2013 Annual Meetings:

Cross Section Evaluation Working Group

US Nuclear Data Program

Preface

The 2013 Nuclear Data Week has been held November, 18-22 at Brookhaven National Laboratory. As usual, the USNDP/CSEWG meetings were accompanied by the Nuclear Data Advisory Group (NDAG) meeting of the Criticality Safety Program. The schedule of the Nuclear Data Week was the following

- USNDP Annual Meeting, November 18-20,
- NDAG, Nov 19,
- CSEWG Annual Meeting, November 20-22,

This arrangement was similar to the one introduced in 2012 and aimed in minimizing overlap between structure and reaction parts to enable participants to attend both meetings if they wished to do so.
The reporting session of the USNDP has been held on Monday morning and followed in the afternoon with the discussion of the USNDP long range planning open to all participants. This has been followed by the discussion limited to PIs, database mangers and the DOE representative. The aim of the latter meeting was to provide more time for sincere discussion of the USNDP performance, potential staff and funding issues and strategies for the future activities.

The CSEWG meeting returned to its traditional schedule starting with the evaluation session followed by validation, measurements, formats and covariance sessions. The evaluation session was facilitated by the CIELO/NEMEA meeting in Geel (Belgium) that had been held two weeks before the CSEWG meeting. Since the major thrust of the US reaction evaluation effort is focused on the CIELO project a significant part of the relevant discussion took already place at the NEMA/CIELO meeting. Highlights and conclusions from this meeting were discussed with the CSEWG participants during a dedicated session.

Next Meeting

The next Nuclear Data Week will be traditionally held at BNL Nov. 3 - 7, 2014. The individual meetings will tentatively be held following the 2013 schedule:

- USNDP: (Monday - Wednesday),
- NDAG: (Tuesday afternoon),
- CSEWG: (Wednesday - Friday),

Apr 23, 2014

Michal Herman
CSEWG chair
USNDP chair

Summary of the 63rd Cross Section Evaluation Working Group Meeting

Held at
Brookhaven National Laboratory, Upton, NY
November 20-22, 2013

The 63rd CSEWG meeting was held on November 20-22, 2013 at the Brookhaven National Laboratory. The 55 registered participants were representatives of national laboratories, academia and nuclear industry of the United States and Canada, as well as three participants from abroad (China, S. Korea, IAEA). As usual, the CSEWG meeting was held next to the USNDP annual meeting, with a common session on modeling of nuclear reactions.

Cross Section Evaluation Working Group

Evaluation Committee Report

T. Kawano representing Committee chair M. Chadwick, LANL

Agenda

- Objectives regarding evaluation plans for ENDF/B-VIII, M. Herman, T. Kawano, 5'
- Overview of Cielo, led by T. Kawano
- Database management for preparing for ENDF/B-VIII, Brown, 15'
- Overview of conclusions from CIELO/NEMEA7 meeting on 1H, 16O, 56Fe, 235,8U and 239Pu evaluation plans,(Round table discussion led by Kawano, with input from CIELO/NEMEA7 attendees) 60'
- Overview of BNL evaluation work/plans, D. Brown, 15'
- Overview of ORNL evaluation work/plans, M. Dunn/M. Pigni,15'
- Overview of LLNL evaluation work/plans, N. Summers, 15'
- Overview of LANL evaluation work/plans, T. Kawano, 15'
- Nuclear data related activities at KAERI, Y. Cho, 10'
- Evaluation efforts at IAEA/NDS, P. Dimitriou, 10'
- Prompt fission PFNS evaluation plans - work from LANL and LLNL, P. Talou, 15'
- Summary of IAEA Standards meeting and plans for next evaluation, A. Carlson, 15'

General Session

ENDF/B library

Future release plan of ENDF announced, and user feedback obtained. The plan of ENDF/B-VII.1.1 includes some bug fixes only, such as replacement of ^{1}H covariances, fixing typos, negative angular distributions, and modest (about 10 eV) energy adjustments. Although these modifications to VII.1 should not cause any changes in the benchmark performance, users were concerned by making additional version number. We may skip this, and work toward on ENDF/B-VII.2 beta0, which includes both bug fixes and several upgraded evaluations. In a longer term we aim at making ENDF/B-VIII, which should reflect the international activities such as CIELO and IAEA Standards projects.

CIELO project

An overview of NEMEA7/CIELO at IRMM given by browsing conclusion remarks by Chadwick and a few presentations at the meeting. Several key issues concerning the CIELO

development includes the standards evaluation at IAEA, inconsistent experimental data and theory for oxygen, difference in nuclear reaction modeling at LANL, CEA, JAEA, and IAEA. A.Carlson made a comment on the ^{1}H data; a new ^{1}H standards will be available in 2014 including high energy extension. P.Talou mentioned the international research program on the prompt fission neutron spectra at IAEA; the IAEA evaluations can be a good candidate for the prompt fission spectrum data in CIELO.

Reaction evaluations at individual laboratories

BNL

- Zr evaluation upgrades, targeting FY14 Q4 release, include elastic scattering angular distributions from the MLBW resonance parameters.
- Fe evaluation planed in the framework of the CIELO project.
- Decay data sublibrary upgrade planned for the next release of the the ENDF/B library.

ORNL

- Evaluation of $^{63,65}Cu$ resonance parameters, including ORELA transmission data, have been completed.
- New resonance parameters of $^{182,183,184,186}W$ are planed for FY14.
- New evaluation of ^{56}Fe resonance parameters goes up to 2 MeV including inelastic scattering. It will be submitted to the CIELO project.
- Evaluation of ^{239}Pu resonance parameters, in collaboration with WPEC/Subgroup 34, has been completed. The covariance data are provided in MF32.
- New ^{235}U resonance parameters evaluation, including new DANCE and RPI capture data, will be completed in FY14. Planed are further benchmark testing.
- Analysis of resonance in Ca, Ce, Dy, Gd is planned for FY15.
- New evaluation of CH2 S(alpha,beta) is planned for FY15.
- Note on minor actinides ν-bar by R.Q. Wright: the Madland-Nix model calculations suggest some changes for 13 minor actinides, such as Np, Cm, Bk, Es, etc. P.Talou will interact with ORNL to see if Madland-Nix calculations are reasonable.

LLNL

- Thermonuclear reaction library ECPL/ENDL99 - charged particle reactions on light targets evaluated by P. Navratil was presented.
- Possibility of transfer of LLNL evaluations into ENDF has been discussed.

KAERI

Y.S. Cho presented status of nuclear data activities at KAERI:

- COVRES code for covariance data evaluation in resolved resonance region was applied to ^{237}Np calculation.

- New ^{237}Np evaluation with EMPIRE and optimization optical potential, aiming at Korean Helium Ceramic Cooled Reactor TBM, Ko HCCR.
- Evaluations for isotopes of W were performed with EMPIRE code.
- Benchmark study for ^{240}Pu - 22 ICSBEP/CSEWG benchmarks were calculated and analyzed.
- Experimental activities include fast neutron source design for photo-neutron source, total cross section measurements on W at HZDR. KAERI participates in ^{238}U capture measurement at IRMM.

Special Interests

PFNS

P.Talou summarized new evaluation works at LANL on the prompt fission neutron spectrum, as well as related activities at IAEA/CRP. Based on M. Rising's paper (Nucl. Sci. Eng.) that reports a systematic study of the Madland-Nix model parameters, as well as recent pre-fission neutron spectrum calculations with the CoH3 code, full evaluations of U and Pu isotopes including higher incident energies ongoing. Available experimental data selected, and new chi-nu data to be included when available.

Standards

A. Carlson summarized results of the meeting held in Vienna in the frame of the IAEA data development project “Maintenance of the Neutron Cross Section Standards”. This project will pursue improvements in the experimental database, consider additional standards, maintain evaluation codes and periodically update the standards so they are available for new versions of data libraries.

It has been reported that all the experiments completed or underway since the completion of the current standards evaluation were reviewed. New experiments suggest improvements have been made for the H(n,n), Li(n,t), ^{10}B(n,a), Au(n,γ), and ^{238}U(n,γ) cross sections. At the same time, inconsistencies for the ^{3}He(n,p), C(n,n), ^{238}U(n,f) and ^{239}Pu(n,f) cross sections have been revealed. There were also new measurements of the ^{235}U(n_{th},f) neutron spectrum made by Kornilov et al. and Vorobyev et al.

Candidates for reference cross sections for measurements of prompt gamma-ray production cross sections have been considered. ^{nat}Ti with large yields of two gamma-lines, 984 keV from ^{48}Ti(n,n'γ) and ^{16}0 keV from ^{48}Ti(n,2nγ), ^{47}Ti(n,n'γ) and Li(n,n’γ) reactions appears to be one of the most suitable.

Several recent measurements support the results of the standards evaluation for ^{197}Au(n,γ). They indicate that Ratynski and Käppeler results are low by about 5-7% from 15 to 25 keV. The IRDF evaluation of ^{27}Al(n,α) reaction cross section by Zolotarev can be used as a

reference cross section for activation measurements. The ^{209}Bi(n,f) cross section is being considered as a possible reference reaction above 20 MeV.

Current standards will be reevaluated using the improved combination procedure developed for the previous standards evaluation. These will involve changes to the R-matrix codes regarding uncertainty determination.

Release of the new standard and reference evaluations is expected in summer 2016. More details on the status of the project are available at: http://www-nds.iaea.org/publications/indc/indc-nds-0641.pdf

IAEA Report

Paraskevi (Vivian) Dimitriou reported on nuclear reaction related activities at the IAEA. Since CIELO project, PFNS and standards were covered by other CSEWG speakers she focused on CRP on the validation of the IRDF library and the Data Development Project on evaluation of charged−particle induced reactions.

The CRP, in addition to the validation, will also include a series of new evaluations that will be added to the IRDF library. These will include high threshold reactions with cross−section peaks located between 20 and 100 MeV and several capture reactions on targets that are often encountered in applications.

The Data Development Project is dedicated to the charged−particle induced reactions at low energies for Ion Beam Analysis applications. The multi−level multi−channel R−matrix code SAMMY will be used to analyze experimental data and produce covariance matrices in ENDF format. Work will start with isotopes most widely used in IBA applications but cases useful for Nuclear Astrophysics will be considered in the second phase.

Cross Section Evaluation Working Group

Data Validation Committee Report

A. C. (Skip) Kahler, LANL
Committee chair

The CSEWG Validation Committee met on Wednesday afternoon, November 20, 2013. Eleven presentations were given by one or more representatives of Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Bettis Laboratory (Bettis), Chalk River National Laboratory (CRNL), Knolls Atomic Power Laboratory (KAPL), Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL) and the University of Wiscousin (UWisc).

The session started on a somber note, as we noted the passing of Dick McKnight earlier in the year. Among his many activities, Dick was the current Chair of the Nuclear Data Advisory Group (NDAG), a leading member of the International Criticality Safety Benchmark Evaluation Project (ICSBEP), a leading member of the International Reactor Physics Benchmark Evaluation Project (IRPhEP), past Chair of the CSEWG Data Validation Committee and a long time CSEWG member. His insight and guidance will be sorely missed by all. The ANS Nuclear Criticality Safety and Reactor Physics Divisions are planning to hold special sessions in Dick's memory at the 2014 Annual Meeting, scheduled for June 15-19, 2014 in Reno, NV.

Dave Brown (BNL) summarized recent enhancements to the NNDC's "ADVANCE" system. The ADVANCE system is designed to trap errors in potential ENDF files by running a series of checking codes and processing codes. Deficiencies noted are immediately available to the submitting evaluator so that they may be promptly corrected.

