BNL Report BNL-213606-2020-INRE

2019 CSEWG Meeting Minutes

4-8 November 2019
Berkner Hall

Status of Action Items from 2018 CSEWG Meeting

ACTION: IAEA to provide connection information for the EXFOR correction system
STATUS: COMPLETED

- Access to the corrections is available from the EXFOR page after the "Data Selection" has been made by ticking the "Apply" box and expanding the "Data re-normalisation..." link. Examples are provided, as well as a "Help" button. As an example, the list of corrections for a dosimetry evaluation by K. Zolotarev is also available there under the "[ZK]" button.
- Description of the correction system is available on https://www-nds.iaea.org/exfor/x4guide/x4corrections/x4corrections.pdf

ACTION: Dave Brown (BNL) to set up ENDF QA document project on GForge. Aim is to have standards fleshed out in 1-2 years so is ready for main library release in ~5-6 years.
STATUS: COMPLETED

- This project has been set up on the NNDC gitlab instance at https://git.nndc.bnl.gov/endf/QA/standards

ACTION: Zaitsev data for heavy water TSL measurements need correction. It has some light water inside and are normalization problems due to messed up EXFOR coding. Pass corrections onto Boris Pritychenko (BNL)
STATUS: CORRECTIONS NEVER SENT

ACTION: Add trackers for feedback on dosimetry reactions to fix received during RPSD-2018 (see David Brown's CSEWG talk):

- **103Rh(n,n')103mRh incorrect (noted in 2 talks, #25409 and #25428)**
- **115In(n,n')115mIn incorrect Tracker #1122**
- **Zr(n,2n), I(n,2n) (noted in #2536)**

STATUS: COMPLETE

ACTION: Add trackers for deficiencies noted during "Assessment of ENDF/B-VIII.0 and TENDL-2015 Evaluated Nuclear Data Libraries Using Stellar Nucleosynthesis Modeling":

- **^{209}Bi, ^{208}Pb could deficient, had to be removed from network**
- **^{76}Se(n,γ) not showing in EXFOR webapp**
- **^{88}Sr, ^{138}Ba, ^{140}Ce give negative r-process abundance: either wrong cross section, wrong abundance or too much production of s-process of ^{138}Ba, ^{88}Sr atlas**
- **TENDL has similar problem for ^{127}I, ^{202}Hg, ^{203}Tl**
- **Need ^{198}Au in ENDF**
- **Need to fill gap between Po and Ra in ENDF**

STATUS:

- **REQUIRES FURTHER INVESTIGATION: ^{209}Bi, ^{208}Pb could deficient, had to be removed from network**
- **COMPLETE, REPORTED TO IAEA: ^{76}Se(n,γ) not showing in EXFOR webapp**

- **TRACKER ADDED TO ATLAS PROJECT: ^{88}Sr, ^{138}Ba, ^{140}Ce give negative r-process abundance: either wrong cross section, wrong abundance or too much production of s-process of ^{138}Ba, ^{88}Sr atlas**
- **COMPLETE: REPORTED TO TENDL PROJECT: TENDL has similar problem for ^{127}I, ^{202}Hg, ^{203}Tl**
- **COMPLETE: TRACKER ADDED TO ENDF PROJECT: Need ^{198}Au in ENDF**
- **COMPLETE: TRACKER ADDED TO ENDF PROJECT: Need to fill gap between Po and Ra in ENDF**

ACTION: Add trackers for deficiencies noted by Caleb Mattoon:

- **d(n,2n) mean value nails experimental data so 5-10% probably realistic, but ENDF uncertainty is 200%**
- **Need covariances for ^{14}N, it is everywhere!**
- **^{54}Fe, ^{58}Ni, and ^{60}Ni have covariances with no cross section data (^{54}Fe has fix in its tracker)**
- **Some uncertainties >> 100%**
- **Some uncertainties way way too small ^{23}Na(n,el), ^{239}Pu nubar**

STATUS: COMPLETE

Arjan Koning (IAEA) requested a format change that would allow Implementation in transport simulation of angular distribution of nucleon emission from breakup reaction. This would require using the extended Kalbach formalism which takes deuteron breakup into account. Kalbach provided modified parameterization for breakup reactions, but it was never included in ENDF. We would need to add a 2nd set of Kalbach parameters, one for regular distribution and other for breakup. Specifically, we would need to be able to describe what happens to the residual nuclei. Need extra parameter (r_{BU}) to switch between two components. A. Koning proposed to add LANG=3 option for Kalbach, so use spot for "a" (which is rarely used) to store r_{BU}. An NJOY patch for this formalism exists, but may need updates. MCNP would need to be extended. LANL has not been included in the development and implementation for NJOY and MCNP. Formats & Processing Committee recommended that the proposal be tabled for now until the above tasks are completed.

ACTION: M. Dunn to make format proposal trackers
STATUS: UNFINISHED

ACTION: D. Brown to add Kalbach paper to tracker
STATUS: UNFINISHED

ACTION: P. Sauvan and A. Koning to generate ENDF manual suggested text. We need usage details captured in ENDF manual (breakup part only applies to n or p since that's what the deuteron breaks up into)
STATUS: UNFINISHED

ACTION: Marco Pigni (ORNL) and Ian Thompson (LLNL) will either prepare a new proposal for a format change to include the Brune parameters or provide an ENDF manual update to explicitly define the frame of reference for the resonance parameters.
STATUS: PARTIALLY COMPLETED

- Mark Paris (LANL) and Ian Thompson (LLNL) submitted a proposal that defines the KRL flag and this proposal is described below

ACTION: if and when new CODATA values published, Jeremy Conlin (LANL) will produce mini-format proposal
STATUS: COMPLETED

- Format proposal presented in Nov. 2019 CSEWG Meeting and described below

Welcome Session

DR ALEJANDRO SONZOGNI — WELCOME

Validation Session

Chair: Andrej Trkov

DR BORIS PRITYCHENKO — STATUS OF ASTROPHYSICAL ABUNDANCES AND RATES CALCULATION USING ENDF/B LIBRARIES

Kadonis compilation is the standard for MACS in the astrophysical community. Recently was big change due big problem in their Au value. Revising to Nuclear Data Standards value lead to dramatic change in results

Boris investigated whether s-process can be explained using ENDF data. Use Bateman equation to solve for abundances. There is an interplay of s- and r-process abundances. S-process can be modeled well and reproduces known solar abundances for the most part. The excess is attributed to r-process.

Did both ENDF and TENDL

Converted ENDF to REACLIB.

KANG SEOG KIM — CASL VERA BENCHMARK RESULTS WITH ENDF/B-VII.1 AND VIII.0 FOR PRESSURIZED WATER REACTORS

- CASL :: Consortium for the Advanced Simulation of Light Water Reactors
- VERA :: Virtual Environment for Reactor Application

VERA includes:

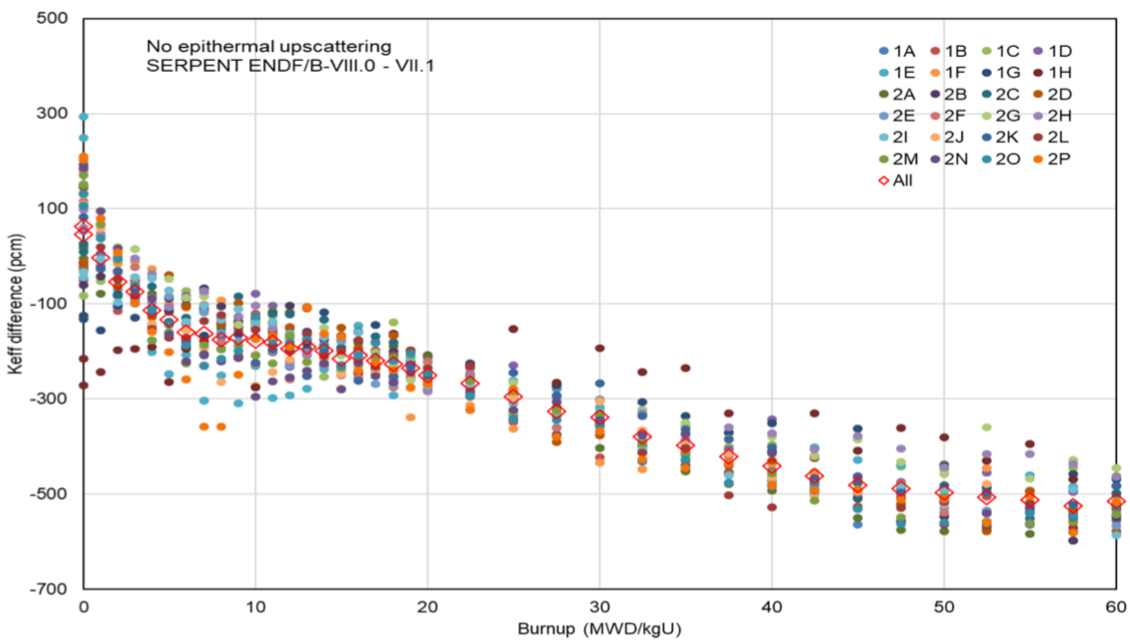
- **CTF**: Subchannel thermal-hydraulics with transient two-fluid, three-field (i.e., liquid film, liquid drops, and vapor) solutions in 14,000 coolant channels with crossflow
- **MPACT**: Advanced pin-resolved 3-D whole-core neutron transport in 51 energy groups and >5M unique cross section regions
- **ORIGEN**: Isotopic depletion and decay in >2M regions tracking 263 isotopes

Neutronics simulators
▪ MPACT : Deterministic 1D (NEM or SPN)/2D (MOC) 3D CMFD Framework
▪ SHIFT : Continuous energy Monte Carlo

AMPX used for data processing

Simulate Westinghouse systems: Westinghouse'ssimulation
– Gary Mangham, "VERA industry validation by Westinghouse"
– CASL IC/SC meeting on 10/15-17
– No epithermal upscattering with ENDF/B-VII.1

Significant difference in reactivity:



First though was that was FPY+decay, but this could not explain change (at least by replacing B7 & B8). Then again, FPY+decay mostly unchanged

- ENDF/B-VII.1:
  - Overall good for the PWR HZP & HFP core reactivity
    - ITC is also good, but slightly more negative
    - BOC is more positive reactivity, but EOC is more negative reactivity
  - Reactivity as a function of burnup
    - Lower at high burnup
    - CASMO-5 is using JEFF-3 data for Pu's
  - Epithermal upscattering would result in more negative reactivity
    - 150-200 pcm more negative

    - Theoretically better, but can not be used

- ENDF/B-VIII.0
  - Significant reactivity bias for depletion
    - ~500 pcm lower at 50 MWD/kgU compared to ENDF/B-VII.1
    - Much bigger thermal absorption reaction rates for U-235 and other Pu's
  - ENDF/B-VIII.0 + epithermal upscattering
    - >500 pcm bias may be bigger than the covariance based uncertainty
    - Cannot be used for the PWR simulation

Roberto: How much is acceptable change to reactivity?
Andrej: Rather than simplified model, want to see results from full-core so see if effect persists

TIM BOHM — DATA VALIDATION FOR FUSION NEUTRONICS

Major uses of nuclear data in fusion

- Neutron flux/fluence (neutron) : structure, magnets
- Radiation damage/dpa (neutron) : structural material, magnet degradation
- Helium production (neutron) : re-weldability
- Tritium production (neutron) : breeding, environmental concerns
- Radiation dose (neutron+photon) : insulators, electronics, personnel
- Total nuclear heating (neutron+photon) : coolant system design, thermal stress, etc. for structure, magnets
- Activation/shutdown dose (photon) : maintenance robotics, personnel, waste disposal

DAGMC — 3d CAD model based Monte Carlo, can use MCNP, GEANT, SHIFT, FLUKA or OpenMC for neutronics

- http://fti.neep.wisc.edu/ncoe/
- http://github.com/svalinn

Focus is on FENDL library

Isotopes of interest:

Isotope	FENDL-2.1	FENDL-3.1
H-1	JENDL-3.3	ENDF/B-VII.1
0-16	ENDF/B-VI.8	ENDF/B-VII.1
Cr-52	ENDF/B-VI.8	ENDF/B-VII.1
Fe-56	JEFF-3	JEFF-3.1.1
Ni-58	JEFF-3	ENDF/B-VII.0
Cu-63,65	ENDF/B-VI.8	ENDF/B-VII.0

Libraries examined:
• Neutron:
  1. FENDL-2.1(21c)
  2. FENDL-3.1(31b,31d)-current version 3.1d
  3. ENDF/B-VII.1(80c)
  4. ENDF/B-VIII.0(00c)
• Photon*:
  1. mcplib84(84p)

ITER-1D computational benchmark

- With ENDF/B-VIII.0 (00c) see neutron fluxes up to 10% lower than FENDL-3.1
- In FENDL-3.1, Fe-56 and Cu data come from JEFF-3.1.1 and ENDF/B-VII.0
- With ENDF/B-VIII.0 (00c) see total heating up to 10% lower than FENDL-3.1
- The isotopes responsible for most differences: Fe-56, Ni-58, Ni-60, Cr-52, Cr-53, Cu-63, Cu-65
- New IAEA replacement Fe: • We see the fe56e80X29r34 has a similar shape to ENDF/B-VIII.0 • We see the fe56e80X29r34 results does not show the large decrease in flux in steel region

MCNP model of Cf-252 source in iron sphere experimental benchmark (Sajo 1993)
• With FENDL-3.1d, we see highest fluxes in the E=0.4 to 5 MeV region
• With ENDF/B-VIII.0, we see lowest fluxes in the E=0.7 to 10 MeV region
• With fe56e80X29r34, we see results similar to FENDL-3.1d in the E=1.0-10.0 MeV region, but not the big peak at E=0.7-1.0 MeV seen with FENDL-3.1d

Other tests:

- U.S. FNSF (3-D and 1-D computational benchmark)
- ITER 3-D computational benchmark
- JET experimental benchmark

Michael Fleming: Are there benchmarks in the SINBAD database that may help?

John Bess: FNG-Cu and FNG-HCLL are currently being looked at for SINBAD as benchmarks, but that's only 2 of the 11 FNG (Friscati) benchmarks

WILLIAM MARSHALL — ENERGY-DEPENDENT BIAS BETWEEN ENDF/B-VII.1 AND ENDF/B-VIII.0 FOR LCT BENCHMARKS

Steps to identify bias:

- Start with C/E plot for all 140 LCT experiments for both ENDF/B-VII.1 and ENDF/B-VIII — CE only
- Note variation in differences
- Identify shared trait for some cases
- Plot C/E versus EALF
- Plot change in C/E versus EALF

Trouble cases:

- Turns out it's LCT-010 cases 14 through 30
- LCT-010 uses two different pitches
    - 2.54 cm for cases 1 – 13
    - 1.892 cm for cases 14 – 30
    - Well that's interesting…
- LCT-078 and -080 are also relatively tight pitch
- Dryer lattice → harder spectrum → bigger difference?

