2015 Annual Meetings:

Cross Section Evaluation Working Group

US Nuclear Data Program

Nuclear Data Advisory Committee

Preface

The 2015 Nuclear Data Week has been held November, 2-6 at Brookhaven National Laboratory. The ND week consisted of the USNDP and CSEWG meetings, which were accompanied by the Nuclear Data Advisory Group (NDAG) meeting organized in the frame of the National Criticality Safety Program. The 2015 ND Week included also meeting of the Nuclear Data Advisory Committee (NDAC), which has been interwoven into the USNDP meeting. NDAC has been formed in 2015 following recommendation of the USNDP review panel in July 2014 and this was the first meeting of the committee. The schedule of the Nuclear Data Week was as following

- CSEWG Meeting, November 2-4,
- USNDP Annual Meeting, November 4-6,
- NDAC Meeting, November 4-5,
- NDAG Meeting, Nov 4,

Similarly to the 2014, all meetings of the ND Week, including NDAC, were managed on the BNL Indico site, that provide a platform for participants registration, time schedule, uploading of the presentations, and their distribution. The respective Indico site can be accessed at https://indico.bnl.gov/event/NDWeek-2015.

Next Meeting

The next Nuclear Data Week will be traditionally held at BNL Nov. 14-18, 2016. The individual meetings will tentatively be held following the schedule:

- CSEWG: (Monday - Wednesday, Nov. 14-16),
- USNDP: (Wednesday - Friday, Nov. 16-18),
- NDAC: (Thursday-Friday, Nov. 17-18)
- NDAG: (to be determined).

Feb 24, 2016

Michal Herman
CSEWG chair
USNDP chair

Summary of the 65th Cross Section Evaluation Working Group Meeting

Held at
Brookhaven National Laboratory, Upton, NY
November 2-4, 2015

The 65th CSEWG meeting was held November 2-4, 2015 at the Brookhaven National Laboratory. After 2014 meeting that has been focused on the CIELO evaluation project, we have returned to the traditional structure of the CSEWG meeting including all five CSEWG committees (Evaluation, Validation, Measurements, Formats, and Covariances). A mini-CSEWG meeting is planned on April 11-12, 2016 at Los Alamos to discuss progress towards ENDF/B-VIII release.

The 58 registered participants attend the CSEWG meeting. These were representatives of national laboratories, academia and nuclear industry of the United States and Canada, as well as seven foreign visitors (3 from Austria (IAEA), 2 from Canada, and 2 from UK). The participants reviewed status (including validation) of the evaluations intended for the next release of the ENDF/B library, including those performed by US and IAEA evaluators in the frame of the CIELO project. The target date for the release of the library is middle of 2017 with related Nuclear Data Sheets issue published in January 2018. New nuclear data measurements were reported during the dedicated session and format proposals were discussed and approved or rejected during the Format & Processing session.

Cross Section Evaluation Working Group

Evaluation Committee

M. Chadwick, LANL

Mark Chadwick, LANL
A summary of the working files for pre-ENDF/VIII and CIELO was given, for 235,8U and 239Pu, as well as 16O and C isotopes.
239Pu uses NEA subgroup 34 resonances and nubar, PFNS from Neudecker above 5 MeV and Romano's thermal tweak, and fast nubar without the previous "tweak" to fit Jezebel.
235U uses much new work from ORNL and the IAEA in the resonance region, including the ~1-2 keV capture reduction inspired by Los Alamos and RPI data. At higher energies it uses the new Talou-Rising PFNS evaluation, which agrees with Chi-nu and NUEX fast 1.5 MeV PFNS data.
238U is a major effort from the IAEA, and ongoing work from IRMM on resonances. At higher energies it uses new inelastic cross sections from theory and measurement. The (n,2n) is supported by recent TUNL data and is close to the higher-rise from threshold ENDF/B-VII.1 data. This rise is supported also by CEA integral data and by LANL critical assembly data. It uses Talou's PFNS.
This overview talked described the cross section and resonance data advances in these nuclei, and showed the plan to release (upgrades) of these files as part of ENDF/B-VIII.

Roberto Capote and Andrej Trkov, IAEA
New standards are planned for release in Dec. 2016, which have time to impact ENDF/B-VIII. This includes thermal constant changes.

16O
Capote noted Kunieda's support for Hale's evaluation for a higher (n,alpha) cross section, from unitarity considerations, more like ENDF/B-VI.8.

235U
Capote noted that the IAEA PFNS CRP project proposes 2.00 MeV for the thermal 235U PFNS, which is being adopted by ENDF/B-VIII.
Standards were first worked by Westcott in 1965, when he was head of the IAEA section. Lemmel, in 1983, noted discrepancies between microscopic and macroscopic data. Axton's ~1986 report was adopted by many committees. 2004 constants from Pronyaev influenced ENDF/B-VII. But to get K1 from Harvey, nubar was increased. The most recent, microscopic-only evaluation of 2.425 is a little lower than the macro-micro 2.432 value. Considering the capture integral ratio to B-VII, set 2 is ~2.5% lower at thermal. Both set1,2 are consistent with the 7.8-11 eV integral, guided by nTOF data.

The capture to fission ratio could perhaps be changed, in resonances, to remove some of the nubar fluctuations they introduced.
Fission in VII.1 appears a few percent discrepant (VII.1 is lower by ~3%) to the standards recommended value in the 100-1000 eV resonance region, and to some nTOF recent measurements (shown at WONDER 2015). He also noted a discontinuity in values between RR->URR that would be nice to fix.

238U
Their total inelastic scattering cross section appears fairly similar to VII.1, and higher than JEND4.0, and the new evaluation at 1 MeV is higher than previous evaluation based on an improved OM analysis, and is supported by old ANL data by Smith et al.
The semi-integral RPI angular-dependent scattering data helped guide the evaluation. Backward scattering is improved and now matches the RPI data.
Their (n,2n) data was influenced by the latest TUNL-LLNL-LANL data, and with Cf-integral data. This supports the higher rise from threshold in VII.1, and suggests Frehaut still low even after 1.09 renormalization. Capote noted that value of potential future SACS (Spec Averaged Cross Section) for 235U(n,2n) and 239Pu(n,2n).

Roberto noted that some changes in the future could be obtained that would further improve some of the intermediate and fast crits.

Michal Herman and Gustavo Nobre, BNL
56Fe
Collaboration between BNL, CNDC, IAEA, IRM, JSI, LANL, ORNL, RPI.

- The China CNDC provided a comprehensive analysis of the experimental data.
- JSI selected 24 benchmarks for testing; additional testing by IAEA and LANL.
- RR built upon ORNL RR Svn revision 43 up to 2 MeV.
- RPI provided the semi-integral scattering benchmarks.
- Fast neutron range evaluated with EMPIRE by BNL and IAEA.

The earlier version 49 was compared against VII.1 for various assemblies, and sensitivity to angular distributions was established. Performance similar to VII.1 was demonstrated. Version 49 was also tested against the RPI data. In some regions, especially between 5-10 MeV, version 49 appeared too high (at 153 degrees), with JENDL-4.0 looking better.
The latest 88 version uses just RR and fast regions, no URR region.

This RPI study led to changes now considered in version 88. The RR region was moved down to 846 keV, the first inelastic state. Geel high-resolution data guided fluctuations up to 4 MeV, and calculations were used above 4 MeV. BNL also used phenomenological Gilbert-Cameron level densities in the model calculations, rather than RIPL-3 microscopic calculations, owing to improved performance for neutron spectra. Adjustments were made to match (n,p) and (n,a) data. Total inelastic agrees with Geel data to 4 MeV and to the (Chinese-corrected) LANL Nelson data. The (n,2n), (n,p) and (n,a) data appear to match the measurements rather well. The neutron emission spectra also agree with the measurements (comparisons were shown in the 8-14 MeV region).

In the 1 MeV region there are differences with JEFF3.2, reflecting some differences in the scattering measurements (JEFF follows the Kinney data generally).

BNL showed validation testing against many assemblies, thermal and fast. Overall the agreement is rather similar to VII.1. HMI001 intermediate spectrum benchmark appears much worse though a ZPR experiment was designed for testing iron in the 1-1000 keV region. A sensitivity study showed sensitivity to capture on 235U in the 1 keV region and iron near 20 keV (the iron window at ~ 24 keV). Using the newer CIELO capture in 235U near 1 keV (reduced) could lead to even worse results – likely a further increase in over-calculation of reactivity for HMI001.

Iron capture in rev. 88 is quite different above 100s of keV=1 MeV. A background is noticed in VII.1 and other libraries down to a few hundred keV, probably adjusted to fit data (or a mistake, carried over from earlier evaluated data which went to 400 keV). Rev. 88 does not have this background. RPI will provide validation using their semi-integral experiment.

A new Leal resonance evaluation is available up to 2 MeV but needs testing (it has zero background).

Zerkle uses a Russian iron transmission/streaming benchmark – it is in ICSBEP and needs to be studied by BNL.

Kawano recommended using smoother angular distributions as opposed to those recreated form resonance parameters, owing to the practical attraction of using smoothed results, which are of approximately equal fidelity in simulations.

Toshihiko Kawano, LANL

Kawano discussed longer term research objectives in using better models and theory, especially improved HF calculations, and improved inelastic and capture cross sections, for actinides.

Including a small M1 component is important to modeling 238U(n,g) data, as demonstrated by DANCE, and supported by DANCE multiplicity data from Jandel.
A simple parameterization of the M1 strength leads to good predictions of the average radiative width, with good capture predictions for known cross sections such as 236,238U capture. This should help for off-stability nuclide predictions (e.g., 239U capture).

On inelastic scattering, improved theory using Weidenmueller et al. insights have been studied. This led to a modification to Moldauer's work, with a new phase factor added, and a prescription to enable numerical calculations. Compared to older calculations, he finds a slightly enhanced inelastic scattering cross section (e.g., for 238U(n,n') 2+ and 4+ states), by <10% generally.

