2012
Cross Section Evaluation Working Group
and
US Nuclear Data Program
Annual Meetings

Preface

The 2012 Nuclear Data Week has been held November 5-9 at Brookhaven National Laboratory. As usual, the USNDP/CSEWG meetings were accompanied by the Nuclear Data Advisory Group (NDAG) of the Criticality Safety Program. On the contrary, Nuclear Physics Working Group (NPWG) has not been hold this year**.** The schedule of the Nuclear Data Week was the following

- USNDP Annual Meeting, November 5-6,
- NDAG, Nov 6,
- CSEWG Annual Meeting, November 7-9,

Taking advantage of the reduced amount of the new evaluation work following release of the ENDF/B-VII.1 in December 2011, and availability of the time slot liberated by the NPWG meeting the traditional format of the Nuclear Data Week has been optimized to possibly avoid parallel sessions of CSEWG and USNDP.
The reporting session of USNDP has been moved from Friday to Monday morning and followed up on Tuesday afternoon, replacing working lunch held in previous years. The motivation was to provide more time for discussion of the USNDP performance, potential staff and funding issues and strategies for the future activities. To improve effectiveness, these meetings were restricted to the USNDP PIs and managers of the USNDP databases. An informal discussion of the technical issues related to the ENSDF evaluation was organized for those participants who did not attend the USNDP reporting session.
The CSEWG meeting was started with the validation session to review performance of the recently released ENDF/B-VII.1 and assemble deficiencies that should be addressed during the subsequent evaluation session when planing future activities.

The present document contains the Summary of the CSEWG and USNDP Meetings that is produced in the electronic form only. It is available, along with all presentations given at these two meetings, at www.nndc.bnl.gov/meetings/csewg 2012/.

Jan 16, 2013 Michal Herman
CSEWG chair
USNDP chair

Summary of the 62th Cross Section Evaluation Working Group Meeting

Held at
Brookhaven National Laboratory, Upton, NY
November 7-9, 2012

Cross Section Evaluation Working Group

Chairman's Summary

Michal Herman
National Nuclear Data Center, BNL

The 62th CSEWG meeting was held on November 7-9, 2012 at the Brookhaven National Laboratory. This year the number of registered participants was 57. It is remarkable that in spite of the hurricane Sandy, which hit Long Island a week earlier, and objective difficulties with accommodation and gas supplies only a few participants cancelled their attendance. Among the participants were representatives of national laboratories, academia and nuclear industry of the United States and Canada, as well as a few participants from abroad. With the ENDF/B-VII.1 released a year ago the main scope of the meeting was to discuss performance of the ENDF/B-VII.1 and further activities leading to the new version of the library in about five years. As usual, the CSEWG meeting was held next to the USNDP annual meeting, with a common session on modeling of nuclear reactions.

It is natural that during the year following the release of the library there are relatively few new evaluations submitted to the NNDC. In this period most of the activities focus on advancing evaluation methodology and infrastructure in preparation for the future library release. Thus the results of this year are not measured by the number of new or modified evaluations but the by ideas and new concepts that will essentially reshape the whole evaluation procedure and eventually result in significantly better performance and reliability of the next library release. The 2012 CSEWG meeting was particularly prolific in this respect and major ideas are summarized below.

- **CIELO project** - M. Chadwick proposed to unify world-wide nuclear reaction evaluation efforts to make more efficient use of dwindling resources (including still available retired experts), tighten scrutiny of the new evaluations, and draw on experience of national/regional projects and previous international collaboration. The present libraries have reached such level of maturity that the next step will likely need more resources than are available within each individual project. For making a qualitative advance we'll need results of the new generation of differential experiments, more complete experimental covariances, and comprehensive modeling of nuclear reactions including such quantities as inelastic scattering cross sections, angular distributions, and PFNS for actinides. Even these will not be sufficient to ensure precision requested by the applications. The essential leap may come only by combining new differential evaluations with the wealth of integral data through the statistically sound adjustment procedure. This implies closer integration of several communities (differential measurements, evaluation, processing, integral experiments, validation/adjustment) which is only achievable

within a broad international collaboration.
Later in November 2012 the CIELO proposal has been discussed at the JEFF meeting at the NEA Data Bank in Paris. It has been decided to form a WPEC subgroup, consisting of participants from all major evaluation projects, which will attempt to evaluate six critical materials (^{1}H, ^{16}O, ^{56}Fe, ^{235,238}U, and ^{239}Pu). These evaluations are expected to constitute the core of a future world-wide file.

- **New experimental efforts** - the ENDF community continues to enjoy direct support of the experimental program. These results are a critical component of the evaluation procedure allowing for calibration of the model calculations and in certain cases entering directly the evaluated files.
  - The nuclear data oriented program carried out at LANCE under the leadership of R. Haight is adding more experiments. New data are expected for PFNS using a new beam line and array of 54 liquid scintillators. Several other experiments address cross sections important for applications (e.g., neutron radiative capture on ^{239}Pu). The Time Projection Chamber is under development to provide very precise measurements of the fission cross sections, while SPIDER spectrometer is supposed to enhance our knowledge of fission products.
  - Another key program of nuclear data measurements is lead by Y. Danon at RPI. While RPI is specialized in neutron measurement in the resonance region, and continues to provide very valuable data in this domain, it has recently added semi-integral measurement in the fast neutron region that are very helpful to constrain evaluations for the critical materials such as Zr and Fe. The RPI portfolio is being extended to cover fission neutron spectra and nubars as well as thermal neutron scattering in water.
  - With ORELA being shut down, the resonance-region cross-sections are being measured by ORNL scientists at GELINA (Belgium) to satisfy needs of the criticality safety program.
  - LLNL, in addition to collaborating with LANL on some experiments mentioned above, is perusing fission and capture measurements using the surrogate technique.
  - LBNL is carrying on the EGAF project of thermal neutron induced gamma emission, which is on the border of reaction and structure data.

  Within next few years, we expect many results that should help to solve ambiguities in evaluations for several important materials.

- **Reaction modeling** - continues to be upgraded with the major thrust towards areas that are believed to have potentially large impact on applications. These include PFNS, inelastic scattering, angular distributions and, last but not least, fission.
  - Work on PFNS modeling is carried on at LANL, BNL (EMPIRE code) and at LLNL (FREYA code). The three efforts are complementary. LANL is working within the refined Los Alamos model and using improved parametrization aims

at consistent evaluation of PFNS for most of the actinides. The BNL attempt consist in implementing Los Alamos and Kornilov model in the EMPIRE code and using the two models in the assimilation exercise to test effect of the difference between the two models on integral quantities and interplay between PFNS and other quantities such as fission and inelastic cross sections, and elastic angular distributions. FREYA takes a different route - it constructs fission neutron spectra through Monte Carlo event generation. This approach has a potential of addressing more details (e.g., various correlations) than the macroscopic formulations mentioned before. Event by event calculations are also performed at Los Alamos providing besides PFNS also gamma-spectra and the variety of cross-correlations.

- New versions of the two major reaction codes CoH and EMPIRE have been released in 2012 - CoH-3.2 Umbriel and EMPIRE-3.1 Rivoli
- Finally, a collaboration of theorists from LLNL, MSU, Texas A&M, Ohio Uni., and ORNL, known as TORUS (www.reactiontheory.org), has been developing new methods that will advance nuclear reaction theory for unstable isotopes by using three-body techniques to improve direct-reaction calculations and by developing a new partial-fusion theory to integrate descriptions of direct and compound-nucleus reactions.

These activities demonstrate that nuclear data community continues to develop solid theory support for the reaction evaluation effort, which should bring tangible results in the nearest future as well as benefit the program in long-term.

- **Covariance data** - Applications of nuclear data require statements of the accuracy of the nuclear data used in order to design for safety and performance margins. The large progress in availability of covariances has been achieved with release of ENDF/B-VII.1 and COMMARA-2 libraries and goes far toward meeting user's needs. However, many of the covariances therein have been estimated 'a posteriori' rather than being produced consistently as a byproduct of the evaluation procedure. With most urgent necessities being satisfied it is time to turn towards more consistent and statistically sound methods. Although much progress has been made the covariance methodology is still not fully established. It will be one of the major tasks for the nuclear data community to develop practical methods for determining realistic covariances combining experimental data and theory calculations. In the meantime, the new QA rules have been proposed by D. Smith that raise requirements on the covariance data accepted in a future ENDF/B library. The role of covariances is critical since they actually determine which quantities are modified and how much they are changed during adjustment of the library to the integral experiments. This aspect is connected to the 'good results for a bad reason' issue mentioned above, and is as important as the issue of safety margins due to the data uncertainties, which is usually considered the major reason for having covariances.

- **Data adjustment** - Typically, the covariances in the ENDF and COMMARA libraries contain only differential experiment and/or theoretical uncertainties. Integral experiments (e.g., on critical assemblies) provide a tighter constraint on nuclear data and have often been used by the application community to tune nuclear data libraries to specific applications represented by the integral experiments. Also evaluators were using integral experiments to improve performance of the basic libraries (e.g., ENDF/B-VII.0, -VII.1 and JEFF-3.1). This calibration was usually performed on a limited range of experiments and is the principal cause of the 'good results for bad reason' issue. Recent results of the WPEC SG33 showed that various statistical adjustment techniques and related codes reached a level of maturity which ensures that different codes provide essentially the same results when using the same input data. Thus, quality of the adjustment depends only on the availability and proper selection of the integral experiments and quality of the covariances employed in the adjustment procedure. G. Palmiotti presented first results of a quite extensive adjustment exercise on the ENDF/B-VII.1 cross sections using COMMARA-2 covariances to provide explicit feedback to the evaluators. The pilot consistent adjustment (assimilation) project, carried out by BNL and INL over last three years, go further in this direction by moving adjustment from the cross sections to the reaction model parameters. This approach not only reduces number of modified parameters but directly involves physics' constraints in the adjustment process.
  Two weeks after the CSEWG meeting the proponents of the CIELO project met with the participants of the WPEC SG33. It has been agreed that the followup WPEC Subgroup will collaborate with the CIELO project on adjusting CIELO evaluations using the validated techniques, new generation of covariances, and extended set of integral experiments, all coupled with decades of experience. This will be an essential change in the way the recommended files are produced - evaluation and validation communities will collaborate in the evaluation process using modern reaction modeling and statistically sound adjustment procedures. Such files will account for differential and integral experimental information as well as for constraints imposed by the nuclear reaction theory, which should ensure optimal performance of the new library.

- **New XML format and infrastructure** - While the ENDF-6 format is sound, the tools that use data in the ENDF-6 format are often difficult to use and support. More problematic is that many of the authors of these tools have left the field either through retirement or death. To revitalize their in-house processing capability, LLNL began developing a new data handling infrastructure and, in the process, sought to modernize the ENDF-6 format to make the job of developing new data handling software simpler. This project led to the development of the fudge code and the Generalized Nuclear Data format as has been discussed during the previous CSEWG meeting and later brought to the WPEC meeting in Paris. There is a consensus that the modern approach is needed to replace the aging ENDF-6 format

(that stems from the punched card image) and supporting tool chain. The international cooperation in the frame of the WPEC subgroup has been established with the charge of formulating the new format within three years. Taking into account the work status it is very probable that a new release of the ENDF/B library will be produced simultaneously in the ENDF-6 and the new XML format.

- **ADVANCE system** - The ADVANCE system comes as a response to the lesson learned during the development of the current VII.1 version, which calls for more timely checking of new evaluations, to avoid discovering major problems a few days before the release. The software industry uses the continuous integration process to check source code every time something changes. D. Brown has adapted this continuing integration process to check and then process the ENDF library. This system is called ADVANCE and is installed at NNDC. ADVANCE performs immediate verification and validation of the newly submitted evaluations and post the results on the dedicated Web-site so that they become available to the authors and entire ENDF community within a few hours from submittal.

