2014 Annual Meetings:

Cross Section Evaluation Working Group

US Nuclear Data Program

Preface

The 2014 Nuclear Data Week has been held November, 3-7 at Brookhaven National Laboratory. The ND week consisted of the USNDP and CSEWG meetings, which were accompanied by the meeting of Analytical Methods Working Group (AMWG) and Nuclear Data Advisory Group (NDAG) meeting both organized in the frame of the National Criticality Safety Program. Exceptionally this year, the scope of the CSEWG meeting was totally focused on the international CIELO project. The schedule of the Nuclear Data Week was the following

- CSEWG/CIELO Meeting, November 3-5,
- USNDP Annual Meeting, November 5-7,
- AMWG Meeting, November 5,
- NDAG Meeting, Nov 6,

This arrangement was similar to the one introduced in 2012 and aimed in minimizing overlap between USNDP and CSEWG to enable participants to attend both meetings if they wished to do so. The ND Week had been preceded by a meeting of WPEC Subgroup 38 dedicated to the development of the new data structure intended as replacement of the current ENDF-6 format. Minutes of the latter meeting are included in the present report.

For the first time, all meetings of the ND Week, including WPEC SG38, 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/conferenceDisplay.py?confId=868.

Next Meeting

The next Nuclear Data Week will be traditionally held at BNL Nov. 2 - 6, 2015. The individual meetings will tentatively be held following the 2013 schedule:

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

Jan 18, 2015

Michal Herman
CSEWG chair
USNDP chair

Summary of the 64th Cross Section Evaluation Working Group Meeting / CIELO

Held at
Brookhaven National Laboratory, Upton, NY
November 3-5, 2014

The 64th CSEWG meeting was held November 3-5, 2014 at the Brookhaven National Laboratory. Exceptionally this year, CSEWG meeting has been fully dedicated to the review of the work carried out within the frame of the international CIELO project. Therefore, with two exceptions, all presentations were related to the evaluation of CIELO isotopes 16O, 56Fe, 235,238U and 239Pu. All aspects of the work pertinent to the above isotopes were covered in the three days of presentations and discussion allowing for a quite detailed picture of the CIELO project status. Because of this focus, however, typical topics covered during usual CSEWG meetings were not addressed. In particular, there was no Formats Committee session. The evaluation, validation, measurements and covariances were covered only for the specific CIELO isotopes while all the work on materials outside the scope of CIELO was left out. We plan to have a mini-CSEWG meeting on May 5-6, 2015 to discuss topics that were eliminated from the last CSEWG meeting.

The 64 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 foreign visitors. Due to the CIELO focus the foreign participation was unusually strong. There

were 8 French visitors, 2 from Austria, 2 from Canada, 2 from UK, 1 from South Korea, 1 from Belgium, and 1 from Slovakia for a total of 17 foreign participants.

Cross Section Evaluation Working Group

CIELO

M. Chadwick, LANL

We dedicate this CSEWG meeting to Cecil Lubitz, KAPL, for his outstanding contributions over the history of ENDF, and hope and expect they will continue in the coming years now that he has retired and has even more time for nuclear data.

Main conclusions and actions

The various files being generated for testing will be archived and put under version control by David Brown at BNL.

Actinides and PFNS.

PFNS:
Inter-compare 235U thermal PFNS from the IAEA with Talou-Rising results.
Inter-compare "fast" 235U PFNS from IAEA with Talou-Rising, ENDF, and with the Morillon CEA proposal, and with Lestone's data.
For 239Pu, create a PFNS mod from Neudecker's work for CIELO/B that (a) is harder in the fast range (to better match the spectra index data for 238Unf/235Unf and 239Pun2n/Punf and Lestone);(b) uses Romano value at thermal, and (c) uses current improvements obtained above 5 MeV.

235U. The CEA will distribute their evaluation in the fast range, combined with the new resonance analysis from ORNL, for testing. A trial version using the new thermal 235U PFNS will also be made and tested. This will allow us to study impact of other changes working in concert with the PFNS, including nu, and oxygen changes.

238U. The IEAE will provide their latest evaluation – which seems to generally perform very well - for testing. The new TUNL 238U n2n will be inter-compared with the IAEA dosimetry evaluation. A question will be the extent to which the present C/E discrepancies of the BigTen critical assembly might be compensated by the proposed 235U PFNS changes (be they CEA,Talou-Rising, IAEA, etc).

239Pu. Inelastic scattering will continue to be studied. A starter file that is ENDF/B-VII.1 with SG33 and with various PFNS options (see above) will be created. The new LANL/DANCE 239Pu n,g data should be used in a trial capture update, and implications assessed. The

resonance analysis teams – ORNL and Cadarache – should consider usage of these new data in their 239Pu analysis, as they did for the 235U n,g case.

Updates to prompt fission gamma spectra should be built into the new evaluations, using recent LANSCE and Geel data. Likewise for TKE energy deposition, using new LANSCE data and Lestone assessments.

56Fe evaluation

In general the new resonance analysis from ORNL-Geel performs well, comparable to older evaluations for criticality, The RPI semi-integral scattering data recently measured provide another test of the evaluation. An area of poorer performance was on the neutron transmission "streaming" benchmarks, where KAPL and Bettis pointed to some deficiencies (compared to JEFF). Can ORNL work to see if a modified analysis can lead to improvements here, for Einc<2 MeV?
BNL will develop a new high-energy evaluation. In the mean time we should assess what starting file to use for CIELO/B.
Ohio may perform new measurements on their iron spheres, to better understand the nonelastic cross section obtained. A major discrepancy exists between the data obtained to-date, and the present evaluations and calculations. BNL will study this, and assess whether any reasonable OMs can reproduce the Ohio nonelastic data.

16O evaluation

Implement the new 235U thermal PFNS from Trkov-Capote (IAEA) in trial evaluations (especially into the latest file that merges new resonance analysis data into ENDF/B-VII.1, and into the CEA's developmental file). Then study the interplay of this PFNS change with 16O criticality changes that come from the new o16 evaluations.
Some priority future experiments on elastic scattering on oxygen, and (n,alpha), will be communicated to the High Priority Request list at the NEA.

Some thoughts on starter files for CIELO/A and CIELO/B

CIELO/A – our best assessments to date
Many files exist – and right now it is fine for CIELO/A to have the various files for testing and assessment. David Brown will put them under version control. For example, for oxygen, the developmental files from Hale, Leal, and Kunieda can all co-exist as CIELO/A options. Eventually we expect CIELO/A consensus advances to migrate into CIELO/B as issues get resolved, and as integral performance improves.

