Brookhaven National Laboratory

Report # BNL-225210-2024-INRE

CSEWG Meeting Minutes

15 - 17 November 2023

managed by Brookhaven Science Associates
on behalf of the U.S. Department of Energy

U.S. DEPARTMENT OF ENERGY

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Special Thanks

Meeting Organization

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CSEWG Committee and Subcommittee Chairs

Evaluation: Mark Chadwick (LANL)
- FPY and Decay Evaluation Subcommittee: Toshihiko Kawano (LANL)
- TSL Evaluation Subcommittee: Ayman Hawari (NCSU)
- Charged Particles Evaluation Subcommittee: Marco Pigni (ORNL)

Data Validation: Mike Zerkle (NNL)
Formats and Processing: Mike Dunn (Spectra Tech Inc.), Doro Wiarda (ORNL)
Measurements: Yaron Danon (RPI)
Covariances: Denise Neudecker (LANL)

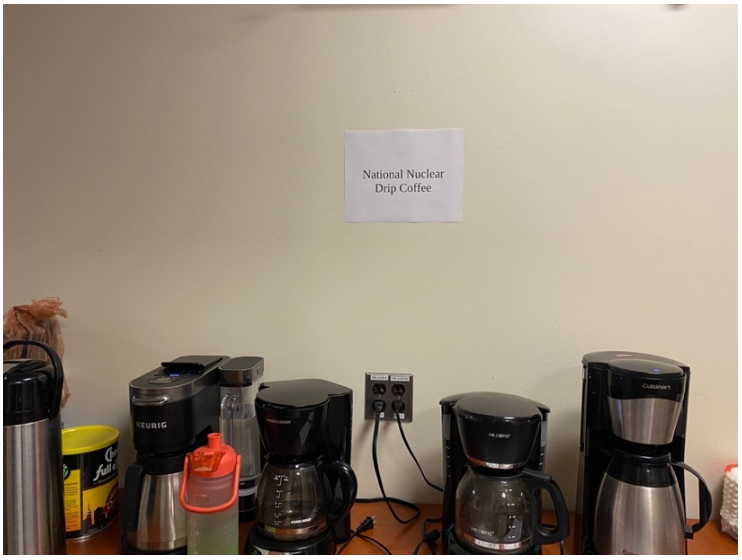


Figure 1 - Meeting Preparation

Figure 2 – CSEWG Group Photo

CSEWG Executive Committee Meeting

Chair: David Brown
Date: Thursday November 16, 2023

Overview: Progress towards the release of ENDF/B-VIII.1 is steady, but not as rapid as hoped. It was decided to push back the release timeline somewhat:

- Target the ENDF/B-VIII.1-β3 release for late December 2023
- Target the ENDF/B-VIII.1-β4/Release candidate for February-March 2024. It was brought up that the full validation process takes 2 to 3 months.
- Aim to submit the big paper in February 2024
- Make the full ENDF/B-VIII.1 release in May 2024
- Publish the big paper in May 2024

In addition, we will need three additional CSEWG meetings in 2024:

- A virtual micro-CSEWG meeting focused on communicating validation results before the February-March 2024 ENDF/B-VIII.1-β4 release
- A mini-CSEWG in late spring, likely hosted by LANL, to cover all the topics that could not fit into this main CSEWG meeting, including: a) format changes, b) new evaluations & models, c) more measurements, d) various organizational updates, e) a "lessons learned" from this release
- A CSEWG Hackathon in late summer, likely hosted by ORNL.

Finally, it was decided to "split the difference" on the two outstanding TSL evaluations:

- Adopt the NCSU polyethylene: NNL validation is consistent with previous testing and points to angular distribution issue in ORNL's evaluation (specifically the ^{1}H scatterer part)
- Adopt the ORNL Lucite: Both evaluations have equivalent performance.

Overview Talks

Chair: David Brown
Date: Friday, November 17, 2023

Welcome

Speaker: David Brown (NNDC-BNL)

Overview: Dr. Brown reviewed the CSEWG meeting Code of Conduct and discussed the meeting food situation. He also announced that mini-CSEWG will be held at LANL sometime in spring 2024 and that the CSEWG Hackathon in summer 2024, potentially hosted by ORNL.

Where are we now? Paper and release status update

Speaker: Gustavo Nobre (BNL)

Overview: ENDF/B-VIII.1 release is imminent and planned for mid 2024 (targeting May 2024). No updates are being made to Nuclear Data Standards for this library – therefore it is not considered as a major release. Actinides, structural materials, and others have been updated. Many new TSLs have been formed, fixes applied to fission yields, 200+ updates to photonuclear data, and few improvements to charged particle sub-library as well. Gitlab repository is being used to perform continuous testing of ENDF library with the help of ADVANCE. An example of the review process is shown for the ^{88}Sr evaluation. A first version of the author list for the ENDF/B-VIII.1 big paper has been formulated. For ENDF/B-VIII.1-β3 expect some more changes with actinides, photonuclear, TSLs, and more. There have been many new contributions for TSLs and the ENDF format ran out of MAT. As a result, MAT numbers are being assigned on per library basis using MAT numbers 1-9999. NCSU polyethylene is being adopted and ORNL Lucite evaluation is being adopted. ^{9}Be photonuclear sub-library is being adopted from the IAEA Photonuclear CRP since NNL evaluation has not been completed just yet. There have been challenges with getting ENDF/B-VIII.1 completed on time so ENDF/B-VIII.1 is planned for May 2024. Once β3 is released the file list and mean values will be frozen and validation will be given 2-3 months. β4 will have fixed covariances, documentation, format, and processing issues and β4 will become the release candidate if there are no issues.

Discussion Items:

- **ACTION**:
  - Contact Gustavo if there are any strong feelings regarding the author list for the Big Paper. For authors, please review the current version of the draft.
- **QUESTION**:
  - Should we commit to the main branch if we have contributions to the paper?
    - (Gustavo) You can commit to a separate branch and I will merge with the main branch periodically. There likely shouldn't be any overlaps between everyone's contributions.
  - (Mark Chadwick) In prep for the next meeting, there was work done where IRDFF IAEA dosimetry cross sections were decided to be adopted. What is the status of that work effort?

        - (Gustavo) thanks for the reminder, we have quite a few slides on that from mini-CSEWG and will add them to this talk and reupload. All work was carefully merged with LLNL and it's already included from Beta2.
    - (Allan Carlson) Those are not complete evaluations; how do you complete them?
        - (Gustavo) Case-by-case solution replaced total, added and adjusted for consistency
- **RESOLVED**:
    - A decision on the polyethylene and Lucite TSL evaluations were made – NCSU polyethylene and ORNL Lucite evaluations are adopted.

Covariance Committee

Chair: Denise Neudecker (LANL)
Date: Wednesday, November 15, 2023

Covariance Session Testing

Speaker: Denise Neudecker (Los Alamos National Laboratory)

Overview: Testing of covariances in ENDF/B-VIII.1 beta releases is ongoing as many covariances have been released. Six covariance template papers have been published as a special issue. If there are issues found in your covariances, please fix them. Another report on uncertainty quantification needs in the next 5-10 years will be released soon. Many changes have been made in covariances between Beta 1 and Beta 2 (see list in slides). CovVal was used to perform covariance testing on mathematical properties and physics properties of covariances. Several issues were found:

- Some correlations slightly greater than 1, are not a huge issue and likely due to binning.
- There are potential issues with covariances for ^{6}Li(n,el) and ^{7}Li(n,tot), (n,el) cross sections if the size of the uncertainties is below 1%.
- Similar issues are observed in ^{9}Be(n, el) and ^{10}B(n, el).
- There are missing covariances for ^{54}Fe(n, el) below 100 eV, ^{86}Kr(n,el) and ^{39}K.
- More physics issues are seen in ^{103}Rh(n, el), ^{132}Xe(n, inl), ^{143}Nd(n, inl).
- There are unrealistically low uncertainties seen in Ce as well. That was fixed by Marco Pigni for beta3. We need to counter-check.
- Additionally, some fast region covariances are zero (Dy was shown as an example).
- Pb covariances are low or missing (potentially a processing issue). That was fixed by Peter Brain for beta3. We need to counter-check.
- The URR in ^{239}Pu nu-bar is below Cf standard.
- The fast ^{240}Pu nu-bar and (n,f) are below standards as well.

Concluding thoughts from covariance session: Please keep working on covariances and answering our important emails!! Thank you for all the excellent work.

Discussion Items:

- **ACTION**:
  - **Please check Denise's emails and respond because updating covariances is important (even though everyone is tired)**
  - Need to document missing covariances for the fast region
  - Possible "physics issues" in covariances: questions for ^{7}Li(n,el), ^{9}Be(n,el), ^{10}B(n,el), ^{103}Rh(n,el), ^{132}Xe(n,inl), ^{143}Nd(n,inl), many others (look to slides!)
  - Missing covariances: elastic scattering – ^{39}K, ^{54}Fe, ^{86}Kr
    - Contact Denise (and team) if you have any information on this
  - Nathan Gibson looking at Pb evaluation from Peter Brain (possible processing issue)
  - (Denise to Gerry Hale - *online*) If you can address possibly too low uncertainties in that representation that is fine. The question I have is "Are they too low?" Also, **please fix the energy cut-off in 6Li**.
    - (Gerry Hale – *online*) Yes, we have a way in that representation to deal with uncertainties that are too small. I will look at the energy cutoff problem in

^{6}Li, and the other problem you showed with low uncertainty on the **n+^{10}B** elastic cross section.
        - (Denise – *online*) Could you also investigate **^{7}Li and ^{9}Be uncertainties**? Or is that Mark's?
        - (Gerry Hale - *online*) We're both looking at these things, so we will decide who does what. The n+^{7}Li evaluation is not R-matrix based, so I am not sure where those covariances came from. We'll check into that, as well as the issues identified for ^{9}Be (which is still being benchmarked, as you know).
- **QUESTION**:
    - (Caleb Mattoon) In the ^{139}La evaluation, there is an MF32 mismatch in resonance parameters, and they do not agree with file 2. There are repeated entries in the covariance.
        - (Denise) Arjan Koning provided a new MF33 to replace the problematic MF32. Would we be interested in adopting a completely new Lanthanum evaluation?
        - (Gustavo Nobre) We need to look at it. However, it depends on the timing and how fast we can look at the new evaluation and perform testing on it.
        - (Denise) There are no criticality benchmarks overly sensitive to lanthanum, so there shouldn't be any large criticality implications.
    - (Marco Pigni) ^{156,157}Dy are minor isotopes, we can't do too much to improve since there is not a lot of measured data. ^{233}U is being worked on as well.
        - We need to document that those covariances are not available due to measurements.
    - (Roberto Capote) URR fix for ^{235}U(n,f) is due to missing uncertainty propagation. ^{233}U is being worked on, but there hasn't been enough time to fix this yet.
    - (Denise to audience) do we know about ^{233}U?
        - (Marco Pigni) The ^{233}U Resolved Resonance region is being worked on.
- **RESOLVED**:
    - ^{140,142}Ce (processing issue was fixed – Marco Pigni)

Pu-9(n,f) covariances and USU

Speaker: Georg Schnabel (IAEA)

Overview: GMAP: Generalized Least Squares code translated to python and modernized (gmapy). All experimental observables are correlated. Experimental data shows that there are unrecognized sources of uncertainty (USU) that must be recognized and propagated. There are two approaches (MAP/MCMC) to obtain evaluated cross section values. By accounting for USU, there are still assumptions made. USU doesn't change the cross section of ^{239}Pu but does slightly change uncertainties on the cross section. There is a PPP correction made that can change the ^{239}Pu cross section at high energies where experimental data are limited. If we update the covariance matrix using Kullback-Leibler (KL) divergence, we will remain consistent with the evaluation itself. Further investigation is required to test MCMC functionality, scrutinize the probabilistic assumptions, and visualize non-linear interactions that explain the difference between the PPP corrections.

Discussion Items:

- **ACTION**:

- Current issues: PPP correction in evaluation
- More rigorous testing of MCMC functionality
- Scrutinize probabilistic assumptions
  - Is a PPP correction justified for ratio measurements?
- Try to visualize/identify non-linear interactions that could explain the difference
- Adjust obtained covariance matrix using KL divergence & evaluated XS from STD2017

- **QUESTION**:
  - (Jesse Brown) Did you see asymmetric PDFs with your chain? Do we need to support more than normal distributions?
    - (Georg - *online*) Mostly symmetric distributions for cross sections, but 3rd/4th moment are probably different
  - (Denise Neudecker - *online*) PPP should be dealt with via the covariance information provided experimentally. There are normalizations attached to ratio data, and I am unsure if the PPP correction is needed. Do you feel comfortable providing ^{239}Pu(n,f) covariances at this point or is additional work needed first?
    - (Georg - *online*) How much time do I have?
      - (Gustavo) Early January to provide ample time for testing.
  - (Vlad Sobes) Can you talk about adjusting to covariance using KL divergence?
    - (Georg - *online*) KL divergence seems the best – how should the library look like?

VIII.0 Covariance Testing

Speaker: Oscar Cabellos

Overview: Processing ENDF files into JANIS database, which takes the PENDF format via NJOY. BOXER files generated for MF-32-25. These files can be downloaded via https://drive.upm.es/s/E4KBmhbtrI5yWQI (password: janis). Sensitivity matrices were provided.

Using the sandwich rule, the full covariance can be generated for selected cases. Uncertainties in critical systems for Pu cases is largely driven by nu-bar when propagating only ^{239}Pu covariances, especially for thermal systems. ^{239}Pu(n,f) and PFNS covariances are very different from one another. ^{233}U study will be updated once ^{233}U covariances are made available. Thermal system uncertainties for ^{235}U have increased, while other system uncertainties have decreased, again driven by nu-bar.