Jeremy Conlin (LANL) described efforts to create an ENDF/B-VII.1 based neutron nuclear data library for the MCNP continuous energy Monte Carlo program. This library has since been distributed with the MCNP-6.1 code release. During processing a variety of issues with ENDF/B-VII.1 files were noted, including (i) zero value for some elastic scattering cross sections while the immediate low and high energy neighbors were non-zero (^{56}Fe, ^{61}Ni); (ii) negative PDF values for some MF6/MT91 ^{153}Eu data; (iii) unresolved resonance cross section issues for a variety of files; (iv) negative KERMA values for a large number of evaluations (a continuing problem over several ENDF/B generations); (v) too many secondary neutrons in ^{231,233}Pa MT5 at high (>30MeV) energy; (vi) missing fission Q-values for selected Ra and Es

evaluations. The zero cross sections were made small, but non-zero; the negative PDFs were set to zero; unresolved resonance processing was not performed when non-physical results were obtained; nothing was done to resolved the remaining errors.

Ian Gould (ORNL) described analyses of actinide production in Hanford reactors. These classified experiments were performed in the late 1960s but were declassified in the mid-1990s. A recent report, "Potential Benchmarks for Actinide Production in Hanford Reactors", CHPRC-01590 (rev 0) by Puigh and Toffer is now available. ORNL's work indicates that ^{240}Pu production is badly under-predicted in low-burnup fuels. Deficiencies in the ^{239}Np(n,γ) cross section are believed to be largely responsible for this under-prediction, which is observed regardless of whether ENDF/B, JEFF and TENDL evaluated files are used in the analysis.

Mohammad Sawan (UWisc) reviewed work on the FENDL-3 library. FENDL-3 is a substantial extension of FENDL-2.1, including higher energy data, incident charged particle data and covariance data. FENDL-3 is a composite library, containing selected evaluated data files from ENDF/B-VII, JENDL-4, JEFF-3.1.1 and TENDL-2010. Results of Sawan's benchmark analyses comparing FENDL-3 and FENDL-2.1 suggest that FENDL-3 "… shows an improved performance for fusion neutronics applications". He noted however that some evaluations are still missing gas production data due to missing D, T and ^{3}He reactions.

Danila Roubtsov (CRNL) reviewed low energy scattering data for ^{16}O, noting that small differences among the various evaluated libraries and the experimental database can have large impacts on reactivity calculations. We note that ^{16}O is one of the nuclides that will be studied by the CIELO collaboration whose goal is to eliminate differences among the various international evaluated nuclear data files. Roubtsov also reported on collaborations with Centro Atomico Bariloche (Argentina) to develop improved H_2O and D_2O thermal scattering files. Initial results appear to have little impact on H_2O moderated systems but D_2O moderated benchmarks are exhibiting calculated reactivity differences of up to 1000 pcm, and often change in the direction to yield improved C/E's. He also noted for heavy water systems that inclusion of O-D_2O scattering is important for improved reactivity calculations.

Rich Lell (ANL) described calculations of recent BFS Fast and Intermediate Reactor Critical Assemblies, benchmarks that appear in the ICSBEP and IRPhEP Handbooks, noting that these experiments are a good complement to the Argonne suite of ZPR and ZPPR benchmark assemblies, as they address reactor design and data issues not covered by the ZPR/ZPPR suite. Reactivity predictions for the BFS-31, 33, 35, 38, 42 and 49 assemblies yield C/E values below unity whereas the BFS-79 and 81 series are greater than unity. Further study of these benchmarks is warranted.

Mike Zerkle (Bettis) reported on the analysis of new Mo-bearing benchmarks in the ICSBEP Handbook. HMF92, 93, 94 and HMM20 contain HEU fuel plates and varying amounts of Mo

or Mo/DU/Be or BeO and polyethylene. The Mo is used as both a reflector and/or serves as a diluent when inserted between HEU fuel plates. Reactivity calculations are generally biased high by several tenths of a percent, increasing to about 0.7% when Mo dilution occurs. This suggests that fast Mo capture cross sections are too low.

Tim Trumbull (KAPL) discussed recent revisions being tested for the isotopic Zr evaluated files. The net, elemental, change is a 2.6% reduction in thermal elastic scattering and a 0.8% reduction in the capture resonance integral. ICSBEP benchmarks used include ICT3 (a Triga reactor) and MMF11 (ANL's ZPPR21 assembly). Little change is observed in the calculated eigenvalues of these benchmarks with the revised Zr files, but further work is planned to review and revise, if necessary, the elastic scattering angular distributions.

Davis (UWisc) compared predicted fluxes from several Monte Carlo codes for a simple, 30 cm radius sphere and a 14 MeV centered point source. Results were obtained for MCNP5.1.60, Serpent (1 & 2) and OpenMC. While a number of differences were observed among the various codes, a fuller understanding of the various code approximations is needed to interpret these results. This represents a "work in progress".

Mark Williams (ORNL) reported on his review of ENDF/B-VII.1 covariance data its inclusion in the ORNL SCALE code package. He compared ENDF/VII.1 data with that currently in SCALE-6.1, or available from JENDL. Large differences in uncertainties are observed in (i) intermediate energy ^{235}U fission, (ii) ^{1}H capture; (iii) ^{235}U ν-bar; (iv) ^{239}Pu ν-bar (including ENDF/B-VII.1 having zero below about 0.008 eV). The ENDF/B-VII.1 covariance data were propagated into reactivity calculations where it was observed that calculated reactivity C/E standard deviations are often less than predicted from nuclear data covariances. ORNL concludes that "… further investigation of ENDF/B-VII.1 is needed before moving to production use …" in SCALE.

Dave Heinrichs (LLNL) reported on thermal library processing/testing. A more complete report, "A Comparative Study of COG Thermal Libraries" is available as LLNL-TR-645096. This work highlighted inconsistencies in the processed thermal data files for several materials. For example, there appears to be a large shift in benzene (C6H6) at the thermal boundary in the processed ENDF/B-VII.1 thermal ACE file. Differences were also noted when comparing ENDF/B-VII.1, ENDF/B-VII.0 and JEFF-3.1.1 for other moderators, including Be, BeO, HZr and graphite. Heinrichs noted that LLNL processing yielded consistent results when using the "SABtoCOG" methods or when converting NJOY produced thermal scattering ACE files to COG format.

A.C. (Skip) Kahler (LANL) reported on ICSBEP benchmark calculations with revised ^{235}U and ^{239}Pu files. The 235U revisions occur primarily in the 2 keV (resolved resonance) region, and are focused on producing more accurate capture cross sections based upon recent RPI and LANL measured data. These measurements support the Japanese assertion that the previous

file over-estimated these cross sections. Changes to the resolved resonance parameters propagate throughout the resolved resonance region, and impact not only capture but also fission cross sections. Calculations with a suite of 45 ICSBEP HEU-SOL-THERM benchmarks confirm that the previous accurate reactivity predictions are retained with the revised file. Another benchmark, HEU-MET-FAST-007, consists of HEU plates and varying amounts of polyethylene. The average fission energy for these configurations span decades in energy … from near 1 MeV to about 30 eV. The decreased capture cross sections results in a small increase in calculated reactivity leading to large C/E values than observed with the original ENDF/B-VII.1 file. The ^{239}Pu revisions represent work performed by WPEC SG34. Revisions have been made in the low energy resolved resonance region to capture, fission and scattering as well as in prompt ν-bar below 650 eV. Past benchmark reactivity calculations are typically biased high by about 500 pcm. For a small subset of these benchmarks we observe a calculated eigenvalue decrease of about 300 pcm, suggesting that a significant component of the historical eigenvalue bias has been eliminated.

Data testing and validation of existing and potentially new evaluated data files remains and important and active endeavor. The committee is gratified by the level of participation in the timeframe immediately following a major ENDF/B release and anticipates a continuing vigorous participation in these endeavors as the CIELO Project gets underway in coming months.

Cross Section Evaluation Working Group

Covariance Committee Report

D. L. Smith, ANL
Committee chair

Session Summary

A meeting of the CSEWG Covariance Committee, with duration of approximately 1.5 hours, was held during the 2013 annual CSEWG meeting that, itself, was a component of Nuclear Data Week 2013. The covariance meeting was comprised of a single session that took place on Thursday, 21 November. Originally, this meeting was slated to consist of two separated sessions, one on Thursday afternoon and the second on the following Friday morning. However, there were only 5 submitted contributions so it was possible to complete the meeting on Thursday by extending the Thursday session to a bit later in the day than had been originally planned. A general discussion period that had been included in the preliminary agenda was eliminated to allow CSEWG to close on Thursday evening rather than Friday morning. The talks presented in this session averaged about 20 minutes each, including questions, comments, and discussions following each presentation. These presentations focused mainly on issues related to methodology and formats, the latter particularly related to the planned eventual migration from ENDF-6 formats to the proposed GND format structure based on XML.

The contents of the presentations given at the present meeting are available as either PDF or PowerPoint files provided by the authors. These can be downloaded from links provided on the CSEWG2013 meeting agenda webpage: http://www.nndc.bnl.gov/meetings/csewg2013.

Overviews of each presentation, and some flavor of the discussions that followed them, appear below.

Presentations

G. Arbanas et al. (ORNL) *Integral Benchmark Experiments in the Inverse Sensitivity/ Uncertainty Computations*

Presentation

It is important to design experiments that provide needed scientific data in the most sensitive, cost-effective manner. This is especially true in an era where personnel and facility resources – which to a large extent translate to financial resources – are acutely limited. Furthermore, the scope of specific requirements is constantly enlarging as new areas of science

and technology areas emerge, thus leading to intense competition for these limited resources. So, in the case of assessing how the stated nuclear data needs for the U.S. Nuclear Criticality Safety Program (NNSA) should be met, and considering the costs associated with providing these data, which are estimated might amount to an average of ~ $400,000 (for differential experiments) to ~ $1,000,000 (for integral experiments) per experiment, great care needs to be taken in selecting and designing these experiments. The key is to determine, through the use of mathematical algorithms, the sensitivity of significant parameters of nuclear systems (e.g., criticality k-eff) to various basic nuclear data, and to then design experiments that offer the greatest promise for providing high quality data, subject to a variety of constraints such as cost and target accuracies.

This paper describes an approach that is being pursued at ORNL based on the concept of Inverse Sensitivity/Uncertainty (IS/U) that incorporates computational resources included in the SCALE analysis system, that has been developed at ORNL to address a variety of issues related to nuclear criticality safety, to assist in the design of more "intelligent" experiments. The approach taken in the analysis is outlined, and the main mathematical concepts involved, are mentioned in this presentation. Some examples are also given to illustrate the main points.

Discussion

There were questions from the audience and some discussion, mainly related to concerns about how the constraint of "cost" could be determined quantitatively, since the issue of "cost" is a complex one involving not only financial costs associated with directly conducting the experiments but also costs associated with developing methods, costs associated with allocating personnel resources to particular experiments, etc. The response from the speaker was that the numerical cost values mentioned in the presentation were not examined in detailed, and were not to be viewed as "hard" values, but rather they are suggested as a means to illustrate qualitatively the magnitude of this issue, as measured against the likely data needs and number of experiments that would be involved in satisfying them. It was agreed that the cost issue was important should be examined in more detail.

C. Matoon (LLNL) *Covariances in GND, and Feedback on ENDF-VII.1 Covariances*

Presentation

This presentation briefly discussed the current status regarding how the covariance data currently found in ENDF/B might be handled in the framework of the new GND format that is currently under development. Work in this area is being led by LLNL, but there is extensive participation in the broader GND project from various labs in the U.S. and abroad. Several aspects of GND specifically related to dealing with covariance data, driven by the nature of covariance information, as well as by the ways these data would be accessed and used in applications, were discussed. Work is still in progress in this area, and the final structure of the GND framework in general, not just for covariance data, has not been finalized.