Next Meeting

Tentatively, the next Nuclear Data Week will be held at BNL, Nov. 18-22. This period avoids conflict with the APS and ANS meeting but needs to be confirmed. The individual meetings will tentatively be held following the schedule of 2012:

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

Cross Section Evaluation Working Group

Evaluation Committee Report

M. Chadwick, LANL
Committee chair
M. Herman, BNL
CSEWG chair

Summary of Work Plans in the Coming Years for Future-ENDF/B

Nuclei for the next-ENDF/B:

Highest Priority

Standards	NIST, LANL. IAEA support for new Standards (in 2 years)
^{239}Pu	ORNL, LANL, LLNL, NIST + JEFF, JENDL?
^{235}U	ORNL, LANL, LLNL, NIST, RPI + JEFF, JENDL?
^{238}U	ORNL, LANL, LLNL, NIST, RPI, + JSI/Trkov+IAEA/Capote, JEFF, JENDL?
^{56}Fe	ORNL, BNL, RPI, LANL, + JEFF, JENDL?
^{16}O	LANL, KAPL, ORNL, + JEFF, JENDL?
Update covariances	including more mu-bar (structurals, ^{16}O, more actinides), PFNS covariances for ^{241}Pu, and other improvements

Next Priority

CP ion reactions	LLNL, LANL
Be	LANL? Not on anyone's work-list!
^{12,nat}C	LANL, LLNL – but not on anyone's work-list
^{23}Na	BNL, (ORNL – funding dependent)
Ca	ORNL
V	ORNL not till 2016
Ti?	RPI
Cr	LANL? For criticality safety?
Ni	LANL
Cu	ORNL (^{63,65}Cu), RPI, LANL
Zr	BNL, Bettis, RPI, (LANL criticality safety in 2016)
Mo?	RPI
Ta	RPI
Gd	RPI, DANCE, ORNL ($^{165\text{-}168,160}$Gd, but by 2015)
Dy	RPI, ORNL ($^{161\text{-}164}$Dy)

Ce	ORNL in FY15
Eu	RPI, ORNL
W isotope updates	ORNL, BNL/Trkov, IAEA/Capote
Pb	not till 2016 for LANL criticality safety
^{240}Am	LLNL – new surrogate fission data
^{236}U	RPI – 5.45 eV resonance may change significantly
^{252}Cf, ^{235}U the PFNS	RPI measurements may influence future evaluations
Minor actinides	LANL for criticality safety – what's on the list? Add covariances for PFNS (e.g., for ^{241}Pu)

Major actinides ^{239}Pu, ^{238}U and ^{235}U

Evaluators potentially involved in the work – Kawano, Chadwick, Capote, Bauge, Iwamoto, Bouland, Fort (?) (fast region inelastic, elastic, capture fission cross section & nu-bar), Talou, Vogt (PFNS, PFGS), RR (Leal, CEA: Cyril de Saint Jean and Guille Noguere), Simakov, Trkov, and Kahler.

- **Inelastic & elastic scattering, 2013,14** – work between Kawano, Capote, Romaine, Iwamoto on CC modeling with HF to seek to resolve discrepancies between ENDF, JEFF, and JENDL in the fast region. Update preequilibrum/ pseudo-level representation at higher energies, Kawano, Bauge, Simakov, for better understanding of double-differential experimental data as well as LLNL pulsed sphere and other transmission experiments.
  ^{238}U elastic and inelastic scattering data will be available from RPI. Quasi differential available (mainly inelastic) from 0.5 MeV up to 20 MeV. ENDF doesn't include anisotropic angular distribution in compound elastic (JENDL has it and does better at backward angles). At forward angles the libraries look OK, while at backward angles there are deficiencies – it appears that ENDF/B-VI did better. Trkov notes that ENDF/B-VI.8 ^{238}U elastic angular distribution matches the measured data better than VII.1 and this perhaps also explains the RPI quasi-differential problems noted by Danon. Trkov has explored substituting the latest JEFF3.2 distributions into ENDF and done testing on the impact in Bigten etc. (leads to a shift in calculated k_{eff}). Chadwick noted that the VII.1-VII.0 results were based on a pragmatic choice a decade ago by Young, MaFarlane and Chadwick on using a Maslov OM that led to good performance of critical experiments (solutions and intermediate and fast).
- **nu-bar, 2013** – if possible, remove the ^{239}Pu tweak LANL made to match Jezebel, and review work by Fort. Fix ^{238}U low energy interpolation. Seek to remove discrepancies with JENDL, JEFF (Talou/Young +).
- **Capture, 2013,14**. New ^{239}Pu DANCE data in 1-2 years (2013-14) with a thicker sample (Kawano, Bouland, Romaine, Iwamoto).
  ^{238}U - Monitor Standards results for any changes, based on new measurements from DANCE, n-TOF, and Geel (Pronyaev, Kawano, Plompen?).
- **Fission, 2013** – adopt Standards work. Leal+Carlson – consider merits of making fission from resonances identical to "Standard" results.

Sub-threshold fission for ^{238}U – discrepancies between different evaluations. Lead spectrometer measurements near 70 keV suggest a problem with ENDF (Kawano, Danon). Some small differences in ~10 keV region, where the discrepancies between ENDF and JENDL might be difficult to be solved from experimental data, have large sensitivities to the critical systems (not given at CSEWG, but talk by G. Chiba at ENDF/NJOY/MCNP workshop).

- **PFNS, 2014** – adopt final results from Chi-nu+other data (other experiments, dosimetry data, nuex) and models, Talou, Vogt, Lestone
- **PFGS, 2013** - separate out prompt fission gamma spectra (PFGS) above 1.09 MeV for ^{235}U and ^{239}Pu. Reevaluate spectrum based on any new LANL, LLNL DANCE data (Kawano, Talou).
- **P(nu), 2013 -** for neutrons and gamma-rays (Talou/Lestone/Jandel/White)
- **PFNS, PFGS as a function of multiplicity, 2013** – Vogt, Talou/Jandel
- **Delayed neutrons** – no change.
- **^{239}Pu Resonance work from WPEC-SG34, 2013** - Leal, CEA. A new file exists (merged into JEFF); the same resonance file will be submitted soon after merging into ENDF /B-VII.1 (which has new resonance parameters, new nu-bar, and new PFNS at thermal) – the current file submitted by Leal has just the resonance parameters integrated into VII.1, but not nu-bar and PFNS changes (thus Skip could test to see the effect of the new resonances). Leal will provide details on these three changes and how they compare with ENDF/B-VII.1. WPEC 34 should be finalized in 2013.

  ^{239}Pu mu-bar, WPEC-SG34 2013 - Cadarache benchmark testing suggests angular distributions are needed from resonance parameters. A new version of NJOY can handle this, or angular distributions can be added in MF 4 painlessly. Will have a potential impact on k_{eff} for a wide range of critical experiments. Cyril de San Jean, Bouland, Kawano, Leal.
- **^{235}U capture, 2013** - update to reflect new DANCE and RPI measurements. ENDF/B-VII.1 now has RR up to 2.25 keV, URR up to 25 keV. JENDL RR analysis presently goes up to 500 eV, URR up to 30 keV. Leal's test case presently also follows JENDL's template. But RR goes up to 2.25 keV, and URR up to 30 keV.

  Yanon noted that one should be careful when putting his RPI data as cross sections since these results are for a thick target. But since SAMMY fits multiple scattering, RPI data can be used. Yaron/Marian/Luiz will develop plots to check consistency of RPI and DANCE data.

^{16}O

People potentially involved in the evaluation work: Hale, Lubitz, Paris, Chadwick, Kawano, Kunieda, Shibata, Leal, Carlson, Roubstov, and Plompen/Giorginis, Noguere, Koning.

- **Thermal elastic scattering, 2013** – Hale, Leal, and others are discussing a possible 3% change in thermal elastic scattering cross section.
- **General resonance analysis** - existing VII.1 hybrid should be compared with ORNL's 2005 evaluation (KAPL-LANL). Hale & Lubitz will look at this with Leal, and recommend path forward. Kunieda-Kawano-Paris will also participate in the comparison and will come up with a plan for any recommended changes. (The 2005 ORNL generated a full R-matrix resonance analysis for ^{16}O using LRF7 formalism. Included were angular distributions, (n,a) but the evaluation has never been tested. It has the advantage of using resonance parameters instead of point-wise cross sections. Leal will send the new evaluation to LANL for testing. ORNL has tested it using the broomstick transmission experiment – looked good apparently.)
- **(n, a)** - likely that VII.1 (n,a) will also need changing, especially above 6 MeV based on new IRMM/IPPE data. Does this higher energy >6 MeV region impact any applications significantly (maybe medical applications)? Carlson notes Mn bath calibration.
- **Angular distribution uncertainties** - need reliable anisotropic ^{16}O scattering uncertainties. Palmiotti thinks Gerry's present uncertainties on mubar are too small.

^{56}Fe

People potentially involved in evaluation work: Leal, Kawano, MacFarlane, Brown, Hoblit, Kunieda, Schillebeeckx, Plompen, Trkov, Pronyaev?, Shibata?

- **Resolved Resonances** - in ENDF/B-VII.1 RR extend up to 850 keV, but pointwise fluctuations extend up to almost 10 MeV. 2013 - ORNL work planned up to 2 MeV. MacFarlane is engaged too, through usage of angular distributions.
- **RPI measured** high-resolution transmission data up to 2 MeV, and scattering data ("quasi differential"), that need an MCNP calculation to compared to evaluation. Energy range covers 0.5 MeV to 20 MeV. These data point to changes in elastic and inelastic combined.
- **Arjan Plompen (Geel)** has inelastic data from 800 keV to 5 MeV (actually, gamma-production) measured this year.
- **Andrei Trkov has shielding benchmarks** that are relevant too. The EURACOS benchmark for SIMBAD. Schillebeeckx and Trkov's postdoc have made some new measurements, and reviewed existing measurements.
- **IAEA coupled-channel OM** work is going on for iron.
- **gamma-production data for iron** by Ron Nelson (LANL) are available.
- **Shibata and Cadarache** might be interested in the evaluation work.
- **Data above 20 MeV** may be needed too, e.g., for fusion applications, using new gas-production data from Haight.

- **Palmiotti noted** that an iron adjustment process is planned (funding permitted), and that there many integral experiments.
- **The Grimes et al. Ohio work** should be looked at too – it is suggesting a big change for nonelastic, but our total cross section is accurate. Their proposed nonelastic change seems surprising and is unlikely to be true – instead, could something else be causing this?
- **Pronyaev** – also doing work on inelastic gamma production. At one point this was being considered as a standard (now it is more likely to use Ti).
- **Vonach, Tagesen** were involved in the last European JEFF evaluation.

Standards – A. Carlson

Overall – recent work tends to support the existing Standards. Still, we will encourage the IAEA to support a new upgrade of the Standards in ~2 years to contribute to future ENDF/B releases.

- **^{1}H** - Development work at Ohio is going on. Source neutrons from C(C,n). New work at PTB by Nolte et al. is starting at 10, 14 MeV. TPC will eventually look at this. Near 100 MeV we still have an inconsistency at back angles, with discrepancies between Uppsala, PSI, and Indiana University.
- **^{3}He** - Not much activity.
- **^{6}Li(n,t)** - various efforts going on at NIST, and also work at GELINA by Hambsch up to 3 MeV.
- **^{10}B(n,a) -** Hambsch plans measurements.
- **^{12}C(n,n)** - Grityav Kiev data coming in that suggest issues with the present standards.
- **^{197}Au(n,g)** - standard above 200 keV, but the standards does have data near 25 keV, important for astrophysics (and the standards value is 5-7% higher than the Ratynski astrophysics evaluation influenced strictly by Macklin and by astrophysics 25 keV measurement.) New Wallner data agrees with the standards, as does new data by Lederer. New Feinberg data at IRMM also agree with our standards. Wallner's 426 keV also agrees with the standards.
- **^{238}U(n,g)** - is not a standard but is part of the evaluation process. New data are coming from n-TOF and Geel; LANL data by Ullmann are being finalized (though with big uncertainties).
- **^{238}U(n,f)** – new data are fairly consistent.
- **^{239}Pu -** Tovesson and Hill data consistent with Standards up to 10 MeV, but are lower above 10 MeV.
- **^{235}U PFNS at thermal** - new data in ratio to Californium are being studied by Pronyaev. Californium PFNS is well known up to 9 MeV at least according to Allan (MBC notes that IAEA dosimetry work would suggest it's accurate to even higher energies).
- **Date for a new standards** – no major changes are needed. Still, it would be desirable to release what is the best. We discussed the fact that overall the

CSEWG community felt a new Standards evaluation within about 2 years is needed. This would require Gerry Hale and Chen involvement.

Individual contributions

M. Chadwick - CIELO project

Chadwick discussed idea of the CIELO: Collaborative International Evaluated Library Organization, which has already been presented to IAEA & WPEC earlier in 2012. The pilot project has informally started and will be formalized at the WPEC meeting at NEA Data Bank in May 2013. The existing ENDF, JENDL, and JEFF libraries have reached a level of maturity to enable us to contemplate this next step – they're already converging! The quality of CIELO will benefit from being a collaborative product from the world's best experts. Computational/methods advances enable a "step function" in improvement, exploring the large phase space of solutions under guidance of realistic covariances. There are mid-career experts to shepherd this project through, and some key retirees who may be able to help. We'll build on initial steps already taken through international collaborations such as IAEA/WPEC lead projects on Standards, RIPL, Dosimetry File, Photonuclear Sublibrary, ^{238}U capture, Fission Products library, and CEA-ORNL collaboration on neutron resonances.