On fission, Kawano found similarities with Ray Nix's WKB calculations of fission penetration, which he is studying in advanced theoretical studies.

David Brown, BNL
Status of the ENDF/B library:

- CAD-AECL provided thermal scattering library evaluations for O and D in D2O and H in H2O. NCSL did Lucite.
- Changes were made using EGAF thermal cross sections for a range of nuclides.
- Cullen changed 300 EPICS evaluations for atomic and photo nuclear libraries.

Brown, Kawano, Thompson fixed various open items in the tracker. A typo in tin isotopes was found by Mughabghab – the fixed file needs testing by our Naval reactor colleagues as zircalloy in commercial reactors uses some tin.

Examples of some issues to fix still include:

- 237Np needs attention, TK will check.
- C has some issues that Gerry Hale needs to check.
- Mn – IAEA to check.
- Ta, Re issues need to be checked (LLNL).
- Delayed fission neutron spectra are missing for many minor actinides.
- Various issues for CIELO nuclides.

86Kr was discussed, as a fusion radchem detector. New data from TUNL on (n2n), and LANSCE on (nn'), have been published.

Allan Carlson, NIST
Summarized the issues associated with the 7.8-11 eV fission integral, which has been issued as a standard since ENDF/B-V. It is often used to normalize cross section data sets. B-VII standards has 246.6 b.eV, but the B-VI and B-VII files are 2% lower than the standard value. In contrast, thermal cross section agrees. The new Leal file has 245.4 (i2, and i2 has 246.4) b.eV, which is encouraging.

Marco Pigni, ORNL (with Leal, Guber, Sobes, Wiarda, Arbanas, Dunn)
The upper energy ranges have been extended for many evaluations. Extension to include charged particle channels has also been a focus.

W extends the resonance range up to 10 keV for many isotopes (5 keV for 183W). 183W has an elastic thermal of 5.7b, double the previous Atlas value (which had a typo).
Tungsten will be tested. Kahler had previously reported on the performance, in the mini-CSEWG in 2015 – similar performance to VII.1 was seen. There are limited low-energy benchmarks, and most feedback came from fast benchmarks.

Copper RRR has been extended up to 300 keV. Kawano had identified an underestimation of capture in previous files; this issue is being worked, to understand where the upper range can be set.

For 40Ca, they have a preliminary set up to 1 MeV. Ongoing work is using capture and transmission data from Geel, and includes (n,a) and (n,p) channels.

16O evaluation is from Nov 2014. The thermal value was 3.78 b. The new file uses a thermal elastic cross section of 3.765 b (at T=0K, 3.884 at 293.6K) as recommended by CIELO, and includes RPI total cross section data. It was not clear what (n,a) normalization is obtained in the 3-6 MeV range.

56Fe resonances are provided up to 2 MeV. Until recent RPI measurements, capture was not available above 600 keV, and was not available to Leal. RPI has new natural iron data.

235U. Previously overestimated capture in the 0.1-2.5 keV has been addressed. Marco showed RPI capture cross section in bins, in units of barns, compared to B-VII.1 which is seen to be too high. The new evaluation agrees well with the RPI data (and LANL data) from 0.1-2 keV.

239Pu. Leal is working on extending the RRR from 2.5-4 keV. Fission integral from 100-1000 eV was studied, per recommendations from NEA-WPEC-5 normalization to Weston (1984), of 9275 b.eV. Leal is planning to use the LANL capture data from Mosby and Jandel (draft data have been sent from LANL).

Goran Arbanas, ORNL
Goran described advances to the SAMMY code system, distributed by RSICC.

DATA TESTING

David Brown, BNL
David described the ADVANCE quality assurance system for ENDF. The system replaces phase 1 testing and finds bugs in the files.

Andrej Trkov, IAEA
The IAEA has supported the CIELO evaluations in various ways. The focus has been on 235,8U, 56Fe, 16O (from Hale), and H2O from CAB. Integral benchmark experiments provide an important contribution to the evaluation decision process.

The latest **238U** file is u238ib44. It uses fission and standard cross section values from the Standards.

- IRMM R-matrix resonance work has been studied; the 20 keV boundary can be adopted. New GELINA capture and transmission data are being studied; LANL data was provided in a format that prohibited a resonance shape analysis (LANL will look into this).

- Talou's 238U PFNS was adopted.
- The RPI semi-integral analysis was important for guiding the evaluation in the 0.5-10 MeV range.
- 238U increases the reactivity of Flattop and Bigten, but aspects of this can be addressed with other evaluation changes.

For **235U**, a developmental file is underway.
High-leakage solutions are impacted very much based on the 235U thermal PFNS. For their proposed higher energy inelastic advances, these can be compensated by nubar increases by 0.2% in the 0.5-1 MeV range. Trkov noted that the corrected ORNL Godiva is just a little higher (in terms of C/E) than LANL Godiva, which calculates near unity (and an earlier Bess presentation showing a very big discrepancy had an error that Bess corrected). Trkov notes that LANL ATLF fitting does not use weighted C/E. He showed that different assumptions lead to different trends. The "i2" curve set appeared to perform fairly well (also using oxygen, 238U and iron and the thermal scattering advances), without a significant trend.
Other observations noted are: UH3 (LANL uranium hydride?) benchmarks show a large reactivity swing; All thermal lattices are under-predicted (owing to the 235U nubar change, perhaps) – where the lattices don't benefit from the nubar tweak; ZPR9/34 is sensitive to U235 and Fe capture, and now appears to be largely over-calculated.

56Fe
An older ib04s evaluation was tested, as well as the recent BNL rev.88 set. Shielding benchmarks were also studied, including EURACOS Fe, ASPIS, IPPE Fe spheres, and Oktavian work. Trkov noted that these benchmark comparisons, while valuable, do not provide any clear feedback on whether the new evaluations perform better or worse than VII.1. He noted that the goal of performance better than VII.1 has not yet been achieved.

Skip Kahler, LANL
Skip summarized first the performance using new 235,8U, 239Pu, and 16O "Pre-VIII" files. For fast assemblies, Jezebel and Godiva the new files perform equally well as ENDF/B-VII.1 but the increased back-scatter in 238U pushes the overprediction a bit higher for the Flattops, and Bigten is a bit lower.
The HST high enriched thermal solutions are plotted versus ATLF, and have done well since VI.3. The new suite performs well, as also noted by Trkov. It has a slight positive trend – this might be even further reduced using the new CAB h-H2O kernel.

The LCT UO2 lattices were studied using a focus on LCT1, 2, 5, 7, 8 (B&W),10, 17. Overall there is a loss of reactivity, by an average of about 100 pcm. The harder systems tend to have the biggest effect, and perhaps the IAEA nubar tweaks in 235U are causing the problem. The IAEA and Leal will look at whether other evaluation possibilities could lead to better LCT performance (e.g., changing alpha c/f in the low resonances, instead of the lower fluctuating nubar). The LCT assemblies are presumably less sensitive to the PFNS changes.

The 56Fe Rev.88 iron file was tested; no clear change in performance was observed.

The plutonium solutions inVII.1 were biased high about 500 pcm, plotted against ATLF. By focusing on a small subset of 7 benchmarks, we found an over prediction of 388 pcm. This was reduced to 116 pcm by SG34. Using oxygen too reduces the discrepancy to ~0 - an excellent result. (Testing a recent Neudecker 239Pu thermal PFNS led to a 948 pcm over-prediction – hence our decision not yet to adopt this softer PFNS).

ORNL: What about 235U eta and temperature coefficient effects, based on the current files? This needs to be assessed.

Dan Roubstov, CNL

Described new S-alpha-beta evaluations for H in H2O, O16 in D2O, and D2 in D2O done under NEA/WPEC SG42. ENDF/B-VIII is planning on adopting these advances.
Mike Zerkle would like the Leapr input decks to make their own finer temperature grid data.

Tim Trumble, KAPL

Tim discussed the status of Hf evaluations, comparing RQ Wrights (ORNL) evaluations, with JEFF3.1.2 and JENDL4.0. All have some origins in JENDL3.3, but ENDF/B-VII.1 was influenced by RPI measurements and JEFF by Geel data. ENDF tends to end resonances at a lower energy. JENDL distributions are less forward-peaked. Tim showed various critical assemblies, where Hf is often used as an absorber/poison: LCTs look reasonable, MCT6 poor (underprediction), and PST vary but often look poor.
He concludes there is no clearly better evaluated file, and no reason to adopt JENDL or JEFF any time soon!
There may be future RPI fast transmission measurements made in the MeV range.

(We heard also that the VII.1 Zr file, which used some JENDL angular distributions, is performing adequately. Some RPI data at lower energies, down to 0.5 MeV and down further to keVs, might be considered in the future (for VIII.0).)

Jessie Holmes, Bettis

Discussed the decay data file NSUB=4, in the context of their MC21 transport code. SF spectra are available from LANL, LLNL, even if not available in ENDF (the only spectrum for SF neutrons in ENDF is for Cf).
For 238Pu and Cf isotopes, JEFF has a softer SF neutron spectrum. JEFF sometimes has discrete spectra, while ENDF has continuous.
He also showed beta decay products creating gamma rays, and noted differences between continuous representations in ENDF, versus JEFF discrete gamma rays.
Just because we know phenomena are discrete, this doesn't imply that the spectra are physically better.

Priorities for Bettis are 242,244Cm, 238Pu, and 241Am PFNS as well as Pu240. Can LANL and Talou do a study on this, for the impact is large in many applications? Previous work of Madland is summarized in NSE 108, p.109 (1991). Russian measured data (Alexandrova) are available for 240Pu. These Russian SF data were used for a Maxwellian fit of 1.27 MeV for 240Pu, 1.38 MeV for 238Pu (calculated?), and 1.21 MeV for 242Pu (Belov data). The average energy is 3/2 times this value. That Madland paper quotes Watt spetrum data for 240Pu with a=0.799, b=4.903. Eav=(3/2)[1+a.b./6]=2.47 MeV (versus the Maxwellian approximation of 1.5*1.27= 1.91 MeV.

