CSEWG-USNDP Annual Meetings'2008

Preface

In the last couple of years the National Nuclear Data Center, BNL, has been organizing three nuclear data meetings in the first week of November. Following tradition started in 2003 the Cross Section Evaluation Working Group (CSEWG) and the U.S. Nuclear Data Program (USNDP) Annual Meetings were organized jointly. Added in 2004 was small Nuclear Criticality Safety Meeting. In 2008, this arrangement was expanded to four meetings covering the entire week and allowing us for the first time to introduce the term 'Nuclear Data Week at BNL'.

In the week of November 3-8, 2008, the following nuclear data groups met at BNL:

- Nuclear Data Advisory Group, Criticality Safety Program Meeting, Nov 3,
- 58th CSEWG Meeting, Nov 4-6,
- 11th USNDP Meeting, Nov 5-7, and
- GNEP Physics Working Group Meeting, Nov 6-7.

This year we witnessed record number of registered participants. Total number was 93 (to be compared to 66 in 2004) of which CSEWG attracted 66, USNDP 48, NDAG 23 and GNEP 17 participants.

The present document contains the Summary of the CSEWG and USNDP Meetings. It is produced in the electronic form only and along with all presentations given at these two meetings it is available at www.nndc.bnl.gov/proceedings/2008csewgusndp.

December 10, 2008

Pavel Oblozinsky
CSEWG chair
USNDP chair

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Summary of the 58th Cross Section Evaluation Working Group Meeting

Held at
Brookhaven National Laboratory
November 4 - 6, 2008

Cross Section Evaluation Working Group

Chairman's Summary

Pavel Oblozinsky
National Nuclear Data Center, BNL

CSEWG Annual Meeting

The 58th CSEWG meeting was held on November 4-6, 2008 at BNL, the number of registered participants being 66. This unexpectedly high number confirms renewed interest in evaluated nuclear reaction data. Among the participants were representatives of national laboratories, academia and nuclear industry of the United States and Canada, as well as a few participants from abroad. The CSEWG meeting was held adjacent to the USNDP annual meeting, with a common session on neutron cross section covariance data.

Plans for ENDF/B-VII.1 release

CSEWG discussed plan for release of ENDF/B-VII.1 and agreed on the target date 2010. This new release will address deficiencies identified in ENDF/B-VII.0, include improved evaluations for some 60-70 materials and provide covariances for more than 100 materials. Overall theme for ENDF/B-VII.1 release is improved criticality safety/structural materials, improved Li and Be as well as improvements to minor actinides.

In order to facilitate the process, a mini-CSEWG meeting will be held on June 22, 2009 at Port Jeff, focusing on preparatory work for ENDF/B-VII.1 release.

Review of ongoing evaluations

Detailed review of ongoing evaluations was done, material by material. The list included H, Li, Be, F, Cl, Ti, V, Mn, Cr, Fe, Ni, Cu, Gd, Cd, Kr, Y, Zn, Zr and W. Special attention was given to actinides, including Big three as well as minor actinides.

In addition to traditional contributors, LANL, ORNL and BNL, it was noted that LLNL appears to be joining CSEWG evaluation effort vigorously with a set of interesting evaluations.

Covariance data

The new Covariance Committee (CovCom) is focusing on methodology aspects of neutron cross section covariances. Considerable progress was reported at the meeting, including resonance and fast neutron energy regions. It is expected that the CovCom will play critical role in the development of covariances for more than 100 materials intended to be included in the forthcoming ENDF/B-VII.1 library.

Next Meeting

The next CSEWG annual meeting will be held at BNL on Nov 3-5, 2009 (Tue – Thu), while the USNDP annual meeting will be held on Nov 4-6, 2009 (Wed – Fri). The NDAG Criticality Safety meeting will be held on Nov 3, 2009 (Mo) and AFCI Physics Working Group on Nov 5-6 (Thu – Fri).

Executive Committee Meeting

The Executive Committee met during the lunchtime on November 4, 2008, with all 11 members present. This included chair (P. Oblozinsky), five committee chairs (M. Chadwick, Y. Danon, M. Dunn, A. Kahler, D. Smith) as well as five regular members (J. Pruett for D. Brown, A. Carlson, M. Herman, L. Leal and R. McKnight).

Agenda

- Organizational matters. P. Oblozinsky informed that, as a part of his retirement plans, he will be stepping down as CSEWG chair early 2009. He proposed Mike Herman (BNL) as his successor. This proposal was fully supported by the Committee. The Committee took also note that Dick McKnight (ANL) stepped down as chair of the Validation Committee, and Skip Kahler (LANL) replaced him as foreseen earlier. The Committee thanked both Pavel and Dick for their outstanding contributions they made over years to the benefit of CSEWG.

- Plans for ENDF/B-VII.1 release. This issue triggered lively discussion. It was agreed that CSEWG should go for release by the end 2010, that is, four years after ENDF/B-VII.0 release in December 2006. This new release should address deficiencies in VII.0, contain number of improved evaluations and add considerable amount of covariance data for about 100 materials.

- Next Special Issue of Nuclear Data Sheets. The 2008 issue (~200 pages) is dedicated to covariances and contains 34 papers presented at the Workshop in Port Jefferson, NY. The 2009 issue should consist of two extensive (~100 pages each) papers, on neutron cross section standards (lead author A. Carlson, NIST) and on RIPL library (lead author R. Capote, IAEA). The 2010 issue would likely contain a paper on ENDF/B-VII.1 along with extensive paper on NJOY.

- WPEC matters. The next WPEC meeting will be hosted by the United States. The host will be NNDC and the meeting should be held at Port Jefferson, NY, from June 24-26, 2009. The US delegation should include 4 official members (CSEWG chair and 3 Committee chairs), some other US representatives are expected to attend as chairs or active contributors to WPEC Subgroups, the rest of US attendees should be given the status of observers traditionally granted to participants from the host country.

- Next meeting: See above.

Cross Section Evaluation Working Group

Evaluation Committee Report

M.B. Chadwick, LANL
Committee Chair

ENDF/B-VII.1 release

Release of ENDF/B-VII.1 is expected in 2010. Overall theme for this release is:

a) Improved criticality safety/structural materials,
b) Improved Li (n,t) and Be possibly,
c) Improvements to minor actinides.

Summary of isotopes and who has ongoing work for ENDF/B-VII.1

Isotope	Lab	Release	Timescale/Actions
3H	LANL	B-VII.1	FY09 – fix T(n2n)
6Li	LANL	B-VII.1	FY09 – new (n,a) above 1 MeV by Hale & Brown (LLNL) check breakup formats
9Be	LANL	B-VII.1 or 2	Goal - R-matrix with RPI data in FY09, but criticality issues complex & may take longer
19F	ORNL/LLNL	B-VII.1	BNL will merge, LLNL etc test against crits
35,37Cl	ORNL	B-VII.1	Some testing needed
39,41K	ORNL	B-VII.1	Some testing needed
Ti iso	LANL/ORNL	B-VII.1	Consider new RPI data, merge with FY10 48Ti ORNL data, LLNL fix(47) and retest
V	LANL	B-VII.1	FY09 – hope that modern higher energy eval will improve criticality testing.
Mn55	ORNL/LLNL	B-VII.2	LLNL/IAEA compare fast region & assess. which merge with ORNL, LANL in future?
Cr iso	ORNL	B-VII.1	Test against crits, incl. ZPRs, IPPE; k-inf, LANL evaluation later.
Fe	LANL	B-VII.1	Fix (n,x alpha) if needed using Haight data.
Ni iso	ORNL/LLNL	B-VII.1	ORNL finish in FY09, submit, test. Should LLNL advances be included? LLNL assess whether fixes keff crit. LANL upgr in '12?
Cu63,65?	LLNL	B-VII.1	LLNL assess whether their evaluation fixes Zeus & n trans. testing; consider adopting.
Gd	ORNL	B-VII.1 or 2	FY10-use new RPI data (~10% change at therm.), test with PSI, Chalk R, Rusian crits
Cd	BNL	B-VII.1	Adopt recent upgrade; comp. with RPI data
Kr78	LLNL	B-VII.1	Check capture because of import. in reactors as FP; compare with B-VII & others & test

Y89	LANL	B-VII.1	Ignatyuk says capture too low at low energies (missing resonances); upgrade?
Zn63-72	LLNL	B-VII.1	Document comparison with ext and B-VII.0, and check (with BNL) that resonances OK
Zr iso	BNL	B-VII.1	Update Zr90 (beta4) and Zr91 as necessary, use new RPI data, retest at Bettis & KAPL
W iso	IAEA/BNL	B-VII.1	Choose between IAEA and KAERI.
U233	LANL	B-VII.1	Fix DN typo
U236	LANL	B-VII.1	Mods to cap, fiss? Based on crit reac rates
U237	LANL/LLNL	B-VII.1	If LANL, use upgraded res. range & fiss to further improve match to LANL crits
Am240	LLNL	B-VII.1	Accept. Have Kawano look it over.
Am241	LANL	B-VII.1	Upgrade cap above 30 keV; possibly tweak fiss based on LANL crit & FCA reac rates
Pu238	LANL	B-VII.1	Ignatyuk says total inelas. bad etc. Upgrade?
Pu239	ORNL	B-VII.1 or 2	Assess whether new Derrien res. improves crit testing including solutions and ZPRs.
Big3	LANL	B-VII.1	Fix fiss spec > 10 MeV wit finer grid.
γ-prod	LANL	B-VII.1	Morgan White to add lost γ-production back.
MA	LANL	B-VII.1	Consider adopting Bk, Cf, Es, Fm, 237Pu isotopes from Japanese actinoid file.

Expected for ENDF/B-VII.2

2H	Chalk River/LANL	B-VII.2	Geel data planned, theory in progress, goal is to improve some of the crit testing.
9Be	LANL		See above.
16O	LANL/ORNL/LAPL	B-VII.2	New evaluation, including (n,alpha)?
Ni iso	LANL?	B-VII.2	Add LANL work from ~FY12.
235U	LANL/ORNL/LLNL	B-VII.2	Capture WPEC upgrade if needed, and new FIGARO fission spectrum
238U	LANL/ORNL/LLNL	B-VII.2	Capt. upgrade if needed, using Wallner data, & new FIGARO fission spectrum
239Pu	LANL/ORNL/LLNL	B-VII.2	New FIGARO fiss spec; capture upgrade, inelastic scattering upgrade if needed.
Big3	LANL	B-VII.2	Possible change to preeq/inelastic based on Bethe sphere testing

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Detailed Minutes – Added into Agenda, Action in Red

- Overview comments and plans for VII.1 and ENDF/A files, Chadwick, Herman, 15'

Mike Herman showed the list of ENDF/A files – files submitted for consideration as a future release. He also described the G-Forge software as a way to keep track of updates to files – built on CVS.

- Release files for ENDF/B-VII.0.fix1, Little, 15'

Little described the MCNP ENDF70 library; it contains all ENDF/B-VII.0 except for 3 materials (Be7, Cf253, Es253 – too incomplete); it was produced at 5 temperatures, between 293.6K and 2500K. The library is being made available by users to RSICC, Oak Ridge. Fixes were made, note the S(alpha-beta) set released earlier by BNL was not quite right – owing to the processing for S(alpha-beta) being unclear.

For 1H, a tiny change was made to the capture gamma-ray energy. An NJOY fix was also made to get KERMA right. 45Sc ang distributions changed to lab frame and poor excitation function definition changed. 89Y MT91 inelastic scattering to the continuum had negative cross sections! These were fixed, but it should be looked at. Action - Patrick Talou to look at this and check that Little's fix is OK – or come up with a new file. 96Zr and Mo-97 – values from Kalbach wrong (9.99 instead of 0.99); Eu153, MT91 had negative distributions; 242gAm had no angular distribution for MT18 fission, and some strange MT51-54. Patrick Talou fixed these deficiencies.

Action - 7 out of 8 fixes have been already sent to BNL, and the last one (Eu) will be sent by Little.

We agreed to make the official version of B-VII.0 → B/VII.0fix. BNL may rebuild an NJOY created MCNP library. If they rerun with NJOY, then they will use Bob Little's inputs, including those that are needed to get S(alpha-beta).

Detailed Agenda for B-VII.1 Upgrade Plans

D. n-d scattering has discontinuities in the 3-4 MeV region. Elastic cross section has a big influence on certain crits, eg ZED-2 at Chalk River. Theory work is being done using Faddeev methods with various potentials with Canton (Padua), but still more theory is needed.

In data testing, Kozier sees a bias in k-eff as a function of leakage for VI.8. The ENDF/B-VII.0 looks the best so far for the ZED-2 CVR, and things get worse when he adopts results from latest theory. But there is still a bias with B-VII.0. He also noted that earlier he was using an erroneous S(alpha-beta), but now he is using the correct ones.

T. For T(n,2n) fusion people claim B-VII worse than B-VI, apparently Hale agrees.

Action – Hale send new T(n,2n) upgrade for VII.1.

Update on IAEA standards group efforts. Allan Carlson discussed standards philosophy. We agreed that standards should have covariance data added to them, and to extend the energy range (eg up to 150-200 MeV). The standard group is collecting new data on: the 252Cf spectrum; the 235U thermal fission spectrum; 197Au(n,g) & 238U(n,g) Wallner experiments. Discussed new 'reference cross sections' (not as well known as standards), eg prompt gamma-ray production cross sections for Fe (n,n'g) and some (n,2ng).

Allan also talked about developing more complete covariance evaluations for the full ENDF/B-VII range.

Action – for 235,238U and 239Pu, to be checked by Allan that right covariances are in the submitted ENDF/A files

6Li(n,t). Fix format error. Hale upgrade based on LANSCE data, and issues related to changing a standard.

Action – Gerry will merge new results with standard below 1 MeV. We will consider – for discussion – the possibility that the standard be changed a bit below MeV if the matching can be doe more easily there. Carlson noted that the 'lower compromise' B-VII.0 evaluation was both a compromise between the LANL and Chen R-matrix evaluations, and also was influenced by other data in ratio to Li. Action - Hale should address the latter issue, and whether this would change his new result below 1 MeV. LLNL will also look at the new evaluation and comment.

Brown (LLNL) has noted ambiguities in what the breakup channels are – due to ambiguities in format treatments, showed toy calculations. Action – Hale, ask Brown for details.

9Be. Insights from new RPI data; fix of VII.0 interpolation problem; plans for future improvements. Hale/Danon/Chadwick, 1-2 slide.

16O. Comments on whether (n,alpha) should be changed, and when? Also note comments by Edwin Kolbe in his testing paper. Hale/Chadwick, 1 slide.