There appears to be a fairly strong trend (as these things go) with larger magnitude bias with increasing neutron energy. More negative is more wrong. The average for ENDF/B-VIII.0 is lower (larger magnitude negative bias) than ENDF/B-VII.1. Initial investigations indicate several isotopes contribute to the bias: **235U, 238U,** and **16O** in different, sometimes canceling, changes

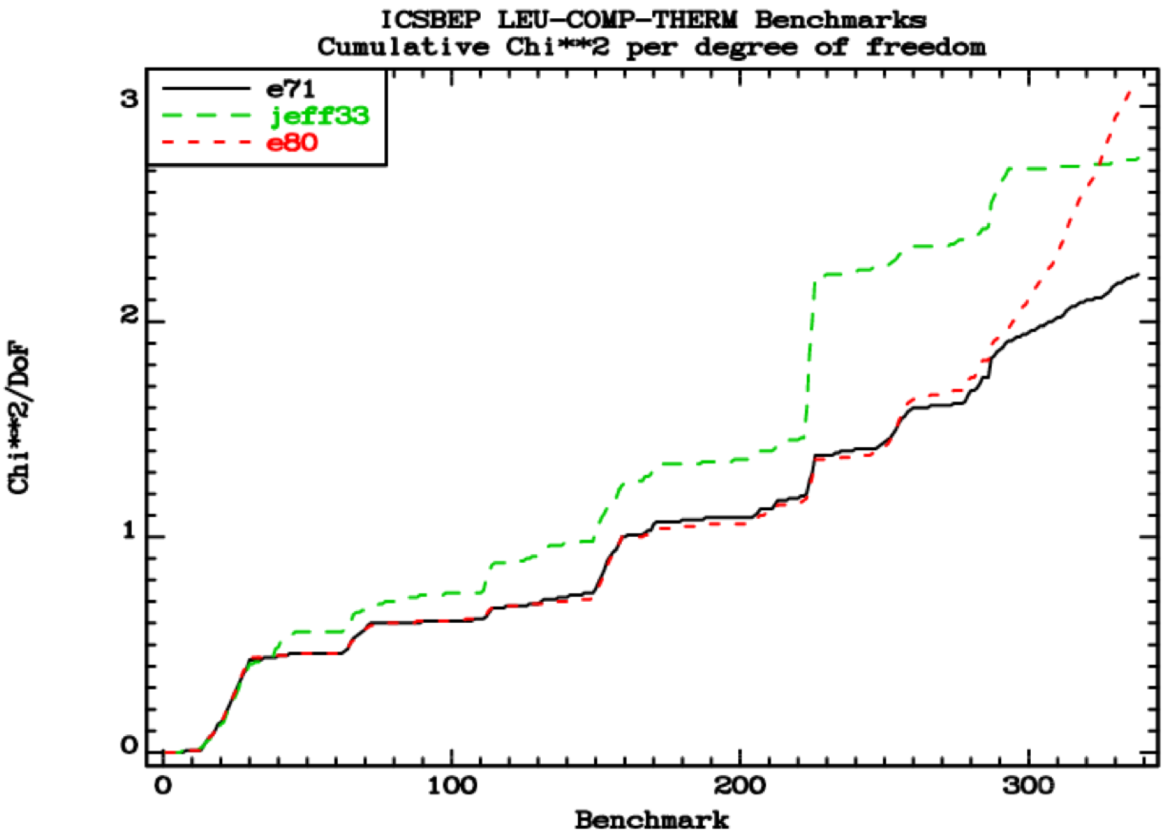
DR ANDREJ TRKOV — CSEWG VALIDATION – CONTRIBUTION FROM THE IAEA (VALIDATION OF CODES FOR ACE LIBRARIES, LCT BENCHMARK ANALYSIS)

- Report from the code-validation exercise for ACE libraries — generally processing codes are in good agreement for cases that require URRPT

- Analysis of ICSBEP LEU-COMP-THERM benchmarks

    - Difference between ENDF/B-VIII.0 and ENDF/B-VII.1 in last cases
    - Seems to be issue with Gd content in the benchmark. It seems that Gd concentration over estimated in the LCT benchmark specifications.
    - LCT-078, 080 and 096 all perform bad-ish, Andrej tracked it down to new 16O evaluation in ENDF/B-VIII.0

- Impact of U-235 on the temperature coefficient. Study by O. Cabellos noted a change in enrichment in some cases. Not clear who's right or wrong, but is disagreement in HCT-016



and KRITZ and others. Andrej investigated a little, but could not come to conclusion

- Iron evaluations — new IAEA fix to 56Fe resolves most of issues, namely leakage around 1 MeV (reducing inelastic and increasing elastic), resolved deep penetration issues but adding background (could use new RRR though),

- Chromium evaluations — is problem with 5 keV resonances in 50,53Cr. ZPR-6/10 very sensitive to them. New measurement needed to resolve disagreement between JRC & RPI

ACTION: John Bess — investigate Gd concentration in LCT benchmark specifications. Situation is complicated because original evaluator (Virginia Dean) passed away

ACTION: LANL — investigate issue with 16O evaluation

JOHN BESS — THE 2019 EDITIONS OF THE ICSBEP AND IRPHEP HANDBOOKS

- ICSBEP Handbook available Sep 2019
- IRPhEP Handbook available Dec 2019
- Key benchmarks of interest to nuclear data:
    - LCT099 – Ti cross section

- LCT103 – U7Mo (~20% 235U) plates
- KRITZ-LWR-RESR-004 – Rod lattices 20 – 250 ºC
- MSRE-MSR-RESR-001 – Molten salt & graphite
- TREAT-FUND-RESR-002 – Graphite & hydrogen sensitivity in fuel

MARIE-LAURE MAUBORGNE — IMPACT OF THE ENDF/B-VIII.0 LIBRARY ON MODELING NUCLEAR TOOLS FOR OIL EXPLORATION

Use tool for spectroscopy in ground:

- Uses LaBr3:Ce spectroscopy detector
- Pulsed Neutron Generator 3.6 x 108 neutron/s nominal

Maybe could be used on Venus lander since designed for high temp/pressure applications

Also DragonFly missing to Titan

Si capture

- Very good reproduction of the silicon capture spectrum
- Use of natural compound in ENDF/B-VI, Si-28 afterward
- Slightly improved with ENDF/B-VIII.0 between 5 and 6.5 MeV
- Look at modeling response without the detector response
- Only plot main lines from IEAE capture handbook above 1 MeV
- Different versions of ENDF are very similar

Si inelastic

- Use of natural compound in ENDF/B-VI, Si-28 afterward
- Modeling benchmark is poorer for inelastic
- Totally different response between ENDF/B-VI and newer releases
- ENDF/B-VI in better agreement with our experimental results above 7MeV

Fe capture

- Iron has been reevaluated through the CIELO collaboration
- Focus on (n, g) cross section
- Not on secondary gamma energy spectrum
- Total count rate is of secondary interest to us
- Use of Fe-56 cross sections
- ENDF/B-VII.1 has the best match with experimental data and IAEA capture gamma-ray emission lines
- ENDF/B-VIII.0 introduces new lines not seen experimentally or in the literature

Mn capture

- Only one isotope found in natural manganese

- Significantly worse in ENDF/B-VIII.0
- ENDF/B-VI and ENDF/B-VII.1 in better agreement with our experimental results and IAEA capture gamma-ray emission lines
- Natural compound in ENDF/B-VI, break into isotopes afterward
- Significantly worse in ENDF/BVII.1 and ENDF/B-VIII.0
- Gamma ray emission energy are very coarse
- ENDF/B-VI is just much better for capture!

Mn inelastic

- Natural compound in ENDF/B-VI, break into isotopes afterward
- Poorer benchmark compared to capture
- Gamma ray emission energies are much finer
- One line at ~1.8 MeV seems to be missing
- Difficult choice, but the 1.8 MeV line is very distinctive
- ENDF/B-VI is better for capture

ACTION: Fe inelastic

ACTION: Mn inelastic

Also issues with Ca, Mg, Ti that haven't been fully analyzed

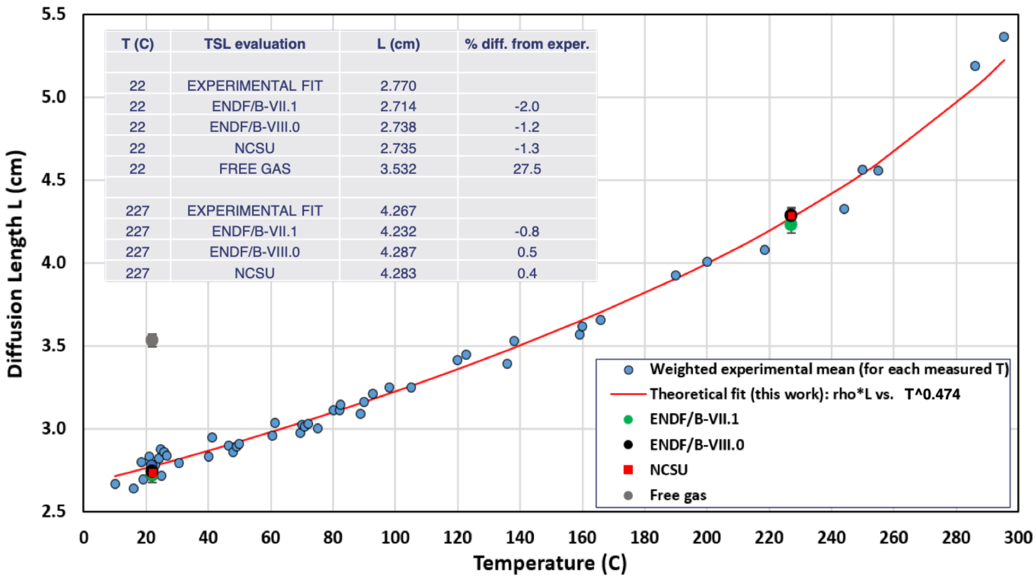
Seems transition from natural evaluations in ENDF/B-V and ENDF/B-VI, to isotopic, meant something got lost. We need to invest more in elemental validation and to add checks for gamma data. In 1990's was big effort to add this data for ENDF/B-VI.

Schlaumberger is investigating how they can collaborate with CSEWG, given IP issues.

DR MICHAEL ZERKLE — VALIDATION OF H-H O AT ELEVATED TEMPERATURES 2 USING DIFFUSION EXPERIMENTS

Experimental results are a based on either the pulsed-neutron die-away (PNDA) method or the static relaxation length method. 24 historic measurements made at various temperatures, below room temp up to 300 deg. C.

Theoretical fit for $\rho L=T(K)^{0.474}$ with curve "pinned" at 22 C based on the weighted mean of diffusion length measurements from 11 different publications (L = 2.770 cm).



Calculated diffusion length L with MC21 PNDA Simulations

BROWN DAVID ET AL. — STATUS OF GITLAB MIGRATION AND ADVANCE CI/CD SYSTEM FOR ENDF

New gitlab process (re)introduces peer review

QUESTIONS: Lots of questions about who “owns” an evaluation and what are the criteria for review

DR DAVE BROWN — PROBLEMS WITH 16O(N,N'A) GAMMAS

ACTION: DAVE ADD ACTION ITEMS FROM TALK HERE

DAVID HEINRICHS — BETA-EFFECTIVE BENCHMARKS

βeff benchmarks available in several cases, but calculation very different than keff

Calculational methods

- COG beta-effective calculational method
- MC21 next fission probability method;
- MC21 correlated sampling method

Good agreement between simulations of ENDF/B-VII.1, are differences in ENDF/B-VIII.0

Bigger changes between algorithms

Compare details of the COG and MC21 models
- Resolve k-eff discrepancies
- Impact of the large “transformation biases” between some ZPR/ZPPR benchmark models and plate-by-plate models (ANL models highly homogenized and this may be causing trouble)

Will add more test cases too

CATHERINE PERCHER — EVOLUTION OF THE ICSBEP AND THE NEED FOR MODERN BENCHMARKS AND EXPERIMENTS

4973 critical, near-critical, and subcritical configurations in the ICSBEP handbook

Major distinction:

> Critical Experiments- Controlled assemblies of nuclear material designed to just achieve the critical point (or slightly lower/higher)
>
> vs.
>
> Critical Benchmarks- Computer simulations of the real critical experiment

Criticality safety validation driving force behind evaluations
—Most experiments evaluated decades later by non-experimentalists
ICSBEP expectations have evolved over time
—Earlier evaluated benchmarks tend to be more brief
—Many evaluated benchmarks are missing major sources of uncertainties
—Computer power was limited, more reliance on simplified geometries
Big spreads in HEU thermal solution assemblies because many are older cases and the solution was poorly characterized (how much acid?). For Pu, situation better.

Poor coverage in intermediate and mixed assemblies

HMF-001:
- Benchmark is subcritical shell experiments completed to inform Lady Godiva design
- “Uncertainties” are only experimental- from extrapolation to idealized critical sphere from subcritical shells
    - Shell radii were not well known!
- Missing MAJOR Uncertainties:
    - Uranium Mass
    - Dimensions of shells
    - Uranium composition
    - 100 pcm uncertainty is likely not right

ZPR/ZPPR plates: very complex configurations, all plates reused, but plate specification differs from reality and the models tend to be simplified

Only 35 Pu cases have intermediate fission fractions > 30%

- 4 modern BFS configurations (Russia, IPPE) [Only trustworthy ones!]
- 1 kinf measurement (UK, small sample reactivity measurement)
- 3 Zero Power Reactor (ZPR) configurations (USA, Argonne Reactor Mock-ups)
- 27 are plutonium oxide polystyrene compacts (USA, Hanford Poly Block experiments)

What does this mean?

- Use caution when relying on a benchmark to inform nuclear data- Read the evaluation and use your judgement
- New OECD Working Party for Nuclear Criticality Safety (WPNCS) Subgroup 8- Preservation of Expert Knowledge and Judgement Applied to Criticality Benchmarks
    - New Subgroup approved in Sept 2019
    - Capture historical and tribal knowledge of benchmark issues
    - Ultimate goal to "grade" ICSBEP benchmarks, similar to past efforts related to differential measurements
    - Will Wieselquist (ORNL), Chair
    - Will help identify candidates for re-evaluation
- Prioritize and complete new, modern experiments that can undergo full uncertainty and correlation assessment

Overview of TEX benchmarks. Large differences seen in ENDF/B-VII.1 versus ENDF/B-VIII.0, on the order of 0.5% in keff
—ENDF/B-VII.1: All cases calculate within 2σ
—ENDF/B-VIII.0: Cases 3 (most intermediate) and 5 (thermal) outside of 2σ
Expected to be included in 2020 Version of ICSBEP Handbook as PU-MET-MIX-002- HEU and U233 TEX in coming years

DR MARIE-ANNE DESCALLE — GNDS IMPLEMENTATION UPDATE: RESULTS OF TNSL AND HEATED URRPT TESTING

Testing of GNDS — FUDGE toolchain at LLNL
Using Mercury & ARDRA
Implemented TSL, URRPT & it works

Executive Committee

Dr. Alejandro Sonzogni

Our executive committee lunch will take place in the usual Berkner A room from noon to 1 PM. Among the items in the agenda are:

1. Transition in the Validation and Formats & Processing Committees leadership.

2. Possible compilation of reaction data during the publication process in Physical Review C, by Alejandro Sonzogni.
3. Possible ENDF/B Hackathon, by David Brown.
4. Do we need a MiniCSEWG in the Spring?
5. Progress on ND2022 by Caleb Mattoon.
6. WINS 2020 announcement by Yaron Danon.
7. New WEPC Subgroup on ENDF/B evaluation documentation, SG49, by David Brown.
8. Any other topics presented by members of the committee.

TRANSITION IN THE VALIDATION AND FORMATS & PROCESSING COMMITTEES LEADERSHIP — ALL

Both committees have currently two chairs, Andrej Trkov and Michael Zerkle on Validation, Doro Wiarda and Mike Dunn on Formats and Processing. As there is plenty of activity in both areas, we have decided to maintain this structure for FY20 and will discuss it again in the next meeting.

POSSIBLE COMPILATION OF REACTION DATA DURING THE PUBLICATION PROCESS IN PHYSICAL REVIEW C — DENISE NEUDECKER AND ALEJANDRO SONZOGNI

For the last two years, articles submitted to PRC containing nuclear structure and decay data are sent to the NNDC during the refereeing process to assess the quality of the data and ensure proper storage in the XUNDL database. We are exploring implementing a similar effort for articles with nuclear reaction data. In addition, we would like that journal editors and referees to become familiar with the uncertainty templates being developed for better uncertainty sources documentation.

ND2022 UPDATE — CALEB MATTOON

The local organizing committee is currently studying different venue options, taking consideration the cost for participants. The final decision on the venue will be reached by end of the year. The LOC will welcome recommendations for plenary speakers, journals where to publish the proceedings and potential reviewers to help with the article's refereeing process. We plan to announce this conference in the upcoming USNDP budget briefing.

WPEC SUBGROUP 49, REPRODUCIBILITY IN NUCLEAR DATA EVALUATION — DAVID BROWN

A new subgroup was formed during the 2019 WPEC meeting, more information can be found at https://www.oecd-nea.org/science/wpec/sg49/documents/WPEC-proposal-Reproducibility.pdf There will be a workshop about this subgroup on November 27, 2019, which unfortunately, no members of the CSEWG executive committee will be able to attend. An effort will be made to participate remotely. Some concern was expressed regarding the documentation and repository of export-controlled codes used in the production of a given evaluation. David Brown is the CSEWG person of contact in this effort.

MINICSEWG AND ENDF HACKATHON — ALL

LANL will likely organize a meeting to present progress on evaluations and validation, sometime in the 2020 Spring. A couple of days will be devoted to fix known ENDF bugs.

2020 CSEWG — ALEJANDRO SONZOGNI

CSEWG will likely require 4 days in 2020 since we have experienced an increased number of participants in the last few years and more time is needed in all sessions to accommodate the submitted talks.

GAMMAS FOLLOWING NEUTRON CAPTURE AND NEUTRON INELASTIC SCATTERING — ALL
The presentation by Marie-Laure Mauborgne highlighted deficiencies in ENDF/B-VIII.0 on the gamma spectra following neutron capture or inelastic scattering for a number of key elements relevant to material identification. We have agreed to start a dialog on this topic among interested parties to remediate this problem.

ACTION: Dave Brown: Engage more with Marie-Laure Mauborgne & Galina Yakubova, invite them to WINS2019. Can they also help with benchmarking? Also, NASA contacts? Participate in WANDA? Send emails!

ACTION: Plan mini-CSEWG at LANL, combined with Hackathon; to focus on QA requirements for ENDF

ACTION: Each committee gets vice chair/heir apparent: Doro for Formats, Mike Z. For Validation, Patrick for Evaluation [reaction]?