A plan has been developed to share our 235,8U, 239Pu, 16O, 56Fe, and S-alpha-beta pre-VIII files for testing by a broader community of data-testers (beyond the present LANL, IAEA & Chalk River testing reported at CSEWG), including the Naval and commercial reactor community. This includes:

- Bettis and KAPL
- Chalk River & Argentina CAB
- Wemple, Studsvik
- Japan JAEA
- (CEA/Cadarache if possible)
- AWE
- continued IAEA and NEA testing
- ORNL feedback on eta.

Cross Section Evaluation Working Group

Validation Committee

A. (Skip) Kahler, LANL

The Cross Section Evaluation Working Group's Validation Committee met on Monday, November 2, 2015 and received reports from Brookhaven National Laboratory (BNL), the Nuclear Data Section of the International Atomic Energy Agency (IAEA), Los Alamos National Laboratory (LANL), Canadian Nuclear Laboratories (CNL), Knolls Atomic Power Laboratory (KAPL), Bettis Laboratory and Idaho National Laboratory (INL).

Dave Brown (BNL) reported on the ADVANCE Quality Assurance system for ENDF that has been under development for several years. This system performs a number of checks on all new files submitted to the National Nuclear Data Center (NNDC) and allows the NNDC and the CSEWG community to correct file errors faster and more efficiently than in past, more manually oriented, systems. Brown noted that this concept is now being implemented at the OECD Nuclear Energy Agency's (NEA) Data Bank. Improvements continue to be implemented into the FUDGE code and in the traditional NNDC checking codes that are part of the ADVANCE system. Processing is done with NJOY2012. Testing using Lawrence Livermore National Laboratory's COG continuous energy transport code has been added to ADVANCE. Use of summer students serves the two-fold purpose of getting additional capability added to ADVANCE and creates a potential pipeline to the next generation of nuclear data professionals.

Andrej Trkov (IAEA) reported on data testing of data files created under the auspices of the Cooperative International Evaluation Library Organization (CIELO). This group is focused on developing new data files for 1H, 16O, 56Fe, 235,238U and 239Pu that will be adoption candidates by the major evaluated data file organizations worldwide. Current files among the ENDF, JEFF (Europe) and JENDL (Japan) communities differ on many important details, a situation that needs to be rectified. The IAEA, in collaboration with colleagues from IRMM in Belgium and JSI in Slovenia, has been an important contributor to both creating and testing CIELO candidate data files. Most data testing reported at CSEWG in recent years has focused on calculated eigenvalues, with few results given to other measured quantities such as reaction rates or for other applications such as Shielding. Andrej's benchmark selection attempted to focus beyond criticality, noting for example that benchmarks sensitive to 238U scattering suggested considerable improvement in the new evaluation. He also empathized that the impact of compensating effects, an apparent improvement in the performance of one evaluation being undone by changes in another evaluation or by other changes within the same evaluation, can be difficult to interpret. As an example, recent recommended changes in the 235U prompt fission neutron spectrum will decrease that spectrum's average energy. The consensus of the community is that this is a fundamentally correct change, but the impact on calculated eigenvalues for HST benchmarks is large and produces C/E values that are worse than before. The uncertainties in other data, such as inelastic scattering or nu(E) may allow those data to partially compensate for this, but additional study is needed. Shielding benchmarks such as EURACOS- Fe, ASPIS, IPPE Fe sphere, OKTAVIAN Fe and LLNL pulsed spheres from the SINBAD database are important sources for testing CIELO 56Fe files. The EURACOS-Fe benchmark has the potential to be particularly valuable, but is also particularly complicated as good data for source pfns and spatial distribution, Fe and impurities therein and other dosimetry reactions are required. Similar observations can be made for ASPIS, which includes the UK's NESTOR graphite reflected reactor with attenuation in steel and water meant to simulate typical PWR shielding.

A.C. (Skip) Kahler (LANL) also reported on criticality (eigenvalue) data testing of CIELO data files. Data testing was performed for a variety of criticality benchmark classes, including fast HEU and Pu systems, thermal HEU solutions, thermal UO2 lattice systems, thermal Pu solutions and various Fe or steel reflected systems. All "systems" are benchmarks taken from the International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook. These calculations are used to determine if the new files (i) produce improved results for systems that have been poorly calculated in the past, and (ii) verify that previous good results have not been adversely affected with the new data files. At present we obtain continued good results for fast, unreflected LANL critical assemblies (Godiva, Jezebel) but slightly worse results for the Flattop (reflected) assemblies. The HST benchmark class continues to be calculated accurately; the LCT benchmark class eigenvalues show a 100 or so pcm decrease but under certain lattice pitch (i.e., water-to-fuel ratio) conditions this decrease can be up to 0.5% which is unacceptably large. Uranium fueled, iron reflected systems exhibit a small increase in calculated eigenvalue (which is in the correct direction compared to ENDF/B-VII.1) but Pu fueled systems move in the opposite direction. Significant effort has been expended in recent years to resolve the long-standing positive bias in calculated eigenvalues for PST systems. The latest combination of light water thermal kernels, 16O and 239Pu continue to show improvements for this benchmark class. A final study, dealing with the impact of prompt fission neutron spectrum (pfns) uncertainties on calculated eigenvalues revealed that the current 239Pu pfns uncertainty contributes to a ±100 pcm calculated eigenvalue uncertainty for the Jezebel critical assembly and a nearly ±300 pcm uncertainty in the calculated eigenvalue of a representative PST benchmark.

Dan Roubtsov (CNL) reported on light and heavy water thermal kernel collaborative work with J.I.Márquez Damián of Centro Atomico Bariloche (CAB) Argentina. This is an extension of the work presented by CAB at the Working Party for Evaluation Cooperation (WPEC) Sub-Group 42 meeting in May, 2015. Their newly developed scattering kernels have been submitted to the NNDC and are available for testing from the NNDC's GForge server. Key points in the new S(α,β) models (i) use of molecular diffusion for translational mother in lieu of the free gas approximation, (ii) new, continuous vibrational spectra from molecular dynamics simulations, (iii) more precise description of the structure of the liquid and (iv) more robust numerics in NJOY. Some of these NJOY improvements have already been shared with LANL and Roubtsov has indicated that the remaining code revisions will be shared soon. Some criticality benchmark testing has been completed. Changes in the calculated eigenvalues of light water systems are small, reflecting the already good thermal kernels available here, but the changes seen in heavy water systems can exceed 1% in reactivity, particularly when combined with the ROSFOND-2010 deuterium evaluation.

Tim Trumbull (KAPL) reviewed the status of the stable isotopic Hf evaluations, comparing the current ENDF evaluations with the evaluated files from JEFF-3.1.2 and JENDFL-4.0. He noted that the resolved resonance range upper limit was generally highest in the JEFF-3.1.2 files (except for 180Hf) while JENDL-4.0's unresolved resonance range upper limit was higher than those in the ENDF and JEFF files. Radiative capture, particularly in 177,178Hf, are important reactions and the three library files are in generally good agreement for the thermal capture and capture resonance integral. Differences in elastic scattering cross sections are large, often exceeding 10% and are likely due to differences in the resolved resonance parameter partial widths; data that is difficult to measure. Elastic scattering Legendre moments are identical for ENDF and JEFF but the more recent JENDL evaluation suggests our Japanese colleagues believe they should be less forward peaked. Despite these differences, calculated eigenvalues are very similar (for a selection of ICSBEP benchmarks, including LCT-029, cases 1 – 5; LCT-061, cases 3 – 6, MCT-006, cases 8 – 12 and PST-031, cases 1 – 7) and so Tim sees no compelling reason for CSEWG to consider revising the current ENDF evaluations or adopting either the JEFF or JENDL evaluations.

Jesse Holmes (Bettis) summarized Bettis' experience with the ENDF/B-VII.1 Radioactive Decay Library, and highlighted important differences between the information available in ENDF versus the European's JEFF file. For example there is only one spontaneous fission (SF) emission spectrum (for 252Cf) in the current ENDF whereas SF is an important decay mode for a number of transuranic nuclides. Jesse also noted that a detailed comparison between ENDF and JEFF revealed 30 ENDF files with continuous neutron and/or photon spectra whereas the JEFF version of those files contained the more physically correct discrete data; data that are consistent with the information available in the Evaluated Nuclear Structure Data File (ENSDF) and other databases. It would seem that upgrading the ENDF Decay File should be one of the objectives included in the next ENDF release, although it is a sad but continuing problem to find the appropriate resources and Sponsor to fund such work.

Andrew Hummel (INL), standing in for John Bess, reported on the status of the International Criticality Safety Benchmark Evaluation Project (ICSBEP). The ICSBEP meets annually to review proposed revisions to existing benchmark evaluations and to accept (or reject) proposed new critical benchmarks. The September, 2015 edition of the Handbook contains 567 evaluations consisting of (i) 4874 critical, near critical or sub-critical configurations, (ii) 31 criticality alarm/shielding configurations, (iii) 207 configurations describing fundamental physics measurements, and (iv) 829 experimental configurations judged to be inadequate to serve as a benchmark.

A second INL report, also given by Andrew, described experiments preformed at the Rossendorfer Ringzonen-Reaktor. This is a zero power Argonaut (Argonne Nuclear Assembly for University Training) type annular core reactor. It uses 20% enriched 235U3O8 fuel, is water moderated and has graphite reflectors. The experiments described by Andrew use a fast insertion lattice consisting of an aluminum or iron matrix filled with various materials. Central reactivity worths were measured for a number of structural elements and selected fission products. Analysis of the data and review of additional experiments at this facility continues. It seems likely that a formal evaluation of these experiments will be submitted for consideration to the International Reactor Physics Experimental Project (IRPhEP).

