CSEWG-USNDP Annual Meetings 2009

Preface

In recent years the National Nuclear Data Center, BNL, was organizing three nuclear data meetings in the first week of November. Following the tradition started in 2004, the Cross Section Evaluation Working Group (CSEWG) and the U.S. Nuclear Data Program (USNDP) Annual Meetings were organized jointly. Added in 2005 was a small Nuclear Criticality Safety Meeting. In 2008, this arrangement was expanded to four meetings covering the entire week and allowing us, for the first time, to introduce the term **Nuclear Data Week at BNL**. This tradition continued in 2009 and, in the week of November 2-6, the following nuclear data meetings were held at BNL:

- Nuclear Data Advisory Group, Criticality Safety Program Meeting, Nov 2,
- CSEWG Annual Meeting, Nov 3-5,
- USNDP Annual Meeting, Nov 4-6,
- AFCI Physics Working Group Meeting, Nov 5-6, and
- AFCI Adjustment, Nov 5.

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/csewg2009/.

December 21, 2009

Michal Herman
CSEWG chair
USNDP chair

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Summary of the 59th Cross Section Evaluation Working Group Meeting

Held at
Brookhaven National Laboratory
November 3 - 5, 2009

Cross Section Evaluation Working Group

Chairman's Summary

Michal Herman
National Nuclear Data Center, BNL

The 59th CSEWG meeting was held on November 3-5, 2009 at BNL. It was attended by 64 registered participants. This relatively high number closely follows the figure from the last year and reaffirms renewed interest in evaluated nuclear reaction data. 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. The CSEWG meeting was held adjacent to the USNDP annual meeting, with a common session on modeling neutron reactions.

Plans for ENDF/B-VII.1 release

CSEWG discussed plan for release of VII.1 and agreed to postpone the target date to December 2011 to allow for more extensive validation of the library. The new release will fix errors identified in VII.0, include improved evaluations for some 60-70 materials and provide covariances for more than 100 materials. Overall theme for VII.1 improvements remains: better criticality safety/structural materials, Li and Be as well as minor actinides.

A mini-CSEWG meeting will be held on June 22, 2010 at Port Jeff, exactly a year after a similar meeting held in 2009. This meeting will focus on progress towards VII.1 release.

The preliminary (beta0) version of the ENDF/B-VII.1 library should be assembled before the next full CSEWG meeting (November 2010) to allow for the validation. Additional prereleases (beta1 and beta2) are expected during 2011.

Review of evaluation work

New or updated evaluations for 37 elements (some of them containing several isotopes or the complete chain of isotopes) were reviewed/discussed. The detailed list is given in the report of the evaluation committee below. The review resulted in 31 actions. These do not include correcting known deficiencies in the ENDF/B-VII.0. By the end of 2009 BNL, LANL, ORNL and LLNL will review the list of deficiencies available at:
http://www.nndc.bnl.gov/exfor/4web/VII.0-deficiencies.html
(to be migrated to the GForge system) and indicate modalities and time schedule for resolving issues in the files of their respective pertinence.

Covariance data

There were ten individual presentations as well as an hour long discussion period devoted specifically to the issue of defining quality assurance (QA) criteria for the acceptance of covariance evaluations that will be considered for inclusion in the next release of ENDF/B-VII.1. The presentations in the session addressed the following technical areas: the ongoing evaluation of covariances, processing of these covariances, user experience in testing the new covariance evaluations, and sources of experimental uncertainty information that impact the evaluation of covariance data. Of particular importance is the fact that explicit comparisons are being made between different evaluations as well as between the results obtained from processing these evaluations with both the NJOY and PUFF processing code systems.

It was decided that the Chair of the Covariance Committee would prepare a document that includes a minimal list of QA requirements. The goal is to finalize this document before the next "mini-CSEWG" meeting that will take place in June.

Next Meeting

The next CSEWG annual meeting will be held at BNL on Nov 2-4, 2010 (Tue – Thu), while the USNDP annual meeting will be held on Nov 1-3, 2010 (Mon – Wed). The NDAG Criticality Safety meeting will be held on Nov 1, 2009 (Mo) and AFCI Physics Working Group on Nov 4-5 (Thu – Fri).

CSEWG Executive Committee Meeting

The Executive Committee met during the lunchtime on November 5, 2009, with all 11 members present. This included chair (M. Herman), five committee chairs (T. Kawano (acting for M. Chadwick), Y. Danon, M. Dunn, A. Kahler, D. Smith) as well as five regular members (N. Summers, A. Carlson, P. Oblozinsky, L. Leal, R. McKnight). T. Barnes, representing DOE Office of Science, also attended the lunch.

Agenda

- Plans for ENDF/B-VII.1 release were revised. It was agreed that the release would be postponed until the end 2011, i.e., a year later than initially planned. The delay was justified by the necessity of leaving enough time for the validation of the new or modified files.

- Next Special Issue of Nuclear Data Sheets. The 2009 issue (~200 pages) consists of two extensive (~100 pages each) papers, on neutron cross section standards (lead author A. Carlson) and on the RIPL library (lead author R. Capote). The 2010 issue would likely contain the extensive paper on NJOY. Two papers on fission product yields being prepared by the LANL (leading author M. Chadwick) were also indicated as possible candidates for the 2010 issue.

- ND2013 conference. M. Herman announced that NNDC is willing to organize the Conference on Nuclear Data for Science and Technology in 2013. Participants discussed various organizational issues, including cooperation with other Labs, possibility for DOE support, and venue of the Conference. It was agreed that the preferable venue would be in the state of New York.

- WPEC matters. The next WPEC meeting will be hosted by the NEA Data Bank in Paris. The US delegation should include 4 official members (CSEWG chair and 3 Committee chairs) and two chairs of the acting working groups (M. Dunn and L. Leal).

- Next meeting: See above.

Cross Section Evaluation Working Group

Evaluation Committee Report

T. Kawano, LANL
Acting Committee chair

Herman (BNL), Kawano (LANL), Dunn (ORNL), and Brown (LLNL) reported status of evaluations at their laboratories. Oblozinsky (BNL) reported status of the covariance data. Lee (KAERI) reported on their new curium evaluations with consistent covariances. Arcilla demonstrated GForge, which will be a new tool for managing evaluated nuclear data files at BNL, and will facilitate collaboration.
Status of new evaluations for ENDF/B-VII.1 is as follows:

H3: LANL fixed (n,2n) completed
Action: LANL, submit the file to BNL

Li6: LANL completed a new evaluation. No change in the format
Action: LANL, submit the file to BNL

Be9: LANL made a new evaluation that includes RPI experimental data. However, this suffers from the same deficiencies as ENDF/B-VI.8.
Action: LANL, finalize the evaluation

O16: LANL made several evaluations.
Action: LANL, finalize the evaluation

F19: LLNL evaluation was based on ENDF/B-VIIb1, and the ORNL evaluation based on ENDF/B-VII.0.
Action: LLNL, remerge the file.

Na23: BNL made a new evaluation with covariances. Strong fluctuations in the fast neutron range were represented by energy-dependent tuning of the absorption and total cross sections. There are still some issues, e.g. (n,2n) cross section adjusted to ENDF/B-VII.0 rather than to experimental data. However, the evaluation can be finalized by the end of FY2010, so that benchmark tests can be performed.
Action: BNL, finalize the evaluation.

Al isotopes: LLNL made new evaluations.
Action: LLNL, finalize the evaluations and submit to BNL.

Cl35, **Cl37**: ORNL submitted new resonance parameters in 2007.

No action.

K39, K41: ORNL submitted new resonance parameters in 2008.
No action.

Ti isotopes: ORNL made covariances for resonance parameters. However, they were for ENDF/B-VII.0 not ENDF/A that includes LANL updates. The gamma-production data submitted by LLNL need to be combined.
Action: ORNL, repeat retroactive method for new resonance parameters for isotopes other than Ti48. Perform a new resonance evaluation for Ti48. LANL, combine the existing gamma-ray production data.

Cr isotopes: ORNL finalized SAMMY analysis for Cr52 and Cr53. Currently Leal is working on Cr50 and 53, which should be ready by April 2010 or so.
Action: ORNL, finalize Cr50 and 53.

Mn55: BNL made a new evaluation, with new resonance parameters from ORNL. Total cross sections well reproduced by Capote's coupled-channels calculation, but still need some improvements.
Action: BNL, finalize the evaluation.

Fe56: Modification to alpha-production cross section in progress at LANL.
Action: LANL, finalize evaluations in the high energy region.

Ni58, 60: New resonance parameters with covariances were evaluated at ORNL. Ni60 resonance range was extended to 812 keV. LANL made new calculations at higher energies, which reproduces the alpha-production data of LANSCE.
Action: LANL, finalize evaluations in the high energy region.

Cu63,65: LANL tested new CENDL-3 data. Zeus Benchmark testing doesn't show much improvement. New evaluations by Shibata for JENDL-4 are in progress.
Action: LANL, perform benchmark testing of pre-JENDL-4 evaluations.

Zn62-73: LLNL made new evaluations. Some apparently too low cross sections need to be investigated.
Action: LLNL, finalize the evaluations.

As isotopes: LLNL made new evaluations for As73,74,75.
Action: LLNL submit evaluations to BNL.

Kr isotopes: LLNL made new evaluations.
Action: LLNL submit new evaluations to BNL.

Y89: Capture cross sections re-calculated. The upper energy boundary of the resonance region needs to be decreased.
Action: LANL, change resonance range, and merge calculations.

Zr90: ENDF/B-VII.0 evaluated by BNL removed KAPL's problem, and a new evaluation was also tested by KAPL. Trkov reported that Zr91 also has relatively large impact on k-eff .
Action: Kawano will make a test version by changing elastic scattering angular distributions of Zr91, and Trkov will test if this is the problem.

Xe isotopes: LLNL made new evaluations.
Action: LLNL submit new evaluations to BNL.

Gd157: BNL reported thermal cross section issue. RPI measurement is 9% lower, and BWR assemblies with Gd pins confirm this. If RPI measurement is adopted, other 6 measurements must be discarded. There was another comment that these 6 measurements are probably not independent.
Action: BNL, decide which thermal capture cross section should be adopted.

Cd113: Thermal capture by Said adopted by BNL. Trkov commented that Geel now has a new evaluation in the entire resonance region.
Action: BNL (Herman), contact Geel whether their resonance parameters are available.

Hf isotopes: Resonance parameters were revised by ORNL.
No action.

Ta isotopes: Ta181 evaluation by LLNL compared with experimental data.
No action.

W isotopes: IAEA is working on a small refinement for better reproduction of integral data. EGAF will be merged in future. However this may take more time. LLNL evaluated cross sections on unstable isotopes, and recommended IAEA evaluation for the stable targets.
Action: BNL, finalize these evaluations, and merge EGAF data if possible.

Re isotopes: LLNL performed new evaluations for Re185,187. Unstable target evaluations will be made.
Action: LLNL, submit evaluations to BNL

Pa232: Resonance parameters were revised by ORNL.
No action.

U233: ORNL provided MF33 with covariances, typo delayed neutrons fixed by LANL.
No action.

U236: Small adjustment of fission and capture cross sections
No action.

U237: LLNL provided new evaluation in addition to the LANL fix of VII.0.
Action: BNL, adopt new LLNL evaluation.

Np236,**238**: LANL reviewed evaluations in JENDL/AC, and recommended to adopt.
Action: LANL, .
No action.

Np237: (n,2n) cross section revised by LANL
Action: LANL, complete evaluation

U239: new LLNL evaluation adopted.
Action: LLNL, submit new evaluation to BNL.

Pu239: New resonance parameters were evaluated in 2008, and tested. Problems in Pu solution benchmarks persist. CEA made a modification to the resonance parameters to technically solve the benchmark problems in JEFF-3.1.1. Carlson/Pronyaev reported that alpha-values calculated from the ENDF/B-VII resonance parameters are inconsistent with experimental data of Gwin.
Action: ORNL, make a new evaluation which may have a similar fix to JEFF LANL, test ORNL new resonance parameters

Am240: LLNL in ENDF/A adopted
No action.

Am241: LANL did small adjustment of fission and capture cross sections.
Action: LANL, submit evaluation to BNL.

Cm isotopes: KAERI made new evaluations of Cm isotopes using EMPIRE calculations. The covariance data are given.
Action: LLNL, review KAERI's new Cm isotope evaluations.

Minor Actinides in JENDL/AC: LLNL reviewed actinides data in ENDL/AC, and made recommendations. Evaluations for some of them, such as Np isotopes, are underway at LANL. Some isotopes amongst the recommended materials might be replaced by new evaluations.