Some examples of specific problem areas encountered by the presenter in dealing with ENDF/B-VII.1 covariances during the course of working on the GND format interface with the ENDF-6 were also mentioned in this presentation.

Discussion

As the GND conversion project moves forward, there continues to be some trepidation in the nuclear data and user communities as to "how it will work", as well as transitioning concerns. It has been decided that for the foreseeable future ENDF/B would be provided in both GND and ENDF-6 formats, but that eventually ENDF-6 will be phased out. There is no rigid time schedule for this to take place since GND is still under development and the various issues that are arising are still being worked out.

D. Neudecker et al. (LANL, ANL, IAEA) *On the Evaluation of Prompt Fission Neutron Spectra: Normalization, Low Variances and Other Issues*

Presentation

The energy spectrum of neutrons emitted promptly in fission (PFNS) is a quantity of importance in modeling all nuclear systems that involve fission. It ranks in importance along with ν-bar, which is a measure of the average number of prompt neutrons emitted per fission as a function of incident energy for some actinides, or in spontaneous fission for certain other actinides. An evaluation of PFNS for Pu-239, at incident neutron energy 0.5 MeV, was recently completed and reported by LANL. This study produced evaluated uncertainties that appeared to be unrealistically small, especially near the peak energy of the PFNS (around 2 MeV) where a pronounced dip is observed. The present talk reported on the status of an investigation that is being carried out to gain a better understanding of how these small uncertainties might arise and be justified, if indeed they are reasonable.

What has been learned from this work is that fully-correlated scale uncertainties usually associated with experimental measurements vanish completely when evaluated spectrum data are normalized to yield shape information, i.e., when the data are converted to a probability representation whereby the integral of the spectrum (or sum of terms for a discrete representation) is forced to be unity. This process of normalizing the evaluation to produce a probability distribution therefore has a strong influence on the obtained uncertainties and correlations for the transformed data, especially when inherently strongly correlated model-calculated data (based on few parameters such as the Los Alamos PFNS model) are incorporated in the experiment through the well-known least-squares procedure. This procedure insures that the small uncertainties generated near the pivot point for the normalized spectrum are extended more broadly in energy as a consequence of the strong model correlations. Possible approaches for avoiding this evaluation "trap" are currently being

considered, along with the development of more sophisticated PFNS models with larger numbers of parameters and, perhaps, weaker correlations.

Discussion

There was some discussion related to the particular roles of ν-bar and the normalized PFNS in actually characterizing the emission yields for prompt fission neutrons as well as the uncertainties. It was pointed out that evaluated ν-bar values and PFNS representations (along with their respective covariance data) are stored in distinct locations in ENDF/B libraries, so the actual neutron emission yields corresponding to fission have to be reconstructed from these two distinct, independently evaluated components. If the uncertainty near 2 MeV is indeed very small, then the uncertainty of ν-bar, which itself tends to be quite small, might end up dominating the reconstructed neutron emission yields, not only at this energy but elsewhere, as a consequence of the strong correlations introduced in the evaluation of the PFNS by inclusion of information from the model component.

M. Pigni (ORNL) *Consistent FPY Covariance Matrices in Uncertainty Quantification Analyses*

Presentation

The yield of fission products (FPY) plays a dominant role in analyzing the decay heat of reactors following their shutdown. Consequently, knowledge of the uncertainties in FPY data is necessary as one aspect of understanding the uncertainties associated with decay heat. This paper addresses the methodologies for generating FPY uncertainty (covariance) data. Several different methodologies have been explored in this work; each has some is believed by the authors to have weak points. These methods, along with some bulleted comments about them, are as follows:

Methodology 1: Based on five Gaussian and Wahl models
• Sum/Mass yields correlations are included (five Gaussian model)
• Fractional yield correlations based on Wahl's model parameters
• Estimation of parameter uncertainties to be updated

Methodology 2: Bayesian Method (T. Kawano)
• Useful to generate evaluations for independent FPY
• Model to define Chain Mass yields depends on branching ratios
• Correlation matrix is sparse

Methodology 3: GEF code (K.-H. Schmidt)
• Useful to generate chain mass and independent FPY covariance matrices
• Model (to define independent FPY and mass chain) is phenomenological
• Estimates on FPY uncertainty are, on average, comparable to ENDF/B-VII.0

Some mathematical details associated with this work were given in the presentation, and the relationship between FPY and decay heat values and their uncertainties was also discussed. There was no intent in this work to re-evaluate the ENDF/B-VII.1 library FPY uncertainty covariances. However, it was pointed out that on the basis of isotopic concentration considerations the authors believe that for the most part the uncertainties given in ENDF/B-VII.1 are too large.

Discussion

It was pointed out by the audience that it is somewhat ironic that while uncertainties corresponding to evaluated covariances in libraries preceding ENDF/B-VII.1 were often criticized as being too small, especially for cross section data, this presentation indicated that in some instances the larger uncertainties provided in ENDF/B-VII.1 to counter earlier criticisms, and therefore project a degree of conservatism, turn out to be too large for decay heat applications. Of course, people familiar with uncertainty quantification tend to agree that there are no "correct" covariances. Covariances are based on contemporary, and sometimes subjective, assessments of data uncertainties. Frequently they are generated as a consequence of evaluation procedures. So the development of what will ultimately be accepted as being "reliable" covariance data by the nuclear community is certainly a long-term, iterative process that is unlikely to ever converge completely, but that, hopefully, will eventually stabilize to a certain extent.

S. Hoblit (BNL) *Consistent Data Adjustment*

Presentation:

Evaluated data users in the nuclear community are tend to be of a mind that cross-section (and other) data of sufficient accuracy for their applications will never be satisfied by either theoretical means or differential experiments. They believe that data of sufficient accuracy for their applications need to be adjusted from the original evaluated values (usually based on differential experimental and modeling data) by means of mathematical methods that incorporate what they view as integral data that are more accurate than differential data can ever be. This view is not universally held, especially by individuals in the data evaluation, theory (long-term), and differential measurements communities. In any event, evaluated differential data are being adjusted by incorporating integral data in order to produce project-specific data libraries that garner the approval of users in these communities. This presentation discusses the methodologies currently use for this adjustment purpose, especially as applied to the ENDF/B-VII.1 library for generating user libraries for the fast-reactor and criticality safety communities, and to libraries based mainly on modeling. Furthermore, these methods have been used to provide adjusted nuclear-model parameter values (a process sometimes referred to as "assimilation"). Examples of adjusted cross section values, model parameters, and derived reactor parameters (and their respective uncertainties) are given in the presentation. It was

noted that the procedure appears to be reasonably stable as long as differences between prior values calculated using the models (or from a library such as ENDF/B-VII.1) differ by only modest amounts from the adjusted values (based on inclusion of integral data). However, that outcome appears to hold only when the adjustment procedure focuses only on certain parameters and when some constraints in the adjustment are introduced so that unrealistic parameters are not generated owing to mathematical artifacts. Non-linear effects associated with adjustment procedures that are basically linear are thought to be mainly responsible for discrepancies and instabilities that arise if the discrepancies are too large.

Discussion:

Various comments were offered, generally associated with such unsettled issues as whether it is reasonable to assume that the nuclear models themselves are sufficiently sophisticated to enable libraries of adjusted data values and covariances to be generated solely using modeling with parameters refined by incorporating both integral and differential experimental data.

Cross Section Evaluation Working Group

Formats and Processing Committee Report

Michael E. Dunn, ORNL
Committee Chair

The Formats and Processing Committee meeting was convened the afternoon of November 21, 2013 at Brookhaven National Laboratory (BNL). The initial part of the meeting was devoted to ENDF/B formats and related issues followed by a status report by Lawrence Livermore National Laboratory (LLNL) on the OECD/NEA Working Party for Evaluation Cooperation (WPEC) Subgroup 38 effort to develop a new ENDF data structure. Subsequently, LLNL, Argonne National Laboratory (ANL), Los Alamos National Laboratory (LANL), and Oak Ridge National Laboratory (ORNL) provided status reports for their respective cross-section processing code systems. The Formats and Processing Meeting concluded with a report from BNL concerning the NNDC efforts on activities related to formats and processing. The following are the minutes from the Formats and Processing Committee meeting.

Formats and Related Issues

Proposal for Evaluated Covariance Data for Decay Spectra (Sergey Badikov, MEPHI, presented by Mike Dunn, ORNL)

Sergey Badikov submitted a proposal requesting that the ENDF formats be revised to permit the representation of evaluated covariance data for discrete radiation decay spectra. Because Sergey Badikov could not attend the CSEWG Meeting, Mike Dunn presented the proposal to the Formats and Processing Committee. Modern radioactive decay data sublibraries have a number of evaluations with decay data, and the ENDF/B-VII.1 and JEFF-3.1.1 libraries have the most complete information. Badikov noted that the ENDF and JEFF evaluated decay sublibraries are in agreement within the declared uncertainties, except for single radionuclides. With regard to deficiencies, Badikov noted that the evaluated decay data are not strictly balanced due to the lack of experimental information or application of physically inconsistent evaluation procedures. Further, covariance information for the evaluated decay data is absent from the sublibraries. Decay data measurements are relative measurements, and when the accuracy of the reference data is poor, the results of the relative measurements correlate and cannot be processed with the assumption of statistical independence. Moreover, the balanced decay scheme must satisfy two conservation laws:

1. A sum of the transition probabilities for particles and gamma quanta feeding any

excited level of a daughter nuclide equals to a sum of the transition probabilities for particles and gamma quanta depopulating the level.

2. A sum of the transition probabilities for particles and gamma quanta feeding the ground state of a daughter nuclide equals to 1.

Badikov noted that the inclusion of the strict balance relationships in the evaluation procedure must inevitably lead to lower uncertainties of the evaluated data and strong correlations between some of the evaluated parameters. The decay data investigation was motivated by a need to generate physically consistent evaluated decay data with complete covariance information. Badikov's presentation provided a detailed decay data analysis example for ^{242}Cm. Additional details are provided in the presentation that is available on the NNDC website for the CSEWG Meeting. As part of the ^{242}Cm analysis, Badikov has produced correlation matrices for ^{242}Cm, but there is not a way to provide this information in the ENDF-formatted data files. Badikov proposed an ENDF format revision to File 8 (MF=8) that would allow the representation of covariance data for discrete radiation spectrum data. Specifically, the proposal will permit the following options for transmitting discrete radiation spectrum covariance data:

- LCOV=0, no covariance data are given;
- LCOV=1, covariance data for continuum spectrum are given;
- LCOV=2, covariance data for discrete spectrum are given;
- LCOV=3, covariance data for discrete and continuum spectra are given.

The proposal included the appropriate changes to the ENDF-102 Manual. The committee reviewed and discussed the proposal. Don Smith noted that from a physics perspective, the proposal makes sense. Both Skip Kahler and Doro Wiarda noted that NJOY and AMPX currently do not process decay covariance information. Morgan White expressed support for the proposal but asked if the covariance data should be moved to a separate file (e.g., File 38) instead of including in File 8. The committee noted that File 8 already allows the representation of covariance data, and the proposal is an extension of the existing format. After further discussion, Morgan White gave a motion to accept the proposal, and a second motion to accept was provided by Skip Kahler.

The proposal was then approved unanimously by the CSEWG.

Proposal to Add a NLIB identifier for TENDL and ROSFOND (Dave Brown, BNL)

Dave Brown presented a proposal to add NLIB library identifiers in ENDF for TENDL and ROSFOND. The proposal originated from Arjan Koning (NRG) who had received a question from a TENDL user about whether TENDL has an official NLIB identifier in the ENDF Format. Currently, the ENDF Format does not specify an identifier for TENDL, and Arjan asked if the ENDF Format could be updated to make TENDL the "17th" library in the Format.