During general discussion during and after these presentations, we reiterated plans for the next general ENDF release. A new Standards evaluation effort is being coordinated by the IAEA and that work is expected to be completed late in 2016. Having a new Standards file is generally the basis for the next generation ENDF. An informal goal is to have the next ENDF, designated ENDF/B-VIII.0, release at the end of 2017. If a schedule similar to that used for ENDF/B-VII.1 is followed that would imply a "beta0" test file by the end of 2017 … a challenging goal given the Standards release schedule. In an effort to keep this work on track there will be a "mini-CSEWG" meeting, focused on Evaluation and Validation Committee work in the Spring, 2016. This two-day meeting will be hosted at Los Alamos National Laboratory.

Cross Section Evaluation Working Group

Measurements Committee

Yaron Danon, RPI

The measurement committee session was held on November 3, 2015. Six presentations representing experimental programs at LANL, ORNL, RPI and, NIST were given; there was also a status report on EXFOR. The presentations provided an overview of current research and measurement performed at the different US laboratories. The full presentations can be found on the CSEWG web site at: https://indico.bnl.gov/conferenceTimeTable.py?confId=1291#20151103.detailed

The Agenda

1. Nuclear Data Experiments at LANSCE: Brief Highlights 2015, Robert Haight (LANL).
2. New Directions on Nuclear Data Activity at LANSCE, Lee, Hye Young (LANL).
3. ORNL Neutron Cross-Section Measurements Activities, Klaus Guber (ORNL).
4. Update on Nuclear Data Research at RPI, Yaron Danon (RPI).
5. NIST Measurements and Standards including Related Work at Other Facilities, Carlson, Allan (NIST).
6. The current state of the EXFOR library, Pritychenko, Boris (NNDC, BNL).

Summary of U.S. Measurement Programs

1. Nuclear Data Experiments at LANSCE: Highlights 2015 (Height, LANL)

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

Summary of recent measurements:

- 236,238U(n,γ) relative to 235U(n,f) – mixed target, Data > 10 keV (M. Jandel DOE ECR)
- 238U(n,γ) showing importance of M1 strength
- 235U(n,γ) capture to isomers (requires fission tagging)
- 242Pu spontaneous fission and (n,f) – gamma-ray spectra (LLNL)
- 67,68Zn(n,γ) astrophysics (with LSU)
- 136Xe(n,γ) Double-Beta decay backgrounds and physics (with IU)
- 161,162Dy(n,γ) Strength functions and resonances (with NCSU, Charles U.)
- 173,174Lu(n,γ) radioactive samples! (CEA)
- 191,193Ir(n,γ) Capture data > 10 keV

Data for 238U(n,γ) was presented and is in good agreement with current evaluation, multiplicity data was used to obtain the M1 strength and improve theoretical calculations
.
Data for radioactive 63Ni(n,γ) results in MACS increase of factor of 2 compared to prior work.

GEANIE – (GErmanium Array for Neutron Induced Excitations)
Measurements discussed:

- 187Re(n,xn)
- Population of isomer in 109Ag(n,2n)108Ag
- 136Xe(n,xn) for 0νββ backgrounds with Josh Albert, Lisa Hoffman, et al. (IU)
- Neutron-induced γ-ray standard measurements: 56Fe, Cr, B, Ti (n,n') γ-ray comparisons as a function of En.

The detector was retired for unknown period of time.

Neutron-Induced Fission Fragment Tracking Experiment (NIFFTE) project
MICROMEGAS detector with segmented anode planes, 5952 hexagonal pads, 3D particle tracking, 4π solid angle coverage, custom electronics, sustained 60 MB/s.
Results of preliminary 235U Fission Fragment Anisotropy measurements were presented as a function of neutron energy from 0.1 to 100 MeV.

SPectrometer for Ion DEtermination in fission Research (SPIDER)
2E2v instrument for high mass resolution fission product yields. Thermal neutron fission fragment mass distribution for 252Cf, 235U and 239Pu were presented. For 235U and 239Pu good agreement with England and Rider was observed.

TKE and mass distributions with a Frisch-gridded ionization chamber
TKE as a function of incident neutron energy (<30 MeV) were presented for 235,238U and 239Pu. The data are in good agreement with the evaluation of Lestone et al 2011.

Chi-Nu - Prompt fission neutron spectra
PFNS was measured using the Li-Glass detector array. Preliminary results for 235U were presented covering the energy range from 0.02-1 MeV. Below 0.1 MeV the new data are slightly higher than ENDF/B-VII.1 but both agree within experimental uncertainty.

2. New Directions on Nuclear Data Activity at LANSCE, Lee, Hye Young (LANL)

16O(n,α) measurement at LANSCE

Reviewed previous work and then discussed Low Energy NZ (LENZ) that is developed at LANL. LENZ uses: twin Frisch grid ionization chamber, multi-target wheel system, at forward angles, silicon strip detectors measures angles and charged particles as a telescope. The detector will be used at LNSCE with a white neutron spectrum. They plan to use solid Ta2O5 target also with ratio to Li2CO3. Total uncertainty is estimated at about 12%

Neutron Array at DANCE (NEUANCE)
DANCE hardware upgrade, provides new measurements on correlated data between neutrons and gammas in neutron-induced fissions with high efficiency. Work is in progress.

3. ORNL Neutron Cross-Section Measurements Activities, Klaus Guber (ORNL)
Results were presented for resonance region transmission and capture measurements on Ce. The measurements were done at IRMM and can be used to improve the resonance region evaluations.
Capture data for V were also presented and transmission will follow.

4. Update on Nuclear Data Research at RPI (Danon, RPI)

Transmission:
Fast neutron transmission from 0.5 to 20 MeV was measured for W and Pb. For W, overall the measured total cross section is higher than ENDF/B-VII.1, at 2.5 MeV the difference is about 2.5%. Pb shows good agreement with the ENDF/B-VII.1 evaluation.

Update was given on O-16 transmission between 0.5-20 MeV. Between 3.2-6MeV the ratio of the new experiment to Cierjacks 80 is 0.968 and to Cierjacks 68 is 1.009. This confirms that the Cierjacks 80 EXFOR data was not normalized as stated in the Cierjacks 80 paper. Below 3 MeV the new experiment has better energy resolution comparted to Cierjacks 68 and is comparable to Johnson 1974.

Fast Neutron scattering
Fast neutron scattering (0.5 MeV - 20 MeV) from a Pb sample was measured at 8 angles. Data was compared to different evaluations. Resonance structure is visible and issues with annular distribution were discussed.

Neutron Capture
Neutron capture on Fe-56 sample was measured from 1 keV to 2 MeV using four C6D6 detectors. Above 847 keV pulse height rejection was used to remove inelastic gammas. The data can be used to improve the current CIELO evaluation especially above 200 keV where only one high energy resolution experimental data set exists.

Thermal neutron scattering
A method to generate a phonon spectrum from double differential thermal neutron scattering experiment was presented. The method was used to produce am ENDF evaluation for polyethylene at room temperature. Experimental data was show for polyethylene comparing with the evaluation generated from the data. The new evaluation agrees better with the experiment and also integrate to total cross section that is in excellent agreement with the experiment of Granada 1987.

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

A review of the latest activity related to ENDF standards was given.

H(n,n) – Concerns about the hydrogen total scattering cross section at low neutron energies led to Van de Graaff work by Daub et al. from 150 keV to 800 keV. The results were systematically slightly larger than the ENDF/B-VII.1 (Phys Rev C87, 014005, 2013). New total cross section measurement from Kentucky by Yang covers the low energy range from 100-400 keV and agrees well with ENDF/B-VII.1

H(n,n) - Angular distributions - work is being done at the Ohio University accelerator facility. Preliminary measurements have been made at laboratory neutron scattering angles from 20 degrees to 65 degrees in 5 degree steps for 14.9 MeV incident neutrons. The plan is to increase the accuracy of the measurements and extend the angular range so that data are obtained from 15 to 70 degrees. Plans have also been made to do similar measurements for 10 MeV neutrons. For this work the 252Cf neutron spectrum standard was used to determine the efficiency of the neutron detector

6Li(n,t) – Absolute measurement of the cross section at 4 meV was competed (NIST, LANL, the University of Tennessee and Tulane University). The cross section obtained 2563.3±7.7 b for a neutron energy of 3.3245±0.0016 meV. When transformed to thermal (0.0253 eV) this measurement is about 1.1% lower than ENDF/B-VII.1.

Above 2 MeV the new Hale evaluation is consistent with the Devlin et al. data. At 2 MeV it is about 4% higher than ENDF/B-VII.0.

At the GELINA LINAC, Hambsch plans angular distribution and cross section measurements for the 6Li(n,t) reaction. The cross section data will be relative to the 235U(n,f) standard. This work will extend from a few keV to about 3 MeV so the resonances at 0.25 and the weak one at about 2 MeV will be covered. The 6Li samples were supposed to be made last year. They are using a digital data acquisition system for these experiments.

10B(n,α) – The IRMM measurement by Hambsch was discuss the some results presented. Impact on standards was not discussed.

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

Additional total cross section work at Kentucky was done by Yang going to lower incident neutron energy of 90 keV.