Discussion Items:

- **ACTION**:
  - Investigate processing ^{115}In into JANIS (failed in the HEATR module)
  - Investigate issues with uncertainty of some reactions in Pu
  - Discuss the uncertainties for ^{239}Pu
- **QUESTION**:
  - (Marco Pigni) There are large uncertainties for the scattering radius of ^{239}Pu. We only modified the resonance parameter. The uncertainty on the scattering radius is 1.7%, which is high and should be reduced. This may in turn reduce some of the uncertainties in ^{239}Pu.
    - (Oscar - *online*) will evaluate these new uncertainties for us

    - (Mark Chadwick) in the Godiva uncertainties table, we also saw PFNS uncertainty reduction for ^{235}U
        - (Denise Neudecker - *online*) Yes, the contribution of PFNS covariances is low, for updated covariances. The reason are low evaluated PFNS uncertainties due to Chi-Nu experimental data that were recently finalized and are of credible high precision.
        - (Mark Chadwick) this is a large and encouraging reduction in uncertainty, not implying that the uncertainty is too low (driven by Chi-Nu data).
- **RESOLVED**:
    - UQ with β2 completed using NDaST in ICSBEP – ICSBEP/**Pu**, ICSBEP/**HEU** (235,^{238}U), ISCBEP/**IEU** (^{235}U), ISCBEP/**LEU** (^{235}U)
    - Processed ENDF/B-VIII.1 β2 into JANIS Database
    - (Denise Neudecker - *online*) John Lestone, Chi-Nu and CEA uncertainties decrease ^{239}Pu PFNS uncertainties at 1.5 MeV Einc, PFNS is being changed for the first time since ENDF/B-VII for Einc, 6 <MeV which can drive some of the changes observed in ^{239}Pu benchmarks.
- **DISCUSSION**:
    - In the ^{235}U evaluation, decreased uncertainty in fast, intermediate and mixed, increased uncertainty in thermal. Nubar changes are most significant.

VIII.0 Covariance Testing

Speaker: William Marshall (Oak Ridge National Laboratory)

Overview: Results have been generated to test covariances for ENDF8-b1. Data-induced uncertainty in VALID benchmarks (HMF, HST, IMF, LCT, LST, MCT, MST, PMF, PST). Covariances have large effects on thermal systems as opposed to fast systems. Uncertainties are being inflated in some benchmark suites, which comes from the nu-bar uncertainty increasing (due to ^{252}Cf(sf) nu-bar increase from the standards in VIII.0, previously 0.15%, now 0.42%). There are large decreases in Pu benchmark uncertainty. Uncertainty on (n, gamma) is down by 95%. Godiva uncertainty was shown to be driven by fission and nu-bar in U5. Nu-bar uncertainty has dropped slightly.

Discussion Items:

- **QUESTION**:
    - (Denise Neudecker - *online*) Regarding the scattering radius uncertainty from Marco Pigni: are these covariances final?
        - (Marco Pigni) Regarding the RRR, we must modify the uncertainty on the scattering radius if possible. ENDF/B-VIII.0 uncertainties are over estimated. We must quantify uncertainties because we couldn't be below standard. Having slightly higher uncertainties on the cross section may support changes needed for crits.
- **RESOLVED**:
    - Testing with β1 (no β2 w/ covariances were available for testing) echoes Oscar Cabellos's testing and repeated from April mini-CSEWG presentation. This is good validation/verification that we're seeing the same thing.
    - Results for HMF-001 (Godiva)

	ENDF/B-VIII.0 uncertainty (pcm)	ENDF/B-VIII.1β1 uncertainty (pcm)
^{235}U Fission	787	787
^{235}U Nubar	399	382
^{235}U Chi	33	33
^{235}U Elastic†	224	224
^{235}U Inelastic	239	239
^{235}U Capture	277	277
^{235}U Sum	982	975
Exp. Uncertainty	100	100
C-E	14	0

†Accounting for cross correlation with fission

- Results for PMF-001S (Jezebel)

	ENDF/B-VIII.0 uncertainty (pcm)	ENDF/B-VIII.1β1 uncertainty (pcm)
^{239}Pu Fission	877	920
^{239}Pu Nubar	317	416
^{239}Pu Chi	179	37
^{239}Pu Elastic	484	360
^{239}Pu Inelastic	-119*	165
^{239}Pu Capture	64	19
Sum	1061	1085
Exp. uncertainty	130	130
C-E	-28	-116

* Cross correlation between elastic and inelastic is larger than inelastic with itself

- Resulting total scattering uncertainty is 469 pcm in ENDF/B-VIII.0 and 396 pcm with ENDF/B-VIII.1β1

- **DISCUSSION**:
  - (Roberto Capote) Everything that we are doing is assuming that we can't be below the 0.42% uncertainty for nu-bar Cf. We know that to be slightly over-estimated, and that will be re-estimated as part of the standard efforts for ENDF/B-IX.0 For capture on fissiles, we seem to be missing some sources of uncertainty related to simultaneous fission measurement. We should go back and take a second look.

We Should Pay More Attention to Covariance Updates!

Speaker: Nathan Gibson (Los Alamos National Laboratory)

Overview: Covariances are very important and should be discussed as much as mean values. There is a need for more passion about covariances. A case study is presented using ^{239}Pu (fast) covariances where covariances came from multiple different efforts. Some moderate manipulation was needed, and more investigation is needed into correlations above 1 in between thermal nu-bar and empty cross section terms. Intermediate energy uncertainty is much higher for the LANL ENDF-VIII.1 evaluation. Uncertainties were driven down compared to ENDF/B-VIII.0 for (n, 2n) reaction. Fission came from standards group and cannot be updated until ENDF/B-IX. Capture uncertainty is coming from IAEA and greatly reduced from ENDF/B-VIII.0. LANL analysis keeps uncertainties closer to ENDF/B-VIII.0. Lots of different models give small uncertainties by default. How do we scale uncertainties? Are experimental

uncertainties trustworthy? Lots of work is being done to finalize covariances for ENDF/B-VIII.1 – but much more work will be needed before ENDF/B-IX.

Discussion Items:

- **ACTION**:
  - More community interaction/participation in uncertainty reduction decisions
- **DISCUSSION**:
  - (Mark Chadwick) There is a concern for what is acceptable uncertainty. Capture or (n,2n) covariances can be validated with thorough understanding of experimental covariances. Improvement of experimental data is encouraging. Capture data and covariances have been improved via experimental data. Requires detailed assessment of experimental data to develop these uncertainties.
    - (Nathan – online) Lockheed n,2n datapoint should be more discussed. This should be a community discussion
    - (Denise Neudecker) Templates of expected measurement uncertainties have been developed with the explicit aim to understand uncertainties of experimental data. At mini-CSEWG, we will have training session to discuss how to apply these templates for uncertainty quantification.
  - (Andrej Trkov) You want to estimate covariance, and then compare to experimental data, not other evaluations. The comparison should always be to the experimental data
    - (Nathan) I totally agree. There are a lot of arguments as to why these newer experimental approaches are better. However, when uncertainties change, more community discussion is needed.

U-234/236 covariance updates

Speaker: Amy Lovell (Los Alamos National Laboratory), Ionel Stetcu (Los Alamos National Lab)

Overview: New fission and capture data were used to update ^{234}U. Covariances were updated based on feedback from Robert Casperson (LLNL, presentation of Robert Casperson from last mini-CSEWG in April 2023). Uncertainties for inelastic were updated. New DANCE data were included in the Kalman fit but were weighted less. Inelastic and capture uncertainties have been updated based on feedback from mini-CSEWG and drafts of the "Big Paper"; the covariances are still derived from Kalman but the magnitude increased.

Toward Rigorous and reproducible uncertainty quantification in resonance evaluation

Speaker: Noah Walton

Overview: Various evaluator choices need to be made (which data sets to use, how to correct them, etc.) for every nuclear data evaluation on experimental data. There may be computational solutions to these problems and, if so, these solutions must be reproducible. While expert judgement is needed for many aspects of the evaluation process (for example: dataset quality, correlations, experimental conditions and using integral data); we can implement an automated procedure for normalization, UQ and Bayes prior. This talk describes work on rendering RRR evaluations reproducible and applying ML but it can be expanded in the future to other energy ranges. Methods include SAMMY, robust, non-

linear least squares algorithm, and feature selection. We are also using a ML approach to test the accuracy of the synthetic data. Training data was generated and fit. We decided to use a least squares to quantify how well the data and its associated uncertainty can be estimated but we are not sure this is the best way. What is a metric that can be used to compare performance?

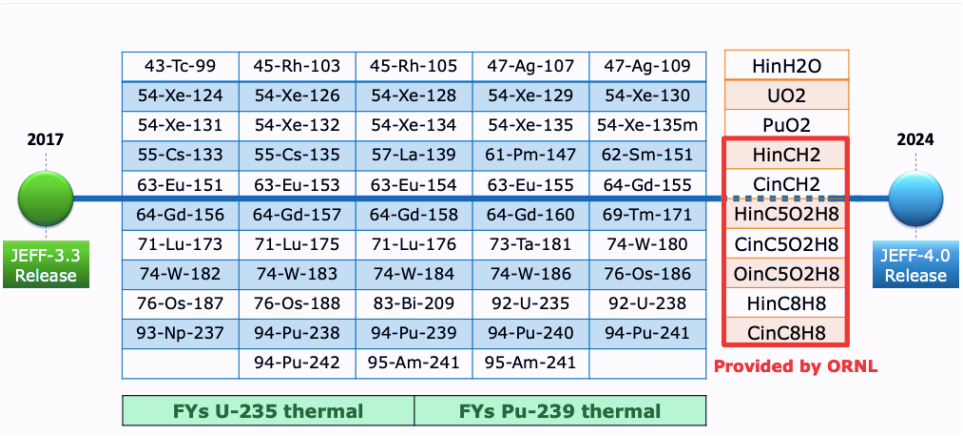
Discussion Items:

- **ACTION**:
  - Looking for feedback from community because synthetic data allows quantitative performance testing but what should the performance metric be?
- **QUESTION**:
  - (Georg Schnabel – *online*) Regarding the regenerative model, how do you go from resonance parameters to the true cross section? How were errors quantified with normalization, calibration, etc.?
    - (Noah) We describe some experimental model that is developed closely with experimentalist to describe data reduction. Generate statistical realizations of that experimental model. Uncertainties are sampled from Monte Carlo.
  - (Georg Schnabel) What if you have cross sections that change by orders of magnitude?
    - (Noah) We have a list of different metrics each time calculating each metric, don't always point to same optimal value.

The JEFF Project Snapshot: Overview, Developments, and Status

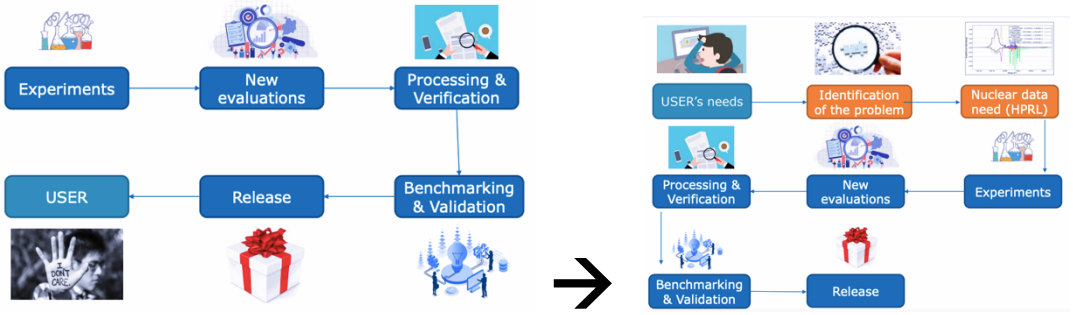
Speaker: Daniela Foligno (OECD NEA)

Overview: Between the JEFF-3.3 release (2017) and JEFF 4.0 there are annual beta releases. The most recent beta is JEFF-4T3 (release coming soon). Actinides, FPYs, TSLs, and other isotopes have been changed between JEFF3.3 and JEFF4.0 (outlined below).



There are two sets of Pu in JEFF-4T3(beta) release. Feedback for JEFF-4T3 will come soon. JEFF-4T2 feedback include strong bias observed in burnup calculations between JEFF3.3 and JEFF-4T3 where JEFF3.3 overestimates reactivity. There is a large impact of ^{239}Pu and fission products in bias present in burnup calculations. JEFF-T3 may be available later this week for testing purposes. NEA has invested in automation of the nuclear data pipeline including formatting and processing codes including FUDGE, CHECKR, PREPRO, etc. The process of identifying urgent nuclear data needs has changed at JEFF where

stakeholders can compile a high-priority list of isotopes/reactions. Additionally, we are suggesting to move from the left workflow of producing evaluations to the right.



Discussion Items:

- **ACTION**:
  - This will be largely discussed next week at the IAEA INDEN meeting (also at JEFF meetings)
- **QUESTION**:
  - (Denise Neudecker – *online*) Do you know how different the unadjusted and adjusted plutonium nuclear data are?
    - (Daniela) One slide about how adjustment is done. No information about how different they are because they haven't been compared yet
    - (Roberto Capote) Next week will be a meeting at the IAEA in which this difference will be discussed

Community Planning

Chair: David Brown
Date: Wednesday, November 15, 2023

DOE-NP Long Range Planning Feedback

Speaker: Ramona Vogt

Overview: There was a charge issued to the nuclear data community from April 2022 to assess challenges, opportunities, and priorities for effective stewardship of nuclear data. Two reports were requested: an assessment on the status of the USNDP and a plan for investment into the USNDP. Recommendations outlined in the 2nd report include 3 existing USNDP capabilities, 8 new cross-cutting initiatives involving measurement, theory, and evaluation to address outstanding nuclear data needs and 3 to modernize and increase the efficiency of the nuclear data infrastructure. Nuclear data deserves its own endorsement in the LRP because it represents one major way that society benefits from nuclear physics research. Nuclear data is directly mentioned in the LRP which is an important proponent for the field. Long Range Plan links: https://nuclearsciencefuture.org/ All NSAC charges and reports found here, including LRP and nuclear data reports: https://science.osti.gov/np/nsac/Reports.

