cross section measurements with a multiplate chamber are planned for WNR and the Lujan Center. The materials involved are 235,238U, 237Np, and 239,242Pu. The objectives are measurement over a very broad energy range and high accuracy.

- Experiments at Yalina Sub-critical Assembly in Belarus (Filip Kondev)

Kondev returned from an experiment at Yalina in Belarus (near Minsk) only a few days before the CSEWG meeting so his presentation amounted to a brief description of this facility. More will be reported next year following analysis of the acquired data. Yalina is a sub-critical assembly driven by a neutron generator that can use either T(d,n) or D(d,n) as neutron a source reaction. The source can be steady-state or pulsed, and various configurations of the sub-critical core assembly can be prepared. The objective is to acquire data for code and cross-section data library testing in support of ADS development.

- Status of CSISRS Compilation (Dmitri Rochman)

A brief overview of the NNDC activity in the area of experimental cross-section data compilation was described. This activity is being carried out as part of a collaborative endeavor involving several data centers around the world. The presentation focused on the convenient user interface to this extensive database that allows for retrieval of information in a variety of useful formats including data lists and plots.

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Cross Section Evaluation Working Group

Formats and Processing Committee Report

N. Maurice Greene, ORNL
Committee Chairman

Format Proposals

Several areas that need revisions to accommodate **covariance data** were noted by N. Larson. The LRF=7 "R-Matrix Limited" format should have provisions to use the LCOMP=1 formats. She noted the need for LCOMP=2 (Compact Covariance Formats) for pointwise data and other things. It was mentioned that LRF=7 allows the calculation of charged particle data. Finally, she suggested that the unresolved resonance region formats should be modernized, and should have provisions for uncertainty data.

In 2004, D. Brown proposed a new format for handling post-fission **beta-delayed photon** data. The format was approved pending some very minor changes about using some fields available in the format records to clearly identify some of the component data collections. The changes were, in fact, made last year before the meeting ended, but, unfortunately, not in time to have a format approval vote. This year the format was approved without further discussion. Brown also noted a slight problem in the way Q-values are defined in Files 3, 8, and 9. He agreed to make the wording changes for ENDF-102, and has subsequently provided these changes so that the manual can be corrected.

A fairly complex format for representing **photon angular distributions** was proposed by R. MacFarlane. The new format requires the use of relativistic kinematics in order to treat the data properly. The new format was approved.

Several changes were suggested by A. Trkov, based on his interactions with members of the European data community. He made a request that NLIB=21 (Section 1 of Appendix I of ENDF-102) be reserved for the WPEC SG23 library. The request was approved. He suggested the masses given in Table 2 of Appendix H in ENDF-102 be replaced by the latest values from Audi-Wapstra. His suggestion was accepted. He noted that most of the changes were insignificant; however, the previous tritium mass is incorrect as it was given in atomic, and not nuclear, units, such that this change is significant. Trkov noted that page 8.4 of ENDF-102 refers to "Appendix E", which should be "Section 0.6.2". Finally, he noted that several persons were interested in using the NRO=1 (energy-dependent scattering radius) format for the *unresolved* energy region. This use of this format was approved.

Processing Codes

R. MacFarlane discussed the status of the NJOY processing system at LANL. He noted that, while the latest code system at LANL was all converted to FORTRAN 95, no definite new-release plans were in place. Currently, there are both FORTRAN 77 and FORTRAN 90 systems that are available, at an equivalent release level.

M. Dunn noted that the AMPX system has been used to produce libraries that had undergone considerable testing against benchmark calculations, and results seemed to suggest that the processing has been done properly. Future work will continue the testing using the latest beta release of ENDF-B-VII data. He also noted significant enhancements to the covariance processing module in the system, which is now able to process the LCOMP=2 formats that were introduced in 2004 into ENDF/B.

D. Brown discussed a collaborative LLNL/LANL effort to convert sections of ENDF/B data into an XML format, and *vice versa*. It was noted that the present system uses PYTHON and can convert a few of the ENDF/B files, but it will not treat all of the files, though this work is being pursued.

R. McKnight discussed the use of ENDF/B-VII at ANL and noted that they had processed the new evaluations; however, he noted that their processing schemes do not require the use of a great number of the files, where the newer format changes have been made.

Other Discussions

M. Herman discussed the status of ENDF-102 and noted that the manual could be downloaded as a complete unit from the CSEWG site, or on a section-by-section basis in either .doc or .pdf formats. He noted that changes to the document (formats, errors, revisions, etc.,) should me made to the .doc format.

Herman also noted that the checking codes and other utilities were being maintained, but that there were areas where checks of the data could be made, that are not in the present checking codes. As an example, he mentioned the covariance data.

A request was made shortly before the meeting by C. Lubitz to discuss several aspects of the present formats that should be considered for revision, primarily in the procedures that are used to prepare an evaluation. Because of time constraints, none of the items was discussed enough to reach any final "conclusion"; however, it is the opinion of the session chair that conclusions were not required, or even expected. The items were presented as "thought-provoking" matters for future discussions and decisions. The topics were: a) explicit bound-atom cross sections, b) explicit dilute cross sections for the unresolved energy range, and c) precision requirements of "total" cross sections and components.

The suggestion on explicit bound-atom cross sections was essentially to have the component cross sections expressed as point data that are a function of energy and temperature in the evaluation, thereby, relieving the user from the chore of calculating it through a complicated procedures that uses S(alpha,beta) data. The primary arguments are two: 1) the cross sections are easily obtained, and 2) the cross section values can be used to check processing procedures that attempt to integrate and obtain the values. The proposal went even further, and suggested that simply replacing the S(alpha,beta) data completely with tabular data, would avoid having to perform the difficult and error-prone processing to obtain differential cross sections from S(alpha,beta) data, and would absolutely specify the cross sections with no ambiguities.

The suggestion to always use the infinite dilution cross sections in the point data for the unresolved energy regions in File 3 would certainly help circumvent the very confusing situation we have right now: Unresolved data are given in File 2, along with an LSSF flag that specifies whether File 3 already has point data given in the unresolved region, or whether the points one calculates from data in File 2 must be added to values in File 3 to get the correct final values. The problem with this arrangement is that one has to read and hold a flag from the File 2 data, in order to know what one must do later on, when the File 3 data are processed. The new suggestion eliminates the confusion, and provides infinite dilution data automatically for those applications that simply need them.

The precision requirements of the "total" versus components of the total relates directly to the fact that, summing cross sections using the ENDF/B interpolation schemes does not ensure that the partials sum to the total, anywhere except the points where all partial are given at the same energies. In other words, the sum of a log-log function with a linear-linear function is neither a log-log, nor a linear-linear function. While every major processing code that deals with this situation "solves" the problem by first converting all cross section arrays to linear-linear functions, which, indeed, do sum to linear-linear functions, and then recalculating the total values using the linearized partials, and just discarding the original totals. This does cause problems. For one thing, the total values are, in many cases, the most accurate values in the evaluation. Other schemes use the difference in total versus partial (scattering) values to calculate an absorption, which can cause problems, if special care is not taken.

Lubitz also suggested that the 2200 m/s cross section values, along with the resonance integrals could be included in the data directory that is given in File 1. A point-of-contention with this suggestion was that the limits for calculating resonance integrals are not absolutely defined.

The discussions that ensued during Lubitz's topic collection were lively and interesting.

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Cross Section Evaluation Working Group

Minutes of the CSEWG Meeting on ENDF/B-VII Validation

Chair M.B. Chadwick, LANL & R. McKnight, ANL

Action Items

Edited by P. Oblozinsky, NNDC

General items

1. Standards. These will be incorporated into full evaluations as much as possible. In addition, new standards sub-library will be created, probably as NSUB=13 (ENDF-102 should be modified accordingly). Carlson will submit a complete set of standards to the NNDC for inclusion into b2. **Action Carlson**.