CIELO/B – out best estimates, but tweaked/informed by integral data testing
There is merit to creating starter files. These can take advantage of advances already made, especially where demonstrated performance has occurred in integral simulations, and such files will be candidates for regional projects like ENDF, JEFF, JENDL to adopt.
We will expect these starter files to be replaced by CIELO/A files as we proceed.
In many cases there might be logic to having starter files built on evaluations from a variety of projects files – ENDF, JEFF, JENDL. Below we give an ENDF focused perspective, as illustration.

Some suggestions of starter files:

16O - ENDF/B-VII.1, with a fix to the total cross section at low energies.
56Fe - New resonances merged into ENDF or JEFF or JENDL files.
235U - New resonances from ORNL (informed by Dance and RPI capture data), merged into ENDF, and IAEA thermal PFNS. (JEFF might want an analogous merging with JEFF file, etc)
238U - IAEA file.
239Pu - SG33 + ENDF/B-VII.1 + Romano_thermal_PFNS + ENDF_PFNS up to 5 MeV + Neudecker PFNS > 5 MeV.

Detailed Notes

16O evaluation

Arjan Plompen, Geel
Georginis has looked at the quality of the 13C targets, and concludes sputtering was an issue - measurement of the target thickness could have been compromised by sputtering, which changes the thickness. He suggested that 30% differences are possible. He thinks Harrisopulos could be strongly effected. Perhaps Bair and Haas is less effected.

Hale has the original numerical data from Bair and Haas from Duane Larson.
Georginis provides now has a new (n,a) recommendation – increased at low energies compared to ENDF/B-VII.1 (and more like VI.8). Hale and Kunieda preliminary evaluations are consistent with these data, whilst Leal's is similar to ENDF/B-VII.1.

Kahler has an NJOY patch to treat angular distributions. There are some impractical numerical issues in the present implementation that he plans to fix.

Romano shows the total cross section at low energies, with Luiz agreeing with Kopecky-Plompen, and Hale being just slightly higher. Both are quite a bit lower than ENDF/B-VII.1 –

the community agrees that a lowering is needed. Elastic data differ by 10% or more near 3 -4 MeV, between both evaluations.
Cierjacks says his 81 data is normalized to the 68 data. But he didn't – EXFOR is low compared to his 68, by about 3%. There was much argument/discussion about this difference. Hale and Kunieda believe that Cierjacks 81 data need re-normalizing up by a few percent; Lubitz is not yet convinced. The high elastic and high (n,a) ``go together'' in an R-matrix sense. So Hale's evaluation is referred to as "high", Leal's as "low".

Benchmark results:
(Note: done with a version of NJOY which was not yet processing angular distributions from resonance parameters).
Criticality results show that Hale's evaluation is low by 50-150 pcm while Leal's is slightly high (15-65 pcm).
Trend with Above Thermal Leakage – by Romano – Leal's looks better, Hale's has a trend.

Ian Hill identified the benchmarks that are most sensitive to oxygen using dice. HMT is at the top of the list.

New measurements are needed, especially for total, and (n,alpha) cross sections.

Summary
Total cross section near 3.5 MeV according to Hale and Kunieda are quite a bit higher than Leal (and Cierjacks).
Requests:
Good measurement to cover whole range 1 eV - 3 MeV will help understanding why Ohkubo and Johnson values at low energy are too high, and the 3.765(25)b.
Experiment to determine normalization at 3.5 MeV. Likely a different experiment to the one above.

(n,a) Georginis data are now higher, like Hale, and Kunieda. Leal is lower, like VII.1. Proposals were made for new experiments at nTOF, and Caen. All current (a,n) measurements are deemed to have issues and questions.

Luiz Leal, ORNL
Leal reported on the new o16ornl1.dat resonance file. He adopted 3.783 b for thermal scattering cross section. For the coherent scattering length Leal gets 5.646 b but the experimental values are more like 5.805 – this discrepancy needs investigation. (n,a) based on the recent Geel measurement is ~30% less than original Bair-Haas result.

We hope to see testing sensitive to the oxygen window data around 2 MeV.

Gerry Hale, LANL
Normalizations to data were obtained from the EDA R-matrix analysis using:
Elastic:
Cierjacks-1980: 1.041
Ohkubo: ~ 1.009

(n,a):
Bair and Haas: 0.9882 – that is, Hale's analysis supports the high (n,a) value
Heil, Drotleff : 1
Kellogg: 1.51

Hale and KAPL angular distributions are very similar. LLNL will check unitarity aspects articulated by Hale (we'll ask Hale to send R-matrix parameters to Livermore).
Lubitz – expressed concerns about bringing Cierjacks' data up by 4% - "different world" was his apt comment. Kunieda also renormalized Cierjacks80 upwards by a factor of 1.03.
Regarding the low energy total scattering, Gerry will redo analysis to lower it, in accord with the new Plompen-Kopecky recommendation.
Lubitz challenges Hale's treatment of Ohkubo data, bringing up concerns about contamination of the sample with water.

Cecil Lubitz, KAPL
Lubitz defined Hale's evaluation of (n,a) as 'High' , and Lubitz evaluation as 'Low'.

He described the different opinions relating to normalization biases in various elastic scattering data, pertaining to water contamination in samples, and to handling of Doppler effects. The 3% problem in the thermal scattering has a small effect and is hard to isolate from benchmarking. It went unnoticed for 22 years!

Indicators:
Keff : Trend with oxygen absorption should be flat. We might have results by the end of the week from Paul Romano and VDM.

Tested evaluations were:
ENDF/B-VII.1,
Hale=Iter1,
Leal–RP=ornl1 with angular distributions for Resonance Parameters,
Leal-E71=ornl1 but with ENDF/B-VII.1 OM angular distributions – run inadvertently but serendipitously!

C/E results for the above mentioned files:
ENDF/B-VII.1: 0.99962 (-39 pcm)
Leal-RP: -106 pcm
Hale: -151 pcm, i.e., under-predicting criticality (it was pointed out that other changes could compensate for this, including 235U thermal changes coming with the new 235U file).