ACTION: Convey issues to SG-49 regarding access to repo, use of export control codes

Measurements Session

Chair: Dr. Yaron Danon

HYE YOUNG LEE — LENZ MEASUREMENT OF THE ^{16}O(N,AL) REACTION AND A CHI-NU STATUS UPDATE

Chi-Nu PFNS Experiment: Analysis Improvements, ^{239}Pu Results, Prelim. ^{238}U Data

^{238}U

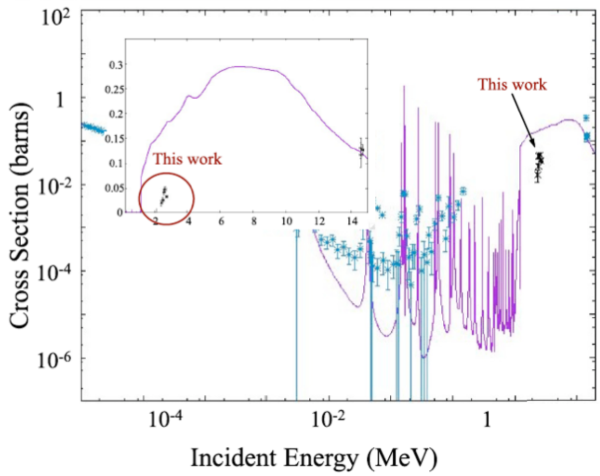
- Second-chance fission later than predicted?
- Signs of third-chance fission appear
- Pre-equilibrium also clearly seen
    - Begins later than predicted in ENDF/B-VIII.0
    - Collect Li-glass data next year, complete analysis soon after

Low Energy (n,z) (LENZ)

- Instead of gas targets, we developed solid & thin-film target fabrications for reducing systematic uncertainty
- Ta_2O_5 + Ta blank
- Detailed modeling of spallation source & collimator
- Simulated detector system in MCNP to build response function
- Gated on specific reactions visible within nToF vs. alpha energy heat map

16O(n,α) reaction normalization

- Experiment : All the resolution functions and detector response functions need to be either estimated or measured in order to validate fidelity of the LENZ MCNP/GEANT simulations
- Theory : Systematically varying inputs (like an uncertainty covariance matrix, various parameter space, etc.) are needed to generate reasonable number of varying cross sections
- For the 16O(n,α) case, where the normalization is an issue, we can deduce a normalization via;
    - a. directly measured cross section with experimental uncertainties



- b. Unitary constraint in R-matrix calculations
    - c. Forward Propagation Analysis
- Currently 30 % uniform Uncertainty is applied to (n,α_0) cross sections, due to on-going effort of estimating corrections for angular distributions, beam-target overlap functions, absolute neutron flux normalization, etc.

Building detailed MCNP model of WNR, including input from LIDAR assay & laser tracking

LENZ data also include double differential cross sections to discrete levels, like 16O(n,α_1), 16O(n,α_2), 16O(n,α_3), etc.

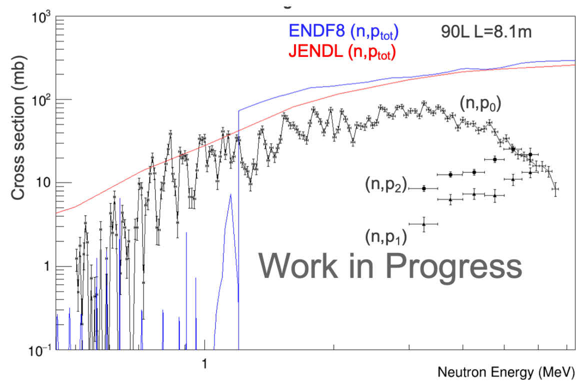
SEAN KUVIN — MEASUREMENT OF THE ^{35}CL(N,P)^{35}S REACTION CROSS SECTION AT LANSCE

The dominant reaction in a fast spectrum molten salt reactor, using chloride salts, is the ^{35}Cl(n,p)^{35}S reaction. (^{35}S $T_{1/2}$ ~ 75 days). Essential for properly characterizing the response of CLYC detectors and simulations of the detector efficiency.

Before (including new LBNL data):

LANL setup

- Annular silicon detectors for detecting charged particles



- 350 and 450 μg/cm^2 NaCl (^{35}Cl enriched) targets evaporated on to 6μm thick brass backing foils
- Two flight paths: 15R(15.2m, forward angles) 15R(14.2m, forward and backward angles) and 90L (8.1m, backward angles)

Definitively confirm the non-statistical behavior of the ^{35}Cl(n,p)^{35}S reaction up to and around ~3 MeV. But is room for improvement. Need to be careful about angular distribution.

CATHLEEN FRY — RECENT EXPERIMENTAL ACTIVITIES AT LANSCE ON PT CAPTURE CROSS SECTIONS

Pt data skimpy, so neutron capture measured at DANCE

DANCE details:

- Nearly 4π coverage (≈3.5π)
- 160 BaF2 crystals - 4 different shapes
- High efficiency for γ detection - collect total energy highly segmented - high rates
- 6LiH inner sphere to absorb scattered neutrons 20.25 m from water moderator
- LANSCE spallation source – 800 MeV p @ 100 μA

Capture data on enriched samples of ^{192,194,195,196,198}Pt were taken recently at DANCE, used ^{208}Pb for scattering backgrounds and ^{197}Au for normalization. Analysis is ongoing
– Initial plan to get pointwise cross sections from ~1 eV to ~500 keV
– Eventual plan to do resonance analysis

ESTHER LEAL CIDONCHA — THE SREFT (SPATIALLY RESOLVING FISSION TRACKER) TIME PROJECTION CHAMBER

Motivation:

- New fission tracking detector at LANSCE (SREFT)
- To measure ...
    - Neutron beam imaging and flux monitoring.
    - Fission Fragments Total Kinetic Energy measurements (TKE) for hot samples and

Fission Product Yields (FPY).

- Minor actinide fission Cross Section ratios.
- Fission Fragment Angular Distributions (FFAD) and anisotropies.
- (n,γ) and (n,xγ) reactions.

- Low cost and relatively easy construction.
- Small size for supporting measurements inside another detector.

SREFT

- Minor actinide fission cross section ratios (unc. > 1%).
- 187 pads per anode => less channels needed.
- Limited cooling required and low power supply.
- Commercial DAQ system.
- Much simpler than the fission TPC, but can fit inside DANCE

Goals

- Thin-walled chamber to allow good auxiliary detector efficiency for outgoing neutrons and gamma rays.
  E resolution ~1 MeV for FF.
- Angular resolution ~3°, vertex resolution ~1 mm.
- Target imaging makes it possible mounting a ^{252}Cf source close to the sample for in-situ energy calibration.
- Good alpha particle rejection.

Plans

- New fission tracking detector SREFT at LANSCE.
- Cross section ratios, FFAD, TKE and FPY measurements.
- Mounting in process: chamber, gas system and electronics (on going).
- Test with ^{252}Cf source planned for the beginning of 2020.
- Future measurements with minor actinides.
- On beam test planned for next campaign (summer 2020).

DR KLAUS GUBER — ORNL NEUTRON CROSS SECTION MEASUREMENTS FOR THE US NUCLEAR CRITICALITY SAFETY PROGRAM

Support the NCSP by measuring thermal, RRR and URR with goal of generating final ENDF evaluations.

NCSP measurements program at JRC is now part of the DOE/Euratom agreement, Action Sheet 66

FINALLY, able to get a sample from the ORNL isotopes program

Transmission & Capture Measuring ^{142}Ce

Used Cerium oxide ($^{142}CeO_2$) and to account for oxygen, used old ORNL (R. Sayer) evaluation since ENDF/B-VIII.0 is point wise (done with EDA).

Analysis on-going, ORNL will use the data to make an evaluation

DR LEE BERNSTEIN — EXPERIMENTAL ACTIVITIES AT LBNL

The DOE Isotope Program has recognized this and initiated a Tri-lab effort (BNL, LANL, LBNL) to measure important (p,x) cross sections from threshold to 200 MeV

LBNL is using stacked target activation measurements

First joint effort with LANL-IPF and BNL-BLIP is ^{75}As(p,x) production cross sections for ^{72}Se and ^{68}Ge. BLIP & LBNL finished, LANL just finished run, haven't finished analysis

Looking into deuteron induced reactions, experiment happening now. To get neutron energy, use double ToF (first one for d, second for emitted n).

Jon Morrell has developed a combined 5 parameter approach using the Kalbach pre-equilibrium and Serber models to describe d-breakup:
- Breakup cross section from Kalbach parameterization
- P(En), P(θ) from Serber
- Add compound and pre-equilibrium background from TALYS (MB)
- One flat background parameter
- Fit yields to literature data

^{35}Cl(n,p) using High Flux Neutron Generator. Measured points verified by DANCE (see Kuvin's talk).

Fission Loading & Unloading Facility for Fission Yields (FLUFFY)
- $^{238,235}U$ + Al_2O_3 irradiated using d-breakup and Li(p,n) neutrons at the 88-Inch cyclotron to determine FPY relative to $^{27}Al(n,\alpha)^{24}Na$
- 5 s irradiation + 125 s counting
- γ-spec compared to FIER
- $^{238,235}U$, ^{239}Pu runs planned
- En=1-10 MeV using Be(d,pn) and Li(p,n)
- Independent yields measured for $t_{½}$ > 1 s

GENESIS array to measure the ^{238}U(n,n'γ), but it will also provide new insight into P(ν(A,Z)) for (n,f)
- Neutrons from 16 MeV deuteron breakup
- 10-20 EJ-309 scint. + Clovers and LEPS

• Initial focus is 56Fe(n,n'γ) (D.L. Bleuel)
• Ph.D. student – Joey Gordon
• 238U(n,fγ) data will provide insight into the A,Z,E,Jπ dependence of P(ν)

FNU KRISHICHAYAN — NUCLEAR DATA MEASUREMENTS CARRIED AT TUNL

Highly shielded gamma counting facility: 10 stations with HPGe detectors

^{147}Np FPY vs. energy using mono-energetic neutrons in 2016, leading to expanded program

Doing photo-fission using Hiγs; previous measurements using Bremsstrahlung sources except for one prior TUNL measurement (Bhike)

Have gamma chain FPY for big 3 [PRC 100:014608 (2019)]

Photofission xs measurements for big 3 [PRC 98: 014608 (2018)]

Moving to cumulative yields $T_{1/2}$ ~min-hr

To get to shorter times: RABITTS (RApid Belt-driven Irradiated Target Transfer System)
Fully automated system

- •Moves between irradiation and counting positions
- •1 m track with 0.4 s transfer time
- •10 m track with 1 s transfer time
- •User set irradiation, transfer, and counting time

Servomotor controls sample position

- •Repeatability to ±33 μm
- •Soft acceleration and deceleration

Data acquisition system

- •Digital DAQ time stamps events to < μs precision

Benchmarked with 7.73 s ^{197}Au isomer & 0.809 s ^{90}Zr isomer & find good agreement with ENSDF

Also looking into isotope production at Hiγs for ^{47}Sc, ^{67}Cu, ^{77}As, and ^{186}Re. Is tricky since different energy ranges in different areas of beam spot, so must make annular targets

Preliminary ^{197}Au(γ,n) measurements from 14-27 MeV

Looking fission isomers: ^{134m}Te, ^{136m}Xe

Published ^{115}Ir(γ,γ')115mIr

Preliminary measurement of ^{238}U(n,γ), big discrepancies

REU student measured ^{191,193}Ir(n,2n)^{190,192}Ir

PROF. YARON DANON — NUCLEAR DATA MEASUREMENT AND ANALYSIS AT RPI

Previous RPI LSDS measurements of capture rate in ^{181}Ta indicated discrepancies with evaluations in both the RRR and UUR.

New time-of-flight measurements of Ta in RRR and URR were completed. Analysis was done with SAMMY/FITACS. Corrections for self-shielded transmission and capture yield were done with SESH in an iterative process. Transmission through a thick (12 mm) sample was used to validate the new URR parameters for shelf-shielding. For this transmission measurement, the self-shielding at the beginning of ENDF-8.0 URR (~300 eV) was about a factor of 4 and thus very sensitive to the URR parameters.

KeV neutron scattering measurements for Zr and Cu were compared to simulations with different evaluations. Some energy regions (~250 keV) show differences and can inform the evaluation on both the cross sections and angular distribution.

Results from ^{235}U ^{239}Pu neutron induced neutron emissions were shown, the data was taken at WNR at LANL and was analyzed and compared to simulations with different evaluations. Some energy ranges with disagreement was noted and analysis of the experimental data continues.

DR ALLAN CARLSON — RECENT WORK ON NEUTRON STANDARDS DATA

H(n,n)H Standard Angular Distribution Work

- This work was initiated to resolve problems with the hydrogen database.
- Previously made measurements at 10 and 14.9 MeV at the Ohio University accelerator facility. The data were obtained by detecting the recoil proton.
- New measurements at 14.9 MeV have been made detecting the neutron in coincidence with the associated proton so that data can be obtained at smaller CMS angles. The data were obtained at the Ohio University accelerator facility
- Paper submitted

Work at the China Spallation Neutron Source by Cui et al on H(n,n)H planned; hope to extend standard up to 150 MeV, possibly 200 MeV, reported at ND2019

^{6}Li(n,t) measurements —A primary effort was focused on measuring the neutron fluence accurately. It was determined with an uncertainty of 0.06%. Last month samples were sent for evaluation by Isotope Dilution Mass Spectrometry to obtain a very accurate value for the mass.

^{6}Li(n,t) Measurements at the China Spallation Source by Bai et al. , reported at ND2019. Preliminary data in very good agreement with standards.

^{10}B(n,α) and ^{10}B(n,α_1) Measurements at the China Spallation Source by Jiang et al. , reported at ND2019. At 2 MeV (above standard region), new measurement of SAD will change the standards fits

Amaducci et al. n_TOF Measurements of 10B(n,α)/6Li(n,t) Cross Section Ratio

^{10}B(n,α) and ^{10}B(n,$α_1$γ) Measurements — Massey et al. have measured ^{10}B(n,Z) reactions for neutron energies from 2 to 20 MeV.

C(n,n) Data — Measurements by Ramirez, Vanhoy have been made at the University of Kentucky of the carbon total cross section from 90 keV to 1.8 MeV. Relative to H(n,n)H

Au(n,γ) Data at Low Neutron Energies — Ratynski and Käppeler results are low by about 5-7% near 30 keV. KADONIS 1.0, has changed the MACS for the Au(n,γ) cross section. Their new value, 611.6 ± 6.0, agrees with the 2017 standards evaluation of 620 ± 11 mb within one standard deviation. Was issue with Cu backing. Two new measurements reported by ND2019 agree with standards.

A measurement was made of the ^{235}U(n,f) cross section from thermal to 170 keV by Amaducci et al. The data are relative to the ^{6}Li(n,t) and 10B(n,α) cross section standards. They are normalized using the 7.8 to 11 eV fission integral. The results obtained in the standards energy region, 150-170 keV agree with the standard

^{239}Pu(n,f)/^{235}U(n,f) cross section ratio measurements made at LANSCE by the NIFFTE collaboration are being analyzed.

Work on the ^{235}U(n,f) cross section relative to hydrogen scattering from 10 MeV to 1 GeV was discussed by Manna et al. (n_TOF collaboration) at the ND2019 meeting. Very preliminary results are available.

Proposed work:

- Haven't had ^{235}U(n,f) thermal cross section since 1960's. NIST proposing to redo it with better source & sample characterization.
- Work is going on to improve the standard NIST NBS-I source
- ^{252}Cf Prompt Fission Neutron Spectrum Measurements, Blain measurement should help reduce uncertainty on standards

DR BORIS PRITYCHENKO — CURRENT STATUS OF EXFOR

- New entries: 63 + 62 (BNL) = 125.
- Corrected entries: 174 + 46 (BNL) = 220.
- 26 Preliminary and 28 final data transmissions (Preliminary transmissions go through the NRDC network quality assurance system, after implemented corrections final transmission are loaded into the database).
- EXFOR database was updated 30 times.
- EXFOR Web retrievals in FY2019: 40,391.
- More compilation details in the IAEA system based on calendar years: http://www-nds.iaea.org/exfor-master/x4compil/.
- Fission yields compilation project is underway.

- Team effort: B. Pritychenko (Project Manager), S. Hlavac, O. Schwerer, O. Gritzay (Contractors), V. Zerkin (IAEA, Web and database developer).

^{88}Zr(n,γ) thermal cross section is (8.61± 0.69) x10^{5} barns [Nature] compared with theoretically predicted 10 barns [TENDL].

Kadonis affair (mentioned earlier in Pritychenko talk in morning and in standards talk)

^{254}Cf spontaneous fission data from Wilhelmy recovered and compiled, helpful for fission recycling in nucleosynthesis

Massive FY compilation project

Cross comparing EXFOR and NSR revealed many missing references.

Data archeology

ELIZABETH MCCUTCHAN — MEASUREMENTS OF BRANCHING RATIOS IN U-238

CoulEx at CARIBU to ATLAS

To inform ^{238}U(n,n'γ) evaluation

It is "studied to death"? No, structure measurements focus on yrast bands, so not much on off-yrast states. The lower states are missing a lot of information and some is conflicting.