2. Covariances. These are currently taken from ENDF/B-VI.8. In b1, there are 4 materials with mf32 and 36 with mf33, often old and with limited information. Only covariances of good quality should be adopted for ENDF/B-VII. Don Smith will review by mid Feb 2006, distribute for comments to endf@lists.bnl.gov, BNL will implement in b2. It is anticipated that only a few covariances now in b1 will make it to b2. **Action Don Smith.**

3. Timetable for ENDF/B-VII.0 paper. All comments, contributions, etc by all to Mark asap, validation chapter more extensive than originally indicated (Dick), list of authors to be finalized (Mark). Full draft complete in March 2006. Then, final review and submittal either to NSE (long processing time, therefore submit early, final touches on tables, figures later) or to PRC? **Action all, coordination Mark.**

4. Timetable for ENDF/B-VII.0 release
   - February 28, 2006 All updated and new files sent to the NNDC.
   - March 15, 2006 Beta2 released by the NNDC for final testing.
   - June 27, 2006 CSEWG validation meeting at BNL to bless the library.
   - July 15, 2006 Official release of the library by the NNDC.

Neutron evaluations

5. 237Np fission. Look at LANSCE new data at lower energies. **Action Kawano & Talou.**

6. Fix format errors (van der Marck list – 84Kr, 4 MAs, 11 FPs; Sublet list – 113In, 126Xe, 152Eu; others) in all files as much as possible. **Action Herman**.

7. 238Np was adopted from JENDL-3.3.

8. Ti isotopes were adopted from JEFF-3.1.

9. New Zr isotopes largely taken from JENDL3.3. Some modifications to capture were made (Kawano; also BNL). More iteration needed, based on Lubitz feedback. What about further Zr testing? We have changed Zr significantly. See also action 10.

10. Lubitz noted that comparing the old Zr data with newer SG23 data, Zr90 thermal abs went from 11 to 78mb in SG23, but Zr91 went from 1240 to 832. The resonance integral went from 0.95 to 1.09 for natural. Cecil noted that the exp spread is large, often 15-20%, increasing up to 50-60% in some cases for radiation width of parameters. **Recommendation: Stick with SG23** for now and Bettis and KAPL will study to assess any integral basis for changing these data.

11. Fix mf2 for 16 FPs where RRR data are not available (Kr-85, Rb-86, Y-90, Ag-111, Cd-115m, Sn-125, Sb-126, Te-132, I-130, La-140, Ce-138, 139, 143, Pr-142, Pm-151, Eu-157. **Action BNL.**

12. Finalize assessment of 232Th from IAEA/CRP that includes Leal resonances. **Action Trkov**.

13. Submit LANL 9Be evaluation to b2. **Action Hale**.

14. Assess 233U performance (Mosteller's comments). **Action LANL**.

15. Adopt 204Pb and also 208Pb(?) from Koning, see also next item. **Action Herman.**

16. Track down Pb data testing results. Any improvements in data testing using the new 206, 207Pb from JEFF-3.1? Testing of Pb needs more work, it seems that b1 evaluations (Koning) did not improve the situation and we may return to b0 evaluations (LANL). **Action MacFarlane.**

17. Remove natural W as it is of very poor quality (MacFarlane). **Action Herman**.

18. Make sure standards are included into ENDF/B-VII, including Au (n,g) and 11B (n,a) and (n,a1g). **Action Hale**.

19. 2H (deuterium). Dennis McNabb thought the n2n spectra looked off (it is based on phase space model, but some experimental info points to importance of di-neutron interaction). **Mark will ask Gerry to check.**

20. 2D S-alpha-beta still uses GA values. Could move to Mattes' too, if Bob has time to do this. **Action MacFarlane**.

21. 232Th will be finalized soon by the IAEA/CRP group led by Trkov. Needs to finalize and fix format issues. His preliminary testing was encouraging – as good as previous evaluations, better in some cases. We need to have tested by Mosteller and by the wider community.

22. When comparing capture RI with Mughabghab Atlas data, some of the discrepancies will be studied and potentially fixed. **Action Oblozinsky.**

23. Need to have Gd isotopes all processed properly, so that Van der Marck can complete data testing for Gd. **Action Rochman**.

24. Gd covariances for 8 isotopes will be completed (mf32 Leal, mf33 Rochman/Herman & Kawano) and submitted to b2. **Action Leal, Herman, Rochman**.

25. Li6 (n,t) standard from thermal to 1 MeV should be included in B-VII. As should the 10B evaluations for (n,a) and (n,a1g), Hale will do this. Gold should be included for 0.2 – 2.5MeV, and thermal, Kawano will do this. **Final action Carlson** – submit all standards to BNL.

26. 238U fission is a standard from 2-200 MeV; Pu fission; 235U fission. Should update beta-1 to use these "final-final" standard data. **Action LANL**.

27. Lubitz also described a recent JAERI /Wu discussion on how 235U in ENDF/B-VII could be improved, by decreasing the resonance integral capture to increase reactivity. He rejects this because it leads to an unacceptable leakage trend.

28. Lubitz mentioned how the 16O(n,a) cross section mod could lead to a further slight increase (say +50) in reactivity for U238 systems. 13C(a,n) and O16(n,a) measurements could solve this. New Harissopulos is 0.63 to 0.72 smaller than the B-VI evaluation, based on Bair and Hass. Other new data (in the low energy region – threshold to 1 MeV in the inverse alpha energy) by Heil also supports a lower cross section. The original Bair data was claimed to have been too low and should be increased by a factor of 2 – Hale took this seriously for B-VI, but it seems the JAERI file never did this. **Action – Hale and Page** will produce a new 16O evaluation within 2 months for (n,a) – using these Harissopulos and other data.

29. Blair. 235U fast systems. Russian Godiva calculates a bit, 3 series of HEU-MET bare metal cylinders (first bare, 2nd reflected with graphite, 3rd poly reflected). Bob showed endf/5 with a .3-0.5 pc bias. HEU-MET-FAST-51 (most are single cylinder, and fairly simple). Kahler noted the usefulness of HMF7 19-43 cases for testing HEU – we are currently slightly high (0.1-0.2%), unlike Russian Godiva where were slightly low (B-VI versus beta1 have gone up about 0.3%). **Action: LANL** will focus on these fast HEU benchmarks, from independent sources, to assess our 235U reactivity.

30. Temperature dependence and Huria's observation. Although for cold systems our criticality has increased by ~0.3 %, for hot systems it goes down slightly. MacFarlane's beta-1 numbers show similar effects – though at the hot temp he doesn't see such a decrease, more like a flat dependence compared to VI.8. MacFarlane has tried to track the effect down… by substituting back old 238, 235 etc,

he hasn't been able to isolate the effect! Perhaps there are coherent non-linear effects between 235 and 238! Unfortunately much temp-dependent data are proprietary.

31. Kahler's data testing. Plots above-thermal-leakage dependence of k-eff for various systems (HST). ENDF/B-VI.8 was excellent as a starting point. With beta-1, we see a very slight drop in reactivity with the new data; very good still. LCT2 and LCT10 involve lead walls next to lattices, and we see a bias where k-eff is too high.

32. ZPRs with spectra a bit softer than Bigten. Overall agreement is good, similar to B-VI. There are some reflector biases still, eg for W. The Pu C-reflected 6/10 (?) is terrible. Why reflector biases always +ve? Bob Bloch thinks that at the higher energies (eg for Fe etc) there are structures and holes in the resonances that may be washed out. If so, transmission is not done rightly – and too much is reflected.