Leal-RP's P1 coefficient is higher making the system leakier and less reactive. (Lubitz notes that with ENDF/B-VII.1 angular distributions results are better).
Hale's angular distributions are very similar to ENDF/B-VII.1 (taken from KAPL many years ago).

As far as leakage trend is concerned Hale's evaluation is worse. Hale believes the trend with ATLE is due to oxygen atoms that stop from getting out.

Lubitz's overall perspective on files for use in application calculations: "We need to fix the thermal mistake, but apart from that ENDF/B-VII.1 looks pretty good."

There has been difference of opinion regarding ATFL. Lubitz thinks it isolated oxygen, and therefore we must be wary of messing with ENDF/B-VII.1 (apart from fixing thermal). Kahler is open to the possibility that something else is going on, including 235U changes (for example, we know the proposed softer thermal PFNS will increase criticality).

Skip Kahler, LANL
Kahler presented a number of MCNP simulations of oxygen system criticality. He found results similar to others - i.e., Leal lower by ~30 pcm , Hale lower by ~80 pcm. These results were obtained with proper NJOY treatment of angular distributions in the ORNL processed evaluation.

Trumbull & Romano, KAPL
Performed calculations for a suite of 135 ICSBEP Models using ENDF/B-VII.1 as the base case for cross section libraries. Separate runs made substituting 16O evaluations from ORNL (Leal) and LANL (Hale). The two new evaluations compared back to ENDF/B-VII.1:
ORNL is more forward peaked than ENDF/B-VII.1
LANL (n,a) is higher

Testing included mainly thermal LEU and HEU. The C/E averaged over all integral experiments are :
0.99961 ENDF/B-VII.1
0.9989 Leal,
0.9985 Hale

Both the Leal and Hale evaluations generally cause increased 16O absorption and leakage. Relative to ENDF/B-VII.1, both Leal and Hale introduce slightly negative
C/E trends with ATLF & ATFF. For HST high leakage assemblies increase in oxygen absorption, and leakage, decreases reactivity (for Hale evaluation) while low leakage assemblies are dominated by (n,a) effects. Excluding the PST benchmarks, there are no notable improvements in average C/E using either Leal's or Hale's evaluation. Results from this study do not support adopting either evaluation in lieu of the current ENDF/B-VII.1 evaluation. We discussed that if we used a new 235U PFNS, results could be different.

56Fe evaluation

Mike Herman, BNL
Herman summarized the work on collecting data for neutron reaction on 56Fe, modeling the reactions with ECIS and EMPIRE, and assessing other existing databases. CNDC did a good job collecting all relevant data in the html file for inter-comparison purposes. The Tagesen-Vonach-Pronyaev evaluation from years ago was much liked by CNDC and BNL. It formed basis of EFF3.1. `Standards level' work was done by these magnificent folk, for: (n,2n), (n,p), (n,a), MT=51-54 + lumps, (n,g),(n,el), and (n,inel) cross sections. JEFF-3.0 update included (n,tot) of Weigmann. JEFF-3.2 was adjusted and Rosfond-2010 was taken from this source too. It has been noted that 56Fe(n,p) is a dosimetry reaction and the most recent and precise data are available from IRDFF-2014.

New EMPIRE calculations were done at BNL to reproduce trends in total and various channel cross sections. These results should still be finalized, assembled with the resonance parameters from ORNL to create ENDF/A starting file for testing. Then some adjustments are needed to make ENDF/B,C.

In the process it has been found that the 6th excited state in 56Fe – the lowest 3- level at 3.1 MeV, which is in RIPL-3 and ENDF/B-VII.1 should be eliminated. ENSDF evaluation notes that it appears to be in 7 different reactions. LANL concluded, from the GEANIE experiment, that there is no reliable evidence for the 3- state, and ENSDF evaluators concur. This level didn't appear in Vonach evaluation and in recent inelastic scattering measurements at Geel!

Luiz Leal, ORNL
Reported on resolved resonance evaluation at ORNL including recent Geel measurement. This evaluation extends resolved resonance region up to 2 MeV. Good representation of transmission data up 2 MeV and of capture data up 650 keV has been achieved. Angular data are well fitted up to 1 MeV. RPI data provide a semi-integral test. Good results were also obtained for 56Fe IPPE benchmark data of IRSN (in collaboration with E. Ivanov) but one

should keep in mind that SAMINT code has been used to improve benchmark results by adjusting resonance parameters.

Yaron Danon, RPI

New high resolution transmission measurement from 0.5 to 20 MeV were performed at RPI. Scattering experimental system uses graphite sample as a standard. Neutron flux was determined from fission detector and liquid scintillator, which enables to calibrate detector efficiencies. The results have been made available to ORNL and used for validation of the new resonance range evaluation.

Overall, JENDL-4.0 did better than JEFF-3.2, and ENDF/B-VII.1 in MCNP modeling of this semi-integral data. However, inelastic to elastic ratio is quite well reproduced up to 2 MeV. BNL will send for testing to RPI a new evaluation consisting of ORNL resonance region and new fast neutron estimates.

Steve Grimes, Ohio University

Pulsed Sphere Experiment

Results from 1, 6, 8, and 10 MeV neutron pulsing pair of iron spheres with neutrons detected at various angles, indicate need to lower absorption for Fe by more than 10%. This would be a very significant change and the measurements are being repeated with more detailed Sphere-Off (source spectra) characterization to confirm the result.

Ramsauer Analysis

A large suite of WNR total cross section data was analyzed. Ramsauer formula fits all these data to about 3%. To constrain nonelastic cross sections, use was made of Dietrich approach and Wicks limit. In the range 7-10 MeV Wicks is good to 1%. Knowing total cross section one gets elastic at 0 deg and then renormalize elastic from OM to get total elastic. Subtracting it from total gives absorption that turns out to be by 10% (or more…) lower than in ENDF/B-VII.1.

Skip Kahler, LANL

Data testing on criticality benchmarks was reported. ENDF/B-VII.1 was giving C/E from 0.997 – 0.999. New resonance file from ORNL performs equally well. (In fact better if one used new cross sections and old ENDF/B-VII.1 angular distributions).

Timothy Trumbull, KAPL

120 ICSBEF benchmarks and various transmission data were studied using 56Fe evaluation from ORNL embedded into ENDF/B-VII.1 (CIELO). On average C/E was good and similar to ENDF/B-VII.1. Some significant improvements were noted for ZPRs. We get more

leakage, for reflector systems, e.g. HMF21, IMF005. When iron is internal, an opposite effects is noted. Trend analysis reveals no significant differences for HST, LST. Trend is seen as a function of 56Fe – might this point to an issue in e.g. 56Fe capture cross sect in resonance region?