Chi: Finer energy grid for prompt fission spectra needed.
Action: LANL, provide interpolated fission spectra

Covariances for ENDF/B-VII.1: BNL and LANL are developing covariances

in fast neutron and resonance regions for 110 materials including 12 light nuclei (coolants and moderators), 78 structural materials and fission products, and 20 actinides in support of the AFCI program. The recently released AFCI-1.2 covariance library, which uses a 33-energy group structure, is a step towards covariances in the ENDF/B-VII.1. The latter will include covariances for the same set of materials as AFCI-1.2 but in the ENDF-6 format rather than in a multi-group structure. LANL already contributed improved covariance data for 235U and 239Pu including prompt neutron fission spectra and completely new evaluation for 240Pu.

Action: BNL contribute improved covariance data for the following materials: 23Na and 55Mn where more detailed evaluations will be performed; improvements in major structural materials 52Cr, 56Fe and 58Ni; improved estimates for remaining structural materials and fission products; improved covariances for 14 minor actinides.

Action: LANL provide new R-matrix evaluation for 16O including mubar covariances.

Cross Section Evaluation Working Group

Data Validation Committee Report

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

The CSEWG Data Validation Committee met on Tuesday, November 3, 2009 and received presentations from eight members representing six institutions – Argonne National Laboratory (ANL), Atomic Energy of Canada, Limited (AECL), Brookhaven National Laboratory (BNL), Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL) and the University of Wisconsin, Madison (UWM)

Alejandro Sonzogni (BNL) described recent advances in the NNDC's SIGMA (www.nndc.bnl.gov/sigma) data visualization system. Sigma is used to display user selected cross section data. Of particular interest is the recent addition of ENDF/A materials to the database so that interested parties may compare existing versus potentially new evaluated files.

Boris Pritychenko (BNL) described efforts to calculate integral quantities such as thermal cross sections, 14 MeV cross sections, Maxwellian averaged cross sections, resonance integrals, etc for various evaluated libraries. Specifically mentioned in his presentation were ENDF/B-VII.0, JEFF-3.1, JENDL-3.3, ROSFOND and ENDF/B-VI.8. These calculated data are available through the SIGMA system noted previously. Comparison of these quantities for the same isotope from the various libraries can be a useful tool to determine how accurate the underlying cross section data may be, although users are cautioned that the compared evaluations must be independent in order to draw valid conclusions about the adequacy of the underlying data and model calculations.

Mohamad Sawan (UWM) reviewed recent work to define the next generation fusion evaluated nuclear data library, FENDL-3. This library will be the end product of a 3-year IAEA coordinated research project (CRP) that was initiated in 2008. The current library, FENDL-2.1, was defined in November 2003 and fails to include much recent evaluation work now available in ENDF/B-VII.0 or the most recent JEFF library. To date, a "starter" library, FENDL-3/SLIB, has been developed where previous evaluations have been replaced with the latest available evaluation. Furthermore if a nuclide's cross section is deemed to be a "standard", that evaluation is also included in the library. This latter rule has the affect of placing the ENDF/B-VII.0 1H evaluation in the starter library in lieu of the JENDL-3.3 1H that is in FENDL-2.1. In total 88 FENDL-2.1 isotopes have been upgraded with evaluations taken from one of the ENDF/B-VII.0, JENDL-HE, JEFF-3.1 or BROND libraries. Numerical benchmark calculations are underway to assess the impact of these new data files. Of particular interest and concern is the softening in calculated neutron flux in the water-cooled magnet region for a 1-D ITER model. The softer spectrum results in greater capture, thereby increasing the photon flux and gamma

heating. This change is a consequence of the switch from JENDL-3.3 to ENDF/B-VII.0 for the 1H data. Additional benchmarking calculations are underway.

Dave Heinrichs (LLNL) reported on calculations of selected 233U benchmarks from the International Criticality Safety Benchmark Evaluation Project (ICSBEP). Of particular interest is a comparison of calculated results using the LANL MCNP program with ENDF/B-VII.0 data processed with NJOY versus results with the LLNL COG program with ENDF/B-VII.0 data processed through PREPRO. Calculations were preformed for 81 benchmarks representing bare metallic, water moderated lattices and solution systems. Generally good agreement between COG and MCNP results were obtained with kcalc differences always less than 0.3% and frequently less than 0.1%. That said, the stochastic uncertainty in these calculated values is often well below 0.1% indicating that differences much beyond 0.1% are statistically significant, suggesting that small differences in either processed nuclear data, coding of collision and tracking physics or both exist between the NJOY/MCNP and PREPRO/COG systems.

Ken Kozier (AECL) reviewed 2H. There have been concerns about this file since the mid-1990s when Russ Mosteller (LANL) noted significant (~1%) decreases in kcalc for HEU-D2O benchmarks. This decrease has been attributed to elastic scattering angular distribution changes below ~3 MeV. In contrast, kcalc for ZED-2 lattices show little (<0.1%) change. A review of new data for 2H suggests that changes are needed. In particular the low energy elastic scattering cross section should be reduced by ~0.15%, from 3.395 barns to ~3.390 barns. Recent data also suggest that the higher energy elastic scattering angular distributions are more isotropic than represented in the ENDF/B-VII.0 data file. In addition it is recommended that when re-evaluated the mf4, mt2 energy grid include more energy points. Additional measurements are underway at GELINA using C6D6 detectors and preliminary analysis of data obtained to date support these conclusions.

Dick McKnight (ANL) reported the results of critical benchmark calculations substituting new 240Pu, 35,37Cl and isotopicW evaluations that reside in ENDF/A. For a series of fast Pu benchmarks a small decrease (~35 pcm on average but varying from a high of 82 pcm to a low of 9 pcm) was observed in kcalc. These benchmarks are accurately calculated with either the original 240Pu evaluation or the new file. A suite of Pu solution benchmarks was also calculated. Kcalc for this class of benchmark has always been too high by about 0.5%. With the new 240Pu file this bias remains and is further increased by ~0.1%. The ICSBEP HST44 benchmark was used to test the new Cl cross sections. These benchmarks have a large uncertainty, but differences in kcalc for varying nuclear data sets are still of interest. Unfortunately there is little difference in these kcalc values and so it is difficult to conclude that the new Cl evaluation is a significant improvement over what is currently in ENDF/B-VII.0. It is interesting to note that the 35Cl file uses the Limited Reich-Moore (LRF=7) resolved resonance representation. It is likely that this representation will become increasingly popular, particularly after the forthcoming release of the Fortran-90 version of NJOY. Finally, Dick summarized results presented previously by Andre Trkov for new isotopic W files contributed by the IAEA. Previous calculations for ZPR9, assemblies 1 through 9 have

exhibited strong trends in kcalc. These trends are largely, but not completely, eliminated with the new IAEA W evaluated data.

Marie-Anne Descalle (LLNL) reviewed ongoing nuclear data validation work at LLNL. She noted that there are a number of evaluations within the LLNL inhouse library, known as ENDL2009, that are under consideration for inclusion in ENDF/B-VII.1. These include 64,66,67,68,70Zn, 78Kr, 240Am and 239U. Isotopic Zn evaluations have not been part of ENDF/B in the past and this will be an important addition to the library. LLNL has also tested several new evaluations against pulsed sphere experiments, including W, Ta, Al, Ti, 57Fe and Au with their AMTRAN (deterministic) and MERCURY (Monte Carlo) codes. Time-of-Flight results for W are significantly improved compared to ENDF/B-VII.0, with little change for the other evalutions. Kcalc results for a suite of ICSBEP fast Pu benchmarks are generally in good agreement with experiment, with the W bearing PMF005 kcalc being significantly improved compared to the ENDF/B-VII.0 result. Fission and activation ratio calculations have also been performed for Godiva, Big-10 and Jezebel. Few calculations of this type have been reported in recent years, but they are an important source for data testing. Selected cross sections for 59Co, 89Y, 93Nb, 169Tm and 193Ir in particular were noted as having poor C/E values.

Skip Kahler (LANL) reported on recent LANL data testing efforts. These included kcalc calculations to test revised 63,65Cu, 113Cd, 9Be, 239,240Pu cross sections plus fission rate ratio calculations to test revised 236,237U, 240Pu and 241Am evaluations. New isotopic copper evaluations are available from CENDL-3 and the proposed JENDL-4 libraries. Kcalc for the ZEUS experiments has exhibited a significant increasing trend with softening spectrum with ENDF/B-VI.x and ENDF/B-VII.0 evaluations. This trend remains with both the CENDL-3 and JENDL-4 evaluated data, although the trend is somewhat reduced with CENDL-3. For ENDF/B-VII.0 113Cd the parameters describing the important 0.178 eV resonance need to be improved. Said Mughabghab (BNL) has recently done so, and there is also a new measurement of this resonance from Geel. Kcalc has been calculated for a suite of HEU solution experiments with varying amount of cadmium. Either of the new cadmium data sets produces more accurate kcalc results than ENDF/B-VII.0 but neither new set is clearly better than the other. Additional study is needed before a specific recommendation can be made. For 9Be, new RPI data have been included in a revised data set submitted to ENDF/A. These data suggest that the 9Be cross sections in ENDF/B-VI.8 are more accurate than those in ENDF/B-VII.0. This is a difficult issue to resolve and there are a variety of fast ICSBEP benchmarks with significant quantities of Be and some are calculated more accurately with ENDF/B-VII.0; others more accurately with ENDF/B-VI.8. Additional analyses of the complete experimental database are ongoing. Data testing has also been performed for a selection of ICSBEP Pu-SOL-THERM benchmarks. ENDF/B-VII.0 kcalc values are ~0.5% high on average for this class of benchmark. New calculations with an ORNL generated data set in ENDF/A and with the latest European evaluation available from JEFF-3.1.1 suggest that the JEFF file can reduce the eigenvalue bias by ~0.3%, although the large spread in kcalc remains. In contrast there is little improvement with the ORNL file. Finally, improved reaction rate ratios are observed in calculations with Godiva, Big-10

and Flattop for revised 236,237U, 240Pu and 241Am.

Covariance Committee Report

D. Smith, ANL
Committee chair

A four-and-one-half hour meeting of the CSEWG Covariance Committee (hereafter referred to as CovCom for convenience) was held on Thursday, 5 November. There were ten individual presentations as well as an hour long discussion period devoted specifically to the issue of defining quality assurance (QA) criteria for the acceptance of covariance evaluations that will be considered for inclusion in the next release of ENDF/B (ENDF/B-VII.1) which is now scheduled for the end of December 2011. The presentations in the CovCom session addressed the following technical areas: the ongoing evaluation of covariances, processing of these covariances, user experience in testing the new covariance evaluations, and sources of experimental uncertainty information that impact the evaluation of covariance data. Significant progress was noted in each of these areas. Of particular importance is the fact that explicit comparisons are being made between different evaluations as well as between the results obtained from processing these evaluations with both the NJOY and PUFF processing code systems. The identification of discrepancies and differences in these various results is leading to improvements in the data libraries.

A synopsis of each presentation made at the present meeting is given below in the order of their appearance in the session agenda as posted on the Web (see URL below). Material extracted explicitly from these presentations is indicated by italics. The complete presentations can be found through links provided on the CSEWG-2009 meeting agenda Web page as follows:

http://www.nndc.bnl.gov/meetings/csewg2009.

C. Matoon (BNL) – AFCI-1.2 Covariance Library

This paper describes the development of the AFCI-1.2 evaluated covariance library, released in August 2009, which represents the latest step in the development of a nuclear data library that can be utilized in Advanced Fuel Cycle (AFCI) R&D nuclear data adjustment exercises. This scope of this library spans the key materials required for this program as specified by this data user community. The overall goal of this AFCI nuclear data project is to use accurate integral experimental data to adjust the covariances and cross sections, as provided in the AFCI-1.2 library, to create an improved cross section library specifically tuned for this application.

The AFCI-2.1 library is comprised of 110 materials (20 actinides, 12 light materials, 78 structural + fission products). Important materials have been treated individually at several institutions. The bulk of library (approximately 70 of 110 files,

FPs and structural) is based on the 'low-fidelity' covariance estimates from LANL, ORNL, and BNL. The covariances from BNL are based on experimental uncertainties in the thermal and resonance regions as well as the model-based covariances from EMPIRE+KALMAN in the fast region. Those from LANL are derived from GNASH-KALMAN analyses while the ORNL contributions generally involve SAMMY calculations. There is an active user community (INL and ANL) that is providing valuable feedback concerning the performance of this library.