33. Bob Schaefer showed some significant changes in delayed neutron parameters compared to B-VI, for beta-0 and beta-1. He saw big changes between beta0 and beta1. Perhaps Bill Wilson's values changed between beta-0 and beta 1. Bob's bottom line was that the overall impact on beta-1 library for beta-effective looks small (fortunately, from their perspective). Bob also saw big changes in the individual 6-group time constants and fractions – though the overall effects was small – this presumably reflects that the important point is the integrated effect of the sum of all 6-groups.

34. Bob Little will send in Gerry's n+T evaluation for use in beta-2. **Action Little**.

35. Through interactions with Koning and van der Marck, we have noted that with beta1 we don't see much improvement for Pb reflectors. For JEFF3.1, they still have problems with the thermal reflector, LCT-10 cases 1-4, but they do much better on the fast reflectors, eg HMF-64. Since beta-1 already uses JEFF for 206, 207, we should also try adopting 204,208Pb, and see if we can do better on HMF-64.

36. Dave Heinrichs on 233U. Looked at thermal, intermediate, and fast 233U assemblies. He showed likely problems in the intermediate energy range assemblies. This should be confirmed for beta-2 testing – but likely no one has time to solve this for our B-VII library. (Van der Marck's testing was positive for 233U, but didn't include these intermediate assemblies).

37. Mosteller's feedback, based on beta-0 testing. 233u issues: 233U fast looked very good, but the Falstaff intermediate spectrum low. The new Thorium from Trkov might help with THOR. Mosteller also looked at intermediate spectra probed by the ZEUS TA-18 HEU-Graphite assembly – we see a trend – perhaps due to deficiencies in the intermediate energy 235U spectra. Cu: Fast Cu reflection looked bad, with B-V looking better. Re Np237, JENDL3.3 gives 0.9967 whereas B-VI is still at 0.9927. Fast Np issues? What did JAERI do re. nubar and fission for Np – would be good to sort out the differences between 235 and 237 in this benchmark? Pu thermal problems too!

38. Ken Kozier. Problems with n+D, really D-U systems. The new ang distributions for elastic (<3.2 MeV and >20 MeV). HST-004, 020. HEU with D20 reflection. Sees a bias versus leakage. This curve is shifted compared to B-VI.4. He has ZED-2 reactor benchmark information. See a big change in reactivity. McNabb suggested trying JENDL data that are based on Fadeev calculations. At 3.75 MeV, for instance, the n2n angular distribution is much broader in JENDL. The corresponding energy distributions are different too. **Mark will ask Gerry to look into this**.

39. Oblozinsky will work with Trkov to check into any important discrepancies in FP RI data, arising from Trkov k_0 comparisons. **Action Oblozinsky, Trkov**.

40. Briggs noted his new criticality safety benchmark handbook for 2005, see http://icsbep.inel.gov, no action

41. Dunn/RQ Wright. New 247Cm evaluation should be adopted from RQ. His new 238Np is also available, and we should adopt. He also has new Pa-232. RQ suggests also adding 23 other minor actinides from JENDL. We will adopt. **Action Herman**.

42. Livermore should add delayed gammas into the file for 235, 238U and 239Pu, NJOY should be able to process them. **Action LLNL**.

43. Add missing actinide evaluations from RQ Wright. **Action BNL**.

44. Extend and include four LANL dosimetry evaluations (89Y, 191,193Ir, 169Tm), after completing them. **Action LANL & BNL**.

45. Include Zinc (6 isotopes, 64-68 and 70Zn), to be evaluated from scratch. **Action BNL**?

46. Some incomplete evaluations may be useful, e.g. for transmutation, they should not be excluded from B-VII (MacFarlane), 253Es? 249Cf? **Action BNL**.

47. C-nat as included in ENDF/B-VI and adopted in b1 is composed of the original 12C evaluation for ENDF/B-V plus 13C resonance that was added for B-VI (Carlson).

48. Temperature effects need to be further studied. **Action MacFarlane**.

49. D needs attention still (see Chalk River talk), and D in D2O from Mattes needs testing. **Action MacFarlane**.

50. List of files modified in b2 compared to b1 should be explicitly provided as a part of b2 release. **Action Herman**.

51. It would be most useful to have official version of NJOY for ENDF/B-VII processing, before b2 is released. No commitment from LANL was made, **action MacFarlane & Kahler**?

52. 238-U (Phil Young, added after CSEWG): The file, issued as ENDF/B-VII beta1, is evaluation u238la8o instead of the most recent version u238la8p, completed around April 2005. The only difference between the two is that u238la8p contains updated resonance parameters from Courcelle. The latest version should be submitted to BNL. **Action LANL.**

Other evaluations

53. p+13C and p+10B from Page will be included in b2 or in ENDF/A. **Action Page**.

54. Resonance extension for g+14N and g+16O from BNL/LANL will be included in b2. **Action Oblozinsky**.

55. Decay data sub-library will be updated, considerably extended and submitted to b2. **Action Sonzogni**.

56. Missing sub-libraries will be included into b2. **Action Herman**.

Concluding items

57. Next meeting
    - CSEWG validation meeting will be held on June 27, 2006 (Tue) at BNL, followed by NDAG, June 28, 2006 (Wed). **Action Oblozinsky**.
    - Next full CSEWG meeting will be held on Nov 6-8, 2006 (Mo-Wed), USNDP on Nov 7-9 (Tue-Thu) and NDAG on Nov 9 (Thu), all at BNL. There should be no parallel sessions in the CSEWG meeting. **Action Oblozinsky**.

58. Full list of neutron materials to be removed or added (partial list for 'to be replaced')
    - 3H (currently from 1965!), replace by new Hale
    - W-nat, remove
    - 208Pb, replace by Koning
    - 204Pb, add Koning
    - 22Na, 58,58mCo (Sublet list), add after review
    - 64-68,70Zn, add if completed (entirely new evaluations, to be done by BNL?)
    - 89Y, 191,193Ir (LANL dosimetry), replace if complete new evaluations available
    - 169Tm (LANL dosimetry), add if complete new evaluation available
    - 253Es, add even if incomplete

59. ENDF/B-VII beta2 total neutron materials expected
    - 387 total in b1
    - 1 remove (W)
    - 12 add (Pb, 3xSublet, 6xZn, Tm, Es)
    - **398 total in b2**, probably too optimistic

Summary of the
8th U.S. Nuclear Data Program Meeting

Held at
Brookhaven National Laboratory
November 9 - 11, 2005

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US Nuclear Data Program

Chairman's Summary

P. Oblozinsky
National Nuclear Data Center, BNL

USNDP Annual Meeting

The 8th Annual Meeting of the United States Nuclear Data Program was held on November 9-11, 2005 and attended by 41 participants. The meeting was held following the CSEWG Annual Meeting, with a common USNDP-CSEWG session on Nuclear Data for Homeland Security, Reaction Modeling and Astrophysics.

Nuclear Structure Working Group

The status of basic databases NSR, XUNDL and ENSDF was reviewed. A considerable increase in ENSDF evaluation productivity (295 nuclides) was noted with satisfaction. This positive result can be, at least partly, explained by several collaborations of U.S. laboratories with new foreign evaluators trained at successful Workshops organized by the IAEA in Trieste.

Nuclear Reaction Working Group

Nuclear reaction activity was driven by evaluations for a new ENDF/B-VII library, scheduled to be released in 2006. Large number of new/updated evaluations (102 reactions) for this library was produced, representing a considerable increase compared to FY04.

A session was devoted to covariance methodology, stimulated by growing needs for cross-section covariance data in many applications.

Data Dissemination

Data dissemination continues to grow. Fairly rapid growth for the USNDP, by 35% in FY05, is largely due to continuing impact of a new generation of services launched by the NNDC for the USNDP in April 2004. ORNL made considerable improvement in its nucastrodata.org webpage, and also LLNL started to provide data service to external users.