JEFF-3.1.2 generally performs better than ENDF/B-VII.1 and CIELO files in transmission experiments at 100-500 keV region. CIELO is a bit better than ENDF/B-VII.1 in the 400 – 1400 keV region.

Zerkle suggests that 56Fe data in ENDF/B-VII.1 are problematic because they perform so poorly in transmission experiments.

Thermal neutron scattering S(α,β) data for H2O and D20

Dan Roubtsov, Chalk River

The new evaluation (in ENDF/B) for thermal scattering law files for heavy/light water is under development and testing. New evaluation (in ENDF-6 format) is based on combining molecular dynamics (MD) simulations and experimental data. The resulting models are implemented in LEAPR module of NJOY.

The key differences are:

- use of molecular (self)diffusion for translational motion of H2O/D2O (instead of free gas approximation (FG) used in all evaluated ND libraries)
- continuous vibrational spectra computed from molecular dynamics (MD) simulation at a given thermodynamic state of the liquid (p, T) and (p, T) (instead of derived from neutron scattering experiments),
- a more precise description of the structure of liquid: models for D and O in D2O are based on experimental results
- better numerics

The resulting scattering kernels/cross sections are an improvement over existing scattering law files available in the modern evaluated nuclear data libraries (ENDF/B, JEFF, JENDL). They are compared with measurements of double differential scattering cross sections, quasi-elastic neutron scattering measurements, angular distributions of out-scattered neutrons, average cosine of the scattering angle, and total cross sections.

When the new thermal scattering libraries are applied to the calculation of international neutron criticality benchmarks (ICSBEP Handbook), we find a significant (up to 1100 pcm) difference in the results of multiplication factors, and improving the calculation in 60% of the critical cases.

A new file will be available for testing in about a year. This is in time for the next ENDF library expected in 2016 or 2017. Bob MacFarlane should test the new file.

New measurements are made at University of Indiana IU-LENS (with D. Baxter, 2014) and also at CRL (NRU reactor n-beam and using a triple-axis spectrometer).

Prompt Fission Neutron Spectra (PFNS)

Patrick Talou, LANL
Discussed the global evaluation of Rising, Talou et al, published in NSE that covers U and Pu isotopes. The covariance matrix includes cross-correlations among isotopes.

The 2-3 MeV kink in ENDF files results from ENDF's attempt to match Boykov data. Talou's recommendation is to decrement the focus on Boykov.
For 235U thermal new estimate from Talou will be compared to Trkov's results. So far they appear to be similar. Comparison versus Lestone results also shows a good agreement.

Denise Neudecker, LANL
Presented evaluation of the 239Pu prompt fission neutron spectrum for incident neutrons from thermal to 30 MeV. This evaluation improves underlying theory taking into account expected physics processes and includes new experiments along with detailed experimental uncertainty qualification. The Los Alamos model was extended by accounting for anisotropy in the neutron emission in the Center of Mass system, by allowing different temperatures in the fissioning fragments, considering multi-chance fission, pre-equilibrium effects, and incident energy dependance of <TKE> and <Er>. Evaluated covariances were provided for all incident neutron energies.
The discussed least squares analysis of Pu PFNS data leads to a spectrum somewhat softer than in ENDF. This is because of the influence of Sarasov at thermal, and of Staples at higher incident energies (Lestone has "corrected" Staples data that support a bit harder spectrum – these should be considered). Chatillon data at the highest emission energies might be too low due to detector efficiency bias.

In data testing of the new file the fast assemblies had reduced keff.

Andrej Trkov, IAEA
Reported on IAEA work on PFNS for 235U at thermal. The proposed average energy is 2.00 +-0.01 MeV while values in previous evaluations range from 1.96 to 2.08 MeV (ENDF/B-VII. 1 is 2.03 MeV). Evaluation is complicated by the ambiguity of the experimental data, e.g., Starostov et al, published their data on 4 occasions during the CRP, with different results.

Pursuing Cf/U responses has been quite illuminating, since any errors in the cross sections fall out. Such comparisons point to a problem in the 238U(n,2n) data perhaps being too high – and there is a hypothesis of contamination by photo-nuclear reactions.

Trkov and Capote applied the same method at fast energies, for 0.5-2 MeV.
Using this approach gave a fast PFNS value (<E> about 2.01 keV) – we need to check how this compares against ENDF and against recent Rising-Talou and also Morillon values.

The IAEA PFNS has been tested in relevant benchmarks. High leakage thermal benchmarks are the ones most sensitive to 235U thermal PFNS.
Thermal systems calculate higher because of the softer PFNS. This could be compensated by nubar or 16O data. Fast assemblies reduce criticality a bit but again this could be compensated by other changes (e.g., in 238U IAEA evaluation).

Robert Haight, LANL
Most of the PFNS measurements are affected by some deficiencies. Typical are: (i) multiple scattering (in sample, in collimators, in detector), (ii) detector response (including scattering and light curves for scintillators) and, (iii) detector calibration problems. The MCNP representation of the Starostov experiment requires many guesses. In addition, californium PFNS shows signs of under-correction for multiple scattering also these may cancel in ratio experiments. Sample specifications need to be corrected for Staples experiment. In the same experiment multiple scattering played a significant role in the 239Pu measurement. For the LANSCE 239Pu measurement with a white neutron source by Noda et al. and Chatillon et al. incorrect efficiency lead to lower PFNS at higher outgoing energies.

Yaron Danon, RPI
Prompt fission neutron spectra for 238U were measured using the gamma tag method. Fission chamber was also used to check consistency with the gamma tag method. RPI results for 252Cf-PFNS agree with ENDF. (Note: for 252Cf-PFNS – Starostov results look pretty bad below 0.2 MeV!).

For 238U RPI data are not so different from ENDF for incident energies below 5 MeV, but perhaps RPI sees an excess near 1 MeV compared to ENDF. Experimental results for 238U provide indication of energy dependence of the PFNS.