Any additional NLIB identifiers would need to be included in Table 2 on Page 8 of the ENDF-102 Manual. Dave Brown also noted that ROSFOND is not identified in the Format. The proposal was discussed, and a motion was made to provide NLIB=17 for TENDL and NLIB=18 for ROSFOND. The motion was seconded. **Subsequently, the CSEWG voted to approve the proposed format change.**

Proposal to Allow AWR and AWI in MF=26 (Dave Brown, BNL)

File 26 provides the distributions of secondary photons or electrons emitted after electro-atomic reactions, the energy given to the residual atom, and the energy transfer associated with the excitation. Currently, the ENDF Format for File 26, specifies that the AWR, mass of the material relative to the neutron mass, is zero. The proposal requests that the ENDF Format be updated to allow AWR and AWI, mass of the projectile relative to the neutron mass, to be used in File 26. The CSEWG discussed the format, and an initial motion and a second motion was made to accept the change.
The CSEWG voted on the ENDF Format change, and the proposed Format change was approved by the CSEWG.

Proposal to Provide a Flag to Identify Lognormal Distributions of Inherently Positive Parameters (Andrej Trkov and Gašper Žerovnik, JSI, presented by Mike Dunn, ORNL)

The proposal notes that inherently positive parameters with large relative uncertainties (typically $\geq$ 30%) are often governed by the lognormal distribution. This assumption has the practical benefit of avoiding the possibility of sampling negative values in stochastic applications. Further, the decision whether to assume normal or lognormal distribution is not straightforward and depends on the evaluator. However, in order to prevent misinterpretations by the nuclear data users, the possibility of using a flag to define which distribution the covariance file in ENDF-6 format corresponds to would be highly recommended. The authors proposed possible options of how to include such a flag in the covariance files of the ENDF Format for Files 30, 31, 32, 33, 34, 35, and 40.

The Formats and Processing Committee discussed the proposal. Don Smith noted that the proposal identifies a real issue that should be considered; however, the processing code issues need to be addressed. Caleb Mattoon asked how a combined lognormal + normal distribution would be processed together. Don Smith noted that the authors have considered this in a paper, but the reality is the lognormal distribution should always be used because in the limit, a lognormal distribution becomes normal. Further, the authors are proposing that the lognormal distribution would be used for all new evaluations going forward. Nonetheless, the recommendation is that we need to spend some more time reviewing and discussing the proposal and processing issues. Doro Wiarda noted that the change will not only affect the processing codes, but the “end-user” codes like SCALE, MCNP, etc. will need to consider the

use of lognormal distributions. Dave Brown noted that the proposal is a "good idea" and suggested that we might want to adopt the proposal now and allow time to work with the processing codes to test the implementation.
After further discussion, the CSEWG decided to table and delay acceptance of the proposal pending further study.

As an additional action item, the CSEWG asked Don Smith to work with the proposal authors to develop a lognormal distribution example for the processing codes to test.

Proposal to Expand Use of MT=50 to Optionally Describe Compound Elastic Scattering (Andrej Trkov and Gašper Žerovnik, JSI, presented by Mike Dunn, ORNL)

Currently, the ENDF Format forbids the use of MT=50 for incident neutrons. The authors of the proposal state the following:

> By analogy with other reactions this would represent the compound-elastic scattering, which is by definition included in the elastic scattering MT=2. With the use of nuclear model codes some evaluators would like to include the compound elastic scattering cross section explicitly. The shape-elastic and the compound elastic together make the scattering cross section, but compound-elastic angular distributions are symmetric in the CM coordinate system, while the shape-elastic angular distributions are anisotropic. By changing the relative contribution of each to the elastic cross section the average cosine of scattering (μ-bar) can be affected, hence the significance of explicitly defining the compound elastic cross section.
>
> The proposal is to remove the administrative restriction on defining MT=50 for incident neutrons. The impact of the change on the processing codes is negligible, since MT=50 does not appear in the summations for the inelastic and the total cross sections. Essentially, it is not required by the transport problems, but could be useful in cross section adjustment schemes due to its influence on the μ-bar.

The proposal provides specific recommended changes to the ENDF-102 Manual to permit the use of MT=50 for incident neutrons. After presenting the proposal, the Formats and Processing Committee discussed the proposal. Morgan White asked whether angular distributions would be provided for MT=50? Mike Herman noted that the angular distributions would be assumed to be isotropic. Morgan noted that it is not clear as to whether this format proposal would create problems without further investigation. Skip Kahler noted that there should not be any impact on neutron cross-section libraries; however, it is not clear as to whether there is an impact on charged particles. Dave Brown asked "what is MT=50 supposed to be for an isomeric target?" The first excited state is the isomer. Mike Herman commented that the only purpose of the proposal is to know how big is the compound elastic cross section.

After concluding the discussion, the CSEWG decided to table the proposal pending further study in order to understand the impact of the proposal.

Proposal to Provide a Flag to Identify Fictitiously Placed Resonances in the Resolved Resonance Region (Andrej Trkov and Gašper Žerovnik, JSI, presented by Mike Dunn, ORNL)

The authors provide the following motivation for the proposal:

> In some evaluations, resolved resonances extends to an energy above possible detection of all resonances with existing experimental methods, i.e. the upper part of the resolved resonance region is to a certain extend unresolved. If the contribution of missing resonances is small, they might be ignored. However, if this is not the case, some small resonances can be added for a better description of the interference effects. Since their exact position is usually not known, the statistical distribution of resonance parameters based on average values obtained from an energy region with good average resonance parameters values is used. In general, statistically placed resonances in the resolved resonance range can be a good method to correct for missing resonances, however in future evaluations such artificial resonances should strictly be "flagged" in order to avoid possible confusion.
>
> If all the widths of a resonance are below 10^{-10} eV, its contribution is truly negligible in any real evaluation. We believe that there are no real resonances below that value present in any application. On the other hand, resonance width cannot reach 10^{10} eV in nature. Therefore, a unique way to flag fictitious resonances would be to multiply all their assumed widths by a factor of 10^{-20}. This would ensure that they are ignored by default (which is also backward consistent), but a user still has the possibility to multiply them by 10^{-20} and use them. They can be detected simply by checking if all the widths are below 10^{-10} eV.

The proposal provides specific changes in the ENDF-102 Manual that would be needed to implement the proposal. After presenting the proposal, the Formats and Processing Committee discussed the proposal. Skip Kahler stated the following "what value are we adding? It seems like this is a dangerous thing to do." From a processing code point-of-view, the resonances are accepted regardless of whether the resonances are "fictitious" or not. Mike Herman noted that the motivation would be for a data expert to be able to look at the evaluation and know which resonances have been identified and which resonance are fictitious. Doro Wiarda noted that the fictitious resonances could be identified in File 1 instead of introducing this flag in File 2. After the discussion concluded, a motion was made to reject the proposal. Subsequently, a

second motion was made to reject the proposal. The CSEWG voted on the motion to reject the proposal, and a majority of votes were received to reject the proposal.
As a result, the proposal was rejected by the CSEWG.

Proposal to Remove "E-less" Format from ENDF [Red Cullen, (retired, LLNL), Maurice Greene (retired, ORNL), and Andrej Trkov (JSI), presented by Mike Dunn, ORNL]

The proposal recommends that ENDF data use "ONLY STANDARD, OFFICIALLY APPROVED FORMATS COMPATIBLE WITH AS A MINIMUM, FORTRAN, C AND C++." In the 1970s, the "E-less" format was introduced to meet the ENDF needs at the time by providing an extra digit in the evaluation file. The format was used for over 30 years until 2002 when it was noted that the "E-less" format is incompatible with C and C++. Furthermore, use of the "E-less" format can be misinterpreted by C/C++ compilers. Therefore, the proposal requests that NNDC and other data centers only issue data in approved, standard formats.

After presenting the proposal, the Formats and Processing Committee discussed the proposal. The Formats and Processing Committee noted that the "E-less" format is fine with FORTRAN, and there are translators available for other languages. Furthermore, the committee noted that this issue has been addressed, and there is no longer a need to worry with the "E-less" format. After the discussion concluded, a motion was made to reject the proposal. Subsequently, a second motion was made to reject the proposal. The CSEWG voted on the motion to reject the proposal, and a majority of votes were received to reject the proposal.
As a result, the proposal was rejected by the CSEWG.

Status Report on the WPEC Subgroup 38 Format Development Effort (Caleb Mattoon, LLNL)

The WPEC established Subgroup (SG) 38 to design an international nuclear data structure. Note that a data structure plus the meta-language defines the new format. WPEC SG 38 has been operating for the past 1.5 years and is progressing toward the development of a new, modern ENDF data structure. The SG38 effort initiated with the LLNL Generalized Nuclear Data (GND) structure, and the SG38 effort is a natural extension of the LLNL goals. Furthermore, LLNL does not want to impose GND on the rest of the community; rather, LLNL would like to get feedback on how to improve the data structure to be more general for all users.

The first SG38 Meeting was held November 29-30, 2012 at the OECD/NEA Data Bank, and the meeting focused on establishing the scope and requirements for the new data structure. Specifically, SG38 defined the overall hierarchy for storing nuclear data and designing the

basic data containers. The LLNL presentation is provided on the CSEWG website and provides additional details for the initial SG38 meeting.

The second SG38 Meeting was held May 21-22, 2013 at the OECD/NEA Data Bank in conjunction with the annual WPEC Meeting. During the subgroup meeting, the requirements document was reviewed and approved with some modifications. The remaining part of the meeting was focused on discussion and planning of the subgroup work tasks:

- Task 1: Design a top-level hierarch for evaluated nuclear reaction data.
- Task 2: Design basic data containers that are general enough to handle evaluated, experimental, and processed nuclear data.
- Task 3: Structure for particle data, including masses, level schemes and decays
- Task 4: Develop Application Programming Interface (API)
- Task 5: Infrastructure that includes generating, plotting, checking, processing, etc.
- Task 6: Quality Assurance
- Task 7: Governance

The next SG38 Meeting will be held December 9-11, 2013 in Tokai, Japan. During the next meeting, the subgroup will review the status of each subtask and discuss what needs to be accomplished. In addition, the subgroup would like potential feedback and discussion of problems that are slowing down the overall project.

Progress with Processing GND (Caleb Mattoon, LLNL)

Caleb Mattoon provided an update on the LLNL progress with processing GND. Specifically, LLNL has made progress on rewriting the LLNL processing codes to handle GND evaluations. GND support for the LLNL Monte Carlo codes is now complete. Efforts are currently in progress to develop the infrastructure needed to support the deterministic transport codes. LLNL has been performing verification tests by comparing processing results with NJOY and AMPX. LLNL has processed ENDF/B-VII.1 and compared results between FUDGE, NJOY and AMPX. Caleb showed results of the comparisons during the presentation.

Status of Processing Codes

ANL (Changho Lee, ANL)

Changho Lee provided a status report on the generation and testing of multi-group cross-section libraries with MC^2-3 for fast reactor analyses. Specifically, the presentation covered the status of ENDF/B-VII.1 libraries produced at ANL and the development of a "Generalized Cross-Section Library." At ANL under the old processing procedure, ETOE-2 / MC^2-2 / SDX were used to produce libraries for reactor physics analyses. Specifically, ETOE-2 processed

the ENDF/B libraries to produce MC^2-2 ultra-fine group libraries. Then, MC^2-2 was used to perform self-shielding calculations. Subsequently, SDX would be used to perform 1D integral transport calculations to account for heterogeneity effects. ANL has developed MC^2-3 for fast reactor analysis.