User Discussion Forum

A new activity was started aimed to strengthen interaction between the user community and USNDP. A half-day session devoted to this initiative was met with generally very positive response.

Planning and Reporting

- Summary of Annual Meeting 2005 should be issued in December 2005,
- Annual Report for FY05 in December 2005, and
- Workplan FY07 in January 2006.

The next budget briefing should be held on February 17, 2005 as a preparation for FY08. Unless otherwise required by DOE, the budget briefing team will include Pavel Oblozinsky and WG chairs (C. Baglin and T. Kawano). In view of the 5% budget cut in FY06, a deep concern was expressed on expected FY07 and FY08 flat-flat scenario and its impact on the US Nuclear Data Program.

Next Meeting

The next USNDP annual meeting will be held at BNL on November 7 - 9, 2006 (Tuesday - Thursday). The next CSEWG annual meeting will be held on November 6 - 8, 2006 (Monday - Wednesday).

USNDP Coordinating Committee Meeting

The Coordinating Committee met at working lunchtime on Thursday, November 8, 2005. All 10 members attended the meeting, including P. Oblozinsky (chair), C. Baglin, A. Carlson, T. Kawano for M. Chadwick, J. Kelley, F. Kondev, D. McNabb, J. Cameron for B. Singh, and C. Nesaraja for M. Smith. In addition, Sid Coon, data program manager of the DOE Office of Science, Office of Nuclear Physics, attended the meeting.

Agenda

- Annual Report FY05: See above
- Workplan FY07: See above.
- Budget Briefing FY08: See above
- Next Meeting: See above
- Other Business: Several positive comments were made on the session 'User Community – USNDP Discussion Forum'. This attempt to strengthen interaction with users was appreciated and continuation of this effort was recommended.

US Nuclear Data Program

Minutes of Structure and Decay Data Working Group Meeting

8:45 am-12:45 pm Wednesday 9 November 2005, and
8:30 am-1:00 pm and 2-2:45 pm Thursday 10 November 2005

C. Baglin, LBNL (Chair)

Present: C. Baglin, S. Basunia, E. Browne, T. Burrows, J. Cameron, R. Haight, J. Kelley, F.G. Kondev, C. Nesaraja, N. Nica, B. Pritychenko, C. Reich, A. Sonzogni, J. Tuli, D. Winchell. Also, M. Carpenter, S. Coon, I.-Y. Lee, P. Page, D. Smith and several others were present for segments of the meetings.

Status Reports

- **ENSDF (J.Tuli):** A summary of literature cut-off dates for A>20 chains was presented. The most recent list of priority nuclides was prepared in February 2005 and contained 150 nuclides. The review process has been further modified so that **all** chains now go back to the reviewer after the evaluator has responded to the review; reviewers should not, at that stage, re-review the work, however. Any reviewers who do not wish to have chains returned to them should inform J. Tuli of that fact.

- **NSR (D. Winchell):** Of the roughly 183,000 entries in this database, 4756 were added during FY2005 and monthly distribution of the database continued. A major update of DOI information was performed. The keyword preparation effort is now being shared with IAEA. An update of the coding manual is ongoing, and subject indexing is being reviewed. The *Recent References* issue of the Nuclear Data Sheets was discontinued this year. It was suggested that it would be beneficial if links to various journal home pages were provided from the NSR page in addition to the links to specific articles.

- **XUNDL (J. Cameron for B. Singh):** This database now contains 1626 datasets. 300 new datasets were added in FY05 and 15 existing ones were revised. These datasets contain information from 1200 primary references and cover ~1100 nuclides spread over ~225 A-chains. Datasets are currently prepared at McMaster by Joel Roediger, an undergraduate student, under the close supervision of Balraj Singh. Communications with authors continue to lead to the correction of many data errors; in fact, many journal errata would become unnecessary if the XUNDL data entry were performed prior to journal publication! Compilation of recent high-spin and low-spin papers is essentially current.

- **ENSDF Analysis and Utility Codes (T. Burrows):** The major effort in FY05 centered on the completion of the Bricc conversion coefficient utility package (see below), version 2.0 of which was distributed at the end of FY05. In addition, the least-squares fitting program GTOL has been revised and Version 7.1a has been distributed. This is now a double-precision code incorporating several modifications suggested by the St. Petersburg Nuclear Physics Institute. χ^2 values are reported and a warning issued if the value exceeds χ^2(critical), and additional summary tables have been added. Evaluators should now rerun GTOL for data sets that include high precision E_γ data such as those from 2000He14 because the single-precision program may have provided quite unreliable results in such cases. Several small bugs still need to be removed and the program also needs to remove from consideration any transitions for which the final level is unknown (*e.g.*, those with 'FL=?'). Version 7.2, to be distributed very soon, will deal with these issues. Some Bricc-related work will be performed soon on FMTCHK, ENSDAT, RadList, GTOL and RULER to enable recognition of partial conversion coefficients and acknowledge the lower uncertainty provided by Bricc.

- **Update on Bricc Package (T. Burrows):** This package was developed by an Australian-Russian-US collaboration and Version 2.0 was released to evaluators in October 2005, as detailed elsewhere in the report of this meeting. Bricc provides conversion coefficients (all shells and/or subshells), electron-positron pair coefficients and electronic factors for E0 transitions for Z=10-95 and it now replaces HSICC for future mass-chain submissions. Exhaustive comparisons between measured data (including the new high precision value for the M4 80.24-keV transition from the 10.53 d isomer in ^{193}Ir) have led to the conclusions that calculations must take into account the effect of the electron hole produced in the internal conversion process and that there appears to be a slight preference for the frozen orbital type of calculation. Consequently, it is this type of calculation that is adopted in the present version of Bricc, in contradistinction to the 'no hole' calculations used for the earlier Version 1.3. The estimated uncertainty in interpolated coefficients is 1.4% compared with 3% for HSICC. Online, interactive calculations of conversion coefficients also can be performed using Bricc at http://www.rsphysse.anu.edu.au/nuclear/bricc/ (or using HSICC at http://www.nndc.bnl.gov/hsicc/). Future plans for Bricc include an extension of Z to 105, resolution of some platform-dependent numeric differences, implementation of calculations for three mixed multipolarity transitions or for E0 transitions and development of a "silent" Bricc for web interface use or for calls from other applications. An effort to reassess "How good are the conversion coefficients now?" is nearing completion. (See full report to this meeting *re* Bricc).

- **New Evaluator Recruitment, Training, and Assimilation (J. Tuli):** With a view to bolstering a waning non-US evaluation effort, a one-week training workshop was held as a pilot project in Vienna in 2002, and this was followed by two-week workshops co-organized by IAEA and ICTP (Trieste) held in November 2003 and April 2005, with the final workshop of this series scheduled for February 2006. Four

USNDP evaluators conduct the ENSDF training and approximately five other professionals provide nuclear theory and experimental techniques lectures. All participants in the pilot program continue to be actively involved in structure and decay data evaluation work and new data evaluation efforts now exist in Argentina, Australia, Brazil, Bulgaria, India and Russia. A number of participants in the subsequent two workshops have also been involved in mass chain evaluations. Mentoring of new evaluators is very important and, in FY05, NNDC and McMaster have contributed greatly to this effort. The challenge that remains is to have the pool of newly trained evaluators funded to do evaluation work. It was noted that young faculty tend to receive very heavy teaching loads and sometimes the credit received for evaluation publications is lower than that for research publications. Combined research+evaluation appointments might solve the first problem. However, there needs to be a greater realization of the importance of evaluations on the part of the people in the international community who control funding. J. Tuli is working with IAEA to start addressing this in Europe.