239Pu Evaluation

Toshihiko Kawano, LANL
Focused on inelastic scattering on 239Pu. Optical potentials gives considerable differences in calculated cross sections. New theoretical development, such as Engelbrecht-Weidenmueller transformation is expected to have significant effect. Kawano combined Engelbrecht-Weidenmueller transformation with the Moldauer approach to width fluctuation correction (with LANL parametrization) and performed improved inelastic calculations. The results differ significantly from the usual calculations neglecting interference between direct and compound reaction mechanisms, especially when direct contribution is strong and number of open channels small. New 239Pu evaluation will be performed using optical potential by Soukhovitskii et al. (with some modification) and Engelbrecht-Weidenmueller transformation.

Skip Kahler, LANL
Presented sensitivities of the benchmark calculations to changes in the PFNS introduced by D. Neudecker. The benchmarks were: (i) PMF1 – Jezebel, a spherical 239Pu assembly including central region spectral indices 238Uf/235Uf; 237Npf/235Uf; 239Puf/235Uf plus selected (n, 2n) ratios, (ii) PMF6 – Flattop-Pu, a spherical 239Pu core plus a natural uranium reflector, (iii) PSTxx – a subset of 8 PST critical assemblies used during SG34 data testing.

Paul Romano and Cecil Lubitz, KAPL
Adjustments to the integral data should be done frequently to observe effect of each change (in evaluation or benchmark description). Adjustment of C/E nearer 1 for PST benchmarks. A stochastically-equivalent data set is being used in the adjustment so uncertainty might stay unchanged - not better physics claim.

Gilles Noguere, CEA
Discussed resonance region in 239Pu, which has been extended up to 4.5 keV. Excellent performance of JEFF-3.2 for MOX fuel calculations was noted. JEFF-311 and JEFF-3.2 provide similar results in THERM spectrum. In MOX calculations the average value obtained with JEFF-3.2 <C-E>=+50 pcm with a standard deviation of 180 pcm. For CIELO Noguere proposes to use SG34 thermal constants (in good agreement with Lubitz and Romano) combined with adjusted PFNS.

Impact of the PFNS mean neutron energy on PST calculations is rather strong. Presently, 300 pcm comes from the uncertainty of <E> in PFNS estimated by Capote to be about 1.5%. MOX calculations from EOLE reactor at Cadarache look pretty good. Noguere showed some PFNS calculations by FIFRELIN that produce -290 pcm in benchmarks. MOX fuel calculations

(EOLE) aren't much effected by the PFNS changes. Adjustment of the mean neutron energy with PST is, however, not recommended by Noguere.

Propagation of the Pu239 resonance parameter uncertainties on EOLE benchmarks shows that final uncertainty is dominated by the capture cross section.
Uncertainties of the latter were reduced from 4.4% in JEFF-3.2 to 1.6% after the Integral Data Assimilation with the CERES program. Assimilation should be redone once other nuclides are finalized. Lubitz suggested that we should agree upon a set of benchmarks.

Tovesson data (2010) confirm fluctuations in the 2.5 keV – 4.5 keV range. Present resolved resonance range ends at 2.5 keV. It could be extend to 4.5 keV using Tovesson data, which change fission by 10% or more. Mazurka and ZPR, SNEAK7a,7b – change by 200 pcm. It seems it doesn't necessarily improve C/E for this benchmark though.

S. Mosby, LANL
Talk on neutron radiative capture studies at the Los Alamos Neutron Science Center was given by Haight. Detailed discussion of the corrections necessary to process data from DANCE detector was presented. Fission produces unwanted signals in DANCE. Scattered neutrons moderate in DANCE crystals and produce light.
Primary challenge for this analysis was to appropriately characterize and subtract off these backgrounds. In addition, there is background from delayed fission gamma-rays and scattered neutrons.

Data reduction procedure was tested on a well known fission cross section on 239Pu. The results agree very well with ENDF/B-VII.1.

Thick target preliminary results for capture agree pretty well with the ENDF/B-VII.1.

Matthew Gooden, LANL
Discussed TUNL measurement of energy dependence of Fission Product Yields from 235U, 238U and 239Pu for incident neutron energies between 0.5 and 14.8 MeV. Joint LANL/LLNL fission product review panel endorsed a possible neutron-energy dependence of 239Pu(n,f)147Nd fission product yield. Two estimates were put forward: change of 4.7%/MeV from 0.2 to 1.9 MeV was suggested by M. Chadwick while Thompson indicated 3.2%/MeV in the same energy range.

Low-energy data come mostly from critical assemblies and fast reactors but there are very scarce experimental data at the MeV-range. Large discrepancy (~24%) exists at 14 MeV.

Measurements were performed at 5 neutron energies (15 measurements) and took almost 80 days of beam time. Each measurement included ~2 months of γ-ray counting. 15 fission fragments have been identified through γ-ray counting : 91Sr, 92Sr, 95Zr, 97Zr, 99Mo, 103,105Ru, 127Sb, 131,133I, 132Te, 135Xe, 136Cs, 140Ba, 143Ce and 147Nd. Data supports a positive slope for 147Nd FPY from 239Pu(n,f)
as suggested by Chadwick.

Fredrik Tovesson, LANL
Fission Total Kinetic Energy (TKE) and Fission Product Yields (FPY) were measured at Los Alamos Neutron Science Center. LANSCE provides neutrons from thermal to hundreds of MeV with excellent resolution for fast neutrons and reasonable resolution for slow neutrons.

TKE experiments were performed on U-238, U-235 and Pu-239 at two neutron facilities: Lujan Center (thermal spectrum) and WNR (1-30 MeV). Fission events were registered in Frisch-gridded ionization chamber developed at IRMM, that measures kinetic energy of two coincident fragments, polar angle of a fragment. Energy resolution for fission fragments is 0.5-1.0%, efficiency reaches ~95%, and mass resolution is 4-5 amu.

For 238U good agreement was obtained with Zoller et al., apart of a slight normalization difference (0.25%). For 235U analysis is in progress. Decrease in average TKE was observed below 1 MeV. Overall normalization agrees with previous experiments. In case of 239Pu sample quality was poor resulting in large uncertainties. New experiment is planned in the next few months. However, first results support Lestone predictions.

Fission Product Yields were measured for U-238, U-235, and Pu-239. Two types of measurements were performed: (i) – 2E method (low mass resolution, high efficiency, revealing gross trends as function of excitation energy), and (ii) – SPIDER spectrometer (high mass resolution, low efficiency, providing precise measurements of FPY at selected excitation energies).