But, ^{238}U used as target to induce CoulEx in other isotopes, so the data is just sitting on disk, ignored! For many many experiments! Super clean coincidence data

Preliminary results for:
- Branching ratios for 22 levels in ^{238}U
- Cross checks between different beams
- Also will analyze neutron transfer, ^{237}U, ^{236}U

Covariance Session

Chair: Denise Neudecker

KEEGAN KELLY — COVARIANCE ANALYSIS OF EXPERIMENTAL SHAPE DATA

Why Shape Data are Different
- The basic problem:
    - Shape data (PFNS shape, probability distributions, relative shape measurements, etc.) are inherently different than absolute data (absolute cross sections, etc.)
    - Primary difference is in the covariance treatment

        - Experimental mean values are scaled with respect to other data/ prior within the evaluation process.
- Typical Experimentalist Treatment:
    - I found a fully-correlated uncertainty source (e.g., normalization factor, number of atoms in the sample). I'm reporting shape data, so I can ignore it
    - I found a partially correlated uncertainty source (most sources)
        - Keep it, or ignore part of it, or state that it's correlated.
        - How much do I keep? What is the covariance of the reduced uncertainty? Give to evaluator and move on.
- A Normalization Procedure with Covariance Propagation Solves This Problem

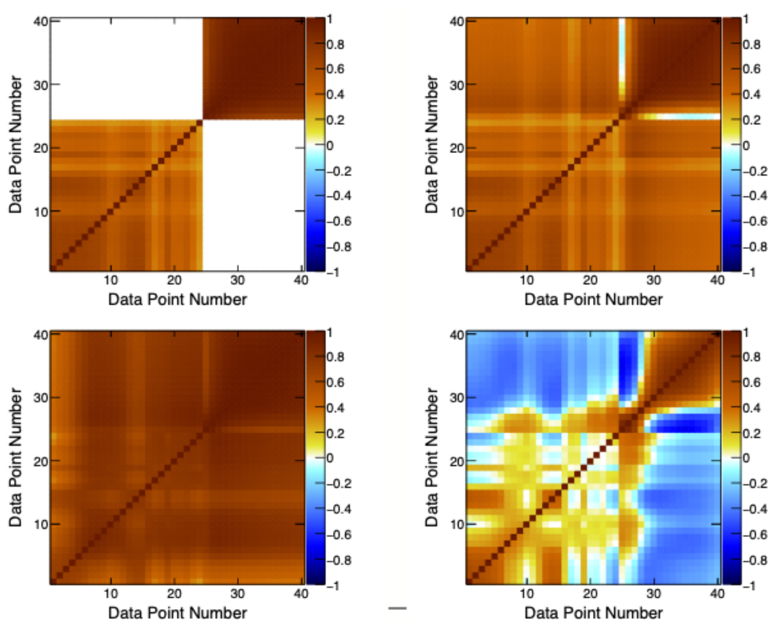
Specific math is required for normalized quantities. See J.M. O'Donnell, D. Neudecker, M. Devlin, J.A. Gomez, Nuclear Instruments and Methods A, Vol. 943, p. 162449 (2019).
When a partial covariance matrix is fully correlated, this specific uncertainty source drops out.

If a data point is measured REALLY WELL, uncertainty gets re-distributed because of normalization procedure and that "well measured" point gets increased uncertainty.

Normalization procedure also redistributes covariance to preserve shape.

Chi-Nu experiment used two different detector systems over two different energy ranges. The two data sets can be combined in two different ways. Combined set has to have one shape, introducing correlation over all energies even if sets started uncorrelated.

Here is an example with Li-glass and liquid scintillator measurements. Top left: before. Off diagonals: scaling one set to other, both variations. Bottom right, final normalization procedure applied.



- Normalization is not “Scaling”, even if scaled such that integral over area below curve is 1. It is a normalization, if also the covariance matrix is normalized.
- Normalization of the covariance matrix of an unnormalized experimental data set yields the covariance matrix of shape data only.
- Normalization is a necessary part of experimental shape data analysis
- Experimental shapes could be misrepresented in evaluations otherwise.
- However, this procedure can be easily applied by evaluators on any shape data set. It needs not be necessarily applied by experimentalist, but it MUST be applied before the evaluation to assign a correct weight to shape data versus absolute data.

DR DENISE NEUDECKER — CSEWG INITIATIVE OF ESTABLISHING TEMPLATES OF EXPECTED MEASUREMENT UNCERTAINTIES

Mini-CSEWG 2019 summary: Joint Experiment/Covariance committee meeting, 35-40 attendees from experimental, evaluator and EXFOR community in Los Alamos, NM, April 29, 30 & May 1, 2019

What is a template of expected?

- A template should list all the typical measurement types for a specific observable.
  - Established based on:
    - going through relevant databases (e.g., EXFOR)
    - discussions with experimenters/evaluators
- A template should list all typical uncertainty sources encountered in measuring this observable.
- A template gives reasonable uncertainty ranges for these sources. These values can be used as a last resort if this information is missing for the uncertainty quantification of a particular data set.
  - Established based on:
    - going through relevant databases (e.g., EXFOR)
    - discussions with experimenters/evaluators
- A template gives estimates for correlation information between uncertainties of the same and different experiment. This information is rarely supplied for the same experiment and missing in most cases between experiments. Nevertheless, this information is needed as input for evaluations.
  - Established based on:
    - Underlying physics sub-processes of the evaluation
    - discussions with experimenters/evaluators

Based on ideas started in

- P. Schillebeeckx, B.Becker, Y. Danon et al., Nucl. Data Sheets 113, p. 3054 (2012). And F. Gunsing, P. Schillebeeckx and V. Semkova, IAEA Report INDC(NDS)-0647 (2013)

    - created EXFOR templates of information that ought to be provided for transmission experiments including but not limited to uncertainties and gave uncertainty procedure to provide information. These templates should be applied to NEW data and do not provide values that can be used by evaluators if this information is missing.
- P. Helgesson, H. Sjöstrand and D. Rochman, Nuclear Data Sheets 145, p. 1 (2017). Provided missing uncertainty values for specific measurements based on information from other measurements of the same observable.

A template can be used by:

- Experimental community as check-list if all uncertainties are provided.
- Templates could become a guideline sanctioned by the community on what (uncertainty) information is needed from measurement to be maximally helpful for evaluations. EXFOR compilers/ editors can point to this document to ask for information.
- May lead to more complete uncertainties in new EXFOR entries.
- More usable information for evaluators in journal publications (editors might not always know what evaluators need)
- Evaluators can make more informed choices to fill in missing uncertainty and correlation information. These choices would be informed by actual experiments of that observable and knowledge of experimentalists doing these measurement.
- Leads to a more balanced uncertainty quantification across different data sets as we do not longer assume 0% for uncertainties that are overlooked.
- More complete uncertainties of future experiments.

Summary of templates we have so far.

- (n,f) cross section: D. Neudecker et al., Nuclear Data Sheets, to be published January 2020.
- The prompt, delayed and isomer gamma measurements template is close to be finished. This template was developed by Amanda Lewis.
- The transmission template is in good shape and is based on the work mentioned above. P. Schillebeeckx led that session.
- The (n,g) template needs more work. P. Schillebeeckx led that session.
- The (n,xn) template is in good shape, R.C. Haight led that session.
- The structure template needs some work, maybe published separately. A. Sonzogni led that session.
- The (n,cp) template is in good shape: ANL Report, ANL/NDM- 85 (1984). D.L. Smith led that session.
- The PFNS template is in good shape. D. Neudecker led that session based on many years of learning from research of the Chi-Nu project and the PFNS CRP co-ordinated by the IAEA.
- FY template just starting. A. Sonzogni led that session. At LANL organized FY workshop in Santa Fe, a few more collaborators could be found. Maybe, these templates can be established.

The impact of applying such a template for evaluations was shown by applying the (n,f) template to updating 239Pu(n,f) covariances in the Neutron Data Standards database. Changing only the experimental covariances changed the mean values by up to +/-2% and increased the evaluated uncertainties by up to 30% compared to the original standard values.

The updated mean values change Jezebel by -90 pcm and Flattop-Pu by -110 pcm! I.e., a significant change.

Short-term goal: publish finalized templates of several observables as journal article(s) and on the homepage of the NNDC as a resource for evaluators, experimentalists, EXFOR compilers and editors for better uncertainty quantification of experimental data.
Mid-term goal: engage with EXFOR and journal edits on how to implement these templates in compiling the data and vetting journal articles.

Long-term goal: Engage international community either through a WPEC subgroup or IAEA working group if there is enough interest.

DR LEE BERNSTEIN — ISOTOPE PRODUCTION CHARGED PARTICLE TEMPLATES

Angle-integrated charged-particle cross sections over a range of energies can be rapidly measured using the stacked target technique.

The monitor foil activation is used to determine the flux at each position in the stack, correcting for flux depletion and allowing for determination of the beam energy throughout the stack by adjusting the Aluminum degrader density using a variance minimization procedure. Careful, the energy you measure at one foil is not the same as at another foil.

MS AMANDA LEWIS — TEMPLATES OF EXPECTED MEASUREMENT UNCERTAINTIES AND EXFOR

Proposed minor format change for EXFOR to enable error sources for templates.
EXFOR is a great resource to extract experimental information. However, uncertainty quantification entries in EXFOR do not lend themselves to automatic retrieval easily:

- Several, distinct, uncertainty sources are often grouped together.
- Other uncertainty sources, on the other hand, can be described with many different terminologies.
- In short, it is hard to extract uncertainties, and close to impossible to extract automatically.

Possible solutions:

- It was proposed by Victor Zerkin that keywords directly corresponding to the template uncertainty sources can be added in the free text.This could help clearly identify the uncertainty sources of old experimental data already in EXFOR.
- EXFOR templates similarly to the work of P. Schillebeeckx, B.Becker, Y. Danon et al., Nucl. Data Sheets 113, p. 3054 (2012). And F. Gunsing, P. Schillebeeckx and V. Semkova, IAEA Report INDC(NDS)-0647 (2013) could be developed for all uncertainty sources. This could help with better formatting and quality of new EXFOR entries.

Amanda Lewis already started to engage the EXFOR community.

DISCUSSION TIME ON TEMPLATES

There is general interest in adding checks using the templates in all journal publications, especially since ENSDF effort led by Libby in checking PRC is so successful. A. Sonzogni already contacted PRC, Elsevier and European Phsics Journal A. However, workload for EXFOR is substantially higher, likely requiring more manpower at the NNDC and elsewhere.

ROBERTO CAPOTE — UNRECOGNIZED SOURCES OF UNCERTAINTIES (USU)

A paper on this topic is currently under review in Nuclear Data Sheets. (Capote et al., if accepted published January 2020.) arXiv 5 Nov. 2019.

USU original: unrecognized systematic uncertainties. Now unrecognized sources of uncertainties as some can be statistical in nature.

In A.D. Carlson et al, Nucl. Data Sheets 148 (2018) 143-188 Evaluation of the Neutron Data Standards, USU techniques by Gai et al. was applied after realizing that evaluated uncertainties obtained by the original standards evaluation were unrealistically small:

- All nu-bar thermal constants: added USU source based on ensemble standard deviation found in 252Cf(sf) nu-bar values. The increase of uncertainty without change of mean values is mathematically justified as only one data point evaluated at a time.
- 6Li(n,t) and 10B(n,a) USU uncertainties were added based on spread of normalization constant. This increase of uncertainty without change of mean values is also mathematically justified
- Fission observable uncertainties were increased by 1.2% (average spread in 235U(n,f) cross-section experimental data). This increase of uncertainties without change of mean values is NOT justified as shown in Roberto Capote and D. Neudecker arXiv 1908.00272 (2019), part of ANS proceedings. This issue needs to be fixed for next version of Neutron Data Standards.

USU often used to “hide” missing or improperly done uncertainty analysis and accounts for a spread in experimental data of unknown reason.

Statistical model to represent USU: y_i = mu + epsilon_i + eta_i + delta_i

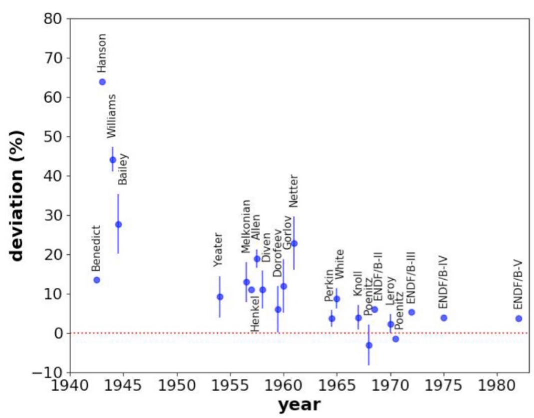
- mu – mean value
- epsilon_i – counting statistics
- eta_i – systematic errors
- delta_i – USU

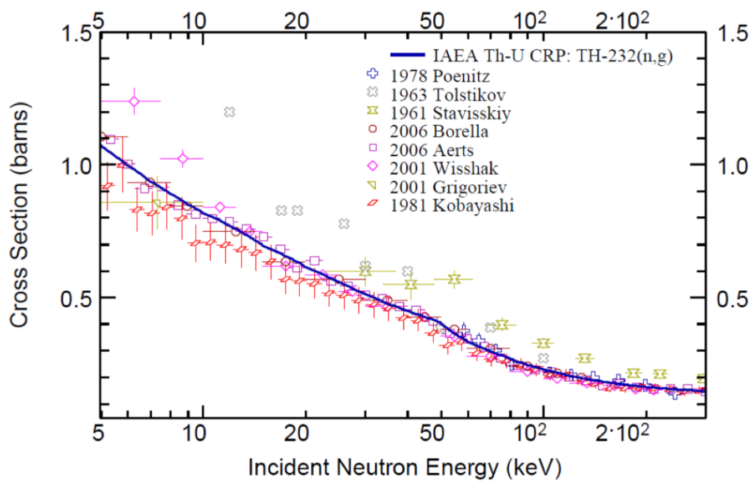
Before identifying USU

- Assess INPUT values, uncertainties & correlations
- Assess KNOWN missing uncertainties (e.g., template)
- Identification and removal of outliers

Example of what is NOT known:

- Known physical effects that were resolved over time, e.g,, 235U(n,f) at thermal. Data that are known to be biased because of an understood physical effect, either need to be rejected or corrected, whatever is feasible.





- Mistakes (e.g. uncorrected H2O contamination) are NOT USU

Paper provides 6 clues that help identify need for USU in experimental data.
2 examples:

- 252Cf(sf) nu-bar: the Chi-square is suspiciously close to 1 of the data and no purely statistical technique indicates clearly that the uncertainties are underestimated. However, if one does the evaluation with 0 correlations between Axton uncertainties for all 15 data points, one ends up with nearly the same evaluated uncertainty as stated by Axton (0.13% versus 0.15%). This fact points towards neglected correlations, especially, considering that only 3 different measurement techniques were employed across all 15 data points. The Physical Uncertainty Boundary method by Vaughan and Preston was applied and indicated that realistic evaluated uncertainties would range between 0.23-0.38% for this observable. I.e., the previous standard uncertainties (0.15%) are clearly underestimated, the current ones (0.42%) are overestimated. Hence, this will be re-evaluated in the near future considering missing uncertainties and correlations between uncertainties.

- Deficiencies in benchmark evaluation may actually be instance of USU not accounted for. More specifically, HEU-MET-FAST C/E keff values of cylindrical assemblies differ systematically from 1 AND spherical assemblies. This difference cannot be explained by nuclear data, as calculated values with ALL libraries shown have the same systematic trend. Switching out data across libraries also did not help.

DR VLADIMIR SOBES — SUMMARY OF SG44 AND TSL COVARIANCE FORMAT

A short summary of each SG44 contribution was shown:

- TSL covariances from Univ. MI. Covariance test cases were produced. Format in development. Gigabytes of data. Ideas were mentioned to just store the principal components.
- New paradigm talk from Mike Herman (see later in CSEWG)
- FPY covariance from Alejandro Sonzogni
- Augmented covariance from Vlad Sobes similarly to talk last year at CSEWG. Vlad Sobes already sent out some test values to members of the team and awaits values from other members of the team.
- Variance-covariance matrices from Gerald Rimpault
- USU from Henrik Sjoestrand. How to apply outlier identification methods in nuclear data evaluations.
- RRR improvements to TSURFER from Chris Perfetti, UNM.
- Templates from Denise Neudecker (reference to talk of before).
- Belief network from Dave Brown.

Discussion of new covariance formats coming (TSL, FY). These covariance formats will likely only be in GNDS and not ENDF-6. Hence, there will be not backwards-compatibility with regards to covariances.

CALEB MATTOON — CURRENT OFFICIAL GNDS COVARIANCE FORMAT AND FORMAT PROPOSALS

- GNDS-1.9 specifications to be published soon by NEA.
  - Draft version available at https://www.oecd-nea.org/science/wpec/gnds/
- Supports most types of covariance data found in ENDF-6 manual, all types found in ENDF/B-VII.1 and ENDF/B-VIII .0
- will briefly describe GNDS-1.9 covariances, and present a draft proposal for new covariances in the next version of GNDS

GNDS covariances fall in 2 categories

- Parameter covariances (like ENDF MF=32)
    - Consisting of an NxN matrix along with links to N parameters. Links can be made to different observables and across isotopes.
    - All co-variant parameters are included in the matrix
- Everything else (MF=31,33,34,35,40)
    - Consist of links to the row (and optionally column) data, a list of energy boundaries along each axis, and a covariance matrix or recipe for deriving a covariance matrix

For parameter covariances, have two parts

- One or more links pointing to N co-variant parameters; A single link can point to multiple parameters inside a table
- An NxN matrix

For everything else, block construction with liberal use of links. Blocks can be within observable or cross observable

Compression, other covariance composition rules given in ENDF are supported

Extra metadata helps handle multidimensional data

TSL and FPY covariances are already supported.