The initial pilot project will focus on ^{1}H, ^{16}O, ^{56}Fe, ^{235,238}U and ^{239}Pu, with a goal to make substantive advances within 2-3 years. Currently, the discrepancies among major libraries and other complex issues are being identified. Next step will be to establish teams of ENDF, JEFF, JENDL, IAEA, … specialists to work on each nucleus, resolve discrepancies and create new CIELO files. Insights will come from experiment (cross sections, spectra, integral experiments), theory, and simulations. The goal is to maintain good integral validation performance (k-eff criticality, reaction rates, etc.) while having more physically-justifiable cross section representation. Based on initial experience, we'll consider expanding the CIELO concept by including more nuclei and involving more evaluators.

Chadwick described LANL priorities for ENDF/B in the time frame of 4-5 years, which are supposed to coincide with the priorities of other projects making CIELO collaboration a natural choice. These priorities include (i) refined covariances, (ii) three major actiondes: ^{235,238}U and ^{239}Pu (remove compensating errors likely present in current ENDF, JEFF, and ENDL evaluations and improve key reaction channels (PFNS, fission, capture, inelastic & elastic)), (iii) ^{16}O, ^{12,nat}C, (^{23}Na, ^{56}Fe, ^{90}Zr – especially BNL), (iv) expand ENDF data for nonproliferation/SNM detection applications, (v) exploit measurements made in the next 2-3 years, (vi) address whether feedback from Adjustment/Covariance efforts point to any cross section changes (SG33, Commara, Japanese ADJ file, etc), (vii) ensure consistency with IAEA dosimetry data, (viii) the new Standards, (ix) make use of validation feedback on Pu-solutions & intermediate energies, fast Be, Ni, V reflectors,

thermal and fats Pb reflectors, (x) continue improvements of Minor Actinides (neutron+ FPs, & FPYs, KERMA).
In the remaining part of his talk Chadwick discussed differences among different libraries and open issues to be addressed by the future evaluations.

T. Johnson, E. McCutchan, and A. Sonzogni - BNL Decay Data

Authors discussed completeness of the decay data, status of FPY, Pn values, and quality of the derived antineutrino spectra.
Calculated ^{89}Rb continuum beta- and gamma-spectrum from ENDF/B-VII.1 is not bad, but discrepancies are observed when compared to measurements. For ^{92}Rb, ENDF/B-VII.1 is better than JENDL-4.0 and JEFF-3.1. In general, however, this is not the case – JENDL is better for certain FPs, and where the data are lacking there can be large differences in the evaluations.
Speakers showed calculated Delayed Neutrons (DN) from FPs versus the evaluated DN values and saw some discrepancies, which is not surprising.
Pn systematics by Pfeiffer *et al*. and Kratz-Hermann can be improved now because masses are known more accurately. A more compact representation with reduced chi-square improved for Pn/half-life has been published by McCutchan. It does better than Pfeiffer et al and Moller *et al*'s QRPA calculations.
Caribu at ANL (1 curie Cf source) is being used to do related measurements.
Anti-neutrino spectra emitted from a nuclear reactor are of great interest because of neutrino-oscillation experiments. Calculations using the latest VII.1 decay data seem to predict the spectra well. Alejandro showed the noticeable effect of including Kawano's CGM work in VII.1. The spectra are also sensitive to the type of actinide decay, and can be used to help identify the fuel type in a reactor for nonproliferation applications. Only 20-30 nuclei determine antineutrino components in the decay heat budget. Anti-neutrinos are not considered in the present ENDF format. Covariances for FPY are needed (a WPEC subgroup is being established), along with those for decay data. Better decay data are also needed.

M. Herman – Assimilation Project

This project did adjustment at the level of the nuclear reaction cross section model code, as opposed to adjustment on evaluated grouped cross sections.
This work has been documented in a thorough BNL-INL technical report, and describes the lessons-learned. They noted issues not originally expected, such as non-linear effects. Also, for lighter nuclei, including iron, there are challenges since resonance-like structures are important, whereas calculated priors from statistical models are poor here (smooth, didn't match the data so well). For ^{105}Pd the integral information pointed to a much bigger capture cross section than makes sense from the fundamental data – the differential and integral data seemed incompatible and discrepant.
For the major actinides, ^{235}U, ^{239}Pu, matching criticality was accomplished easily, largely by modeling the fission cross section higher. One can easily get the right answer for the wrong reason. This project has provided many valuable lessons as the community

endeavors to use adjustment and assimilation feedback to point to advances needed in the underlying cross sections.

L. Leal and Y. Danon

^{235}U

New data are available from RPI on capture and FPY, and from DANCE for capture. Leal and Danon also looked at the Zeus benchmark that are sensitive to intermediate energies (previously the Japanese, and Bob MacFarlane, noted that this can be better modeled by capture changes). RPI data to show lower values in the 1-2 keV region.
In the 200-400 keV region the RPI resolution is better than LANL's, and this led Leal to use RPI more than LANL. LANL and RPI results are similar, but some notable differences still remain. The trend in Zeus1-4 is modeled better with the new evaluation, and even better than with JENDL-4. The new evaluation still over-predicts ZEUS4 sensitive to the highest energy neutrons (80 keV) – Jandel's higher-energy data could fix this. Question will be how Leal can use Jandel's lower-resolution data directly, not just RPI. Generally, modeling all the fast criticality experiments is going to be a challenge.

^{239}Pu

The 0.3 eV resonance produces fissions and therefore increases the reactivity. Current evaluation ^{239}Pu RR evaluation is divided into three disjoint resonance parameter sets. The new evaluation covers 10^{-5} eV to 2.5 keV as a single range. The k_{eff} is improved without changing anything else in ENDF/B-VII.1. Nubar is also being changed by Eric Fort and work on PFNS is continuing.

Leal has evaluation plans also for Cu and W isotopes and Fe up to 2 MeV – all for 2014.

A. Davies, (University of Wisconsin)

MCNP shows wiggles at low energies for ^{154}Eu. Starting with Be, TRIPOLI code created a 1% offset compared to MCNP. TRIPOLI follows the ENDF data no matter what, while MCNP uses the ACE data including perhaps some fixes. GOG and TRIPLOI showed strange results for ^{240}Pu too.

J. Comlin

Problems reported for the probability distribution functions for ^{153}Eu secondary energies - after NJOY has run, XCP-5 has set them to zero. Erroneous zero cross section values are in MT=2 at 1.1971 MeV. They have replaced 0 with 1e-6. Similar problems found for ^{61}Ni near 0.7 MeV and 0.8 MeV.
We should re-integrate these fixed files into BNL's repository – Dave has many such errors.

N. Summers

Light ion reactions for incident d, alpha, ^{6,7}Li evaluations are only available in ENDL format, but could be converted to ENDF. They have an inverse kinematics script too.

MCNP will soon (1-2 years) be able to transport these charged particle reactions.
LANL has some tables but they are often incomplete – don't go up to 20 MeV. Documentation says whether these were done in forward or backward kinematics.

Thermal neutron scattering sub library needs to be put in GND. We may ask French for devising the GND format for thermal scattering.

Cross Section Evaluation Working Group

Data Validation Committee Report

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

D. Brown et al, BNL

Brown reported on the continuous checking system "Advance" intended for immediate QA of newly submitted/modified evaluations. He reported that Fudge code is finding quite a few bugs, even though BNL checking codes, NJOY99, PREPRO, and INTER did not.

Discussion. How to avoid "last person to submit a file" defines the latest version. David Brown suggested using ENDF-A as a development area as a possibility.
Action – we need resolution on a path forward.

Action - how to avoid the ignoring of bug reports? Shall we authorize David Brown to be proactively fixing evaluation errors? Dave noted it's a case-by-case situation.

G. Palmiotti

A comprehensive adjustment was carried out using 87 integral experimental values (k_{eff}, spectral indices, …), ENDF/B-VII.0 library, and COMMARA-2.0 covariance matrix. A 33 energy group structure was adopted and sensitivity coefficients were calculated. Generalized Perturbation Theory (by ERANOS system) was used for static integral parameters and Depletion Perturbation Theory for time dependent parameters (done at ANL). Only five major reactions were included in the adjustment: fission, elastic (including mu-bar in two cases), inelastic, capture and (n,2n) and PFNS in 3 cases.

Pino identified cases where he thought ENDF/B-VII.0 uncertainties are too low: Pu-238 capture, Am-241 fission, Pd-105 capture, U-238 fission, Pu-238 fission, Pu-239 fission, Na-23 elastic, Na-23 inelastic, Fe-56 elastic, O-16 elastic, Pu-239 fission spectrum.

He said he cares more about uncertainties than about the mean values. This is because he does adjustment of the central values to prepare the application library.

Capture central values for ^{238}Pu ^{242m,244}Cm, ^{105}Pd, ^{133}Cs, ^{151}Sm, ^{153}Eu needed to be changed. Chadwick noted that in the BNL-INL work it was shown in some cases the adjustment proposed really looks inconsistent with the fundamental data, e.g., for ^{105}Pd capture.

^{235}U capture, ^{238}U, ^{239}Pu inelastic, ^{237}Np fission and FP captures, have promise for reducing uncertainties on neutronic design.

Bob Haight asked if the adjustment process is underdetermined – Pino agreed. That is, there are more adjustable parameters than constrains. The solution, however, is uniquely determined by the covariance matrix. McKnight noted that there are many things missing in the adjustment process, e.g., angular distributions – and this is important because it "adjusts what it has".

I. Gauld

They tracked large amount do data for ORIGEN. Cross sections were taken from ENDF/B-V,VI,VII, JEFF3.1/A. But need >2000, and so went to JEFF to get the special purpose file (formats are compatible).

Isotopic productions of many FPs improved going from ENDF/B-V to VII.0, using SCALE, probably due to better thermal cross sections.
Orders of magnitude changes for HEU unirradiated fuel gamma-ray decay spectrum were observed when using ENDF/B-VII.0 – problem in ^{234}Th decay going to the g.s. (wrong state, should be meta of ^{234}Pa). Further review and testing pointed to many errors in decay energies for g, beta, alpha, ^{238}U spontaneous fission, and many errors for fission products in ENDF/B-VII.0. ^{235}U fission energy release using VII.0 was showing ~10% discrepancies in some of the time-dependent energy releases in the gamma-rays, e.g., at 1000 seconds.

On the contrary, experience with ENDF/B-VII.1 decay sublibrary has been very good. ENDF/B-VII.1 has been fully integrated into ORIGEN.

Systematic testing of ENDF/B using benchmarks should be extended to include the decay sublibrary – data are widely used and quality is important.

Alejandro Sonzogni noted that the ENSDF database had problems that led to ENDF Decay problems for ENDF/B-VII.0. He had seen similar feedback for poor ENDF/B-VII.0 performance and fixed them for VII.1. He noted that the decay heat wouldn't reveal these problems. **It has been suggested to withdraw VII.0 decay data from distribution**.

Dave Brown suggested that we should have our own activation file, perhaps initially build on adopting European efforts.

R. McKnight

ZPR15 a,b,c,d tested metallic fuel performance for LFMBF program (oxides). These were U10%Zr. A bias appears to reflect ^{235}U performance.

JENDL was pushing for a ^{235}U capture change based on a trend the Japanese were observing in their testing. These trend was not really seen by US and EU teams – although JEFF group might be observing similar indications now. The US experience is more with Pu fuel, not with the Japanese FCA which were U cores, so the US didn't have the void experience to guide them.
Dick tried swapping our ^{23}Na, and ^{235}U with JENDL in his sodium void calculations. He notes that the void issues are influenced by both ^{235}U and ^{23}Na (and Japanese sodium evaluation is very different).

Overall, he sees pretty good performance of VII.1 for his void worth simulations, but he notes these are mainly Pu dominated, not ^{235}U dominated experiments – we need to import info for ^{235}U dominated systems.

Kawano noted that the ^{90}Zr angular distributions from an OM calculation from Japan was used. He could create angular distributions from resonance parameters instead – and this kind of testing could be useful to point to future work. He feels that local fluctuations from resonances could be important (he had learnt this from his experience with nickel).