V. Anything new?

1**9F**. Updates from ORNL, LLNL, Dunn/LeaL/LLNL-EGAF 1-2 slides. New Reich-Moore LRF7 format were used for cases where 2 inelastic channels open up. The new evaluation was done up to 1 MeV; used 3 transmission measurements done by Larson et al from 5 eV to 20 MeV, and 1 capture measurement at ORELA by Guber up to 700 keV. Also used shape of data from Los Alamos, and used inelastic data from Obninsk. Covariances are being made available too.

Dunn noted some intermediate benchmarks are sensitive to fluorine – these will be tested. This might involve Livermore experiments. Lubitz has some data with fluorine too. Action – the data testing committee will establish a small group to test and give feedback on the new evaluation. Try to involve Dave Heinrichs too because of LLNL fluorine crits experience.

Thermal neutron gamma-ray production has been evaluated by Firestone et al. DICEBOX is also used to get discrete and quasi-continuum gammas. The same total capture cross section was used.

Action – We agreed to use the new LLNL/LBL data. BNL will merge the 2 files from ORNL and LLNL.

Action – LLNL 19F experience in data testing for gamma-ray leakage, which show deficiencies, will be looked at by LLNL who produced the new gamma-production evaluation for EGAF.

22Na. Resonance-total-width, who?

Ti isotopes. VII.0 took Ti from JENDL3.3. New evaluations from LANL. Testing in crits and pulsed spheres? ORNL 48Ti(n,g) – was this used? Note Danon's expt talk on total x/s measurement 0.5-20 MeV and need for res. energy shift. Kawano/Leal 2 slides.

Neil Summer found bug in 47Ti(n,n') – previous file had gamma-multiplicities way too high. TALYS calc was used for the old evaluation and LLNL recreated new multiplicity.

Action – Kawano will include LLNL fix in his new Ti isotope evaluations.

Kawano described new LANL evaluations. New resonance parameters were adopted from the Atlas, and the resonance energy was extended. GNASH calculations were done, also using Dashdorf et al GEANIE/LANSCE data for 48Ti. The elastic scattering distribution is important for matching crits. Kawano adopted B-VII.0 data that uses Argonne 1950s era scattering data. He found that using a modern OM model didn't give as good a prediction of the crits. He also reevaluated the total cross section by doing a least square fit of the measured total data (fluctuations exist up to 6 MeV).

Good benchmark testing was obtained for the HMF79,34 crits. where HMF79 was the new Ti benchmark from Russia. We agreed to adopt this new evaluation. Kawano also noted that the transmission testing didn't seem to improve.

ORELA will be working on 48Ti – when they have new data in FY10, Kawano will include it for testing.

Action for Kawano: Danon's data at 0.5 MeV (resonance energy shift) and his new total cross section data should be considered; likewise for new ORNL data.

55Mn. New ORNL evaluation. Results including comments on ZPR performance. Has LLNL worked on this too? Leal/McKnight/Marco Pigni, Summers 2 slides**.**

New data from GELINA Geel was included, as well as new ORNL data. Benchmark testing has been done with the NEA. McKnight has also done data testing and things look much better for the ZPR.

BNL has done covariance estimates for 55Mn in the fast region. There is also an effort by Capote at the IAEA at higher energies, which will be a complete file with covariances. LANL is also scheduled to do high energy next year. The resonance structure in the MeV range needs to be carefully accounted for. LLNL is doing an evaluation at higher energies.

Action – Brown will send 55Mn to BNL, who will review it, and the IAEA evaluation. We also encourage LLNL and Capote/IAEA to interact.

McKnight has tested against ZPR6/10, B-VII gave a 4% error. Earlier testing showed that 239Pu may be part of this (using B-V does better). Similar problems with B-V for Cr and Mn appeared. The new ORNL Mn evaluation seems to have the same good effect as using B-V for the Mn.

35,37Cl. ORNL evaluation submitted in Feb 2008; has it been tested? Dunn/Leal 1-2 slides.

New evaluation has been processed by NJOY08 (allows LRF7). It will also enable testing of covariances. Action – Skip will delegate some data testing.

39,41K. ORNL evaluation submitted in Oct 2008, Leal/Dunn, 1 slide

Action – Skip will delegate some data testing.

50,52,53,54Cr. ORNL measurements and plans to submit evaluations in FY 2009, Leal/Dunn, 1 slide

Leal has a preliminary set for 52,53Cr. He is also working on 50, 54. 53Cr and nat-Cr transmission & capture were done recently by Guber. They go up to the first inelastic channel.

Most data testing doesn't have enough Cr in steel to show much effect. But the ZPR6.10 with carbon and Cr is very sensitive. Blair Briggs noted a k-infinity benchmark is quite sensitive to chrome – at IPPE. ENDF/B-V did a good job – it was elemental.

Action – Leal will finalize Cr evaluations this year (FY09), and these will then be tested by Kahler et al.

LANL is doing high energy work, but not till FY 2011.

58,60Ni. ORNL measurements and plans to submit evaluation in FY09, Leal/Dunn, 1 slide

LANL is doing high energy work, but not till FY12. LLNL has done some work in the high energy region.

Data testing needed for LLNL's 58,60Ni to see if HMF3 improved.

Derrien has worked on this with Leal. New Guber measurements have been included. ORNL will finish in future.

LLNL evaluation work. Overview of LLNL evaluation methodology and summary of evaluations for isotopes of Kr, Co, Ni, Cu, Zn, Ga, Summers – a few slides**.** LLNL is submitting two sets of evaluations, 78Kr and 63-72Zn. There are two projects - partial activation cross sections for ENDF/A which are now being extended:

- First set was done with STAPRE by Hofmann. Koning global potential used. Regional systematics developed for level densities, strength function, etc to allow extensions to unstable region. More recently, TALYS was used to calculate spectra and angular distributions, ENDL files created, and then ENDF files made.
- TALYS used for whole evaluation for Co, Ni, Cu, Zn, Ga. They are not evaluating ones that exist in ENDF, but use them to calibrate/test their simulations for the off-stability targets.

78Kr – LLNL when finalized it will be sent and likely be adopted.

Action – pay attention especially to capture because of its importance in reactor applications as FP. Compare with earlier VII evaluation which was probably part of the NEA/WPEC Subgroup 2?

63-72Zn – LLNL has new evaluation for these isotopes. They continued over information on resonance parameters. Action – LLNL will finish, submit evaluations and documentation (esp. plots) to show various reaction channels. Livermore did use resonance parameters from earlier VII.0 evaluation (elemental eval gave individual elemental parameters) - LLNL will also work with BNL/Mughabghab to check if they are OK.

Pb, W, Ta, Re, Al – LLNL**.** Action for Pb, W, Ta, Re, Al – Neil will tell us if any of the ENDF stables need updating.

Cu63,65. Problems in the fast range have been noted by Mosteller, from his testing of the Zeus assembly. ORNL is working on intermediate range.

Action – Mosteller will send Zeus MCNP decks to LLNL (Marie-Anne Descalle), and she will see if new LLNL Cu63,65 evaluations perform better in Zeus. Likewise, it would be good to see if the LLNL evaluations perform better than B-VII for 14 MeV transmission experiments (B-VII performed poorly).

Fe(n,alpha). Did B-VII.0 at higher energies use Haight's (n,xa) data, and if not, can we do this, Talou/Haight.

Gd. Note planned RPI capture expts this year; ORNL evaluation planned for 2010. Mosteller comments from reactor community experience – longstanding view on 155,157Gd (the main absorbers) is that "Gd burns out too fast".

RPI paper was published on the Gd measurements, 155 and 157Gd isotopes will be re-measured, to augment the elemental measurements. A 10% change was observed in 157Gd at thermal in the previous. ORNL's work will be done in FY10, though Danon will have resonance parameters earlier.

If we get a preliminary file from Danon (using his measured resonance parameters) we will test against some Russian experiments, and Chalk River & Cadarache (PSI experiments). Limited testing was already done at Cadarache claiming better results. Olivier Serot noted that the isotope and elemental capture values are inconsistent.

90Zr. Should the beta4 version be released? Feedback from KAPL & Kozier, as well as possible issues in VII.0 noted by Trkov in reactor testing? Note Yaron Danon's expt talk on elemental Zr total x/s measurement 0.5-20 MeV suggesting B/VI.8 was better. Marco Pigni, 1-2 slides.

RPI total cross section shows VI.8 was better than VII.0 below 16 MeV**.**

Propose deleting the bound level in 90Zr and adjust gamma-width of first few levels in 91Zr. New data suggest raising the 91Zr capture cross section at thermal (with a corresponding change to 90Zr) so as to also match the Zr data.

Action – the new evaluation will be sent to Bettis and KAPL as well as Kozier to test.

Trkov noted worse performance. Danon showed data in the higher energy region ~ 4 MeV. BNL should consider using these data.

Cd. Adoption of BNL upgrade and positive results from data testing? Note Danon's expt talk on how RPI capture and transmission data support the change in the thermal region. Herman/Mughabghab/Mosteller, 1-2 slides

Action – Bettis will test Cd evaluation.

182,183,184,186W evaluations. ORNL resonance measurement (evaluation not till FY11?); LLNL work; adoption of new IAEA evaluation shown by Trkov at Physor08? Herman/Leal/Kim/(LLNL-EGAF) 1-2 slides

There are two evaluations:

- Now available, KAERI evaluation that uses EMPIRE. They used ENDF/B-VII resonance parameters, but made some changes to the unresolved resonances (G_gamma) in order to improve criticality predictions. Their evaluation does better against the 11 MeV (n,xn) spectra. Slight improvement to 14 MeV Octavian and FNS leakage spectra, but still discrepancies (slight improvements over B-VII). For criticality, ZPRs look much better.

- The IAEA evaluation. ORNL did covariances, but did not change the cross sections except changing the representation. ORNL will do measurements in FY09.

The present file is complete and has covariances. The match to ZPR etc criticals was improved (but not by changing resonance parameters); Ignatyuk - odd isotopes are responsible since the capture cross sections are highest and low energy inelastic – this should be addressed in case improvements in the odd isotopes are possible.

Action – not specified.

Cu. LLNL evaluation. Testing against crits including Zeus? Summers, 1-2 slides, new Chinese evaluation is underway. Future ORNL work in FY11? Chadwick, comments.

Pu and U isotopes. Fix fiss spec > 10 MeV to have finer points, Chadwick 1 slide

240Am. New LLNL evaluation, Summers 1 slide. No previous evaluation, they used TALYS and Younes/Britt surrogate data for the fission. They used 242(m probably) Am resonances.

Action – accept LLNL file, and have LANL/Kawano look at it for completeness.

241Am (n,g) upgrade – higher cross section, Kawano 1-2 slide

Action – we will adopt this new evaluation above 30 keV. Kawano will also fix thermal values (e.g. capture) as necessary – including insights from DANCE – and also Japanese and Plompen talk (?) from Santa Fe workshop.

MA. Possible adoption of certain Japanese minor actinide files in B-VII.1, Kawano. He proposes using recent JENDL files (JENDL4 "Actinoid") for Bk, Cf, Es, Fm and 237Pu.

Action – Kawano will provide a list of new evaluations.

Possible modification to fission cross sections for 241,243Am, 237U, etc based on LANL reaction rate crit assembly testing and Japan FCA testing, Chadwick 2 slides

237U from LLNL. Summers**,** LANL 237U upgrades**,** Chadwick 1-2 slide

Possible cumulative FP yield upgrades of E&R for certain fission products, Chadwick.

Action – keep an eye on this issue as it develops.
233U delayed neutrons fix to B-VII.0, Little, 1 slide**.** We will adopt this.

Action – ask Bill Wilson to ensure the fixed values are in reasonable agreement with measurements/WPEC evaluation.

237Np planned upgrade – (n,2n), chi? Anything else planned? Kawano/Chadwick 1 slide.

Action: Kawano will also include upgrade (Mughabghab) to 237Np(n,g) at thermal.

Missing photon data that was erroneously not-carried-over from B-VI, and plans to include in B/VII.1, White 1 slide

S-alpha-beta in ENDF/B-VII.0 and in fix1. Comments, including observations from PHYSOR08 meeting**,** Little 1 slide

Action: Little will provide NJOY processing values/input decks used to create ENDF70 S(a,b) to the NNDC for posting. Kahler/MacFarlane/Little will address the ambiguities present in NJOY by clarifying how to do this in the NJOY manual.

Need to be able to use LEAPR to generate data at arbitrary temperatures – requested by Kahler and MacFarlane. Need Bob's help to document this. Chalk River says that Bob had found the old files, but they didn't reproduce the B-VII values.

Detailed Agenda for longer-range issues for possible B-VII.2 release

1H(n,p) scattering, Strakovsky, 10' + slide from Hale. They have a low-energy fit below 25 MeV (LE08). The latest Arndt evaluation agrees within ~1% with ENDF/B-VII.0.

Showed new data from Ohio-08? Carlson said it would be interesting to see what differences the Arndt versus Hale methods would give if they used the same database. We asked if he could compare his scattering length with the value Gerry noted, where there are discrepant measurements.

Action – Hale will review this analysis and consider adopting insights from it as necessary. Hale will work with standards community to consider using these new analyses to extend B-VII.0 up to higher energies (~150 MeV).

2D. Any new data from Geel? Comments from Kozier, Hale. No new data yet from Geel.

239Pu. Resonance region, including collaboration with JEFF, Leal, 1-2 slides

239Pu, 235,238U. Fission chi spectrum LANL/LLNL plans; 235U recent Geel expt, Shusaku Noda, 2 slides

239Pu, 235,238U 14 MeV inelastic scattering/preeq plans and Bethe sphere testing. Chadwick, 2 slides

235U. Capture update, WPEC subgroup, Leal/Kawano, 1 slide

238U. Capture & standard evaluation & Walner measurement, Chadwick comments

240Pu upgrade in fast region. Any testing results? Talou, 2-slides,

Actinide inelastic scattering in fast region. Future theory and evaluation work, Kawano, 1-2 slides

Dy. ORNL measurements and plans to submit evaluation in FY11, Leal/Dunn, 1 slide

239Pu – new Derrien ORNL resonance file is available for testing.

Action – Kahler, Talou et al check which is the file in ENDF/A, we need to test the new ORNL file against solution crits, ZPRs, etc.

Covariances Planning for ENDF/B-VII.1

232Th, 233,235,238U, 239Pu are in very good shape. BNL can create MF32 for resonance region from Atlas for many nuclides. Our goal is to produce covariances for ~ 100 materials. The full set of preliminary covariances produced in FY08 for GNEP/AFCI data adjustment project contains 108 materials:

- 19 actinides – 5 high-fi in ENDF/A; 14 MA based on SG26+Maslov update. Mark Williams replaced low energy Atlas with his own ORNL assessment, but overlap between GNEP and low-fi is a bit ambiguous. GNEP version had Atlas at low energies, but there were some problems at thermal and this is being modified.
- 75 low fi covariance files
- Light nuclei from LANL (~10); 1H, 6Li, 7Li and 10B are of good quality, but 16O is simple Kawano's estimate.
- Remaining structural, heavy, FPs from BNL.