Proposal to add “sandwichProduct” covariances

DOROTHEA WIARDA — ISSUES IN ENDF/B-VIII.0 GNDS COVARIANCES

Puff_iv can now read both ENDF & GNDS formatted files to search for differences

Doro found issues in the version of the GNDS files that were shipped for ENDF/B-VIII.0. These issues have been fixed in FUDGE & GNDS, but not the distributed files. In particular:

- Some links to cross covariance cross section matrices are broken
- LB=2 (Fractional components correlated over all energy intervals) matrix not converted correctly
- For compact matrices correlation are not correctly translated to GNDS values.
- Covariances in the URR do not contain data for level densities.

ACTION: Dave & Caleb, provide corrected files

GNDS allows us to break things like covariances up into different files. This way you don’t have to eat some giant file you don’t need. Also, covariances might be given in separate files from the mean values that we do not have to read such large files.

GNDS also allows you to save different flavors of the same file with “styles”

Both features allowed the distribution of Margo Pigni's gigantic 235U RRR covariance file

Parameter covariance is very flexible and much easier to use than ENDF

Extension to multi-D data easy, example for TSL data given.

DISCUSSION: New TSL covariance will only be available in GNDS, no one has a good way to back port. Backwards compatibility will be lost.

KENT PARSONS — MU-BAR COVARIANCES, IMPORTANCE AND ISSUES IN ENDF/B-VIII.0

As given in the evaluation files and then processed in NJOY, mubar is given by incoming group – and its value includes the sum of all outgoing group cross sections.

There are some physical constraints on mu-bar. It cannot be smaller than -1 or larger than +1. Therefore, uncertainties large enough to go beyond this limit are unphysical. But such values were found in ENDF/B-VIII.0.

For a specific incoming group:

- Mubar = (sum of outgoing P1 elastic xs) / (sum of outgoing P0 elastic xs)
- Includes up-scatter (if present), self-scatter, and down-scatter

NJOY only calculates the P1 contribution for mubar.

Unlike cross section uncertainties and sensitivities, mubar does NOT directly affect the reaction rates

- Mubars interact with the P1 fluxes therefore leakage rates
- Cross sections interact with the P0 fluxes therefore reaction rates

Problems with O-16 mubar variances

- ENDF/B VIII.0 O-16 mubar covariance data stops at 7 MeV
    - It is because more reaction channels open up for O-16 at these high energies
- Complicates R-matrix theory
    - The Japanese O-16 mubar covariance data goes at least to 17 MeV
- ENDF/B VIII.0 O-16 mubar covariance data has very large uncertainties at lower energies as noted by Pino Palmiotti. Has been fixed by G. Hale. A LANL internal corrected file exists, but not submitted to ENDF. Still issues at selected high energy resonance points. The angular distribution for higher angular momentum (p-wave) resonances have unrealistical uncertainties.
- The Japanese O-16 mubar covariance data is 0.0 below 2.53e-8 MeV and small at energies just above room temperature

Other observables:

- NJOY cannot process parts of 235U covariances as it cannot handle the formats correctly. This is being worked on by the NJOY team.
- 239Pu mu-bar covariance are processed without problems by NJOY.

MCNP does not break mu-bar sensitivities in Legendre-coefficients, however, solution was mentioned. Jeff Favorites's SENSMG code can do it properly.

> "It was found that in the case of small systems with large leakage effects, such as JEZEBEL Pu239, the sensitivities due to mubar, are non-negligible and contribute relevant uncertainties. ... It was also noted that, as expected, the mubar sensitivities are mainly distributed in the high energy range." (from a 2012 paper by Aliberti and McKnight)

DISCUSSION: ~160 pcm (0.00160 in keff) was the estimated overall uncertainty due to mubar – in either 30g or 250g analysis. This is comparable in magnitude to the "official" cross section (total, elastic, inelastic, fission, capture, nubar, and fission spectrum) uncertainties for Jezebel as given in the CIELO / ENDF/B VIII release paper. The official values range from ~30 pcm and ~900 pcm. This is non-negligible and mu-bar should be considered in future covariance analyses.

DISCUSSION TIME ON FORMATS AND ISSUES

RAMONA VOGT — COVARIANCES BETWEEN FISSION OBSERVABLES COMING FROM THEORY

- Performed least-square analysis of three types of data using her open-source code of FREYA
  - Mass yields as a function of A, Y(A)
  - Average total kinetic energy as a function of heavy fragment mass, TKE(AH)
  - Width of TKE distribution, sigmaTKE, as a function of AH
- Generated best mean value as well as covariance matrix containing uncertainties and correlations, as outlined below
- A total of 15,000 yield functions were generated for input into FREYA to study consequences of varying the input on neutron observables

^{252}Cf(sf) data is best case because of a wealth of data.

  - Mass and charge yields
  - Average TKE vs. heavy fragment A
  - Width of TKE(AH) not well determined

Once FREYA's inputs set, generate events using FREYA. Calculated various observables and their covariances, including PFNS, P(nu), angular distributions.

Correlations between TKE & nubar and their covariances. The resulting TKE distribution was too wide, so had to add a bias based on experiment.

Can download the code and many papers (but the link to this work is missing! Ask Ramona)

DR MARCO PIGNI — STANDARDIZING A RENEWED FISSION PRODUCT YIELD LIBRARY AND RELATED COVARIANCES

Extended TSURFER for nuclear data adjustment, including prior. Basically uses Lagrange multiplier approach (first used by Householder at ORNL!) to implement constraints, so is constrained generalized least-squares approach as in FUDGE's linearAlgebra.py module.

Set up IFPY, factorizing it into sum yield, fractional yield and isomeric yield. Each one has sum rules/constraints that must be obeyed.

Tried # fragments == 2 constraint and A_init = A_final - nubar constraint

With or without constraints, matrix is sparse.

Tried same, but instead of each yield varying by itself, use 5 Gaussian model.

GORAN ARBANAS — BAYESIAN MC EVALUATION FRAMEWORK FOR DIFFERENTIAL AND INTEGRAL DATA

Outline:

- Extant methods (linear approximation)
- Bayes theorem for generalized data
- Schematic diagram
- Framework Demonstration on U-233 integral and differential data

Developed constrained generalized least squares but use MCMC since linear approximation isn't always that good.

Specific MCMC == Metropolis Hastings

Not quite conditional MC

Test run of MCMC on ^{233}U RRR covariance. Found that linearization dramatically underestimates uncertainties in some cases and that the distribution is not Gaussian. Demonstrated on U233-SOL-INTER-001.

Non-linear response of bound resonance leads to giant uncertainty at thermal range.

Evaluation [Reaction data] Session

Chair: Mark Chadwick, Vice chair: Patrick Talou

JASON THOMPSON — BE9 PHOTONUCLEAR EVALUATION

Four reactions, four-is modes, all lumped into one reaction in current ENDF file

- $9Be(\gamma, n0)8Be$ 1.665 MeV
- $9Be(\gamma, n1)8Be$ 4.695 MeV
- $9Be(\gamma, n2\alpha)$ 1.573 MeV
- $9Be(\gamma, \alpha)5He$ 2.308 MeV

All result in neutron (after breakups) so file them as (γ, n).

Current evaluation has strange threshold behavior because it uses the threshold for $(\gamma, n2\alpha)$ for generic (γ, n) reaction. But physically it doesn't make sense.

Nucleus has a lot of astrophysical interest so there is a lot of new data available with great energy resolution. Mostly use laser Compton backscattering to get mono energetic gammas.

Did MLBW fit of resonances, however difficult to determine the partial widths and literature doesn't help enough. So they made a choice. More measurements would help sort it out, esp. secondary distributions.

ACTION: Should compare with IAEA photonuclear library work – Kawano et al, 2019 (final report due shortly)

QUESTION: can you also distribute the final RRR parameters even if NJOY can't use them? GNDS has a place for them even if ENDF doesn't.

PATRICK TALOU — PLUTONIUM ISOTOPES

Would like to have internally consistent set of evaluations. Multichance fission couples different isotopes' (n,f) cross section and PFNS. FPY also couples prompt and beta delayed

	xs (fast)	xs (RRR)	xs (URR)	PFNS	Nu-bar	Covariances
236	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	31,32,33,34,35
237	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	31,32,33,34,35
238	ENDF/B-VII.1	JENDL-4.0	JENDL-4.0	ENDF/B-VII.1	ENDF/B-VII.1	31,33,35
239	ENDF/B-VIII	ENDF/B-VIII	ENDF/B-VIII	ENDF/B-VIII	ENDF/B-VIII	31,32,33,35
240	ENDF/B-VII.1	ENDF/B-VIII	ENDF/B-VII.1	ENDF/B-VII.1	ENDF/B-VII.1	31,32,33,35
241	ENDF/B-VI	ENDF/B-VI	ENDF/B-VI	ENDF/B-VI	ENDF/B-VI	ENDF/B-VII
242	JENDL-4.0	ENDF/B-VII	ENDF/B-VII	JENDL-4.0	JENDL-4.0	31,33,34,35
243	ENDF/B-V-VI	ENDF/B-V-VI	ENDF/B-V-VI	ENDF/B-V-VI	ENDF/B-VIII	
244	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	ENDF/B-VIII	31,32,33,34,35
245	ENDF/B-VIII?	ENDF/B-VIII?	ENDF/B-VIII?	From Pu243	From Pu243	
246	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	ENDF/B-VIII	31,33,34,35

ENDF/B-VIII.0
Older ENDF/B
Recent, OK
Needs work
Bad
Nothing
Other evaluation

IFY & CFY. So, need model(s) that couple all of these. FY19-23 NA22-sponsored effort on FPY will address some of those issues for Pu239.

Many new models e.g. R-matrix to couple class I & II state transitions.

Strong (anti)correlation between TKE and nubar means nubar strongly constrains TKE, as uncertainty on nubar is usually smaller than the corresponding TKE uncertainty.

New NIFFTE & ChiNu data to fully incorporate into or guide new evaluations.

New PFGS measurements and new data from DANCE shows fission isomer leading to “prompt delayed” gamma emission.

Small change to 239Pu(n,2n) cross section near threshold, motivated by PROFIL studies and internal LANL data testing

Realistic UQ cannot be done without consistent evaluations.

DR MARCO PIGNI — R-MATRIX EVALUATION OF ACTINIDES

Trying to improve Big 3 URR by using data from RRR which extends up to higher energy, but is not used. There are clearly fluctuations above RRR, but they are not really reflected in the libraries. Want to include these in the files while still preserving good performance in applications.

Energy resolution of experiment deteriorates as we go up in energy. So take Reich-Moore and do Lorentzian average. Replace <S> with <S> calculated with <R>. This is SPRT method, developed by Moldauer.

Assembly	Date	^{233}U	^{235}U	^{238}U	^{237}Np	^{239}Pu	R-values	Actinides	FC	PNNL	LLNL	Sponsor(s)
Comet/ZEUS	Sep-11		✓	✓		✓	✓	✓		✓		NA-10/80
Comet/ZEUS	Sep-12		✓	✓			✓	✓		✓		NA-22
Flattop (half)	Jun-13	✓	✓	✓			✓	✓		✓		NA-22
Flattop (half)	Aug-14		✓	✓	✓		✓	✓		✓		NA-22
Flattop (full)	Apr-15		✓	✓		✓	✓	✓		✓		NA-22
Planet (special)	Jun-16		✓	✓			✓	✓			✓	DTRA
Flattop (full)	Mar-17		✓	✓	✓		✓	✓			✓	DTRA
Planet (special)	Jul-17		✓	✓			✓	✓			✓	DTRA
Flattop (full)	Apr-17		✓	✓			✓	✓	✓	✓		NA-22
Flattop (full)	Apr-18		✓	✓	✓		✓	✓	✓	✓		NA-22
Planet (special)	Jun-18		✓	✓			✓	✓			✓	DTRA
Planet (special)	2019		✓	✓			✓	✓	?	✓	✓	NA-10/NCSP
Flattop (full)	2020		✓	✓			✓	✓	✓	✓		NA-22
Flattop (full)	2022		✓	✓		✓	✓	✓	✓	✓		NA-22

Good consistency between average S-matrix and the OMP for elastic widths. However, averaging over a window does not match perfectly the Lorentzian approach without big averaging window.

LUIZ LEAL — EVALUATIONS AT IRSN

Isotope	Energy Range	Resonance Covariance Evaluation	Target date for delivery the evaluation
^{233}U	Thermal to 2 keV	RP + CV	Ongoing
^{239}Pu	Thermal to 4 keV	RP + CV	Ongoing
Gd isotopes	Varies according to the isotopes	RP + CV	Completed
^{56}Fe, ^{54}Fe	Thermal to 2 MeV Thermal to 1.2 MeV	RP + CV	Ongoing
Pb isotopes (204, 206, 207, 208)	Varies according to the isotopes **Common task IRSN-ORNL**	RP + CV	Ongoing
Mo isotopes	Varies according to the isotopes	RP + CV	Ongoing

This talk will also be shown during NDAG.
233U — extending upper energy from 600 eV to 2 keV using ORELA data; is new alpha measurements from n_TOF to include; URR under development. Need capture data!

239Pu — address issues on reproduction cross section from 2.5 keV to 4 keV; revise external levels & better fit of thermal cross sections. Improved agreement with TEX benchmarks for k_eff. Use of recent Mosby (LANSCE)'s capture data.

Gd — with Vlad Sobes; uses new RPI (transmission & capture) and n_TOF (capture) data. Improves MIX-SOL-THERM-006 but made PU-SOL-THERM-034 slightly worse. Because all isotopes have comparable abundance, properly attributing resonances tricky, requiring tricks like Delta3 statistic etc.

56Fe — New high resolution transmission measurements done at the RPI extending the resonance region up to 5 MeV; Inelastic cross-section measurements done at IRMM; Use the SAMMY/RML feature to include inelastic channel in the R-matrix analysis

54Fe — High resolution transmission data of Cornelis (GELINA) and Harvey (ORELA); Calculated direct capture with the CUPIDO code from G. Arbanas (ORNL) included;

Pb — (204, 206, 207, 208) collaboration with ORNL - Vladimir Sobes; Transmission and capture data for enriched samples are needed!

Mo — (95, 96) Transmission data and Capture cross section measurements have been carried out recently at J-PARC by IRSN and JAEA; Assessment of existing evaluations (ENDF, JEFF, JENDL) is being conducted. RPI transmission data for enriched 95,96Mo are needed; Transmission and capture measurements for 95Mo done by Paul Koehler not yet available.

HYE YOUNG LEE — ANGULAR AND ENERGY DISTRIBUTION EVALUATIONS FOR 62 N,Z REACTIONS

Work done by H.I. Kim.

ENDF missing a lot of (n,cp_i) data for discrete levels. Also need outgoing angular

- Status of evaluations on (n,x) reactions in ENDF/B-VIII.0 (x=p,d,t,α) (total: 557 nuclei)

Particle	A	B	C	D
proton (p)	189	265	9	94
alpha (α)	163	273	25	96
deuteron (d)	18	246	4	289
triton(t)	14	227	3	313

- $(n,x_{tot})=(n,x_{level})+(n,x_{cont})$, level: g-s, 1st excited level, 2nd excited level, . . .
- A: (n,x_{level}) and (n,x_{cont})
- B: (n,x_{tot}) only
- C: (n,x_{level}) or (n,x_{cont})
- D: no data

distributions. Situation not so good:
Discrete gamma data missing too.