Skip Kahler

EFF-3.1.2 have modified Pu library bringing their evaluation down to 1.00195 bias instead of 1.00576 in VII.1. Latest Leal work yields 1.00285 – better, but not perfect. (JENDL-4.0 gives 1.00746). How has RR, nu-bar, and PFNS changed in the new Leal's file?

Mike Zerkle

Zr elastic scattering angular distributions are too forward peaked below 0.5 MeV. New evaluation should aim to resolve feedback from many integral tests.

Cross Section Evaluation Working Group

Covariance Committee Report

D. L. Smith, ANL
Committee chair

Session Summary

A 3½-hour meeting of the CSEWG Covariance Committee was held during the 2012 annual CSEWG meeting. It was composed of two approximately equal-length sessions that took place on Thursday, 8 November, and Friday, 9 November, respectively. There were nine individual presentations given during this meeting. Each lasted from 10 to 15 minutes. In addition, there were two discussion periods of approximately 15 minutes each, devoted to thermal-moderated covariance data issues and experience gained in using ENDF/B-VII.1 covariance data. This meeting reflected an ongoing interest in generating covariance data for ENDF/B as well as in applications of ENDF/B-VII.1 covariance data during the year following release (in late 2011) of this most recent version of the ENDF/B library.

Neudecker et al. (LANL) discussed a technique that is being applied at LANL to generate cross sections and covariance matrices for structural materials. This approach takes into consideration information generated from nuclear models (including model parameters and their uncertainties), experimental cross sections (as well as their uncertainties), and estimates of uncertainties due to model defects, in generating complete evaluations expressed in ENDF-6 format. Hoblit (BNL-NNDC) described the approach being taken at the NNDC to generate a processed covariance library for COMMARA-3 that is being used for fast-reactor applications. This applications library is based largely on covariances associated with ENDF/B-VII.1, but it is being supplemented with data from other sources. Various methods are being applied in this work, depending on the priority needs (importance) of the materials considered. Cho (KAERI and BNL-NNDC) discussed ongoing covariance activities related to evaluations in the resonance region (using the kernel approximation) as well as at higher energies (above the resonance region). Aliberti et al. (ANL) discussed the use of covariance information for both differential and integral data in the process of creating adjusted data libraries for fast-reactor applications. Palumbo et al. (BNL-NNDC) described work on producing covariance data for ^{239}Pu to be applied in assimilation (data adjustment) applications for the fast-reactor development program. Pigni et al. (ORNL) described the development of methods to predict uncertainties in used nuclear fuel properties due to the underlying uncertainties (and related correlations) in decay and fission-yield data. Rising et al. (LANL) described the development of methods to generate covariance data for prompt fission-neutron spectra (PFNS). The importance of uncertainties in these spectra, as well as cross-section uncertainties, in estimating the uncertainties of physical quantities that

are of actual interest for applications was stressed. Smith discussed the importance of implementing quality assurance (QA) procedures for ENDF/B covariance data. It was pointed out that the establishment of procedural quality standards is necessary for these data since no integral tests of quality tend to exist for covariances, such as those available for central values (e.g., cross sections). Suggestions were offered for further updating of the covariance QS requirements document that was approved prior to the release of ENDF/B-VII.1.

More detailed discussions of the contents of the presentations given at the present meeting are provided below, in the order of their appearance in the session agenda that is posted on the NNDC website. The complete presentations are available for downloading from this location (as either PowerPoint or PDF documents) through links provided on the CSEWG-2012 meeting agenda webpage: http://www.nndc.bnl.gov/meetings/csewg2012.

Presentations

D. Neudecker et al. (LANL) - The Full Bayesian Evaluation Technique

In this work, application of the Full Bayesian Evaluation Technique provides cross sections and covariance matrices for structural materials. The ingredients of this approach include: nuclear modeling; model parameters; parameter uncertainties; model defects; experimental cross sections; and experiment covariance data. This information is then combined mathematically within the framework of the generalized least-squares technique to generate covariance matrices. The relatively new aspect of this investigation is an attempt to estimate systematic deviations of model-calculated and experimental data, and to include these as components of the overall estimated uncertainties associated with ENDF/B evaluations. In this context, a "model defect" is considered to be a systematic deviation of the model results from comparable experimental results which can be observed for several isotopes in a similar energy regime within a selected model space.

In this analysis, it is important that the experimental data explicitly employed in a particular evaluation not be considered in estimating these defects. Rather, these model defects should be estimated from discrepancies between experimental data and calculated results for distinct but similar isotopes relevant to the one in question. Uncertainties due to model defects should always be considered if the model used shows significant deficiencies, as reflected in obvious discrepancies between the model and experimental values for a particular material and reaction process.

An outstanding issue that is being explored is how to deal with "kinks" in the evaluated cross-section curves that tend to emerge when model defect uncertainties are included, as compared the smoother evaluated results that do not take such defects into consideration.

In the Full Bayesian Evaluation Technique, correlations of systematic uncertainties are being considered (but only roughly) for single experiments as well as between different experiments, leading to evaluated uncertainties of about the same magnitude as the correlated systematic uncertainty. As part of this activity, work is also being undertaken to compile available uncertainty values for specific uncertainty sources appearing in different experiments in order to simplify estimating experimental data uncertainties in those situations where there is sparse uncertainty information given but where correlations between the experiments is strongly suspected. The techniques discussed in this work are being applied to evaluate data from a LANL experiment involving measurements of 237Np-to-235U fission cross-section ratios, and to the 239Pu fission-neutron spectrum measurements (Chi-Nu) being performed at this laboratory.

S. Hoblit (BNL) - COMMARA-3.0: Processed ENDF/B-VII.1 Covariance Library

A specialized nuclear data library called COMMARA is being developed to satisfy the needs of the fast-reactor development community. In particular, this community has as one of its objectives the generation of an adjusted, specific applications library based on consideration of carefully selected differential and integral data. To serve this purpose, it is required that COMMARA include complete covariance information for the included materials and reaction channels. COMMARA is currently based on a subset of materials included in ENDF/B-VII.1, and it is structured as a processed, group format library that is most suitable for direct usage in this specific applied activity. The current version of COMMARA is COMMARA-2.0.

COMMARA-2.0 includes 110 materials that are deemed to be the most relevant to fast-reactor R&D. These are: 12 light nuclei (LANL); 78 structural materials (BNL); and 20 major and minor actinides (LANL + BNL). Note that the laboratories responsible for generating this information are also indicated by (…). The current COMMARA library consists of 135 files: 110 cross section covariances; 20 nubars; 3 PFNS; and 2 mubars. By comparison, ENDF/B VII.1 provides covariance data for 184 isotopic materials: 12 light elements; 99 structural elements; and 73 actinides. While COMMARA-2.0 data are drawn from ENDF/B-VII.1, other sources of data, including new evaluations, are being considered in updating this library to the new version, COMMARA-3.0. This presentation discusses work now in progress to generate the next version of COMMARA.

This presentation also discusses procedures used to develop the covariance data used in this library. These procedures are chosen pragmatically to take into consideration the relative importance of particular materials. Relatively rigorous approaches to developing the covariance data are used for the most important materials. Approximate methods are applied to deal with less important materials where, in any event, the data needed for application of more rigorous evaluation approaches are usually far more limited. A brief description is also given in this presentation of quality assurance (QA) procedures that are being applied in developing the COMMARA-3.0 library. A new web-based Sigma-

QA utility program (author, A. Sonzogni) allows visual and also quantitative inspection of differential uncertainties and integral uncertainties. The NNDC checking code UnCor is also being applied to the full library. It performs eight tests and posts warnings for possible file problems including: small uncertainties, e.g., (n,tot) <1%, (n,el), and (n,γ) <2%, etc.; non-positive-definite matrices (fixable for all but PFNS); and PFNS covariance matrices where there is failure to sum to zero for rows and columns (not usually a problem). Non-positive-definite matrices are usually fixable by slightly reducing the off-diagonal elements. If not, more drastic measures are sometimes required. Specific examples of problem areas that have been encountered (showing fixes) are given in this presentation. Consideration is also being given to estimating cross-reaction covariances.

Y-S Cho (KAERI and BNL) - Covariance Activities at KAERI

Covariance evaluations in the resonance region were performed using code KERCEN and the multi-level Breit-Wigner (MLBW) formalism. Sample calculations were reported for ^{55}Mn. In addition, covariance evaluations in the high-energy region (fast neutrons) were carried out using the EMPIRE-KALMAN code system. Results were reported for ^{237}Np and ^{240}Pu.

Updates to the code KERCEN were discussed in this presentation. This code was originally developed by BNL and KAERI to generate covariances in the resonance region using the kernel approximation. The work was undertaken to address some technical issues encountered during recent years, including File 32 processing concerns. Among these were: a decrease in the uncertainties after collapsing covariances into multigroup representations; discrepancies between NJOY and PUFF in processing File 32; and proper handling of scattering radius uncertainty. The recent updates were undertaken to accommodate the MLBW formalism, in addition to incorporating the kernel approximation. One of the main objectives of this effort was to validate the original kernel approximation by approaching the problem in a somewhat more sophisticated way. The more accurate formalism includes incorporating a MLBW resonance treatment within a similar framework as the earlier methodology. The KERCEN code uses a formalism (either with the kernel approximation or the MLBW) that is encompasses resonance parameter uncertainties from the Atlas of Neutron Resonances (Mughabghab). This code handles scattering radius uncertainties explicitly. It also generates uncertainty data for cross sections directly (MF33), thus bypassing possible MF32 processing issues. However, correlations have to be supplied by an evaluator in this approach. In KERCEN, the entire resonance energy region is divided into smaller regions called bins. Information on resonance-potential scattering, scattering-scattering, capture-capture, scattering-capture, and bin-bin correlations are supplied as input. This method has been employed in developing resonance-region evaluated covariance data for ^{55}Mn.

The EMPIRE-KALMAN code system has been employed for determining the high-energy region covariances. Sensitivity matrices have been deduced by examining 5~10%

variations of the model parameters around their optimal value. Uncertainties from experimental measurements were considered when available. Otherwise, if no measurements are available, pseudo data have been used, with 10% uncertainty assumed for the cross sections provided by model calculation. Covariance files in ENDF-6 were generated for category MF33 and MT=1,2,4,16,17,18,22,24,(51-91),102,103,107. MF32 data were obtained from ORNL for (^{237}Np, ^{240}Pu, and ^{244}Cm). JENDL-4 provided the nu-bar, fission neutron spectra, and MF 31 results.

The main problem encountered in this work was that it often generated what appeared to be too small uncertainties for many measured data. To cope with this issue, uncertainties were increased using scaling factor based on systematic errors, if available, or eye-guide judgments.

G. Aliberti and R.D. McKnight (ANL) - An Example of Cross Section Adjustment: A Broader Discussion of Covariance Needs

This presentation aimed at broadening the dialog on covariance data needs. Contemporary applications of covariance data tend to fall into two broad categories: sensitivity / uncertainty analysis or error propagation; data assimilation or data adjustment. This presentation focuses on contributions by ANL to the current WPEC SG33 data adjustment exercise. The scope of this subgroup effort was outlined in a single slide that lists the integral assemblies considered and the particular integral experiments included in the analysis procedure. The following laboratories are involved in the WPEC SG33 effort: ANL, JAEA, CEA, KAERI, CIAE, NRG, INL, ORNL, IRSN, and PSI.

The approach taken at ANL for this project involves using the following methods and data: the generalized least-squares fitting code GMADJ; cross section data from ENDF/B-VII.0; covariance data in 33-groups from COMMARA-2.0; χp only for ^{239}Pu and ^{240}Pu; μ-bar only for ^{23}Na and ^{56}Fe; 33-group sensitivity coefficients calculated with ERANOS (transport theory) based on ENDF/B-VII.0 data; and 1266 group constants considered. The isotopes involved are: ^{235}U, ^{238}U, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{56}Fe, ^{52}Cr, ^{58}Ni, ^{16}O, ^{23}Na, and ^{10}B. The reactions considered are: capture (or n-α for ^{10}B); fission; the prompt fission neutron spectrum; total nu, elastic scattering; inelastic scattering; and mu-bar

The SG33 exercise specifies that four case studies should be examined by the participants:

Case 1:
Adjust cross sections for the initial twenty selected experiments (including experimental and calculation uncertainties without correlations, i.e., diagonal uncertainties but no off-diagonal elements of the covariance matrices).

Case 2:
Adjust cross sections for the initial twenty selected experiments (including consideration of experimental correlations but omitting calculation error correlations).

Case 3:
Adjust cross sections for the initial twenty selected experiments (including consideration of both experimental and calculation uncertainty correlations).