MC^2 ENDF/B-VII.0 library has been generated and tested using ~80 homogeneous and 1D heterogeneous problems with various combinations of compositions. Verification and validation has also been performed with ~30 experiments and experiment-based benchmark problems. Recently, ANL has generated ENDF/B-VII.1 MC^2 libraries, and efforts are currently in progress to test the VII.1 data using benchmark problems. Subsequently, Lee show recent testing results with both the VII.0 and VII.1 libraries.

During the remainder of the report, Lee presented the status of ANL efforts to develop a "Generalized Cross-Section Library." The objective is to overcome the limitations associated with multi-group cross-section libraries that are currently used for deterministic neutron transport. Furthermore, the objective is to develop a generalized library that is applicable to various reactor types including light water reactors (LWR), very high temperature reactors (VHTR), and sodium cooled fast reactors (SFR). The new library would then been used with PROTEUS, which is an unstructured mesh, discrete ordinates neutron transport code, to simulate complex geometries and compositions of advanced reactors. Lee provided an overview of the cross-section library generation effort that includes the development of a base ultrafine group (UFG) library using 2158 groups. For the resonance region, the library includes resonance integral tables as a function of background and temperature. For transport calculations, the UFG library is condensed to a broad-group library (< 400 groups) using a "group-optimization" algorithm for the reactor of interest. Preliminary results with the new, generalized libraries were presented for SFR, LWR, and HTR applications.

In summary, ANL has generated MC^2 libraries based on ENDF/B-VII.1, and the libraries are currently being tested. Also, ANL has produced generalized cross-section libraries for various reactor applications, and the libraries are currently undergoing testing at ANL.

NJOY (Skip Kahler, LANL)

Skip provided a summary of the recent changes to the T-2 Group website with emphasis on the "Nuclear Information Service" (NIS) and NJOY. The http://t2.lanl.gov web address is now the top level link for the LANL T-2 Group, and the NIS link, previously the top link, is now one of the various links on the new T-2 website. All NIS links (e.g., data, codes, publications, etc.) are still available. Skip noted that any bookmark that contained "t2.lanl.gov" should be changed to "t2.lanl.gov/nis" in order to directly access the NIS information.

Information about NJOY is now located at http://t2.lanl.gov/nis/codes.shtml. Links to both NJOY99 and NJOY202 are provided at this website. Future developments of NJOY99 will be

very limited since NJOY2012 is available. Furthermore, distribution of NJOY2012 is now coordinated through LANL's Technology Transfer Division, and more information about obtaining NJOY2012 can be found at http://t2.lanl.gov/nis/transfer.html.

Skip provided information about the NJOY webpage. The NJOY user's manual (LA-UR-12-27079) has been updated, and the NJOY manual is available for download as a PDF file. Also, the webpage provides information concerning the NJOY installation instructions and testing information. With regard to the code package, NJOY2012.0 was released in December 2012, and NJOY2012.8 was released in August 2013. Currently, additional NJOY2012 patches are being finalized for release in December 2013.

AMPX (Dorothea Wiarda, ORNL)

Dorothea (Doro) Wiarda provided a detailed status report on the AMPX development and maintenance activities since the November 2012 CSEWG meeting. As part of the AMPX modernization effort, ORNL made the decision to merge the AMPX software repository (including software configuration control) and build system with SCALE. Merging the AMPX and SCALE development infrastructure offers many advantages with the primary motivation being software quality assurance.

Currently, all SCALE development and testing is performed under the SCALE Quality Assurance Plan (QAP). Moreover, the SCALE QAP specifies the development infrastructure and testing harness that is used to meet the software QA requirements. By merging the AMPX repository and build with SCALE, all of the AMPX development and testing can be managed using the SCALE QA infrastructure. During FY2013, the AMPX repository, build and testing infrastructure were merged with SCALE, and as a result, AMPX development and testing is now performed under the SCALE QAP.

Using the same repository and build system makes code sharing easier, and the AMPX developers took advantage of this feature in two recent updates in AMPX. In particular, SCALE developers have created an "in-memory" data resource to hold a multi-group (MG) library. While the on-disk version of the MG library remains limited to 999 groups, the in-memory resource can accommodate a much larger number of groups and offers readers and writers for the new on-disk formats. The MG resource is written in C++ and offers FORTRAN bindings. Many of the AMPX modules were updated to use this new resource, which allows easy switching to any new on-disk format if desired.

Doro also reported on the development of the AMPX capability to generate "intermediate" resonance self-shielding factors. By merging the AMPX and SCALE development, modules in both systems can be shared and utilized more efficiently. AMPX has been used to generate 252-group ENDF/B-VII.0 and ENDF/B-VII.1 libraries that include the intermediate resonance self-shielding factors.

As part of the AMPX modernization effort, the AMPX collision kinematics processing module, Y12, has been refactored or re-written in C++. As part of the Y12 rewrite, a "data layer" has been implemented so that AMPX modules do not have to read the ENDF data directly; rather, all the interaction with the ENDF files are not handled through an API, and this improvement will enable AMPX to transition to the new ENDF format under development under WPEC SG38.

In addition to the AMPX processing modernization effort, the new AMPX modules have been used to generate ENDF/B-VII CE and MG libraries for release with SCALE 6.2. For the MG data, AMPX was used to generate an ENDF/VII.1 252-group neutron library, including the self-shielding factors (λ-factors and the homogeneous f-factors) that are needed for problem-dependent resonance self-shielding calculations in SCALE. In addition, two coupled libraries (200 neutron groups with 47 gamma groups and 28 neutron with 19 gamma groups) were also created. Note that the neutron transport portion of these coupled libraries use the same AMPX processing capabilities as the 252-neutron group library.

Extensive data tests have been performed with the new libraries. The AMPX library testing includes numerous validation benchmark calculations along with ~6000 transmission and leakage verification tests that involve comparisons between MCNP and SCALE. The transmission tests are much more sensitive to the kinematics data than just comparing k_{eff} values. As a result, the transmission tests have been used to thoroughly test the cross-section data libraries for SCALE. Doro showed some example results from the V&V testing of the AMPX-generated cross-section libraries.

BNL Activities Related to Formats and Processing

BNL Status Report on Activities Related to Formats and Processing (Dave Brown, BNL)

Dave Brown provided a status update on the ENDF Manual. Since the last CSEWG meeting, three out of four changes from the November 2012 CSEWG Meeting have been implemented. Specifically, the following format changes have been implemented:

- Add new sublibs for new projectiles
- Add new STYP for (anti)neutrinos
- AP, APL clarification for RRR's LRF=7

At this point, BNL still needs to implement the removal of the line numbers from the ENDF evaluations. This work is in progress.

In addition to the format changes, Dave provided a status report on the manual bug fixes that have been implemented during the past year. The following fixes have been made:

- #780: Implemented Otsuka's MF=40 wording corrections.
- #697: Implemented Vanhanen's wording corrections.
- #781: Implemented Lubitz's RRR wording corrections.

The following corrections are still outstanding and will be addressed in the future:

- #559: Kalbach parameters are given in a LIST field, but an interpolation method needs to be specified.
- #661: AWI MF=26 fix is needed. A format proposal has been submitted for this CSEWG meeting. As noted earlier in the meeting, the format proposal has been approved.
- #792: Caleb Mattoon has noted a fix is needed for the MF=6 LCT flag. This will likely be an evaluation error.

In addition to the manual corrections, there have been requests for additional format clarifications. Specifically, LLNL and KAPL have requested further clarification for the method of corresponding energy interpolation scheme. LLNL has also requested clarification for the n-body phase space formulae. Furthermore, KAPL has requested clarification for the RRR about whether the signed AJ convention could be used to provide both components by repeating the energy and splitting the width between them. As an additional enhancement to the manual, BNL plans to add angular distribution formulae for the MLBW resonance representation. Currently, BNL is planning to release an updated manual by the fall of 2014.

Following the BNL status report, the Formats and Processing Committee Meeting concluded at 5 PM on November 21, 2013.

Cross Section Evaluation Working Group

Measurements Committee Report

Yaron Danon, RPI
Committee chair

The measurement committee session was held on the morning of November 21, 2013.
Eight presentations representing experimental programs at LANL, ORNL, RPI, BNL, NIST and LBNL were given. The presentations provided an overview of current research and measurement performed at the different US laboratories. The full presentations can be found on the CSEWG web site at: http://www.nndc.bnl.gov/meetings/csewg2013/

The Agenda

- Nuclear Data Experiments at LANSCE: Highlights 2013, Robert Haight (LANL), 30'
- Recent ORNL Measurements, Michael Dunn (ORNL), 30'
- Recent Nuclear Data Research at RPI, Yaron Danon (RPI), 20'
- Current status and future directions of the EXFOR project, Boris Pritychenko (BNL), 20'
- NIST Measurements and Standards including Related Work at Other Facilities, Allan Carlson (NIST), 20'
- Recent EGAF Thermal Neutron Cross Section Measurements, Richard Firestone (LBL), 15'
- Experimental Determination of Photon Strengths for 0-10 MeV Gamma Rays, Richard Firestone (LBL), 15'
- Possibilities for nTOF at BNL, Steve Peggs (BNL), 20'

Summary of U.S. Measurement Programs

1. Nuclear Data Experiments at LANSCE: Highlights 2013 (Height, LANL)

Capture measurement with DANCE (Detector for Advanced Neutron Capture Experiments)

Summary of recent measurements:
Non Actinides
^{152,154,156,158}**Gd** - Bayarbadrakh Baramsai, NCSU/LANL, Published
^{97}**Mo** - Carrie Walker, NCSU PhD dissertation, completed

^{117,119}Sn - Carrie Walker, NCSU PhD dissertation, in progress
^{173}Lu – Capture, O. Roig (CEA), in progress
^{184,186}W - Capture, Marian Jandel LANL, in progress
^{191,193}Ir - Capture; Todd Bredeweg LANL,
^{136}Xe - Capture, gas target; data taken
^{161}Dy - Capture, data taken

Actinides

^{233,235}U, ^{239,241}Pu - Capture to fission: LANL, LLNL, in progress. **^{235}U (n,γ)** experiment was published in Phys. Rev. Let. **^{239}Pu** for E<1 keV was submitted for publication. ^{242}Pu data was taken by LLNL.

^{235}U, ^{239,241}Pu - Fission gamma ray multiplicity and spectra: LANL/LLNL, (Prelim **^{239}Pu**,**^{235}U** was reported) Comparison Paper: submitted to Phys. Rev C. **^{239}Pu (n, γ)** cross section was presented, it is generally in good agreement with ENDF.V-VII.1, disagreement in some resonances (~65 eV).

^{239}Pu - fission gamma spectrum was shown for different multiplicities.

^{238}Pu - Capture, capture/fission: LLNL, was published.

^{252}Cf - Fission gamma multiplicity and spectra: LLNL published in Phys. Rev. C.,

$^{242m, 243}$Am - Capture, Marian Jandel LANL, preliminary report submitted

^{238}U - Capture cross section, gamma rays, John Ullmann LANL, near completion

Cd – gamma ray spectrum as a function of multiplicity was shown and compared with DICEBOX calculations.