Target	p	α	Target	p	α	Target	p	α
^{27}Al	20 (20)	20 (20)	^{50}Cr	10 (0)	10 (0)	^{64}Zn	10 (0)	10 (0)
^{28}Si	14 (14)	16 (16)	^{51}Cr	10 (0)	10 (0)	^{65}Zn	10 (0)	10 (0)
^{29}Si	16 (16)	20 (20)	^{52}Cr	10 (0)	10 (0)	^{66}Zn	10 (0)	10 (0)
^{30}Si	6 (6)	12 (12)	^{53}Cr	10 (0)	10 (0)	^{67}Zn	10 (0)	10 (0)
^{31}Si	1 (1)	15 (15)	^{54}Cr	10 (0)	10 (0)	^{68}Zn	8 (0)	10 (0)
^{32}Si	1 (1)	1 (1)	^{54}Fe	34 (34)	24 (24)	^{69}Zn	17 (17)	18 (18)
^{35}Cl	30 (30)	21 (21)	^{56}Fe	10 (10)	19 (19)	^{70}Zn	1 (0)	1 (0)
^{36}Cl	16 (16)	32 (32)	^{57}Fe	18 (18)	39 (39)	^{73}As	10 (0)	10 (0)
^{37}Cl	10 (0)	6 (6)	^{58}Fe	17 (17)	10 (10)	^{74}As	10 (0)	10 (0)
^{39}K	10 (0)	10 (0)	^{58}Ni	10 (0)	10 (0)	^{90}Zr	12 (12)	9 (9)
^{40}K	10 (0)	10 (0)	^{59}Ni	10 (0)	10 (0)	^{91}Zr	6 (6)	40 (40)
^{41}K	10 (0)	10 (0)	^{60}Ni	10 (0)	10 (0)	^{92}Zr	1 (1)	40 (40)
^{46}Ti	10 (0)	10 (0)	^{61}Ni	10 (0)	10 (0)	^{93}Zr	17 (17)	27 (27)
^{47}Ti	10 (0)	10 (0)	^{62}Ni	10 (0)	10 (0)	^{94}Zr	10 (10)	40 (40)
^{48}Ti	10 (0)	10 (0)	^{63}Ni	26 (26)	28 (28)	^{95}Zr	16 (16)	9 (9)
^{49}Ti	10 (0)	10 (0)	^{64}Ni	10 (0)	1 (0)	^{96}Zr	3 (3)	10 (10)
^{50}Ti	9 (0)	10 (0)	^{58}Co	40 (40)	40 (40)	^{107}Ag	10 (0)	10 (0)
^{49}V	40 (40)	40 (40)	^{59}Co	10 (0)	10 (0)	^{109}Ag	31 (31)	2 (2)
^{50}V	10 (0)	10 (0)	^{63}Cu	10 (0)	10 (0)	^{180}Ta	10 (0)	10 (0)
^{51}V	10 (0)	10 (0)	^{64}Cu	40 (40)	40 (40)	^{181}Ta	10 (0)	10 (0)
			^{65}Cu	10 (0)	10 (0)	^{197}Au	10 (0)	10 (0)

So, using CoH3, added all of these! Parentheses indicate # levels already in ENDF file. Simulated LENZ performance using GEANT4 & G4LND and MCNP. Discussed in NIMA (2019) paper. Would like to add them to ENDF.

Paper submitted to NIM-A.

ACTION: Add them to ENDF!

IONEL STETCU — U ISOTOPE EVALUATIONS AND 208PB

208Pb

- FRDM-based pre-equilibrium
- Agreement with (n,2n) data from Simakov, Frehaut data may need rescaling

234,236U — Extensive and consistent evaluations based on CoH3 calculations, with parameters adjusted to experimental data (DANCE, WNR)

- All open channels included
- KALMAN-based evaluation for fission channel to include cross section data from WNR
- re-evaluation of nubar, consistent PFNS
- PFGS and gamma multiplicity taken from the recent 235U evaluation (we could do better)
- Added in the fit data by Lisowski and Tovesson for (n,f)
- Refit DANCE data for (n,g); M1 scissors mode included (same parameters as U238)

- Some ICSBEP benchmarking, but nothing conclusive

DR GUSTAVO NOBRE — STATUS OF CR EVALUATIONS

Fluctuations problematic, but biggest problem currently is a cluster of resonances in 50,53Cr around 5 keV (those isotope cross sections are dominant in this energy domain)

- 53Cr:
    - Inconsistency between Stieglitz 1971 (RPI) and Guber 2011 (ORNL)
    - Partly is question of multiple scattering and self sheilding
    - New experiment planned at RPI to measure 53,50Cr capture; if data reaches us in time it will be immensely helpful!
    - Direct capture can explain all of thermal cross section
- Marco Pigni did create revised 50Cr that helps quite a bit; most data is natCr so get at 53Cr another way?
- These helps benchmarks, but we need clarification!

Fast region progress:

- Generated proto-evaluations for 52Cr and 53Cr using EMPIRE. Focused on smoothed parts of cross sections.
- Optical Model Potential
    - Using at the moment a generalized soft-rotor optical potential from 56Fe (RIPL #2602).
    - New chromium-specific soft-rotor dispersive OMP fitted to the Abfalterer natural natCr(n,tot) data (RIPL #616).
    - However, not fully implemented yet in EMPIRE, so it is still not fully usable.
- Low-energy level densities are strongly parity asymmetric: using the RIPL-3 HFB LD as a stopgap and testing adjustments to them to improve the agreement with spectra data.
- Once the main cross sections are better defined, we will attempt to match inelastic gamma cross section data by Mihailescu et al. (Geel).
- Attempting to clean up (n,tot) database: isotopic data used a lot of powder samples that were really hard to correct away.
    - Trying to get Foster Jr. and Abfalterer to be consistent since Abfalterer was used in OMP fit, but both are best way to pin down smooth part
    - Want higher resolution data to build in fluctuations
- Work on 52Cr(n,p)52V helps constraint LD, which then helps differential spectra

SUMMARY OF RQ WRIGHT NUBAR EVALUATIONS FOR CF, U, PU, AM ISOTOPES

Using same methodology as used in ORNL/TM-2015/30, R.Q. Wright re-evaluated prompt nubar for Pa-230, Pa-232 U-230, U-231, U-232 Pu-237, Am-243, Am-244, Am-240, Cm-240 over energy range from 1e-5 eV — 20 MeV.

Cf-250, Cf-252, Cf-254 redone, but recommend keeping ENDF/B-VIII.0

DR ANDREJ TRKOV ET AL. — 7LI AND A PRODUCTION – DO WE NEED AN LR FLAG FOR MT=102?

The 7Li capture reaction's decay path is:

$$7Li(n,\gamma)\rightarrow 8Li\rightarrow 8Be + \beta\rightarrow\alpha+\alpha$$

where the 8Li half-life is less than 1 second and the subsequent 8Be break-up is essentially instantaneous.

Although 8Li decay is not a "break-up" reaction, given its relatively short $t_{1/2}$, should an LR=29 flag be set for the 7Li MT=102 reaction?

DISCUSSION: A lot of votes against: should be handled in decay library. But we do it in a few other cases.

Needed for gas production

Evaluation [FPY & decay data] Session

Chair: Toshihiko Kawano

TOSHIHIKO KAWANO — CURRENT STATUS OF EVALUATION FOR ENDF FPY DATA SUBLIBRARY

Overview view talk for big collaboration

Evaluation

- EXFOR compilation (BNL, IAEA)
- Evaluation of experimental FPY data (BNL)
- FPY model development, and production of the final evaluation (LANL)
- Coordination with international FPY evaluation efforts, such as IAEA consultancy meeting, CRP, JENDL, and JEFF (LANL)
- Micro/Macro (LANL) or Microscopic fission model development (LLNL)

Experiment

- FPY measurements in critical assemblies, R-value (LANL)
- Energy dependent FPY measurements (LLNL, LANL, TUNL)
- FPY measurements with several neutron sources (PNNL), [see Pierson's talk] SPIDER and TPC measurements (LANL, PNNL)
- Measurements at LBNL cyclotron (LBNL, U. Berkeley)

Inclusion of multi-chance

- pre-fission neutrons should be "exclusive"
- Include energy dependence of TKE, per chance

Microcopic / Macroscopic Approach to Fission

- Angular momentum of fission fragments
    - Bertsch, Kawano, Robledo, PRC 99, 034603 (2019)
- Finite-Range Liquid Drop Model (FRLDM) potential energy surface Fission dynamics calculation on PES
- Charge-distribution by the number projection technique
    - Verriere, Schunck, Kawano, PRC 100, 024612 (2019)

Fission Product Yield Experimental Data (FPYEx) Meetings

- Coordination with IAEA Nuclear Data Section (N. Otsuka)
    - Los Alamos, NM, USA, 8/20-23 (2018), LA-UR-18-28309
        - 12 participants from 4 countries (Austria, Japan, Korea, US)
    - Tokyo Inst. Tech, Tokyo, Japan, 5/27-30 (2019), INDC(NDS)-0793
        - 15 participants from 6 countries (Austria, China, France, Japan, Korea, US)
- Prepare a common experimental database of FPY for new evaluations, and share it among the nuclear data community

International Workshop on Fission Product Yields 2019; LANL hosted workshop in Santa Fe, Hotel Loretto

- Sep. 30 - Oct. 3 (and a closed session on Oct. 4 in LANL)
- 41 talks and 60+ participants from Austria, France, Japan, US Experiments (21), Database (2), Theory (6), Application (4), Evaluation (8) Early career scientists, postdocs, and students participated
- Special talk by J. Wilhelmy "Fifty Years of Fission"

ERIC MATTHEWS — A METHOD FOR GENERATION OF FISSION YIELD COVARIANCE MATRICES

- The goal of this work is to generate a set of covariance matrices for the fissioning systems of the England and Rider evaluation with as little fission model bias/uncertainty as possible.
- This method seeks to use simple conservation rules in order to constrain a sample space for Monte-Carlo bootstrapping.
- The resulting covariance matrix will predominantly reflect the evaluated uncertainties in the independent fission yields.
- Once these matrices are generated, making them available online will be a priority.

Bootstrapping

- Bootstrapping is a Monte-Carlo method for uncertainty estimation and propagation.
- Given a dataset with characterized uncertainty; one builds a new series of datasets by resampling the original one.
    - This can be used to assess uncertainties and covariance in an output calculation by varying the input data.
    - It could also be used to assess covariances between the values in the original dataset.

When sampling, treat each error as uncorrelated, so need to add in correlations somehow. Plan is to implement constraints: Total Yield, Total Charge, Total Mass, Mass Yields, Charge Parity, Mass Symmetry. The way in which a set of fission yields are resampled can be structured to conserve these relationships:

1) Randomly selected the "light" or "heavy" side of the fission product spectrum to resample.
2) Randomly select (weighted by uncertainty) a product in each ; chain, resample its yield about its evaluated uncertainty.
3) Scale all other yields in that ; chain by the same percent change.
4) Normalize the resampled yields such that they sum to 1.
5) Generate the fission yields on the complementary side of the fission product spectrum using the neutron multiplicity of the compound system.
6) Repeat steps 1-5) Y times. Select Y such that statistical noise is minimized.
7) Calculate the resulting correlation matrix from the Y trials.

Method (last constraint really) requires good P(nu) data, and there's an energy dependence. Generated consistent P(nu, A) consistent with evaluated yields and recalculated yields. Get P(nu,A) that looks quite realistic, including dip at A=132. However, resampled yields don't look realistic, ends up bimodal.

Looking for other ways to get P(nu,A), perhaps from FREYA.

Comparing covariance to Mills from SG-37

There are errors in England & Rider, not fixed in this analysis

TODD BREDEWEG AND BRUCE PIERSON — UPDATE ON PNNL EXPERIMENTAL MEASUREMENTS

Irradiate at NCERC (mainly Flattop & Godiva, some Comet/Zeus and Planet), radiochemically assay for FP. Have done 233U, 235U, 238U, 237Np and 239Pu.

Only relative yields. Adding fission chamber to get absolute yields. Working to optimize the fission chamber

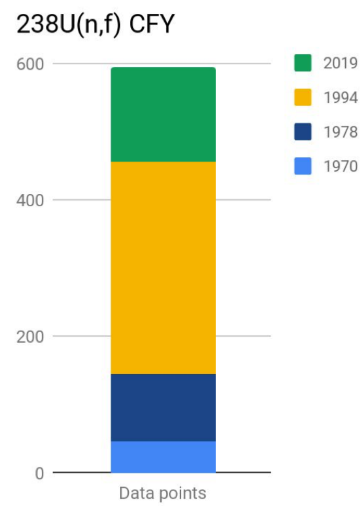
NDS paper describing measurements in review. Big changes in 128Sn, 129Sb, 130gSb, 131mTe, 133I

ANDREA MATTERA — UPDATE OF THE COMPILATION EFFORT AT BNL

Status of the current evaluations

- ENDF/B-VIII inherited FPYs from ENDF/B-VII.1
  - Revision and update of FYs for 239Pu+n (new evaluation at 2 MeV)
  - Other FYs largely based on the Eng&Rid evaluation of 1993
    (that extended the 1983 evaluation from 34 to 60 fission reactions).

- JEFF3.3 updated FYs in the new release (UKFY3.7)
    - includes new measurements (up to 2016)
    - GEF used to predict mass+charge distros of FYs (superseding 5-gaussian fit & Wahl's Zp model)



Ongoing work at NNDC:

- NSR + EXFOR compilation
    - Continued work to include new and not-so-new experimental datasets in EXFOR
    - References of England & Rider's work
    - Mills' evaluation work + references
- EXFOR to JSON (G. Fabricante & V. Zerkin)
    - Adapting the format of experimental files to the needs of FY compilation (simpler, lighter, more intuitive)
    - Make it easier to access, plot, verify and update experimental values currently stored in the EXFOR format
    - Modernizing the format to make it more human-friendly

BALRAJ SINGH — A NEW EVALUATION OF THE 147ND BETA-MINUS DECAY

Prominent long-lived fission product: 11 d half-life. CTBTO views it as one of 40 most important, asked IAEA-NDS to provide recommended value.

About 70 primary publications: β and γ spectroscopy, conversion electrons, angular distributions/correlations, etc. Latest articles:

- 1997Sa53: PRC 56, 2468 (1997): γ and conversion electron measurements.
- 2019Br01: ARI 144, 54 (2019): ORNL-HFIR: Half-life measurement.

Two experiments aimed at determining precise %Iγ for the main gamma rays have been done during the last 2-3 years:

1. LLNL+UC-Irvine+Texas A&M+ANL: data analysis in progress: preliminary results in a Ph.D. thesis by A.M. Hennessy, UC-Irvine, 2018.
2. CEA, LNE-LNHB, Saclay. Results not yet available.

Latest evaluation done in 2008, but corrections in 2013.

Summary of decay scheme:

- Half-life: 10.98(1) d in ENSDF: re-evaluated now to 11.03(3) d.
- Q value: 895.5(5) keV (2017Wa10, AME-2016)
- Spin-parity of the g.s. of 147Nd is 5/2-
- The decay scheme is well known through the measurement of energies and intensities of 22 γ rays populating 8 levels in 147Pm up to an excitation energy of 685.9 keV, with confirmed β feedings to 6 levels.
- Most intense β feedings: 80.9% to 91.1, 5/2+ level, and 15.2% to 531, 5/2+ level.

- Most intense γ rays: 91.1 keV: Iγ=28.2%, and 531.0 keV: Iγ=13.0%.

For high-precision photon emission probabilities, intensities of both these gamma rays are of importance.

Problem is, DDEP used Ig = 12.7% for 531 keV line

Other places used VERY bad numbers in literature

Final evaluated results: %Iγ=13.00(34)

In process found several mistakes in previous evaluation (4 extra gammas + 2 gammas that should have been internally converted)

This is a discrepancy in the half life still. So after averaging, including discrepant data, get 11.03(3) d

Still missing parts:

- About 15 references from 1966-1997 considered for Iγ data, and 6 from 1961 to 1997 for Eγ in the re-evaluation. Present (2008, 2013) ENSDF evaluation uses only 1 reference for Iγ data and 2 for Eγ.
- Beta-Shape code by Xavier Mougeot (Saclay) will be used for log ft values and beta radiation data.
- Atomic radiation data: yet to be included, when BrIcc-Emis code by Tibor Kibedi (ANU) becomes available.

DR ALEJANDRO SONZOGNI — CUMULATIVE FISSION YIELD CORRELATIONS

$dN_i / dt = -lambda_i N_i + r IFY_i + S lambda_k p_{ki} N_k$

lambda = $\ln(2)/T_{1/2}$
r=fission rate
p=decay probability
IFY=independent yield

Why:

- Reactor antineutrino anomaly: We are missing 6% of antineutrinos at distances ~1.5 km from reactor core.
- Daya Bay published in 2017 work that showed no sterile neutrino otw. would have seen in both 235U & 239Pu
- RENO in 2019 disagrees
- Z boson resonance in production cross section best fit with 3 species

Without correlations, get antineutrino yields that are ok, but with wildly low uncertainties
With correlations, introduced using GEF modeling, get more reasonable uncertainties, so correlations important. Delayed nubars don't have same need.

Using mass conservation, can get much smaller uncertainties. However, in process, found large fission product uncertainty in ENDF/B-VIII.0 for 90Zr and 135Cs. Seems to have been mistake in uncertainty propagation of isomeric yields. Appears to have crept in between ENDF/B-V.2 and ENDF/B-VI.8.

Also, now suspect that E&R adjusted FY thermal uncertainties to match nubar thermal

238U prompt gamma energies now better

RAMONA VOGT — LLNL EFFORTS ON FPY EVALUATIONS

Complementary approaches to FPY and their observable consequences:

- Density functional theory (DFTNESS & FELIX)
- Complete event Monte Carlo (FREYA)

Two main activities:

- Estimate the evolution of initial yields as a function of incident neutron energy
- Calculate the initial conditions of the fission fragments prior to de-excitation

Microscopic calculations will provide insights into trends that can be encoded empirically and tested in FREYA

FREYA will be augmented by FIER data to be able to study both independent and cumulative FPYs for major and minor actinides

FREYA can also test empirical formulations of the fragment excitation energy calculated in the DFT approaches

Fission Mass Distributions: Microscopic models have predictive power and can provide baseline or trends as a function of Z, N and neutron incident energy

Number of Particles in Fission Fragments: Particle number projection could be key to reproducing odd-even staggering effect of charge distributions. Generates odd-even staggering effect

Excitation Energy Sharing: We will compute the excitation energy of fission fragments and extract empirical laws that can be easily implemented in FREYA/CGMF

Using GEF as input, checked that FREYA and GEF de-excitation/emission done differently

FREYA only does prompt, needs decays to go from IFY to CFY. Incorporate FEIR code from LBNL.