Discussion Items:

- **QUESTION:**
  - (Mike Zerkle) For validation efforts, have you considered adding scattering lengths to the compilation efforts? This has not been covered over 30 years.
    - (Ramona) It is covered but not explicitly.
- **DISCUSSION**:
  - (Lee Bernstein) The LRP is for DOE nuclear physics and science not necessarily tailored to applications. The fact that the science community recognizes the importance of nuclear data is a huge step forward.
  - (David Brown) LRP report is really important and has set the stage on what is happening in the future.

Nonproliferation Stewardship Program Mission Survey

Speaker: Kaipo McCartney

Overview: This talk describes the Department of Defense Nuclear Nonproliferation Research and Development Program. The purpose of the program is to grow and sustain a technically proficient workforce for the mission of non-proliferation. For this, the program is developing a map of key competencies and how they map onto mission needs, specifically in the area of Nuclear Data, to complement other existing maps. There are 3 main sections for developing stewardship: infrastructure, science/technology, and workforce. Competencies refer to the underlying technical skills that allow the NSP relating to fuel cycles and weapons development, NOT the application. Not the detection or safeguard building, but the workforce and capabilities focus. Monitoring the competency between

specific facilities and the workforce assigned to those facilities. Organizational structure is set up to categorize workers and their facilities to keep track of competency. Some activities and competencies have been uncategorized. Questions to consider:

- Relevance: how relevant a given competency is for a specific mission?
- Risk of Inaction: how long would it take to build the competency to complete the given mission?

For nuclear data, there is currently a high risk of knowledge being lost due to aging workforce. Overall, this is a work in progress and the goal is to share resources, so the DOD and DOE are not working on the same issues.

Discussion Items:

- **QUESTION**:
  - (Mike Zerkle) When discussing competency, are we talking about national labs or US universities?
    - (Kaipo) The current focus is US national labs for competency. For now, some initial work is into looking at US universities competencies. However, this is not about specific projects but the whole workforce.
  - (Patrick Griffin – *online*) You say the scope is "just NNSA lab sites and plant competencies" Since some of your stakeholders include DTRA, i.e., DoD labs, are they included in the applicable scope? For example, with respect to neutron facilities, do we consider the DoD supported WSMR FBR?
    - (Kaipo) No, right now the scope is just the national lab sites and plants. We would like to broaden the community to use the resources we already have to make progress.
    - (Lee Bernstein) there are critical experimental facilities at universities (like RPI) so we need to be aware of that and bring them into the discussion
    - (Yaron Danon) universities will also bring the "people" that we need to continue the work (AKA students)
    - (Kaipo) Yes, we hear you and will take it into account
    - (Mike Zerkle) interagency working group could possibly help
  - (Yaron Danon) I think you should also look at what do you have currently in the system and ask how do you integrate this to what we need in the future (ex. Quantum computing)?
    - (Kaipo) There are threats and opportunities down the road. The challenge will be determining how to rank them in importance.
    - NSP is meant to be complementary to R&D but not stomp on each other
    - (Kaipo) This is not going to be an NA-22 project – meant to be a larger and broader mentality toward the field and stewardship of what we have
  - (Ramona Vogt) What if someone is very good at something now but will retire in several years?
    - (Kaipo) The access risk is a snapshot of time, but some of that work involves anticipating workforce access. You may have access to someone now but not in two years, and that is something that needs to be studied further. We do inventory by workforce career stage (early, mid, late) and take that into account.

WANDA Planning

Chair: Todd Bredeweg
Date: Wednesday, November 15, 2023

Introduction

Speaker: Todd Bredeweg (Los Alamos National Laboratory)

Overview: The goal of the Nuclear Data Working Group (NDWG - https://www.nndc.bnl.gov/ndwg/) is to facilitate communication, collaboration, coordination, and prioritization of nuclear data efforts across multiple program offices, the national laboratories, universities, and industry. The Nuclear Data Interagency Working Group (NDIAWG) is composed of federal program managers from across the US government that fund nuclear data efforts through an annual collaborative NDIWG Funding Opportunity Announcement.

WANDA 2024 Details
Where: Hilton Arlington National Landing, Crystal City, VA
When: February 26 – 29, 2024 (Mon-Thu)
Program Chairs: Amy Lovell (T-2) & Jesse Brown (ORNL)

Session Topics:
- Plenary (high level program overviews from federal PMs)
- Isotope Production and Targetry
- ND for Fusion Energy: Fusion Neutron Transport, Tritium Production and Material Damage
- Uncertainty quantification
- Funded Project Updates/Session Closeouts

Questions for each session:
- What do we do right and what are the issues for this topic?
- What programs care about this topic?
- What work is currently being funded to address the issues?
- What work is not being funded to address the issues?
- Where is there synergy between programs?

Discussion Items:
- **QUESTION**:
  - (Allan Carlson) Can WANDA be a hybrid presentation?
    - No, it will not be hybrid.
  - (Keith Jankowski – *online*) While there are 3 sessions intended to be fusion energy driven, I believe (and hope?) that connections will be made to other application areas.
    - (Lee Bernstein) Yes!

Fusion Energy Systems (FES) Workshop: Nuclear Data for Fusion Meeting at the Office of Science Technology Policy

Speaker: Lee Bernstein

Overview: Fusion energy has received an increasing amount of attention from the Biden Administration: new DOE FOA to accelerate fusion energy development and Rian Bahran convened a meeting (at the WHITE HOUSE) to address nuclear data for advancing fusion research. The US Innovation to meet 2050 Climate Goals document includes nuclear in the fusion section only so we need to contribute in this area. We identified ND needs including tritium breeding, neutron-induced damage, gas production and activation, electronics/sensor damage, and thermonuclear reactions. Here is a compiled list of questions to answer: What new energy differential measurements are needed? What sort of integral benchmarks are needed? Are there significant holes in the compiled data? Who are the domestic partners (e.g., stewardship science, fast reactors, nonproliferation)? Who are the international partners?

Discussion Items:

- **ACTION**:
  - ENDF data is needed for recoils and (n, α)
  - NJOY data processing *needs* to be modernized for fusion community

WANDA Planning

Speaker: Amy Lovell (Los Alamos National Laboratory), Jesse Brown (ORNL)

Overview: There will be a poster session for students and young career scientists! Below is an outline of the workshop timeline.

	Monday	Tuesday	Wednesday	Thursday	Friday
8am-12pm	Intro & PMs	Tritium Production	Isotopes	Project Reports	Restricted
1-5pm	Rxn's & Transport for Fusion	Material Damage	Uncertainty Quantification	Project Reports & Session Wrap-up	

Mike Loughlin from ORNL is asking how do we determine what data we need first? The three fusion technical sessions are summarized below:

ND for FE: Reactions & Transport for Fusion

Modeling and simulation of fusion energy sources will involve a range of charged particle and neutron reactions. Fusion energy reactors based on D-T fusion reactions will produce intense sources of high energy (14 MeV) neutrons, where these neutrons will interact with the surrounding materials causing potential radiological and engineering hazards.

- What are the anticipated reactions for energy production, and do specific data needs exist?
- What are the products of these reactions, and are there data needs for understanding secondary reactions?
- Are there gaps in current neutronics code capabilities to accurately model the interactions?
- ND must accurately predict shielding, activation, dose rates, and neutron diagnostics. Uncertainties are needed too.

- What data are necessary to operate neutron sources (IFMIF, FPNS, etc.)? What data do we need to *interpret* data from neutron sources? IFMIF has tail up to 60 MeV neutrons.

Discussion:

- (Amy Lovell) Are there any particular people we should contact regarding needs to interpret the data from these neutron sources?
    - (Lee Bernstein) I have some names that I can pass along.
- (Lee Bernstein) I think we also need to be asking the question what is necessary for fusion applications to have to interpret the data? (don't only focus on the data but also the way the data is being used)
- (Vlad Sobes) What about covariance and uncertainty on fusion data? Do fusion people care about that? Is anyone doing that?
    - (Roberto Capote) FENDL library developed by IAEA for ITER project, but the need for uncertainty was not considered and it was not requested at the time. Libraries need to go up to 60 MeV, there are also very big needs for charged particle induced reactions in addition to neutron induced reactions. Charged particles induced reactions are not understood well (specifically for tritium production).
    - (Jesse Brown) Mike Loughlin has been working on this and hopefully others are too
- (Nathan Gibson – *online*) Any discussion of reactions at 14 MeV should discuss pulsed spheres, which would bring in a common topic that we see here at CSEWG.
    - (Amy Lovell) very good point, Jesse is writing it down.
    - (Mark Paris) Brian Haynes @ LANL and ICF integral benchmarks
    - (Thomas Miller) SINBAD data base for more shielding-type benchmarks
- (Amy Lovell) Charged particles will come in with the material damage session, we also have a tritium production session so let's focus on reactions for this discussion.
    - (Jesse Brown) Transport could be a catch-all but we are going to use charged particles for tritium production session
- (Tim Bohm) For an overall view, look at IAEA FENDL project meeting last week. We went through same exercise for decades. All of the presentations on IAEA NDS website, great place to start for this information
    - (Georg Schnabel – *online*) Presentations of the FENDL meeting Tim mentioned are available at: https://conferences.iaea.org/event/373/
- (Lee Bernstein) Considering neutron multiplication is a needed! This is a reaction transport issue.
- (Vlad Sobes) suggesting a speaker from SINBAD database: maybe Thomas Miller ORNL?
- On the subject of who to reach out to:
    - Private companies:
        - Pacific Fusion: Lee will reach out to contact
        - Daniel Clark at Type-1 Energy
        - (Nick Thompson) reach out to Commonwealth fusion
    - NIF: Shawn Cauter, Tammy Maw, (Lee Bernstein) Nuclear diagnostics folks from NIF should be contacted for participation
    - Mike Loughlin
- On the subject of additional gaps:
    - (Mark Paris) Standing diagnostics program associated with NIF for D-T, high energy neutrons (above 14 MeV)
    - (Mark Paris) Stopping powers in plasmas and materials for 14-30 MeV neutrons
    - (Mark Paris) Ab initio calculations relevant in hi-E neutrons (LLNL, LANL)

ND for FE: Tritium Production

Fusion-based reactors are anticipated to breed tritium (^{3}H) which is needed to fuel energy production. However, quantities of this isotope will be needed during reactor startup, and it may be in short supply. Tritium is currently produced in Canadian Deuterium Uranium (CANDU) nuclear reactors as a waste product. However, about half of the current 19 reactors will be retiring in the next decade and the tritium supply will quickly decline. We must look to private companies for collaboration

- Are there other production processes or reactor materials that can be used to establish a new source of tritium for fusion energy applications?
- Which nuclear data are necessary to support testing and operation of liquid blankets?
- Ceramic blankets?
- What are the uncertainties and sensitivities to tritium breeding ratio?
- What is necessary for the leading designs of breeding blankets? What chemical changes happen during operations?

Discussion:

- (Vlad Sobes) If you are looking for session chairs... suggest reaching out to the industry (MIT SPARC?)
- (Amy Lovell) Industry people here? Speaker suggestions to reach out to?
- (Nick Thompson – *online*) For Fusion industry companies to reach out to, **Commonwealth Fusion**. I have a contact there if you want.

ND for FE: Material Damage

The intense neutron fields produced in fusion energy reactors can affect the materials in the reactor, changing the performance and safety over time. Nuclear data may be needed to improve predictive capabilities that may affect reactor material choices and costs.

- What nuclear data needs exist for estimates of displacement-per-atom (DPA) rates that may cause material embrittlement or failure?
- Are there gas producing reactions (e.g. H, He products) that may affect material swelling or fracture?

Discussion:

- No chair for meeting currently
- (Lee Bernstein) Talked to materials group at UC Berkeley: the current design for fusion reactors involves ReBCO (Rare-earth Barium Copper Oxide) high temperature superconducting ribbons. These need integral and differential measurements. Nobody has taken ReBCO and put it in front of high MeV neutrons to see what happens. Another issue is on the chemistry side. In real time, the chemical composition is changing, I.e., water is being produced. What kind of effect does this have?
- (Tim Bohm) Radiation limits for low temp have been investigated, but no high strength 14 MeV sources available. – ORNL fusion materials for structural
    - Steve Zinkel and Lance Snead?
- (Pat Griffin) There is an absence of uncertainty data in recoil spectra for material damage
- (Lee Bernstein) What kind of materials are needed for ICF?
    - (Tim Bohm) looked a lot at activation, NIF contact Sean Conner (?) and Tammy at LLNL
    - (Katelyn Cooke) There is also University of Rochester Laboratory for Laser Energetics (UR-LLE) for ICF applications – will send Amy/Jesse an email with contact

    - (Lee Bernstein) Alex Zylstra (from LLNL, now Pacific Fusion)
    - (Amy Lovell) Livermore connections, some have been suggested
    - (Tim Bohm) Type-1 Energy, Daniel Clark used to be FES Program Manager
- On the topic of benchmarks:
    - (Mark Paris) The closest thing to integral benchmarks is simulations of ICF capsule implosions. Brian Haynes is the contact at Los Alamos.
    - (Mike Zerkle) suggests that someone gives an overview talk about how the process works. We should focus on learning from previous experiments
- On the topic of computing damage cross sections (or equivalent):
    - (Mike Zerkle) coupling of theory + experiment is important, large effort ($) to generate
    - (Mike Zerkle) increase the cross-pollination between material science and nuclear data field
    - (Roberto Capote) Processing ND and formats -> how to go from XS to damage XS?