We should use ORNL structural etc – K, Mn55, Cl, F; Ti, Gd in pipeline.

Proposal for discussion at the CSEWG meeting:

Take present starting point as ~108 materials which have high-fi, medium, and low-fi covariance data and upgrade as necessary:

- Adding ORNL work (4-8 materials)
- Add normal LANL upgrades Ti, V, Pu240, 241Am, 16O, 237Np med/high quality
- Add fission spec for big 3
- Add 16O ang dist uncertainty (mu-bar)
- Add ang dist for 239Pu, 238U, 56Fe, 23Na
- Replace low energy Williams low-fi with Atlas (MF32)

Goal – complete covariance files, even though some crude, in ENDF/B-VII.1 that can be used by customers.

Cross Section Evaluation Working Group

Data Validation Committee Minutes

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

The CSEWG Data Validation committee met for approximately 4 hours on Tuesday afternoon and Wednesday morning, November 4th and 5th, 2008. Contributed reports were given by ten speakers representing five US national laboratories (Argonne, Brookhaven, Lawrence Livermore, Los Alamos and Oak Ridge National Laboratories) with addition presentations from academia (University of Wisconsin, UW) and foreign laboratories (AECL-Chalk River and IPPE-Obninsk, with the latter a recent visitor to the NNDC at BNL).

Interested readers are encouraged to review these presentations, which are posted at the CSEWG meeting web site, http://www.nndc.bnl.gov/meetings/csewg2008/. Highlights from these presentations include:

- Dick McKnight (ANL) noted that control rod worth calculations for the ZPPR-10A assembly are accurately calculated with either ENDF/B-VI or ENDF/B-VII.0 data, but that sodium void worth calculations with ENDF/B-VII.0 data are under-predicted and exhibit changes with core loading whereas these worths were over-predicted but displayed a constant bias with ENDF/B-VI data.

- Mike Herman (BNL) noted that links from the ENDF/B-VII.0 home page (http://www.nndc.bnl.gov/exfor/endf00.htm) include a "deficiency list" that describes all reported errors in ENDF/B-VII.0 files and a "benchmarking" link for past data testing reports; many of which were submitted to the NNDC at various times during the year but were not included in subsequent CSEWG meetings.

- Marie Descalle (LLNL) described recent Livermore nuclear data processing efforts that allow for in-house translation between ENDL and ENDF formatted data files, including efforts to upgrade ENDL99 with the more recent ENDF/B-VII.0 evaluations. They see good agreement in k_{eff} calculations for a variety of "fast" ICSBEP benchmarks, but poor agreement in benchmarks that are sensitive to the unresolved resonance and thermal regions (due to known deficiencies in LLNL methods that remain focused on the fast region). She notes, in a conclusion supported by others that apparent data deficiencies remain in ^{9}Be plus the isotopes of nickel and tungsten.

- Several reports were given by LANL personnel. Russ Mosteller reported on a suite of k_{eff} calculations for various ICSBEP benchmarks that have been performed for a variety of cross section libraries in recent years. While ENDF/B-VII.0 derived cross sections are found to generally produce the most accurate k_{eff} results, Russ concludes that there are a number of specific

evaluations that require further review, including portions of ^{2}H, ^{9}Be, ^{63,65}Cu, ^{113}Cd, ^{232}Th, ^{233,235}U, ^{237}Np and ^{239}Pu. Skip Kahler, reporting for Bob MacFarlane reported on a code comparison study among MCNP5, VIM, COG/TART and the French Tripoli code with the Big-10 benchmark. Excellent agreement in calculated eigenvalues and fluxes were observed, lending confidence that conclusions on the adequacy of ENDF/B-VII.0 data testing with MCNP5 will be seen by these other code systems and are not unique to LANL's MCNP5 code. Finally, Skip reported on ICSBEP benchmark calculations for fast Ti and V reflected HEU systems. Current isotopic Ti cross sections in ENDFB-VII.0 perform worse than the old elemental evaluation available in ENDF/B-VI.8, but new evaluation work at LANL partially eliminates this deficiency. The V benchmarks calculate about 0.5% high and it seems likely that improvements are needed in the elastic scattering angular distributions for the ^{iso}Ti and V data sets.

- Mark Williams (ORNL) describes efforts to create ENDF/B-VII.0 based cross section libraries for SCALE-6 that were created by AMPX. Their data testing includes k_{eff} calculations of more than 1000 ICSBEP benchmarks. While the critical eigenvalues are calculated with good accuracy for the vast majority of these benchmarks, there are a number of instances where the k_{eff} calculations are several standard deviations outside the expected value. Given the many accurate results, this suggests that in selected cases there may be deficiencies in the ICSBEP handbook and it was suggested that these deficient cases be highlighted to the ICSBEP community for further study.

- Mohamed Sawan (UW) noted that the FENDL-2.1 library contains 40 isotopes or elements from ENDF/B-VI.8 and undertook a comparison of changes, if any, in these evaluations that appear in ENDF/B-VII.0. He performed calculations for a 1-D cylindrical geometry representative of an early ITER design and noted that the new calculations yielded only slightly higher flux values in the various benchmark zones and therefore modifying FENDL-2.1 to include the most recent ENDF/B-VII.0 cross sections is not an urgent need for the ITER community. Additional calculations, analyzing experiments with fusion neutrons incident upon W, stainless steel and copper are underway.

- Ken Kozier (AECL) reminded the audience of continuing deficiencies in our ^{2}H cross sections and their impact upon calculated D_2O moderated HEU benchmark eigenvalues and ZED-2 coolant void reactivity coefficients. Calculations with new UO_2 thermal scattering data exhibit little net reactivity impact although there is evidence for cancellation of large positive and negative reactivity contributions from elastic and inelastic cross section components. Ken repeated his previous request for better documentation on processing thermal kernel data through NJOY.

- Anatoly Ignatyuk (IPPE, BNL visitor) described his review of possible ENDF/B-VII.0 deficiencies. In contrast to Russ Mosteller's study which was based upon integral benchmark calculations, Anatoly focused on the underlying

microscopic data plus comparisons with other internationally available libraries (including the soon to be released BROND-3). Among the isotopes that exhibit differing evaluated data, generally in inelastic or (n,2n) cross sections, are ^{89}Y, ^{90,93}Zr, ^{96}Mo, ^{101,102,103}Ru, ^{107}Pd, ^{108,113}Cd, ^{145}Nd, ^{151}Sm, ^{238}Pu, ^{242m}Am (fission xs) and ^{242,243}Cm.

- ENDF/B-VII.0 deficiencies observed by A. Ignatyuk and summarized by Mark Chadwick:
    - Noted (n,g) in 89Y and 113Cd in the resonance region appears too low – missing levels
    - 238Pu n total - inelastic is terrible
    - 242mAm fission looked pretty jagged
    - 242Cm fission is very bad, as is total inelastic scattering. 243Cm fission is taken from Minsk - he would recommend a higher value now

Elsewhere it was noted that a new version of LANL's continuous energy Monte Carlo code, MCNP5 version 1.50, has been released to RSICC. Accompanying this release are LANL's official ENDF/B-VII based neutron and thermal cross section libraries. While there is an active data testing community, as evidenced by the presentations noted above, the distribution of these new libraries should allow for greater participation in future data testing efforts by the technical community and the CSEWG Data Testing Committee welcomes this potential increased effort.

Cross Section Evaluation Working Group

Minutes of the Covariance Committee Meeting

D. Smith, ANL
Committee Chair

The CSEWG Covariance Committee (hereafter referred to as CovCom for convenience) underwent a year of consolidation since the last CSEWG meeting in November 2007. Fifteen individuals (so far) from the CSEWG community have formally agreed to participate in CovCom, and the Committee clearly drew considerable strength from the fact that covariances are a current hot topic in the nuclear data field. This is also reflected in the fact four hours were allotted for the meeting this year. Accordingly, there were fifteen separate presentations during the course of the meeting. The overlap of interest in this topic between CSEWG and the USNDP was clearly evident, since the development of evaluated covariance data is an important part of the funded work plan of the USNDP.

CovCom is in the process of defining its appropriate role in CSEWG. CovCom does not generate covariances for ENDF/B. The development of covariance information stems from experimental and nuclear modeling work and, ultimately, is closely associated with the evaluation process which merges all available information. Covariance generation cannot be decoupled from these more traditional knowledge production activities. Consequently, there is a strong overlap of CovCom with the Evaluation and Measurement Committees of CSEWG. Ultimately, covariance information is used in processed form by nuclear system analysis codes. Thus, evaluated covariance information must pass through the filter of processing. Therefore it is a concern for the Formats and Processing Committee of CSEWG as well. Given these practical considerations, it is apparent that the main responsibilities of the Covariance Committee will be in the areas of fostering the development of covariance producing methods and in ongoing quality assurance (QA) activities relevant to the covariance information that is accepted by CSEWG for inclusion in ENDF/B.

During the past year CovCom addressed two specific technical topics that it was asked to consider by CSEWG. The first was a request to review chapters in the Methods and Formats Manual which has been under revision during the past year. Assignments were made to individual members of CovCom, and these reviews were completed and delivered to the ENDF Manager at the USNDC in a timely manner early during the 2008 calendar year. The second project was to examine the issue of covariances for normalized neutron spectra and to make recommendations for specifying and formatting this information properly in ENDF files. A lively exchange of correspondence on this issue, involving not only CovCom members but a number of interested foreign contributors as well, led to a consensus concerning recommendations for a set of rules for specifying this covariance information based on rigorous mathematical principles (as described below by Yang). These recommendations were submitted to the Formats and Processing Committee of CSEWG for implementation, and they are included in the recent revision to the Formats Manual (ENDF-102). A webpage exclusively devoted to CovCom was

established during the past year within the CSEWG website (as described below), and a Charter was prepared and posted there. It defines the responsibilities and methods of operation for the Committee. Finally, several members of CovCom were involved in assisting the NNDC in organizing the Covariance Workshop held in June 2008 in Port Jefferson, New York (also described below).

A brief synopsis of each presentation made at the present meeting appears below. The actual presentations can be found on the CSEWG-2008 meeting agenda Web page as follows: http://www.nndc.bnl.gov/meetings/csewg2008/#agenda.

D. Smith (ANL) --- *CovCom website*

The Covariance Committee (CovCom) has the responsibility for addressing the topic of covariances relevant to evaluations that are to be included in the U.S. ENDF/B Library. While the actual generation of covariances is the responsibility of individual evaluators who produce these evaluations for ENDF/B, this committee maintains oversight and provides technical assistance and advice in the following areas: i) Encourage the development of methodologies for generating reasonable and reliable covariance information; ii) Establish quality assurance (QA) criteria for the covariances included in the ENDF/B library; iii) Review covariance files submitted for inclusion in the ENDF/B library; iv) Advise other committees of CSEWG on matters related to covariances; v) Maintain contact with the nuclear applications community regarding their requirements for nuclear data uncertainties; and vi) Provide sources of information concerning covariances. The website elaborates explicitly on each of these points through the CovCom Charter. It also provides an up-to-date list of the Committee membership, information about ongoing and completed CovCom projects, a list of references on covariances, and links to documents pertaining to covariances. Since the Committee is relatively new, the information that is currently available through these various links remains sparse but will grow over time.

D. Smith (ANL) --- *Covariance Workshop report*

A Workshop on Neutron Cross Section Covariances was held on 24-27 June 2008 (Tuesday morning - Friday noon) in Port Jefferson, New York. The Workshop was organized by the National Nuclear Data Center which is part of Brookhaven National Laboratory. The organizers were: Pavel Oblozinsky, Mike Herman, Alejandro Sonzogni, and the NNDC staff. The Program Committee consisted of: Mark Chadwick, Yaron Danon, Michael Dunn, Anatoly Ignatyuk, Makoto Ishikawa, Toshihiko Kawano, Arjan Koning, Dennis McNabb, Giuseppe Palmiotti, Massimo Salvatores, and Don Smith. A link to the Workshop Agenda as well as to all the talks and the posters can be found at: http://www.nndc.bnl.gov/cw2008/program.jsp. Some statistics pertaining to this workshop are as follows. There were 53 registered participants [United States, 37; foreign visitors, 16 from 10 countries (Austria, Belarus, France, Germany, Israel, Japan, Netherlands, Slovenia, South Korea, and United Kingdom)]. There were 39 contributions [oral talks, 32; posters, 7]. The contributions by topic were: introduction & summary, 2;

user's perspective, 4; methodology, 12; evaluations, 12; applications, 7; data retrieval and visualization, 2.

Some highlights from the Workshop include: i) Methods (some new) for generating covariances in both light and heavy nuclei by both deterministic and Monte Carlo techniques were described; ii) The importance of attempting to assess the uncertainties associated with the use of nuclear models in producing evaluations and their covariances was addressed; iii) Progress in implementing procedures to produce covariance in the major nuclear data evaluation codes was reported; iv) The possibility for progressing from nuclear model parameter and experimental data values and their uncertainties directly to reactor system response analysis and uncertainty assessment was suggested and illustrated; v) Technical details associated with processing covariance data and utilizing it in various system response uncertainty analyses were described; vi) The various roles for incorporating integral data in evaluations as well as in producing adjusted libraries for specific applications were discussed; vii) Progress achieved in evaluation projects for specific nuclei was presented; viii) The "Low Fidelity" covariance collaboration of BNL, LANL, ORNL, and ANL was described; ix) Various applications for covariances in fast reactor design, criticality safety, and reactor dosimetry were discussed. And many more issues were introduced, described, and debated! Refereed written papers from the Workshop will be published in an issue of *Nuclear Data Sheets* (most likely to be issued in December 2008).

P. Oblozinsky (BNL) --- BNL Covariance Effort

This presentation provided an overview of the broad capabilities that have been developed at the NNDC for nuclear data evaluations, including covariances. The evaluation and covariance matrix production procedures for neutron reaction evaluations are incorporated in the nuclear modeling and evaluation code EMPIRE. For the fast neutron and unresolved resonance regions, the approach combines modeling and experimental data in a systematic manner based on the KALMAN filter procedure to produce evaluated cross sections and their covariances. A different approach, recently developed at NNDC and implemented in EMPIRE, is applied for the thermal and resolved resonance region. It is based on extracting resonance parameter information (including uncertainties) from the Atlas of Neutron Resonances and converting this information to a form consistent with the ENDF formats. In some cases estimates based on statistical and systematic considerations are used to compensate for the lack of specific resonance parameter values in the Atlas. The uncertainties in these evaluated data that are included in ENDF-formatted covariance files can then be processed to produce group cross section uncertainties.