Case 4:
Adjust cross sections for the initial twenty selected experiments plus the multiplication factor of ZPR-9 Assembly 34 (including both experimental and calculation error correlations).

For applications such as data adjustment or assimilation, in addition to needing nuclear data covariance information, it is also necessary to have covariance data for integral experiments and to employ appropriate computational methods. The status of this effort is similar to that for differential nuclear data evaluation in that the importance of various aspects is still evolving.

This presentation provided several tables of results produced by the ongoing work.

A.Palumbo et al. (NNDC) - ^{239}Pu covariances for assimilation

This presentation provided an overview of ongoing work at the NNDC to generate covariance data, primarily for the ^{239}Pu prompt fission neutron spectrum (PFNS), for use in fast-reactor development applications. The analysis makes use of both differential and integral data that are currently available as well as the Los Alamos fission neutron spectrum model.

M.T. Pigni et al. (ORNL) - Covariance Matrices for Nuclear Decay and Fission Yield Data

Considerable covariance data have been generated by the nuclear data community for cross sections whereas much less information is available for the uncertainties of data associated with other nuclear processes. The present project has as its goal to develop methods to predict the uncertainties in used nuclear fuel properties due to the underlying uncertainties (and related correlations) in decay and fission yield data. To this end, ORNL is drawing on its existing capability to propagate cross-section uncertainties/ correlations. The aim is to apply this capability to decay data and fission product yields. The approach that is being followed is:

Step 1: Generate a covariance library for nuclear decay and fission yield data (Williams/Gauld/Pigni).

- Compile uncertainties for nuclear decay and fission yields data.
- Develop methods to generate related covariance matrices.

Step 2: Monte Carlo-based uncertainty methods developed for analysis of covariance matrices are being used to generate the perturbed covariance libraries mentioned in Step 1 (Wiarda/Gauld/Pigni)

The uncertainty data to be generated by this approach will be used in applications related to fuel decay heat, radio-toxicity, and burn up credit analysis.

Estimates of uncertainties in calculated radio-isotope production are based in part on Monte Carlo sampling of cross-section covariance data. In the ENDF/B-VII.1 library, uncertainties of cumulative and independent yields as well as of half-lives and energies are already present. No new evaluations are needed. The present work consists of generating covariance matrices, e.g., of fission independent/cumulative yields, with no intent to re-evaluate the ENDF/B-VII.1 library. Initial assumptions used to generate correlation information for fission product yields are: no energy dependence; no cross-material correlations; and no cross-isotope correlations. The project plans to proceed as follows:

- Compile uncertainties for nuclear decay data and fission yields.
- Develop the methodology to be used to generate covariance matrices (some aspects of the formulism are described in the slides shown at this meeting).
- Develop an ENDF format (perhaps it will be called File 38) for independent/cumulative fission product yield covariance matrices (most likely in a compact format).
- Develop perturbed libraries using decay and FPY covariance data, and apply these libraries to demonstrate uncertainties associated with applications involving used fuel decay heat, radio-toxicity, and burn-up credit.
- A final technical report describing the uncertainty analysis system and data, with quantitative applications to used fuel disposition, is to be delivered in Fall 2012.

M.E. Rising et al. (LANL) - PFNS: Consistent Evaluations, UQ, and Propagation of Uncertainties

This work has been motivated by the need for nuclear data uncertainties in the nuclear applications community (Uncertainty Quantification) for the areas of cross sections, angular distributions, prompt fission neutron spectra, etc. In this context, it is desired to update/include PFNS evaluations, with covariances, in the ENDF/B-VII library. Factors to consider are: theoretical model changes and new experimental results. One aspect of Uncertainty Quantification involves recognizing that nuclear data uncertainties are meaningless unless the impact on applications is quantified, and that there is a need for feedback from data users to the nuclear data community. This feedback can guide future theoretical physics work, experimental measurements, assessment of correlations in older experiments, etc.

The framework for assessing uncertainties in PFNS is the Los Alamos Model (LAM. This model is originally predicated on nuclear evaporation theory and averaging over fission fragment distribution. There are few tunable parameters. However, recent inclusion of an anisotropy parameter has led to an extended LAM. The present evaluation process requires input experimental data. Differential data are extracted from the EXFOR database (with some modifications). The GMA code methodology is then used to calculate experimental covariances. A linear KALMAN filter approach is invoked to combine model and experimental data. A normal distribution shape is assumed for the posterior probability distribution while the LAM is introduced in a linear first-order approximation to carry out the combination process. The analysis leads to posterior parameters and uncertainties for the LAM (adjusted by inclusion of the experimental data). These adjusted parameters and their uncertainties and correlations are propagated to generate evaluated covariance matrices for the PFNS. Of course, the normalization requirement for a PFNS must also be taken into consideration. Correlations between major and minor actinides are introduced through the LAM parameters.

This project has generated new evaluations for PFNS, and their uncertainties, for all uranium and plutonium actinides below second-chance fission. Modified ENDF/B-VII.1 data files, based on these new evaluations and covariance matrices, are available for testing.

D.L. Smith (ANL) - Covariance QA Procedures: Why Are They Necessary

Central values – what we traditionally consider to be the most important results from an ENDF evaluation – can be quality assured rather well by data testing (e.g., C/E comparisons of calculated keff and other important integral parameters for a suite of integral benchmarks). There is no comparable way to independently check the "quality" of covariance data, so an alternative approach is needed to address the issue of QA in the particular case of covariances. Since there is no independent way to establish the quality of covariance data, we must rely on:

1. Establishing "quality" requirements for the procedures used to actually generate evaluated covariance data.
2. Performing automated tests of covariance files to assure that they fulfill the essential mathematical and physical requirements to be expected for these data.
3. Defining and enforcing adopted requirements for documentation.
4. Carrying out timely, independent, "common sense" human reviews of covariance data before their release.

The overall quality of the covariance data found in ENDF/B-VII.1 is reasonably good considering the magnitude of the task of providing these data and the limited resources then available. But, there are some acknowledged deficiencies:

1. There are often procedural disconnects between the evaluated central values and the related covariance data.
2. The documentation provided is often sparse (or missing).
3. The files for certain materials and processes represented in ENDF/B-VII.1 include no covariance data.
4. Independent reviews before release of the library were hastily done and involved only a few people.

Some recommended improvements that should be implemented before the next ENDF/B ("raising the bar") are:

1. Effort should be made to insure that a closer "linkage" exists between evaluating the central values and generating the corresponding covariance data.
2. Provide more detailed and specific documentation on the covariances as an integral part of the ENDF/B library (MF=1).
3. Provide covariance files for at least every new evaluated cross section included in the next ENDF/B.
4. Independent human reviews should be performed as early as possible for future ENDF/B evaluated covariance data.

A document that defines the contemporary QA requirements for evaluated covariances (and that is formally adopted by CSEWG) should serve mainly to guide evaluators in this area, but it should not strive to rigidly micromanage the evaluation process. This document should be compatible with the ENDF/B Formats Manual (which may need updating). Regardless of what QA requirements are established and spelled out in a formal document, the quality of these data ultimately will depend on the integrity of the evaluators who generate them.

D.L. Smith (ANL) - Covariance QA Document: Suggested Update

The QA requirements in effect for ENDF/B-VII.1 should be updated for future ENDF/B releases. The revised requirements should reflect more stringent criteria ("raising of the bar") consistent with what is feasible and reasonable. These updated requirements should be widely publicized within the nuclear data community and serve to guide evaluators as work progresses toward the next release of the ENDF/B library.

The existing ENDF Covariance QA Document is currently posted on the NNDC/CSEWG website at: http://www.nndc.bnl.gov/csewg/covdocs.jsp. The motivation for having this QA document in the first place was discussed in the preceding presentation. Most existing provisions of the ENDF/B-VII.1 QA document are retained in the suggested revision. The recommended additions are consistent with points also mentioned in the preceding presentation. The entire QA document was shown in a series of slides during the presentation. For ease of visualization, the text for the current adopted version appeared

in black font, while suggested revisions were indicated using double strikethroughs for deleted text and red font for newly added text.

The recommended changes to the ENDF/B-VII.1 covariance QA document reflect an incremental sharpening of the quality requirements without requiring any backtracking (backward compatibility). They are intended to be consistent with the capabilities and experience gained by the data evaluation and data applications communities during the time that has elapsed since the release of ENDF/B-VII.0. The spirit of “guiding” and not “micro-managing” the evaluation process, as reflected in the ENDF/B-VII.1 version of QA document, is also preserved.

There was a lot of positive discussion over this QA document following this presentation. Three main points were put forth by the audience:

1. Since these are guidelines, words like "requirement" and "must" should be softened to "guidelines" and "strongly encouraged".
2. There is a need for clarification concerning what a "Physical Process" actually is in the discussion of completeness.
3. In the minimum uncertainty table, there should be some notion of the requirements imposed by the neutron standards. In the regions where there are standards data, we cannot have an uncertainty smaller than the standards for non-standard reaction processes. Whenever the uncertainty reflected in an evaluation approaches the small values found for comparable standards reactions, then that situation should be flagged during the review for further consideration by the evaluator.

Any discussion about QA issues related to covariances should not be approached without also considering a comparable review of ENDF files in general. The NNDC ADVANCE continuous integration system software (see http://www.nndc.bnl.gov/endf/b7.dev/qa/index.html) already automates many of the covariance and mean-value QA tests. The NNDC will try to implement others that are recommended in the QA document. However, automation doesn't remove humans from the QA review process. It just aims makes their life easier.

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 8, 2012 and morning of November 9, 2012 at Brookhaven National Laboratory (BNL). The initial part of the meeting on November 8 was devoted to ENDF/B formats and related issues followed by a status report of the Generalized Nuclear Data (GND) structure development being led by Lawrence Livermore National Laboratory (LLNL). During the morning session on November 9, Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and Argonne National Laboratory (ANL) provided status reports for their respective cross-section processing code systems. The Formats and Processing Meeting concluded with a report from BNL concerning the development of an ENDF I/O package that can be used to interface with the existing ENDF/B evaluated data files. The following are the minutes from the Formats and Processing Committee meeting.

Formats and Related Issues

File 2 Scattering Radius Manual Clarification (Chuck Wemple, Studsvik)

Chuck Wemple presented a proposal to clarify the File 2 scattering radius implementation in ENDF/B evaluations. For LRF=3, the ENDF-102 Manual Section 2.2.1.2 currently requires that if the ℓ-dependent scattering radius, APL, is zero, then the value of the scattering radius, AP, should be used for APL. In the present manual interpretation, if APL is used and levels are specified, then AP would not be required. This interpretation creates an inconsistency for non-resonant isotopes. The issue is whether AP needs to be provided if all APL values are provided. For non-resonant isotopes, no resonance parameters are given except for the scattering radius, AP. Further, AP is included for the convenience of users who need an estimate of the potential scattering cross section, and AP is not used to calculate a contribution to the scattering cross section, which in this case is represented entirely in File 3. AP is also provided for all other File 2 formats in use now, and the need to calculate a potential scattering cross section is not limited to non-resonant isotopes. The proposal requested a revision to the Section 2.2.1.2 format requirement for LRF=3 as follows: If the ℓ-dependent scattering radius, APL, is zero, APL=AP, and if APL is provided for all NLS levels, a value for AP is still required. The proposed revision provides consistency with other resonance formats requiring AP for all

presently used resonance formats. The **proposal was discussed and approved** by the CSEWG.

Beta Decay Anti-neutrino Spectrum (Dave Brown, BNL)

Dave Brown presented a proposal to add an anti-neutrino STYP so that anti-neutrino spectra can be stored with the electron spectra from a beta decay. The ENDF/B-VII decay sub-library stores the beta decay information for thousands of isotopes. Beta decays produce an electron and an electron anti-neutrino in addition to the daughter nucleus. Currently, the ENDF format has no provision for storing the anti-neutrino spectrum. This format limitation is problematic because neutrino detectors are finding a niche in the area of non-proliferation. As a result, nuclear data evaluators cannot provide the end-users (e.g., detector developers) with anti-neutrino data. As noted in the proposal, the only ENDF-102 Manual change is to update the STYP list in Chapter 8, Section 8.4.c to include the anti-neutrino STYP. The **proposal was discussed and approved** by the CSEWG.