4 year timeline of project

Formats and Processing Session

Chair: Michael Dunn, Vice chair: Dorothea Wiarda

DR BRET BECK — ENDF-102 CLARIFICATION FOR DISCRETE GAMMA EMISSION (TRACKER #1155)

What is the problem

- At LLNL we were comparing our Monte Carlo code Mercury results to MCNP results
- Energy deposition agreed well when transporting neutrons only
- Energy deposition did not agreed well at low neutron (projectile) energy when
- gammas were added to transporting
- I concluded that the difference was due to the fact that FUDGE was implementing the formula for the primary gamma energy as specified in Chapters 12 and 13 in the ENDF manual and NJOY was not.
- I also was concluded that the formula in the ENDF manual is incorrect, and speculated that NJOY developers realized this and had implemented a more correct formula
- Basically, the formula in the ENDF manual ignores the recoil of the residual

Propose to correct the formula to match what is in use in NJOY, but including relativistic corrections. And state things in center of mass.

ACTION: Bret, provide formal writeup so we can implement in manual.

Provisional Approval Pending resolution of action items

JESSE BROWN — PROPOSAL TO INCLUDE A "BACKGROUND" R-MATRIX TERM IN THE LRF=7 FORMAT (TRACKER #1151)

R-external functionality in ENDF was incompletely specified. In particular, for File 2, LRF=7, need:

- Complete the description in the format manual – Current description is incomplete (Section 2.2.1.6)
    - Initiated with formalism from Froehner and Larson
- Provide evaluators with concise, clear formalism
- KBK flag indicates additional LIST rec. in current format in all spin groups
- What's new:
    - Specify the length of the list

Current workaround is two resonances on either side of resonance region using Froehner's prescription.

Currently no evaluation uses the option.

Will require (minor) updates to NNDC checking codes, FUDGE, NJOY

DISCUSSION: Move LBK flag so rest of LIST specifications can be in the right place. This fixes all KBK options.

DISCUSSION: Do we have a test evaluation?

ACTION: Wim will work with Jesse to correct the location of the LBK flag and complete the specification. Once complete, format is approved.

ACTION: Jesse will provide test file (an RPI Ta evaluation) that can be circulated with all processing code teams

ACTION: Dave will circulate these with other processing code teams

Provisional Approval Pending resolution of action items

DR JEREMY CONLIN — FORMAT PROPOSAL: CODATA2018

Update constants to latest version of CODATA

ACTION: Approved, but Dave and Mark Paris, double check change before committing final version.

ACTION: Jeremy, provide list of % changes for constants. Big issue is that the fundamental constants change then changed the definition of the amu, impacting the neutron and proton masses.

Provisional Approval Pending resolution of action items

DISCUSSION: perhaps only change them when Nuclear Data Standards change.

DR IAN THOMPSON ET AL. — DEFINE RELATIVISTIC FLAG (KRL) IN LRF=7

Clarify MF=2, MT=151, LRU=1, LRF=7, KRM=4 to define KRM>0 behavior. Currently only KRM=0 defined. Enables inclusion of EDA R-matrix parameters

Defines kinetic energy E to be E(s) computed using E(s)=(s-m_c^2)/2m_c. Because s is invariant, E(s) is invariant. It reduces to kinetic energy of projectile in lab frame. Using the channel mass makes the definition of E(s) also channel invariant.

DISCUSSION: The frame of reference for the projectile kinetic energies, etc. are not clearly specified in the format proposal.

DISCUSSION: Need test file to make sure we all can reproduce the reconstructed cross section

Provisional Approval Pending resolution of action items

ACTION: Provide test file & test values of reconstructed cross section

ACTION: Revised ENDF specification so is no ambiguity in frames and non-relativistic limit.

DR ANDREJ TRKOV — ENDF-6 FORMAT PROPOSALS

Proposal #1: To enable storage of activation data on elemental targets, remove sentence "File 10 is allowed only for evaluations that represent the data for single isotopes."

DISCUSSION: For MF=10, need to also specify rule for LIS, LFS, QM and QI. Also is discussion in section 10.3.1 on "Isomer production"

ACTION: Expand format description beyond removing sentence and resubmit expanded proposal.

Provisional Approval Pending resolution of action items

Proposal #2: formalize and legalize the use of MT=261 to represent neutron fields in special purpose libraries like the IRDFF Dosimetry Library

There are other MT's used for derived data quantities.

DISCUSSION: looks like MF=3, but with funky units. Other derived data MT's have same poorly spelled out specification (what units are x & y?). Can we expand format proposal to address all derived data MT's?

ACTION: Dave and Andrej to expand & clarify proposal.

Provisional Approval Pending resolution of action items

Proposal #3: change interpolation rule for URR parameters — interpolate parameters, not cross sections.

Nobody likes the current rule.

DISCUSSION: proposals like this have been torpedoed because of the potential change to validation results. Can we test the impact? Caleb has comparisons between FUDGE & NJOY which handle URR interpolation the proposed way and old way respectively. In practice it appears there are differences in unimportant materials and for important

materials the evaluators provide enough interpolation points so issue is irrelevant. At least in ENDF/B-VIII.0….

ACTION: Need full format proposal

Tabled, pending resolution of action items

DOROTHEA WIARDA — SAMMY CODE REPORT

Sammy infrastructure

- SAMMY was migrated to ORNL git-lab repository, sharing the same ”eco-system” as SCALE and AMPX.
- This allows to set up automatic Pipelines that run the SAMMY regression tests on demand.
- Merge request can be easily reviewed and will not be merged unless the Pipeline is successfully executed.
- Discussions including modifications on the merge request can be easily monitored and are preserved.
- This code development environment makes developers and related staff members promptly aware of changes to SAMMY.

Use of container array in SAMMY

- Advantage:
    - One memory allocation, little churn.
    - Only way before the advent of allocate
- Disadvantage:
    - Hard to debug using tools like Valgrind.
    - Memory manager does work the operating system and compiler can do
    - Array is fixed and needs to be dimensioned for largest desired problems.
- Problem is, memory misallocated all over the place, so now have to do massive cleanup in addition to modernizing. Also, some of old test cases depended on broken behavior. SAMMY used temp files occasionally to avoid this.

Strategy: Share code with AMPX

- Since AMPX already has classes to access resonance parameters, it would be advantageous to use the same classes in SAMMY.
- Currently, AMPX uses SAMRML (stripped-down version of SAMMY) for some calculations. However, we would like to link AMPX use to the full and modernized version of SAMMY.
    - Advantage: Improvements in the resonance formalism implemented in SAMMY are immediately available to the processing code.
- To achieve that, SAMMY internally links to AMPX, which is in a different repository. Developers will have to check out AMPX and SAMMY to build. This will ensure that we do not duplicate code. For internal developers this is not a problem, since they contribute to SCALE and SAMMY.

- For official distribution with RSICC, the shared code will be distributed with SAMMY. External users will not need to have access to SCALE if using the RSICC distribution for SAMMY.
- Started to use AMPX routines, wrapping with help of CIX (a SCALE tool)
- SAMMY uses C++ data structures for almost all resonance parameters
- Will switch to AMPX I/O, which will enable connection to GNDS

Brune transformation

- In contrast to the “formal” parameterization (for which the resonance energy Er is affected by a shift factor), the Brune basis representation provides resonance parameters that have a more intuitive meaning since their values can be visually related to corresponding measured values.
- A code to transform between ”formal” to “Brune” and vice versa was developed and added to the repository. The input and output is an ENDF file with the resonance parameters.
- During the conversion from the formal R-Matrix parameters to the Brune R-Matrix parameters, several non-linear eigenvalue solves must be performed; we use the method of successive linear approximations, which is easy to implement and robust for our purposes.

Future plans: Continue modernizing, then will add complex channel radii & relativistic effects

MICHAEL DUNN — PREPRO2019 PROCESSING CODE RELEASE

More checking; 32 bit -> 64 bit.

ACTION: Dave post PREPRO2019 version 2

DR JEREMY CONLIN — NJOY PROCESSING CODE REPORT

5 updates were made to NJOY21
6 (+3) updates were made to NJOY2016

CI/CD apparently not functioning right now

- Production version: NJOY21
    - Most recent version:1.0.52019-08-25.
- Legacy version: NJOY2016.49 2019-02-21.
- NJOY2016 is deprecated
- The NJOY2016 manual is still valid for NJOY21

Email: njoy@lanl.gov

https://github.com/njoy/NJOY21 — go here for issue/feature requests

ACE Format Specification

- Formerly in MCNP5 Manual (controlled publication)
- Open Availability
  - Open Source Release LA-UR 19-29016
  - github.com/NuclearData/ACEFormat
- S(a,b) specification by Paul Romano
- Still incomplete—help requested

DOROTHEA WIARDA — AMPX PROCESSING CODE REPORT

As reported last CSEWG:

- We have code to read GNDS files and process 1-D data (includes resonance parameters) and covariance data.
- With this code we can compare the results from ENDF formatted and GNDS formatted files.
- In order to support kinematic data a lot more coding is needed.

Since GNDS is now defined by JSON…

- Write code that translates JSON files to C++ low level classes.
- This worked well (again for 1-D and covariance data):
  - Some low-level data containers (XY-1D and array) are not generated by the JSON translator.
- Kinematic data needs to make sure that data containers with the same name have different name spaces:
  - Example: Tag name “Energy” is used for energy of a nuclide level and for energy distribution.
- Documentation generation code has solved this problem, but not yet implemented in AMPX

AMPX classes generated from JSON are not an API

- The classes generated from JSON follow exactly the description in the manual.
- There is a lot of code needed to put the data into the AMPX in-memory structure. Of course we can reuse most of the code from the “hand-coded” GNDS.
- For testing we ran the same comparison between GNDS and ENDF formatted files from ENDF/B-VIII.0
- The classes are not yet merged into the main branch, but because it is easier to track GNDS specifications, these are the ones we will use going forward.

SCALE Libraries

- Beginning with SCALE -6.3b3 SCALE contains ENDF/B-VIII.0 based libraries.
- ENDF/B-VII.0 based libraries have been removed (Libraries from previous release still work with the current SCALE release).
  - Exception: All covariance libraries are still available.
- ENDF/B-VIII.0 CE libraries are distributed in new HDF5 format.

- MANY libraries are available within SCALE, all based on ENDF/B-VII.1

Previously SCALE read WHOLE library, then threw out what it didn't need for problem at hand. This led to huge startup times. Now only read header, then read just what's needed. Enables fast run of small problems.

AMPX Training available

CALEB MATTOON — FUDGE PROCESSING CODE REPORT

- Current version is FUDGE-4.2.3 — supports GNDS-1.9
    - Python 2.7 — BSD license

- New version to be released soon — GNDS-1.10
    - Python 2.7 and 3.6+
    - Switching to MIT license
    - Several new capabilities (see later slides)

GIDI and MCGIDI are in use in LLNL codes

GIDI is open source (https://github.com/LLNL/gidiplus)

Recent developments in FUDGE

- Identified long-standing bug in multi-group thermal upscatter adjustment
    - need denser grid of scattering cosines at forward angles
    - Problem is most noticeable in P(E' | E,mu) at forward angles
- Added TNSL processing for deterministic and Monte Carlo
    - Good agreement with MCNP
- New unresolved resonance region probability table generation
  (for Monte Carlo only, brute force!)
    - Draw random resonance parameter realization using evaluated average widths / level spacings, then reconstruct resonances
    - For all desired temperatures:
      — Doppler broaden cross sections
      — Compute pdf(cross section) at several incident energies
    - Repeat until cross section pdfs converge
- Added capability to generate ACE files

Future work:

- Processed GNDS files store all data in ASCII text
  — consumes lots of disk space, slow to read in
  — now working on hybrid XML/binary storage for faster data loading

- LLNL code ‘Kiwi’ uses covariances to sample nuclear data
  — latest release only supports LLNL’s legacy ENDL format, need to finish
- porting it to support GNDS

BROWN DAVID — EG-GNDS STATUS REPORT

Specifications for GNDS-1.9 are ready — matches format ENDF/B-VIII.0 released in

Managed with NEA’s Gitlab

We have format improvement mechanism that mirrors git-ified version of ENDF formats committee process. Most of discussion on git trackers in open. Works very well and asymptotes to consensus.

Request for format proposals:

- New covariance format(s)
- PoPs formats?
- New FPY formats
- New documentation markups (proposal finished)
- New TSL formats (proposal finished)
- format renaming for clarify confusing names
- move <fastRegion> out of <background>
- GNDS has lots of different units, please simplify!
- several RRR improvements were discussed, we need to make them a formal proposal!

Git management:
Master branch -> big merging happens at WPEC meetings.
How to make the proposal:

- Make a branch
- Make changes and review:
  - Chair proposes a reviewer
  - EG participants are asked to add more reviewers
  - All reviewers must accept before merge

Discussion

Mattoon: Consistent branch naming to help understand purpose of branch
Conlin: Avoid multiple changes in one proposal
Brown: Has happened already but should be avoided. Chair’s responsibility to avoid that.

DR JEREMY CONLIN — SG-43 STATUS REPORT

API status

- LLNL has two implementations of read/write API, compliant with GNDS 1.9 (ENDF/B-VIII.0)
    - Fudge(Python) https://github.com/LLNL/FUDGE
    - GIDIplus(C++) https://github.com/LLNL/GIDIplus
- ORNL has a partial implementation in AMPX (C++)
- LANL is writing a specification document for NJOY (C++)
- CEA will be starting its implementation soon in GALILEE (C++)
- JAEA is planning to use LLNL implementations, when available

Planned work:

- Continue implementations as needed
- Extract actual APIs from working implementations
- Post in NEA-Gitlab
    - Identify similarities/differences
- Start draft report
    - Situation assessment before end of 2019

Stretch goals have not even attempted yet.

BROWN DAVID — ENDF MANUAL UPDATE

Current version is revision 215, released with ENDF/B-VIII.0

Revisions so far:

- Fix a subscript in the equation for the photo-atomic coherent scattering cross section [David Brown]
- Removed some rogue unicode characters
- Tweaked build script to be Python-3 ready
- Fix fonts for matrices in appendix D [Mark Paris, fixes tracker #1156]
- Clarify acceptable formats for integers/floating-point numbers [Paul Romano]
- MT=101 should have been 104 in list of production reactions on p. 192 [David Brown, addresses tracker #1150]

ADDITIONAL REMARKS

Frendy code is another available processing code, developed by K. Tada at JAEA. Please see https://rpg.jaea.go.jp/main/en/program_frendy/

Announcement for the WINS 2020 workshop

Evaluation [ML, TSL, CP] Session

Chair: Mark Chadwick, Vice chair: Patrick Talou

DR DENISE NEUDECKER — VALIDATING NUCLEAR DATA BY MEANS OF MACHINE LEARNING METHODS

Can machine learning help with nuclear data validation? (Spoilers: yes!, the answer is more complex than this)

Approach:

- Random forests: Build a prediction model for the bias as a non-linear function of the large set of potentially informative features:

$$\Delta k = \text{keff(exp)} - \text{keff(sim)} = f(X1,\ldots,X21000) + \varepsilon$$

- Importance of features assessed with SHAP metric

Training Data:

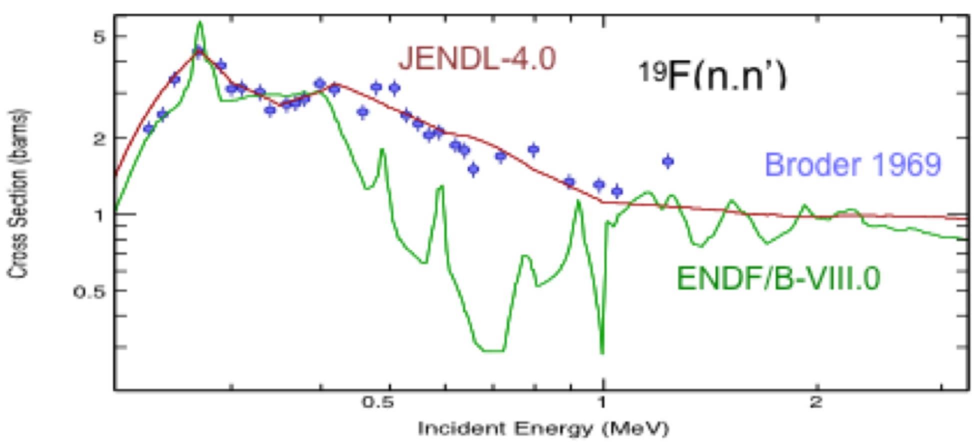
- Input: 875 Δkeff values using ENDF/B-VII.1 and ENDF/B-VIII.0

- Features: for each experiment:
    - ~21000 sensitivity coefficients of nuclear data related to keffsim
    - ~ 50 measurement features (e.g., reflector material, spectrum)

Fabricated shortcomings in nuclear data perturbed to simulations of ICSBEP crits.: According to SHAP metric, RF correctly identifies the perturbation

Known actual shortcomings in previous and current libraries: Also noted issues with thermal values in 239Pu (nubar, RRR, etc) in ENDF/B-VII.1. ML also noted improvement in ENDF/B-VIII.0

Unknown actual shortcomings in current nuclear data libraries



* Found issue in 19F:
Marco has correction already, but was rejected because of format problems. Mike is looking into corrections.