These tools have been used in several covariance evaluation projects. One of this was to generate a library of covariances for the WPEC Subgroup 26 collaboration that addressed the need to generate covariances for fast reactor data needs assessment. Another is the "Low Fidelity" covariance project aimed at producing an extensive starter covariance library for the Nuclear Criticality Safety Program to enable testing of the uncertainty estimation capabilities of the SCALE code package. Finally, contributions have been

made to the GNEP Covariance Library. Work is also underway to produce high-quality covariance evaluations for the ENDF/B Library. In the later case, careful attention is paid to an assessment of the experimental data and their uncertainties in the evaluation process. Viewed from a quality perspective, the covariance evaluations that have been completed to date at NNDC are as follows: Sophisticated (high-quality) --- 8 isotopes of Gd; Medium quality --- ^{55}Mn and ^{90}Zr; Simple quality (low fidelity) --- 35 materials for SG26 and 307 materials for the NCSP "Low Fidelity" project.

The NNDC has also been active in covariance processing and covariance visualization activities. The ability to process libraries with the recent versions of both NJOY and PUFF-IV is available at NNDC, and these tools have been used to check those files produced at NNDC as well as others that have been submitted from ORNL and LANL for the projects mentioned above. These processing capabilities are also used to check on all new submitted evaluations before their inclusion in ENDF/B-A.

The NNDC hosted the Covariance Workshop which was held in Port Jefferson, NY, in June 2008. Considerable effort was spent by NNDC in recruiting referees and subsequently editing the written papers to be published in a special Issue of *Nuclear Data Sheets* dealing with covariances.

M. Pigni (BNL) --- Recent Covariance Evaluations at BNL

This contribution provided an overview of the ^{55}Mn and ^{90}Zr covariance evaluations mentioned in the preceding presentation. Some specific details of the procedures used and model parameterizations were discussed, and plots of evaluated results and comparisons with experimental data were shown. Processed results using a 44-group representation were also shown, including 2-D covariance plots. In this work covariances were produced for the following reaction channels: Total - MT=1; (n, n′) - MT=4; (n, 2n) - MT=16; and (n, γ) - MT=102. Future refinements to this work will involve the following tasks: i) Systematic analysis of the impact of correlations in resonance parameters; ii) Improvements of prior cross sections and, consequently, of sensitivity matrices; iii) Acquiring a deeper analysis of the statistics and systematics of the experimental data (in collaboration with Otto Schwerer); and iv) More accurate covariance analysis of other reaction channels such as (n,p) and (n,α).

L. Leal (ORNL) --- Recent Covariance Work at ORNL

This presentation provided an overview of the extensive program at ORNL of generating evaluations in the resonance region, including covariances. The isotopes mentioned were: ^{19}F; ^{35}Cl, ^{37}Cl; ^{39}K, ^{41}K; ^{48}Ti; ^{50}Cr, ^{52}Cr, ^{53}Cr, ^{54}Cr; ^{55}Mn; ^{182}W, ^{183}W, ^{184}W, ^{186}W; ^{233}U, ^{235}U, ^{238}U; and ^{239}Pu. The motivations for each aspect of this work were indicated in this contribution. Consideration of the availability of materials and experimental data, the needs for applications (mainly for criticality safety), and availability of manpower for measurements and/or data analysis or opportunities for collaboration were mentioned in this context. Analyses of these data sets have been or are being carried out using the code SAMMY, and the results are being used to produce covariance evaluations for inclusion

in application libraries such as the "Low Fidelity" Library for NCSP, for the GNEP Library or for ENDF/B. Extensive plots of both experimental and evaluated results as well as processed covariance information were shown.

R. Vogt (LLNL) --- LLNL Covariance Overview

Quantifying the relationship between physics uncertainties and system performance can benefit applications and guide science investment. This presentation describes the LLNL approach to achieving this objective. It examines the flow of physics processes starting with input experimental data, including measurement uncertainties, and/or model input, with physics uncertainties used to simulate the system in question, through to the output of the model, thereby revealing information about the performance of the system and its related uncertainties. Quantitative information on system performance gives a two-fold result. Some level of confidence in the system design is provided and an indication of areas where improvements are needed is achieved. It also allows prioritization of uncertainties in order to examine the question: Where do you put your money to make science investments that will actually reduce the uncertainties?

A probabilistic approach is used in the LLNL approach. However, specifying probabilities for nuclear data is hard because of poorly understood model inputs and complicated external data. How do we quantify the probability for a given set of input data to give the right output? It is assumed that the probability for a certain outcome should be proportional to the probability of the inputs being correct. From this reasoning it has been concluded that improvement of the nuclear models should be the focus of this exercise. The analysis procedure examines each link of the data development process and assesses the strengths and weaknesses. The same statistical assumption used for system assessment can be used for quantifying the probability for a nuclear data set to be correct. For many problems where experimental data are available, the probability for a set of parameters is not important since it can be understood from the data to begin with. The probability for a given set of inputs to produce a correct output can be factorized into three components, with each component assessed independently. This was shown mathematically in the presentation. One can then calculate the uncertainties (covariances) and correlations in inputs/outputs in a fairly simple way using moments of an input or an output observable with respect to the overall probability distribution.

LLNL has applied this method to fission neutron spectrum evaluations using the code system FREYA (Fission Reaction Event Yield Algorithm). This approach studies fission event-by-event. It samples spectra for different physics input parameters with up to 4 microscopic model parameters used in the evaluation for incident energy less than 3.5 MeV. They then calculate spectra and multiplicities for each parameter set (1-4) sampled. This exercise generates probabilities from the known data where the $\chi 2$ includes that of the fission spectrum and average multiplicities sampled. This approach is very convenient for including integral experiments because one can always add more integral experiments, and no information lost in defining correlations.

In summary, LLNL is developing formal uncertainty quantification tools. It involves a library of evaluated uncertainties, on the fly data processing, and dynamic checking for integral systems. This approach has been used in programmatic applications for several years now. A fairly simple formalism gives uncertainties in neutron spectra. Depending on the parameters, mean neutron spectra and multiplicities are unchanged but the correlations are altered. Factorization of probability gives great freedom. Integral constraints can be accounted for at run time, and simulations of integral constraints are almost always cheap compared to full system simulations.

P. Talou (LANL) --- Recent Covariance Work at LANL

LANL continues with its program to develop uncertainty quantification (UQ) methodologies, and to apply these to the generation of covariance data for neutron nuclear reaction processes in the actinide and light nuclei regions. The recent data produced fall into the following categories: i) "High fidelity" UQ for Major Actinides (^{233,235,238}U and ^{239}Pu via a LANL/ORNL collaboration); ii) "Low Fidelity" UQ for Minor Actinides (from ^{225}Ac to ^{255}Fm); iii) Very precise ("High Fidelity") R-Matrix analysis for some light elements (^{1}H, ^{6}Li, ^{10}B); iv) "Low Fidelity" UQ for other light elements (from ^{1}H to ^{19}F, except for ^{7}Li); v) UQ for the prompt fission neutrons spectrum (first calculations have been performed for ^{235}U+n at 0.5 MeV).

The work for "High Fidelity" UQ for Major Actinides (^{233,235,238}U and ^{239}Pu closely follows the ENDF/B-VII.0 evaluation procedure in that it incorporates both model parameter and experimental data uncertainties. The codes GNASH, CoH, KALMAN, GLUCS, and SOK are used. In the case of ^{235}U, the fission cross-section covariances are from IAEA Standards evaluation.

For the "Low Fidelity" Minor Actinides from ^{225}Ac to ^{255}Fm (DOE Criticality Safety Program) the following procedure was followed: KALMAN calculations were performed using the CoH and GNASH reaction codes with the default global optical model potential of Koning-Delaroche. The sensitivity to the model parameters was determined. A simplified UQ was then performed for the fission cross sections.

A very precise analysis was performed with the EDA R-Matrix code for the light elements. Elastic scattering and capture on ^{1}H were evaluated in the entire energy range. This work for elastic scattering was included in the Standards evaluation. Small uncertainties and strong correlations are exhibited. The elastic scattering evaluation represents the ideal case for a covariance evaluation.

"Low Fidelity" UQ was performed for the other light elements using various evaluation procedures depending on the elements considered (R-matrix, least-squares fitting, simple interpolation, guesswork, …). Resonance parameter covariance matrices are not available for use in such analyses. These analyses included many cross-sections "derived" from distinct processes such as (n,α)=(n,α0)+(n,α1)+… .

UQ for the prompt fission neutron spectrum (PFNS) follows the "High Fidelity" UQ approach for major actinides. Use is made of the Los Alamos model for PFNS calculations and the procedure combines model sensitivity calculations with experimental data via the KALMAN code. The first test case is for the n(0.5 MeV)+^{235}U fission neutron spectrum.

Finally, recent advances to the NJOY processing code to enable better handling of covariance data were described.

A. Ignatyuk (IPPE, Obninsk, Russia) --- Covariances of Fission Cross Sections and Nubars for Actinides

Work at the Institute for Physics and Power Engineering, Obninsk, Russia, on the generation of evaluated covariances was described. This presentation focused on covariances of fission cross sections and nu-bar for actinides. The generated covariances were used to calculate uncertainties that are averaged over the ^{252}Cf spontaneous fission neutron spectrum. An analysis was performed for neutron spectra from fission for the following actinide materials: ^{235}U, ^{239}Pu, ^{237}Np, ^{241}Am, and ^{245}Cm. These results were compared with comparable values produced elsewhere.

An essential part of the approach used in this work was application of a method for estimating unrecognized errors (mostly correlated), thus avoiding the reporting of too small uncertainties. This analysis approach was demonstrated for the ^{235}U(n,f) reaction. The total number of experiments considered was 107 (about 10 thousand experimental points). Some 53 experimental sets were omitted by the initial selection process. Then the following procedure was applied: i) All data were fitted by the optimal Pade parameterization; ii) A distribution of each experimental data set around a shifted individual description of the set estimates an average statistical error of this work; iii) A shift of the individual data set relative to the common fitted curve estimates a systematic error of the work in question; The width of the systematic error distribution estimates the general uncertainty of all data.

This general approach was used to estimate reasonable uncertainties for several fission cross sections and these were compared with recent comparable evaluated covariance results from projects outside of Russia. The conclusions from this investigation are as follows: i) For the main fissile nuclei there is a reasonable agreement between the uncertainties of recent evaluations for the fission cross sections and the fission neutron multiplicities; ii) For minor actinides the BOLNA (used in the GNEP studies of FBR systems) uncertainties set should be revised at energies above threshold for both the cross sections and the neutron multiplicities.

P. Griffin (Sandia) --- Covariances and Neutron Dosimetry: Status and Needs

The needs of covariance information for specific reaction processes of interest for neutron dosimetry – largely for LWR pressure vessel radiation damage surveillance and for fusion materials damage assessment – was described. It was stressed to the CSEWG

community that the elimination of covariance information by CSEWG in migration from ENDF/B-VI.8 to ENDF/B-VII.0 has generated great difficulties for the dosimetry community. This happens because of the way regulations regarding the quality (QA) and use of covariance information have evolved and been implemented in the various ASTM and ANSI guidelines for dosimetry. The QA infrastructure and associated regulations that has been implemented in the dosimetry community were described in this presentation to clarify this point.

An important aspect of these QA criteria is the requirement that the evaluations of dosimetry reactions must be completely traceable, and that optimal use should be made of experimental and model-calculated data in the evaluation process. Furthermore the approach of attaching covariances to the dosimetry library that were generated in a manner that was essentially decoupled from the original process that the produced the evaluated central values, even though they may represent reasonable uncertainty estimates, is consider to be strictly forbidden for dosimetry applications. Unfortunately, contemporary evaluation methodology within the CSEWG community appears to be moving away from this rigorous restriction for pragmatic reasons that stem mainly from the fact that the data needs for sponsors in the area of reactor development, criticality safety, and weapons applications are far more extensive than they are for neutron dosimetry. The CSEWG nuclear data community has recognized that restricting the evaluation of covariances to procedures that are completely rigorous would lead to a need for manpower resources far in excess of what the community can muster or could expect to have supported for the foreseeable future in order to meet the needs of current sponsors of nuclear data development in a timely manner. This has led to adoption of certain compromises that appear to be unacceptable for reactor dosimetry. Resolving these conflicting requirements will be a major challenge to both the data producer and data user communities, including dosimetry, during the next few years.

G. Aliberti (ANL) --- Use of Recent Covariances for Fast Reactor Studies

Under the Fast Reactor Campaign of the Global Nuclear Energy Partnership (GNEP), work (in collaboration with INL, LANL and BNL) was initiated to improve the nuclear data by a combined use of the science-based covariance data and integral experiments. The objective of this activity is to precisely account for existing integral experiment data to reduce the uncertainty of reactor performance predictions. Integral experiments play an essential role in the reduction of design uncertainties related to reactor neutronics calculations. The present contribution discussed ongoing work for this project.

For the initial phase of this study, the equilibrium cycle metal and oxide core configurations of a reference 1000 MWt Advanced Burner Reactor (ABR) were selected as the tentative target systems. For the present purpose, it was decided that the proposed experiment should exhibit neutronics computational features similar to those of the target reactor concept. A quantitative and synthetic measure on which to judge the relevance of selected experiments to the ABR systems can be based on the “representativity” concept. The approach uses a sensitivity methodology associated with selected integral parameters

and is based mathematically on the Generalized Perturbation Theory (GPT). The relevant formulation of this theory was described in this presentation.

To carry out a representativity study, sensitivity coefficients first have to be calculated for the selected integral parameters. Three response parameters are considered: the core multiplication factor, the spectral index of ^{238}U fission to ^{239}Pu fission at the core center, and coolant void reactivity worth. For the spectral indices, only the indirect effect of the sensitivity coefficients has been considered, since the direct effect, which essentially dominates the sensitivity profiles with the ^{238}U and ^{239}Pu fission reaction, is of a minor interest. For the present analysis, cross sections were generated using the MC2-2 code and the ENDF/B-VII nuclear data processed into a 33 energy-group-structure. Sensitivity coefficient calculations were performed in diffusion theory using the VARI3D code. Flux, adjoint flux, and generalized adjoint flux were calculated with the finite difference diffusion theory option of the DIF3D code. Previous studies demonstrated that for the kind of systems under investigation, the transport and diffusion approaches show generally non-negligible differences in the parameter calculated values, but no significant difference is observed for the sensitivity coefficients. Extensive tables of calculations and some associated plots were shown during the presentation to provide a sense of the relative importance of various nuclear data types.