<u>Isotope Production & Targetry</u>

This session will be focused on cross-cutting developments, challenges, and needs in the field of targetry for nuclear data applications, including the availability of enriched stable and radioactive isotopes. Invited talks and discussion will be focused on target needs for a variety of nuclear data application spaces, the availability of these targets, and novel targetry fabrication techniques.

- The intent of this session is to discuss unmet needs and identify areas in which investment would benefit the quality and availability of targets for end users to generate nuclear data

<u>Uncertainty Quantification</u>

This session seeks to highlight the **identified biggest needs to enable proper uncertainty quantification of nuclear data from theory and experiment through evaluation and all the way to end users**.

- Challenges for well-versed UQ people: the incomplete and inconsistent quality of existing covariance information
- Challenges for new UQ: complications as to the meaning and trustworthiness of covariance data, as well as the complexity of techniques for forward propagation, require training and resources from those established in the community.
- This session will make the case for the exciting and modern approach of UQ-oriented nuclear data work.

Discussion:

- (Nathan Gibson) This session should build on previous WANDA sessions. It will be very covariance and nuclear data heavy. We are looking to bring in users from various aspects of the pipeline.
- (Amy Lovell) Model and parametric uncertainty theorists have reached out to connect with the nuclear data community.
- (Keith Jankowski – *online*) I'll offer that even if the fusion community isn't very concerned with UQ, the nuclear data community should be (based on conversations with some fusion industry reps, I think they are).
- (Jesse Brown) Could Nathan comment on any plans to look to current tools to propagate data to applications, such as Whisper and TSUNAMI? Will there be any focus on what current tools need to change for future fusion needs?
    - (Nate Gibson) There is a current LANL project focused on nuclear material handling operations covariances that do not make it to the end user for integral benchmarks.

- (Allan Carlson – *online*) ask Denise for chair suggestions for UQ
    - (Denise – *online*) No worries, Allan, Nathan did already ask me.
- (BJ Marshall – *online*) Would this be a session we can move forward the idea of EVALUATED covariance and not just MEASURED covariance?
    - (Yaron Danon) There is no measured covariance, it's just something you calculate.
    - (BJ Marshall) Correction to my question: covariance of measurements vs. covariance of evaluations.
    - (Jesse Brown) This topic has been coming up more recently – we will consider it.
- (Nick Thompson) For end users, I know Westinghouse has been using some UQ / sensitivity tools... just not sure how much they would share publicly.
    - (Nate) Will reach out to Westinghouse
- (Yaron Danon) On the covariance session we are making covariance on differential data. One important topic is how do we propagate to criticality safety applications? What additional experiments are needed for different physics? The next step of covariance is to bring into format that is usable. We need to hear from users.
- (Amy Lovell) For this session, it is not solely focused on experimental data, or what we have to measure better. We need *all needs* to be identified.
- (Roberto Capote) Need to talk about producing and processing damage cross section data. Start getting additional methods into processing codes, NJOY only uses 1 method (NRP) that has been established a long time ago. This is something that the community has to discuss: how are cross sections compared to damage cross sections? At the IAEA intercomparison, participating processing codes were using different methods -NRP and ARC-DPA. This is very important for fusion applications.
- (Jesse Brown)'s notes:
    - Med-fi covariances would be handy
    - (BJ Marshall) consider adjustment
    - How does differential data covariance need to be propagated and adjusted for applications beyond crit safety (shielding, fusion, etc.)?

Discussion Items:

- **ACTION**:
    - **PLEASE EMAIL JESSE/AMY WITH IDEAS/SUGGESTIONS IF YOU THINK OF THEM LATER**
- **GENERAL DISCUSSION**:
    - (Vlad Sobes) Is the poster session open to all topics?
        - (Amy Lovell) Yes, might be good to have posters for people with research ideas in the 5 technical session topics and outside. Can open it up to anyone who wants to bring forward ideas in nuclear data.
    - (Mark Paris) I see two gaps present:
        - Longstanding very useful diagnostics program run by NIF using secondary reaction. When we have DT primary burn that produces 14 MeV neutrons, they also do secondary reactions with D & T. They produce a very high spectrum, up to 30 MeV. What kind of power is available at that energy? Look into Anna Hayes or Jared Young (?) at LANL
        - The second gap is regarding plasma properties. What kind of stopping power is at play for a given temperature or density? Lighter nuclei allow use

of ab initio methods. Gerry Hale and Joe Carlson have made contributions that could be useful.

- (Roberto Capote) One issue we could be missing regarding processing the data is radiation damage. Nuclear data depends on the method you are using. NJOY uses NRP but there are others, and the community needs to discuss them. IAEA has done some other methods, and it can be important for fusion.
  - (Lee Bernstein) yes – molecular dynamics codes should be included in the discussion
  - (Patrick Griffin – *online*) Roberto, I strongly agree with your comments here on modeling the damage. One major consideration here is the fidelity of the recoil spectra captured in the nuclear data evaluation. The absence of any uncertainty data on the recoil spectra is a major issue.
  - (Mike Zerkle) ARC-DPA should be included in the modeling damage processing discussion
- (Lee Bernstein) ICF diagnostic effort that would utilize areal density – processing code did not include 4.4 MeV in carbon – they are using processing codes (not necessarily using our databases/codes so they are missing data)
- (Amy Lovell) We need cross-cutting applications and funding sources so we can make good progress.

Formats and Processing

Chair: Doro Wiarda (ORNL) and Mike Dunn (Spectra Tech.)
Date: Wednesday, November 15, 2023

NJOY Status

Speaker: Wim Haeck (LANL)

Overview: Update on the status of NJOY, introducing MF7 MT451. Every ENDF/B generation comes with new data, such as mixed format thermal scattering data. The focus of last year was implementing MF7 MT451 data. A new version of NJOY released every quarter. There were no major changes to processing, but changes were implemented to allow NJOY to read MF7 files. Most modifications were done to MODER module. For background R-matrix elements, multiple options are now available. NJOY (Nov 2023) version is required for R-matrix elements. Changes were made to MODER to read R-matrix data, RECONR tests were done to protect against NJOY2016 limitations. Other updates include HEATR fixes, ERRORR allows for MF34 to select sub-sub-sections, and there are fixes to LEAPR. NJOY was also modernized by shifting from module-based to component-based optimizations. Toolkits ENDFtk and ACEtk are being developed with remaining work needed to reduce dependencies. New component add-on, SCION, includes interpretation of tabulated data, interpretation of polynomial expansions and linearization functions. You can now process data into an ACE file without old NJOY. We will continue to maintain and develop NJOY2016.

Discussion Items:

- **ACTION**:

    - **Continue to inform NJOY developers via the git of any bugs or issues**
- **QUESTION**:
    - (Denise Neudecker) With Codex, will it also be possible to format covariances?
    - Does ENDF8.1 break certain things in MCNP6.2?
        - (Wim) Mixed mode thermal scattering both coherent and incoherent scattering break so you will need to move to MCNP6.3 if you would like to use these new features.
- **DISCUSSION**:
    - (Skip Kahler – *online*) Also fissile TSL kernels … say U-UO2 … only work in 6.3.

FUDGE Status

Speaker: Caleb Mattoon (Lawrence Livermore National Lab)

Overview: LLNL is translating nuclear data to GNDS format using the FUDGE processing code. LLNL transport codes can also handle transport for GNDS formatted files. FUDGE now supports generating URR probability tables. URR probability tables were compared against NJOY and FRENDY; and was tested on crits and shielding benchmarks. Recent updates focused on supporting new TSL evaluations and various issues regarding processing were fixed. Additional physics testing was added to FUDGE. There are a few open issues that are GNDS translation failures. A FUDGE training course is available at the NEA in Paris in 2024.

Discussion Items:

- **ACTION**:
    - Some TSLs do not interpolate properly – need to investigate
- **QUESTION**:
    - (Roberto Capote) In criticality comparison, there were differences due to processing in the URR. Do you use the same set of benchmarks?
        - (Caleb) this was the comparison done in 2018 so I need to check with Marian. We made several fixes in FUDGE so we will look at that comparison again.
    - (Denise Neudecker) ^{206,207}Pb have differences in the covariance when processing with NJOY. You get 0 uncertainty in the resonance range. Could this be a NJOY or ENDF issue?
        - (Caleb) The issue we have is L-dependent scattering radius uncertainty is used which is not implemented in FUDGE.
    - (Mike Herman) I knew about the problem with Platinum just haven't gotten to it
    - (David Brown) I saw something in the last slides about GEANT?
        - (Caleb) Yes, GIDI+ was implemented with GEANT. Internally, we have a new version that should be available by the end of the fiscal year (Brett Beck)
    - (Gerry Hale – *online*) I think what caused the confusion about MT=51 in the d+t file is that we took into account the width of the 4He* and put its mass at ~ the p+t threshold. Mark can discuss this with you at the meeting.
        - (Caleb) will discuss with mark - thanks

AMPX Status 2023

Speaker: Jordan McDonnell (UT-Battelle)

Overview: To process TSL files with the new mixed-elastic scattering format, AMPX and SCALE need development effort. The size of the CE SCALE libraries are very large (97 GB of ENDF-8B2). Distributing updates is difficult for users due to amount of Bragg edges in TSL files. General development highlights include enhancing PUFF processing, enhancing performance of refined angular gridding, support for modernized POLIDENT code and developing photonuclear sublibrary SCALE multigroup format. The current SCALE 7.0.0 beta version includes the photonuclear processing capabilities, the ENDF/B-VII.1 CE library, and a multigroup library with 31 neutron groups and 23 photon groups.

(*these were extra slides*) General ENDF Issues encountered: resonances with total widths greater than the sum of partial widths (for ^{203}Hg, ^{144,145,146}Pm, ^{158,161}Tb, ^{49}V, ^{175}Yb) and incorrect NVER (^{50,52,53,54}Cr, ^{54,56}Fe [also bad NLIB], ^{78}Se, ^{235}U [bad NLIB], ^{181}Ta, ^{122}Te).

Discussion Items:

- **ACTION**:
  - Look into negative XS at 0 K for ^{54,57}Fe, ^{60}Ni, ^{141}Pr (MT=2)
  - Missing 1D data for ^{14}N MT=28,32
- **QUESTION**:
  - (Mark Paris) ^{12}C has not been changed. What about ^{9}Be?
    - (Jordan) We are talking about photonuclear sublibrary, not neutrons for both materials.
  - (Jason Thompson) The ^{14}N reactions have secondary gamma information but no cross section, is that what you mean? Yes
  - (Caleb Mattoon) The SCALE library is double differential for TSL CE?
    - (Jordan) Yes, this is something we're looking into
    - (Doro Wiarda) thought we can either make the transport or the processing code more complicated. Unfortunately, both needed updates.
- **RESOLVED**:
  - Negative XS at 0 K for ^{65}Cu MT=3 was corrected during Hackathon (after β2)
  - AMPX photonuclear library was updated

NDEX Overview

Speaker: Jason Thompson (NNL-KAPL)

Overview: Over the past few years, NNL has been developing a fully independent nuclear data processing code, NDEX. The goal of NDEX is to provide the most physically accurate and "true to evaluation" processing as possible while also processing nuclear data in a way which has a beneficial impact to MC21's performance. Moreover, the physics represented in NDEX should match that implemented in MC21 to as great a degree as reasonably possible to ensure a consistent physical representation through all nuclear design calculations. NDEX should be as user-friendly as possible to minimize the learning curve (easy input code – most users are not nuclear data experts), minimize error-prone steps, and simplify the overhead of performing checks on input and output. NDEX should be designed in a way to be easily understood, extended, and maintained, and be thoroughly tested. MC21 development has allowed for (alpha, n) and XRF with emphasis on maintaining "good" development practices including comprehensive testing. Progress includes Doppler broadening, processing TSLs, URR probability tables, secondary particle distributions, reconstructing RRR/URR/HER into a 0 K cross section, and KERMA generation. NDEX generates the photon incoherent scattering cross section for each

subshell and sums to a total using only electron momentum distributions. It also features parallelization and 0 K reconstruction.

Discussion Items:

- **QUESTION**:
  - (Caleb Mattoon) What is the source of the discontinuity in your example?
    - (Jason Thompson) That was ENDF/B-VIII.1(beta2) from ^{35}Cl or ^{40}K in the (n,p) channel.
  - (Doro Wiarda) Is the reconstruction doing more than linear interpolation?
    - (Jason) The code is approximating the resonances and interpolating.

SAMMY Update

Speaker: Dorothea Wiarda (ORNL)

Overview: Shifted to APMX so that one code "rules them all." To support file 32 with GNDS, changes are needed to the SAMMY input file itself. Indexing is important but it is difficult to implement. Following the update of SAMMY, the nuclear data group will be able to expand the capabilities. Updated input handling will allow for less temporary input files, additionally the SAMMY input is currently read three times, which is two more times than it should be read in an ideal scenario. The program flow should be easier to handle in general. Improvements will continue to be made to the overall program flow. SESH has been integrated into SAMMY by Alec Golas as well but is not yet available on the public branch.

Use of MT=900+ for primary gamma two-body channels, and MT=102 being derived from these for backward compatibility

Speaker: Ian Thompson (LLNL)

Overview: New format proposal to specify primary capture gammas. The ENDF format currently does not allow for correlated primary/secondary gammas. MT=102 format is complicated as it must describe both primary and secondary gammas. MT-102 does not allow for listing of branching ratios and additional information that is needed, so new formats are needed. Two-body reactions for particle products exist for n,p,d,t,h and a, but not for gammas (g)!! We propose to use MT=900-998 for the first 99 discrete primary gammas needed and MT=999 as continuum channel for any further primaries. MT-102 is the sum of the proposed MT-900-998. Backward compatibility must be guaranteed.