- **IAEA-CRP on "Updated Decay Data Library for Actinides" (F.G. Kondev):** The objective is to produce improved decay data files for actinides of relevance to nuclear facilities, waste management, safety assessment, safeguards/proliferation issues as well as non-energy applications. Participants from eight countries, together with the program officer M. Kellett (IAEA), met at the IAEA headquarters in Vienna on October 17-19, 2005 and decided on evaluation methodology (to be based on that used by the Decay Data Evaluation Project, but using Bricc for conversion coefficients), which nuclides should be evaluated and/or measured and by whom. Evaluation assignments were made for 58 decays and an extended list of 94 additional nuclides was drawn up. Measurements on 14 nuclides were assigned also. The evaluated data will be made available in ENSDF and ENDF formats.

- **ENSDF Editor Software (A. Sonzogni):** The ENSDF-format editor described at the last USNDP meeting has undergone further testing and refinement and the β release zip file became available in September 2005 from http://www.nndc.bnl.gov/nudat2/evp. The editor is designed to minimize the impact of the ENSDF format on ENSDF evaluation work and the data input function has been integrated with ENSDF checking and calculation codes and the NuDat interactive level and decay-scheme plotting tool. The release of Version 1.0 is scheduled for 1 December 2005. Future plans include a search capability and the ability to hide unused text boxes and areas.

Formats/Procedures/Jπ Rule Topics

- **Clarification of B(σλ) Entries in ENSDF:** Some users would like transition probability entries in ENSDF to include an indication of whether they are for excitation or deexcitation. T. Burrows will look into the possibility of modifying the

production programs so that this is automatically indicated for values outputted from B(σλ) fields in ENSDF. Evaluators would still need to ensure that values in comments clearly indicate the transition direction.

- **Nomenclature for Rotational Bands and Configurations and Jπ Rule for Strongly-Coupled Bands (F.G. Kondev):** F.G. Kondev and B. Singh are working on a document on these topics. When completed, it will be circulated among evaluators for comment well ahead of the next USNDP meeting.

- **Quality/Legibility of Level Scheme and Band Drawings:** As has been noted in the past, these drawings often are less legible and informative that might be desired. The RadWare style band drawings, in particular, are usually inferior to those in journal publications and evaluators frequently opt for the old-style drawing instead; however, it was judged that, in order to do better, it would take more human intervention in each drawing than we have manpower to support.

- **Revision of Segments of Nuclear Data Sheets Introductory Material (C. Baglin):** It was noted that items 1 and 2 in the left-hand column of page *v* of the Introductory Material in NDS describing default practices are not consistent with reality and changes were suggested to remedy this:

"The following policies apply to the presentation of data in reaction and decay datasets. Any deviation from these policies will be noted by the evaluator.

1. The Jπ values in [the] decay data sets [and reaction data sets with gammas] are taken from the associated Adopted Levels, Gammas data set. For [other] reaction data sets the Jπ values are from the reaction data. The Jπ value to the capture state in thermal-neutron capture is assigned assuming s-wave capture.
2. The *multipolarity* of a γ ray and its
3. mixing ratio *given in a decay data set* are from the associated Adopted γ radiation table."

For item 1, it was proposed that we **remove** the text shown above in square brackets. After discussion, this was accepted without objection (moved: J. Cameron; seconded: T. Burrows).

For item 2, it was proposed that the words shown in italics be **added**. After considerable discussion, this too was accepted without objection (moved: F.G. Kondev; seconded: J. Kelley). However, the long-term practice of treating decay data sets differently from all others was debated. Regardless of whether more or less material were to be imported into decay data sets from Adopted Levels, Gammas datasets, such a change would represent a significant alteration of established policy. Since the meeting had no prior

preparation for such a discussion, no carefully considered proposal was on the table and the time for discussion was limited, the Chair asked that further discussion be deferred until after this meeting. Some progress should be possible *via* email during the year and the question can be revisited at next year's USNDP meeting.

While on the topic of Introductory Material for NDS, J. Tuli referred to the document on classification of β decays prepared by B. Singh and Y. Akovali and accepted at the USNDP and IAEA-NSDD meetings in 2003. It had been noted recently that this document had not been added to the NDS Introductory Material. He proposed that the entire document be incorporated in the Guidelines for Evaluators but that only the (minor) revisions to the rules be added to the NDS Introductory Material. These actions were considered reasonable assuming they satisfy the IAEA-NSDD's intent for the document.

- **Nuclear Moments:** Nick Stone's compilation of nuclear moment measurements has now been published (2005St24). However, his evaluation is not yet available, so 1989Ra17 is still the latest evaluation. Evaluators could confer with Nick on a case-by-case basis; otherwise they should check the numbers in the compilation and probably should avoid using weighted averages when several measurements of the same quantity are available.

- **Need for Mixing Ratio Calculation Program:** In the VAX-computer era, some evaluators had access to programs which calculated mixing ratios from a set of subshell ratio measurements; the need for such calculations remains, but the program does not. E. Browne will provide the citation for a published code and A. Sonzogni has agreed to prepare a suitable program for evaluators to use.

Other Topics

New Web Interface for Evaluated B(E2) Data (B. Pritychenko): A newly-constructed web interface providing online access to evaluated B(E2) data from 2001Ra27 was described. It is accessible at http://www.nndc.bnl.gov/be2. It is integrated with the NSR database. Future plans include an expansion of scope to include all nuclides, not just the even-even ones, along with other B(Eλ) data. This is seen as a nuclear structure help tool; another topic which might be addressed similarly in the future is double β decay.

Nuclear Data Sheets – Impact Factors (A. Sonzogni): This report followed on from one at the USNDP meeting in 2003 which showed a rather low and decreasing impact factor (see definition in detailed report to this meeting) for the journal Nuclear Data Sheets. The impact factor is currently much higher, and this may be attributable to (i) the impact from papers that cover a range of masses (*e.g.,* the superdeformed band or proton emitter publications) and (ii) increased web visibility of the journal *via* its page on the NNDC website that provides an up-to-date index and direct links to articles.

In addition to mass chain evaluations, it is anticipated that some articles on topics that directly impact ENSDF will be published in Nuclear Data Sheets in the future; possibilities include a shape-isomer evaluation and some decay evaluations that are in progress.

The increasing inaccessibility of the journal due to the escalating costs of Elsevier publications was noted, but it is unclear what can be done about the situation.

J. Tuli noted that we need to publicize a consistent way of citing ENSDF data, from the journal or from the web. Vicki McLane's version of several years back probably could benefit from revision by now.

Proposal to Prepare a "Table of Nuclides" Type of Product Drawn Directly From ENSDF (J. Tuli): With relatively little effort, it should be possible to modify the present NDS production codes to extract adopted and decay data from ESNDF, devoid of all comments and keynumbers, and provide this summary information for all nuclides both on the web, on CD-ROM and in several hard-copy volumes. Work could start in Spring 2006 and continue through Fall 2007. For the hard copy, it was proposed that an entire volume or two (*i.e.,* 4 or 8 issues/months) of Nuclear Data Sheets could be devoted to it.

The ensuing discussion noted that many users liked to have information for all nuclides in a single publication through which they could riffle, even though hard copy is not searchable. Concerns centered on (i) how much manpower would be diverted from evaluation work, since experience teaches that preparation of such a product cannot be a push-button operation, (ii) how many volumes of NDS would be needed to accommodate the amount of material generated and, consequently, how many mass chain publications would be significantly delayed as a result of this publication, and (iii) who constitutes the target audience, since structure researchers and the applied community will want different features in order to be satisfied.

Next Meeting: The USNDP meeting in 2006 has been scheduled to run from Tuesday 7 November through lunch time Thursday 9 November in order to avoid the Veteran's Day holiday to be observed at BNL on Friday 10th.