Work was then undertaken to improve the nuclear data by a combined use of the science-based covariance data and integral experiments. The metal and oxide core configurations of a reference ABR were selected as the tentative target systems. To identify the most relevant experiments for the selected target systems, a representativity study (as mentioned above) was performed. In this approach, the similarity between the target system and a selected experiment in connection with the response parameter of interest is quantitatively evaluated by comparing the sensitivity profiles of the response parameter with respect to nuclear data in the two systems, filtered by the estimated covariance data. The estimated covariance data play a critical role, since the representativity factors employed in the comparison are dominated by the sensitivity components that correspond to the cross section having significant uncertainties. It has been found that the ZPPR-2, ZPPR-9, ZPPR-15A, ZPR6-7, CIRANO, MUSE-4 and COSMO benchmark experiments show quite good similarities with both the metal and oxide core ABRs; only the coolant void reactivity worth shows significant discrepancies for some experiments because of different fuel-to-coolant loading ratios. However, with respect to k-eff, even the experiment providing the strongest representativity is not sufficient to bring the initial k-eff uncertainty below the desired accuracy of 0.3% for both ABR systems. Degradation in the representativity factors is then observed when the ZPR3 and ZPR6-6A experiments are compared with the ABR cores. Similar conclusions can be made for the GODIVA, BIGTEN, JEZEBEL and FLATTOP experiments. However, by the combined use of two experiments at the same time it has been demonstrated that, with respect to the multiplication factor, the strongest representativity provided by the single experiment (ZPPR-15A for the ABR metal core and ZPR6-7 for the ABR oxide core) is further improved if, in addition, it is considered to include in the analysis an experiment that introduces totally complementary information (i.e., low representativity factors between the two experiments), like ^{240}Pu JEZEBEL for both the target systems.

W.-S. Yang (ANL) --- Neutron Spectrum Covariances in Uncertainty Analyses

Recently, issues associated with the normalization of fission spectrum evaluations and the impact on covariance generation for these spectra, as well as that of sensitivity coefficients, has been discussed in the nuclear applications community. This discussion arose due to some misunderstandings and ambiguities associated with interpreting the ENDF formats. The issue was investigated by Yang from Argonne in great detail. It was also considered by researchers elsewhere. A consensus about formats and normalization issues related to neutron spectra was finally reached as a consequence of this discussion. This presentation reports on the Argonne contribution to this effort.

The treatment described in this presentation is quite mathematical. However, numerous numerical examples were shown to illustrate the points and to provide a quantitative sense of the effects associated with this issue.

A summary of the conclusions reached from the present work is as follows: i) The method to renormalize the covariance matrix to satisfy the zero-sum constraint is a congruent transformation of the covariance matrix using the oblique projection operator that maps the normalized fission spectrum space onto itself; ii) When the covariance matrix is already normalized this transformation does not change the covariance matrix; iii) Imposition of the fission spectrum normalization condition on sensitivity coefficient calculations is equivalent to renormalizing the covariance matrix to satisfy the zero-sum constraints; iv) Both unconstrained and constrained sensitivity coefficients yield the same response uncertainties when a normalized covariance matrix is used; v) If an un-normalized covariance matrix is used, the constrained sensitivity coefficients yield the correct response uncertainty; and vi) Numerical precision of the covariance matrix (round-off problem) appears to be manageable and of minor importance when the matrix is normalized to satisfy the zero-sum constraints.

D. Muir (ANL) --- Covariance Quality Checks

As part of the U.S. effort to create a comprehensive, even if “low-fidelity”, covariance evaluation for the Nuclear Criticality Safety Program, Argonne National Laboratory has the responsibility for performing an overall quality assurance (QA) examination of the file. As part of this QA effort, an eigenvalue analysis of each of the symmetric LB=5 sub-subsections in the present version of the low-fidelity covariance evaluation has been performed. A small, special-purpose checking code, based on a collection of subroutines extracted from the GANDR system, has been utilized for this study. This exercise discovered significant negative eigenvalues in 44 of the 373 materials tested (around 12% of the files examined). By "significant", it is meant that negative eigenvalues that are much larger in absolute value than the small values that could possibly result from the rounding of covariances to 6 significant figures in the formatted files. The reason is traced to the inclusion of overlapping regions of high correlation in many of the evaluations. These matrices should be modified to avoid this problem.

Furthermore, this presentation offers some recommendations about the use of allowed covariance formats in the ENDF system as follows: i) Widespread use of the LB=8 format should be avoided; ii) NI-type sub-subsections should not be used with LB=5 (use LB=6 instead); iii) LB=1 and LB=5 sub-subsections should not be used in the same subsection.

D. Muir (ANL) --- Partial Contributions to Total Variance

A basic tool for modern neutronics analysis is a library of multigroup cross sections, accompanied by a covariance matrix describing the uncertainty of these data and their correlations. A common application of such a covariance library is to provide input for the calculation of the variance D(z), due to the data, of a calculated integral quantity z. This presentation describes a proposed methodology for determining the contribution from an individual parameter, or an identified group of parameters, to the variance of z. It is shown that the magnitude of the contribution depends, in an important way, on the extent of data correlations.

The treatment involves considerable, though straightforward, matrix algebra which was described in its entirety in this presentation. Some authors use the uncertainty profile L(z,i) to quantify the contribution of parameter *i* to D(z). This is an attractive approach for three reasons: First, the profile is straightforward to calculate. Secondly, it provides a useful indicator of where the "action" is in the variance summation. Finally, the quantities L(z,i) sum up to the variance D(z). However, these advantages are offset by the following serious disadvantages: Although L(z,i) has the units of variance (barns-squared), it is not a variance. For this reason, it cannot be guaranteed to be a positive quantity. The square root of L(z,i) is not a standard deviation and can even be imaginary. The treatment described in this presentation avoids this problem, is mathematically rigorous, and guarantees that negative variances will never be obtained. It involves defining and, ultimately, deriving a quantity P(z,**w**) denoted as the “variance penalty”. In contrast to the uncertainty profile approach, where L(z,i) is computed as a weighted sum of k covariances, the calculation of the variance penalty P(z,**w**) requires a matrix inversion and several matrix multiplications. Nevertheless, the mathematical clarity of the variance penalty approach, with its guarantee of a positive result, makes it attractive for general use in characterizing the contribution of uncertainty in data subset w to the variance of z.

A. Sonzogni (BNL) --- Sigma: Covariance Retrieval and Visualization

A brief description of the new Sigma data retrieval and viewing interface being developed at NNDC was presented. The development is proceeding in three phases. The first two phases have been completed and the third phase will be completed in 2009. With regard to covariances, the ability to select and observe covariance information with a few clicks with an easy to use GUI was demonstrated. The system will be interactive when completed so that the user can choose energy limits and various other options to tailor the image to his requirements. The possibility of being able to upload a user-generated covariance for visualization was suggested from the audience and, although not considered in the current campaign, in principle this could be realized.

D. Smith (ANL) --- “Comedy” of Errors

A long standing issue in science is distinguishing the terms “error” and “uncertainty”. At its roots, this problem can be traced to ambiguities in the English language. Through an examination of a series of e-mail messages exchanged between certain members of the nuclear data community via the SG-30 communications list, it was illustrated in a humorous way how the ambiguities associated with use of these two words can lead to confusion. The serious message in this presentation is that the nuclear science community ought to use “uncertainty” to signify the lack of precise knowledge of a physical quantity that necessitates expressing a number not as just “x” but as “$x \pm \Delta x$”, where Δx is the uncertainty in x. On the other hand, “error” should be used to signify a mistake (e.g., a typo in a table of cross sections). Viewed this way, nuclear scientists would undoubtedly accept that their reported results can have uncertainties but, hopefully, not contain errors.

Cross Section Evaluation Working Group

Formats and Processing Committee Report

Michael E. Dunn, ORNL
Committee Chair

The Formats and Processing Committee meeting was convened on November 5, 2008. The initial part of the meeting was devoted to format related issues. No new format proposals were submitted for review and approval; however, Cecil Lubitz (KAPL) gave a presentation concerning the short collision time (SCT) approximation and error in the formula provided in the ENDF-102 manual. After a review of current format issues, status reports on the major processing codes were presented. The Formats and Processing meeting concluded with a status report from BNL concerning NNDC activities related to Formats and Processing. The following are the minutes from the Formats and Processing Committee meeting.

Formats and Related Issues

Short Collision Time Issue (Cecil Lubitz, KAPL)

Cecil Lubitz reviewed the original literature documenting the SCT approximation as intended by General Atomics, GA (Ref GA-9950, UC-80, Reactor Technology, G. M. Borgonovi). The current ENDF-102 SCT equation is incorrect; however, the new, unpublished version of the manual has been corrected. Cecil noted that NJOY is correct now, but he is not sure about the impact of the error over the past years. When asked about the impact on integral calculations (i.e., k-eff), he noted the impact is ~50 pcm in the problems KAPL has examined.

Status of Processing Codes

NJOY (Skip Kahler, LANL)

NJOY99.279 will be released by the end of November 2008. The current version is 99.259. Updates for the next release are listed on slide 2 of the presentation that is available for download from the CSEWG-2008 meeting website. Skip reviewed the details of each of the major updates for the next release.

With regard to covariance processing capabilities, Skip noted that ERRORJ99.259 cannot process a large number of groups. Increased array limits and better memory management in 99.279 resolves this issue. A test job (Pu-239 from ENDF/A 10/1 version) with many groups has been used to provide a sanity check for the increased number of energy groups.

After reviewing the NJOY99.279 updates, Skip provided a status report on the NJOY2008 developed and release plans. NJOY2008 will be the next major release of the NJOY processing system. All NJOY coding has been converted to F90/95. LANL is currently debugging the LRF=7 cross-section format, and efforts are in progress to test NJOY with F-19 and Cl-35 evaluations from ORNL. LANL plans to release NJOY2008 by end of CY2008.

Regarding NJOY training activities, training workshops were provided at the ICRS meeting in April 2008 and ANS meeting in June 2008. Training plans for 2009 include the ANS summer meeting in June 2009 and JEFF/NJOY user group meeting in November 2008.

AMPX (Dorothea Wiarda, ORNL)

Dorothea (Doro) Wiarda provided a detailed status report on the continuous-energy (CE) and multigroup (MG) libraries that have been generated for distribution with SCALE 6. The AMPX cross-section and covariance processing capabilities have been updated in FY2008. A new version of the PUFF-IV covariance process package has been submitted to RSICC. RSICC is nearing completion of the testing, and the new version of PUFF-IV should be available for distribution very soon from RSICC. The new version of PUFF-IV is needed to process the F-19 LRF=7 evaluation that was submitted to NNDC in September 2008. Also, the EXSITE GUI is being developed for SCALE and AMPX. Doro provided examples of how he EXSITE GUI is being used to produce and test AMPX libraries.

LLNL (Neil Summers, LLNL)

Neil Summers provided a schematic overview of the LLNL processing system, new physics, and rewriting of the processing system to use the XML format. LLNL converts the ENDF files to the ENDL format then processes the files to produce libraries for the LLNL transport codes. For new physics, LLNL uses NJOY to produce probability tables for the unresolved resonance region. LLNL has performed some testing of the new URR capability in the LLNL codes (MCAPM). The testing revealed reasonable agreement with MCNP results. LLNL added energy-dependent Q-values for fission utilizing Madland's method. They added expected-value momentum deposition that is used to calculate expected-value momentum deposition by reaction in Monte Carlo (MC) calculations. LLNL has have added atomic fluorescence and MC codes now sample fluorescent photons for each photoelectric reaction.

Currently, LLNL is rewriting processing codes to write XML output data (xProcessing) for use by subsequent codes. Neil also provided xProcessing future development. LLNL plans to have this activity completed during FY2009 and this capability will be released when completed.

ANL (Won Sik, ANL)

Won Sik provided the status report of the ETOE-2/MC2-2 Processing System. For the past year, ANL received GNEP funding to make improvements to the ANL MG system. ANL completed updates to ETOE-2 to process ENDF/B-VII data and completed processing of all major actinides, intermediate and light isotopes. Also, ANL has made improvements to MC2-2 to improve accuracy [ultra-fine group (UFG) spectrum calculation, resolved-resonance treatment for self-shielding UFG generation, addition of anisotropic inelastic scattering treatment is currently in progress]. Won Sik provided a comparison between the old and new procedures for MG cross-section generation. In addition, ANL has performed resonance region comparisons with the CE data with NJOY for ENDF/B-VII.0 isotopes (results shown for Pu-239, U-238, and Fe-56 and good agreement is observed between NJOY and MC2-2). Won Sik provided benchmark calculation results for ZPPR benchmarks using new MC2-2 data with the ANL transport codes. Won Sik provided comments on future work plans that are noted on the last slide of the presentation that is available for download from the CSEWG-2008 meeting website.

BNL Activities Related to Formats and Processing

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

ENDF-102 Manual

Mike Herman distributed 2 draft copies of the latest manual that has been developed by Andrej Trkov and Mike Herman. Many issues were addressed over the past year. The changes that were lost between 2003-2005 have been recovered. Andrej completed proof reading of the entire document. Mike also noted that Eq 7.8 for the SCT approximation has been corrected per Cecil Luitz's comments. A preliminary version of the historical perspective by N. Holden has been added as Appendix I.

The manual has been modernized to include color to differentiate between formats and text. The manual is now in LaTeX format, and hyperlinks have been added. Mike noted that many typos/errors have been corrected. Furthermore, several sections have been reviewed, but additional reviews are needed. Cecil Lubitz agreed to review the File 7 thermal scattering documentation.

The remaining to-do list is to complete the transfer of figures and finalize and review major chapters. If possible, annotated examples could be added, more figures, hyperlinks to real files in the electronic version. Mike noted that these additional items are optional, but would be desirable if there is time to add these features to the manual. The LaTeX source will be managed under GForge, and this will facilitate quality control of the manual for the future. The electronic version of the latest manual will be placed on NNDC website by the end of the calendar year.

Checking Codes (Mike Herman, BNL)

There is a new suite of checking codes (Version 8.0) based on updates by Trkov and includes contributions by Roberto Capote (IAEA) & Arjan Koning (NRG). Recent format updates have been included in checking codes, and improvements have been made to improve diagnostics with less complaining. The updates include less amounts of output. Previously, the codes would provide up to 5 MB of output that was really unmanageable. The output is now limited to essential output. The updates include minor bug fixes, and the codes have been checked with various Fortran compilers.