Fission Cross Sections Fission Total Kinetic Energy Fission Fragment Yields

U-233,234,236,238 (n,f) measured from 0.2-200 MeV, completed, submitted to Nucl. Sci. Eng. Plots of results were shown comparing the data to ENDF/B-VII and JENDL 3.3 and 4.0

High precision cross sections with TPC

- **U-238(n,f)** relative to U-235(n,f): Data collection and analysis in progress
- P**u-239(n,f)** relative to U-235(n,f): Production data collection in progress
- **Pu-239(n,f)** relative to H(n,n)H: not yet started

Total kinetic energy (TKE) release in fission

U-238: Data collection completed, analysis in progress
U-235: Data collection completed, analysis in progress
Pu-239: Experiment scheduled for Dec. 2013

Mass yields of fission fragments

SPIDER: **U-235(n,f)** mass yields measured at thermal, analysis in progress
Gridded ionization chamber: same status as TKE

GEANIE – (GErmanium Array for Neutron Induced Excitations)

Summary of recent activity:

- **^{86}Kr (n, xn yp γ)** - 10 new transitions (N. Fotiades ND2013). A plot with the new transitions was shown.
- **^{109}Ag (n,xγ)** - over 100 transitions in 12 reaction channels leading to Ag and Pd – in progress (N. Fotiades)
- **^{124}Xe, ^{176}Lu (n,xγ)** – in progress
- Millisecond isomers: **^{71m}Ge, ^{114m2}I, ^{208m}Bi, ^{88m1}Y, ^{88m2}Y, and ^{75m}As** - M. Devlin. An Example of the measured half-life of **^{75m}As** was presented.
- Various elements for a neutron-induced gamma-production reference cross sections (R. Nelson): **^{7}Li (n,n')^{7}Li*, Ti, Cr, Fe**
- x-ray yield from n-induced fission (R. Nelson and Thierry Granier - CEA) - published

The Chi-Nu project

Designed to measure prompt fission neutron spectrum using a fission chamber and neutron TOF to liquid scintillators and Li-Glass detectors. The system is now housed in a new building on a dedicated flight path, the new building has low mass floor. In addition to 54 liquid scintillation neutron detectors, it is now instrumented with 22 Li-Glass neutron detectors to allow measurement of fission neutrons with E<0.5 MeV. High alpha background in **^{239}Pu** PPAC was discussed.

Two new publications on **n+^{3}He** were discussed.
A comprehensive list of recent publication can be found in the presentation.

2. Recent ORNL Measurements, (Michael Dunn, ORNL)

- **183,184W** - New transmission data was taken at GEEL using 30m and 60m flight path without fixed notch filters and preliminary results were shown.
- **Ca** - Preliminary capture yield was shown (60m flight path), several new resonances were observed. Transmission data was taken at a 50m flight path and preliminary SAMMY fits to that data were shown.
- **Ce** - Capture data was taken (60m flight path).
- **182,183,184,186W, 63,65Cu, Ca-nat** resonance analysis is in progress.

3. Recent Nuclear Data Research at RPI (Danon, RPI)

Transmission:
^{92,94}Mo – data were measured at 30m and 100m flight path in the energy range from 5-600 keV, many new resonances were observed. Preliminary SAMMY fit of transmission data from 10-40 keV were presented.

Capture
Measured **Fe** in the energy range of 100 eV - 500 keV at 45m flight path. This measurement was a test for new capture gamma detection system.

Fission
Measurements using the gamma tag method were discussed. Prompt fission neutron spectra were measured for **^{252}Cf and ^{238}U**. Experimental data for **^{252}Cf** from 50 keV to 7 MeV were presented and showed very good agreement with ENDF/B-VII.1. Preliminary data for **^{238}U** were shown from 0.5 MeV to 7 MeV for incident neutrons bin from 0.5 to 20 MeV.

Thermal neutron scattering
Measured double differential scattered neutron spectrum for incident energy of 55 meV was compared with ENDF/B-VII and MCNP scattering kernels (ACE files). The data is in better agreement with the RPI generated ACE files

Data Analysis
- **Re** – Resonance analysis of transmission and capture measurements in the energy range of 0.01-500 eV was completed.
- **^{151,153}Eu** - Resonance analysis of transmission and capture measurements in the energy range of 0.01-500 eV was completed.
- **^{95,96,98,100}Mo** – preliminary resolved and unresolved data analysis was completed and published in a PhD thesis.
- **^{56}Fe, ^{238}U** – analysis of neutron scattering and angular distribution in the incident energy range from 0.5-20 MeV was completed.

4. Current status and future directions of the EXFOR project, (Boris Pritychenko, BNL)

A review of the recent status and activity related to EXFOR was given. About 145 new EXFOR entries were added in 2013. Expert meeting in IAEA resulted in new Template for resonance data.

5. NIST Measurements and Standards including Related Work at Other Facilities, (Allan Carlson, NIST)

A review of the latest activity related to ENDF standards.

H(n,n) – Concerns about the hydrogen total scattering cross section at low neutron energies led to Van de Graaff work by Daub et al. from 150 keV to 800 keV. The results were systematically slightly larger than the ENDF/B-VII values but generally within their uncertainties of 1.1 to 2%. (Phys Rev C87, 014005, 2013). Including these data in the new hydrogen being done by Hale and Paris will cause a slight increase in the evaluated cross section. This would then lead to a somewhat better agreement with the Arndt Evaluation. Now the Arndt evaluation is larger than ENDF/B-VII by about 0.1% at low energies and about 1% at about 12 MeV.

H(n,n) - Angular distributions - work is being done at the Ohio University accelerator facility. Preliminary measurements have been made at laboratory neutron scattering angles from 20 degrees to 65 degrees in 5 degree steps for 14.9 MeV incident neutrons. The plan is to increase the accuracy of the measurements and extend the angular range so that data are obtained from 15 to 70 degrees. Plans have also been made to do similar measurements for 10 MeV neutrons.

^{3}He(n,p) - This measurement would constrain the fundamental nucleon-nucleon interaction models that underlie all of our cross section work. This work could help with Hale's R-matrix evaluation of the ^{3}He(n,p) cross section.

^{6}Li(n,t) – Absolute measurement of the cross section at 4 meV was competed (NIST, LANL, the University of Tennessee and Tulane University). Flux accuracy is known to 0.05% and mass accuracy to 0.25%, total error of about 0.3% is expected.

^{10}B - New branching ratio measurements by Hambsch (correction to Nucl. Sci. Eng. 156, 111, 2007) in the 1-2 MeV energy region are now in better agreement with the ENDF/B-VI and ENDF/B-VII evaluations.
Measurements have been made of the ^{10}B(n,α1), ^{10}B(n,α0), ^{10}B(n,p) and ^{10}B(n,t) cross sections using four E-ΔE telescopes at WNR-LANL in a LANL-Ohio University collaboration. The neutron fluence was determined using a ^{238}U fission chamber. Due to the thickness of target, there was a problem separating the alpha groups. Also it may not be possible to separate the proton and triton groups. Analysis is being done now to see if the separation can be improved.
It is possible that only the ^{10}B(n,α) cross section and the ^{10}B(n, p+t) cross section will be obtained from the new analysis The data extend to 5 MeV. It is not clear what impact this work may have on an R-matrix evaluation of the standards.

C(n,n) - Daub et al. made very accurate measurements of the carbon total cross section from 150 keV to 800 keV. The results were systematically very slightly lower than the ENDF/B-VII values but generally within their uncertainties of 1.1 to 2%. These data have already been put into the carbon evaluations being done by Hale and Young.

^{238}U(n,γ) - Ullmann et al. made measurements of the ^{238}U(n,γ) cross sections using the DANCE (160 BaF_2 crystals) detector at LANSCE and thin samples. The neutron beam was monitored with a ^{235}U fission chamber, a BF_3 counter, a ^{6}LiF detector and a ^{3}He detector. Analysis is in progress.

^{235}U(n,f), ^{238}U(n,f) and ^{239}Pu(n,f) - additional work should be done in the high energy region of the cross sections to support of the needs for better standards in that energy region.

Au(n,γ) - Wallner using AMS with a simulated Maxwellian neutron source spectrum of 25 keV mean energy obtained a ratio to the standards evaluation for gold capture of 1.04 ± 0.05. The Au(n,γ) cross section measurements of Borella et al. support the standards evaluation. Schillebeeckx repeated that experiment of Borella et al. with considerable concern about corrections to the data. The new results support the standards results.

Work on prompt gamma-ray production reference cross sections considering **^{nat}Ti** with large yields of two gamma-lines, 984 keV from ^{48}Ti(n,n'γ) and 160 keV from ^{48}Ti(n,2nγ) and ^{47}Ti(n,n'γ).

6. Recent EGAF Thermal Neutron Cross Section Measurements (Richard Firestone, LBNL)

Measurements done at the Budapest reactor using HPGe detectors. Samples includes standards such as B, H, N, Cl, S, Na, Ti, Au. Uses DICBOX to calculate the contribution from the continuum level states. Data for ^{23}Na,^{39,40,41}K(n,γ) was recently published:

- **^{23}Na**: σ_0(Atlas)=0.541(3), σ_0(this work)=0.517(4),
- **^{39}K**: σ_0(Atlas)=2.1(2), σ_0(this work)=2.28(4)
- **^{40}K**: σ_0(Atlas)=30(8), σ_0(this work)=90(7)
- **^{41}K:** σ_0(Atlas)=1.46(3), σ_0(this work)= 1.62(3)
- Data for **^{182,183,184,186}W(n,γ)** were submitted for publication and were presented.
- Data for **^{152,154}Eu,^{155,157}Gd(n,γ)** were submitted for publication and were presented.

7. Experimental Determination of Photon Strengths for 0-10 MeV Gamma Rays (Richard Firestone, LBNL)

A method to obtain the photon strength using gamma lines and additional parameters from the Atlas of neutron resonances was presented.

8. Possibilities for nTOF at BNL (Steve Peggs, BNL)

BNL is considering adding a neutron beam line which will allow neutron cross section and other low energy physics measurements. The parameters will be improved over the setup at nTOF in CERN. 24 GeV protons, 1-12 bunches per pulse which allows short pulse operation and higher neutron flux. They plan of flight paths at 20-200m.

Summary of the 16th U.S. Nuclear Data Program Meeting

Held at
Brookhaven National Laboratory, Upton, NY
November 18-20, 2013

US Nuclear Data Program

Chairman's Summary

M. Herman
National Nuclear Data Center, BNL

The 16th Annual Meeting of the United States Nuclear Data Program was held on November 18-20, 2013 and attended by 44 registered participants. The meeting was held adjacent to the CSEWG Annual Meeting, with a common USNDP-CSEWG session on nuclear reaction modeling.

In FY2013 the USNDP continued its statutory activities comprising following scientific objectives and targets:

- Perform measurements, compilation, evaluation, validation, dissemination and archival of nuclear structure and nuclear reaction data for nuclides and reactions of importance to basic science and nuclear applications. The latter include safe and economical utilization of nuclear power, research and development of innovative reactors and advanced fuel cycles, radioactive waste transmutation, national safety and security, nuclear medicine, and nuclear analytical methods. The objective is to provide, in a timely manner, the highest quality nuclear data responding to the users' needs to ensure safety, reliability, efficacy, and sustainability of nuclear technologies. In particular:
  - Preserve accumulated knowledge by maintaining archives of nuclear physics databases containing compilation of bibliographical data (NSR - over 100 years of nuclear research) and results of measurements (EXFOR - reaction measurements since 1935, and XUNDL -structure measurements) as well as the evaluated libraries ENSDF and ENDF.
  - Maintain NSR, EXFOR and XUNDL up to date by regular compilation of new publications and results of new experiments.
  - Improve evaluation methodology by advancing reaction modeling and covariances.
  - Evaluate nuclear structure and reaction data to update ENSDF and ENDF databases.
  - Disseminate nuclear physics data using modern Internet technology and NDS journal.
  - Maintain/develop nuclear data formats and data verification codes.
  - Maintain expertise by promoting training of new evaluators.

The USNDP has been reviewed and discussed on the first day of the USNDP meeting. The lab reporting session was followed by the open discussion of long range planning and subsequent closed session restricted to the USNDP PI's, database managers and DOE program manager.