US Nuclear Data Program

Minutes of Nuclear Reaction Working Group

T. Kawano, LANL (Chair)

Nuclear Models

Model code development

Kalbach, TUNL presented several improvements in the exciton model code PRECO, which were isospin conservation and uncounted residual nucleus states. The isospin conserved and mixed pre-equilibrium reactions were distinguished by the excitation energy and symmetryenergy. The missing residual state problem at low excitation energies was resolved by including the effect of Fermi energy change during a particle emission.

Talou, LANL summarized a current status of the McGNASH code. Some utility codes such as GSCAN, RECOIL, were incorporated into McGNASH. The code also has RIPL-2 interface, DDHMS module, and plotting capability with GNUPLOT. The ENDF formatting module was also improved. He also summarized a future plan.

Herman, BNL described recent developments of the EMPIRE code for nuclear data evaluation work. An automatic fit of optical potential parameters, and a covariance generation were implemented. Two methods were used to calculate the covariance matrix, the KALMAN approach and the Monte Carlo method. As an example, the covariance matrices for Gd isotopes were shown.

Fukahori presented new model codes developed at JAEA, Japan. The POD code is designed to calculate cross sections in the FP region. The COCOON code system is mainly for evaluation of minor actinide data. Those codes will be used for JENDL-4 evaluation.

Nuclear Astrophysics

Nesaraja, ORNL gave a talk on the computational infrastructure for nuclear astrophysics, which aims at getting the latest nuclear evaluations into astrophysical simulations. The new features added were, nuclear mass model evaluator that compares the theoretical and experimental masses, the element synthesis simulator that visualizes a change in the element abundance at the nucleo-synthesis simulation. Comments on reaction rate can be shared with the rate commentor.

Reifarth, LANL gave a talk on the s-process modeling. He showed some important branching points in the s-process such as Zr95 and Gd153, and emphasized how new experiments at LANSCE/DANCE will reduce the uncertainties in the s-process calculations. Capture cross sections on Eu152, Eu154, and Gd153 are planned to measure.

Covariances

Leal, ORNL presented a method to generate covariance data for resonance parameters using SAMMY. When a new resonance analysis is available, the covariance data are automatically generated by SAMMY. The U233 covariance data were processed with ERRORJ to produce COVERX formatted data, and benchmark calculations were done with TSUNAMI. It was shown that contribution of U233 resonance parameter uncertainties to k_eff is about 0.5% for the U233 thermal system (u233-sol-therm-015). We also need to use a retroactive method to evaluate the covariance data for existing resonance evaluations, U235 and Gd isotopes, for example.

Herman and Rochman, BNL evaluated covariance data for Gd isotopes using the EMPIRE+KALMAN system. Sensitivity matrices were calculated with EMPIRE, and those were fed to KALMAN to generate the covariance in the ENDF-6 format. A correlation matrix shown as an example revealed a structure that comes from nuclear reaction models used. The EMPIRE code with the Monte Carlo technique is also used for a Th evaluation at IAEA.

Brown, LLNL presented a covariance work at LLNL. A new format for the covariance data in XEndl was developed, which allows to store the correlated data sets. A new uncertainty quantification based on the Monte Carlo method was also presented. Many sets of nuclear data are sampled randomly, and run a simulation code for each set to construct the distribution of simulation results. Then the weight of each data set is calculated. The method is flexible to handle a non-Gaussian distribution and inconsistent evaluations.

US Nuclear Data Program

User Community-USNDP Discussion Forum

D.F. Winchell, BNL (Chair)
2:00-6:15 pm Wednesday, November 9, 2005

As part of the 2005 USNDP Meeting, a half-day session was arranged in which four outside researchers were invited to give half-hour talks on their recent work. The intent of the session was to create an additional avenue of communication between people in the data program and the users of the nuclear databases and other USNDP products. It was hoped that evaluators would learn about recent and upcoming research, and find out more about how the data is used. In addition, the researchers might learn more about the process of data compilation and evaluation, and share this information with co-workers at their home institutions.

The schedule for the session allowed for approximately 90 minutes of discussion following the presentations. The following were listed in the agenda as possible discussion topics:

- How are current services utilized?
- How can current services be improved?
- How can the research community contribute?
- Would a USNDP user group be worthwhile?

Presentations

The session began with a joint presentation by D. Winchell, A. Sonzogni, and B. Pritychenko (all BNL). This presentation provided an overview of current USNDP databases and related activities. It was followed by four talks given by researchers from outside the USNDP.

The 1st research talk. The talk was given by **I-Yang Lee** of LBNL, on "Physics Opportunities of the Gamma-ray Tracking Detector". These arrays consist of highly-segmented high-purity germanium detectors. The segmentation allows reconstruction of full gamma-ray energies based on the positions and energies of interaction points as the gamma-ray Compton scatters within the germanium. The use of the gamma-ray tracking technique will allow the construction of arrays with much greater total efficiency, precise Doppler correction, and gamma-ray polarization information. Several arrays based on these ideas are being designed or built, including the GRETINA array at LBNL, which has a scheduled completion date of 2010.These arrays will allow the study of nuclear physics phenomena that are inaccessible to the current generation of arrays, and should extend our knowledge of nuclear structure at extremes of mass, angular momentum, deformation, and stability.

The 2nd research talk. The talk was given by **Michael Carpenter** of ANL on "The Study of Proton-Rich Nuclei in the Pb region: A Tale of Three Shapes". For some time, the coexistence of spherical, oblate, and prolate shapes has been known in the mid-neutron-shell nuclides in the lead region of the chart of nuclides. Extending our knowledge of nuclear level schemes to the more neutron-deficient nuclides provides insight into shell structure and configuration mixing near the proton drip-line. In recent years several nuclides in this region have been studied using the Gammasphere array and the Fragment Mass Analyzer at Argonne. This combination allows the study of nuclides produced with small cross section, by using the recoil-decay tagging technique, in which prompt gamma rays are correlated with decays of mass-separated recoil nuclei. The level schemes and alpha-decay properties of ^{181}Tl and ^{181}Pb have recently been studied in some detail.

The 3rd research talk. The talk, entitled "Small, Medium, and Big Ideas on Nuclear Data", was given by **Paul Cottle** of Florida State University. Changes in nuclear shell closures far from stability are an area of ongoing research. Recently, one- and two-nucleon knockout reactions on exotic nuclei have been studied at the NSCL facility at Michigan State University. Cross sections for two-proton knockout from ^{46}Ar and ^{44}S (leading to ^{44}S and ^{42}Si, respectively) were found to be smaller than predicted, indicating a Z=14 shell closure for this region of the chart of nuclides.

The 4th research talk. The talk was given by **John Millener** of BNL, on "Hypernuclear gamma-ray Spectroscopy". Excited states in hyper-nuclei, which consist of neutrons, protons, and one or more hyperons, can be studied with the same spectroscopic techniques as regular nuclei. They can and have been formed in reactions using incident pions, kaons, or electrons. The measurement of these excited states allows a better understanding of fundamental hyperon-nucleon interactions. In recent years level structures for dozens of hypernuclei have been studied experimentally.

Discussion and Conclusions

Each of the first three speakers spent some time discussing the use of nuclear data and related products in their research. In particular, it was noted that the data was used extensively in planning experiments, comparing new results with existing data, and studying systematics of nuclear properties. In the third talk, several specific suggestions were made, including separate indexing of polarized and unpolarized-beam reactions in NSR, indexing of reaction energy in NSR, and more detailed coverage in ENSDF of nuclides with A < 40. It was noted that some of these recommendations are already being implemented. There was also discussion on possible new publishing models in nuclear structure research. This topic was discussed further in the latter part of the session (see below).