The checking codes are available from the EMPIRE CVS repository. Currently, the EMPIRE repository is the only available repository for the BNL codes.

Covariance Processing at BNL (Ramon Arcilla, BNL)

The processing platform at BNL is a Linux Cluster (upgraded in August 2008). The Linux cluster includes 3.8 TB disk storage. The total RAM is 152 GB, and the cluster can be used for parallel processing. Currently, MCNP is used in parallel on the cluster.

Ramon noted that BNL is using NJOY99 and PUFF-IV to process covariance data files. During the past year, NNDC has used the processing tools to verify new LANL-ORNL covariance evaluations for U-233, U-235, U-238, Pu-239, Mn-55, and F-19. Furthermore, NNDC has processed the full MF=32 resonance parameter covariance matrices for the U and Pu isotopes. Also, BNL has processed the converted File 32 to File 33 matrices that were prepared by ORNL to reduce the evaluation file size.

With GNEP funding during the past year, the NNDC in support of development a new collapsing algorithm produced 15-, 33-, 230-group covariances for Fe-56, Na-23, Pa-239, U-235, and U-238 using JENDL-3.3.

Sigma Retrieval System (Boris Pritychenko, BNL)

Boris provided a summary of recent developments in the past year to the Sigma Retrieval System. Sigma 1.0 was released in April 2007. Sigma 2.0 was released in April 2008 and has the following new features: angular distributions of emitted neutrons, secondary energy distributions, web implementation of ENDFVER package (full spectra). Boris provided a detailed description of each new feature that has been added to Sigma 2.0. With regard to future plans, Sigma 3.0 is under development, and new features will include plotting of energy-angle spectra of emitted photons and residual nuclei (MF=6). A Sigma article will be published in December 2008 in Nuclear Data Sheets.

Cross Section Evaluation Working Group

Measurements Committee Report

Yaron Danon, RPI
Committee Chair

The measurement committee session was held on the morning of November 5, 2008. Seven presentations from representatives of experimental programs at LANL, ORNL, NIST, LBNL, LLNL and RPI were given. The presentations provided an overview of current research and measurement performed at the different laboratories. A presentation of recent issues with EXFOR was also given in this session.

The Agenda

1. Nuclear data measurements at ANL, Kondev, 15'
2. Status of standards measurements, Carlson, 15'
3. Nuclear data experiments at LANSCE - Highlights 2008, Haight, 30'
4. ORNL cross section measurement activities, Dunn, 15'
5. LLNL experimental overview, Wu, 15
6. Cross section measurements at Rensselaer, Danon 15'
7. LBL thermal cs evaluations and measurements, Firestone, 15'
8. EXFOR - compilation and issues, Hlavac, 10'

The LBL talk by Firestone was not given.

U.S. Laboratory Measurement Programs

1. Experimental Nuclear Data Activities at ANL, Filip G. Kondev

Decay studies of selected actinide nuclei:

Work related to measurements on ^{233}Pa was presented, Initial measurements (FY07) using a mass separated ^{237}Np source (4 nCi) & γ−ray counting of ^{237}Np/^{233}Pa in equilibrium. New measurements at ANL (August/September 2008) ^{233}Pa γ−ray emission probabilities using chemical separation to extract ^{233}Pa from ^{237}Np. Several new ^{233}Pa gamma emission lines were detected in the energy range from 28.57 -311.94 keV.

Development of a Total Absorption Gamma-ray Spectrometer (TAGS) was presented. The system is based on a large NaI detector and a Si detector to tag beta events. The instrument will measure gamma lines following beta decay for isotopes far from stability with a large Q value. The measurements will help complete the information on the beta decay energy (heat) distribution.

Work on ^{237}Np(n,2n) cross section by measurement of the partial ^{237}Np(n,2nγ) and addition of theoretical calculation was presented. No results were shown.

2. **NIST Nuclear Data Standards Measurements, Allan D. Carlson (NIST)**

A review of current worldwide measurement activity on standards was given:

- Measurements of H(n,n) at 14.9 MeV incident neutron energy by a collaboration of NIST, Ohio University, LANL and the University of Guelma were discussed. New angular measurements were obtained. Different angular distribution measurements at 162 MeV and 194 MeV were discussed and show disagreement with each other.
- ^{3}He(n,p) measurements were completed at NIST. Data includes scattering length measurements with a polarized beam and target.
- ^{6}Li(n,t) measurements by collaboration of NIST with the University of Tennessee and Tulane University at ~4 MeV were completed but no results were shown. Measurements by Zhang et al and LANL were shown.
- Data from ^{10}B(n,α) was reviewed. There are discrepancies above 2.5 MeV.
- Capture measurement for Au were reviewed new data from GELINA from a few keV to 100 keV show good agreement with ENDF/B-VII.
- New ^{238}U/^{235}U fission cross section ratio measurements by Nolte et al. are in general agreement with the more accurate measurement by Lisowski et al. The measurement to 800 MeV by Calviani at n_TOF is in good agreement with the Lisowski et al data.

Development of a time projection chamber (TPC) by LANL and LLNL was mentioned. The TPC will be used for high accuracy fission measurements.

3. **Research directions at LANSCE, Robert C. Haight (LANL)**

FIGRARO - work on ^{235}U and ^{239}U fission neutron spectra was completed and summarized in a LANL report LA-UR-09-2585. New measurement with a better ^{239}Pu detector is being analyzed. Improvement in the experiment is in progress and includes reduced scattering from fission chamber, Better neutron detection efficiency below 1 MeV, development of a new fission detection (LLNL-LANL collaboration) and improvement in geometrical efficiency of the neutron detectors. New measurements for ^{235}U, $^{239,240\text{-}244}$Pu, ^{238}U, ^{237}Np are planned.

Other measurements of MeV (1-200 MeV) neutron scattering from ^{56}Fe and Mo isotopes are in progress.

N,Z Reactions – for Z = p, d, t, ^{3,4}He. Measurements in support of a Li(n,α)t were performed at different angles targeting 1-3 MeV incident neutron energy region. The measurements are normalized to ^{235}U fission. Results for incident neutron energy range from 100 keV to 10 MeV were presented. Discrepancies from previous Zhang measurements and a stronger 2 MeV resonance were observed. R-Matrix analysis shows 8.8 % higher cross section at the 2 MeV region.

GEANIE – All data is taken for incident neutron energies in the range 1 MeV $<E_n<$200 MeV. Excitation function of ^{202,204}Tl from ^{203,205}Tl(n,2n) measurements were reported. Performing measurements between micropulses (1.8 us apart) and macro pulses (16.7 ms apart) allows measurement of half lives in the microsecond to millisecond range. Several new levels in ^{202,204}Tl were reported.

Work on a search for a better (n,n'γ) standard was reported, considering Nb, Au and Ti.

Capture measurement with DANCE – New data for ^{241}Am was presented and a thermal cross section of 665±33 b was obtained which is in agreement with JEFF (647 b) but not with ENDF/B-VII (620 b), results of a SAMMY fit to the data with resonance parameter were published.

Fission cross section – measurements for ^{239,240,241,242}Pu were completed. New Results for ^{239}Pu above 30 MeV (to 100 MeV) were presented.

Pulse Stacking – The test of pulse stacking demonstrated that the number of protons in a micropulse could be increased by a factor of 170 with a pulse width of less than 4 nanoseconds FWHM using the present components. Further improvements will result from a higher-frequency buncher to shorten the pulse length to 1-2 ns and a fast kicker that will increase the number of micropulses per second and therefore the time-averaged beam current by a factor of up to 20.

4. New neutron-induced cross section measurements for improved nuclear data, Mike Dunn (ORNL)

Improvement in setups for capture and transmission measurements was presented. A new digital data acquisition system was installed.

New results for ^{53}Cr transmission and capture measurements were presented. $^{53}CrO_3$ sample measured. The data shows deviations from ENDF/B-VII especially near the 3-8 keV cluster of strong resonances.

New capture data on ^{58,60}Ni was presented. New measurements of transmission and capture for ^{95}Mo were presented, 212 new resonances were observed. Spin and parity information was obtained from singles and coincidence in the two segment capture detector.

5. Overview of LLNL experimental program, Ching-Yen Wu (LLNL)

Recent data for ^{241}Am(n,2n) was presented and shows good agreement with ENDF/B-VII.0.
Recent data from ^{241}Am(n,γ) taken at DANCE at LANL was presented, more information was given in section 2.

Surrogate reaction experiment, excited ^{234}U and ^{236}U nuclei were formed via inelastic α-particle scattering and the ratio of their fission probabilities was compared to the known ^{233}U(n,f)/^{235}U(n,f) cross section ratio. The data show good agreement for the excitation energy range from 8 to 24 MeV.

Current activity in surrogate reaction measurements include ^{239}U(n,f) cross section using ^{238}U(^{18}O,^{16}O)^{240}U* and ^{153,155,157}Gd(n,γ) cross section using ^{154,156,158}Gd(p,p′).

Measurements of (n,f) and (n,γ) for ^{242m}Am were completed at DANCE with 98% enriched sample. Preliminary results were shown.

Experiments to measure ^{239}Pu(n,2n) at TUNL f are planed for FY08-09.

A short review of the TPC project which is a collaboration of LLNL and LANL was given. The detector is designed to improve fission measurement.

Development on ALEXIS: an intense, tunable neutron source at LLNL is delayed

6. **Cross Section Measurements and Analysis at Rensselaer, Yaron Danon (RPI)**

Measurements of the total cross section of Zr in the energy range from 0.5 – 20 MeV were presented. In the cross section deep at about 4.5 MeV the data agrees with ENBF/B-VI.8 and is about 8% lower than ENDF/B-VII.0, JENDL-3.3 and JEFF-3.1. Above 16 MeV there is better agreement with the ENDF/B-VII.0 data. Below 1.5 MeV the data shows resonance structure with fluctuations of about ±25% that are not represented in the evaluations.

Similar data was shown for Ti. Above 2 MeV there is good agreement with JEFF 3.1. Below 2 MeV the measured data shows higher resolution than the current evaluations. Some evaluations (ENDF/B-VI.8 and JEFF 3.1) show an energy shift to lower energy. Capture and transmission measurements of Dy-164 were completed and documented in Molly Ernesti's MS Thesis. In the 147 eV and 450.3eV resonances the data show small deviations from ENDF/B-VII.0.

New preliminary transmission data for Eu was presented the data will extend the ENDF/B-VII.0 resonance region above 100 eV.

New experiments with neutron resonance scattering from the 36.68 eV resonance in ^{238}U indicates that the implementation of the free gas model in MCNP 5 (400 KT limitation removed) and GEANT 4 does not agree with the data for back scattering. An improve model by Dagan shows good agreement.

Neutron scattering experiments in the energy range from 0.5-20 MeV for carbon show good agreement with MCNP calculations using ENDF/B-VII.0. Similar experiments for

Be shows reasonable agreement except for forward scattering where the data is higher than the calculations. Data for Mo shows an improvement of ENDF/B-VII.0 over ENDF/V-VI.8, however the measured data is still higher at forward angles (more forward scattering).

Work with the Lead Slowing Down Spectrometer in collaboration with LANL yielded a measurement of the (n,α) reaction in Sm. The information on ^{149}Sm is new and the data is fitted best with ^{147}Sm data from ENDF/B-VI.8 and ^{149}Sm from ENDF/B-VII.0

Results of incident neutron energy dependent fission fragment mass and energy measurements for ^{252}Cf, ^{235}U and ^{239}Pu were presented. The data was also used to study the mass distribution symmetry in the resonance region.

7. **Neutron Cross Section Measurements at LBNL, Richard B. Firestone (LBNL)**

This presentation was not given as the speaker could not attend the meeting.

8. **EXFOR Compilations and Issues – Stanislav Hlavac (Bratislava)**

Since November 2007 S. Hlavac is doing EXFOR compilation under subcontract with the NNDC. It is expected that this arrangement will continue for several years.

Statistics on EXFOR compilation was given, all newly published papers are compiled in timely fashion. New data should be provided digitally to help avoid digitization errors.

A general plan to correct errors in EXFOR and improve the overall quality of the data (WPEC Subgroup 30) was presented. Plans to add missing data was discussed.

Summary of the
11th U.S. Nuclear Data Program Meeting

Held at

Brookhaven National Laboratory

November 5 - 7, 2008

US Nuclear Data Program

Chairman's Summary

P. Oblozinsky
National Nuclear Data Center, BNL

USNDP Annual Meeting

The 11th Annual Meeting of the United States Nuclear Data Program was held from November 5-7, 2008, with the number of registered participants being 48. The meeting was held adjacent to the CSEWG Annual Meeting. A common USNDP-CSEWG session was organized on neutron cross section covariance data.

Nuclear Structure Working Group

The status of basic nuclear databases, NSR, XUNDL and ENSDF, was reviewed. The ENSDF evaluation productivity continued to be fairly high and the number of nuclei in the database reached 3,045, NSR added ~3,500 bibliography references and XUNDL added structure and decay data from ~220 publications.

The new Nuclear Data Sheets software for drawing bands was tested and put into trial use, but further improvements are necessary. Usage of NuDat continues to grow rapidly, reaching 1.1M data retrievals in FY08.

Promising developments were reported on strengthening European ENSDF evaluation effort, although the situation with mass evaluations has not yet been satisfactorily resolved.

Nuclear Reaction Working Group

A common CSEWG-USNDP session was devoted to covariance methodology, stimulated by the growing needs for cross section covariance data in many applications. The future US effort should be geared towards producing fairly large set of covariances for ENDF/B-VII.1 library, to be released in 2010.

Recent progress in the nuclear reaction model code development was reported by several laboratories. Effort continued in updating neutron cross section standards. Computational Infrastructure for Nuclear Astrophysics was upgraded at ORNL.

User Forum

This activity, established several years ago and aimed to strengthen interaction between the user community and USNDP, continued in 2008. A half-day session was devoted to presentations and discussions with two prominent scientists from the United States and

one from Europe. For the first time opportunity was given to a young scientist from the US.

Planning and Reporting

- Summary of the present Annual Meeting should be issued in December 2008,
- Annual Report for FY08 in January 2009, and
- Workplan FY11 in February 2008.

The next budget briefing is likely to be held at the end of February 2009 as a preparation for FY 2011. The budget briefing team should include USNDP chair and WG chairs. Alan Chen should also join to provide McMaster perspective and 1-2 scientists from other laboratories may join depending on the actual situation. USNDP should emphasize positive trend in solving the European ENSDF manpower problem. Attention should be given to explaining the value of nuclear data as a vital link between basic nuclear science and nuclear energy.