- MT=900: Production of a primary-γ particle leaving the residual nucleus in the ground state
- MT=901-998 Production of a primary-γ particle, with residual in 1st to 98th excited state
- MT=999: Production of a primary-γ particle in the continuum not included in the above discrete representation.
- MT=102: Radiative capture: production of one or more gammas (photons) plus a residual.
  - Redundant: sum of MT=900-999, if they are present.

If this proposal is accepted, and new MT numbers are being used, the secondary decay gammas need to be specified either by transition probability arrays with MF=12 data (preferred), or separately for each of discrete MT channels (900-998) or in a continuum distribution for MT 999.

Discussion Items:

- **QUESTION**:
  - (Andre Trkov - *online*) Is it possible to construct distributions for MT=102 from the partials MT=900-999 without approximations?
    - (Ian) Yes, normally. No, if the primary gammas have multiple distributions.
  - (Mike Herman) I do not understand something because the 999 should increase secondaries and anything not included in the discrete levels.
    - The secondary gammas need to go somewhere
    - (Bret Beck) the 102 includes all 102 not included and the secondary gammas they would produce
    - (Mike Herman) are there multiplicity issues?
    - (Bret Beck) MT=999 needs to have all gammas that were excluded from 900-998
    - (Mike Herman) you can do that but it will not sum to 102 – it would be added too many times?
    - (Bret Beck) 999 has to be 102-(sum of 900-998) so you need to have the capture cross section.
    - (Mike Herman) The questions is do you have specific cross section...?
    - (Bret Beck) - one gamma goes to continuities, other go to spectrum
  - **SUMMARY: gammas are confusing – it's hard to store them**
  - (Roberto Capote) This format is good for light elements when you see all of gammas. As long as you see all the primaries, the thermal capture cross section should be OK. However, for most heavy isotopes we don't have all the gammas
    - (Ian Thompson) agrees with Roberto
    - (Bret Beck) this is like MT=91... you have the continuum; gammas can come out of them as a result from the 3 to 2 level
    - (Mike Herman) it's a different thing, gammas can have multiplicity
    - (Bret Beck) - you can have multiple gammas come out, but if you sum all the gammas you will get the same as file 102
    - (Jason Thompson) trying to understand – it's storing the gamma data the same as neutron multiplicity?
    - (Bret Beck) secondaries are stored via branching ratios
    - (Mike Herman) But the sum of all gammas is ~3 times more that the primaries
    - (David Brown) There are two types of gammas: primary and secondary. Most primaries are in special MT, all other go in other files. The sum of all gamma primary multiplicity weighted XS need to sum to the total (the application of sum rule is very tricky) when you get to the 999 case, it becomes difficult and you need to write in the manual
  - (Cedric Jouanne - *online*) Why don't we use negative energy in MF6 to sign primary gamma as in JENDL5 Library (for example Fe56)?
  - (Ian Thompson) I am finished *he returns to his chair*
  - (Mike Zerkle) The proposed MF 102 markup is needed as well.

Proposed manual clarification for MT=5

Speaker: Michael Dunn (Spectra Tech, Inc.)

Overview: Currently, everything is dumped in MT=5. If it already has a home, please don't put it in MT-5 below 20 MeV! Proposal report is linked to the Indico page.

The summary is that there is blatant misuse of the MT=5 reaction (which is primarily meant for high energy reactions were distinct reactions cannot be separated easily). MT=5 is being used for many lower energy reactions where the predicted reactions do not neatly fit into the ENDF reaction scheme. Often however, these lower energy MT=5 uses have very small cross sections (micro-barns). It is argued that these reactions can be removed and we can stick to the ENDF reaction scheme. Naturally this leads to animated discussion.

Discussion Items:

- **ACTION**:
  - Limit MT5 to ONLY above 20MeV (request)
  - **NEED TO SCOPE THE PROBLEM (figure out how bad the problem is) TO DISCUSS AT NEXT MEETING** – no one is volunteering – people are actively leaving
  - Solution would be applied to ENDF-IX
    - (Jordan McDonnell) will ENDF-9 be GNDS only?
    - (Dave Brown) I have opinions, but we need to get 8.1 out first and then we can worry about that
    - (Doro Wiarda) not for the formats section anyway!
- **QUESTION**:
  - (Nathan Gibson) read the 20 page report. You are talking about the neutron sublibrary for above 20MeV? Sublibraries use MT5 for other types of data such as gammas.
  - (Andrej Trkov) How many users are there for who this is a problem?
  - (Roberto Capote) 20 MeV is not a physical limit. In reality, there are some actual problems when we start doing the evaluations that we don't know how to deal with. So, it's hard for someone else to make these strict requirements if they're not the one doing the evaluation.
    - (Mike Herman) agree
    - (Doro Wiarda) cannot change anything for the current release because we cannot get rid of the data
  - (Bret Beck) in one gamma library a user asks where's (g,n)? In MT=5, one product out, neutron multiplicity 1? Isn't that the fission? [Katelyn summary: there are people that are confused about what this data actually is]
    - (Doro Wiarda) Fission gammas are in MT3 because it cannot be separated. It is a known fact that fission gammas are in MT3.
    - (Nathan Gibson) lumped channel that lots of neutrons can come out of so we need to look at residual coming out because XS given absorbs the multiplicity
  - (Dave Brown) MT=5 usage is unavoidable in many cases but there are avoidable cases where MT5 should not have been used at all – 20 MeV cut proposal is not possible. Can we identify legitimate uses for MT=5?
    - (Mark Paris) can 175 evaluations be backed out into MT? Comment in appendix b – particle can be identified w/ multiplicity in file 6
    - (Roberto Capote) This is what happened in MT5 (we cannot separate different reactions).

- (Doro Wiarda) library maintainer needs to say case by case if MT=5 can be used

Validation Committee

Chair: Mike Zerkle (NNL)
Date: Thursday, November 16, 2023

Introduction

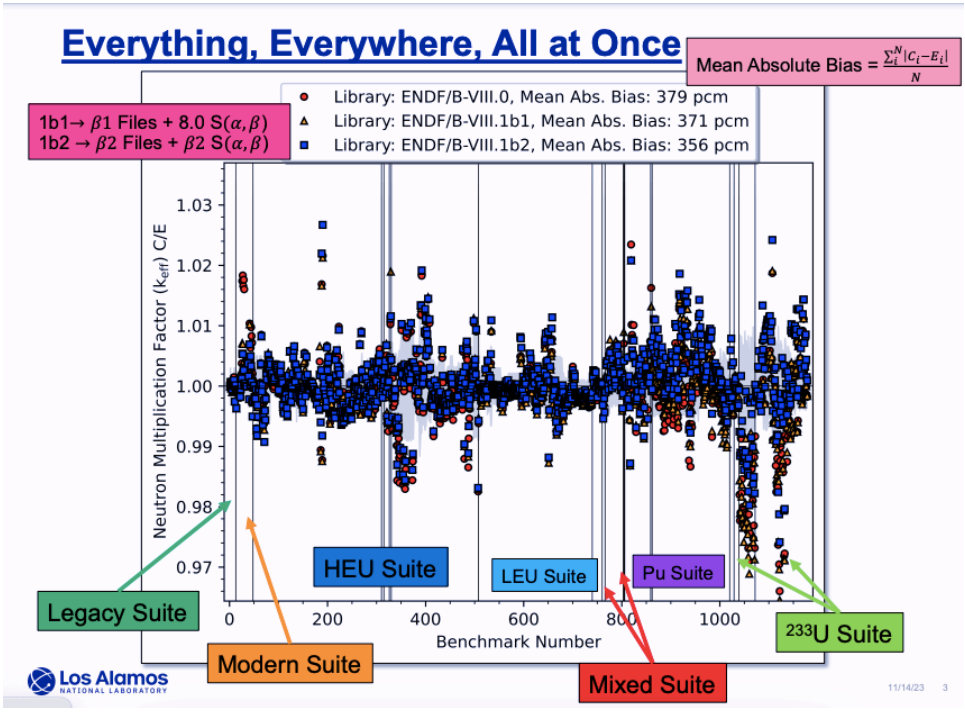
Speaker: Michael Zerkle (Bettis Atomic Power Laboratory)

Overview: An overview is given of the full-day validation session, the schedule will be very tight.

Validation of ENDF/B-VIII.1(beta 2) Files

Speaker: Noah Kleedtke (LANL)

Overview: ACE files that were used in validation testing were processed using NJOY2016.71. The mean absolute bias when compared with critical benchmarks has decreased relative to ENDF8 and ENDF8.1b1. Changes in Bethe sphere experiments come from high energy changes in Uranium and Li. Not many large changes are observed in the legacy benchmark suite from LANL. A modern benchmark suite comprised of newer experiments that are well-characterized is shown to test cross sections across all energy regions for different materials. Overall changes from ENDF8.1b2 are mostly favorable. For different sets of benchmarks, ENDFb2 reduces the mean absolute bias with a few exceptions.



Discussion Items:

- **ACTION**:
  - The LWBR Seed-Blanket (^{233}U) benchmark performing worse with ENDF/B-VIII.1-β2 – need to look into why
- **QUESTION**:
  - (Roberto Capote) This is a very comprehensive validation, but there is concern for ^{6}Li and ^{7}Li. We worked a lot to improve gas production which we would expect to be in ENDF/B-VIII.1-β2 file, specifically stored in 203 and 207 files to make sure users don't need to worry. However, the data was somehow lost.

Validating ENDF/B-VIII.0(beta2) with LLNL pulsed spheres and EUCLID experiments

Speaker: Denise Neudecker (Los Alamos National Laboratory)

Overview: This validation study is using same set of ACE files from NJOY as Noah. LLNL pulsed spheres were used to validate nuclear data up to 15 MeV. Differences in LLNL pulsed sphere C/E are observed for Li, Be, Pb. 2 experimental configurations were designed using ML and executed at NCERC to explore compensating errors in fast ^{239}Pu ND. Six measurement responses were studied with the experiments. k_{eff} sensitivities are like Jezebel for fission but different for scattering. Calculated k_{eff} is mostly below experiment and varies with ^{239}Pu library by 10s to 100s of pcm. They point towards ^{239}Pu inelastic/elastic being the problem which needs to be studied for IX.0.

Discussion Items:

- **ACTION**:
  - Significant structures introduced by ENDF/B-VIII.1-β2 in Pb Livermore Pulsed Spheres that need to be investigated.
    - Changes could come from $^{206\text{-}208}$Pb: (n,2n) cs/ angular distribution, elastic angular distribution, or (n,inl) cs/ angular distribution (comparably small).
  - The predictions of Mg Livermore Pulsed Sphere is bad and must be improved.
- **QUESTION**:
  - (Andrej Trkov) Could you provide some figure of what is the surface to volume ratio in EUCLID experiment?
    - (Denise Neudecker) Figure was in the slide deck. 2 means you have 2 ZPPR plates and 1 means 1 row of ZPPR plates.
    - (Mike Zerkle) The ZPPR plates are 2 by 3 inches
- **RESOLVED**:
  - ^{6}Li: problem in ENDF/B-VIII.1-β1 nuclear data was fixed. ENDF/B-VIII.1-β2 better than ENDF/B-VIII.0
  - ^{7}Li: problem in ^{6}Li ENDF/B-VIII.1-β1 nuclear data was fixed, can be also seen in ^{7}Li LPS (LPS has small ^{6}Li content)
  - ^{9}Be: ENDF/B-VIII.0 better than ENDF/B-VIII.1-β1 or ENDF/B-VIII.1-β2 right after elastic peak.
  - ^{239}Pu: large changes coming from inelastic scattering.
    - The changes we see are coming from inelastic cross sections and angular distributions (MF={3,4,6}). The continuum spectrum could play a large role
  - Concrete: changes in ^{16}O and Si lead to slight changes in Livermore Pulsed Spheres but well within experimental uncertainty:
    - ENDF/B-VIII.1-β1: ^{16}O changes.

        - ENDF/B-VIII.1-β2: Si changes.
        - While C/E gets slightly worse for changes in both, ^{16}O and Si. These changes are well within experimental uncertainty and, hence, no strong indication for a need to fix data.
    - Negligible changes: light water sphere, ^{27}Al and $^{235,238}U$: changes were already seen in ENDF/B-VIII.1-β0, nothing new with ENDF/B-VIII.1-β2, all fine.

NNL Validation Testing of ENDF/B-VIII.1(beta2)

Speaker: Adam Ney

Overview:

Updates to fluorine in β1 and β2 yield significant improvements over 8.0. Errors introduced in beryllium and silicon in β1 resolved in β2 (Be: HMF058, Si: HMM005, HMF057). Noted increased bias in LCT010 Pb-reflected cases. Reduction in mean C/E – 1 for HEU and IEU benchmarks, increase for LEU and Pu benchmarks in β2. Increase in LEU suite mean C/E – 1 due in part to degraded LCT010 performance. Pu benchmark suite bias flipped from under-predication to over-prediction on average. TSLs were also tested for Poly and Lucite for PMT004 for both ORNL and NCSU evaluations. Lucite TSL was not shown to have significant impact, and NCSU and ORNL evaluations perform similar to each other for bare configurations, but moderated reflected cases show slight overprediction of reactivity for ORNL evaluation.