This contribution also outlines details concerning the specific origins of various components of the library. It gives examples to show what some of the processed results look like when plotted and notes certain problem areas. Considerable attention is being devoted to quality assurance (QA) issues related to the covariances in this library. This library has been processed into 33-group files throughout thereby facilitating automatic checking for some of the noted deficiencies. Of particular concern is the problem of "too-small" uncertainties, particularly in the RR region, as well as sudden discontinuities in the magnitudes of the uncertainties at certain boundaries between the thermal, RR, URR, and fast neutron regions. In other instances, problems associated with "too large" uncertainties are also being noted. Work is in progress to resolve these issues.

G. Aliberti (ANL) – Uncertainty Analysis with the AFCI-1.2 Covariance Matrix

The ongoing interactions between the nuclear data evaluation community and the AFCI reactor development community during the past several years have proven to be extremely valuable for both of these communities. The differential data evaluators are learning what the impact of their evaluated covariance information is on the calculation of uncertainties in key reactor operating parameters. The reactor physicists, in turn, are now able to specify to the differential data evaluators what uncertainties in these evaluated data are needed, isotope by isotope, in order to satisfy their accuracy requirements.

The present work shows an extensive application of the recent AFCI1.2 matrix, with the determination of the uncertainty for the main integral parameters (multiplication factor, power peaking factor, Doppler reactivity coefficient, coolant void reactivity worth and burnup reactivity swing) of a series of fast reactors (ABR metal core, ABR oxide core, SFR, EFR, GFR, LFR, ADMAB). The obtained AFCI1.2 parameter uncertainties are also compared with the results presented in previous studies with the BOLNA correlation matrix.

Some key features of the AFCI-1.2 data base are as follows: *Processed/used isotopes:* ***U234, U235, U236, U238, Np237, Pu238, Pu239, Pu240, Pu241, Pu242, Am241, Am242m, Am243, Cm242, Cm243, Cm244, Cm245, Cm246, Fe56, Fe57, Cr50, Cr52, Ni58, Ni60, Zr90, Zr91, Zr92, Zr94, Na23, O, He4, Si28, C, N15, B10, B11, Pb204, Pb206, Pb207, Pb208, Bi209, Mn55, Mo92, Mo94, Mo95, Mo96, Mo97, Mo98, Mo100****.Processed/used reactions:* ***ν, fission, capture, elastic, inelastic and n2n*** *for fissile isotopes and* ***capture, elastic, inelastic and n2n*** *for structural isotopes. For most of the isotopes AFCI1.2 contains covariance data for the reaction itself, only for* ***U235, U238,***

Pu239, Cm246, Fe56, Cr52, Ni58, O, Zr90, C, B10, B11, Mn55, N15 *some cross-correlations have been also provided. In the AFCI1.2 matrix there are no "cross-material" correlations.*

This presentation provides extensive tabular information on derived and target uncertainties for the seven distinct reactor designs (ABR metal core, ABR oxide core, SFR, EFR, GFR, LFR, ADMAB). The uncertainties for the main integral parameters (multiplication factor, power peaking factor, Doppler reactivity coefficient, coolant void reactivity worth and burnup reactivity swing) of this series of fast reactors are determined using the AFCI-1.2 library as well as earlier libraries and these are compared. In some cases, the calculated reactor parameter uncertainties are larger using the latest library and in some cases smaller. However, it is believed that the results obtained with AFCI-1.2, regardless of the magnitude of uncertainties observed, are much more realistic and reliable than those derived using earlier libraries.

R. Arcilla (BNL) – Covariance Processing Issues in ENDF/B-VII.0 and ENDF/A

The two main processing codes used by the ENDF community are the NJOY and PUFF systems. In principle, these two codes should yield comparable results if they both operate on the same evaluated file. Since processing is the conduit through which microscopic nuclear data evaluations included in the ENDF system reach most of the applied data user community this is a very important issue to investigate. The scope of the present investigation is as follows:

Selection of Materials---

- *ENDF/A (16 materials)*
  - *F-19, Cl-35, Cl-37, K-39, K-41, Mn-55, Pu-239, Pu-240 U-233, U-235, U-238, W-180, W-182, W-183, W-184, W-186*
- *ENDF/B-VII.0 (14 materials)*
  - *Gd-152, Gd-153, Gd-154, Gd-155, Gd-156, Gd-157, Gd-158, Gd-160, Ir-191, Ir-193, Li-7, Tc-99, Th-232, Y-89*

Processing Codes Investigated---

- *NJOY-99.305 (with A. Trkov's patch* to correct an error in the ERRORJ module*)*
- *PUFF-IV (10-02-2009)*

Test Criteria---

- *Processability of the files with NJOY-99.305 and/or PUFF-IV (10-02-2009)*
- *If processable,* what are the *differences between NJOY and PUFF results*

The outcome of this important exercise is to point out that serious discrepancies still remain in the ability to reliably process the tested libraries with both codes and expect to obtain the same results. In some cases this may be due to deficiencies in the processing codes. In other cases problems can be traced to the evaluated files themselves. Examples were shown to illustrate these points. Two specific recommendations were offered: 1) *Urgent need for NJOY capability to process materials with new R-Matrix*

Limited (LRF=7) format; 2) *Urgent need to investigate and fix NJOY and PUFF discrepancies, mostly in the resonance region.*

P. Oblozinsky (BNL) – Covariance Review of ENDF/B-VII.0 and ENDF/A

A detail examination of the covariance information in the ENDF/B-VII.0 and ENDF/A libraries has been undertaken in order to identify both deficiencies and apparent discrepancies. This was accomplished by generating plots of uncertainties as well as correlation patterns for the evaluated data in a 33-group structure and then examining them in detail. To insure consistency, certain criteria were established to guide the judgment process, as follows:

Analyze uncertainties --

- *Use experience from several reviews of AFCI covariance library, including feedback from users*
- *Use experience of covariance developer in producing covariances in both the resonance and fast regions*
- *Pay specific attention to low uncertainties – Elastic [standards ~ .5-.8%. low < 1-1.5%]; Capture [standards ~ 1–2 %. low < 2–4 %]*

This presentation showed numerous plots with examples of discrepancies and unreasonable uncertainties highlighted for the convenience of the viewer. The scope of the investigation is as follows:

Covariances in ENDF/B-VII.0
14 materials with complete covariances

- ^{7}Li *taken from ENDF/B-VI.8*
- ^{89}Y, ^{99}Tc, $^{191,193}Ir$ *new, all data in MF33*
- $^{152\text{-}155,156\text{-}158,160}Gd$ *new, MF32,33*
- ^{232}Th *new, MF31,32,33*

12 materials with partial covariances
Evaluations should be done from scratch for VII.1
Covariance nomenclature
MF31 = nubars
MF32 = resonance parameters
MF33 = cross sections
MF34 = angular distributions
…. considerable deficiencies in 6 files:

- ^{89}Y, $^{191,193}Ir$ *- issues mostly in RRR (BNL)*
- $^{156,158}Gd$ *- issues in RRR (ORNL)*
- ^{232}Th *- issues in URR and fast (IAEA)*

Covariances in ENDF/A
9 materials with complete covariances

- $^{180,182\text{-}184,186}W$ *MF32,33,34 (*^{180}W *MF33 only)*

- *^{233,235,238}U MF31,32,33 (MF32 converted to MF33)*
- *^{239}Pu MF31,32,33 (MF32 converted to MF33)*

7 materials with partial covariances

- *^{19}F MF32, MF33 partial from VII.0*
- *^{35,37}Cl MF32 only*
- *^{39,41}K MF32 only*
- *^{55}Mn MF32 only*
- *^{240}Pu MF33, fast region only*

.... found deficiencies in 10 materials

- *^{39,41}K, ^{55}Mn - RRR (ORNL)*
- *$^{180,182-184,186}$W - mostly RRR, partly fast (IAEA)*
- *^{233}U - RRR and URR (ORNL)*
- *^{235}U - fission(?), nubar (LANL)*

8 additional materials will be reviewed later

- *^{52,53}Cr, ^{58,60}Ni, ^{46,47,49,50}Ti – quick review: fairly good*

The summary conclusions drawn from this systematic review of covariances in ENDF/B-VII.0 and ENDF/A (30 materials) are as follows:

- *VII.0: Deficiencies in 6 materials*
- *ENDF/A: Deficiencies in 10 materials*

Typical deficiencies

- *Unrealistically low uncertainties (< 1%)*
- *Uncertainty decline in RRR high-end*
- *Mismatch between RRR and fast region*

Actions needed to fix deficiencies

Parties involved: BNL, LANL, ORNL, IAEA

P. Talou (LANL) – Covariance Work at LANL: Status and Future Work

The scope of the work described in this presentation is as follows:

- *Upgrades on 235,238U and 239Pu Covariance Matrices*
- *235U (n,γ)*
- *239Pu $<\nu_p>$*
- *239Pu Prompt Fission Neutron Spectrum*
- *16O $<\mu>$ near the 440-keV resonance*
- *New n+240Pu Evaluation including UQ for all major reaction channels*
- *NJOY Improvements (see talk by A.C.Kahler)*
- *Testing 235U and 239Pu (n,f) Cross-Section Covariance Matrices*
- *Propagation of uncertainties in Jezebel critical assembly*
- *New work as part of ARRA and toward ENDF/B-VII.1*

Some highlights from this activity that were presented are as follows:

Upgrades on 235,238U and 239Pu Covariance Matrices

- *.... 235U(n,γ) cross section uncertainties lowered from 30 to 20% in the 1-100 keV region: ad-hoc modification motivated by feedback from ANL*
- *.... 239Pu prompt fission neutron multiplicity <ν> covariance matrix smoothed out and fixed the thermal point uncertainty*

16O <μ> Uncertainties

- *.... Full R-matrix evaluation to be completed*
- *.... Uncertainties on <μ>, the mean scattering cosine, near the 440-keV resonance*

Further details were illustrated by showing plots in such areas as development of improved 239,240Pu prompt fission-neutron spectrum representations, a new 240Pu evaluation with detailed uncertainty quantification, and work on evaluation data testing. Progress is being made toward ENDF/B-VII.1 with activities being pursued by LANL in the following areas: *Work with BNL to produce a host of new covariance matrices for ENDF/B-VII.1. On LANL's list: 241,242g,242m,243Am; 240,241Pu; review of present minor actinides covariance evaluations (Cm, Np, ...); PFNS for most actinides; R-matrix evaluations for light nuclei: 16O, 4He, 9Be; improvements in UQ methodology; Quality Assurance.*

D. Smith (ANL) – Quality Assurance Requirements for ENDF Covariance Evaluations

This presentation was offered with the intent to stimulate the community to consider what basic QA requirements ought to be put in place prior to accepting available evaluated files for ENDF/B-VII.1. Two years remain until the scheduled release of this library so time remains to implement some of the more basic QA requirements.

The main issue*: Everyone agrees in principle that evaluated covariances files ought to be of good quality to be included in ENDF/B (a QA requirement). However, it is also evident that there is widespread disagreement on what these specific QA requirements ought to be.*

Challenge*: To agree very soon on a set of minimal QA requirements for evaluated covariances in order for them to be acceptable for inclusion in ENDF/B-VII.1.*

A fundamental consideration*: To decide on exactly how we should interpret the meaning of covariances in an evaluation? 1) As the strict outcome from a mechanical process of combining various estimated uncertainty components that are treated by an evaluation procedure or algorithm (e.g., least squares, etc.)? ...or ... 2) As an evaluator's best assessment of the current state of uncertainty of the evaluated physical quantities based on both objective and subjective considerations, including experienced judgment?*

A Pragmatic Approach*: 1) Agree now on a few very basic covariance QA requirements for ENDF/B-VII.1 evaluations. 2) Continue to develop more sophisticated and comprehensive methods for producing, representing, processing, testing, and utilizing evaluated covariance data. 3) Gradually increase the minimal QA requirements*

for covariance data in future releases of ENDF/B, according to both the evaluation and user community capabilities to benefit from these more stringent requirements.