Au(n,g), 238U(n,γ) – Wallner (U. of Vienna) made measurements of the 238U(n,g)/ 197Au(n,g)
cross section ratio at 426 keV. Accelerator mass spectrometry was used to measure the 239Pu resulting from the 239U. Activation was used for the gold measurements. The measurement has a large (150 - 200 keV FWHM) energy spread. That ratio, 0.99± 0.04, compared with the standards evaluation is in excellent agreement

238U(n,γ) - Ullmann et al. made measurements of the 238U(n,γ) cross sections using the DANCE (160 BaF2 crystals) detector at LANSCE and thin samples. The neutron beam was monitored with a 235U fission chamber, a BF3 counter, a 6LiF detector and a 3He detector. Analysis is in progress. The data was normalized at 80 and 145 eV resonances, and only the shape can be used for an evaluation. They associate a 2 percent uncertainty to this normalization. The energy range is 10 eV to 500 keV. In the evaluation, the data will be used up to 10 keV and above 200 keV because of an apparent contribution from aluminum resonances from the encapsulation of the sample. The data include some points that do not agree with the recent IRMM experiment and the evaluations.

235U(n,f) - There have not been any new measurements. However work at the n_TOF facility in a publication by Barbagallo has raised some concerns about the cross section in the energy region from about 10 to 30 keV (not in the standards energy region). Their work compared fluence determinations based on 10B(n,α), 6Li(n,t) and two 235U(n,f) based detectors. The two 235U(n,f) based detectors agreed with each other but were about 10% lower from about 10 keV to 30 keV than the 10B(n,a) & 6Li(n,t) detectors. This could indicate a problem with the 235U(n,f) cross section or a problem with the n_TOF data. This requires more investigation.

238U(n,f)/235U(n,f) Measurements - Four measurements of the cross section ratio were made at the n_TOF facility. From 0.5 MeV to 200 MeV the measurement is in good agreement with ENDF/B-VII.0 and the Lisowski measurement. There is some issue with resolution (grouping?) or background in one of the deeps need 20 MeV.

238U(n,f) - Measurements have been completed and analyzed by Miller from the University of Kentucky of the 238U(n,f) cross section relative to hydrogen scattering. The absolute data are shape measurements extending from 100 to 300 MeV. The data were obtained at the LANL WNR facility. The data is in good agreement with the Lisowski measurement.

239Pu(n,f) - The most recent 239Pu(n,f) cross section measurements were made by Tovesson
and Hill at WNR-LANL. The data are actually two separate measurements, one for energies from 0.01 eV to 200 keV and one for 200 keV to 200 MeV. In the low energy experiment, structure not present in other experiments, is present. Only the data below 30 keV will be used in the next evaluation of the standards. For the high energy experiment, it agrees reasonably well with the ENDF/B-VII standards evaluation and the

Lisowski et al. and Shcherbakov et al. measurements up to about 10 MeV. The new measurements have somewhat smaller uncertainties than these other two data Sets.

Current status and future directions of the EXFOR project, (Boris Pritychenko, BNL)
A review of the recent status and activity related to EXFOR was given. Old data from ORELA is in the pipeline to be entered to EXFOR.

Cross Section Evaluation Working Group

Covariance Committee

Donald L. Smith

A meeting of the CSEWG Covariance Committee, with duration of approximately 2 ½ hours, was held during the 2015 annual CSEWG meeting that, itself, was a component of Nuclear Data Week 2015. The covariance meeting was comprised of a single session that took place on Wednesday morning, 4 November. There were 5 submitted contributions. The contents of the presentation files are available on-line through the Indico conference management platform. These can be downloaded from the following webpage:

https://indico.bnl.gov/conferenceTimeTable.py?confId=1291#20151104.detailed

These presentations deal with evaluation methodology as well as specific results from recent evaluations.

D.L. Smith (ANL), R. Capote (IAEA), and D. Neudecker (LANL)

UMC: Unfinished Business

The deterministic generalized least-squares (GLS) methodology has been a workhorse for over four decades in the nuclear data field for use in generating evaluated mean values and covariances. In principle, it is based on a rigorous statistical foundation. However, the actual equations used in realistic evaluations for ENDF/B and other nuclear data libraries involve approximations that, in instances where uncertainties are large, non-linear effects are involved, and discrepant data are considered, can lead to biased results, e.g., the PPP (Peelle's Pertinent Puzzle) phenomenon. For this reason, some nuclear data researchers are investigating alternative and more sophisticated approaches to data evaluation based on more inclusive stochastic formalisms that strive to address these issues and that may prove beneficial in the future. These new approaches tend to be computationally intensive, and this is the main reason, but not the only one, why they have not been widely implemented to date. UMC (Unified Monte Carlo) is one of these approaches. This talk described the basic principles and issues associated with the UMC technique. It was shown that there are two approaches to implementing this method (see the slides for this presentation). Each has its advantages and disadvantages. The presentation identified technical areas that need to be investigated in order to better understand UMC and to assess its practical worth for realistic evaluations. It was concluded that these issues can be investigated at the outset using simple test cases, especially ones involving extreme conditions of non-linearity, large uncertainties, and discrepant information. This ground work should be addressed first before launching large-scale evaluation projects that utilize UMC.

R. Vogt (LLNL & UC Davis), P. Talou, T. Kawano, I. Stetcu (LANL), and J. Randrup (LBNL)

Sensitivity Studies of 252Cf(sf) Observables to FREYA Inputs

This work utilized the code FREYA that is being developed to study neutron fission phenomena. The presentation emphasizes issues related to fission-fragment total kinetic energy (TKE) and prompt fission neutron spectra (PFNS). The relationship between TKE and prompt fission neutron observables for neutrons and photons has been investigated, and is discussed here. It has been observed that average TKE has a huge impact on average neutron multiplicity. Furthermore, it is observed that TKE(A)/<TKE> is rather similar for different isotopes and different energies. An important issue addressed in the present work is that of assessing how much changing TKE(A) influences the above-mentioned prompt fission observables. 252Cf spontaneous fission has been used as a test bed for this investigation. To date, FREYA calculations have been performed with various input TKE distributions to investigate this matter. To do this, code FREYA had to be modified to read in sampled yields and produce coherent output. A covariance analysis of TKE(A) data was made, and the resulting covariance matrix was sampled to produce 1000 TKE(A) files to use as FREYA input. It was found that parameter variations within the constraints placed by this covariance matrix generally produce fairly small spreads in most of the neutron observables. The recommended error for <TKE> for 252Cf(sf) is 1.5 MeV. It was seen that varying <TKE> by 0.1% can make the average neutron multiplicity vary by 0.7%. This is a huge error on this critical value. The greatest variation in neutron multiplicity and neutron kinetic energy as a function of mass A is for A < 90 and A > 160 where the TKE(AH) spread becomes large. The sensitivity of the neutron multiplicity distribution is small near shell closure at A = 132. The average energy is also small at this point where the deformation is small, i.e., more deformed light fragments near symmetry emit more energetic neutrons. Turning to PFNS, the spectral shape (divided by average neutron multiplicity to normalize to unity) shows little variation (at least on a log scale) at low outgoing neutron energy, but the high energy tail is broadened. The average emitted-neutron energy decreases overall for higher neutron multiplicity. Furthermore, it has been found that the correlations are relatively insensitive to TKE(AH)! This is an important result for applications interested in correlations. The presentation also mentioned some other new developments with FREYA. For example, Version 1.0 of FREYA has been published: Comp. Phys. Comm. 191 (2015) 178.

M.T. Pigni, S. Croft, and I.C. Gauld (ORNL)

Uncertainty Quantification in (α,n) Neutron Source Calculations in an Oxide Matrix

This presentation emphasizes the importance for applications of α-particle interactions with materials, reviews the current status of data for (α,n) cross sections, and discusses a methodology for generating 17,18O(α,n) cross section covariances as well as U and O stopping power covariances. The present approach is applied to estimate the uncertainty in the neutron generation rates for uranium oxide fuel types due to the uncertainties in cross section and stopping power values. This research is a component of a joint project with LLNL and LANL to quantitatively assess nuclear data uncertainties for safeguards and nonproliferation applications. ORNL has focused on cross-section covariance data for light nuclei used for neutron source calculations. Experimental (α,n) cross section data as a function of energy, most of it rather old, are available from both thick and thin target experiments that involved alpha-particle energies below 5 MeV. The resonance analysis code SAMMY has been used to fit these available experimental data. Covariance information was also obtained for the calculated cross sections as a product of the resonance parameter fitting process implemented in SAMMY. A determination of cross sections and uncertainties at energies above 5 MeV also made use of available data for natural oxygen, but it did not involve a resonance analysis. An analysis of analytic function fits to ASTAR stopping power data were used to calculate stopping power values and corresponding covariances.

M.T. Pigni, M.W. Francis, and I.C. Gauld (ORNL)

FPY Covariance Matrices in the Thermal and Fission Spectrum Energy Range

There is a need for FPY covariance data to satisfy a Defense Threat Reduction Agency (DTRA) project. This provided a motivation to improve FYP predictions for two noble gases (Kr and Xe). Presently, there is an inconsistency between the FPY sub-library (MT=454 for independent and MT=459 for cumulative) and the decay data sub-library (MT=457) for ENDF/B-VII.1. The evaluated FPY values originate from an evaluation of both independent and cumulative FPYs by England et al. that dates from 1993. It was based on a compiled list of open literature measurements and calculated distributions. Since then, the decay data sub-library has been updated. Although the uncertainties for cumulative FPY evaluated data are reasonable, those obtained for independent (component) FPY are found to be too large to be useful. In 2012, ORNL started a project to develop and investigate methodologies to generate more reliable FPY covariance data. Use has been made of a sequential Bayesian method developed by Kawano. Complete covariance files have been generated for independent FPY data for 235U(thermal, 500 keV, and 14 MeV), 238U(500 keV), and 239,241Pu(thermal). FPY data that exhibit improved agreement with experimental data. Results for the noble gases krypton and xenon have been provided. Consideration was given in these analyses to contemporary knowledge of the decay schemes involved in these processes.