Next Meeting

The next USNDP annual meeting will be held at BNL on Nov 4-6, 2009 (Wed – Fri), while the CSEWG annual meeting will be held on Nov 3-5, 2009 (Tue – Wed). The NDAG Criticality Safety meeting will be held on Nov 3, 2009 (Mo) and AFCI Physics Working Group on Nov 5-6 (Thu – Fri).

USNDP Coordinating Committee Meeting

The Coordinating Committee met at working lunchtime on Wednesday, November 6, 2008. Except for R. Firestone all remaining 9 members or their representatives attended the meeting, including P. Oblozinsky (chair), C. Baglin, A. Carlson, T. Kawano, J. Kelley, F. Kondev, R. Vogt for D. Brown, B. Singh, and C. Nesaraja for M. Smith. The meeting was also attended by Ted Barnes, DOE-SC.

Agenda

- Organizational matters. P. Oblozinsky informed that, as a part of his retirement plans, he will be stepping down as USNDP chair early 2009. He proposed Mike Herman (BNL) as his successor and this was fully supported by the Committee. The Committee thanked Pavel for an excellent service he provided over years to the benefit of USNDP.

- USNDP Status: An overall manpower and funding situation at the USNDP laboratories was discussed. The situation is complicated by continuing resolution (CR) implying flat-flat funding. The NNDC is expanding its engagement with

postdocs (currently two, early 2009 another one), search for Tom Burrows replacement is in the final stage; TUNL is getting some help by funding from Duke University; McMaster is searching for new postdoc and summer students; ANL reports no major issues, though it is more difficult to hire postdocs; ORNL situation looks more promising due to staff position given to C. Nesaraja, they are looking for summer students; LANL reports no change in manpower, they face re-organization and creation of huge T-II division; LLNL reports difficulties due to significant reduction in overall manpower, J. Pruett is new leader of data group; LBNL has new group leader – R. Firestone, funding for S. Basunia does not go beyond the end of FY09.

- Ted Barnes has given DOE perspective on the budget, currently we are under 6 months CR, though it might get better in the middle of FY. His best assumption is that flat-flat budget should be expected in future.

- Annual Report FY08 and Workplan FY10: To be prepared as usual, flat-flat scenario should be assumed for FY10.

- Budget Briefing FY11: Expected to be held by the end of February 2009. USNDP should be represented by USNDP chair and WG chairs, A. Chen expressed interest to join and provide McMaster perspective, perhaps 1-2 other people should join as well.

- Next Meeting: See above.

US Nuclear Data Program

Minutes of USNDP Structure and Decay Data Working Group Meeting

2:10 pm - 5:45 pm Wednesday 5 November 2008
8:35 am – 12:15 pm Thursday 6 November 2008

B. Baglin, LBNL
Working Group Chair

Present: D. Abriola, C. Baglin, S. Basu, S. Basunia, M. Bhattacharya, J. Cameron, C.J. Chiara, S. Geraedts, J. Kelley, F.G. Kondev, E. Kwan, C. Nesaraja, N. Nica, C. Ouellet, B. Pritychenko, C. Reich, B. Singh, A. Sonzogni, J. Tuli. Also, A. Chen, M. Herman, N. Holden, T. Kawano, P. Mőller, S. Mughabghab, P. Oblozinsky. S. Tandel, and P. van Isacker were present for segments of the meeting.

The meeting opened with recognition of the recent passing of two of our ENSDF evaluators, T.W. Burrows (NNDC) and S.-C. (Alice) Wu (LBNL); they and their contributions to ENSDF will be sorely missed. On a positive note, however, the recent prestigious award of a Medal of Science to Fay Ajzenberg-Selove, author of many editions of the nuclear data evaluations *Energy Levels of Light Nuclei,* was noted with satisfaction.

Databases and Codes: Status Reports

- **ENSDF & NDS (J.Tuli):** The ENSDF database is now a 177 Mb file containing ~16402 datasets that provide structure and decay data for ~3045 nuclides. It is distributed twice a year (latest release in October 2008). 17 mass chain evaluations, occupying a total of 2724 pages, were published in NDS during CY2008. This averages out to 160 p./chain, an increase over the previous year's 129 p./chain and comparable to 154 p./chain in 2006. Color is now provided online for band drawings prepared using the new band-drawing software. Elsevier reports a total of 4705 online user accounts as of December 2007, and Elsevier's total paid downloads from the entire journal grew from 7896 in 2006 to 11675 in 2007 (39% to Europe, 33% to Asia, 25% to the Americas in 2006-7). Given the large fluctuations in the number of mass chains in the publication pipeline, J. Tuli (Editor) sees no present need for drastic new steps to cut mass-chain length. However, it was noted that several mass chains finalized during FY2008 were added to ENSDF but have not been published in NDS. If some evaluations are published while others are not, this raises several questions, *e.g.,* 1) what is the criterion for choosing the evaluations that will not be published in NDS?, and 2) what impact might the lack of a refereed journal publication have on institutional support for data evaluation work or on a potential evaluator's interest in participating in this activity? Various approaches to publishing just a part of an evaluation were mentioned, but it was emphasized that a uniform

approach was needed to avoid non-uniformity of the final product. It was also felt that better guidance needed to be provided for citation of the ENSDF database itself; citations need to include the version (date), but the database is not presently archived by date.

- **NSR (M. Bhattacharya):** 3532 references were added to NSR during FY2008, bringing the total to 194348, and web queries for the year totaled 192K. M. Kellett at IAEA/NDS continues to keyword articles from NPA, EPJ-A and PLB, a McMaster undergraduate student (S. Geraedts), under the supervision of B. Singh, has been preparing draft keywords for PRC since October 2007, and several other people assisted with NSR compilations when M. Bhattacharya was on family leave earlier this year. This kept NSR up-to-date throughout the year. RHIC-type articles no longer receive keywords. A decline in the number of papers published in NPA and EPJ-A was noted; in 2001 through 2005, NPA and PRC were comparable, but now PRC dominates. The meeting expressed a concern that, given the importance of this database to both nuclear structure data evaluators and the low-energy nuclear physics research community, outsourcing of the NSR work from NNDC must always be closely scrutinized to ensure that standards are maintained; we were assured that NNDC is indeed providing such quality control.

- **Compilations: XUNDL and Atomic Masses (B. Singh):** The **XUNDL database** now contains 2830 compiled datasets created from ~2050 journal publications in 1995-2008 for 1570 nuclides ranging from ^{7}Li to ^{294}118. In FY2008 alone, 450 datasets were compiled from ~220 publications, most by S. Geraedts and B. Singh at McMaster, with some contributions from ANL and Univ. of Jordan. Also, 60 existing datasets were revised and, since November 2007, old datasets have been revisited to insert their permanent NSR keynumbers. Communication with authors continued throughout the year, occasionally prompting authors to send details of data and publish errata. A new use of the database occurred this year: by pre-arrangement with the authors, 14 datasets for transfer-reaction studies covered in a PRL paper were prepared and added to XUNDL and the paper itself then cross-referenced the XUNDL database. This suggests the potential use of the database as a repository for unpublished data referred to in a publication. In view of the large number of new, precise **atomic mass** measurements that have become available since the AME-2003 evaluation (~45 primary publications from 2003-2008, many for nuclei far from stability for which only systematic values were previously available), the McMaster group has begun a new compilation activity. All publications since AME-2003 have been compiled, but are still being checked. However, a sample file based on publications during January – July 2008 has been posted on www.nuclearmasses.org at ORNL. The listing gives the newly-measured mass excess, the AME-2003 value and the difference between the two.

- **NDS Software: new band drawings; proposed new Tables (S. Geraedts):** The development of new software to produce greater legibility and flexibility for Nuclear Data Sheets band drawings and, hopefully, also improved presentation of tabular

information was begun under contract to NNDC in January 2007. However, the project was not completed by the original contractor so, this year, the McMaster group (Geraedts, Ouellet and Singh) developed his incomplete codes to the point where they could be implemented. A test version of the band-drawing software has now been distributed to evaluators, and it has already been used in three mass chain publications, providing clearer drawings and enabling the utilization of color in the online version of NDS. Drawings can be generated for a single nuclide or, in batch mode, for an entire mass chain. However, the new software has not yet been integrated into the NDS Production program so each nuclide's .pdf file has to be integrated into the mass chain .pdf file from the NDS production program, accompanied by appropriate repagination. This requires some manual work and the addition of these drawings is proving somewhat too time-consuming at present for NNDC to use them in all mass chains. In discussions prior to the Working Group meeting, it was agreed that a 'config.in' file modification should be made in the code by the McMaster group so evaluators could assist by submitting that, along with their ENSDF file, if they wished; however, it was unclear how soon that change could be achieved. The code for producing tabular material required much additional development; this has now been done, and preliminary sample tabular output was distributed during the meeting, accompanied by a request for evaluators' input on its effectiveness. It would be highly desirable to have a single code to generate both drawings and tables, and it was suggested that this should be pursued in the future.

- **Status of NuDat (A. Sonzogni):** NuDat continues to be an especially popular resource for nuclear scientists in national labs, research organizations and universities, and in FY2008 there were 1.1 M retrievals from the database (~60% of all NNDC retrievals). E-mail questions from users outside of the evaluation community average about 10/month. Currently, the 2D color-coded nuclear charts can be colored according to $T_{1/2}$ or predominant decay mode; plans for the next release of NuDat envisage an expansion of possible properties to include, *e.g.*, Sp, B(E2) from ENSDF, Qα, or (Audi03 Atomic Mass)-(Liquid Drop Model Fit); suggestions of other useful possibilities would be welcomed. A hardware upgrade is also planned. It was recommended that NuDat should always indicate the date of its most recent update (since updates are not performed on a continuing basis).

- **Status of ENSDF analysis and utility codes (C. Baglin):** Subsequent to the USNDP07 meeting, T. Burrows and T. Kibèdi (ANU) continued work on upgrades to BrIcc and, following Tom's death, T. Kibèdi and collaborators have carried on with this work and provided the following update. The planned extension of Z range was completed (now Z=5-110), identical energy meshes are now used for 'frozen-orbital' and 'no-hole' calculations, binding energies have been updated, and atomic mass numbers for the most abundant isotope are adopted from the 2007 IUPAC Commission on Atomic Weights and Isotopic Abundances (thereby correcting a previous small error in BrIcc for Z=82). Version 2.2 was released in April 2008, followed by Version 2.2a in July 2008 (incorporating a small data file update). The keynumber for the recent publication describing BrIcc is 2008Ki07. Future plans

include extensions of Ω(E0) tables for conversion electrons and for pair production (work now underway at ANU) and a mechanism for correct calculation of coefficients for E0+E2(+M1) transitions. The interactive BrIcc web interface at http://wwwrsphysse.anu.edu.au/nuclear/bricc/ is proving popular (5120 unique visitors in 2008). Mixing ratio (MR) calculation software, utilizing BrIcc v2.2 theoretical coefficients, was released in May 2008. It is Windows-based and calculates MR from ICC or sub-shell ratio data using the CFIT routine of Ryšavý and Dragoun (1980Ry04) or, for ICC data, by finding the MR for which the χ^2(MR) hypersurface is minimal. Progress on incorporating correlation effects (with V. Vanin, Brazil) is proving to be slow. During the past year, small bugs in both COMTRANS and the NDS production code generating decay drawings have been fixed, and E. Browne submitted his revised code for GABS to NNDC for checking prior to release. The release of GABS and solutions to small problems known in FMTCHK and probably in RULER await the attention of Tom Burrows' successor. Meanwhile, evaluators are urged to check their RULER.RPT files carefully.

Reports

- **Systematics of M1 Transition Rates (B. Singh):** Current recommended upper limits (RUL) for B(M1)(W.u.) values are based on surveys of experimental data performed by P. Endt in 1974-1981. B. Singh and S. Geraedts (McMaster) have completed a survey of the highest and lowest experimental values currently in ENSDF in different mass regions. After careful examination of values lying at the two extremes (to eliminate any erroneous values and to exclude transitions in magnetic dipole rotational 'shears' bands), RUL values of 12, 4 and 3 were proposed for A=6-20, 21-44 and A≥45, respectively. It was also recommended that a comment be added to Jπ-rule 12 pointing out that values in magnetic rotational 'shears' bands may exceed RUL. It was noted that a disturbingly large number of B(M1)(W.u.) values in ENSDF are erroneous, making the database unreliable for surveys of values. Some problems stem from missing (but significant) conversion coefficients or incorrect mixing ratios or omission of partial widths for particle-unbound states. It was emphasized that evaluators need to carefully monitor output from the RULER code; should the code have problems, they will be fixed, but it has yet to be demonstrated that it is the code which is at fault.

- **Update on Topical Evaluation of Z=9-14, N=16-24 Nuclides: Island of Inversion (S. Basunia):** The evaluations of 21 of the nuclides in this region that were proposed at the USNDP07 meeting has been completed by evaluators at LBNL (S. Basunia) and McMaster (S. Geraedts, C. Ouellet and B. Singh). These have been added to ENSDF and B. Pritychenko has completed the beta version of an NNDC web page dedicated to disseminating the information. Experimentalists and theorists at other labs (including V. Tripathi and S. Tabor (FSU), A. Gade (MSU), R. Clark and P. Fallon (LBNL) and Y. Utsuno (Univ. Tokyo)) have been supportive of this effort and, at a brief *ad hoc* meeting between B. Singh and 4 researchers (from NSCL, LBNL and FSU) during the June 2008 NS-2008 conference, it was decided to expand the list

of nuclides covered and to prepare a review article on this topic. This entails the update of 16 more nuclides in the LBNL region of responsibility and 11 more from the McMaster region; these should be completed by July 2009. V. Tripathi (FSU) will probably spearhead the preparation of the review article. Also, enhancement by B. Pritychenko of the features on the web dissemination page at NNDC would be desirable.

- **Recent Work on ENSDF and NSR (S. Basu):** While on leave from the Variable Energy Cyclotron Centre, Kolkata, S. Basu has been a guest at NNDC, working on both the keywording of at least 100 papers for NSR and, in collaboration with A. Sonzogni, on ENSDF evaluations for A=95 and 150. Upon return to Kolkata, he would be keen to continue his involvement in this work.

- **IAEA-CRP on updated decay data library for actinides (F.G. Kondev):** Participants in this IAEA-CRP held their 3rd meeting in October 2008 and completion of the CRP is scheduled for June 2009; F.G. Kondev (ANL) is the US participant in this CRP, and he summarized the scope of the CRP and progress on measurements and evaluations. ANL has completed evaluations for ^{246}Cm, ^{206}Tl and ^{206}Hg and those for ^{243}Cm, ^{245}Cm, ^{209}Tl and ^{209}Pb are underway; those for ^{207}Tl and ^{211}Pb have yet to be initiated. Extensive experimental work has included measurements of lifetimes, ^{243}Cm α-emission and γ-emission probabilities, and ^{233}Pa γ-emission and X-ray emission probabilities, leading to the resolution of some earlier data consistency problems.