What we can agree on now *(Maybe …): 1) Covariances should be provided for the main isotopes of important materials that figure in contemporary applications. 2) Covariances in a particular isotopic evaluation should be provided for at least the main neutron reaction processes, depending on the specific mass number: e.g., total, elastic scat., inelastic scat., (n,p), (n,α), (n,2n), (n,γ), fission, nu-bar, etc. 3) The energy ranges for covariances must equal those of the evaluated physical parameters and incorporate adequate "resolution" to fully reflect variations in the variances and correlations present in the evaluated data. 4) Evaluator covariance matrices must be square, symmetric, and positive definite. 5) Diagonal correlations must be unity and off-diagonal correlations smaller than unity in magnitude. 6) Covariance matrices for particle emission spectra must satisfy the "sum-to-zero" requirement for both rows and columns to the extent allowed by the ENDF format's precision. 7) Evaluated covariances must be represented numerically using approved ENDF-6 formats. 8) To be useful, all covariance data provided in a particular evaluation must be amenable to being processed by the major contemporary processing codes.*

Future QA requirements**?** (and issues): *1) Restrictions on use of some existing ENDF formats (i.e., eliminate certain older formats). 2) Require covariances for ALL evaluated reaction processes for any given isotope. 3) Require covariance data for ALL evaluated isotopes included in ENDF/B. 4) Require that only covariances which are mathematically linked to the core evaluation process be acceptable in ENDF evaluations (e.g., as currently mandated by the dosimetry community). 5) The role of integral data in ENDF evaluations. 6) Provide covariances for particle emission angular distributions. 7) Provide cross-reaction covariances. 8) Provide cross-material covariances for the important materials encountered in applications. 9) Reconcile conventional C/E consistency testing with covariance error propagation analyses. 10) Examine advantages and pitfalls of "tweaking".*

<u>D. Muir (ANL)</u> – Integral Testing of Covariance Files

This presentation suggests *the use of practical and meaningful integrals tests as part of the quality assurance of covariance files submitted for inclusion in nuclear data evaluations in ENDF format. … The construction, testing and dissemination of large sets of recommended nuclear data are expensive activities. These costs can only be justified on the basis of tangible benefits delivered to end users of the data. Such attention to the requirements of data users is especially important in the production of evaluated data covariances, because the number of data covariances that need to be produced for a given data set is, in principle, equal to the square of the number of data values. … The history of covariance formatting and processing has been dominated by the search for ways to compress covariance files without destroying the usefulness of the data in the intended applications. This basic tension between the conflicting goals of compactness and usefulness makes the production of "application independent" covariance data files a nearly impossible task.*

The four most important uses of covariances are: (1) ***forward error propagation:*** *estimating the accuracy of calculations of applied quantities (critical mass, personnel dose, breeding ratio, etc.) due to the uncertainties in the basic data; (2)* ***data adjustment:*** *refining the information obtained in a nuclear data evaluation by taking into account highly relevant integral experiments, such as reactor criticality data; (3)* ***reactor dosimetry:*** *measuring reaction rates in standard foils in order to infer the neutron fluence and spectrum at a given location in a fission or fusion reactor; (4)* ***remote sensing:*** *measuring reaction rates in a known fluence in order to infer the material composition of an inaccessible sample, such as in oil-well logging, baggage inspection, or space exploration. Of the four applications listed above, the first two (forward error propagation and data adjustment) are arguably the most important. ... For brevity, lump them together under the single heading of "forward error propagation." ... Reactor dosimetry and remote sensing* require *fairly specialized files that need the attention of a dedicated set of specialists. ... The CSEWG program does not appear to be supported sufficiently at the present time to take on this responsibility. ...* (Therefore) *ENDF/B covariance files must provide adequate support for forward error propagation in the neutronic systems of primary interest. Error propagation provides data users with the answer to their most urgent data question: Is this evaluation accurate enough to meet my needs? In forward error propagation, many fine details of the data covariances. ... would get integrated away in the neutron transport process. ... Relatively coarse grids can be used in specifying energy- and angle-dependence. However, one cannot ignore data correlations ... Data correlations do not "integrate away" in the way that many quasi-random effects do.* The nuclear data community must decide whether the intended usage for contemporary evaluated covariance information is indeed as stated above.

This presentation proceeds to make a case for using comparisons of calculated with measured values and their uncertainties for integral quantities as a means for testing the "quality" of the estimated uncertainty files. It is stated in this manner: *The question to ask in this case is "Is the data file (with its stated uncertainties) consistent with key integral data (with their stated uncertainties)?" Although this kind of testing requires a non-trivial investment of effort, it offers the advantage that it would relieve CSEWG and the Covariance Committee of the burden of having to decide in advance (like, right now) on all of the fine details, such as what constitutes a "minor" isotope or a "minor" reaction channel, or whether to include or omit cross-reaction and cross material correlations. ... Application of these procedures will naturally encourage a dialog between evaluators and the CSEWG data testing specialists.*

<u>All Session Participants</u> – Open Discussion of QA for Covariances

A lively discussion followed the preceding two presentations. What emerged from this exercise is that at this point in the evolution of uncertainty quantification files for ENDF, those QA requirements that can be readily imposed at a practical level need to be rather minimal. The audience generally agreed with Muir that the near-term goal should be covariance evaluations suitable for "forward error propagation". There was further agreement that it was necessary to be cautious about introducing any requirements that

could not be met in the relatively short time period before the release of ENDF/B-VII.1 without having to discard available files for specific materials that are required right away for applications in the areas of Criticality Safety and Advanced Fuel Cycle Reactor R&D just because they do not satisfy all the requirements on some QA list. However, it was also agreed that there were certain minimal QA requirements that could and should be met now, and that it would be useful to have these requirements "on the books" to motivate devoting some attention to checking codes and data file testing codes that at this time might need some upgrading to fulfill their intended functions in these areas, and thereby establish a well-defined minimum quality standard for ENDF/B-VII covariances.

It was decided that the Chair of the Covariance Committee would draft a document that includes a minimal list of such QA requirements. This document would be circulated within the CSEWG community and a few interested individuals outside this community for comment and refinement over the next few months. The goal is to finalize this document before the next "mini-CSEWG" meeting that will take place in June 2009 so that it can be formally approved at that meeting.

K. Guber (ORNL) – Experimental Uncertainties

It is universally acknowledged that accurate experimental data and realistic uncertainties and correlations for these data are essential to producing good quality evaluations and covariances. It is further recognized that much of the compiled experimental data (EXFOR) do not meet these requirements, and that many of these archived data are of poor quality with unrealistic assigned uncertainties, as clearly demonstrated by the large number of discrepancies evident in this data base.

The present contribution provided an overview of the essential aspects of white-source neutron cross section measurements at several facilities, e.g., ORELA, GELINA, n_TOF, and others, with an emphasis on sources of uncertainty. The main emphasis is on the first two facilities. The *"Ingredients for Cross Section Measurements" are: 1) Neutron source (spallation or e^- driven). 2) Sample (oxide compounds problematic, stoichiometry of the sample). 3) Flux monitor (Standard Cross Section). 4) Detector (Efficiency, PHW, Backgrounds). 4) Normalization (Standards, Au, Fe, ^{235}U, ...).*

The uncertainty of the creation location of the neutron inside the moderator has to be taken into account ... in the resolution function. This can be quite sizeable for large target and moderator assemblies. The effect is that it will put tail on the resonances in the resolved neutron energy region. Additionally, it will produce a background in the unresolved region which cannot be corrected for. The major issues associated with samples are uniformity of the material in composition and density, sample geometry, stability, and sample stoichiometry. The measurement of time, especially relative time, is very important in white source measurements, and its determination can lead to uncertainties in the data. Another critical factor is identification and correction for background effects from various sources, both time-correlated and time-uncorrelated. Detector calibration, especially for energy-dependent effects, is very important. It relies on a combination of measured and calculated quantities, all of which are subject to

uncertainties. This presentation indicates the levels of accuracy that can be expected for various measured quantities as a consequence of these particular sources of uncertainty, and it explains how this comes about.

The determination of such direct cross sections as neutron capture and neutron fission depends strongly on the use of measurement standards. Their uncertainties must be known and taken into consideration. Additional uncertainties are introduced in complex data reduction processes, e.g., those used to extract resonance parameter information such as resonance energies widths, spins, parities, etc.

D. Smith (ANL) – Uncertainties in Experiments: A Collaborative Project

The collaborators who are participating in this project are of the opinion that insufficient attention has been devoted to the methods for estimating, documenting, and reporting uncertainties in nuclear data measurements. The objective of this project will be to investigate various aspects of this issue, especially as they relate to the use of experimental data in evaluations, with the intent of eventually documenting this work in a journal article to be submitted for publication in a future issue of Nuclear Data Sheets. ***Project Collaborators****: D. Smith –ANL; R. Haight–LANL; Y. Danon–RPI; A. Plompen–IRMM (Geel); P. Schillebeeckx–IRMM (Geel); N. Kornilov–Ohio University; M. Baba – Tohoku University. The following is a preliminary list of topics that will be addressed in this work:*

- *Basic principles of experimental nuclear data uncertainty quantification.*
- *How experimental data and their uncertainties are employed in contemporary nuclear data evaluations.*
- *Propagation of basic experimental uncertainties to derived physical parameters.*
- *Modeling of neutron experiments for uncertainty quantification.*
- *Sources of uncertainties of typical parameters encountered in neutron experiments.*
- *Proper handling of uncertainties in the measurement standards employed in neutron experiments.*
- *Examples of uncertainty quantification for a few simple, hypothetical experiments.*
- *Examples of uncertainty quantification for several actual neutron experiments.*
    - *A specific list of particular experiments that are representative of broader categories of such experiments will need to be prepared.*
- *Suggestions on how to insure that uncertainty data estimated at a basic level in the measurement process are not lost or corrupted through transitioning to a higher level by the application of complicated data analysis procedures.*
- *Guidelines for adequate reporting of experimental data uncertainties as required for modern evaluation applications.*
- *Can unreported uncertainty components for older experiments be resurrected (estimated) from the collective experience of contemporary experimenters who are familiar with such experiments based on existing documentation?*

    - *This is a VERY difficult issue to address, but it is also especially important given the current state of the experimental database in EXFOR.*
- *Suggested options and approaches for adequately reporting experimental uncertainties: e.g., journal articles, detailed laboratory reports to supplement journal articles, EXFOR, etc.*
- *Educating the next generation of experimenters in proper estimation, handling, use, and reporting of data uncertainties.*

It is anticipated that a minimum of two years will be required to complete this project. Serious work on the various details will begin early in 2010.

Cross Section Evaluation Working Group

Formats and Processing Committee Report

Michael E. Dunn, ORNL
Committee Chair

The Formats and Processing Committee meeting was convened on November 4, 2009. The initial part of the meeting was devoted to format related issues. New format proposals or corrections were submitted Jean-Christophe Sublet (UKAEA), Skip Kahler (LANL), and Andrej Trkov (JSI). In addition, Cecil Lubitz (KAPL) and Luiz Leal (ORNL) provided a status report on the work progress of WPEC Subgroup 32 "Assessment of the Unresolved Resonance Treatment for Cross Section and Covariance Representation." After a review and discussion of the format proposals, status reports on the major processing codes were presented. The Formats and Processing meeting concluded with a status report from BNL concerning NNDC activities related to the ENDF-102 Manual. The following are the minutes from the Formats and Processing Committee meeting.

Formats and Related Issues

Activation Reaction Format Proposal (submitted by Jean-Christophe Sublet, UKAEA)

Jean-Christophe Sublet submitted a proposal to add MT numbers to completely specify the reaction mechanism for activation-transmutation analyses (i.e., in similar format to activation files). The proposal is co-authored by A Koning (NRG-Petten), R. A. Forrest (IAEA), and J Kopecky. Unfortunately, no representative for the proposal was present at the CSEWG meeting to present the proposal for review and approval (i.e., per the CSEWG Formats and Processing Committee expectations for new format proposals). As a result, a formal decision on the proposal could not be made during the meeting. Nonetheless, Dunn brought the proposal before the CSEWG for discussion in order to identify possible concerns/issues with the proposal.

In essence, the proposal requests the addition of 50 more defined MT numbers in Appendix B of the ENDF-102 Manual. The additional MT numbers would make any reaction description complete (+/- 10 mb) up to an incident energy of 60 MeV for all foreseeable light and heavy target nuclides. Moreover, the format change would enable consistency with the European Activation File (EAF) format. Overall, the CSEWG did not reject the proposal idea; however, some concerns/questions were identified in the discussion. Without a representative of the proposal at the meeting, it was not possible to resolve the issues at the time of the CSEWG meeting. The primary concern resides with the processing codes. Once the additional MTs are introduced into the formats manual, all the processing codes must be updated to handle the MTs appropriately. In

correspondence prior to the CSEWG meeting, Red Cullen (LLNL) provided a word of caution that "regardless of the intent, once MT numbers are defined in Table 1 of ENDF-102, they are open for use throughout the ENDF/B formatted evaluations (i.e., in an MF)." In addition, the CSEWG questioned whether 50 MTs are really needed, and could a small number (e.g., 10 or so) be used to accomplish the objectives of the proposal. As a compromise, the CSEWG wanted to know if it would be possible to reserve a block of MTs for activation file support; however, the block of MTs would be reserved for derived data evaluations thereby eliminating the need for the processing codes to be concerned with the activation MT numbers. The discussion concluded, and Dunn agreed to provide the information back to the proposal authors.