M.C White, D. Neudecker, T.N. Taddeucci, R.C. Haight, H.Y. Lee, and M.E. Rising (LANL)

Impact of Detailed Experimental Uncertainty Quantification and Previously Unknown Biases on the Evaluation of the 239Pu PFNS and Benchmark Calculations

Experimental measurements of PFNS are difficult, mainly because of three effects: 1) the paucity of neutrons in the spectra at high energies, 2) perturbations of the low-energy portion of these neutron spectra by the down-scattering of higher-energy neutrons, and 3) difficulties in calibrating neutron detectors. The conduct of PFNS evaluations requires the consideration of both experimental and model-calculated values, inclusive of uncertainties for both categories of data. Inconsistencies between different experimental data sets, e.g., due to the above-mentioned issues, as well as between experiments and theory, are the norm rather than exception for PFNS evaluations. The present work focused on an examination of experimental PFNS mean values as well as their uncertainties. Owing to clear inconsistencies in the available experimental data, in this case for the 239Pu PFNS, especially at the high- and low-energy ranges of the spectrum, the authors of this work were led to pursue an extensive study of the impact of the experimental apparatus and measurement procedures involved in producing the various old data sets considered for their evaluation, particularly as they pertain to the estimation of uncertainties. A particular emphasis has been placed on the issues of neutron scattering and detector calibration. To accomplish this, detailed models of the individual experiments were generated, to the extent possible based on descriptions provided in the literature and/or discussions with the original experimenters, and these models were then employed in Monte Carlo simulations. It was found that, in general, the original authors of these works either under-estimated or ignored corrections to their measured data that were found, from the Monte Carlo simulations conducted in the present work, to amount to as much as several 10s of percent, mostly at the low- and high-energy ranges of the data sets. It was decided by the LANL evaluators to retain the originally reported mean values for the experimental data but to enhance the uncertainties by including a number of additional estimated uncertainty components that emerged from the simulation exercises. This approach did not lead to actual rejection of data points in most cases, but certainly to their down-weighting in the least-squares evaluation procedure. A discussion following this presentation addressed the matter of whether corrections such as those deduced from contemporary analysis of older experiments should be applied before performing an evaluation. It was agreed that the data recorded in EXFOR should not be altered, and certainly that the data should not be altered in an evaluation unless approved by the original author(s), if they can be located, unless the corrections involve such transparent issues as known revisions in the standards used in such works

Cross Section Evaluation Working Group

Formats & Processing Committee

Micheal Dunn (ORNL)

The Formats and Processing Committee meeting was convened the afternoon of November 2, 2015 at Brookhaven National Laboratory (BNL). No format proposals were submitted for the CSEWG meeting. The initial part of the meeting was devoted to the ENDF library open tracker items in GForge, and these tracker items are summarized in the subsequent meeting notes. During the remainder of the Formats and Process meeting, Lawrence Livermore National Laboratory (LLNL) provided a status report on the OECD/NEA Working Party for Evaluation Cooperation (WPEC) Subgroup 38 effort to develop a new ENDF data structure. Subsequently, Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and LLNL provided status reports for their respective cross-section processing code systems. The Formats and Processing Meeting concluded after the code processing system reports. The following are the minutes from the Formats and Processing Committee meeting.

Formats and Related Issues

ENDF Formats and Manual Updates (David Brown, BNL)

Dave Brown provided a review of the ENDF library open tracker items in GForge. The following is a brief summary of the discussion for the open tracker items:

Tracker ID 950 – Incoherent scattering description in ENDF-102

> There is a need to update the incoherent scattering discussion in the ENDF-102 manual. Brown noted that this manual revision is straight forward, and he plans to resolve when he has time to update this section.

Tracker ID 834 – Multi-level Breit Wigner (MLBW) Angular Distribution in ENDF-102

> The manual needs to include a discussion about calculating angular distributions from MLBW evaluations. Brown requested assistance from Goran Arbanas (ORNL) to contribute to this manual update.

Tracker ID 941 – Clarify kinematics discussion in ENDF-102 Appendix E

> Currently, the collision kinematics discussion in the manual is confusing, and the committee discussed the need to update the manual to clarify the description. An

action to review the kinematics discussion was assigned to Bret Beck (LLNL), Skip Kahler (LANL), Morgan White (LANL), Doro Wiarda (ORNL), and Goran Arbanas (ORNL).

Tracker ID 898 – Fission neutron P(nu|E) and Chi(nu,E)

Dave Brown has updated the manual to include a discussion related to the P(nu|E) and Chi(nu,E) distributions. An action was assigned to LANL to review this manual update for accuracy and provide any needed revisions.

Tracker ID 707 – Line number removal

BNL checking codes need to be updated to "process" evaluation files without line numbers. The removal of line numbers is a format change previously approved by the Formats and Processing Committee. Andrej Trkov (IAEA) noted the line numbers are now optional, and there is still a use to have line numbers available to help locate items in a file (e.g., during a evaluation file review). Brown agreed the line numbers are now optional. Further, Brown noted that he will remove the line numbers from the evaluations and process with the BNL checking codes to see which codes crash.

Following the tracker item discussion, Brown noted another open action item pertaining to the need for a new format proposal to define interpolation in Kalbach-Mann kinematics data. Specifically, the ENDF format rule for interpolating r(E,E') fails to obey $0 \leq r \leq 1$. Different laboratories handle the interpolation of r differently; therefore, a new interpolation is needed. An action was assigned to Caleb Mattoon (LLNL) and Bret Beck (LLNL) to define the special interpolation scheme and submit a new format proposal to the CSEWG.

During the question and answer session, a question was asked as to "how is continuous integration (CI) handled at NNDC?" Dave Brown discussed the CI process. Basically, evaluation submittals come to NNDC on a monthly basis, and BNL "manually" runs ADVANCE to check for changes in the baseline evaluation files. The changes are assessed, and if there are issues identified, NNDC works with the evaluator to resolve the issues.

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

The WPEC established Subgroup (SG) 38 to design an international nuclear data structure. Note that a data structure plus the meta-language defines the new format. The initial WPEC Subgroup 38 effort was proposed in 2012. WPEC SG 38 has been operating for the past ~3 years and is progressing toward the development of a new, modern ENDF data structure. The SG38 effort initiated with the LLNL Generalized Nuclear Data (GND) structure, and the SG38 effort is a natural extension of the LLNL goals. Furthermore, LLNL does not want to impose GND on the rest of the community; rather, LLNL has been working to get feedback on how to improve the data structure to be more general for all users.

The main deliverable is the documentation of the requirements and specifications for the new hierarchy that includes:

- Outline of how the data are evaluated, processed and used;
- Definition of initial data types that the new format must support;
- Specify how the data will be organized.

The draft SG38 requirements documents are complete and serve as guides for developing the format specifications. The three draft requirements documents address: 1) general-purpose data containers, 2) top-level hierarchy, and 3) particle properties. With regard to the general-purpose data containers, there is still disagreement in the SG38 on how best to proceed. The SG has discussed issues with competing goals of the subgroup (e.g., flexibility versus being very efficient, avoiding redundancy by storing data only once versus storing related data together, etc.). The top-level hierarchy requirements document addresses how the data are organized inside an evaluation and/or library. The particle properties requirements document appears to be complete and provides sufficient information for reaction evaluations but likely is not comprehensive enough for an ENSDF-style database. Overall, the requirements are still subject to change as SG38 refines the specification documents. The GND structure is getting more feedback through the SG38 working group effort, but more feedback is solicited and welcome.

Mattoon provided a status report on the translation from ENDF/B-VII.1 to GND. Currently, charged particle evaluations still have problems during the translation. A decay sub-library capability needs to be added to the translation. Also, the ability to translate thermal moderator evaluations [i.e., $S(\alpha,\beta)$] is needed.

Additional details pertaining to the GND hierarchy were presented and are provided in presentation available at the NNDC meeting website.

Currently, SG38 still needs to reach consensus on specific points: 1) element names versus evaluation versus material versus MAT, etc. 2) How many special cases should be supported. 3) Are the data containers general enough? Are more options needed? As a result of these outstanding items, SG38 requested an extension until May 2016 to complete the SG38 effort. The main deliverable will be the requirements and specifications documents with other tasks remaining. After completion of SG38, a new subgroup proposal will be submitted to the WPEC to focus on infrastructure, API, and quality assurance. Furthermore, a new long-term subgroup is envisioned that will oversee the new format once the new format is established.

Following Caleb Mattoon's presentation, the floor was open for discussion. The audience asked: "what will GND provide that the current format does not provide?" The new format will not be limited to 11 digits. Also, the new format will provide improved quality assurance (QA) on the data. Also, GND will enable expanded physics information to be provided in nuclear data evaluations. Morgan White (LANL) noted that we will be able to provide correlated data for (n, 2n) reactions that are needed for detector response functions. Also, the new format will enable consistency checks on the data.

With regard to the new governance model, Mike Zerkle (BAPL) noted: we need to make sure the new governance model includes ownership to ensure the new format will survive and carry on for a number of years into the future. The current ENDF/B format has served the community for ~60 years.

Andrej Trkov (IAEA) noted: the IAEA is interested in coordinating a verification project to make sure processing codes are properly tested to ensure the codes can process the new format. Robert Capote (IAEA) noted the IAEA has established a new consultants meeting (CM) to focus on the process code development and testing effort.

Status of Processing Codes

NJOY Status Report (Skip Kahler, LANL)

Skip Kahler provided a presentation "NJOY – Current Status and Future Plans" that included an overview of the NJOY Nuclear Data Processing Code System including recent history, the current status, and future upgrade plans. The current public release of NJOY is NJOY2012.50 that was released in February 2015. The latest release includes improved memory management and transition of the code language to FORTRAN 95. Skip noted that new code patches are nearing completion and will be released in the next few months after the CSEWG meeting. Subsequently, a review of the current NJOY updates in process was provided during the presentation:

- Detailed elastic scattering angular distributions associated with LRF-7 evaluations. A coding patch is available to provided the angular distributions from the resonance parameters, and this patch has been shared with the CIELO working group to allow testing of the new LRF=7 evaluations such as ^{56}Fe. Currently, the patch will over-write the File 4 angular distributions, and we need to assess whether this is the best approach going forward. The patch provides very detailed angular distributions, and LANL is still assessing ways to reduce the number of angular distributions.
- NJOY will include THERMR and LEAPR improvements resulting from the WPEC SG42 effort.
- An update has been developed to add the latest "CODATA" physical constants. Skip noted that there is a need to compare with AMPX and FUDGE because the new constants will impact computational results. So, the comparison study is needed to make sure we are all consistent in the processing effort.