TKE measurements for 238U are completed and publication is being prepared.
Analysis of 235U results is in progress, completion is expected early in 2015.
Pu-239 will require new experiment in 2014 (thermal and fast), if successful new results should be out in mid-2015.

Fission Product Yields for 235U and 239Pu thermal yields are being measured over the next few months.

235U evaluation

Luiz Leal, ORNL
Presented resonance evaluations of 235U for the CIELO project. A well established issue is an overestimation of 235U capture cross-section in the resonance region range (0.1 to 2.5 keV). Recently new data from from RPI (capture and fission yields) (kind of alpha measurements) and new capture data from LANL became available. These data were fitted with SAMMY code. JENDL4 file was used as the template.
RPI capture data confirmed prediction of WPEC SG29. Four transmission measurements, eight fission cross section measurements and four capture cross section measurements were used in the evaluation. Evaluation was performed up to 2250 eV with 3197 resonances (3168 in the energy range analyzed and 29 external)
using the Reich-Moore formalism. Fitted also were integral data such as K1, Westcott factor, capture resonance integral.

The new evaluation was tested in ZEUS benchmark calculations (FCA not available).
Benchmark calculations were done with MCNP with everything else from ENDF/B-VII.1. Results are between ENDF/B-VII.1 and JENDL-4 and are generally in better agreement with the benchmark although there is a trend , which is similar to the one observed with the other two libraries.

Skip Kahler, LANL
Tested ENDF/B-VII.1 and JENDL-4 .0 with the resonance region replaced with the new ORNL evaluation. Tests were performed on GODIVA (HEU-MET-FAST-001), Flattop-25 (HEU-MET-FAST-028), Big-10 (IMF7, detailed model). JENDL-4.0 + ORNL FAST benchmark results are generally worse than those obtained with ENDF/B-VII.1 + ORNL, but JENDL-4.0 + ORNL calculated eigenvalues are more accurate than ENDF/B-VII.1 + ORNL.

P. Romain, B. Morillon, CEA
Presented status of the 235U evaluation in the fast neutron energy region. The calculations were done with the TALYS code. The new file (vers3) was constructed combining CEA fast work with Leal's resonance data. They tested both, the verse file and the Leal+JENDL-4.0 combination (vers2). The verse PFNS is a bit softer than in other libraries. Zeus benchmark turns out to be over-predicted. In this case capture is especially important.
Authors used de-re-construction approach replacing various parts of the vers3 evaluation with corresponding parts of the vers2 evaluation until full transformation of vers3 into vers2 was attained. At each step authors check the effect of the replacement on the Godiva and some other benchmark results. The optimal mixture of the two evaluations was denominated vers4.

Improvement was obtained for Zeus and Jemima but Bigten was still reproduced poorly. Other scenarios were also tried.

Need to redo testing using 238U from IAEA, and 235U thermal PFNS from Trkov. What about spectra indices and (n,xn) dosimetry threshold reactions?

Cecil Lubitz, KAPL
Comment on 235U adjustments - there are still many new developments, so let it play out until dust settles. Meantime we should track changes in a central repository. We need to understand 16O versus 235U-PFNS interplay. We must be careful of taking too much faith in the PFNS given all the spread and arguments in community. NJOY needs to fix number of energy points.

In oxygen broomstick experiment, value at window bottom favors "low evaluation" (Leal). We need work from ORNL to get benchmark detailed/modernized. Cierijacks data has 100 mb while other experiments go as high as 120.

238U evaluation

Andrej Trkov, IAEA
The previous IAEA evaluation, denominated 'ib33', has been derived from 'ib25' after including better physics in the modeling. This resulted in higher inelastic and lower (n,2n) reaction. There are, however, indications for higher (n,2n) cross sections from PROFIL and SPA experiments (see "https://www-nds.iaea.org/CIELO_U238/"). The new 'ib34' version changes (n,n') and (n,2n) again.

There are speculations on possible sources of errors in the (n,2n) measurements inside the reactors. Due to strong gamma field it can't be excluded that (n,2n) measurements are contaminated by (g,n) reactions. It should be checked by calculating (g,n) effects in FNSm and PROFIL. Chadwick noted that LANL criticality experiments, including Big Ten, overlap with the energy range of (n,2n) on 238U.

When looking at the SPA cross section ratio 252Cf(sf)/235U(nth,f) one should expect a smooth trend. Indeed this is observed, except for Manhart (Kobayashi tends to follow the trend). New measurements would be helpful.

Skip Kahler, LANL
ICSBEP benchmarks used for 238U (IAEA "ib33") testing were: (i) Flattop-25 (HEU core and natU reflector), (ii) Big-10 (a large heterogeneous assembly of uranium plates), (iii) Cases 1 and 4 ("Jemima" plates), and (iv) Flattop-Pu (Pu core and natU reflector). Calculated

eigenvalues with the "ib33" file were often closer to unity than those obtained with pure ENDF/B-VII.1 cross sections. Flattop is slightly better,
Big-10 got worse by 100 pcm (but new u235 thermal cross section may compensate this difference), Jemima and Flattop-Pu are slightly better.

Yaron Danon, RPI
The paper on quasi-differential neutron scattering from 238U has been published. This measurement is designated as 'quasi-differential' since MCNP calculations are needed to compare evaluated data with the results of such experiment. Analysis showed that, overall, the JENDL-4.0 evaluation provided better agreement with the new RPI measurement than other libraries. Similar calculation using the IAEA-ib33 evaluation provided even better fit and served as essential feedback to the ongoing development of the IAEA 238U nuclear data file. Furthermore, uncertainties were reduced providing tighter constrains for the new IAEA evaluation.

Summary of the 17th U.S. Nuclear Data Program Meeting

Held at
Brookhaven National Laboratory, Upton, NY
November 4-7, 2014

US Nuclear Data Program

Chairman's Summary

M. Herman
National Nuclear Data Center, BNL

The 17th Annual Meeting of the United States Nuclear Data Program was held on November 4-7, 2013 and attended by 49 registered participants. The meeting was held adjacent to the CSEWG Annual Meeting, with a common USNDP-CSEWG session on nuclear reaction modeling.