Discussion Items:

- **QUESTION:**
    - (Skip Kahler – *online*) Internally NR often quotes 95% confidence intervals. Is that true here or are these 1-sigma uncertainties?
        - (Adam) 1-sigma
    - (Noah Kleedtke) It looked like the TSL testing results were very similar. Do you have a recommendation for one file over another, or are the results too close to recommend anything currently?
        - (Jason Thompson) NDEX needs to resolve the Bragg edge issue with ORNL TSLs, so it is premature to give a recommendation.
    - (Kemal Ramic) It is interesting to see that the reflector changes, likely different angular distributions between the two evaluations for TSLs.
- **DISCUSSION**:
    - (Mark Chadwick) All of the analysis looks very encouraging so far.

Testing of candidate evaluations for ENDF/B-VIII.1b3 in burnup calculations

Speaker: Andrej Trkov (Jozef Stefan Institute)

Overview: Reactivity loss in burnup calculations using more recent libraries like ENDF/B-VIII.0 tends to be stronger by several hundred pcm. OpenMC was chosen to perform calculations with ENDF-7.1,8.0,8.1b2, 8.1b2n (similar to b2 with a small reduction of thermal nubar). The reactivity loss with burnup using ENDF/B-VIII.1 b2 library is very similar to that of ENDF/B-VII.1 for the low-enriched (2.6 %)

and the highly enriched (4.75 %) light water reactor fuel; the reactivity loss is less pronounced compared to ENDF/B-VIII.0. Although the accumulation of strong absorbers can be important, it seems that the dominant effect is the Plutonium build-up. Small changes in the ^{239}Pu nubar (introduced after "beta-2", label suffix "n") do not affect the results significantly. Feedback from the users on power reactor analysis is needed to verify the observation on the reactivity loss with burnup.

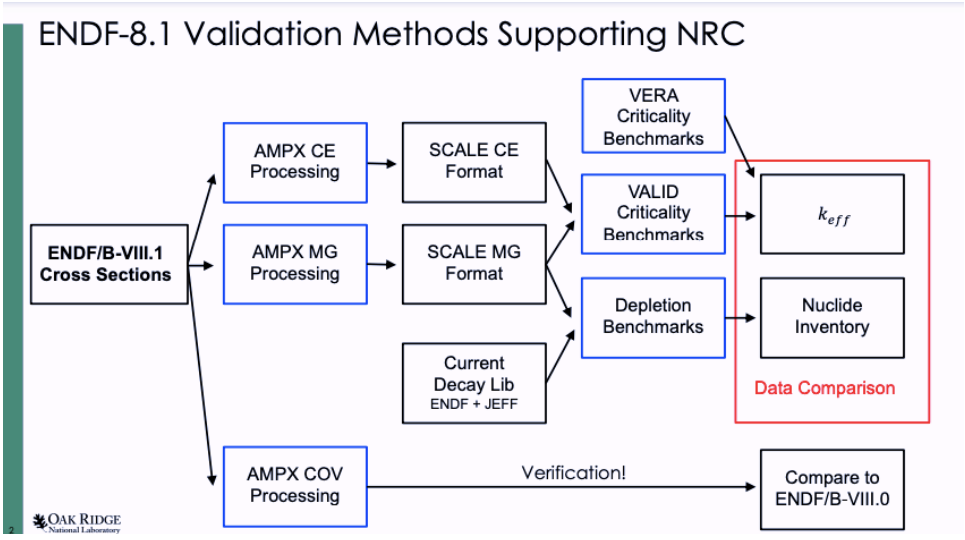
Discussion Items:

- **QUESTION**:
  - (Mark Chadwick) If I understand lowering nu-bar at thermal didn't affect burnup but did bring criticality a bit which is an improvement. Do you propose putting the lower nu bar in beta3, and how does it agree with the standard assessment?
    - (Andre) The decrease in nubar was within the uncertainty. There was not a big change, but it does bring Pu benchmark down and if you look at the diagram the effects are small. The change in nubar has no effect with reactivity loss for burnup, and this is acceptable for using OpenMC. We can go along with the reduced nubar if we check temperature coefficient. If that is ok, then I would recommend this version of nubar.
  - (Gustavo Nobre) - Does the file you used have the suffix "nu1"? That is the most current version.
    - (Andre Trkov) - That is the file I have been using.

Multi-Application Validation of ENDF/B-VIII.1

Speaker: Jesse Brown (ORNL)

Overview: ORNL performed testing of beta2 libraries for NRC (described with figure below). TSL data size is a problem due to Bragg edges but might be remedied by movement to HDF5 format from XML5 format.



For advanced reactors, decreasing reactivity for 8.1b2 compared to 8.0 led to some unexpected nuclides causing major differences (^{19}F, Cr) but there was no clear performance difference when compared to experiment. For depletion RCA, high impact isotopes are closer to ENDF-7.1 and there is

small improvement on average (^{235}U, ^{239}Pu, and BC FPs) which is worse for Am and Cm. For fuel reactivity, 8.1b2 has higher reactivity at high burnups than 8.0, but is likely underpredicting k_{eff} for PWRs at high burnups. DBRC correction was not used due to lowered reactivity. Many applications are needs to test libraries rigorously and unexpected nuclides are causing major issues (^{19}F, Cr), etc.

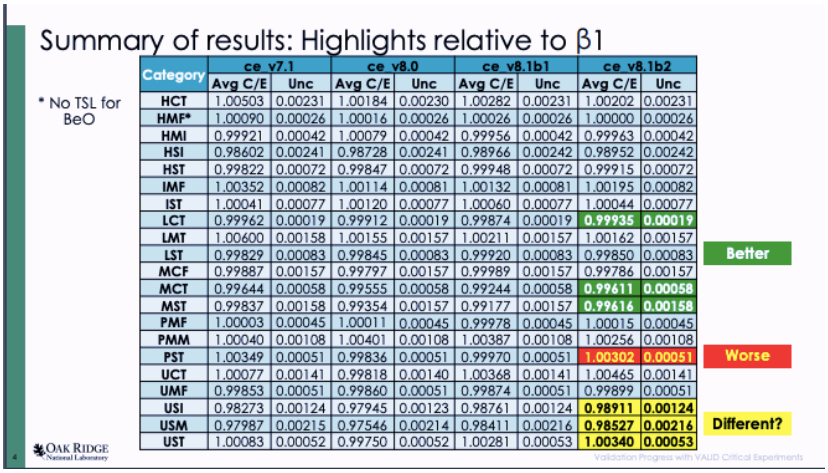
Discussion Items:

- **ACTION**:
  - Discuss tagging sublibraries with Gustavo
  - We need ***many applications*** to rigorously test library
- **QUESTION**:
  - (Tim Trumbull) You mentioned DBRC – if you run without the DBRC, you don't get the correct resonance scattering treatment so you really need it.
    - (Jesse Brown) I agree, but it makes your results look worse
    - (Andrew Holcomb – *online*) That's the rub, in the past evaluation integral performance has been judged without DBRC. So if you turn on DBRC for an evaluation that has its performance tweaked to work assuming no DBRC, then performance will of course change but not necessarily be better.
    - (Jesse Brown) Yeah there is a different basis
    - (Yaron Danon) But the physics are correct so you need to use it. The DBRC of course testing was done with MCNP 6.2, but 6.2 does not have the correction. DBRC was only implemented in 6.3.
    - (Mike Zerkle) For benchmarks sensitive to DBRC you may need to reassess the benchmark simplification bias to account for the difference in methods bias for calculations w/ and w/o DBRC.
  - (Yaron Danon) In the first slides about fluorine, is that difference compared to experiment? Is it a good or bad difference?
    - (Jesse Brown) If we look at MSRE benchmark there is an increase in reactivity,
    - (Hye Young Lee) I would recommend not to look at comparison to benchmark for MSRE, there is some issues in the benchmark evaluation. We are looking for better benchmarks that do not exist.
    - (Mike Zerkle) The MSRE benchmarks are likely missing hydrogen fluoride (HF) in the fuel salt compositions that is typically added for chemistry control and this is suspected to be one of the sources of bias.
  - (Roberto Capote) Very nice to see these calculations, and I am concerned to see differences between different methods used in SERPENT, WIMS, MCNP, or OpenMC. This does not produce clear picture, maybe there is something more than fission products to compare. At this point not sure where we are, because this does not coincide with Andrej's calculation
    - (Jesse Brown) I was curious how his normalization procedure works. I wonder if that changed. I was surprised that Andrej results look closer to ENDF7 than us.
    - (Andrej Trkov – *online*) If I remember correctly, FPY were not changed in e8b2 and it would not affect the benchmark we are analyzing.
    - (Gustavo Nobre) FPY were not changed – correction for 240 or 241
    - (Andrej Trkov – *online*) Conclusion is results might change if new FPYs are introduced

ENDF/B-VIII.1β2 Testing with the VALID Library at ORNL

Speaker: William Marshall (Oak Ridge National Laboratory)

Overview: Will summarize k_{eff} results for CE calculations with VALID. The VALID suite at ORNL has been expanded in recent years to include more ICSBEP benchmarks. More categories of experiments are covered, though some of them have very few cases. Deuterium- and polyethylene-moderated systems have been added, expanding validation basis for moderators beyond light water. Continuous energy results are shown in the table below:



Summary of results: Highlights relative to β1

* No TSL for BeO

Category	ce_v7.1		ce_v8.0		ce_v8.1b1		ce_v8.1b2		
	Avg C/E	Unc	Avg C/E	Unc	Avg C/E	Unc	Avg C/E	Unc	
HCT	1.00503	0.00231	1.00184	0.00230	1.00282	0.00231	1.00202	0.00231	
HMF*	1.00090	0.00026	1.00016	0.00026	1.00026	0.00026	1.00000	0.00026	
HMI	0.99921	0.00042	1.00079	0.00042	0.99956	0.00042	0.99963	0.00042	
HSI	0.98602	0.00241	0.98728	0.00241	0.98966	0.00242	0.98952	0.00242	
HST	0.99822	0.00072	0.99847	0.00072	0.99948	0.00072	0.99915	0.00072	
IMF	1.00352	0.00082	1.00114	0.00081	1.00132	0.00081	1.00195	0.00082	
IST	1.00041	0.00077	1.00120	0.00077	1.00060	0.00077	1.00044	0.00077	
LCT	0.99962	0.00019	0.99912	0.00019	0.99874	0.00019	**0.99935**	**0.00019**	
LMT	1.00600	0.00158	1.00155	0.00157	1.00211	0.00157	1.00162	0.00157	
LST	0.99829	0.00083	0.99845	0.00083	0.99920	0.00083	0.99850	0.00083	Better
MCF	0.99887	0.00157	0.99797	0.00157	0.99989	0.00157	0.99786	0.00157	
MCT	0.99644	0.00058	0.99555	0.00058	0.99244	0.00058	**0.99611**	**0.00058**	
MST	0.99837	0.00158	0.99354	0.00157	0.99177	0.00157	**0.99616**	**0.00158**	
PMF	1.00003	0.00045	1.00011	0.00045	0.99978	0.00045	1.00015	0.00045	
PMM	1.00040	0.00108	1.00401	0.00108	1.00387	0.00108	1.00256	0.00108	
PST	1.00349	0.00051	0.99836	0.00051	0.99970	0.00051	**1.00302**	**0.00051**	Worse
UCT	1.00077	0.00141	0.99818	0.00140	1.00368	0.00141	1.00465	0.00141	
UMF	0.99853	0.00051	0.99860	0.00051	0.99874	0.00051	0.99899	0.00051	
USI	0.98273	0.00124	0.97945	0.00123	0.98761	0.00124	**0.98911**	**0.00124**	
USM	0.97987	0.00215	0.97546	0.00214	0.98411	0.00216	**0.98527**	**0.00216**	Different?
UST	1.00083	0.00052	0.99750	0.00052	1.00281	0.00053	**1.00340**	**0.00053**	

OAK RIDGE National Laboratory

Validation Progress with VALID Critical Experiments

In conclusion, there are large differences in thermal Pu systems with β2 (post-β2 nubar adjustment moves partially back towards β1 and ENDF/B-VIII.0). The new fluorine evaluation dramatically reduces the energy dependent trend in ORCEF UF_4/CF_2 experiments (the bias now negative, magnitude may be slightly smaller, impact on fluoride salt FHRs and MSRs). There was improvement on energy-dependent trends in LCT and ^{233}U and bias improvement for LCTs (still not as good as ENDF/B-VII.1).

Discussion Items:

- **QUESTION**:
  - (Roberto Capote) Did you consider the TSL for Fluorine (I.e., CF_2)? Because that will have an additional impact.
    - (BJ Marshall) That is correct, we do not have a TSL. I expect it would have an impact. Once I get a file I will incorporate it.
  - (Luiz Leal) Any impact in connection to the F cross section itself?
    - (BJ Marshall) We are closer to zero bias and have become flatter as well.

SCALE/MCNP testing of ENDF8.1 TSLs for graphite thermal reactor benchmarks

Speaker: Kemal Ramic (Oak Ridge National Lab)

Overview: ENDF 8.1 added porose graphite. Wanted to assess the impact of the graphite utilizing benchmarks. Only 3 benchmarks exist. (HTR-10, HTTR, PROTEUS). Differential measurements exist for graphite that show that crystalline graphite matches experiment, however different porosities of

graphite do not match the experiment (measurement talk regarding these findings will be shown on Friday). In graphite structure as inelastic xs goes up, k_{eff} goes down. Additionally, in pebbles, as inelastic xs goes up, k_{eff} also goes up. For HTTR, if inelastic goes up, k_{eff} also goes up for all cases. For HTR-10, in graphite structure SANS reflects neutrons back into core and k_{eff} goes up and vice versa for pebbles when looking at the impact of graphite TSLs on criticality. For Proteus the porous graphite seems to perform better but this is actually due to the packing structure in the different core configurations.