- An update is in process to expand ACE to include covariance data. At this point, the specifications have been developed, and the code development is in progress.
- An ACE version 2 format has been developed. ENDF/B-VII.1 (.80c – 0.86c) has already been issued in a preliminary "v2" format, but this new format is not recognized by the current version of MCNP6. Further revisions are in progress in an effort to make this format more robust.

In the near term, work will be performed to complete the updates noted above. Also, there is work in progress to develop and deploy a new clean code version, NJOY2016. At LANL, efforts are in progress to work with LANL management and LANL Tech Transfer on the release process for NJOY2016. Currently, some customers have to pay to obtain NJOY. The LANL technical organization that develops NJOY is hoping to retract some of the software release policy that has been set in place by LANL Tech Transfer. The overarching goal is to help make it easier to obtain NJOY for the end user.

With regard to long-term plans, Skip noted that he plans to retire. A new, modern version of NJOY is being developed by Jeremy Conlin. NJOY21 will be able to process the new GND format. During the presentation, Skip provided a status report on the NJOY21 development effort. The new code will maintain capability of and backwards compatibility with NJOY2012. The code package is being developed with modern software development practices (e.g., unit test, regression tests, issue tracker, etc.). Also, NJOY21 will be written in C++ with Python bindings, and the software will be maintained in a GIT repository under version control. As an additional goal, LANL is working to "eliminate export control restrictions" and develop an "open source" version of NJOY.

Following the NJOY presentation, the floor was opened for discussion. The initial question: "Will NJOY2016 be available to support processing of ENDF/B-VIII?" Skip noted the new version of NJOY2016 will be released later in CY2016 after the release of ENDF/B-VIII Beta 0.

The subsequent discussion focused on the need to process angular distributions for LRF=7 resonance evaluations as part of the CIELO effort. Also, the CSEWG needs to be able to assess what level of angular thinning is needed for applications. Furthermore, there is a need to have a patch available to the broader community to allow users to assess whether File 4 should be kept over angular distributions computed from the resonance parameters.

The Formats and Processing Committee asked if NJOY2016 will keep all of the current capabilities and will NJOY21 keep all of the features as well. Skip noted that NJOY2016 will maintain all capabilities. NJOY21 will also keep most, if not all capabilities; however, we will need to re-assess whether all capabilities are needed.

A final question was asked: will NJOY ever be updated to accommodate parallel processing? In principle, the answer should be "yes," but in practice, a single processor mode does accommodate all current processing needs.

AMPX Status Report (Dorothea Wiarda, ORNL)

Dorothea (Doro) Wiarda provided a detailed status report on the AMPX development and maintenance activities since the previous Formats and Processing Committee meeting. The presentation covered improvements to the multi-group processing capabilities, the ability to process ENDF/B File 35 covariance data for exit energy distributions, and the AMPX modernization effort.

With regard to multi-group (MG) processing, the AMPX group-averaging code, X10, has been completely refactored and re-written in C++ to take advantage of a new "in-memory" MG resource that also removes the restriction on the maximum number of energy groups. The MG resource allows all data to be stored and accessed in memory for a myriad of processing operations. Also, AMPX has integration routines that can be shared within the AMPX code system. Also, a new SCALE/AMPX class has been developed and defines the sum rules for redundant cross sections and functions that apply the rules for MG data. Furthermore, the new X10 code applies more rigorous consistency (i.e., 2D matrices are renormalized to 1D data to avoid numerical problems, integration of group-averaged 1D data is analytical, etc.). With regard to integration capabilities, integrals can be translated into a system of ordinary differential equations, and a fourth-order Runge-Kutta method is used with an adaptive step size. AMPX supplies a C++ base class that is used for integration operations. Furthermore, the group averaging of scattering matrices has been improved to utilize the new AMPX integration capabilities (i.e., translate outer integral to differential equation and use fourth order Runge-Kutta method).

In addition, the capability to provide resonance self-shielding factors has been enhanced. The AMPX code to calculate Bondarenko factors, FABULOUS, has been rewritten in C++. All integration is performed with subclasses of NumIntegrate. As an additional functionality, narrow resonance f-factors are generated in the unresolved resonance region (URR) from probability tables.

In addition, AMPX has been expanded to provide "intermediate" resonance self-shielding factors that lead to improved computational results over the Bondarenko factor approach for reactor analyses. AMPX now includes capabilities to generate "homogeneous" f-factors for nuclides with A>40 in the resolved resonance range. The factors are generated using the SCALE CENTRM pointwise Sn tool to calculate a CE flux for a homogeneous pin-cell model. The CE flux is then used in the MG library generation to provide the intermediate self-shielding factors. Likewise, a new SCALE/AMPX procedure has been developed to calculate intermediate f-factors based on a heterogeneous pin-cell model. These self-shielding factors are then stored on the MG library for subsequent transport calculations. In order to account for better in-group elastic scattering treatment, a new procedure has been developed to provide "with-in" group scattering f-factors, and these factors can be added to an AMPX-generated MG library for reactor calculations. Subsequently, Doro presented results using the new POLARIS lattice physics code in SCALE. Using the new MG progressing capabilities, the lattice physics calculations are within 15 pcm of CE results for a PWR pin cell calculation.

Since the last CSEWG meeting, the AMPX covariance processing capabilities have been updated to process Chi covariance data available in File 35. Doro showed results for ^{235}U correlation matrices from ENDF/B-VII.1. With the new processing capability, AMPX has been used to generate Chi covariance data for SCALE 6.2, and the new SCALE covariance library includes covariance data from ENDF/B-VII.1 as well as JENDL 4.0.

With regard to AMPX modernization tasks, the following modernization tasks have been completed:

- Merge AMPX with SCALE software repository,
- Develop AMPX under SCALE QA plan,
- AMPX development performed under SCALE continuous integration framework,
- The AMPX collision kinematics module, Y12, has been completely refactored in C++,
- The AMPX MG processing module, X10, has been completely refactored in C++,
- The AMPX modules needed to produce self-shielding factors, FABULOUS, has been refactored in C++.

In the coming months, the AMPX modernization effort will involve code-refactoring efforts for PUFF (covariance processing module), POLIDENT (code to produce CE data from File 2/3 data), JAMICAN (CE collision kinematics processing for Monte Carlo libraries), PLATINUM (code to assemble CE libraries), and BROADEN (Doppler broadening module). All of the CE codes will utilize a new “in-memory” resource that is shared between SCALE and AMPX.

In addition, efforts are in progress to update AMPX to support the WPEC SG38 effort and process the new GND data structure. ORNL is participating in the SG38 effort and has developed initial tools to enable working with GND.

After the AMPX presentation, there were no questions or comments for Doro regarding the AMPX status.

FUDGE Status Report (Bret Beck, LLNL)

Bret Beck provided a presentation titled “LLNL’s Nuclear Data Infrastructure.” The LLNL processing code is FUDGE (For Updating Data and Generating ENDL and For Updating Data and Generating Evaluation), and this code package handles all LLNL nuclear data management, updating and processing tasks. The code effort was initiated in 2002. The top level is written in Python that allows for scripting and interactive running. LLNL has added support for GND, and the main development efforts are now focused on GND. LLNL plans to port FUDGE to GIT. Then, the code package will be available on GIT Hub. Currently, LLNL is sending the software for distribution from the NNDC website.

During the presentation, Bret reviewed the current capabilities in FUDGE. During the last year, LLNL had to deal with a "nuclear data crises" that consumed much of the staff time. Specifically, there was an issue converting ENDF to ENDL, and the effort showed how limiting the ENDL format is. During the past year, much effort has been devoted to updating GND based on comments from SG38, and FUDGE has been updated to track with the changes to GND.

FUDGE has been updated to provide particle capability improvements. Previously, ENDL supported the transport of 7 particles. With the new updates, we can now support processing of "any" localized collision with "any" input and output particles. Subsequently, Bret presented the current processing capabilities in FUDGE, and the details are available on the presentation slides located at the NNDC CSEWG meeting website.

Currently, LLNL is performing checks and verifications with other processing codes (e.g., "heating," 1D processing, etc.). FUDGE supports cross-section processing for deterministic transport codes and includes capabilities such as grouping and computing transfer matrices. They need to implement self-shielding and thermal neutron scattering capabilities. In addition, FUDGE also supports Monte Carlo processing. With regard to thermal nuclear processing, they have a capability in ENDL and need to implement in FUDGE/GND. At this stage, FUDGE does not support thermal neutron scattering, self-shielding, and URR methods (e.g., probability tables and multi-band).

In summary, LLNL will release a new version of FUDGE in one month. Furthermore, the code package will be released under BSD licensing that is more liberal than GPL. BSD licensing was requested by the SG38 collaborators in Japan. Another version of FUDGE will be released early next year, and this new version will include transfer matrix processing.

Following the LLNL presentation, the floor was open for discussion. The Formats and Processing Committee asked when will thermal neutron scattering be implemented in FUDGE. Bret noted that this capability will be added in another year.

Mike Herman noted that CIELO files have been converted to GND and back to ENDF using FUDGE. Based on this translation, everything appeared to work fine.

Following the LLNL status report, the Formats and Processing Committee Meeting concluded at 4 PM on November 2, 2015..