Scattering Radius Uncertainty Proposal (Skip Kahler, LANL)

Skip Kahler presented a proposal to extend the MF 32 format to accommodate the scattering radius uncertainty. The proposal was prepared in consultation with Dorothea (Doro) Wiarda (ORNL), and D. A. Rochman (NRG-Petten). The proposal also included the requisite changes to the ENDF-102 Manual. During the discussion, Luiz Leal and Andrej Trkov noted that the proposal does not permit any correlations of the scattering radius uncertainty to be defined. There may exist correlations between the uncertainty in the scattering radius and the resonance parameters of low-lying resonances. The CSEWG recognizes that the current proposal is a step in the right direction, and the proposal could be expanded to accommodate the correlations. The current proposal includes an addition of an ISR flag in the CONT record of Section 32.2, and the ISR flag would indicate the presence (ISR=1) or absence (ISR=0) of uncertainty data for the scattering radius. As an alternative, the recommendation was made to let the ISR define the number of APL (angular momentum-dependent scattering radius) entries to be considered for having uncertainties, and to include them in the full parameter covariance matrix. For example, the first entry of the matrix could be the variance of the scattering radius, followed by the cross covariance with other parameters and the rest of the covariance matrix would be the same as before. No format changes (except for the definition of ISR) would be needed and the format would be fully backward compatible. The proposal was approved by the CSEWG with the change noted for the definition of the ISR parameter.

File 40 Format Correction (Andrej Trkov, JSI)

Andrej Trkov and Arjan Koning have identified a "trivial" omission in the MF 40 format. When IZAP was added into MF 10, IZAP was not added to MF 40. Trkov and Koning provided a formal proposal request to add IZAP to the CONT record of subsection MF 40. The proposal also included the requisite changes to the ENDF-102 Manual. Trkov was present at the meeting to represent the proposal. The proposal was reviewed and approved by the CSEWG.

Status Report for WPEC Subgroup 32 URR Investigation (Luiz Leal, ORNL, Cecil Lubitz, KAPL)

Luiz Leal and Cecil Lubitz provided a WPEC SG32 status report covering the first year work activities by the subgroup with the intent to keep the CSEWG informed of the progress and the potential impacts on the URR treatment in the formats and procedures.

The overall objective of the subgroup is to: 1) assess the URR methodology based on the Single Level Breit-Wigner (SLBW) formalism, 2) evaluate other existing formalisms for treating the URR, and 3) make recommendations for treatment by ENDF. When the work of the subgroup is complete, additional URR format modifications (if needed) will be presented to the CSEWG.

Status of Processing Codes

NJOY (Skip Kahler, LANL)
NJOY99.304 was released October 2009, and an unofficial patch for the newly approved MF32 scattering radius format is planned for November 2009. The updates going from NJOY99.259 to NJOY99.304 include: improved graphics for uncertainties; MF35 covariance processing (includes implementation of the "zero-sum" rule and correction of matrix elements if necessary); energy-dependent scattering radius format in URR; increased array sizes and more bounds checking; compact covariance processing for 2 to 6 digit integers improved; more robust coding to produce ratio plots; revised sampling in PURR to more accurately define low probability bins; and miscellaneous code improvements to keep NJOY 99 in sync with the NJOY2009 development.

In addition, LANL, ORNL, and BNL have been working to resolve computational differences with the covariance processing codes, and efforts have focused on the new 55Mn resonance parameter covariance evaluation by ORNL. The work has resulted in an error correction in the Reich-Moore routine imported from ERRORJ. At this point, small differences in MT102 uncertainties remain near the top of the resolved resonance region. Nonetheless, significant progress has been made to improve the covariance calculations.

LANL is continuing to work on NJOY2009. A new version has been developed and is currently undergoing final testing and debugging. NJOY2009 will have little change from the user perspective; however, the code package is based largely upon FORTRAN90. NJOY2009 can process the Limited Reich-Moore (LRF=7) format. Moreover, a "beta" version of NJOY2009 is available on a limited basis while the documentation and code package submittal to RSICC is finalized.

AMPX (Dorothea Wiarda, ORNL)
Dorothea (Doro) Wiarda provided a detailed status report on the AMPX development and maintenance activities since the November 2008 CSEWG meeting. A significant effort has been performed to convert AMPX completely to double precision. At this point, all the codes needed to create multi-group (MG) libraries have been converted to double precision, and many of the modules needed to create continuous-energy (CE) libraries have been converted as well. In addition, the covariance processing module, PUFF-IV, has been updated to process the new MF32 scattering radius uncertainty proposal. The SAMRML routine used to calculate resonance parameter sensitivities analytically was updated to calculate derivatives with respect to the true and effective channel radius. This update allows full correlation between the scattering radius and resonance parameters if provided in an ENDF evaluation. In addition, PUFF-IV has been updated to read and use the TENDL scattering radius uncertainty using the new MF32 format

proposal. A patch to the standalone PUFF-IV package for processing the scattering radius uncertainty has been prepared, and a new version of the PUFF-IV package will be made available from RSICC in 2010.

AMPX is used to provide nuclear data libraries for the ORNL-developed SCALE radiation transport package. In 2009, ORNL released the SCALE 6.0 package, and AMPX was used to prepare the following nuclear data libraries for distribution with SCALE: 238-group ENDF/B-VI.8 and ENDF/B-VII.0 general-purpose libraries; ENDFB-VI.8 and ENDF/B-VII.0 coupled neutron/gamma libraries (200-neutron groups/47 gamma groups) for shielding applications; 27-neutron/19-gamma groups ENDF/B-VII.0 library; ENDF/B-V, ENDF/B-VI.8, and ENDF/B-VII.0 CE libraries; and comprehensive covariance data libraries. In addition to the noted libraries, AMPX was also used to develop new ORIGEN depletion data libraries for SCALE 6.0. The new ORIGEN libraries include decay and fission product data based on ENDF/B-VII.0. Also, the ORIGEN libraries include JEFF-3.0 data.

With regard to new library generation efforts, Wiarda reported on efforts to generate new VITAMIN-B6 and BUGLE libraries based on ENDF/B-VII.0. The new VITAMIN and BUGLE libraries will be completed during the next year and distributed with an update to the SCALE code package.

ORNL is currently working on a new Java-based graphical user interface (GUI) tool named ExSite that can be used for SCALE and AMPX. Wiarda provided a summary of the ExSite development effort and showed examples as to how ExSite can be used to develop AMPX input files. Also, the ExSite tool has the capability to parse both SCALE and AMPX output files to investigate results from both code packages. Work is continuing on the ExSite tool that will be released from ORNL.

With regard to future work activities, ORNL plans to complete conversion of the remaining AMPX modules to FORTRAN 90 and double precision; develop the capability to produce CE gamma libraries for coupled neutron/gamma CE transport; expand ExSite capabilities; continue the development of a fine-group neutron library; improve the AMPX test package; and release AMPX from RSICC by 2011.

LLNL (Bret Beck, LLNL)

Bret Beck provided an update on the LLNL processing codes. LLNL converts the ENDF files to the ENDL format then processes the files to produce libraries for the LLNL transport codes. The LLNL codes historically are based on C, C++, and FORTRAN, and the LLNL efforts have been focused on converting the coding to the FUDGE (For Updating Data and Generating ENDL)/Python package. The new FUDGE LLNL processing package is nearly complete for ENDL data processing to produce data for the transport codes. Currently, FUDGE uses Python when speed is not an issue, and C/C++ is used for computationally intensive tasks (i.e., heating cross section calculations, calculating transfer matrices, cross-section calculations, resonance region parameter processing, etc.). In addition, LLNL has a post-doc working to expand the FUDGE package with regard to reading/converting ENDF data.

ANL (Won Sik, ANL)

Won Sik provided the status report of the ETOE-2/MC2-2/SDX code system for producing multi-group cross-section data for fast reactor system anaysis. ANL has developed a new multi-group cross-section generation code, MC2-3 by rebuilding the legacy codes MC2-2 and SDX and incorporating new analysis methods. MC2-3 can perform ultrafine (2082 groups) transport calculations with the following capabilities: homogeneous mixture; 1-D slab and cylindrical geometries; resolved resonance self-shielding with numerical integration of CE cross sections using the narrow resonance approximation; URR self shielding with the generalized resonance integral method; and elastic scattering transfer matrices obtained with numerical integration of isotopic scattering kernel in ENDF/B data. Also, MC2-3 provides a hyperfine group (point-wise cross section) transport capability with a consistent P1 transport calculation for the entire resolved resonance energy range with anisotropic scattering sources. The hyperfine group capability can be used (optionally) for accurate resolved resonance self-shielding and scattering transfer matrix generation calculations. MC2-3 is currently being integrated with a 2-D method of characteristics (MOC) solver. Moreover, MC2-3 provides an efficient strategy to generate accurate multi-group cross sections for heterogeneous assembly or full-core calculations using various solution options: 1-D hyperfine group cell, 1-D ultrafine group whole-core calculation (with homogenized regions), 1-D CPM or MOC calculation, and 2-D MOC calculation in several hundred groups. MC2-3 is now integrated with UNIC that is a deterministic neutron transport package for reactor analysis.

In the ANL presentation, Won Sik showed results of the hyperfine-group versus ultra-fine group spectra calculations. In addition, the presentation included recent benchmarking results for fast criticality experiments. Overall, the benchmarking results are in excellent agreement with experimental results (i.e., within ~200 pcm Δk). Furthermore, ANL has performed preliminary analyses of the MONJU reactor startup tests in Japan. Assembly averaged 230-group cross-sections have been generated at different temperatures, and nodal transport calculations have been performed with VARIANT.

With regard to future work efforts, ANL plans to further optimize the code package to reduce memory requirements and computational time. In addition, more validation studies are planned for the 1-D and 2-D MOC solvers. ANL plans to implement parallel execution. Furthermore, ANL plans to finalize the cross-section storage procedure for use in coupled physics calculations. Also, ANL plans to implement seamless coupling with UNIC for online cross-section generation tasks.

BNL Activities Related to Formats and Processing

ENDF-6 manual and checking codes (Andrej Trkov, JSI and Mike Herman, BNL)

ENDF-102 Manual

Andrej Trkov provided a presentation on the ENDF-102 manual, and the presentation was co-authored by Mike Herman. BNL has been working to convert the ENDF manual to LaTeX to avoid many of the problems encountered with word processing tools over the years. The new manual should be easier to maintain in the future. At this point, the conversion to LaTeX is complete, and the text has been carefully checked against old versions of the manual. The complete document is available for distribution. The master LaTeX files are maintained at NNDC, and M. Herman is responsible for the manual with support from A. Trkov. The manual will be updated on the NNDC website in accordance with CSEWG approvals and recommendations. BNL plans to use the GFORGE system for configuration control and maintenance of the manual.

At this point, all known updates approved by CSEWG are included in the current version. Some remaining typing errors have been corrected and will be posted in the next CSEWG-approved distribution. Subsequently, Andrej presented the following improvements and clarifications for CSEWG approval (i.e., not format extensions), and the specific details are included in the presentation that is available at the CSEWG-2009 webpage:

- Expanded discussion of the channel spin for File 2
- Expanded discussion of the R-Matrix Limited (RML) format for File 2
- Expanded discussion of Section 2.4.20 Channel Spin and Other Considerations
- Clarification of the channel spin and summation of the partial widths defined by Equation 2.8
- Notation change request for RML (LRF=7)
    - The IPP parameter which is a floating point number should be changed to PPI to be consistent with modern FORTRAN programming conventions
    - In SAMMY, the shift (SHF) parameter is set to 1 (on) or 0 (off). In the ENDF manual, SHF for the same quantity is 1 (on) or -1 (off).
    - The CSEWG decided to keep the ENDF convention, and ORNL agreed to change SAMMY and update the existing LRF=7 evaluations accordingly
- Clarification footnote for Equation 7.8 for the short-collision time (SCT) approximation. The footnote notes that the SCT equation is given correctly in the General Atomics GA-9950 report but is misprinted in the LA-9303-M VOL II (ENDF-324) report from 1982 and the BNL-NCS-44945-05 report (June 2005 ENDF-102).
- Expanded discussion for the competitive reaction cross section in Appendix D.1.1.4 and D.1.1.5
- Revised equation for Mult-level Breit Wigner (MLBW) elastic scattering (Equation D.15)

All the format improvements and clarifications as noted in the presentation by Andrej Trkov were approved by the CSEWG.