Discussion Items:

- **QUESTION**:
  - (TerraPower Oscar) Did you get any results where had one scattering library with pebbles and they were different
    - (Kemal) Yes, this is in all of these results.
  - (Jesse Holmes) What is the difference between the SANS models?
    - (Kemal) These are differences between modelling SANS but there needs to be more thorough investigation of cross section and k_{eff} impact from SANS.
  - (Jesse Holmes) What kind of measurements can you tell the difference between these models? Inelastic scattering or transmission?
    - (Kemal) Transmission works
  - (Mike Zerkle) Do the different SANS represent different grain sizes?
    - (Kemal) Yes

E8R1 Beta2 Testing in Studsvik's CASMO5 Lattice Physics Code

Speaker: Charles Wemple (Studsvik Scandpower Inc.)

Overview: Results were presented at mini-CSEWG. Trends seen in beta1 results continue with the beta2 results. Burnup calculations have been problematic. Large defect was seen in reactivity in burnup calculations in beta1 but has improved moving to beta2 for BWR and PWR configurations (dropping to within 200 pcm).

Discussion Items:

- **QUESTION**:
  - (Mike Zerkle) Is the best performance coming from b2?
    - (Wemple) What we are comparing as basis is E7R1 library with JENDL4.0 Pu, and everything else is compared against.
  - (Jesse Holmes) Just for verification, you saw a flat -200 pcm difference between 7.1 and 8.1 for the pcm?
    - (Chuck Wemple) Yes

Fast Criticality Benchmark Testing of ENDF/B-VIII.1 beta2

Speaker: Mark Cornock (AWE.Plc)

Overview: AWE has done b2 testing using MCNP and deterministic codes.

Criticality - Generally, there are very small changes from ENDF80 to beta2 (on average ~ 20 pcm) There is a small decrease in Criticality PMF1 Variants vs 8.0 (~10 pcm statistical uncertainty of MCNP calcs ~10 pcm). Beryllium Benchmarks are still misbehaving. There were changes seen in MMF7 (Be) for

beta1 removed for beta2. However, improvement in HMF66 (Be) with beta1 removed in beta2 (trend with reflector thickness also very different with beta2). Groupwise results are consistent with pointwise. No major issues with Fast Critical systems in Groupwise or Pointwise calculations.

Pulsed Sphere - ^{239}Pu, ^{235}U and Ta beta1 and beta2 are the same but different from 8.0. Lead includes new changes for beta2. High energy changes in ^{6}Li sphere introduced in beta1 removed in beta2, still some small differences between beta1 and beta2. Beta2 is slightly lower, the difference decreases with energy). There were changes in seen in MMF7 and HMF66 beta1 vs beta2 are not obvious in the Be sphere (some subtle difference seen at low energies?). It is in the very initial analysis stage but nothing stands out as show-stopping.

Discussion Items:

- **QUESTION**:
  - (Nate Gibson – *online*) Jezebel changes are due to tuning to r5 rather than older revisions. And there will be more Be explaining some of what you're seeing this afternoon!
    - (Mark Cornock) Great!
- **DISCUSSION**:
  - (Denise Neudecker) COMMENT On Li6, angular distributions were changed up to 8 MeV incident energy. It is in an energy range that pulsed spheres are sensitive to but critical systems really aren't.
    - (Mark Cornock) We would like to understand those changes as well.

Test results of ENDF/B.VIII.I.β2 in GNDS format

Speaker: Marie-Anne Descalle (LLNL)

Overview: The ENDF/B-VIII.x evaluations were processed with FUDGE 6.1.0 in GNDS 2.0 format. Cases with IMF22(Cu) reflectors and Pb show largest differences: Al, Du and U nat & W. Jezebel rev 5 simplified excellent agreement, PMF good agreement UMF overall improvement. IMF overall decrease in k_{eff}, overall poorer agreement when including IMF022 (Cu). For Cu, HMF shows better agreement while for IMF agreement is worse. For Pb, C/E improved. For LLNL pulsed spheres: Pb, Ta, ^{239}Pu show spectral changes, smaller effect seen for Cu and ^{235}U. ^{239}Pu improved; ^{235}U and Cu remained similar; Ta local improvement; Pb should be reviewed. C/E of U233-MET-FAST benchmarks were improved when using ENDF/B-VIII.1 beta2 compared to VIII.0 and VIII.1beta1. C/E of HEU and PU-MET-FAST did not show major changes using ENDF/B-VIII.1 beta2. C/E of IEU-MET-FAST benchmarks are lower and worse than those simulated with VIII.0 and VIII.1beta1. Changes seen were driven by reflector, mostly Pb, Cu and Be. The Be ENDF/B-VIII.1 beta2 results are improved compared to ENDF/B-VIII.1 beta1. The Cu ENDF/B-VIII.1 beta2 results are improved for HEU-MET-FAST cases, not for IEU-MET-FAST but unlikely to be related to the Cu evaluations. Pb ENDF/B-VIII.1 beta2 results are improved for 4 cases, the Pulsed sphere spectrum shows odd features.

Discussion Items:

- **ACTION**:
  - Review of Pb evaluation to resolve features present in LLNL pulsed sphere experiments.

- **QUESTION**:
  - (Yaron Danon) In lead 206 at 4 MeV, the lead keeps repeating which Peter addressed. Does Gustavo have the updated version?
    - (Gustavo) That is after beta2
  - (Mike Zerkle) Mark Cornock do you remember what IMF benchmark you used in your benchmark testing?
    - (Mark Cornock) Swedish reactor
- **DISCUSSION**:
  - (Andrej Trkov – *online*) Testing of e81b2 at IAEA/JSI for the Swedish benchmarks showed slightly worse results compared to e80, but within (or close to) the uncertainty band.
  - (Roberto Capote) There is a very big improvement on the IMF with ENDF 8. The copper data testing seems to be okay, but IMF22 should be double checked.
    - (Marie-Anne) That would be good.

Feedback on ENDF/B-VIII.1b2 on a selection of Benchmarks

Speaker: Oscar Cabellos

Overview: Processing was done in JANIS format, verification of nuclear data uncertainties in ICSBEP Benchmarks perturbation analysis was done using NDaST tool. ENDF/B-VIII.1b2 was translated into ACE format using NEA options. Using Mosteller's suite of 123 benchmarks**.** For shielding, FNS and OKTAVIAN is discussed for Cu, Mo, Ti, Co, W, Teflon, Al, Nb. Problems in Cu. There is good agreement in the WPNCS/BUC Phase-VII benchmark. No changes were seen when testing ND FPDH. Seems that there is still a burnup issue for applications in LWR – Depletion: Fuel Assembly–PWR17x17, 4.8w/o, 3.1w/o and 2.1w/o.

Discussion Items:

- **ACTION**:
  - Review needed for Gd effect on PST34
- **QUESTION**:
  - (Denise Neudecker) Should the thermal ^{233}U PFNS be revised for ENDF/B-IX.0?
    - (Mark Chadwick) I don't remember this changing
    - (Roberto Capote) Work was taken from IAEA and it is clear that this PFNS is different from ENDF/B for both ^{233}U and ^{239}Pu
    - (Mike Zerkle) The U233-COMP-THERM-001-003 (LWBR SB) benchmark is the best thermal spectrum ^{233}U benchmark available in the ICSBEP Handbook.
    - When you have high leakage, there is a big dependence on PFNS. However, the problem we are facing with thermal is not related to PFNS, it is related to something else.
    - (Mike Zerkle) that is one of the good ^{233}U benchmarks that we've got.
    - (Roberto Capote) That is clear, but the issue is coming only partially from PFNS. We know there is a problem with thermal, but we didn't have time to finish.
    - (Denise Neudecker to Roberto Capote) Did you change also nubar to agree? How does nubar thermal compare to thermal?
    - (Roberto Capote) Yes, I think so.

ENDF/B-VIII.1(beta2) testing for Fusion Applications: Impact of latest INDEN Cross sections in Fusion Applications and Update of the Fusion Evaluated Nuclear Data Library (FENDL)

Speaker: Tim Bohm (University of Wisconsin-Madison)

Overview: Important fusion neutronics responses include neutron flux, radiation damage/dpa and transmutation products, hydrogen/helium production, tritium production, radiation does, total nuclear heating and activation/shutdown dose. The goal of this work is to look at the neutronics impact of using the updated neutron libraries in a realistic model of fusion systems using MCNP with FENDL and ENDF libraries (all computational benchmarking). 1D Cylindrical Computational Benchmark models include the Fusion Nuclear Science Facility (FNSF), FNSF with a 2(LiF)-1(BeF2) blanket and ITER. Preliminary ^{56}Fe results show that for ITER neutron flux and total nuclear heating; results are close to each other for FENDL-3.2b and FENDL-3.2b+fe56e80X29r67. For FNSF neutron flux and total nuclear heating, FENDL-3.2b and FENDL-3.2b+fe56e80X29r67 are generally in good agreement with each other except deviation at OB LTshield. Good agreement was also observed for TBR, dpa and helium production. Results were also shown for ^{63,65}Cu and ^{19}F, where good agreement is seen with new Cu evaluations from the INDEN collaboration, but a processing error and missing MT numbers can cause discrepancies seen up to 15%. The FENDL library has many sublibraries and the Big paper will appear in nuclear data sheets (FENDL 3.2).

Middle of plot is plasma towards center is the inboard side, towards the edges is the outboard side.

Discussion Items:

- **QUESTION**:
  - (Mike Zerkle) At least we're seeing promising performance so far
  - (Yaron Danon) What does it mean if we don't agree with this library?
    - (Tim) All these results are compared to FENDL 2.1. We have not built any of these reactors, so we have no experimental validation. The only D-T fusion reactor (JET) has provided some experimental results.
    - (Yaron Danon) Do you know if these are good or bad contributions to this FENDL version?
    - (Tim) We don't have an exact answer.

Examination Beryllium Scattering using RPI Quasi-Differential Measurements with Current ENDF Evaluations

Speaker: Adam Daskalakis (Naval Nuclear Laboratory)

Overview: The RPI HESS was used as a validation measurement for Be evaluations at different scattering angles. Carbon is used as a reference sample and experiments are compared to MCNP simulations of the experiment. Comparisons between the experiment and evaluations is shown for Be at the forward and back angles. Beryllium total cross section at higher energy is higher than experiments and it seems that (n, 2n) reaction is being double counted.

In conclusion, data was collected at the RPI LINAC HES system and used to compare ENDF-8.0 to b2. Discrepancies were observed at several energies and angles (forward detectors – below 1 MeV,

NOTE: Due to technically difficulties Tim Trumbull presented the first half of the talk.

Discussion Items:

- **QUESTION**:
  - (Allan Carlson) These are large samples of beryllium. How did you determine flux shape and efficiencies?
    - (Adam) The flux shape and detector efficiencies were determined from other measurements. The source term is independent from the graphite.
- **DISCUSSION**:
  - (Mark Chadwick) thanks for finding these issues - found a problem in the file that will be discussed later by Mark Paris

ENDF/B-VIII.1 Testing for Pb Libraries

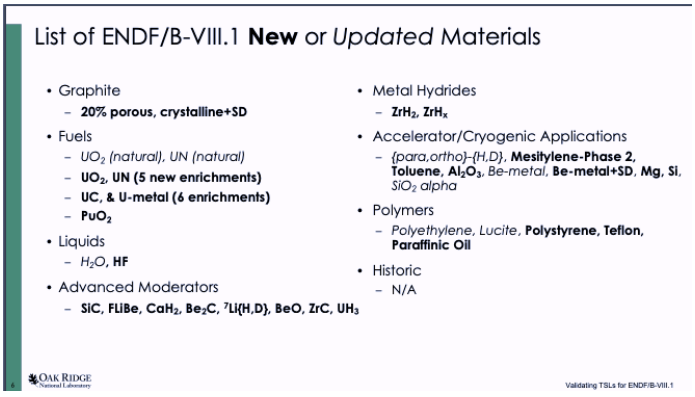
Speaker: Peter Brain (RPI)

Overview: This talk was not presented.

ORNL TSL Valiation for ENDF/B-VIII.1

Speaker: Chris Chapman (Oak Ridge National Laboratory)

Overview: Is there well defined publicly available data to validate TSL files? Cross section measurements including double differential scattering and total cross section as well as validation measurements including integral and PNDA measurements. There are many new materials for the latest ENDF release (list below) – 70 materials over 112 ENDF files. There is currently no mechanism to combine TSLs and resonances so a choice of one or another needs to be made for some materials. Moving forward, it may be useful to force requirements of providing DFT/MD input files for extra validation of materials or need for experiment.



	Cross Section Measurement	No Cross Section Measurement
Benchmark	UO2 & U-metal Light water, ZrH_2, ZrH_x, graphite, BeO, polyethylene Lucite, polystyrene, Be-metal, paraffinic oil, Teflon, SiO_2	PuO_2 HF, UH_3
No Benchmark	UC, UN CaH_2 Mesitylene – Phase II, Toluene, Si, Mg, {para,ortho}-{H,D}, Al_2O_3	 FLiBe, Be_2C, SiC, ZrC ^7LiD, ^7LiH

Discussion Items:

- **ACTION**:
  - Discuss if we can get access to proprietary or classified data sets to validate TSLs?
- **QUESTION**:
  - (Dave Brown) Out of 15 sublibraries, only the neutron sublibraries have any serious validation, and 13.5 libraries have zero validation. The test coverage is garbage. We have a possible solution for this sublibrary, so don't remove just because there's no validation currently.
    - (Allan Carlson) Validation is needed for criticality applications but may not be needed in other sublibraries. It should be up to the community to decide whether tests are needed.
    - (Mike Zerkle) We are developing capabilities to perform validation measurements including subthermal transmission and PNDA.
    - (Chapman) Outstanding physics-based issues I would like answered, the impact from this is 10s of pcms or less.
- **DISCUSSION**:
  - (Yaron Danon) I think in the ENDF community, all XS go under some validation should have a comment on the file... something like "*Provided with no validation*"
    - (Chris Chapman) Yes that is a good suggestion. It could be provided in the header.