Summary of the 18th U.S. Nuclear Data Program Meeting

Held at
Brookhaven National Laboratory, Upton, NY
November 4-6, 2014

US Nuclear Data Program

Chairman's Summary

M. Herman
National Nuclear Data Center, BNL

The 18th Annual Meeting of the United States Nuclear Data Program was held on November 4-6, 2015 and attended by 42 registered participants and comprised also the first meeting of the Nuclear Data Advisory Committee. The meeting was held adjacent to the CSEWG Annual Meeting, which allows for some savings since some of the CSEWG participants are also NDAC or USNDP members.

The presence of the NDAC meeting has imposed necessary changes in the USNDP meeting schedule. First of all, there was no time for the usual session on nuclear reaction modeling. This omission will have to be rectified in future. The traditional reporting session was also replaced by the USNDP report to the NDAC meeting. Effective time available to the ENSDF community for discussing technical issues has been drastically reduced. The possibility of having an additional, structure evaluation and compilation oriented, meeting in odd years is being considered (there is the international NSDD meeting that could be used for such discussions in even years).

The final conclusions of the NDAC are discussed in details in the NDAC report prepared after the meeting. Here we bring up only salient points from the closeout session. NDAC was impressed by high performance teaming (XUNDL, NSDD, Berkeley meeting), results of the BLIP/NNDC/ANL/UMASS collaboration on medical radio-isotope production, and concluded that the reaction library ENDF is advancing very well with effective international collaboration. NDAC also noted that 7 out of 9 review panel recommendations were adequately addressed by the USNDP.

On the 'to do' side, NDAC pointed to the development of the comprehensive document on strategic priorities for the USNDP. There has been open discussion between members of the NDAC and USNDP on the way ENSDF and Nuclear Data Sheets are managed. The Committee expressed their concerns and suggested that the ways the ENSDF and Nuclear Data Sheets journal operate need rethinking in terms of work assignment, bottlenecks, and evaluation productivity. Related issue discussed lively during this session was improved metrics, which NDAC sees as a part of the broader issue - ENSDF operation). Finally, NDAC recommended organization of a workshop on basic-science nuclear data needs (similar to the one on applications' needs held at Berkeley in May 2015).

In the final report NDAC suggested the following priorities:

- Are activities aimed at maintaining and updating the flag ship ENDF and ENSDF libraries (top priority)
- Data measurements and evaluation in support of DOE operated high energy accelerator Isotope Production Program
- A Midwest group at ANL, MSU and Notre Dame should be considered
- Modernization of the ENSDF infrastructure, including development of a new structure (format)

The USNDP total permanent scientific staff in FY2015 was 12.1 (plus 0.6 FTE ECA of Jandel) hitting absolute minimum since FY2007. It should be stressed that in FY2015 there was very little external funding and most of the staff was fully covered from the USNDP budget.

The USNDP budget in FY2015 was $7,054K (plus $500K of ECA) essentially the same as in FY2013. While the ECA funding supports very important measurement of direct interest to ENDF evaluation effort it does not alleviate funding difficulties in some USNDP Labs. If this $500K is subtracted from the USNDP funding in FY2014 and FY2013 it turns out that actual funding in FY2015 was nearly exactly the same as in FY210 and FY2011 and $250K lower than in FY2012. In 2013 USNDP funding (net of early career award) was cut by $1.036M, which affected mostly carry over at the NNDC. Until the end of FY2014 impact of this reduction was mostly offset by the existing reserves at the NNDC and remnants of the ARRA funding at ANL. In order to balance the budget NNDC used the carry over and strove to reduce expenses (travel, purchases, software licenses, some contracts). These measures helped to curtail negative effects of the budget shortage in FY2014 and FY2015 but will not be sufficient to save FY2016, in which shortage of $200K is expected.
LLNL operate on a tiny budget, which is supposed to mostly cover flow of the LLNL evaluations to the ENDF library. LANL lost $59K in FY13 and remained on the flat-flat budget since then.

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

As mentioned on several occasions, modernization of nuclear data formats, facilitating compilation by employing artificial intelligence, and wider usage of nuclear theory and modeling will be necessary to retain healthy USNDP program meeting users' needs and attractive to the young generation of future evaluators.

Three highlights of the FY2015 are:

- Measurement campaign in support of the Isotope production program (papers were published by ANL and by NNDC/BLIP collaboration),
- Workshop on Nuclear Data Needs and Capabilities for Applications at Berkeley, May 2015,
- Calculations of antineutrino spectra at NNDC and related ND experiment at ORNL.

Next Budget Briefing

The next budget briefing will be held at the DOE Headquarters on February 10, 2016. The USNDP team will include USNDP Chairman(M. Herman) , WG chairmen (S. Basunia and T. Kawano) and the members of the USNDP executive committee who have specific issues to bring to the briefing.

US Nuclear Data Program

Structure And Decay Data Working Group

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

Present: T. Barnes, S. Basunia, J. Batchelder, L. Bernstein, D. Brown, J. Chen, P. Dimitriou, R. Firestone, M. Herman, A. Hurst, T. Johnson, J. Kelley, F.G. Kondev, E. Mccutchan, C. Nesaraja, B.Pritychenko, M. Smith, B. Singh, A. Sonzogni,M. Thoennessen, J. Tuli.

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

Status of ENSDF & Nuclear Data Sheets: The ENSDF database has increased in size by roughly 1.9% over the past year. Presently there are 3296 nuclides reported. Along with many revised/updated datasets, 339 new datasets were added to ENSDF. There were 16 mass chain evaluation articles published in the Nuclear Data Sheets (FY15). The number of mass chains in the review/publishing process was given as 26. An additional 24 mass chains are listed as currently being evaluated. General usage statistics for ENSDF and products derived from ENSDF (Nuclear Data Sheets, NuDat, etc.) shows a high usage and popularity on the NNDC website and the Elsevier site.

Status of XUNDL: Based on regular scanning of nuclear physics journals, datasets were compiled and another updated for new publications. The XUNDL database presently carries 6442 datasets covering 2347 nuclides from over 280 mass chains. Over the past year there were an additional 50 or so communications with the authors to resolve data-related issues and obtain additional data in support of their findings. Effective October 1, 2015, E.A. McCutchan at NNDC, BNL has taken up the responsibility of coordination of XUNDL effort.

Status of the NSR: A total of 4215 new articles were added to the NSR database. USNDP contributions are from B. Pritychenko (manager), E. Betak, B. Singh and J. Totans. The database is up-to-date and in good shape. Some effort is being spent to add "historically important" references. At the USNDP meeting, we learned about evaluator access to the NNDC PDF library – a great step forward.

Horizontal Evaluations and Other Data Related Activities: Reports were given on a variety of "Horizontal Evaluations and Other Data Related Activities" involving USNDP structure evaluators. A summary list of these activities includes the following.

- IAEA technical meetings on ENSDF evaluation and analysis codes: Kondev, Singh, Tuli
- IAEA-CRP on Delayed Neutron Emission Probabilities: Singh, Sonzogni, McCutchan, Johnson.
- IAEA-CRP on Nuclear Data for Charged-Particle Monitor Reactions and Medical Isotope Production: F. Kondev,
- The Atomic Mass Evaluation effort (AME) and NuBase: Kondev
- K-isomer evaluation s and fission hindrances: Kondev
- Atlas of Nuclear Isomers: Singh
- B(E2) evaluation for first 2+ states in all the e-e nuclei: Pritychenko, Singh
- Horizontal evaluation of beta-delayed proton emitting nuclei: Batchelder
- nucastrodata.org and the Computational Infrastructure for Nuclear Astrophysics (CINA): M. Smith,
- Collaboration with BLIP on the measurement of decay properties for a few radionuclides: E.A. McCutchan.
- Research activities of the Bay Area Nuclear data Group: A. Hurst, L. Bernstein.

Business and discussions (supplemented by presentations online at BNL)

The meeting began with a short session on the policies and procedures for processing XUNDL work assignments under the new coordination of Libby McCutchan. An overview of the current status of XUNDL was given by Balraj Singh. Then a round table, led by Dr. McCutchan, contemplated various web/cloud driven approaches for managing work products at various stages.

Several discussion periods throughout the meeting were dedicated to developing a plan for implementing NDS JAVA as the mechanism for producing print ready documents for Nuclear Data Sheets manuscripts. This activity has sprung out of prior DoE projects with McMaster University and has found new life in connection with the IAEA technical meetings on ENSDF evaluation and analysis codes. Jun Chen and Balraj Singh have carried out much of the effort (with McMaster student support). The plan is to continue debugging the code until a "beta" version can be rigorously evaluated at a special workshop in the spring – perhaps at TUNL.

An overview of the IAEA Nuclear Data section, relevant to nuclear structure and decay data, was given by Vivian Dimitriou. Important progress, such as the addition of new NSDD structure evaluation data centers, was presented along with other details of their activities.

A discussion on workforce and commitments addressed issues such as timeliness in responding to actions in the A-chain evaluation review process, and continued discussion on metrics. The discussions showed the need for production of a new guideline for NSD reviewers, that gives clear guidance of tasks required of reviewers.

In connection with the IAEA technical meetings on ENSDF evaluation and analysis codes, there was a general discussion on the status of ENSDF evaluator tool codes, including Java Gamut, log ft, Ruler etc. In recent years there has been extended discussion on the present state of ENSDF analysis codes. Several codes are known to have "bugs, which are in need of repair, but there has been little ability to update some codes.

Finally, there were detailed comments given on evaluation and presentation techniques that can be implemented to add clarity in the evaluations as they are presented to the data user community. In addition to these, some notable examples of issues that evaluators encountered were presented and discussed.

As the final meeting action Shamsu Basunia was appointed chair of the Structure Working Group.

US Nuclear Data Program

Nuclear Reaction Working Group

T. Kawano, LANL
Nuclear Reaction Working Group Chair

The Nuclear Reaction Working Group did not meet due to time constraints related to the NDAC meeting.