Proposal for New Sub-libraries for ENDF/B-VII.X (Dave Brown, BNL)

Dave Brown presented a proposal to add 9 new sub-libraries to the ENDF format in order to address emerging nuclear data needs for fusion research and development. With regard to a specific fusion application example, in a typical ICF capsule, there are many components, including plastic and foam spacers. In a plasma environment, these materials ionize and effectively make their component atoms into projectiles. NNDC has had requests from users at both LLNL and LANL to extend the existing charged-particle sub-libraries to include ^{12}C, ^{6}Li and ^{7}Li. In addition, LLNL's ECPL library also includes a ^{4}He sub-library with complete evaluations. In the format proposal, NNDC requested that new sub-libraries be added for the following incident particles: ^{4}He, ^{6}Li, ^{7}Li, ^{9}Be, ^{10}Be, ^{10}B, ^{11}B, ^{12}C, and ^{13}C. With regard to the ENDF-102 Manual, the current list of sub-library designators is provided in Table 3 on Page 7, and NNDC proposed extending the list of sub-libraries to include 9 materials with a $Z \leq 6$. The **proposal was discussed and approved** by the CSEWG.

Proposal to Remove Line Numbers from ENDF Files (Dave Brown, BNL)

Dave Brown presented a proposal to exclude line numbers in ENDF files that are currently provided in columns 76-80. Historically, the line number feature of the language was very useful when the ENDF data files were routinely printed out or in older text editors that did not show the line number one's cursor is on. Currently, ENDF files are rarely (if ever) printed out and all modern text editors provide the user with the current line number. In short, the line-number feature used to be convenient but has outlived its usefulness. Furthermore, the line numbers actually inhibit progress by preventing the proper functioning of the Unix "diff" utility -- a utility used in the CSEWG GForge site as part of the version control package. Adding a single resonance in the SLBW RRR format will add one line of new information to an ENDF file; however, because the line numbers now shift by one, the entire evaluation appears different when

using "diff". This issue has an outsized effect on the CSEWG versioning. All version control software works by storing the difference between two files rather than the entire files. Without line numbers, the difference is one line. With line numbers, the difference is every line. Therefore, NNDC proposes to drop the line numbering in columns 76-80 entirely. Further, NNDC believes this change will be seamless because the NNDC codes STANEF and its successor code STAN and the LLNL code FUDGE all can reinsert the line numbers for users who still need them. The ENDF manual would have to be edited in Section 0.6.3 to remove reference to the NS field of every record type.

The **proposal was discussed and approved** by the CSEWG with the implementation provision that NNDC will have to add a capability to strip line numbers if an evaluation is submitted with line numbers. In addition, NNDC will strip off line numbers from existing evaluations in ENDF/A. Note that ENDF/B-VII.1 and previous releases will retain line numbers.

Status Report on the GND Format Development (Bret Beck, LLNL)

With the recent emphasis on developing a modern, ENDF nuclear data structure, LLNL provided a status report on the GND development effort that was discussed at the previous CSEWG meeting. The initial GND status presentation was given by Brett Beck. As noted previously, LLNL has developed a new reaction structure called GND that replaces LLNL's previous ENDL and ENDF evaluation structure. GND is a physics-based structure, and LLNL has developed tools to support the community's transition to a modern, nuclear data structure. Currently, LLNL is working to publish a detailed article on the GND structure in Nuclear Data Sheets. The latest release of the GND structure and tools are available from the BNL website.

With regard to GND, the structure is "XML-like," and the basic components include the "Element," "Dataset," and the metadata and attributes. The purpose of the reaction database is to share data (i.e., evaluated and processed radiation transport libraries). Moreover, the LLNL GND structure allows sharing/transmitting both evaluated and processed data files. Beck discussed other reasons or justifications for GND: 1) future generations will want to use modern computing practices, 2) reading legacy Fortran codes can be difficult and GND will help alleviate this need, and 3) the GND structure lends itself to documentation with hyperlinks.

During the past year, the Working Party for Evaluation Cooperation (WPEC) established Subgroup 38 to design an international nuclear data structure. Note that a data structure plus the meta-language defines the new format. WPEC Subgroup 38 is now working on developing a new, modern ENDF data structure. The subgroup will evaluate GND and determine if GND can be used with modifications as needed. The expectation is that it will take 3-5 years for Subgroup 38 to complete their work and provide recommendations. LLNL will use the current GND structure and transfer over to the new Subgroup 38 recommended structure. Likely, the existing ENDF format will be used for

at least the next 10 years. Subgroup 38 will meet at the end of November 2012. Beck proposed that Subgroup 38 should have a Wiki to enable information exchange pertaining to the new data structure.

Progress with Processing GND (Caleb Mattoon, LLNL)

Caleb Mattoon provided an update on the LLNL progress with processing GND. Specifically, the progress report addressed the status with resonance reconstruction, processing for deterministic transport, processing for Monte Carlo transport, storing/ sharing processed data with GND, and provided comments on the future work.

Regarding the resonance reconstruction, the capability is now built into the FUDGE software package at LLNL, and the capability supports ENDF LRF=1,2,3,7 for RRR and LRF=1 and 2 for the URR. LLNL has performed testing with GND/FUDGE and compared the resonance reconstruction results with RECENT and PREPRO. Also, FUDGE has been expanded to have the capability to visualize and compare cross-section data reconstructed from resonance parameters.

For deterministic transport, LLNL has developed a new C++ code "get_transfer" to produce transfer matrices from any distribution supported by ENDF-6. Efforts are in progress for testing the get_transfer tool by comparing transfer matrices with the NJOY GROUPR module. In addition, work has been performed to support processing the GND structure to provide data for Monte Carlo (MC) libraries. At LLNL, there is an effort to move toward "minimal processing" with most of the data work being handled by access routines for the MC transport. Moreover, tasks such as Doppler broadening and generating transfer matrices are "expensive" whereas grouping, equi-probable binning, making CDFs, reaction-specific transfer matrix summing are "cheap." In the minimal processing approach, the "cheap' tasks happen at run-time, through access routines. The minimal processing approach will give users more flexibility for their respective implementation.

Future work will require providing heating cross-section data, continued testing with other processing codes, and translating to other formats such as ACE, LLNL's legacy MCF, NDF formats. In summary, Mattoon noted that much progress has already been made to process GND files, and more work is needed especially to support legacy codes. LLNL plans to compare with NJOY, AMPX, and other processing codes as they implement new processing capabilities.

Status of Processing Codes

NJOY (Skip Kahler, LANL)

NJOY99.364 was released in the spring of 2011, and NJOY 99.385 is scheduled for release in mid-November 2012. The list of fixes and capabilities in NJOY 99.385 will include the following:

- Larger fixed arrays
- Fix lingering 32-bit/64-bit inconsistencies (will not be NJOY2012 issue)
- Recognize new reaction MT values defined by CSEWG-2010
- New user plotting options in COVR for correlation scaling
- Implement extension of fission energy release format (mf1/mt458)—polynomial format
    - Note: ENDF/B-VII.1 has units error (1/MeV) for quadratic coefficients
- Increased precision for selected ACE file
- Allow smaller values in GROUPR before truncating to zero
- Correct PENDF directory error when running multiple HEATR jobs
- Allow variable "NE" values as a function of URR (l,j) state;
- Improved MF34 processing in ERRORR
- Improved ZAID calculation in ACER

With regard to transitioning from NJOY99.X to NJOY2012, the long overdue release is imminent, and preliminary beta versions have been released to some users. NJOY2012 will include a new, improved manual. Furthermore, LANL has made the decision to handle the distribution of NJOY2012 through the LANL Technology Transfer Division. Likely, future versions of MCNP will be distributed in the same manner as NJOY2012. The following are new capabilities that are in NJOY2012 but not in NJOY99.X:

- LRF=7 format
- Can calculate elastic scattering angular distributions from resonance parameters
- No limit on number of temperatures
- No limit on number of sigma zeros
- Revised input to THERMR and ERRORR
    - NJOY99 formatted input will abort in THERMR
    - ERRORR will internally condense any GROUPR file to only contain data for one temperature, on infinitely dilute sigma zero, no more than P1 for all MATs (need to use Card 3 to select temperature of interest)

For NJOY2012, there will be no input changes for standard ACE file creation. With NJOY2012, there is a revised ACE format being developed by Jeremy Conlin, XCP-5. Specifically, a new ACE format is required to overcome the limitations of the current 10-character ZAID + suffix notation. Also, a new, (up-to) 24-character variable has been defined. Please refer to the NJOY presentation on the NNDC for additional details concerning the new ACE format.

AMPX (Dorothea Wiarda, ORNL)

Dorothea (Doro) Wiarda provided a detailed status report on the AMPX development and maintenance activities since the November 2011 CSEWG meeting. During the past year, improvements have been made in the collision kinematics processing procedures in AMPX. In addition, AMPX has been used to develop new continuous-energy libraries and a new 252-group library for use with the SCALE radiation transport package. During the past year, ORNL has used AMPX to process the ENDF/B-VII.1 evaluations and generate a prototypic library for testing at ORNL.

With regard to the collision kinematics processing, AMPX has been updated to include improved kinematics processing capabilities that will support multiple end uses (and codes). Specifically, AMPX has moved to continuous-energy or pointwise PDFs and CDFs for Monte Carlo transport codes. Wiarda showed comparisons between the older Legendre-moments-based distributions relative to the more detailed pointwise distributions. In addition, improvements have been made to the unit-based transform interpolation scheme that results in improved spectral results during the radiation transport calculations. Using the new, improved CE processing capabilities, new ENDF/B-VII.0 CE libraries have been generated and are undergoing testing for release with SCALE.

At ORNL, efforts have focused on developing a 252-group neutron library to replace the existing 238-group, general-purpose library in SCALE. Significant efforts have focused on defining the new 252-group structure and improved problem-dependent resonance self-shielding capabilities for reactor physics applications. Results with the 252-group library have reduced the bias between multi-group and continuous-energy lattice physics calculations in SCALE.

ANL (Changho Lee, ANL)

Changho Lee provided a status report on the verification and validation of the multi-group cross-section generation Code MC^2-3 for fast reactor analyses. 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, and MC^2-3 was released to RSICC in September 2012. MC^2-3 has the following capabilities:

- Resonance self-shielding using numerical integration based on pointwise, untrafine groups (~2000) 0D or 1D transport calculations (optionally use PENDF from NJOY);
- Hyperfine group (~400k) 0D or 1D transport calculations;
- Use of high-order anisotropic scattering source in lab or center-of-mass systems;

- Use of anisotropic inelastic scattering and incident energy dependent fission spectrum
- Self-shielding of resonance-like scattering cross section of Fe, Ni, Cr, etc.
- Ultrafine group 2D whole-core transport calculation for region dependent cross section generation
- Processed ENDF/B-VII data by ETOE-2

After reviewing the capabilities of MC^2-3, Lee presented recent 0D/1D validation tests that include ~30 reactor core problems calculated with TWODANT or DIF3D. The calculated core eigenvalues are estimated within 200 pcm of Monte Carlo results. In addition, ANL provided recent calculation results for the ZPPR-15A critical experiments using VIM and TWODANT. Finally, Lee presented results demonstrating the validation of MC^2-3/UNIC (UNIC: unstructured mesh high-fidelity transport code) for the ZPR-6/7 benchmark, and the MC^2-3/UNIC results compare well with experiment and the MCNP results. In addition, 69 foil activation measurements were analyzed for the ZPR6/7 foil measurements, the MC^2-3 results are equivalent in accuracy to the results using MCNP based foil cross sections.

In summary, the ANL V&V results with various compositions, numerical benchmark cases, and criticality experiments demonstrate that the eigenvalues from the deterministic calculations with MC^2-3 cross sections agree well with Monte Carlo calculations within ~200 pcm. Future work at ANL will focus on processing the ENDF/B-VII.1 evaluations.

BNL Activities Related to Formats and Processing

BNL ENDF I/O Package (Sam Hoblit, BNL)

Sam Hoblit presented the current status of developing an ENDF I/O package for the existing ENDF/B evaluations. With regard to motivation for the work, NNDC had existing FORTRAN95 (F95) routines for reading/writing MF3, MF33, etc. There were individual routines for specific files and the array size was usually hardcoded. Over time, the reading/writing routines evolved as needed to read other MF sections. At NNDC, the decision was made to assemble a library of I/O routines to unify the interface for various MF sections and extend the support to the entire ENDF format. The goal is to move from a “file-centric” model to an “API-centric” model. With an API-centric model, the code can be written to the API interface, and the I/O library can deal with the details of the ENDF file format.