* Pointed also to several benchmarks

DISCUSSION: spurious correlations get picked up (e.g. 14N in Pu solutions), so is up to user to check what the ML algorithm finds

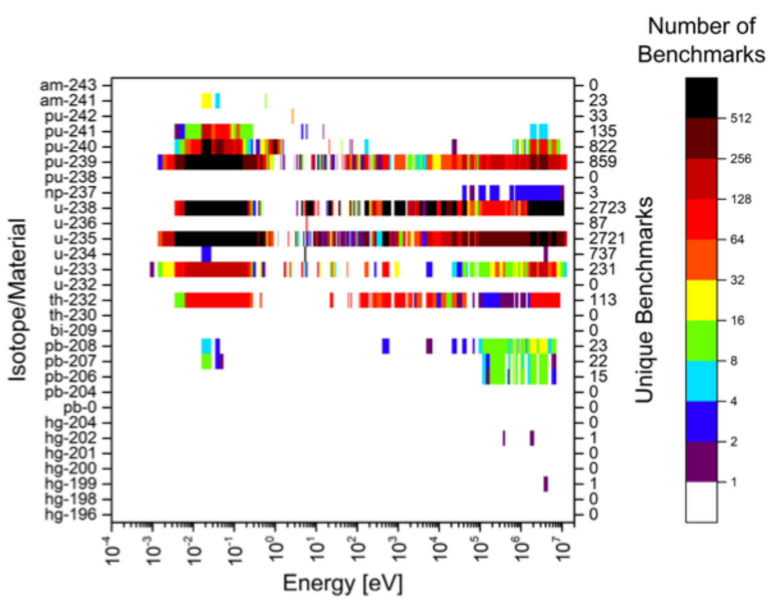
DISCUSSION: more information available with this algorithm than with plain sensitivities e.g. DICE

ROBERT LITTLE — LOS ALAMOS ARCHIMEDES PROJECT

ARCHIMEDES is a LANL LDRD reserve project with the goal of designing new integral experiments that match nuclear data sensitivities to specific applications.

The process has four main steps:

- first, computational models are generated,
- next cross-section sensitivities are investigated (SENSMG in PARTISN),
- then a gap analysis is performed, and
    - Look at all existing benchmarks, all isotopes, all reactions, all energies
    - Use these existing sensitivity files to determine where gaps exist for application sensitivities
    - Distill data down to a readable form (Heatmaps)
    - Generic heatmap of the number of benchmarks that have a sensitivity > 10-3 for



each energy (238 groups), for each isotope (this example is for total cross section).

- finally experiment optimization takes place
    - Uses a probabilistic model to make informed global guesses of optimum

    - Model as a function of configuration using a GP
    - GP optimized using Expected Quantile Improvement

Configuration are spherical or cylindrical shells, vary material and thickness

PF-4 allocation: Plutonium casting
- Decided on what sensitivities for application
- Let code design optimal experiment
If optimal experiment works, enables Pu casting with much higher throughput (therefore less $)

Currently similarity limited to ck (related to keff), would benefit from more parameters to optimize against.

DR MIKE HERMAN — NEW PARADIGM FOR NUCLEAR DATA EVALUATION

Why?
- Integral experiments not fully included.
- General lack of cross-correlations
- Compensation of errors.
- Some evaluations are desperately old.
- Format is from the previous millennium

Starting with the current library:
- **Store** all the details of evaluations in electronic form (inputs, codes, exp. data, assembly scripts) to allow automated adjustment and, if needed, re- evaluation of a file within days.
- **Adjust** the whole library to a representative and trustworthy set of integral experiments covering the whole field of applications, in response to each new or modified evaluation.
- **Review** each adjustment (help from automation needed).
    - if any adjustment exceeds an upper limit (e.g.1 sigma) it should be reviewed and, eventually, the material should be reevaluated.
- **Maintain** 3 libraries (branches in version-control speak).
    - A - purely differential and model based.
    - B - A tuned to integral data (as existing ones).
    - C - fully adjusted (as discussed here).

SARM3 ?

Most parts already are under active development

DR DAVE BROWN — ENDF AS A GAUSSIAN PROCESS REGRESSION MODEL AND THE ENDF BELIEF NETWORK

PROF. AYMAN HAWARI — TSL EVALUATIONS

Who:

- The team at North Carolina State University
- Collaboration with LLNL and NNL: David Heinrichs et al, Michael Zerkle, Jesse Holmes, Jonathan Wormald
- Collaboration with INL : John Bess, Mark DeHart

Funding

- US NNSA Nuclear Criticality Safety program
- US Naval Nuclear Propulsion Program
- US DOE office of Nuclear Energy (NE) NEUP program

Evaluations:

- FLiBe,
- Single crystal sapphire (used as a filter)
- Heavy paraffinic oil,
- light water,
- Hydrofluoric acid

Methods: Continued development of advanced methods within FLASSH platform

- Liquid physics
- Generalized TSL (exact structure, polarization information as input)
- Doppler Broadening (uses exact structure)
- GUI
- FUDGE & GNDS

Experimental measurements: Facilities established at the PULSTAR reactor to enable diffraction and transmission experiments

International collaboration:

- Kick-off in May 2020 during WPEC meeting
    - Objectives
        - Motivate the TSL evaluation effort in support of various nuclear science and engineering applications
        - Advanced reactors (e.g., various molten salts)
        - Criticality safety (e.g., various U and Pu based fuels)
        - Neutron science (e.g., cryogenic moderators)
    - Review the development of advanced TSL evaluation methods and tools with consideration of modern simulation approaches
    - Address issues related to data validation, covariance generation, and data formats, ...
    - Act as the focal point with other WPEC subgroups (SG44, SG45, GNDS, etc.)

    - Ensure follow-up on the recommendations of SG42

CHRIS CHAPMAN — TSL EVALUATIONS

Thermal Scattering Law Covariance Methodology : Use UMC

Light Water

- Used molecular dynamics; characterized by number of sites (3-6, including dummy sites)
- Used the TIP4P/2005f [5] parameter set and varied 8 model parameters (7 in red below plus spacing between oxygen and 'dummy' atoms) using Latin hypercube sampling (±5%) to ensure representative sampling of phase space
- From those 1615, the 250 simulations with the diffusion coefficient and density closest to their experimental values were chosen
- These 250 accepted results were used to compare against experimental data gathered at the SNS
- UMC weights then used to calculate mean values and covariance matrices of:
    - TIP4P/2005f parameters
    - Thermophysical properties
    - pDOS
    - Double differential & total scattering cross section
- Mean values and variance of thermal scattering law $S(\alpha,\beta)$ also generated
    - Methods of storing $S(\alpha,\beta)$ covariance matrix not studied here
- Compared averaged $S(\alpha,\beta)$ against ENDF/B-VIII.0 evaluation for 3 sets of benchmarks: LCT-078 (298K), LCT-079 (300K), LCT-080 (298K)
- Promising, but not as good as existing evaluation

Temperature-Dependence of Polyethylene Thermal Scattering law

- Aim is to determine if there are any temperature-dependent effects of polyethylene not present in the current ENDF evaluation
- Carried out in collaboration with RPI as a follow up on [6]
- Experiments carried out at 2 different beamlines : ARCS & VISION

DR MARK PARIS — TN EVALUATIONS

- LANL cross section evaluation codes
    - EDA5: Simultaneous fit of all reaction/scattering data in R-matrix approach
    - SPECT: Spectra calculated in resonance model with auxiliary code/input from EDA5, this enables breakup reactions

- CSEWG evaluation criteria
  – LANL light-element data pipeline
  – Evaluation revision criteria

– Recommendations for ADVANCE CI/CD [git repos]

- New ENDF-6 formatted evaluations
  – p-002_He_004.endf
  – d-002_He_004.endf
  – a-002_He_004.endf

Discussed LANL workflow to TN evaluations

	H1	H2	H3	He3	He4	Li6	Li7
n	VIII.0	VII.1	VII.1	VII.1	VII.1	VIII.0	VII.1
p	VII.1	VII.1	VII.1	VII.1	**2020***	VII.1	2001**
d		VII.1	VII.1, 2018	VII.1	**2020**	VII.1	2003**
t			VII.1	VII.1	2011*	VII.1	--*
^{3}He				2001	2011*	VII.1	--
α					**2020***	--	--

Planned & current LANL evaluations

Recommendations for evaluation review

- Evaluation chair's current (if informal) policy

  "the lab that had made the current ENDF file has the responsibility to assess its accuracy/deficiency - as informed by their own knowledge and by knowledge and input from the other lab suggesting alternatives/updates" –M. Chadwick 2018 Oct

- Recommendation #1
  - Proposed modifications (replacement, extension, correction, ...) must be reviewed by existing evaluation's evaluators, if at all possible
  - Timeline : To give reviewers sufficient time to review proposed modifications and avoid last-minute efforts to replace existing evaluations
- Recommendation #2
  - well in advance (3-4 months) of CSEWG Deadline for Phase I submissions (locked after)
  - Previous file evaluator (Reco #1) must approve
  - Final approval by exec-committee requiring 2/3 (or something like that)

Public release of EDA R-matrix parameters coming

EDA5 -> EDA6 modernization in process

DR IAN THOMPSON — CHARGED PARTICLE EVALUATIONS

Major R-matrix code cross comparison exercise

- AMUR: Japan - S.Kunieda
- AZURE2: Notre Dame – James de Boer
- EDA: LANL – Gerry Hale and Mark Paris
- FRESCOX: LLNL – Ian Thompson
- GECCCOS: TUW – Thomas Srdinko
- SAMMY: ORNL – Marco Pigni and others
- CONRAD: CEA – Tamagno and Archier

Tested Coulomb functions & found discrepancies vs. COULCC

Test Case: 3He+4He // p + 6Li

Results:

- A very useful exercise!!
- Used LLNL code FERDINAND.py translate parameter files between all the code inputs.
- We thought this would be all easy, but no -
    - Several bugs were found in several codes.
- On the whole, all the codes agreed to within 0.1– 0.3% which is far below the uncertainties of the existing experimental data in this low-energy region.

Dr Marco Pigni — Evaluation and Validation of the α+17,18O Cross Sections

Nuclear data impact every aspect of nuclear nonproliferation modeling and simulation, from the design of nuclear detection instruments used in nondestructive technologies to the interpretation of measurement data

- R-matrix analyses for (α,n) reaction channels up to about 5 MeV was based on available experimental data sets
    - (α,n) experimental data are based on Bair's measurements for both nuclei. However, Bair's data are convoluted and it is impossible to quantify accurately the partial cross sections related each excited states
    - In JENDL-AN (2002) the partial cross sections were based on Hauser-Feshbach (HF) calculations
    - In Sources4C the calculations of the partial cross section related to each excited states are also based on HF calculations performed by the GNASH code
- For 18O Elastic channel, the spin assignment was based on measurement and the resonance analysis of Goldberg (Phys. Rev. C 69, 24602, 2004) for available excitation energies
    - Goldberg's elastic angular excitation functions and angular distributions not possible to fit together with (α,n) data sets

- Some information on the proper distribution of the excited states may be obtained from integral measurements
- A suite of integral measurements (neutron yields and energy neutron distributions) available for oxide compounds was generated to validate the oxygen cross sections

Implemented in SOURCES4C, compares quite well

Joint Measurement Campaign (ORNL + Notre Dame)

- 10B(α,n0)13N (2.2<Eα<4.9 MeV) performed at National Ignition Facility
- 17O(α,n0,1,2)20Ne performed at Notre Dame facility (2019)
- 18O(α,n0,1,2,3,4)21Ne performed at Notre Dame facility (in progress)
- 13C(α,n0)16O performed at Notre Dame to test agreement/disagreement with Harissopulos' measurements

WANDA Session

Chair: Cathy Romano

DR CATHERINE ROMANO ET AL. — NDIAWG FOA DISCUSSION

- Notifications are running late
- Will be review at Berkeley in Jan
- Only funded project was (a,n) scoping study

D. BROWN — USNDP POC DISCUSSION

USNDP POC role in Nuclear Data FOAs was not defined in the FOA. We assume its addition was a reaction to the wish for an "embedded evaluator" and other related ideas.

The USNDP POC has many benefits:

- To the funding program: Accountability both of the project leads and the USNDP and enforcing data retention policy
- To the project PI: Timely response of USNDP to project needs and ensure all segments of nuclear data pipeline are "in the loop"
- To the USNDP: Timelier & higher quality compilation — Makes sure information not lost – talk to experimenter while fresh
- To the USNDP POC: Education

DISCUSSION: Discussions echoed many of issues raised already

DISCUSSION: USNDP is very small part of CSEWG/ENDF. It plays important coordination role, but only modest evaluation effort (compared to other institutions) and no experimental impact. Feeling that USNDP is ALL OF NUCLEAR DATA.

ACTION: Request clarification regarding role of USNDP POC

DR CATHERINE ROMANO —WANDA PLANNING SESSION

NDIAWG FOA:
- The proposal reviews are running behind, and there will be a review session in January in Berkeley
- Only NA-22 scoping studies were funded (a,n) and neutron interrogation. Romano as PI.

NDWG Update:
- New NDWG Charter – Goal is to facilitate cross communication between programs, labs, universities and industry
- The NDWG is not a decision making body. That is the WANDA attendees role. They help plan WANDA, produce position papers and facilitate coordination of nuclear data efforts.
- NDWG Membership & Charter
    a. Nominated to serve by PMs or National Labs (2 for each).
    b. The NNDC director is automatically a member.

WANDA 2020:
- March, 3-5 with classified session on 3/6
- Organizer is Julie Marchand (LLNL)
- Primary goal is to bring together Users, Evaluators, Experimentalists etc,
- Agenda
    - Review of NDIAWG FOA projects
    - Single summary of programmatic nuclear data needs Leave the decision of whether or not a PM would talk to the PMs
    - Nuclear Data 101 *Panel* that includes experts from data evaluation, users
    - Breakout session summaries would come after a break where we hear from the previously funded projects. This would give them time to prepare their summaries.
    - Catering lunch rather than dinner is a better idea.
    - Poster session.

- Tim requested we look at ways to increase science visibility of WANDA
    - Publish proceedings in a Journal
        - Journal of Applied Radiation and Isotopes (ARI)
        - There are journals that publish reviews (EPJA) or NPA.
        - Nuclear Physics News ?
            - Probably too long for this
    - Highlight young promising researchers
        - Session leads should incorporate a young co-lead.
    - Highlight cutting-edge research
        - How to do this?
- Session Topics – Physics or program based?
    - Physics based is cross cutting
    - Program based works better for users
    - Mix of both should work
    - Cathy has guidelines for session leads.

- Unlike CSEWG the focus has to be on the gaps in WANDA.
- Charge the session leads to make sure that every component of the nuclear data pipeline gets addressed.
- Each session lead should make sure to include all aspects of the pipeline

- **University Session:**
    - Tim suggested inviting Deans from Universities to hear about how important this area is.
    - Nuclear Engineering departments aren't looking at Nuclear Data so much.
    - Most people agreed that they would sit through a 2-hour university session
    - John Kelly mentioned that FRIB could contribute on Isotope Harvesting.

- **AI/Machine learning session** – Tim's request
    - LANL has a machine learning project and has worked with PMs.
    - Four townhalls held on this. Got split into NP and HEP. Tim wanted to split out NP.
    - ML and ND people don't know each other so well.
    - Huge potential. Challenge is to keep focus on ND needs and applications. This is a gold mine.
    - Should we organize an INT workshop on this topic?
    - One lead from each lab: Dave Brown, Michael Smith, Vlad Sobes, Mike Grosskopf (LANL), Kyle Wendt, Patrick Talou?

- ***Covariance/Sensitivity/Uncertainty/Validation***
    - This is very closely connected with the "Nuclear Data Pipeline" session.
    - Also connected with Code Development and Evaluations sessions as well.
    - Denise Neudecker and Robert Casperson as a co-chair.
- ***Scattering, Transport and Shielding***
    - Matt Devlin, Mike Dunne
    - Need an up-and-coming young person
- ***Gamma production***
    - Improved detectors are providing new data.
    - Inelastic scattering, capture, fission, alpha,n all included.
    - Alejandro Sonzogni and Lee Bernstein
    - Amanda Lewis as an up-and-coming scientist to co-chair
- ***Isotope Production***
    - Etienne Vermeulen, and Greg Severing?
    - need a cochair and/or young scientist
    - Revise program in light of any FY20 FOA decisions
    - Include radioisotope sessions.
- ***Detector Models, Atomic data and Stopping Powers.***
    - Bethany Goldblum, Brian Quiter and Bruce Pierson
    - Radiolysis (as part of atomic data)

- **Start a new High-Priority Nuclear Data List for Applications**
    - There has to be sufficient context and backing documentation.
    - Moderated by the Nuclear Data Working Group.
    - A proposal for the effort and ongoing support is required to move forward.