The USNDP statutory activities comprise following scientific objectives and targets:

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

The 2014 USNDP meeting was the first after a detailed review of the USNDP program by the external committee in July 2014. The report of the Review Panel was officially released to public shortly after the USNDP meeting but its major recommendations were known during the

USNDP meeting and were subject of discussion during the dedicated session on afternoon Nov. 5. Two working groups have been formed to work out response to the Panel recommendations, one to establish the USNDP Advisory Committee and another to draft the white paper on future directions for the USNDP. Other issues discussed lively during this session included improved metrics, making preparation of the budget briefing more transparent and preserving young talents within the USNDP system. It was noted that the new version of the USNDP mission has been developed before the meeting, approved and is actually in effect.

The USNDP activities have been reviewed and discussed on the second day of the USNDP meeting during the lab reporting session.

The USNDP staff was relatively stable in FY2014 after significant retirements in FY2013. At LLNL the USNDP PI Neil Summers separated from the Lab and his function was taken over by Ian Thompson. At the NNDC Letty Krejci joined in April 2014 (admin) and Annalia Palumbo left in May 2014 (postdoc). Another PostDoc G. Nobre was extended to the end of calendar year and recently for additional 6 months till end of June 2015. Nuclear data program at LBNL has been in a phase of reorganization and the Bay Area Nuclear Data group has been established shortly before the USNDP meeting in November 2014. It is expected that the new structure will have a strong ENSDF/XUNDL related component.

The USNDP total permanent scientific staff in FY2014 was 15.4 decreasing only slightly from 15.5 in FY2013. It should be stressed that in FY2014 there was very little external funding and most of the staff was fully covered from the USNDP budget. There has been a slight decrease in the temporary staff (postdocs) which went down from 4.4 to 4.05 (including early career award at LANL) mostly due to the departure of the postdoc at the NNDC.

The USNDP budget in FY2014 was $7,031K - nearly $800K higher than in FY2013. The figures for the last two years, however, include $500K of the early career award at LANL. While this 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 FY2014 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 FY2014 these resources were depleted at ANL and reduced to $250K at the NNDC. In order to balance the budget NNDC used $658K from the carry over and strove to reduce expenses (travel, purchases, software licenses, some contracts). On top of it, to reduce the cost, NNDC staff maximized usage of vacations days. These measures helped to curtail negative effects of the budget shortage in FY2014 but will not be sufficient to save FY2015.

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 in FY2014.

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 FY2014 should be mentioned:

- Positive outcome of the USNDP Review in July 2014,
- Relocation of the NNDC (including its library and servers) to more adequate premises,
- Establishing the NNDC/BLIP collaboration on advancing new methods of isotope production.

Next Budget Briefing

The next budget briefing will be held at the DOE Headquarters on February 9, 2015. The USNDP team will include USNDP Chairman(M. Herman) , WG chairmen (J. Kelley and T. Kawano) and the members of the USNDP executive committee who have specific issues to bring to the briefing.

US Nuclear Data Program

Structure and Decay Data Working Group

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

Present: C. Baglin, T. Barnes, S. Basunia, L. Bernstein, D. Brown, E. Browne, P. Dimitriou, R. Firestone, M. Herman, T. Johnson, T. Kawano, J. Kelley, L. Kirsch, F.G. Kondev, S. Kumar, E. Mccutchan, C. Nesaraja, N. Nica, B.Pritychenko, B. Singh, R. Slaybaugh, A. Sonzogni, M. Thoennessen, J. Tuli.

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

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

The ENSDF database has increased in size by roughly 1.3% over the past year. Presently there are 3259 nuclides reported. Along with many revised/updated datasets, two hundred thirty seven new datasets were added to ENSDF, including 13 “Adopted Levels” datasets, 66 decay datasets and 138 reaction datasets. There were 15 mass chain reviews published in the Nuclear Data Sheets (A= 28, 54, 60, 69, 85, 88, 91, 129, 148, 152, 195, 210, 215, 228, 243). The number of “mass chains” in the review process was given as 31. An additional 37 mass chains are listed as “currently being evaluated.” General usage statistics for ENSDF and products derived from ENSDF (Nuclear Data Sheets, NuDat, etc.) showed a high usage and popularity on the NNDC website and the Elsevier site.

Throughout several sessions, Dr. Tuli expressed great concern over the present low number of articles being submitted into the NDS/ENSDF review process (there were 12 in the past year) and in the number of evaluations approaching a publication ready state in the system. He suggested we may reach a limit where we are unable to sustain a reasonable rate of publications in Nuclear Data Sheets, which could cause Elsevier to lose interest in carrying the journal. A great deal of discussion ensued. Topics included: the low rate of new evaluations

entering the review process, a slow pace for new evaluations to reach publication ready quality, evaluator experience and training, evaluator FTE levels committed to activities that are not necessarily high priorities for this project, etc. As was noted in prior years, poorly prepared mass chains are being submitted to NNDC with little serious effort to implement corrections so the evaluation can be published.

Much of the discussion focused on the status of the ENSDF database. Dr. Tuli quantified an estimate of the number of mass chain productivity needed from the international NSDD network to sustain a reasonable currency of ENSDF as around 20 mass chains per year (for A>20). He added that the submission of new evaluations into the system lacks merit if the evaluations are of poor quality, and if there is no intention to revise the evaluations to bring them to a publishable quality. There was further discussion that there should be a prioritization of various USNDP-sanctioned activities, and discussion on how effectively decreasing budgets are impacting effort.

Status of XUNDL (B. Singh)

The XUNDL database presently carries 5812 datasets covering 2271 nuclides from over 280 mass chains. A total of 448 new datasets from about 210 articles were added to the XUNDL database in the past year. McMaster University carries the bulk of the activity (318) with TUNL (53), LBNL+UCB (30), ORNL (37), ANL (8) and BNL (5) also contributing some. NNDC (Tuli) acts as the database manager and updates the XUNDL database as new compilations are approved by Dr. Singh. As a parallel activity, McMaster has compiled 14 current papers on mass measurements comprising data for about 65 data points (masses, pairs of mass differences, Q values, etc.).

During the meeting, the XUNDL collaborators held a short session to discuss present and future effort commitments. Continued support of the activity was found in the group, with a new commitment from MSU. It is apparent that McMaster will continue to carry the majority of responsibility.

Status of the NSR (B. Pritychenko)

A total of 3130 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. In the presentation, Dr. Pritychenko mentioned the up-to-date EXFOR E-library; significant discussion on access ensued.

Status of ENSDF Analysis codes

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. In addition, there

is presently a desire from several within the network to have development of codes that function on a broader variety of OS platforms. In the discussions, it was emphasized that Tim Johnson at NNDC is responsible for maintaining the present codes that are available from the NNDC website. The issue of moving forward with development of new equivalent applications having broader flexibility is the subject of a recent IAEA working group that met over the summer.