Cross Section Evaluation Working Group

Measurements Committee Report

Yaron Danon, RPI
Committee chair

The measurement committee session was held on the morning of November 4, 2009.
Nine presentations from representatives of experimental programs at LANL, ORNL, ANL, LBNL, RPI, ORNL/HRIBF, NIST, and LLNL were given. The presentations provided an overview of current research and measurement performed at the different laboratories.

The Agenda

1. Nuclear data experiments at LANSCE - Highlights 2009, Haight, 30'
2. ORNL cross section measurement activities, Guber, 20'
3. Nuclear data measurements at ANL, Kondev, 20'
4. LBNL thermal cross section measurements and evaluations, Firestone, 20'
5. Cross section measurements at Rensselaer, Danon 20'
6. Decay and neutron emission measurements at HRIBF, Rykaczewski, 20'
7. NIST Measurements and Standards Work at Other Facilities, Carlson, 20'
8. Experimental nuclear data activity at LLNL, Burke, 20'
9. Thermal neutron capture in Gd isotopes, Choi (ORNL), 15'

Nuclear Data Experiments at LANSCE: Highlights 2009, Robert C. Haight (LANL)

FIGRARO – renamed to Chi-Nu, new fission spectra measurements for ^{239}Pu and ^{232}Th were done and data analysis started. Comparison to the Madland and Nix model for different incident neutron energies show good agreement. Differences of 30-40% between the measured spectra and ENDF/B-VI around 12 MeV where shown. Upgrade of the system to cover the lower energy part of the neutron spectra with Li-Glass detectors is in progress.
New LLNL ppac fission detector was successfully tested. This detector will enable better double TOF measurements to measure nubar and the fission neutron spectrum.

N,Z Reactions – New measurements for ^{56}Fe and ^{58,60}Ni, additional information was not provided.

GEANIE – data is taken for incident neutron energies in the range 1 MeV $<E_n<$200 MeV.

^{191,193}Ir and ^{197}Au isomer production – accepted for publication in Physical Review C, ^{150}Sm(n,n'γ),(n,2nγ) – cross sections & modeling paper submitted to Nuclear Inst. and Methods in Physics Research, B.
(n,xγ) for backgrounds in 0νββ decay experiments, CdZnTe – data acquired 8/2009, ^{nat}Cu, ^{76}Ge –analysis in progress, ^{nat}Pb published Phys. Rev. C 79, 054604, 2009, ^{nat}Te published in Michelle Dolinski dissertation, UC Berkeley.
^{nat}Lu(n,xγ), –levels, isomers in ^{176}Lu –presented at APS DNP meeting 10/2009.
Evaluation of "Fast-neutron-induced gamma-ray reference cross sections", ^{nat}Ti, V, Nb, In and Au(n,xγ) – Ti and V are most promising candidates for reference gamma cross sections.

Capture measurement with DANCE – Analysis is in progress for ^{89}Y, ^{155,156,157,158}Gd, ^{94,95,97}Mo, ^{63}Ni, ^{238}U. Analysis of capture to fission ratio for ^{239}Pu, ^{233,235}U, ^{242m,243}Am.

Fission cross section measurements - (0.2 eV to 200 MeV) for ^{239,242}Pu, ^{243}Am, new TPC detector is in progress.

Neutron Cross-Section Measurements Activity at ORNL, K.H Guber (ORNL)

ORELA activity is suspended in 2009 awaiting a new safety analysis document. Measurements were done at IRMM. Neutron capture measurement of ^{182,183,184,186}W samples was completed. Neutron transmission measurement for ^{nat,184}W samples was completed and reduced to cross sections. Transmission and capture data for ^{184}W show discrepancies from ENDF/B-VII and many missing resonances above 2.6 keV.

Experimental Nuclear Data Activities at ANL, Filip G. Kondev (ANL)

Decay studies of selected actinide nuclei: studies of ^{233}Pa, ^{237}Np, ^{240}Pu, ^{242m}Am, ^{243,244,245,246}Cm & ^{249,250}Cf were mentioned and will be part of IAEA-CRP titled "Updated Decay Data Library for Actinides"
Activity for Standardization of ^{177m}Lu decay data – calibration standard for the novel gamma-ray tracking detectors.
MANTRA - Measurement of Actinide Neutronic Transmutation Rates with Accelerator mass spectroscopy is a new project at ANL/INL and ISU. The project includes irradiating (small) samples of pure MA at the ATR facility at INL, and measurements using the AMS technique at the ATLAS facility at ANL.
Decay data measurements & evaluations for decay heat calculations is a new collaboration of ANL and UML to improve calculations of decay heat.
CARIBU - CAlifornium Rare Ion Breeder Upgrade. This is a 1 Ci ^{252}Cf coupled to the Argonne Tandem Linac Accelerator System (ATLAS) and gamma spectroscopy (Gammasphere, HELIOS, FMA, TAGS) to enable n-rich accelerated fission products physics studies.

IAEA CRP: Development of a Database for NAA, Richard B. Firestone (LBNL)

Compare values activation analysis of σ_0 (thermal radiative capture cross section) and k_0 (thermal yield) ratios (defined at 1 for Au) to produce a consistent set of thermal radiative capture cross sections. The results are included in the EGAF-2 database this will also result in a new RIPL update.

Nuclear Data at Rensselaer, Yaron Danon (RPI)

Measurements completed in 2009 include:

High energy transmission (0.5-20 MeV) for natural samples of Ta. The Ta measurements are in good agreement with previous measurements but indicate problems in the ENDF/B-VII.0 total cross section in the energy range 0.5 to 4 MeV, where the ENDF/B-VII.0 data is substantially lower.

High energy neutron scattering (0.5-20 MeV) for natural samples of Zr. Scattered neutrons were measured as a function of incident neutron energy at several detector angles. Preliminary analysis shows good agreement with ENDF/B-VII.

Epi thermal capture (2-2000 eV) for ^{155,156,157,158,160}Gd metallic samples was measured. Initial SAMMY fits indicated many new resonances above 300 eV for both ^{155}Gd and ^{157}Gd

Thermal capture (0.01-20 eV) for ^{nat}Eu and ^{153}Eu samples, samples were measured but results were not shown.

(n, alpha) cross sections for ^{147}Sm and ^{149}Sm – measurements with the RPI lead slowing down spectrometer were done with about 10 mg samples. The ^{147}Sm data is in good agreement with previous data from ORNL. This is the only measurement of (n,alpha) cross section for ^{149}Sm in the energy range from 0.1 eV to 100 keV.

Resonance region transmission for ^{95,96,98,100}Mo isotopes. First measurement using a flight distance of 100m and a new large area Li-Glass modular detector array were completed, data were not shown.

Capture to fission ratio – in the low resonance region (0.01-30 eV). Experiments with ^{235}U were performed to qualify a new method based on gamma measurements. Data were not shown.

Decay studies including b-delayed neutron emission at the HRIBF (K. P. Rykaczewski (Physics Division, ORNL)

The Holifield Radioactive Ion Beam Facility (HRIBF) at ORNL is used for measurements on neutron rich fission products. Fissions are induced by a 10 microampere, 54 MeV proton beam incident on a 6g ^{238}U target and deliver about 10^{11} fission/sec. Decay data is measured using HPGe detectors. Branching ratios for ^{76,77,78}Cu were presented and differ from previous measurements.

The Low-energy Radioactive Ion Beam Spectroscopy Station was also discussed. This facility allows measurement of negative and positive ions, results were shown for ^{81}Zn (half-life of ~315 ms).

A new 80% efficient thermal neutron detector was also mentioned. This detector will be used to measure neutron emission from β-delayed neutron emission precursors.

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

Progress on H(n,n')H angular distribution at 14.9 MeV was discussed, measurements are done at Ohio university. Angular distributions at higher energies (~200 MeV) were reviewed.
^{3}He(n,p) Measurements at UNC were mentioned, results were not shown.
New measurements of ^{6}Li(n,T) at ~4 meV were mentioned and accuracy is expected to be 0.25%, this is a collaboration of NIST, LANL, the University of Tennessee and Tulane University. The LANL measurements of ^{6}Li(n,T) in the energy range from 0.2 to 10 MeV was also reviewed.
Au(n,γ) and ^{238}U(n,γ) standards were discussed and several new measurements were reviewed in particular IRMM measured Au(n,γ) in the keV region. Measurements of the ^{238}U/^{235}U ratio in the MeV region were discussed. The measurement of Calvianiet at n_TOF was compared to other measurements and is in good agreement with previous results.
Measurements of the ^{239}Pu(n,f) cross section by Tovesson& Hill show lower value than previous measurements above 20 MeV.

Update of LLNL experimental activities, Jason T. Burke (LLNL)

New LLNL fission chamber is now under tests at LANL (see LANL report).
Surrogate measurements of the ^{233}U(n,f)/^{235}U(n,f) in the energy range of 7-25 MeV are in good agreement with ENDF/B-VII.0.
^{236}U(n,f) measurements in generally good agreement with ENDF/B-VII but higher by about 25% in the range of 15-20 MeV
^{237}Np(n,f) measurmentin the energy range of 10-20 MeV is in good agreement with ENDF/B-VII and JENDL 3.3
^{239}U(n,f) – data from 1 to 20 MeV was shown and compared with ENDF/B-VII and other calculations, above 8 MeV the cross section is about 40% lower than the ENDF/B-VII evaluation.
Developing a new experimental technique to measure capture cross section using the surrogate method, measurements of ^{153,155,157}Gd(n,γ) are planned.

Thermal neutron capture in Gd isotopes, (H. D. Choi currently at LBNL)

Used DiceBox model with EGAF-RIPL3 input parameters to calculate level population and used this information with the ground state cross section to calculate the thermal capture cross section. Results for ^{155}Gd yields σ_{th}=65200(4100) b which is higher with in error of Mughabghab atlas value of 60,900(500) b. For ^{157}Gd a value of σ_{th}=216,000 (5000) b was obtained and is lower than the Mughabghab value of 254,000(815) b but closer to the new RPI measurement of 226,000 b

Summary of the 12th U.S. Nuclear Data Program Meeting

Held at
Brookhaven National Laboratory

November 4 - 6, 2009

US Nuclear Data Program

Chairman's Summary

M. Herman
National Nuclear Data Center, BNL

The 12th Annual Meeting of the United States Nuclear Data Program was held on November 4-6, 2009 and attended by 51 participants. The meeting was held adjacent to the CSEWG Annual Meeting, with a common USNDP-CSEWG session on nuclear reaction modeling.

Nuclear Structure Working Group

The status of basic databases NSR, XUNDL and ENSDF was reviewed. The ENSDF evaluation productivity remains on a fairly high level.

There has been a vigorous discussion of the current status and future of the NSR compilation. It was noted that collaboration with evaluators has been improved since B. Pritychenko took over as the manager of the NSR. Certain concerns were raised regarding outsourcing of the NSR compilation. The NNDC stand is firm – the outsourcing is working well and is cost efficient. In long term, however, one has to consider modernization of the NSR compilation procedure.

The size of Nuclear Data Sheet publications continues to grow, which is a matter of concern. It has been discussed that if this trend is not reversed it might be inevitable to move to the electronic form of publication. For the time being the participants are committed to maintain the traditional form of publishing. It has been noted with satisfaction that impact factor of NDS has reached a respectable value of 3.4.

A post-doc has been hired at ANL using ARRA funding. This fact strengthens the pool of structure evaluators by bringing in a young researcher to the community. Various attempts have been made in recent years to encourage greater European participation in ENSDF – these efforts started to bear fruits this year.

Nuclear Reaction Working Group

A common CSEWG-USNDP session was devoted to recent advances in development of nuclear reaction model codes in several US laboratories. Progress has been made in using Monte Carlo techniques, especially useful for taking into account various correlations between ejectiles in the statistical decay. Fission prompt neutron spectra and covariance methodology were also addressed.

User Discussion Forum

This activity, established in 2005 and aimed to strengthen interaction between the user community and USNDP, continued in 2009. A half-day session was devoted to presentations and discussions with a prominent scientist from the United States and a nuclear mass expert from Europe.