In FY2013 there have been several important personal changes within the USNDP. In June 2013 the McMaster component of USNDP ceased to be funded following retirement of Balraj Singh. His contribution to USNDP is only partially (70%) recovered through the contract with NNDC and a drop in the productivity is expected. Nuclear data program at LBNL is in a phase of reorganization after retirement of two signor staff members by the end of FY2013. In this context, it is critical to preserve nuclear structure and decay data component at LBNL. The situation has been finally stabilized at ORNL with $230K funding increase that secures 1 ENSDF dedicated FTE. The continuity of expertise in the field of structure and decay data evaluation appears to be secured.

Overall, USNDP budget in FY2013 has been considerably reduced compared to the FY2012. The impact of this reduction was mostly offset by the existing reserves at NNDC and remnants of the ARRA funding at ANL. These resources will be depleted in FY2014 and maintaining current level of staff with the foreseen budget will be very difficult. LANL, and LLNL operated on a very tight budget. LANL has lost $59K in FY13, which caused postponing of reaction modeling development, and delays in the ENDF evaluation effort.

The USNDP permanent scientific staff has increased from 15.0 in FY2012 to 15.5 in FY2012. This reversing of the declining trend in recent years would be a good sign if it were not due to the disappearing non-USNDP funding resulting in scientific staff previously covered by other sources to be moved under the USNDP umbrella. There has been a very consistent increase in the temporary scientific staff (post-docs), which went up from 1.6 to 4.4 FTE. This growth, again, was mostly due to moving existing post-docs to the USNDP funding but one should note addition of one FTE at LANL thanks to an early career award - the first one ever in the nuclear data program.

Compilation of structure and reaction data at NNDC is partially outsourced. This cost effective solution allows redirecting NNDC staff to other tasks critical for the ND Center operation. Outsourcing plays also important role in the structure evaluation, where it is possible due to the existing pool of retirees, who perform structure evaluations under contracts with NNDC. In the period of limited funding it is critical to keep this cost effective option open. In a longer term it has to be accompanied by the training of new evaluators to avoid losing expertise.

Modernization of nuclear data formats, facilitating compilation by employing artificial intelligence, and wider usage of nuclear theory and modeling will be necessary to retain healthy USNDP program meeting users' needs and attractive to the young generation of future evaluators. Recently new ideas have emerged that will reshape the evaluation procedure and eventually result in better performance and improved reliability of the nuclear data libraries:

- Preliminary work has shown that ENSDF library represents a solid starting point for modeling anti-neutrino spectra and reactor heat calculations. Further work in this direction would foster closer interaction between structure and reaction communities.
- Pilot CIELO project focusing on evaluation of ^{16}O, ^{56}Fe, ^{235,238}U, ^{239}Pu has been established as a first step towards worldwide nuclear reaction data library.
- Reaction modeling is being advanced in areas such as coupled-channels, scattering angular distributions, fission, and prompt fission neutron spectra.
- Future ENDF/B library will deploy more complete set of covariances, for estimation of the security margins in applications and for guiding library adjustment to integral experiments.
- New XML infrastructure is being developed by the international community on the basis of the LLNL GND project supported in recent years by the ARRA funding. There are plans that it unifies structure and reaction data and accommodates experimental as well as evaluated results.

Three highlights of the FY2013 should be mentioned:

- Early Career Award for Jandel (LANL) for experimental work on actinide isomers,
- Organization of the major nuclear data conference at New York City,
- Experimental program established at NNDC in addition to already running ones at ANL, LANL, LBNL, and TUNL.

Next Budget Briefing

The next budget briefing will be held at the DOE Headquarters on February 4, 2014. The USNDP team will include USNDP Chairman(M. Herman) , WG chairmen (J. Kelley and T. Kawano) and the members of the USNDP executive committee who have specific issues to bring to the briefing.

US Nuclear Data Program

Structure and Decay Data Working Group

J.H. Kelley (NCSU & TUNL)
Nuclear Structure Working Group Chair

Present: R. Arcilla, C. Baglin, T. Barnes, S. Basunia, L. Bernstein, D. Brown, E. Browne, J. Chen, Y. Danon, P. Dimitriou, P. Fallon, R. Firestone, M. Herman, T. Johnson, T. Kawano, J. Kelley, F.G. Kondev, C. Matoon, E. McCutchan, S. Mughabghab, C. Nesaraja, N. Nica, B.Pritychenko, B. Singh, A. Sonzogni, J. Tuli, R. Workman.

The nuclear structure working group emphasizes evaluation of measured nuclear structure and decay properties for all isotopes. These data are maintained at the National Nuclear Data Center (NNDC) in the Evaluated Nuclear Structure Data File (ENSDF). Production of ENSDF is an international effort operating under the auspices of the IAEA Nuclear Structure & Decay Data (NSDD) network. ENSDF is an important source of information for derivative databases and applications including NuDat, Nuclear Wallet Cards, RIPL, MIRD and ENDF/B. Evaluations are published as peer-reviewed articles in Nuclear Data Sheets for A>20 and in Nuclear Physics A for A≤20.

Status of ENSDF & Nuclear Data Sheets (J. Tuli)

The ENSDF database has increased in size by roughly 2.2% over the past year. Presently there are 3246 nuclides reported. Along with many revised/updated datasets, three hundred new datasets were added to ENSDF, including 72 "Adopted Levels" datasets, 51 decay datasets and 116 reaction datasets. There were 12 articles covering 16 mass chain reviews published in the Nuclear Data Sheets (A=28, 31, 60, 75, 89, 91, 150, 152, 211, 215, 231, 251-259 (odd)). The number of "mass chains" in the review process was given as 30 (this can be compared with 20 mass chains that were in the system in 2004 (see summary notes 2004). An additional 40 mass chains are listed as "currently being evaluated." General usage statistics for ENSDF and products derived from ENSDF (Nuclear Data Sheets, NuDat, etc.) showed a high usage and popularity on the NNDC website and the Elsevier site.

Throughout several sessions of the meeting, Dr. Tuli expressed great concern over the present low number of articles approaching a publication ready state in the system. He expressed that we may reach a limit where we are unable to sustain a reasonable rate of publications in Nuclear Data Sheets. A great deal of discussion ensued. Topics included: a slow pace for new

evaluations submitted to NNDC to reach publication ready quality, DOE's emphasis on metrics that appear to count submitted nuclides rather than published mass chains, evaluator experience and training, evaluator FTE levels committed to ENSDF evaluation production vs. effort committed to other activities that are not necessarily high priorities for this project, etc. Notable comments suggested: poorly prepared mass chains are being submitted to NNDC with little serious effort to implement corrections so the evaluation can be published, significant national and international effort has been invested in evaluator training while outside of a few success stories the long-term gain from these activities is debatable, and a parallel was drawn suggesting USNDP commitment to produce evaluations is similar to the decline in international contributions from the NSDD.

Much of the discussion focused on the status of the ENSDF database, which involves at least two issues. A great deal of the discussion centered on FTE involvement and commitment to inject new evaluations into the "review system." Dr. Tuli quantified an estimate of the number of mass chain productivity needed from the international NSDD network to sustain a reasonable currency of ENSDF is around 20 mass chains per year (for A>20). On two occasions, there was a call for each group to commit to providing a certain number of new evaluations into the system. Results from such a pole resulted in commitments of 13 mass chains from the 6.5 FTE of USNDP efforts. On the other hand, the submission of new evaluations into the system lacks merit if the evaluations are of poor quality, and if there is no intention or motivation to revise the evaluations to bring them to a publishable quality. It is the view of some evaluators that the issue of "quality of submissions" is perhaps more important than the number of new submissions. For comparison, in 2004 there were only 20 evaluations in the review system compared to the 30 evaluations listed today, but at that time there was no great concern that we would run out of articles for Nuclear Data Sheets. It is clear that this critical issue involves both a commitment to submit and publish evaluations, and at present these parts are perceived to be disconnected. Somewhere near the surface of these conversations is the issue that there should be a prioritization of various USNDP-sanctioned activities.

Status of XUNDL (B. Singh)

The XUNDL database presently carries 5390 datasets covering 2202 nuclides from over 280 mass chains. A total of 446 new datasets from about 240 articles were added to the XUNDL database in the past year. McMaster University carries the bulk of the activity (353) with TUNL (65), ANL (28) and a few others (TU Darmstadt, Krishnath College-India, Sophia-Bulgaria) also contributing some. NNDC (Tuli) acts as the database manager and updates the XUNDL database as new compilations are approved by Dr. Singh. As a parallel activity, McMaster has compiled 15 current papers on mass measurements comprising data for about 130 nuclides; this information was contributed to ORNL's nuclearmasses.org webpage.

A workshop on the role and future of XUNDL was held at TUNL on May 16-17 resulting in changes in the overall process of XUNDL compilation. The formal retirement of Dr. Singh is a great concern, as he and his group continue to carry the majority of effort for XUNDL. At present McMaster, TUNL and ANL intend to continue contributing, along with new participation from ORNL (Dr. Nesaraja). The level of support from ANL depends on available funding to support Jun Chen (post-doc). There was a discussion on the utility of undergraduates; McMaster has enjoyed a high efficiency using undergraduates to prepare XUNDL datasets while ANL and TUNL have found the process rather inefficient. A plausible explanation includes the general utility of having undergraduates transpose large tables of data into the ENSDF format vs. and inefficiency when articles are highly technical with smaller amounts of data. A second topic requesting implementation of a NuDat type interface with XUNDL was discussed.

A key part of recent discussions on the XUNDL activity is the need for more involvement from other data centers to participate in compilation of datasets. Even with the new organization and involvement of ORNL, Dr. Singh and his students at McMaster University carry the bulk of activities. For the XUNDL to survive into the future, other data centers must join in the activity.

Status of the NSR (B. Pritychenko)

A total of 3430 new articles were added to the NSR database. USNDP contributions are from B. Pritychenko (manager), E. Betak, B. Singh and J. Totans. The database is up-to-date and in good shape. Some effort is being spent to add “historically important” references. There was some discussion of how we should deal with conference proceedings where the talks and/or contributions are distributed on memory jump-disks. Dr. Singh made a comment about the outdated nature of NSR compiler code, indicating that it is cumbersome for both NSR compilers and users of NSR database to encode/search through Z or A chains of a large number of nuclides reported in articles such as fragmentation studies; he suggested the need for changes in the code so that one can enter a range of nuclides in NSR rather than specifying each individual nucleus.

Status of ENSDF Analysis codes

At a few points throughout the meeting there was discussion on the status of ENSDF analysis codes. The general consensus was reached that many of our evaluation codes are in need of attention to fix several bugs. Dr. Kondev would like to see more codes supported for Apple products, and he has begun writing new script codes that meet his needs. There is a general concern over the decades old FORTRAN used for most of the analysis codes. Continued use of these analysis codes will hamper many gains of a sometimes talked about transition to XML formatting of the database. However, in general there is a lack of commitment to invest effort in support of either rewriting the analysis codes or transferring the ENSDF database to XML.

Other Business and discussions

Feedback from the Low Energy Community Meeting: (E. McCutchan)

The Low Energy Community Meeting, held in E. Lansing on August 23-24, included a Nuclear Data session. Presentations were given by John Kelley, Michael Thoennessen, Richard Cybert and Aaron Couture. In addition a plenary talk on the USNDP activities was given by E. McCutchan. Throughout the meeting a survey on USNDP services was circulated amongst the 200 participants; there were 70 respondents. Results showed a high usage of the USNDP nuclear structure products and a high regard for their quality; see figure below.