In terms of organization, all of the I/O for ENDF is collected in a common library, and changes to the format can be addressed with modifications to the library. As a result, the processing code is not burdened with the details of the ENDF file structure. In the BNL approach, F95 modules are used to define data types and supply the routines that operate on the data types. Moreover, the I/O package has dynamically allocated types so memory

is allocated as needed (no preset limits). The ENDF data types hold an entire ENDF file. The I/O library approach simplifies the processing codes. Subsequently, Hoblit presented some examples of ENDF data types and coding for MF3, MF33, and MF8. Also, the I/O package has provisions for an external user interface. Additional details are provided in the presentation on the NNDC website.

In summary, the ENDF I/O F95 library provides a "gentle" migration of existing F77 coding with compatible F95 modules. The I/O library performs format checking automatically. With the data types and dynamic array allocation, there are no preset coded memory limits. The I/O package provides an API interface thereby enabling the user code to focus on the physics and not the formats. In terms of operating system, the I/O library supports UNIX/Mac, but all operating system dependencies are contained in a small jacket routine that is easily extendable to other operating systems (e.g., Windows). The I/O library has been developed by NNDC for use at NNDC, but the source code is available from NNDC. If users do utilize the I/O library, please provide feedback to NNDC.

Cross Section Evaluation Working Group

Measurements Committee Report

Yaron Danon, RPI
Committee chair

The measurement committee session was held on the morning of November 8, 2012. Nine presentations representing experimental programs at LANL, LLNL, ORNL, RPI, LBNL, BNL and NIST 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/csewg2012/.

The Agenda

- Nuclear Data Experiments at LANSCE, Haight,
- The TPC and SPIDER project, Meharchand,
- The Chi-Nu project, Perdue,
- Recent ORNL Measurements, Guber,
- NIST Measurements and Standards including Related Work at Other Facilities, Carlson,
- Update of experimental activites in low-energy nuclear physics at LLNL, Scielzo,
- Nuclear Data Related Activity at RPI, Danon,
- Thermal neutron-capture measurements on the Cu isotopes, Rogers,
- New measurement of the radiative thermal-capture cross section for the rare isotope W-180, Hurst,
- EXFOR database and recent changes, Pritychenko,
- Criticality measurements and plans in Nevada to NCERC, Chadwick, 15'

U.S. Measurement Programs

1. Nuclear data experiments at LANSCE (Height, LANL)

GEANIE – (GErmanium Array for Neutron Induced Excitations)
Summary of recent activity:

- Cu(n,xnγ), x = 1,2,… for double-beta decay papers submitted to Phys Rev C.
- Ar(n,xnγ), x=1,2,... Phys. Rev. C 85, 064614 (2012).
- NaI(n,xnγ) for data libraries (N. Fotiades) – data taken.
- ^{86}Kr(n,xnγ), x= 1,2,... (Matt Devlin), data taken; structure and transitions.

- Various elements for a neutron-induced gamma-production reference cross sections (R. Nelson): ^{7}Li (n,n')^{7}Li* (LiF target – "optical window"), Ti (n,xγ), Cr, Fe.
- X-ray yield from n-induced fission (R. Nelson and Thierry Granier - CEA).
- ^{114}In Isomer search continues.
- Results for Ni(n,xγ) were shown for several gamma transitions.

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

Summary of recent activity:

Non Actinides

- **^{152,154,156,158}Gd** - Bayarbadrakh Baramsai, NCSU/LANL,
- **^{97}Mo** - Carrie Walker, NCSU PhD dissertation, in progress,
- **^{117,119}Sn** - Carrie Walker, NCSU PhD dissertation, in progress
- **^{184,186}W** - Capture, Marian Jandel LANL (in progress),
- **^{173}Lu** – Capture, O. Roig (CEA) (In progress)
- **^{191,193}Ir** - Capture; Todd Bredeweg LANL,

Actinides

- **^{233,235}U, ^{239,241}Pu** - Capture to fission: LANL, LLNL, ^{235}U (n,γ) experiment published in Phys. Rev. Let. Results for ^{235}U capture cross section shown between 1-2.5 keV the new data is lower than ENDF/B-7.1 by about 20%. Above 3 keV the data is higher than ENDF/B-7.1 by 5-10%. Overall the new data is in better agreement with JENDL 4.0. Preliminary Capture cross section for ^{239}Pu was shown; above 1 keV the data seems lower than previous experiments and lower than ENDF/B-7.1
- **^{235}U, ^{239,241}Pu** - Fission gamma ray multiplicity and spectra: LANL/LLNL, (Prelim ^{239}Pu,^{235}U reported) Comparison Paper: submitted to Phys. Rev C. Results on gamma multiplicity and energy spectrum for Pu-239 fission were shown.
- **^{238}Pu** - Capture, capture/fission: LLNL,
- **^{252}Cf** - Fission gamma multiplicity and spectra: LLNL submitted to Phys. Rev. C.,
- **^{242m,243}Am** - Capture, Marian Jandel LANL (preliminary report submitted),
- **^{238}U** - Capture cross section, gamma rays John Ullmann LANL (preliminary report submitted).

Fission cross section measurements

- **^{233,238}U** - New measurement was completed.
- **^{236}U, ^{243}Am** - Measurements of are in progress. Results for ^{236}U were also shown and are in good agreement with the Lisowski data.
- **^{234}U** - Results for fission cross section of where shown. Between 1-10 MeV the data seem slightly high than ENDF/B-70.01 and JENDL-4.0.

LSDS

^{237}U ($t_{1/2}$=6.75d) - Fission cross section was measured (2 eV- 2 keV) and follow up measurement of the decayed sample was shown.

2. The TPC and SPIDER project, (Meharchand, LANL)

A general overview of the TPC and SPIDER projects was given. The TPC objective is accurate measurements of fission cross section by reduction of uncertainties due to alpha emission, sample and beam non uniformities and by using a hydrogen standard. Production runs on ^{235,238}U with 2976 channels were planned for 2012.

SPIDER (SPectrometer for Ion DEtermination in fission Research)

Designed to measure fission fragment properties such as mass, charge and kinetic energy. First beam experiments were planned for 2013.

3. The Chi-Nu project (Perdue, LANL)

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. The system is still under development; fast timing PPAC fission detector was developed by LANL, The digital DAQ system was completed and test of the different detector started.

4. Recent ORNL Measurements, (Guber, ORNL)

- **183W** - New transmission data was taken at GEEL using 30m and 60m flight path and preliminary results were shown.
- **Ca** - Preliminary capture yield was shown (60m flight path), several new resonances were observed.
- **Ce** - Preliminary capture data was shown (60m flight path).
- **^{182,183,184,186}W, ^{63,65}Cu, Ca-nat** - Resonance analysis is in progress.

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

- **H(n,n)** – Several regions that need more work (some are in progress) were highlighted. Small angles in the CMS near 15 MeV, at intermediate and high energies where data are sparse and typically not available for a large angular range, there is the lingering concern for back angles in the hundred + MeV region. Measurements at Ohio University are in progress. For the neutron source they study X(X,n)Y reactions such the neutron distribution is symmetric (isotropic) and thus reduce uncertainty due to source angular distribution. Successful results were obtained from the C(C,n) reaction.

- **^{3}He(n,p)** - Collaboration of NIST with Indiana University and the University of North Carolina is measuring the coherent scattering length with the objective of helping R-matrix evaluation of the ^{3}He(n,p) cross section. More work is continuing at IRMM to measure the cross section from few keV to about 3 MeV
- **^{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** - standards need additional work with emphasis on extending the energy range to higher energies.
- **^{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.

6. Update of experimental activities in low-energy nuclear physics at LLNL, (Scielzo, LLNL)

The group measured gamma rays distribution from fission using the DANCE detector at LANL.

- **^{239}Pu, ^{235}U, ^{252}Cf** - Results for the gamma energy spectrum and multiplicity spectrum from 0.5-9 MeV measured at DANCE were shown. The observed most probable multiplicity (6-8) is increasing with mass.
- **^{238}Pu** - preliminary results of the capture cross section of which looks almost 50% higher than ENDF/B-7.0 were shown.

Summary of surrogate reaction measurements

- **^{240,241,242}Am(n,f)** - Cross section measurements of have been completed. Evaluations are underway and expect to be complete by December 2012.
- **^{88}Y(n,2n)** - Cross section measurement of is complete and final evaluation is underway. Evaluation to be complete December 2012.
- **^{87,88}Y(n,γ)** - Data for has been taken and data analysis and reduction is underway, evaluation to be completed September 2013.
- **^{239}Np(n,f)** - Final analysis being completed on cross section, results to be submitted to peer-reviewed journal.
- **^{237}U** - Nuclear structure investigated: 2 new states and 10 new γ rays discovered
- **^{235}U** - Nuclear structure investigated: 1 new state and 6-8 new γ rays discovered
- **^{236,237}Pu(n,f)** - Data taken and analysis underway for cross sections over neutron energy range 0-6 MeV.
- **^{232,233}U(n,f)** - Data taken and analysis underway for cross sections over neutron energy range 0-6 MeV.
- **Yb** - Data taken on isotopes to validate (p,d) reaction channel in preparation for Lu measurements in FY13.

- **^{95}Mo(d,p)** - Data taken on to benchmark surrogate technique in spherical region for (n,γ) reactions

7. Nuclear Data Measurements at RPI (Danon, RPI)

Transmission:

Several transmission measurements were completed this year and total cross sections were presented for:

- **Ti** - measured at 250m flight path, energy range 0.5-20 MeV, this improves the previous RPI data at 100m and based on EXFOR the best resolution available. JEFF 3.1 shows some energy shifts.
- **Cu** - measured at 250m flight path, energy range 0.5-20 MeV, an energy shift was observed in some of the evaluations. Care was taken to make sure the RPI energy grid agrees with C and ^{56}Fe.
- **^{92,94}Mo** – data measured at 100m flight path was presented many new resonances were observed.

Neutron scattering

- **^{56}Fe** – Data for neutron scattering in the energy range from 0.5-20 MeV was presented. The data has sufficient resolution to show individual resonance, the data seems to have shaper resonance structure compared to the evaluations.
- **^{238}U** - Neutron scattering data in the energy range from 0.5-20 MeV was presented differences between evaluations and experimental data are more evident in back angles.

Fission:

RPI is developing a system to measure fission neutron energy distributions using a gamma tag. Results for ^{252}Cf were shown for fission neutron in the energy range from 0.2-5 MeV

Analysis

- **^{151,153}Eu** - Thermal capture cross sections were extracted from capture and transmission measurements and show slightly higher values compared ENDF/B-VII.0.
- **Rh** - Resonance parameter analysis of capture and transmission measurements is ongoing data for the energy range of 10 eV to 100 eV was shown.
- **^{95,96,98,100}Mo** – preliminary resolved and unresolved data analysis was presented.

8. Thermal neutron-capture measurements on the Cu isotopes, (Rogers, LBNL)

- **^{64,66}Cu** - Thermal neutron capture measurements were shown. Gamma levels are measured and combined with model simulation (DICEBOX) for the continuum

($E>E_{crit}$).. For ^{66}Cu σ_0=2.27±0.08 b compared with 2.17±0.03 b from Mughabghab 2006.

9. New measurement of the radiative thermal-capture cross section for the rare isotope ^{180}W, (Hurst, LBNL)

Measurements of tungsten capture cross section measurements at the Budapest reactor were discussed. The updated results: ^{182}W, $\sigma\gamma$=20.9(26), (atlas, $\sigma\gamma$=19.9(3)), ^{183}W $\sigma\gamma$=9.5(12), (atlas, $\sigma\gamma$= 10.4(2)), $^{184}W\sigma\gamma$= 1.45(28), (atlas, $\sigma\gamma$= 1.7(1)), $^{186}W\sigma\gamma$= 33.0(12), (atlas, $\sigma\gamma$= 38.1(5)). For ^{180}W the preliminary result is $\sigma\gamma$=21.0(43) (current value 4b<$\sigma\gamma$<150b)

10. EXFOR database and recent changes, (Pritychenko, BNL)

A review of recent changes and data additions to EXFOR was given. There were 121 new compilations in FY12 and 392 modifications to existing data.

11. Criticality measurements and plans in Nevada to NCERC, (Chadwick, LANL)

An overview of the critical experiment plan was given with little detail.

Summary of the 15th U.S. Nuclear Data Program Meeting

Held at
Brookhaven National Laboratory, Upton, NY
November 5-6, 2012

US Nuclear Data Program

Chairman's Summary

M. Herman
National Nuclear Data Center, BNL

The 15th Annual Meeting of the United States Nuclear Data Program was held on November 5-6, 2012 and attended by 43 registered participants. The meeting was held adjacent to the CSEWG Annual Meeting, with a common USNDP-CSEWG session on nuclear reaction modeling.