Task Forces

The two task forces (Nuclear Data for Astrophysics and Nuclear Data for Homeland Security) continue their activity and presented their reports.

Planning and Reporting

- Summary of the present Annual Meeting should be issued in December 2009,
- Annual Report for FY09 in January 2010, and
- Workplan FY12 in February 2010.

The next budget briefing will be held February 12, 2010. If possible, the budget briefing team may include all members of the USNDP Coordinating Committee. If this number turns out to be impractical the USNDP Chairman, WG chairpersons and those who have specific issues to bring to the meeting should attend. One should reiterate positive trend in solving the ENSDF manpower issue and explain ENSDF value for nuclear structure science, cross section evaluations, and applications.

Next Meeting

There has been a motion to hold the next USNDP meeting adjacent to the DNP meeting in Santa Fe. After a detailed analysis it turned out that there serious logistical issues related to such an arrangement, therefore, following the tradition, the next USNDP meeting will be held at BNL in the first week of November 2010. However, to allow some participants to attend the DNP meeting, the USNDP meeting will begin on Monday rather than on Wednesday, i.e., the actual dates will be November 1-3, 2010 with a possibility of reducing the duration of the meeting to two days. The CSEWG annual meeting will be held on Nov 2-4, 2010 (Tue – Wed), while the NDAG Criticality Safety meeting, if requested, will be held on Nov 1, 2010 (Mo) and AFCI Physics Working Group on Nov 4-5 (Thu – Fri).

USNDP Coordinating Committee Meeting

The Coordinating Committee met at working lunchtime on Thursday, November 5, 2009. 11 members attended the meeting, including M. Herman (chair), P. Oblozinsky, R. Firestone, C. Baglin, A. Carlson, T. Kawano, J. Kelley, F. Kondev, N. Summers, B. Singh, and M. Smith. The meeting was also attended by Ted Barnes, DOE-SC.

Agenda

- M. Herman proposed to have the Conference on Nuclear Data for Science and Technology in 2013 organized by the NNDC. Possible venues were discussed and the participants agreed that the search should focus on the New York state.

- USNDP Status: An overall manpower and funding situation at the USNDP laboratories was discussed. The overall funding has dramatically improved due to the influx of the ARRA money. By the same token it has been very difficult to recruit new staff members or even PostDocs since the general shortage of candidates qualified in low energy nuclear physics became even more acute. The LBNL has been successful in retaining a temporary staff position, ANL has hired a PostDoc and LLNL is closing on hiring another one. BNL has added a third PosdDoc in the beginning of the 2009 and replaced Tom Borrows with Sujit Tandel. Unfortunately, the latter has left for an extended leave of absence and is still waiting in India for a US visa. Surprisingly, the funding of C. Nesaraja, which seemed to be settled, turns out to be precarious again. LANL reports no change in manpower.

- Annual Report FY09 and Workplan FY11: To be prepared as usual; we have the advantage this year of knowing our FY 2010 Appropriation.

- Budget Briefing FY12: the USNDP and WGs chairs should represent USNDP. If possible, the participation might be extended to other members of the USNDP Coordinating Committee. In particular, those reporting real issues and/or benefiting from the ARRA funding should join.

- Next Meeting: See above.

US Nuclear Data Program

Structure and Decay Data Working Group

2:10 pm - 5:40 pm Wednesday 4 November 2009
8:40 am – 12:20 pm Thursday 5 November 2009

C. Baglin (LBNL),
Working Group Chair

Present: D. Abriola, C. Baglin, T. Barnes, E. Browne, J. Cameron, J. Chen, R. Firestone, G. Gurdal, J. Kelley, F.G. Kondev, E. Kwan, C. Nesaraja, N. Nica, C. Ouellet, B. Pritychenko, C. Reich, B. Singh, A. Sonzogni, J. Tuli. Also, H. Choi, M. Herman, T. Kawano, S. Mughabghab, P. Oblozinsky, B. Pfeiffer, K. Rykaczewski, M. Smith and B. Sherrill were present for segments of the meeting.

The meeting opened at 2:10 pm following a morning devoted to informal round-table discussions of technical issues. The topics raised had included correct units for B(E2) values (and electric Q moments), limits to precision of $T_{1/2}$ measurements, sign conventions for mixing ratios from $\gamma(\theta)$ and $\gamma\gamma(\theta)$ data, calculations by BrIcc for mixing ratios reported as limits, and interpretation of delayed-particle (%2p, %β-2n, *etc*.) data.

Databases/Compilations/Dissemination/Codes

- **Status of ENSDF & NDS (J.Tuli):** The **ENSDF** database has grown to be a 182.5 Mb file containing ~16635 datasets that provide structure and decay data for ~3066 nuclides. The number of mass chains in the production pipeline during the year has varied between 24 and 32. **Nuclear Data Sheets** (NDS) devoted 3106 pages to a total of 18 mass chain evaluations during CY2009. The average length of a chain rose to 173 p/chain cf. 160 p/chain in CY2008 (more data, less manpower to pare down size of publication). As of Aug. 2009, Elsevier had 4374 user accounts and their paid downloads from the entire journal totaled 12736 in CY2008. In 2009, the greatest percentage of downloads have been by the US and China. ENDF/B-VII downloads (191) remained popular this year, followed by A=151 (168) and A=179 (76). The Journal's impact factor in 2008 was an impressive 3.404. Elsevier's printed-copy subscriptions are very few compared with the electronic-access subscriptions. This may point to electronic-only publications in the future; Jag (as Editor) could push for that but is disinclined to do so at present because the print version remains popular with users. Before going to electronic-only, there are basic decisions to make concerning how citations will be made, where archival copies will reside (ENSDF itself changes continually), how pagination will be handled, *etc.*, as was discussed at some length. Other possible future changes: (1) Elsevier may be

able to provide electronic access by 'nuclide' (from the chain's index page). (2) Print only part of the chain (maybe Adopted and Decay datasets) but provide the remainder as supplemental material online; downloads would provide the complete package and Elsevier may be able to do this now.

- **NSR Through the Prism of a User (F.G. Kondev):** This database is used on a daily basis by basic and applied scientists at national labs, scientific user facilities and universities, and no viable alternative exists in the entire world (Google can't begin to compete!). NSR's quality impacts the quality of ENSDF. It needs to be comprehensive, complete, up-to-date and readily accessible. But can this be achieved with the reduced effort level at NNDC (0.2 FTE for NSR Manager) and the outsourcing of a lot of the work to people who may be quite close to retirement? Is a crisis looming several years hence? Outsourcing has its virtues, but the opinion was expressed that primary responsibility (including quality control and development) should rest with the USNDP (NNDC). Continuing modernization is needed as new facilities, techniques and physics evolve, calling for new keywords and search capabilities (*e.g.*, Primary-Secondary Beam searches). APS-DNP now requests authors to provide a keyword abstract; could a Journal Abstract Web Tool be developed to facilitate this? Can NSR become a repository for PhD theses, lab reports, private communications, *etc.*, as suggested by a Japanese scientist at last month's joint DNP/JPS meeting? Some doubt was expressed about the quality of keywords provided scientists but it was agreed that some modernization was called for.
- **NSR Keywording: Content and Relevance – a Compiler's Perspective (B. Singh):** About 24% of NSR entries come from Physical Review C at present and McMaster undertook a pilot program with undergraduate student participation (currently B. Karamy) to provide these. For the 24 issues from Oct. 2007 through Sept. 2009, there were 1923 papers, 66% of which received keywords. Among the latter papers, 592 were experimental and 680 were theoretical, and 360 were ENSDF/XUNDL related. Reaction and radioactivity theory papers are proving to be the hardest to keyword. Are keywords useful for these papers? The style of information entry seems out dated; the format is inflexible, it does not allow the entry of a range of nuclides and has difficulty handling large numbers of nuclides in a single paper (two recent papers containing 300 and 500 nuclides were cited). It is suggested that some format modernization is called for. It might also be useful to record some additional information, such as facility names (which are currently omitted).
- **Status of NSR (B. Pritychenko):** NSR management at NNDC was added to B. Pritychenko's responsibilities in June 2009 and at that time new features and improvements were added to the Web interface. Also, problems with proceedings, lab reports and some keynumbers were recognized; E. Betak is now taking care of lab reports and conference proceedings, and the keynumber problems have been fixed. An exorbitant increase in charges by Sybase necessitated the migration of the database to MySQL by 1 August 2009. Unfortunately, some stored database procedures did not migrate properly; these were fixed shortly after the meeting (D. Winchell assisted with this), but evaluators had been able to work around those problems by using the Sybase version of NSR, which remained available from IAEA

at http//www-nds.iaea.org/nsr/index.jsp. Few users were affected by these problems, however. A DOE BNL cyber security audit uncovered numerous vulnerabilities, which have now been successfully addressed. In FY2009, 2715 references (1588 keyworded) were added to NSR, bringing the database total to 197195. IAEA/NDS and McMaster University continue to contribute to the journal article keywording effort. Future plans for NSR include the addition of a reaction textbox in the "Quick Search" option, addition of an NSR-EXFOR connection (similar to the NSR-XUNDL one), continued interaction with users (especially the reactions community) to better meet their needs. Also, closer ties with NSDD meetings would be desirable. Evaluators were urged to contact Boris directly with keynumber requests and examples of missing fundamental (or other) papers. It was suggested that an expanded keyword base was needed.

- **Status of XUNDL and Atomic Mass Compilations (B. Singh):** The **XUNDL database** now contains 3320 compiled datasets created from ~2280 journal publications in 1995-2009. In FY2009, 490 datasets were compiled (390 at McMaster University, 37 at TUNL, 39 at ANL, 14 at IFJ-PAN (Krakow), 5 at University of Jordan and 1 at Manipal (India)), and 35 existing datasets were revised. NNDC provides database management. Of the 290 papers compiled, 165 came from Physical Review C. Active communication with authors to resolve data-related questions continued throughout the year. Three recent Physical Review Letters or Physical Review C publications chose to present their experimental data in XUNDL alone. It was noted that additional help with XUNDL compilations would be appreciated – possibly two people each compiling one paper per week. **Atomic mass** measurement papers published in 2008 and 2009 have been compiled at McMaster and are now posted on www.nuclearmasses.org at ORNL.
- **Compilation of Directly-Measured J Values (B. Singh):** Directly measured J values constitute a strong argument for J assignments in ENSDF. However, the most recent compilation of such values is 1976Fu06 with a 1974 literature cutoff date, and many measurements have been published since then. A. MacDonald, B. Karamy and B. Singh at McMaster have prepared a new compilation of such J values for ground and isomeric states, drawing on recent publications, the ENSDF and NSR databases and the 1978 Table of Isotopes, in addition to Fuller's 1976 compilation. A preliminary draft of a possible publication of this compilation was presented. The meeting endorsed the desirability of such a publication (probably in NDS) and it was recommended that evaluators check entries in the draft document for nuclides in their domain.
- **NuDat Refinements (A. Sonzogni):** Plans to expand the range of properties according to which the 2D color-coded nuclear charts can be colored have been implemented (21 categories now). New options include mass-related properties such as Sn or Q(α), selected cross section or nuclear structure properties such as $\sigma(\gamma,n)$, β_2 or E(4+)/E(2+). There are now additional zooming possibilities, a wide-screen option and mouse-over effects on level and decay schemes and a gamma coincidence table for decay data was added to satisfy a user request from DoE (Nevada). During the year, the database was migrated to four new powerful servers. For the future, consideration is being given to introducing double-click for zooming and centering, to adding comments in list of levels, to improving level and decay schemes or possibly

introducing mouse drag events. NuDat continues to be an especially popular resource for nuclear scientists in national labs, research organizations and universities, and in FY2009 there were 1.3 M retrievals from the database. Some interest in a chart color-coded according to nuclear radius was expressed.

- **Status of ENSDF Codes (J. Tuli):** Responsibility for these codes and their distribution now rests with S. Tandel at NNDC, but he is presently on extended leave. Apart from BrIcc, which continues to be supported by T. Kibedi at the Australian National University, only a few small changes have been implemented in the remaining codes since T. Burrows last worked on them in October 2007. Some refinements in GTOL recommended by the St. Petersburg group were implemented and that group will work on known problems with the code GAMUT if LBNL sends them the appropriate material. RADLST needs to be updated to handle new quantities provided by BrIcc. Several bugs in RULER have been fixed. It was noted that E. Browne's revised version of GABS had not yet been distributed; Eddie will make sure NNDC has a copy so this can be rectified.