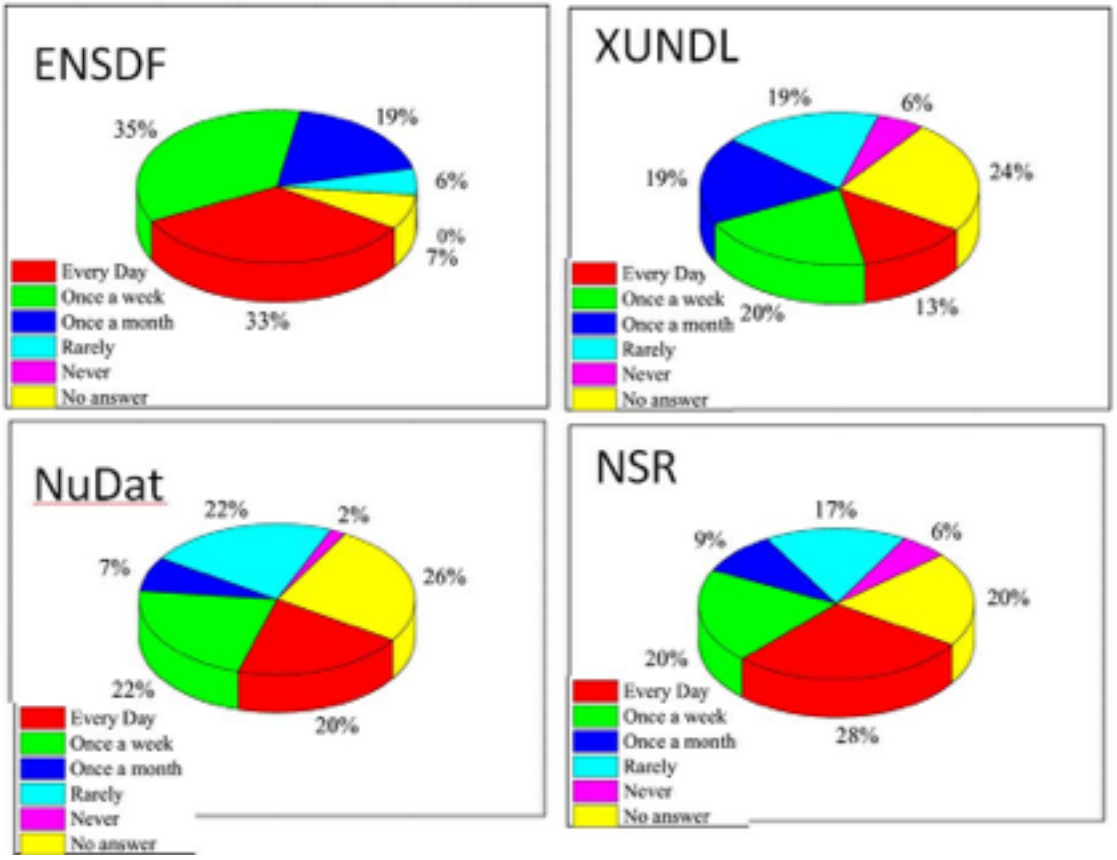

Fig 1: Survey results indicating usage of USNDP Nuclear Structure Products.

XML Format Transition

Caleb Matoon gave a presentation on LLNL's Generalized Nuclear Data project. In spite of years of dialog, at the moment there is no activity and no plan to convert the ENSDF database into an XML relational database. There are two major hurdles: firstly there is no funding to support a conversion from the 80-character ascii format into XML. Second, such a conversion would have minimal utility for evaluators since there are no plans to convert the ENSDF file processing codes into a modern form that could take advantage of strengths of XML.

Discussion on Evaluation issues and procedures

There was a good discussion on a variety of issues relative to our procedures. Dr. Singh made a few comments on the treatment of levels where a single decay transition is observed. There can be issues of confusion especially when the total strength/width is not accounted for. An extension of this topic debated the greater utility of giving partial widths for decay channels rather than just giving relative decay branching ratios.

There was a bit of discussion about utility programs that give unrealistic outputs for uncertainties, especially when limits or asymmetric uncertainties are input. The topic arose a few times, especially in connection with an assumption that the lack of uncertainty in a published value results in the assumption of 10% accuracy in the uncertainty; many evaluators felt that such an assumption was too generous and that uncertainties more like 20-30% were more reasonable.

The issue of “relevancy for giving precise values in the uncertainty of log ft values” was discussed. For the most part, log ft is used to evaluate spin-parity assignments so high precision in the reported values is of little use. There are a few cases, such as 0+ to 0+ decays, and decays to IAS, where a high precision is required; though analysis of such cases demands a special treatment of physics corrections to be useful.

Problems associated with normalization inputs in particle decay datasets were discussed in a presentation by Dr. Basunia. The issue is that some normalization factors are not included to avoid errors in the FMTCHECK code, but when this is done the ENSDF output is sometimes not displayed properly. This issue was discussed at NSDD-13 and action is in place.

There was a brief discussion on computerizing the XREF cross checking of level parameters between the “adopted levels” and reaction and decay datasets.

Evaluators were reminded that 0- to 0+ (M0) transition records in ENSDF are not correct and should have a second look and be reconsidered. Dr. Singh mentioned in the meeting that he had scanned ENSDF for such transitions which are erroneous in ENSDF. Most of these 20 or so cases have now been corrected in ENSDF or evaluators informed to make corrections.

Dr. Singh gave a presentation titled "Tale of Two (simple) Nuclides in ENSDF." The context of the first part of the presentation was motivated Michael Thoennessen and his research into the discovery of 195Os. In 1958 the 195Os isotope was first reported in the Table of Isotopes based on work reported in 1957Ba08; however a later study in 1974CoYN suggested an error in the prior work. The progression of un-discovering 195Os snowballed as the collection of nuclear structure databases (ENSDF, Table of Isotopes, Wall Charts, NUBASE, etc.) began to cross reference each other and the 1974CoYN suggestion, rather than reevaluating the work reported in 1957Ba08 (and its derivative publications). Dr. Thoennessen was contacted by Juan Flegenheimer (CNEA Argentina), who was a colleague of authors of 1957Ba08. The un-assignment was called into question, and two additional articles were introduced that supported the initial discovery by 1957Ba08. By resolving the issue of 195Os, a subsequent problem in the half-life value of 195Ir was illuminated and resolved. A second study into the existence of 63Cu led to multiple exchanges between Dr. Singh and Bertram Blank (Centre d'Etudes Nucl ´eaires de Bordeaux Gradignan). In this second case, an evaluator had assigned particle stability to 63Cu based on the presence of two counts in a fragmentation yield spectrum. Correspondence with Dr. Blank indicated that fragment production systematics indicated hundreds of counts should have been present in the spectrum where only two spurious counts were observed; he indicated that such an observation was not sufficient to indicate particle stability of a nuclide. *The moral of the stories is given as: evaluators must avoid copying blindly from other evaluations, references outside NSR may be required to accurately resolve some issues, and communications with original authors can help resolve many issues.*

Along these lines, Drs. Kondev and Chen gave presentations on 67Cu. In this case, the lack of uncertainties in a decay study resulted in an assumption of accuracy that was implemented in the decay evaluations. A key problem was a significant error in the ground state-to-ground state decay branch that had been assumed by the evaluator; a further issue with folding in uncertainties to obtain the absolute decay-intensity values was also a problem. Subsequent measurements have indicated a larger decay branch to the ground state; this has a significant impact on determining the production quantities for this important medical isotope.

Horizontal Evaluations:

Several "Horizontal Evaluations" are in preparation or in progress. A summary list of the activities is given here.

- IAEA CRP on beta-N: related to its horizontal compilation and evaluation of P_n and associated half-lives :B. Singh,
- Compilation and evaluation of BE2 for first 2^+ states in e-e nuclei: B. Pritychenko,
- IAEA-CRP on Evaluated Gamma Activation File (EGAF):R. Firestone,
- IAEA Consultants Meeting on a Database of Photon Strength Data: R. Firestone,

- IAEA-CRP on Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production: F. Kondev,
- IAEA Technical Meeting on Auger Electron Emission Following Nuclear Decay: Data Needs for Medical Applications: F. Kondev,
- Configurations & Hindered Decays of K-Isomers in deformed nuclei with A>100: F. Kondev,
- AME and NUBASE: F. Kondev,
- nucastrodata.org and the Computational Infrastructure for Nuclear Astrophysics (CINA): C. Nesaraja.

Experimental Research Activities:

In addition to activities mentioned in the laboratory reporting session, four talks on experimental research activities were given.

- Why do we need new data on 67Cu?, F. Kondev
- Beta- and gamma-ray emisson probabilities in decay of 67Cu, J. Chen
- Another interesting case of ICC measurement: the 88-keV, M4 transition in 127mTe, N. Nica
- NNDC Experimental Activities, E.A. McCutchan
- Neutron induced fission measurements at TUNL - J. Kelley

US Nuclear Data Program

Nuclear Reaction Working Group

T. Kawano, LANL
Working Group Chair

Model code development

R. Workman of George Washington University gave an overview talk on the SAID program and the partial wave analysis results. The SAID code accesses the database of hadron/nucleon interactions, performs model fitting, and visualization. The partial wave analysis results are accessible trough the Web interface at Center for Nuclear Study, Data Analysis Center of GWU. The SSH interface is available too. This facilitates, for example, experimentalists for planning new experiments or cross-check with multi-channel data analysis.

M. Herman of BNL summarized the new features in EMPIRE-3.2 (Malta), and status of the code development since the latest released version. The major changes since the last USNDP meeting are; improvements of the width fluctuation correction for deformed systems, energy balance, and break-up and transfer reactions. The ^{235}U fission cross sections were fitted by EMPIRE, and discussed the structure in the 300 keV to 1 MeV energy region seen in the Standards cross section.

G. Nobre of BNL gave a talk on the deformed optical potentials in the rare earth region. It was shown that the spherical optical potential of Koning-Delaroche applying to the coupled-channels calculations gives reasonable fits to experimental data. In the expansion of the potential, conservation of the potential volume is also considered.

D. Brown of BNL presented some issues concerning the scattering angular distributions calculated from the MLBW (Multi-Level Breit-Wigner) resonance formalism. Although MLWB does not ensure unitarity, it may be useful for calculating elastic scattering angular distributions from the resonance parameters. Examples were shown for O-18 and Zr-90.

R. Vogt of LLNL summarized the recent updates of FREYA. The new version allows for initial angular momentum of the compound nucleus as well as angular momentum of the fragments in a way that conserves total angular momentum throughout the fission process. Thus, in addition to statistical gamma-ray emission already in FREYA, gamma-ray emission along the yrast line is also accounted for. FREYA was also incorporated into MCNP in order to provide neutron angular correlations and photon emissions as an event-generator to be useful for detector development and simulations.

P. Talou of LANL gave a talk on the code developments at LANL. A new addition to CoH3 is the prompt fission neutron spectrum calculation with the Los Alamos model, including pre-fission neutron emissions. The CGMF code, the Monte Carlo Hauser-Feshbach approach to the prompt fission neutrons and gamma-rays, applied to Cf-252 spontaneous fission neutrons, fission gamma-rays, and other observables. Integration with MCNP6 is planned for near future.

G. Arbanas of ORNL presented two subjects, the method to calculate covariances of S(alpha,beta), and the direct capture calculation with the coupled-channels method. He reviewed several possible methods for calculating the S(alpha,beta) uncertainties, and feasibility was discussed. The coupled-channels calculation was performed for Fe-56 including one and two-phonon states with FRESCO. This allows us to perform the direct capture calculation in a self-consistent way.

J. Hirdt of St. Joseph's college and BNL, gave a talk on interconnection of experimental data sets given in the EXFOR database by applying the graph theory. Important nuclear reactions can be visually identified by drawing the network of connected experiments. It was shown that there are a large number of independent measurements. Analysis of the network is ongoing.