- **Methods to Cope with Discrepant Data - ^{198}Au $T_{1/2}$ Evaluation (C. Ouellet):** ^{198}Au is important in medical physics (Au-seed injection for cancer treatment), and its 411.8-keV γ-ray provides the vital reference point for γ energy calibration. Numerous measurements of its half-life are available, but the data are discrepant. C. Ouellet, B. Singh and S. Geraedts have applied six averaging techniques to these data to try to obtain the 'best' $T_{1/2}$ value (weighted mean, unweighted mean, limitation of relative statistical weight, normalized residuals, Rajeval technique and bootstrap median). The last technique is a computationally intensive resampling technique, commonly used in biological sciences but not in physics, which does not consider experimental uncertainties. Averages of ^{198}Au $T_{1/2}$ data calculated by each technique were checked as successive measurements were incorporated, chronologically, into the dataset to show how readily each technique converged toward the "true value" as new data points were added. The Bootstrap method converged most rapidly, was not easily affected by outliers or a single high-precision measurement and its uncertainty was large enough to encompass the results from the other methods. The half-life obtained using this technique was recommended as the "adopted value".

- **New Precision ICC Measurements as Tests of Internal Conversion Theory: ^{197m}Pt Case (N. Nica):** Precision conversion coefficient measurements provide a particularly important test of different ICC calculation techniques. The latest data

from Texas A&M provides α_K for ^{197m}Pt(M4, 346.5γ); the value obtained (4.26 4) is in excellent agreement with the 'frozen orbital' calculation (4.27), and is somewhat higher than the no-hole prediction (4.19). The literature value of 4.02 8 agreed with neither calculation.

- **IAEA: International Initiatives and Collaboration in Nuclear Structure and Decay Data (D. Abriola):** Personnel at IAEA Nuclear Data Section continue to be active in technical work: key wording for NSR (primarily M. Kellett), ENSDF evaluations (D. Abriola; in collaboration with A. Sonzogni at NNDC), DDEP evaluations (A. Nichols, as part of a CRP), JEFF Project (M. Kellett, decay data library) and new decay data evaluations for fusion/activation (A. Nichols). The section also provides oversight of Coordinated Research Projects (the Actinides CRP mentioned above is the only structure and decay one active at present). It also co-sponsors training opportunities (an IAEA/ICTP Workshop was held in Trieste 28 Apr.-9 May, 2008, and another is planned in 2010) and organizes the biennial meetings of the International Network of Nuclear structure and Decay Data Evaluators (next meeting in Vienna, 23-27 March 2009). The Nuclear Data Section is seeking to promote increased input to ENSDF, especially from Europe. An informational meeting on "Reference Data Libraries for Nuclear Applications – ENSDF" will be held 10-11 November 2008 in Vienna; ~27 participants from 13 countries are expected to attend. The meeting plans to look at the decline in European evaluations for ENSDF over the past 20 years, to try to identify European scientists and institutions interested in taking part in this work, and to discuss possible strategies to fund such activities in Europe. We were also reminded that the IAEA-NDS stands ready to assist us by organizing a technical meeting to address an NSDD topic if we identify a suitable topic. P. Oblozinsky noted that there are presently no suggestions for new structure/decay CRP topics; such projects must include an 'applied' component.

- **Report on IAEA/ICTP Workshop, Apr./May 2008 (J. Tuli):** This was the fourth in a series of training workshops on *Nuclear Structure and Decay Data: Theory and Evaluation w*hich aim to develop a pool of young scientists who may become involved in structure data evaluation work and, thereby, increase the involvement of the international scientific community in this work. This was a particularly successful workshop attended by 25 participants and 7 ICTP Associates/Affiliates from 20 countries; 4 were active evaluators from US/Canada and another 8 potential evaluators could be identified from India, Bulgaria, Ukraine, China and the US. The instructors included C. Baglin, E. Browne, F.G. Kondev, A. Sonzogni and J. Tuli from the US.

- **European Participation in ENSDF (J. Tuli):** Attempts have been made in recent years to encourage greater European participation in ENSDF. A. Nichols (IAEA) has spearheaded this, with active support from D. Balabanski (Bulgaria) and J. Tuli, and with guidance from P. Oblozinsky and F.G. Kondev. In recent years, initiatives included contacts with European Laboratories, the EU in Brussels and the Nuclear

Physics European Collaboration Committee (NuPECC), in whose journal *Nuclear Physics News*, an awareness article (Nichols, Kondev, Tuli) was published this year and, in September 2007, J. Tuli presented an invited talk at the Eurisol/Eurons Joint Town Meeting in Helsinki. NuPECC now seems aware that European support for data stewardship is not adequate. NuPNET, consisting of 20 participants from funding agencies and ministries from 14 EU countries and chaired by S. Gales (GANIL), could coordinate funding for a European data effort. S. Gales will attend the November 2008 informational meeting at IAEA (already mentioned in D. Abriola's presentation) which will bring together interested European groups. At this meeting, US/Canada presentations will be made by J. Tuli, F.G. Kondev and B. Singh. GSI's attempt to obtain funding for atomic mass evaluation (mentioned in last year's Working Group meeting) was not successful.

Outreach

During last year's USNDP meeting, we targeted a number of upcoming conferences/meetings at which structure-data evaluators planned to be present and might promote US Data Program offerings (*e.g.*, *CGS13, NS2008, Nuclei in the Cosmos X,* and *Exotic Nuclei and Atomic Masses (ENAM*)). We also decided to pursue the possibility of a nuclear data minisymposium during the October 2008 APS-DNP meeting in Oakland (CA) and a small subcommittee was set up to do that. The minisymposium did not happen, and the next DNP meeting (in Hawaii) is a joint meeting with Japan with a different meeting structure. Obviously, an invited data talk at that meeting would be highly desirable, but this was believed by at least one person to be an unrealistic ambition. In general, it was felt that talks were preferable to posters at meetings, but much harder to get at conferences. F.G. Kondev recommended that presentations should be from the entire Working Group rather than from individuals, but there was also support for a multifaceted approach which could include mentions of data evaluation as part of research presentations, use of handout material, and personal interactions promoted by a poster presentation. B. Pritychenko has a contributed talk on nuclear data (including structure data) at the 8th International Conference on Radioactive Nuclear Beams (RNB8) in Grand Rapids (MI) in May 2009 and will also carry handout material to that meeting.

Other Business:

- **Guidelines on Inclusion of Unbound Level Information in ENSDF:** During informal discussions prior to this Working Group meeting, it became clear that revised guidelines for the inclusion of particle-unbound levels in ENSDF are desirable. At present, unbound levels need to be included if they are analog states, giant resonances or unbound levels for which γ-ray information is known. However, information such as energy, Jπ and partial decay widths for other unbound states may be important for astrophysics. This is particularly important for the lighter nuclides. J. Cameron, C. Nesaraja, C. Ouellet and B. Singh agreed that they would constitute the nucleus of a subcommittee which would draft appropriate guidelines indicating

which resonances and what parameters should be included in source data sets and how much of this information should be transferred into Adopted Levels. Neutron resonance parameters used to be excluded from ENSDF (they were evaluated independently) and they are quite voluminous: need they be added to ENSDF or can readers simply be referred to their independent evaluation?

The meeting was adjourned at 12:15 pm.

US Nuclear Data Program

USNDP Nuclear Reaction Working Group

T. Kawano, LANL
Working Group Chair

Nuclear reaction model code development

Herman, BNL, presented recent developments of the EMPIRE code for nuclear data evaluation work. The resonance module, developed by BNL/KAERI collaboration, takes resonance parameters from ATLAS then put them into MT32 compact format by considering thermal cross section uncertainties and statistical properties of resonance parameters. The EGSM (Enhanced/EMPIRE Generalized Super-fluid Model) level densities are updated to reproduce RIPL-3 D0 values. The microscopic level densities were upgraded to the RIPL-3 version with parity distribution. The new fission module allows to utilize any arbitrary fission barriers calculated with microscopic models and accounts for multi-hump barriers with absorption in unlimited number of wells.

We had extensive discussions on nuclear fission including 3 talks: fission potential surface by **Moller**, LANL, measurement and data analysis of fission neutron spectra for U235 and Pu239 by Noda, and fission spectrum calculation by Vogt. Moller presented a new fission barrier calculation and compared with the Hartree-Fock model. The fission neutron spectra in the fast energy range were measured with the FIGARO detector at LANSCE, and the Madland-Nix model calculation was made. Experimental data are still preliminary. Vogt gave a talk on the event-by-event modeling code FREYA at LLNL. Sensitivities of model parameters to the calculated fission spectra were discussed.

Recent developments in the SAMMY code at ORNL were reported by **Arbanas**. Sammy Release 8 will be available from RSICC on December 1, 2008. New options added in Release 8 are an energy dependent nu (average number of neutrons per fission), variable target thickness for transmission, a revised self-shielding and multiple scattering module, a Gaussian width can be a linear function of energy, and a new input method of resonance parameters to avoid numerical error near threshold energies. Arbanas pointed out that Data Covariance Matrices (DCMs) separated into data and data-reduction components require much less storage and CPU-time than explicit DCMs. He also reported that conventional DCMs may give unexpected consequences.

Standards

Carlson, NIST gave a talk on the status of the neutron cross-section standards effort. Measurements of the H(n,n)H angular distribution, by detecting the recoil proton,

by a NIST collaboration at the neutron incident energy of 14.9 MeV have been completed and a paper is being written for journal publication. A measurement of the n-3He coherent scattering length using both a polarized neutron beam and a polarized target has been completed. New plans to measure angular distributions of scattered neutrons from the H(n,n)H reaction; and the 6Li(n,t) and 10B(n,\alpha) cross sections were also discussed. A short summary of the first IAEA consultants' meeting on the nuclear data development project "Maintenance of the Neutron Cross Section Standards," was given.

Astrophysics

Nesaraja, ORNL gave a talk on various nuclear structure and reaction activities of several USNDP member institutions. The talk also included the data software project at ORNL; Computational Infrastructure for Nuclear Astrophysics and the new initiative to aid research in Nuclear Masses (nuclearmasses.org) In the former, new tools were added to manage workflow of evaluation, which streamline tasks that are repetitive, mundane, or inconvenient with existing technologies. The latter software project was launched to help facilitate a proposed new effort in nuclear mass evaluations. The laboratory reports at USNDP described efforts on nuclear astrophysics, and a summary talk was given by Nesaraja at the taskforce report on nuclear data for astrophysics, which included nuclear structure studies at ANL, proton and alpha-particle capture rate evaluation at McMaster University, resonance and spectroscopic factor evaluations at ORNL, and neutron star and fission barrier studies at LANL.

US Nuclear Data Program

2008 USNDP User Forum

A. Sonzogni, BNL, chair

This year's User Forum speakers were Robert Tribble from Texas A&M University, Pieter Van Isacker from GANIL (France), Alex Brown from Michigan State University and Sujit Tandel from the University of Massachusetts at Lowell. A brief summary on some of the topics covered in their presentations follows.

Robert Tribble presented results on cross sections measurements that are of importance in nuclear astrophysics. These cross sections have to be known at very low energies and one possible way to determine them is to use Asymptotic Normalization Coefficients (ANC) that can be obtained from transfer reactions. Several examples were shown, in particular new results on $^{14}N(p,\gamma)^{15}O$, where changes in the cross section shifted the age of globular clusters by 1 billion years. Prof. Tribble also mentioned an upcoming Institute for Nuclear Theory workshop on solar fusion cross sections.

Pieter Van Isacker made a presentation on the Interacting Boson Model (IBM). As an introduction, excited level calculations using IBM on Ru isotopes were presented. A far heavier task was to calculated levels and masses for all nuclide with $50 < Z < 82$ and $82 < N < 126$. The impressive results on mass predictions and 2+ and 4+ energies were shown. Among feedback to NNDC activities were 1) no mass evaluations since 2003, 2) nuclear radii evaluations, 3) correct band assignments in ENSDF.

Among several case studies, **Alex Brown** discussed ^{48}Ni, a doubly magic nuclide which exhibits double proton radioactivity; the 2-proton separation energy was correctly predicted by Brown in 1991, 15 years before its measurement, using shell Model calculations that mapped Isobaric Analog States. The experimental half-life of the ^{48}Ni was also well accounted for. The impact of modern computers on shell model calculations was also discussed as well as the new code NuShellx@MSU. Among Prof. Brown's suggestions were 1) to make the NNDC Interactive Chart of Nuclide closer to Google maps, 2) to add interactive features on the list of levels produced by NuDat, 3) to facilitate the data mining of the ENSDF database by making available to the public the codes the NNDC uses to access it.

Sujit Tandel presentation covered the subject of gamma spectroscopy of trans-uranium isotopes. Due to the very low fusion-evaporation cross sections, the knowledge of high-spin levels for the actinides and beyond is very limited. Experimentalists have to be very creative on devising ways of obtaining high-spin data. Highly detailed data for ^{254}No were obtained using the cold-fusion reaction $^{208}Pb(^{48}Ca,2n)$, and similarly data were obtained for ^{252}No and ^{250}Fm. At a bit lower Z-values, data were also measured using deep inelastic reactions for $^{246,248}Cm$, ^{244}Pu. Sujit also made comments on several NNDC web products.

The forum ended with a discussion on the issue of Atomic Masses. The last Atomic Mass evaluation by Audi *et al.* was published in 2003, yet in the last few years many highly precise mass measurements were published. For ENSDF evaluation, these measurements are very important and the apparent lack of a mass evaluation effort is troubling.

US Nuclear Data Program

USNDP Reports

M. Herman, BNL, chair

Altogether 12 reports were given. USNDP web services as offered by the NNDC continued to grow by 41% in FY08. Two Task Forces are currently being active, addressing nuclear data needs for homeland security and nuclear astrophysics. Nine laboratory reports were given, see www.nndc.bnl.gov/proceedings/2008csewgusndp.

1. USNDP web services, B.Pritychenko

Task Force Reports

2. Nuclear data for homeland security, D.Brown/R.Vogt
3. Nuclear data for astrophysics, M.Smith/C.Nesaraja

Laboratory Reports

4. NNDC report, P.Oblozinsky
5. ANL report, F.Kondev
6. LANL report, T.Kawano
7. LBNL report, R.Firestone
8. LLNL report, D.Brown/R.Vogt
9. NIST report, A.Carlson
10. McMaster report, Chen/Singh
11. ORNL report, M.Smith/C.Nesaraja
12. TUNL report, J.Kelley