Reports

- **Access to Archival Material from P. Endt for A=21-44 (J. Cameron):** When P. Endt's office was closed several years ago, J. Cameron was able to salvage two boxes of archival material consisting of hand-written notes, correspondence files and private communications related to Endt's A=21-44 evaluations. These should be preserved and John Cameron will not have space to house them indefinitely. The material has now been indexed and it was recommended that this index be posted on the web right away. The documents themselves could be scanned and preserved as .pdf files, and ANL could provide space for the originals when needed.
- **Resonance Reaction Data in ENSDF (B. Singh):** As a result of discussions during the 2008 Working Group meeting, a sub-committee (J. Cameron, C. Nesaraja, C. Ouellet and B. Singh) was appointed to consult with interested parties and prepare revised guidelines for the inclusion of particle-unbound level information in ENSDF. A draft document was prepared and presented to the NSDD meeting in Vienna in March 2009 and NSDD attendees were given until June 2009 to comment on it. B. Singh presented a summary of the resulting recommendations, which call for slightly different approaches for charged particle and neutron resonance data. The user-community wishes to know widths (including partial widths), Jπ, L and numerical level energies, so we should provide these. Source datasets should include the resonance energy also. It was recommended that our former use of 'Sn(or Sp) + E(res)' for level energy in source datasets be discontinued except in the special case of unresolved very-low energy n resonances. This point generated very extensive discussion. One concern was that evaluators would make too many mistakes as separation energies changed over time, but this objection was withdrawn subsequent to the meeting. New wording for Item 7 of the General Policies for Reaction and Decay Datasets will need to be drafted.
- **Jπ Values from R-Matrix Analyses (J. Chen):** R-matrix analysis of an excitation function in the vicinity of a resonance takes into account both Coulomb and resonant scattering and their interference and a good fit to the experimental cross section can

provide resonance energy, resonance width and often the resonance Jπ. Illustrative examples of fitted excitation functions for ^{21}Na(p,p) (scattering), ^{14}N(p,γ) (capture), ^{3}He(n,p) and p(^{25}Al,p) reactions were presented.

- **Uncertainties of Normalized Particle Emission Probabilities (E. Browne):** A Java language program, PABS, has been written to calculate absolute particle emission probabilities and their correct uncertainties from a set of relative intensities. This program avoids the same basic problem of overestimating uncertainties as does GABS for EC and beta decay datasets and could, in fact, be used for those datasets also. PABS cannot at present accept an ENSDF file as data input; the meeting recommends that it be modified to allow this before submission to NNDC for testing and release.
- **Jπ Values from (n,γ) Measurements and Statistical Model Calculations (R. Firestone):** Except for the low-Z nuclides, level schemes deduced from thermal neutron capture data are usually incomplete due to the existence of unresolved continuum γ-rays. Using the DICEBOX Monte Carlo code, known discrete photon intensities, suitable level density models and photon strength functions, the statistical continuum feeding to levels above some critical excitation energy can be calculated. Since there should be no intensity imbalance at excited states, the simulated population intensity should equal the experimental depopulation intensity. Any deviation from this may expose the assumption of an incorrect Jπ or branching ratio. Several illustrative examples from calculations for ^{106}Pd and ^{185}W were presented. However, the use of DICEBOX is time-consuming and far from trivial, and no simple code is presently available to evaluators.
- **Nuclear Structure and Decay Data Activities at the IAEA (D. Abriola):** IAEA Nuclear Data Section activities encompass oversight of Coordinated Research Projects (CRPs), evaluator training workshops, direct financial support for new evaluators, participation in ENSDF evaluations and NSR compilation and data dissemination. The one active structure and decay data CRP (Updated Decay Data Library for Actinides) will end in early 2010; no new structure projects have been proposed. The IAEA co-sponsored with IFIN-HH (Romania) the ENSDF-2009 Workshop to train 11 potential new ENSDF evaluators from Europe and Turkey, will support a DDEP Workshop in Madrid in June 2010 and is planning another Theory and Evaluation Workshop in December 2010 (the latter currently has ICTP approval but zero ICTP funding). Several new contracts have been approved: India (A=139 for ENSDF), Poland (A=61 for ENSDF and several XUNDL nuclides), Romania (A=75 for ENSDF), Hungary (A=129 for ENSDF and 2 nuclides for XUNDL), Ukraine (A=65 for ENSDF) and China (atomic mass evaluation); an additional proposal to compile and evaluate nuclear moments has just been received. ENSDF evaluation work includes A=72 (with A. Sonzongni; accepted for publication), A=144 (with A. Sonzogni; just started) and ^{84}Nb (in collaboration with Spain). 412 papers have been compiled for NSR since Jan. 2009, primarily by M. Kellett, who also mentored a future NNDC consultant compiler (Emil Betak) during 2009. A collaborative visit to IAEA by B. Pritychenko will take place in Nov. 2009. For data dissemination, M. Verpelli has developed a "LiveChart" of nuclides on the web and this has attracted visits from 1151 cities (and 86 countries) since May 2009. These varied activities

evidence a very strong commitment by the IAEA to structure and decay data activities.

- **Summary of NSDD Meeting (Vienna, March 2009) (J. Tuli):** Since many members of the Working Group were unable to attend this meeting, J. Tuli updated us on major items from the meeting of which we should be aware. This meeting also included a special technical/historical session in honor of Alan Nichols on the occasion of his retirement from the Nuclear Data Section of the IAEA.

Manpower

- **European ENSDF Evaluation Developments (J. Tuli):** As detailed during last year's Working Group meeting, various attempts have been made in recent years to encourage greater European participation in ENSDF. The effort was spearheaded by A. Nichols , with active support from D. Balabanski (Bulgaria) and J. Tuli, and with guidance from P. Oblozinsky and F.G. Kondev. Significant progress was made in the past year, beginning with an informational meeting organized by A. Nichols at IAEA in November 2008. This brought together interested European groups and was attended by S. Gales, chair of NuPNET (which consists of 20 participants from funding agencies and ministries from 14 EU countries). At this meeting, presentations were made by J. Tuli, F.G. Kondev and B. Singh, representing USNDP. This led to the drafting (and ultimate signature) of a Memorandum of Understanding for the European community, the naming of D. Balabanski and C. Scheidenberger as spokespersons for the group and a decision to hold a workshop in Bucharest in April 2009 to train 11 prospective evaluators from Europe and Turkey nominated by the laboratories represented at the Vienna meeting. For the **Bucharest Workshop**, 7 mentors were chosen from attendees of the NSDD meeting (Vienna, March 2009) and, with overall coordination by B. Singh, the trainees and the nuclides in the A=84 mass chain were divided into seven groups so the trainees could receive hands-on evaluation experience, culminating in the publication of A=84 in the November 2009 issue of NDS. Most trainees came well prepared for their respective assignments and seemed motivated and involved, so the bulk of the evaluation was completed by the end of the Workshop. Some trainees did not contribute to the follow-up of the evaluation subsequent to the Workshop though, leaving the mentors with considerable work; however, the Workshop was an overall success and some trainees have expressed interest in remaining involved in this work.

Outreach

Following up on discussions during last year's Working Group meeting, a talk on the USNDP Structure and Decay Data evaluation effort was presented at the October 2009 joint meeting of the Nuclear Physics Divisions of the APS and the Japan Physical Society in Hawaii. F.G. Kondev prepared and presented the talk on behalf of all active US-Canada structure data evaluators (who were listed as co-authors). Although the talk was scheduled very late in the meeting, attendance was encouraging and worthwhile questions and discussions followed the talk. It was agreed that this was one effective means to gain some exposure for our work. Next year's APS-DNP meeting is scheduled for November 3-6 in Santa Fe close, if not identical, to the likely time for the 2010 USNDP meeting. If logistics could be worked out and expenses proved manageable, the Working Group felt

that this provided an excellent opportunity to revert to a former practice of scheduling the USNDP Structure Evaluator meeting adjacent to a DNP meeting, thereby increasing the interactions between structure evaluators and the research community. This recommendation was subsequently conveyed to the Coordinating Committee meeting, but it is already clear that logistical problems exist. It was also agreed that it would be good to have another data evaluation talk at the 2010 DNP meeting. Anyone interested in presenting this should contact the Structure Working Group Chair.

There has being no additional business, the meeting was adjourned at 12:20 pm.

US Nuclear Data Program

Nuclear Reaction Working Group

T. Kawano, LANL
Working Group Chair

Herman presented recent developments of the EMPIRE code for nuclear data evaluation work. A new version can handle six ejectiles including d, t, 3He, and arbitrary light ions. Capabilities of ENDF-6 formatting use of combinatorial level density in RIPL-3, and the resonance uncertainty evaluations were improved significantly. A ZVView covariance plotting capability was also implemented. Several tasks will be undertaken at BNL before EMPIRE-3.0 release, such as easier installation and more user-friendly GUI.

Kawano gave a talk on recent model code development at LANL. A new Hauser-Feshbach code, CoH. ver.3. and a Monte Carlo gamma-ray cascading code, CGM, are utilized, not only for nuclear data evaluations, but also beta-delayed neutron and gamma calculations. The code calculates particle emission spectra by a Monte Carlo method. In addition the Monte Carlo method allows us to investigate correlations between emitted particles in the nuclear reactions.

Capture gamma-ray modeling at LLNL was summarized by **Summers**. DICEBOX models capture gamma-ray cascade using the Monte Carlo method. The cascade modeling indicates uncertain level spins, and critical energies above which levels overlap. The thermal capture cross sections can be estimated through the simulated gamma-ray transitions from continuum to the ground state, together with the experimental gamma-ray production.

Vogt gave a talk on the event-by-event prompt fission neutron spectrum modeling code FREYA at LLNL. Since experimental data are often insufficient for comprehensive understanding of the fission process, Vogt et al. looked into other physical parameters such as TKE, asymptotic level density, relative excitation of the light and heavy fragments, and tuned them to reduce uncertainties. Covariances were obtained from the model calculations. The obtained neutron spectra for Pu239 were about 8% lower than the ENDF evaluation in the low energy region.

Kunieda of JAEA nuclear data center presented a new global coupled-channels optical model, which is primarily for JENDL-4 nuclear data evaluation, but their results will be very useful in general. Experimental total cross sections and elastic scattering angular distributions for neutrons and protons, in a wide mass and energy range, were analyzed in terms of a rigid rotor model to study general trends of model parameters. Kunieda also discussed the soft rotor model for even-even nuclei.

US Nuclear Data Program

2009 USNDP User Forum

A. Sonzogni, BNL
User Forum Chair

This year we had two speakers, Bernd Pfeiffer from GSI (Germany) and Brad Sherrill from Michigan State University. Both speakers discussed two topics that are very relevant in the nuclear data community, Atomic Mass Evaluation by Pfeiffer and FRIB facility by Sherrill.

The latest full atomic mass evaluation was published in 2003 by Audi and collaborators. Work is being performed on the new evaluation that is expected to be published in 2013, which will incorporate the large amount of data from Penning traps that have been obtained since. Additionally, Bernd presented some very interesting results regarding the S and R processes.

Brad Sherrill gave an overview of the Facility for Rare Ion Beam (FRIB) facility at MSU, which is expected to be completed in 2017. We learned about the new accelerators, the beam intensities that can be expected, as well as the type of experiments that will be performed. One can expect that most of the ENSDF evaluations will take place for near-drip line nuclei using the data that FRIB and similar facilities will produce. A discussion of having USNDP staff embedded in FRIB ensued.

US Nuclear Data Program

USNDP Reports

P. Oblozinsky, BNL
Session Chair

The reporting session started with the talk on the USNDP web services by Pritychenko who reported on recent migration of the NNDC services from the Sybase to the MySQL database system and discussed improvements in the retrieval interfaces for the major NNDC products: Nudat, NSR, Sigma, and EXFOR. Ouellet vigorously advocated the concept of 'data trees' as a way for modernizing the USNDP databases.

The two Task Force reports were delivered by the respective chairmen: Nuclear Data for Astrophysics by M. Smith, and Nuclear Data for Homeland Security by Brown.

Nine laboratory reports were given:

1. NNDC report, Herman
2. ANL report, Kondev
3. LANL report, Kawano
4. LBNL report, Firestone
5. LLNL report, Summers
6. NIST report, Carlson
7. McMaster report, Singh
8. ORNL report, Nesaraja
9. TUNL report, Kelley

Viewgraphs of all the talks are available at:
http://www.nndc.bnl.gov/meetings/csewg2009