Essential change in organization of the 2012 USNDP meeting was introducing of the second reporting session, instead of the working lunch, to allow more time for discussion of current activities and future plans.

Task Forces

The reports of the two task forces (Nuclear Data for Astrophysics and Nuclear Data for Homeland Security) were not presented during the USNDP meeting. Chairman of the Astrophysics task force had to leave the meeting early and LLNL representative did not attend the meeting because of the Sandy hurricane. There is an open issue with the chairmanship of the Homeland Security task force created by the transfer of the current chairman from LLNL to BNL. M. Herman retains that the chairmanship should remain with LLNL.

Planning and Reporting

- Summary of the present Annual Meeting should be issued in January 2013,
- Annual Report for FY 2012 in January 2012, and
- Workplan FY 2014 in March 2013 (delayed due to the ND2013 conference).

The next budget briefing will be held at the DOE Headquarters on February 14, 2013. The USNDP team will include USNDP Chairman(M. Herman) , WG chairmen (R. Firestone and T. Kawano) and the members of the USNDP executive committee who have specific issues to bring to the briefing.

Next Meeting

Tentatively, the next USNDP meeting will be held at BNL, Nov. 18-19, 2013. This period avoids conflict with the APS and ANS meetings but needs to be confirmed because of the difficulties with securing meeting rooms at BNL.

USNDP Coordinating Committee Meeting

This meeting has been replaced by the extended reporting session.

US Nuclear Data Program

Structure and Decay Data Working Group

R.B. Firestone (LBNL),
Nuclear Structure Working Group Chair

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

The USNDP also evaluates the Evaluated Gamma-ray Activation File (EGAF) on behalf of the IAEA which provides precise neutron capture gamma-ray cross sections, total radiative thermal neutron cross sections, activation data, and neutron separation energies. It leads the Decay Data Evaluation Project (DDEP) in collaboration with LNHB, France, which provides precise radioactive decay data for isotopes of applied importance. In addition, the USNDP is actively engaged with the research community by participating in experiments and helping plan future activities in nuclear science.

Evaluation Status

ENSDF: Data for 3174 nuclides are compiled in ENSDF, managed by the NNDC, and the file increased by ≈3% during the past year. In 2012 16 mass chains were published and 31 are currently in review. ENSDF is widely accessed on-line through NuDat where 1.6 M retrievals were recorded in FY12. ENSDF is supplemented by the XUNDL database, managed at McMaster University, where recent nuclear physics publications are compiled in ENSDF format for immediate dissemination prior to evaluation into the ENSDF database. Approximately 300 papers are compiled annually into XUNDL from all the major nuclear physics journals. The XUNDL effort has been particularly successful in uncovering and correcting data errors in publications and also acquiring additional data not available in the original publications.

EGAF: The EGAF file evolved from an LBNL led IAEA Coordinated Research Project to evaluate thermal neutron capture gamma ray cross sections. These data were not previously available in other nuclear databases. Capture gamma ray cross sections from 395 isotopes and isomers in EGAF were published by the IAEA in 2007, and data for Z=1-19 have been provided in ENDF format. An international, LBNL led, collaboration has been formed to analyze the EGAF data, supplemented with statistical model calculations, to determine total radiative thermal cross sections. These data are being published in Physical Review C and will be incorporated into the ENSDF and ENDF files. In 2012 the evaluations of data for the K, Eu, Gd, and W isotopes were completed. Measurements of the 12C total radiative neutron cross section found that previous values were discrepant by 10%, the ENDF database has been updated accordingly in 2012.

DDEP: The Decay Data Evaluation Project (DDEP) is coordinated by ANL in collaboration with LNHB, France. DDEP evaluations are published in Applied Radiation and Isotopes and are available in ENSDF format. Evaluations of decay data for 197 nuclides were published through 2012.

NSR: The NSR database and its content is managed by the NNDC in collaboration with evaluators at the IAEA, McMaster and Slovakia. NSR contains over 200,000 references and is a starting point for all USNDP evaluations.

Other Activities

- The USNDP helped organize Nuclear Structure 2012 at ANL. The scientific program was devoted to the latest research and development in experimental and theoretical Nuclear Structure Physics, with emphasis on the properties of nuclei at the extremes of isospin, mass, angular momentum, and excitation energy.
- USNDP evaluators led a discussion of the development of a FRIB nuclear data working group. Positive discussions were begun on how the USNDP can work with FRIB researchers to most effectively evaluate and disseminate these data.
- USNDP evaluators played a major role in the DDEP meetings in Paris, October 8-10, 2012. The integration of DDEP methodology into ENSDF decay data evaluation procedures was discussed.
- A new initiative to evaluate continuum particle/gamma ray coincidence data has been proposed by the Oslo Cyclotron group and LBNL to the IAEA. This effort would coordinate the evaluation of photonuclear, CACTUS (Oslo), DANCE (LANL), STARS/LiBeRACE (LLNL) and similar data not currently covered by the USNDP. The participation of the Oslo group would revive the participation of Western Europe in the NSDD.
- A collaboration to measure and evaluate prompt gamma ray cross sections in actinide isotopes has been joined by LBNL, LLNL, Budapest Nuclear Center, Munich FRM II Reactor, and FZ-Jülich GmbH. The collaboration will generate and validate nuclear data for actinides to update gamma ray and neutron capture

cross sections. This effort brings Germany back into the Western European nuclear data effort.

Future directions

The USNDP recognizes that many challenges lie ahead in responding to emerging new nuclear science research and application needs in an environment of diminishing resources. As critical personnel move towards retirement, new people are stepping forward to carry the USNDP further into the 21st century. Responses to these challenges will include

- Streamlining evaluation procedures to maximize evaluation efficiency.
- Coordination of international evaluation efforts to avoid redundancy and improve quality.
- Revitalization of the international nuclear data community.
- Greater participation of the experimental nuclear physics community in providing, evaluating, and disseminating nuclear data.
- Coordination of the nuclear structure and reaction evaluation communities in the evaluation of the ENSDF and ENDF databases.

User Forum

The User Forum was not held due to the vicinity of the ND2013.

US Nuclear Data Program

Nuclear Reaction Working Group

T. Kawano, LANL
Working Group Chair

Model code development

Herman (BNL) - summarized the new features in EMPIRE-3.1 (Rivoli) released in March 2012, and status of the code development since the latest released version. The major changes since the last USNDP meeting are: (i) new input/output routines for the ENDF-6 format, (ii) prompt fission neutron spectrum calculation with the Los Alamos and Kornilov model, (iii) calculation of angular distributions for the compound elastic/ inelastic scattering, and (iv) adjustment of compound cross sections when strongly coupled channels exist. Large scale test calculations were performed with the built-in model parameters to confirm the stability of the code system.

Nobre (BNL) - gave a talk on the implementation of prompt fission neutron spectrum calculation in EMPIRE. The Los Alamos model and Kornilov model that has two Watt spectra for the first chance fission were implemented. Sensitivities of the calculated fission neutron spectra to model parameters were shown, and these parameters were fitted to experimental data using the KALMAN code. This allowed them to obtain the covariances for the fission spectra.

Arbanas (ORNL) - gave a talk on the TORUS collaboration (www.reactiontheory.org) - Theory of Reactions for Unstable Isotopes, in which LLNL, MSU, TAMU, OU, and ORNL are involved. This collaboration addresses deficiencies in the current reaction theories, such as the distorted wave Born approximation, and neglected of higher order paths in the direct reactions. Their goal is to develop (i) full three-body model calculation, (ii) Coulomb distorted Faddeev equation, and (iii) R-matrix method for the (d,p).

Kawano (LANL) - presented the status of the CoH3 and DeCE codes. CoH3 is the coupled-channels and Hauser-Feshbach code, which is employed for the nuclear data evaluation work at LANL. In addition to the standard capabilities of similar Hauser-Feshbach codes, CoH3 runs in a Monte Carlo mode to calculate the correlated particle and gamma-ray emissions. DeCE is an ENDF-6 formatting utility code written in an object-oriented manner, which helps to produce the evaluated files for ENDF/B-VII.

US Nuclear Data Program

USNDP Reports

M. Herman, BNL
Session Chair

The reporting was held at the beginning of the USNDP meeting, and consisted of two sessions - the first on Monday morning and the second on Tuesday afternoon. Both sessions were restricted to the USNDP PI's and database managers. In previous years USNDP organizational issues were discussed during the working lunch being subject to very strict time limitations. This format has been changed to allow more time for thorough exchange of views about the program and permit discussion of the Annual Report. The latter turned out to be unrealistic even within expanded time frame. Eventually, the discussion focused on Lab reports and future priorities.

The scientific personal status has been reviewed. In general, the situation has been rather stable although there were some replacements. The total permanent and temporary (postdocs) FTE at BNL has increased nearly by 2 mostly because the two postdocs were employed for the whole year instead of a quarter in FY2011. This increase has been reflected in USNDP funded FTE growing by 1.2. In FY2013 the total and USNDP funded FTE are going to increase by additional 2.2 FTE because of the completion of the ARRA projects. This will stretch NNDC budget, which in FY2013 has been cut by $600k. LANL has seen exchange of one scientific staff and hired two new postdocs (not fully USNDP funding). There have been no significant changes in staffing in the remaining institutions participating in the USNDP.

Compilation (NSR, XUNDL, EXFOR) and evaluation (ENSDF) activities were approximately on the same level as in FY2011. There has been drop in the reaction evaluations (ENDF/B) that is natural after release of the new library in December last year. ANL (F. Kondev) was involved in the mass evaluation, an important activity which now has been delegated to China. Evaluation of neutron capture gammas (EGAF) and thermal cross sections has been advanced by LBNL.

The 12 issues of Nuclear Data Sheets were published including the December issue traditionally dedicated to nuclear reaction data (ENDF/B-VII.1 release).

The major achievement was the release of the ENDF/B-VII.1 version of the US evaluated nuclear reaction data library; the first update since original release in 2006. This work is the result of the CSEWG coordinated effort by several national laboratories with significant USNDP contribution.

Two reaction codes EMPIRE-3.1 (Rivoli) and CoH-3.2 (Umbriel) were released to the public. For EMPIRE it is a new version following previous release of EMPIRE-2.19 (Lodi) in 2005. In case of CoH it is the first open release. Both codes substantially advance of our capabilities of modeling nuclear reactions and will be used as evaluation tools in preparation of the next release of ENDF/B library.

Novelty in the USNDP activities was NNDC work on the calculation of anti-neutrino spectra from nuclear reactors in response to the direct request by the Daya Bay experimentalists investigating neutrino fluctuations. It proves relevance of nuclear data to the cutting-edge science research.

Increased involvement of the USNDP in the experimental activity was noted. In addition to the existing facilities, such as DANCE, ATLAS/CARIBU and GRETINA installed at MSU cyclotron, new opportunities open with bringing into operation the UC Berkeley Neutron Generator Laboratory and neutron beams at the 88" Berkley Cyclotron. The latter is capable of providing monoenergetic neutron beams in the range of 8-33 MeV. The TransActinide Nuclear Data Evaluation and Measurement (TANDEM) in Germany and evaluation of particle/g-ray continuum data in Oslo (Norway) should provide a possibility of extending range of structure evaluations bridging gap between structure and reaction data, bringing into the evaluation community European contribution .

USNDP participated in organization of several national and international conferences. LANL has organized highly regarded conference on nuclear reactions in Varenna (Italy), as well as workshop on inelastic scattering in Boston and the MCNP/ENDF/NJOY meeting in Los Alamos. ANL organized Nuclear Structure 2012 at Argonne. NNDC, in addition to regular ND Week, has been organizing the major nuclear data conference ND2013 to be held in NYC in March 2013.

The ADVANCE system has been installed at NNDC to perform immediate verification and validation of the newly submitted ENDF evaluations and post the results on the dedicated Web-site so that they become available to entire ENDF community within a few hours from submittal. It is a central element in the effort to ensure high quality of the future libraries.

Work continued on the new XML format and infrastructure supported by the ARRA funding at LLNL. This project lead to the development of the FUDGE code and the Generalized Nuclear Data format. There is a consensus that the modern approach is needed to replace the aging ENDF-6 format and supporting tool chain. The international cooperation in the frame of the WPEC subgroup has been established with the charge of formulating the new format within three years.

Links to the individual Labs presentations that are given below provide access to more details regarding activities performed in each of the USNDP institutions.

- BNL/NNDC, Herman
- ANL, Kondev
- LANL, Kawano
- LBNL, Firestone
- LLNL, Summers
- McMaster, Singh
- TUNL, Kelley
- NIST, Carlson