Filip Kondev gave an overview talk on his perspective of the situation with ENSDF analysis codes working group. Within his presentation, he showed examples of evaluators who are developing their own codes, which are apparently intended for personal use. For some this approach is viewed as a reasonable option, since it does not entail programing for end-user preferences, nor does it require a detailed manual. However, as Filip pointed out, such an approach can lead to duplication of effort within the network. Furthermore, the lack of validation from within the network can, for example, lead to variations in treatments of uncertainties and give rise to systematic errors in the library. Filip gave an overview of some aspects of the IAEA sponsored ENSDF analysis code workshop, including comments on different "programming languages" such as the python uncertainties module. A subsequent talk by Rachel Slaybaugh iterated the strengths of PyNE.

Other Business and discussions

A pressing issue connected with changes in the preparation of print ready manuscripts for review and publication in the Nuclear Data Sheets motivated significant discussion. Due to shrinking resources and a retirement at NNDC, the ENSDF evaluators are expected to play a greater role in preparation of the print ready manuscripts. As detailed in Jag Tuli's 9-11/2014 email, Dr. Viktor Zerkin of IAEA/NDS is developing a web site, myEnsdf, that provides tools permitting an evaluator to control the .pdf output generated while processing the ENSDF files. Dr. Firestone expressed the point that all other Elsevier journals prepare publication ready manuscripts for any author who submits an article to a journal; he cannot understand why Nuclear Data Sheets cannot also provide this service. Several agreed with this point of view. In any case, Grace Sheu (the TUNL project manager) has agreed to assist evaluators in using the myEnsdf website, after the site becomes available.

The issue of archiving past versions of the ENSDF data file was raised, which resulted in a decision to maintain access to two different versions of an ENSDF archive. In the first archive, the as published A-chain evaluations will be collected so there is an accessible archive of information found in the print versions of Nuclear Data Sheets. In the second archive, the semi-annual distributions of the ENSDF will collected so that changes within the ENSDF can be identified with a reasonable periodicity. There was a decision to make the archive available to the general public on the NNDC website.

Discussion on Evaluation issues and procedures

There were a variety of discussions on different aspects of our formats, policies and procedures. Evaluators are asked to review and give comments on the policy for determining half-life values. In addition, evaluators are asked to follow the current policies on absolute intensities. Dr. Basunia raised questions about listing of the ground state of particle-unbound nuclei in ENSDF, when unbound resonances were reported, and Dr. Kelley raised questions about including unique information on unstable nuclei that is obtained from mirror or analog nuclei/reactions.

The formats, policies and procedures session reached a conclusion after we reviewed highlights of the NSDD action items from the 2013 meeting in Kuwait.

Horizontal Evaluations and Other Data Related Activities:

A summary list of the horizontal evaluations and other data related activities mentioned throughout the meeting are given here.

- IAEA Technical meeting on ENSDF codes: Kondev, Singh, Tuli, Johnson
- IAEA CRP on beta-N: related to its horizontal compilation and evaluation of P_n and associated half-lives: B. Singh,
- IAEA-CRP on Evaluated Gamma Activation File (EGAF):R. Firestone,
- IAEA Consultants Meeting on a Database of Photon Strength Data: R. Firestone,
- IAEA-CRP on Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production: F. Kondev,
- K Isomers in deformed nuclei with A>100: F. Kondev
- AME and NUBASE: F. Kondev,
- Nuclear Structure Insights on Reactor Antineutrino Spectrum: E. McCutchan,
- Evaluation of Heavy Uranium Isotope Production: A. Sonzogni,
- Analysis of Nuclear Physics Authorship Trends: B. Pritychenko,
- nucastrodata.org and the Computational Infrastructure for Nuclear Astrophysics (CINA): M. Smith.

Experimental Research Activities:

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

- Nuclear Data Activities at ANL: F. Kondev
- UC Berkeley Neutron Measurements and Capabilities: L. Kirsch
- Internal Conversion Coefficient Measurement in 111mCd: N. Nica

- A Tale of Three Cities: J. Kelley (omitted because of time constraints).
- Deep Inelastic Reactions: T. Johnson
- Present and Future BLIP-USNDP Collaboration: E. McCutchan

US Nuclear Data Program

Nuclear Reaction Working Group

T. Kawano, LANL
Working Group Chair

Model code development

M. Herman of BNL summarized the new features added to EMPIRE-3.2 (Malta) since last year. The major changes since the last USNDP meeting are; internal calculation of angular distribution for the compound reaction, and non-linear fitting and covariance package based on CERNLIB. A Windows-version EMPIRE became available, and some files are converted into Fortran90/95. For quality assurance, EMPIRE is managed under the ADVANCE system, which runs benchmark tests and compares the results with a stable version automatically.

D. Brown of BNL presented the angular distribution calculation in EMPIRE, mentioned by Herman. They performed two test cases: the elastic scattering angular distributions in the 40 keV to 2 MeV region, comparing with the ECIS results, and the Legendre coefficients in the resolved resonance range, compared with the resonance predictions. Problems in a phase of coupling coefficients were reported.

R. Vogt of LLNL reported their recent FREYA calculations, which particularly focus on observables such as neutron correlations and photons. The neutron observables include the neutron multiplicity distributions as well as that as a function of fission fragment mass, and angular correlations between two neutron or neutron and fission fragment. The photon results for U-235(n,f) and Cf-252 are compared with available experimental data. It was announced that incorporation of FREYA into MCNP6 is in progress.

G. Arbanas of ORNL gave a talk on the recent updates of the SAMMY code. Two new resolution functions for RPI neutron detectors were implemented in the resonance analysis code SAMMY, which are the lithium glass neutron detector array called MELINDA, and the EJ-301 liquid scintillator. SAMMY modernization future plans are summarized. He also mentioned the update of S(alpha,beta) project shortly, in which the molecular dynamics approach will be considered.

T. Kawano of LANL gave a talk on the recent development of the statistical model code, CoH3 (ver. Titania and Oberon). The new version includes new features of; the Madland-Nix fission spectrum calculation, Maxwellian average cross section calculation, nuclear mean-field

model calculations, and Kunieda's deformed optical potential. Nuclear deformation effects on the inelastic scattering and the radiative capture calculations were demonstrated.