Following the talks, there was about one hour of open discussion. One topic of particular interest was publishing models. At the end of his talk, Paul Cottle suggested that a policy of making all nuclear physics papers freely accessible, in the same way that the NIH is making government-funded medical literature available, would be beneficial to the research community. While this suggestion is somewhat outside the scope of USNDP

activities, there are related issues of interest to the data community. It is often the case that, due to space concerns or other reasons, there might be additional data associated with journal articles that is not published. J.Millener mentioned the repository kept by *Physical Review C* of additional data not published in the journal. In the past, there have been discussions about the NNDC being a repository for this data. Due to manpower issues this has not been implemented, though it seems to be considered a worthwhile concept. There is also structure data that is never published but might be of interest for archival purposes. Attempts to collect this type of data, by David Radford at ORNL and others, have had limited success.

- The possibility of forming a nuclear data user's group was also discussed. Such a group could provide an organized way foster communication between the USNDP and the researchers that use and supply data. One format for this communication could be user group meetings at selected conferences. For user facilities, these groups typically have a role in advising and advocating the facility's activities. Paul Cottle and I-Yang Lee were both in favor of the formation of a USNDP user group.

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Cross Section Evaluation Working Group & US Nuclear Data Program

Nuclear Data Needs for National Homeland Security Program

Dennis McNabb, LLNL
Task Force Chair

Draft Report UCRL-MI-207715

Introduction

At the November 2003 USNDP session on Homeland Security it was agreed that a needs list for new nuclear data and new database capabilities should be developed. Through an informal survey of homeland security technical programs at LLNL and LANL and input from the US Nuclear Data Program community we have developed this document. Only items requested by currently funded research and development projects are listed; no attempt has been made at this point to prioritize these needs.

There appears to be two main program drivers for this needs list:

- Detection of radiological and nuclear materials being transported into or through the US or its concerns
- Monitoring, detection, and analysis of nuclear explosions and nuclear weapons proliferation through radionuclide monitoring and other detection capabilities.

Some related aspects of these programs drivers, including international treaty negotiations and emergency response, also have a few data needs.

Projects under these two program umbrellas typically encounter nuclear data issues when variant detection schemes or event scenarios are modeled using sophisticated simulation codes such as MCNP(X) or GEANT. These simulations are used to lay the groundwork for proposing and planning new projects and also to optimize the design or analysis of different configurations. Many calculations can be performed quickly, whilst individual experiments involving SNM require extensive authorization and are costly. Simulations of fielded experimental interrogation configurations can be used to interpret the measured data. And very importantly, simulations can extensively explore "what if?" questions.

The simulation capabilities are built upon high-quality fundamental nuclear cross section and decay databases, in the ENDF nuclear data library. These evaluated databases incorporate the detailed information available from experiments and from nuclear models, and allow transport simulations to model the underlying physical phenomena accurately. Several of the projects surveyed had encountered the need for advances in simulation methods and in the underlying ENDF library. These needs range from particle correlations in energy, angle and multiplicity to improved data for photonuclear reactions to improved cross sections for neutron reactions involving unstable or rare isotopes to improved gamma-ray production data.

There were also many projects surveyed where nuclear decay, reaction and structure libraries as well as specific references were consulted to address or explore issues and ideas analytically. The resources used included the ENSDF nuclear structure library and NSR references library, and these resources were typically accessed through a variety of web-based dissemination projects -- the usefulness of these resources depends on the ease of use and the completeness and accuracy of the information present. In many cases the ENSDF and NSR resources were used as input to calculations to generate data for transport simulations or to generate physical constants used to assay a sample. Several of the projects surveyed indicated a need for better decay half-life and branching ratio information in specific cases, e.g. the spontaneous fission half-life of ^{240}Pu, and some had plans to make measurements to acquire the information they were missing, or to benchmark the data that is presently available in ENSDF and ENDF.

Correlated particle information from fissile materials

The timing data stream of neutron counts contains information that can be used to determine properties of the source of neutrons. For materials that support fission chains, a random event that spontaneously creates neutrons, such as a spontaneous fission or an (alpha, n) reaction, is followed by a correlated number of neutrons emitted by the fission chain. The rate of spontaneous fission events is proportional to the amount the spontaneous fission isotope. The length of the fission chain is related to the system multiplication. The number of neutrons emitted in an individual fission satisfies a probability distribution that is approximately Gaussian, with typically about three neutrons emitted on average, but with a reasonable probability that no neutrons are emitted or as many as eight neutrons are emitted. (The nuclear data for the neutron distributions has been tabulated by Holden and Zucker from Brookhaven.) In a multiplying medium this intrinsic fluctuation for each fission is amplified for a fission chain, with a very high probability the chain creates many more than the average number. The large fluctuations in the number of neutrons are a great advantage for detection and for assay. Similar large fluctuations in the number of fission gamma rays emitted are also likely to be advantageous.

Gamma ray timing also carries information about the fission chain. First, when neutrons are absorbed in an (n, gamma) process, the gamma continues the same information about the fission chain as the original neutron out from the absorber, especially as these are penetrating high-energy gammas. The timing of the (n, gamma) neutrons also carries the same information about the moderation process (~ 100 microsecond time scale) as the original neutrons. In addition, each fission in the chain emits a burst of gamma rays, the entire fission chain gamma cascade being prompt (~ 100 ns) compared to the moderation time scale.

Projects involving detection or assay schemes using particle correlations have lead to the following new data needs:

i) *The probability distribution for the number of prompt gammas created by an individual fission*

While the average number emitted is known it is the actual distribution is needed. Given the large number of decay channels the final distribution is likely nearly Gaussian by the central limit theorem, but the width is not known.

ii) The correlation between the number of emitted neutrons and gamma rays

When very few neutrons are emitted by a fission event, do there tend to be more gamma rays emitted? When there are eight neutrons emitted, is it more likely that there are fewer gammas emitted?

iii) Energy - number correlation for gamma rays

When many gammas are emitted, do there tend to many soft gammas after hard gamma emission? The gamma energy correlation is important because of the energy dependence of penetrability.

iv) Delayed gamma distributions

The fission fragments will beta decay on second time scales, long compared to diffusion time scales, but there will tend to be cascades. There will also tend to be a series of beta decays, each with a different cascade. How do the number distributions of the cascades change in the subsequent beta decays, both in number distribution and energy distribution?

v) Non-fission gamma cascade number and energy distributions

These cascades could, for example, follow (alpha, n gamma), (n, n' gamma) or (n, gamma). All of these processes emit multiple gamma ray bursts, on time scales short compared to time between subsequent scatterings in an event chain. Are there other time scales from metastable states? The gamma rays from these correlated processes are statistically distinguishable from potentially large gamma ray backgrounds, both from the environment and from the alpha decay chain gammas. It is especially the large fission chain fluctuation bursts that contain the most information.

Gamma-ray production information

The gamma-ray lines emitted in radioactive decay or as an excited nucleus decays to its ground state provide a unique, characteristic signature of the decaying element or isotope. Provided that there is an external probe that can broadly induce such radioactive decay, such as a neutron or photon source, this information can be used to detect or assay materials. The rate of photon production is proportional to the amount of material being irradiated folded with the energy-dependent cross section for inducing the radioactive decay signature. The detection probability depends on the attenuation of the characteristic gamma-ray lines in surrounding absorbing material and the rate of

background photon production. Detection works best when (1) the absorbing material has a low atomic number, e.g. hydrogenous materials, (2) the characteristic gamma-ray lines are higher in energy, and (3) there is a time or energy dependence to the signal which distinguishes it from background photons. For example, the detection of delayed gamma rays from fission with energies above 3 MeV has been proposed as a detectable signature of fissile materials interrogated with external sources. Assay works best when a detectable signal exists from all elements present. For example, the neutron capture gamma-ray spectrum is starting to gain favor as an assay method in a technique known as Prompt Gamma Ray Activation Analysis.

Projects involving detection or assay schemes using gamma-ray spectroscopy have lead to the following new data needs:

i) Delayed gamma-ray energies and half-lives from fission with half-lives ≈ 0.5 s and $E_\gamma > 3$ MeV

Data in this half-life range is sparse. However, if there is a penetrating radiation with significant yield at times greater than 100 ms, then it would effect design considerations for detection schemes for fissile materials.

ii) High resolution (≈ 1 keV) gamma-ray spectra from neutron capture ($E_n < 50$ keV) on all naturally-occurring materials

High-resolution spectroscopy can be used as an assay tool that is relatively broad based in that most elements except helium have a naturally occurring isotope with significant gamma-ray production following neutron capture.

iii) An event generator to source spectrally correlated gamma rays from decay cascades following neutron capture and other reactions

Investigations of detector response and backgrounds caused by naturally occurring or external neutron sources often require one to conserve energy and spectral shape on an event-by-event basis. This capability is generally not available in traditional transport codes.

iv) Improved representation of neutron scattering and subsequent photon production in germanium detectors, particularly inelastic scattering leading to "neutron bumps"

There are several instances where a promising signature is co-located with neutron bumps in germanium detectors. A better model of the processes involved will allow engineers to consider designs to minimize the interference via simulation.

v) Complete gamma-ray spectra from proton and alpha induced reactions

In some cases, these data were needed in order to model background processes. For example, alpha decay can sometimes result in an alpha-induced reaction from which a photon cascade is emitted. In other cases, the secondary photon spectra are used as a probe. This is discussed in more detail in the next section. It should be noted, that induced photon lines from alpha-induced reactions often have hard-to-model line shapes due to kinematic recoil, which need to be characterized for some applications.

Photonuclear data

Photon sources offer some possible advantages over neutron sources for active interrogation schemes: (1) the source can double as a radiograph source and (2) photons are more penetrating than neutrons for hydrogenous cargos. These advantages have led to some initial work to model photonuclear processes in transport simulation codes. For instance, new capabilities have been developed to model photonuclear and photofission reactions in MCNP(X), with an accompanying development of evaluated photonuclear cross section databases. A first demonstration capability was developed, and some initial comparisons with validation experiments were successful. However additional research is needed to improve the simulation tools. These include:

i) Development of photonuclear data for $\gamma + {}^{235,238}U$ and ${}^{239}Pu$

ii) Photofission delayed-neutron probabilities, energy spectra, and time-dependences for the delayed neutrons
With photon sources, the compound nucleus that fissions is different from neutron sources. Delayed neutron probabilities and energy spectra can vary widely from isotope to isotope.

iii) Development of nuclear data to support interrogation methods for conventional and nuclear explosives, using resonant photonuclear absorption on nitrogen and SNM.
There are two issues here. First, these processes are not included in transport simulation codes because the data is not part of the standard evaluated data files (ENDF) that get incorporated into transport simulation codes. In most cases, however, the known resonances and subsequent decay patterns are tabulated in ENSDF. The second issue is that many of the resonances that would be most useful from the viewpoint of a practical system have never been measured. For example, *(γ,γ')* resonances in ^{235}U have only been tabulated up to excitation energies of 1 MeV.

There are some data needs in the area of photon source development based resonant processes that should eventually be addressed. One scheme is resonance absorption of approximately 9-MeV photons prom p + ^{13}C in $1^{4}N$. The other scheme is Argonne FIGARO approach in which 6-7 MeV photons from $^{19}F(p,\alpha\gamma)$ are used to interrogate for SNM via (γ,n) and photo-fission processes. In both of these areas, protons are incident on target materials. Data on protons with energies below 5 MeV (higher energies are impractical because the accelerator would be too large) incident on thick stopping targets of various materials are very sparse. There are some thin-target data available, but experience shows that trying to fold incomplete thin-target data with stopping power information to generate effective thick target results is generally quite inaccurate and thus unproductive for applications. A systematic study involving a number of potentially important target materials could be readily accomplished at a small accelerator facility.

Furthermore, improved (γ,n) data on such materials as deuterium has also been requested since these processes can lead to neutron background problems in some of the proposed interrogation schemes.

Neutron cross sections on unstable and rare isotopes

One national goal is the ability to analyze chemical, biological, and nuclear materials, assemblies and/or debris and identify the origin and user of these materials. Radio-chemical signatures can often facilitate forensics work. Accurate nuclear cross sections are needed in this program, many involving nuclear species off stability that are hard to measure directly. The current focus with relevant nuclear data needs is on the development of new forensics signatures of actinide materials and debris. This is motivating some challenging nuclear theory and evaluation projects, and some new measurement efforts.

Current needs include:

i) Improved neutron-induced fission cross sections among U, Np, Pu, Am, and Cm; both long-lived and short-lived species are of interest, and these entail measurements and reaction modeling for $E_n < 20$ MeV.

ii) Improved neutron-induced capture cross sections on long-lived and short-lived actinides, with similar comments as above.

iii) Accurate (<10%) (n,2n) cross sections for ^{235,23,}U, ^{239,240}Pu and ^{241}Am across the energy range of interest, and in particular within 1 MeV of thresholds.

iv) Accurate estimates of evaluated cross section uncertainties, including model uncertainties.

Other data needs

Neptunium is of concern as a proliferant material, as it is created in nuclear reactor waste. There is a need to better determine neptunium critical mass to guide non-proliferation activities. Values reported in the literature for the critical mass vary widely, from 50 – 80 kg. Using different nuclear databases (e.g. ENDF/B-VI, ENDF/B-V in the US, JENDL in Japan, etc) in radiation transport simulations gives calculated critical masses that vary widely, reflecting difference in the underlying evaluated nuclear cross sections.

Feedback from emergency response personnel and the transport security administration indicates that they desire a user-friendly catalog of radioactive decay signatures. The catalog should include their basic properties, e.g. half-life, decay modes, and decay radiations. The method of production and the industry utilizing the source should also be listed. A shorter list of nuclides of common availability with their basic properties should

be available in easy to handle formats, e.g. an electronic file, a poster, a wallet card or credit-card sized pocket reference.

In fact, the natural backgrounds on the surface of the earth is of broad concern in the community for two reasons: (1) these interferences need to be understood so as not to be confused with other weak signals, and (2) in one case there is interest in using cosmic muons as a probe for a detection system. About a third of the natural radiation background originates from cosmic rays. Cosmic rays are usually highly clustered in space and time, and much of the natural background is not purely Poisson in its time distribution. The natural time and spatial variation of environmental background radiation is not well understood and is difficult to model. We have little data how fast natural radiation can change due to rain, thunderstorms, wind blown duct etc. In the case of muon-based systems, it was noted that muon-induced fission in heavy elements, and the time and energy distribution of the reaction products is poorly known.

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US Nuclear Data Program

USNDP Reports 2005

Altogether 12 reports were given, 3 on Task Force activities and 9 on laboratory activities. Actual reports are at www.nndc.bnl.gov/proceedings/2005csewgusndp, though not all of them are available.

Task Force Reports

1. Task Force on Nuclear Data for Astrophysics (C. Nesaraja)
2. Task Force on Nuclear Data for Homeland Security (D. McNabb)
3. Task Force on Nuclear Data for RIA (T. Kawano)

Laboratory Reports

1. NNDC report (P. Oblozinsky)
2. ANL report (F. Kondev)
3. LANL report (T. Kawano)
4. LBNL report (C. Baglin)
5. LLNL report (D. McNabb)
6. NIST report (A. Carlson)
7. McMaster report (J. Cameron for B. Singh)
8. ORNL report (C. Nesaraja for M. Smith)
9. TUNL report (J. Kelley)

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