Zirconium Hydride TSL Validation

Speaker: Ingrid Švajger

Overview:

JSI and NNL evaluations predict small dependence on the crystal structure of ZrH, but the results for reactivity prediction differ. XJTU evaluations for the two phases produce different results: those for the δ-phase agree with JSI, while those for the ε-phase agree with NNL. NNL evaluations and the XJTU evaluation for the ε-phase produce results very similar to the older TSL evaluations from ENDF/B-VIII.0. Overall, the JSI evaluations tend to decrease the spread in the results, but the discrepancies are still rather large and require a more detailed investigation.

Discussion Items:

- **QUESTION**:

- (Mike Zerkle) For the NNL evaluation how is Zr being treated – is it free gas or bound Zr? You should not be using free gas approximation for Zr with the NNL evaluations
  - (Ingrid) We used the hydrogen TSL only, did not use the zirconium.
  - (Andrej Trkov) We were focusing on the hydrogen and did not use the zirconium, but I do agree we should use the zirconium as well.

Evaluation Committee

Chair: Mark Chadwick (LANL)
Date: Thursday, November 16, 2023

Actinide evaluations below 100 keV toward ENDF/B-8.1

Speaker: Roberto Capote (IAEA NDS)

Overview: It is important to get good criticality performance and this performance is driven by fission cross-section fluctuations in the URR. ^{235}U and ^{239}Pu were changed to better match fission experimental data in the URR. Changes have been also made at the thermal point and the ^{235}U thermal cross section is in excellent agreement with experimental data. Relative to RPI capture data, the capture yield in ENDF8 was overestimated by almost 10% in some energy regions. Changes in ^{235}U nubar were made below 100 keV.

An underprediction of reactivity as a function of burnup at high burnup in ENDF/B-VIII.0 is noticeable in comparisons with power plant data and prevents ENDF8 from being endorsed for LWR simulations. For ENDF8.0, the ^{238}U RRR was replaced by JENDL5 RRR evaluation and this preserves the BOC criticality but eliminates higher depletion at high burnup and this is due to higher capture seen above 100 eV. Convergence is observed between JEFF and INDEN evaluations for ^{238}U nubar. These changes were validated on LCT-006 and results are in excellent agreement with ENDF7.1 evaluation (which historically performed well). New ^{239}Pu resonance parameters were adopted in ENDF/B-VIII.0 but new thermal PFNS recommended by IAEA was not adopted. INDEN pu239e81nu1 is a new solution that can improve criticality in thermal only benchmarks. ^{233}U improvements are needed, there are also new other evaluations from INDEN to ENDFb2. ^{16}O improvement in the evaluated total XS from 5 to 8 MeV is needed to improve description of differential and integral data.

Discussion Items:

- **ACTION**:
  - There needs to be increased collaboration between evaluators and reactor physicists.
- **QUESTION**:
  - (Denise Neudecker) The recommendation by evaluators for ^{238}U nu-bar in the fast range was not to adopt new evaluated nu-bar fast data yet because it was unclear what experiment to follow (2% difference). Therefore, I recommend leaving ^{238}U and E8.0 there. Also, new experiments are coming soon to nail down with 9.0. Regarding the ^{233}U covariance processing, the evaluated uncertainties are slightly below californium standard. You should take a second look to see if it is correct.
    - (Roberto) Yes thanks we haven't even looked at ^{233}U covariances.
    - (Roberto) We have changed the U238 nubar to be in better agreement with measured data (similar to JENDL-5).

ORNL contribution to ENDF/B-VIII.1 release

Speaker: Marco Pigni (ORNL)

Overview: ORNL has contributed to ENDF8b2 with a ^{239}Pu update by extending RRR from 2.5 keV to 5 keV. Capture widths were averaged in that energy region since there was no data available, but transmission measurements were fit from Harvey. Negative levels need to be played with to improve performance of the MISTRAL benchmarks. A compromise was made between performance in critical systems and depletion calculations since shifting the energy of the 0.3 eV resonance improves criticality but is inconsistent data. We need verification experiments in ^{239}Pu for this resonance.

For ^{235}U, the performance of criticality benchmarks is preserved. Capture data from RPI (2017) was used to fit capture and fission channels, which does not impact depletion calculations. ENDF8.0 matches some parts of the experiment and doesn't fit other parts very well. Another evaluation was done on Si, revised the scattering radius and direct capture (see ORNL internal report). Improvements of 800 pcm seen in some critical systems.

^{88}Sr evaluation was from Koehler also has a report.

Looking to achieve performance with ^{233}U but adopting an external function of ^{233}U coupling with OMP will be considered.

Covariance method for cerium was also done (look at Chris Chapman report), looking for feedback from Denise.

Copper is also an open item to look into (specifically Legendre polynomials was considered).

^{235}U and ^{239}Pu isotopes are converging to a stable configuration with an overall satisfactory benchmark performance. **Strontium evaluation was included in repository and has been tested by processing codes and cerium covariance matrices are being updated to address review comments and the magnitudes of the uncertainties.**

Discussion Items:

- **ACTION**:
  - Verification experiment for the energy of the 0.3 eV ^{239}Pu resonance.
- **QUESTION**:
  - (Mark Chadwick) On copper you're thinking of this long term?
    - (Marco) We already have extended this task in NCSP
  - (Hye Young Lee) Did you improve the pcm for thermal or fast regions?
    - (Roberto Capote) There is a difference observed in Si the direct capture component. The thermal point was changed in Si
    - (Mark Chadwick) was there motivation for your question?
    - (Hye Young Lee) I have dataset of Si, and I'm moving setup to Lujan center to address thermal
  - (Denise Neudecker) You showed plutonium data and compared to Weston data. You both seemed to trust them, and it looked like your evaluation was going up into URR
    - (Marco Pigni) I'm showing results up to only 5 keV, Roberto did lower energies. Also, this was not used for beta1.

Evaluation updated for ^{9}Be and Charged Particles

Speaker: Mark Paris (LANL T-2)

Overview: For the n+^{9}Be evaluation, R-matrix is used. This increased elastic distributions, introduced new channels (scattering and capture) and the upper energies in the R-matrix evaluation increased.

(Stuff hit the fan when) Yaron Danon pointed out a MT1 issue that revealed inconsistencies between MT24 (n,2nα)+MT52(n,n1) and MT1 & MT2. Possible solutions include removing MT52 information (addresses Be pulsed sphere problem at high energy) which would be done for the ENDF-9.0 release.

Discussion Items:

- **QUESTION**:
  - (Mark Chadwick) This file with the new capture exists and will be available for testing?
    - (Mark Paris) That is right. It can be made available within an hour.
  - (Roberto Capote) How does new capture compare to old capture?
    - (Mark Paris) good question. The old capture does not have of resonance above 100keV, it goes through thermal and goes flat, there is no strength.
    - (Roberto Capote) Generally capture is very important to criticality, so your criticality is going to be lower.
    - (Mark Paris) Thermal doesn't change
- **DISCUSSION**:
  - (Denise Neudecker) You've been busy fixing the file, and the key is in resonance region. It's worth taking a second look.
    - (Mark Paris) Your concerned in the total?
    - (Denise Neudecker) In total there is uncertainty that is 0.2%. If you could take a look at it together.
    - (Mark Paris) oh this small uncertainty. Sure.
  - (Mark Chadwick) If we could look at that angular uncertainty again, that back angle is better than the latest.
    - (Mark Paris) I think there are cases where you have 8.1 performing worse at back angles but some cases where it is better, especially at high energies
    - (Mark Chadwick) one thing that would help is a balance especially with energies in fast region (5 MeV) if you had a measure to show which one is better.
    - (Mark Paris) Chi-squared has something in that energy.
    - (Roberto Capote) This type of difference is relevant to for the RPI quasidifferential experiments, which are very sensitive. In general, you will see back angles, and what is a good choice and what is a bad choice.
    - (Mark Paris) Yes, we did see that in an earlier talk. Thank You.

Nuclear Astrophysics Testing of the ENDF/B-VIII.1b2 Library

Speaker: Boris Pritychenko (NNDC, BNL)

Overview: Overall, the ENDF/B-VIII.1b2 library has great astrophysical potential. For thermal neutron XS, the perfect agreement between two or more ENDF libraries indicates that evaluated nuclear data libraries adopted the same evaluation for a particular target nucleus. The large disagreement of theoretical ^{240}U capture cross sections between ENDF/B-VIII.1 and JENDL-5 libraries is noticeable (factor 50 for capture). The similar situation was observed between calculated and measured capture cross section in ^{88}Zr (5 orders of magnitude). Recent measurement confirms large thermal cross section in ^{88}Zr but disagrees on resonance integral (LECM 2023). These cases underline issues with theoretical

modeling at thermal energies when no experimental resonance data are available (R. Capote: R-matrix is not working without experimental data). Experimental research and EXFOR project are essential.

Westcott factors and resonance integrals for ENDF/B-VIII.1b2, JEFF-3.3, JENDL-5, BROND-3.1, and CENDL-3.2 libraries have been calculated and the analysis is in progress. Maxwellian-averaged XS are important for stellar nucleosynthesis applications. The ASTRAL database is used in the current work to compare calculated ENDF library MACS with astrophysical data. When comparing ASTRAL to ENDF, there is agreement in most cases but strong deviations in ^{13}C, ^{34}S, ^{36,38}Ar, and ^{196}Hg and minor deviations in ^{40}Ca, ^{64}Ni, ^{120}Te, and ^{126,129}Xe cases. The analysis of the EXFOR database shows that there are no experimental data for ^{36,38}Ar and ^{126}Xe above thermal region, and the observed differences are due to the previously-discussed issues with theoretical modeling. For ^{129}Xe and ^{196}Hg, ASTRAL results are based on single measurements and for ^{40}Ca, we need to consider three contradictory measurements and choices of ENDF and ASTRAL evaluators.

Discussion Items:

- **QUESTION**:
  - (Allan Carlson) Is your database being used by astrophysicists?
    - (Boris Pritychenko) Occasionally it is used, but only if it is published. And we are going to publish.
- **DISCUSSION**:
  - (Mark Chadwick) These comparisons only show improvements which is useful and good to add into our big paper.

Consistent evaluation of Pt chain of isotopes + Ta181 update

Speaker: Mike Herman (LANL)

Overview: There are 9 isotopes of Pt and 22 isomers. The evaluation concept was described with EMPIRE used to process the data. The evaluation is fully contained in the model input. A dedicated framework was developed to *simultaneously* evaluate all stable isotopes to compare with natural experimental data. There is a consistent set of model parameters for all isotopes and RR/URR was taken from VIII.0 (URR for self-shielding only). Fast neutron evaluations for 9 Pt isotopes merged with VIII.0 resonance region and were uploaded to NNDC Git repository (one glitch mentioned by Caleb – repeating Q-values). There was general improvement over VIII.0 mostly due to the superior optical model in the incident channel. There is consistent model parametrization across the whole chain of isotopes (with a single exception) and reproducibility of the evaluation has been demonstrated. Sensitivities for all 9 isotopes are calculated but covariances need to be done. The possibility of cross-reaction and cross-isotope correlations needs to be discussed. In Ta, there will be discrete gammas in the ENDF file and the (n, 2n) cross section was about 20-30% too high just above the threshold by changing the optical model parameters for the second (n, 2n) neutron.

Discussion Items:

- **ACTION**:
  - (Denise Neudecker – *online*) Yes, please, Mike, provide covariances 😊
  - (Mark Chadwick) I would like someone to create toy criticality test files for Pt
- **QUESTION**:

- (Nathan Gibson – *online*) Isn't ENDF/B-VIII.0 taken from TENDL? Is that a real resonance evaluation? What did JENDL-5 use?
  - (Gustavo Nobre) Mike is next to me, he's saying sometimes TENDL would take from other places like JENDL, but it's worth investigating
- (Marco Pigni) Does the change in Ta(n,2n) affect the inelastic channel?
  - (Mike) Yes, at 8 MeV
- (Hye Young Lee) Which isotope was discrepant?
  - (Mike) I fitted all of them but if I sum them the total is slightly lower by a factor of ~5%.
  - (Roberto Capote) For applications generally use natural platinum. Plotting natural capture is more useful than plotting each isotope. If you need it for reactor calculations, 5% will make a big difference
  - (Mike) Of course. I agree, but natural doesn't go into the file
  - (Mark Chadwick) We will wrap this up. Separate people should make toy criticality tests/files for Pt

LANL contributions to charged-particle evaluation

Speaker: Mark Paris (LANL T-2)

Overview: For charged-particle sublibraries, R-matrix formalism was discussed. Proposed additions/revisions to ENDF library were also presented. First, the tapes were all extended energy/better agreement with more data and covariances are planned. p-002_He_004.endf is ready and submitted to phase1. d-002_H_003.endf is being checked. d-002_He_003.endf was submitted. d-003_Li_006.endf is ready. n-003_Li_006.endf was submitted. t-002_He_004.endf is ready and submitted to phase1]. Testing is also sugessted using NJOY,IAEA/Dunford codes [checkr, stanef, fizcon, psyche, inter], ENDF > ACE (checkace [LANL ACE format checking tool] and mcnp6.1 pencil beam (d+3He only)) Finally, comparisons with ENDF/B-VII.1 (aka, "CP2011"), VIII.0 and LLNL Evaluated Charged Particle Library (ECPL-2018) should be done.

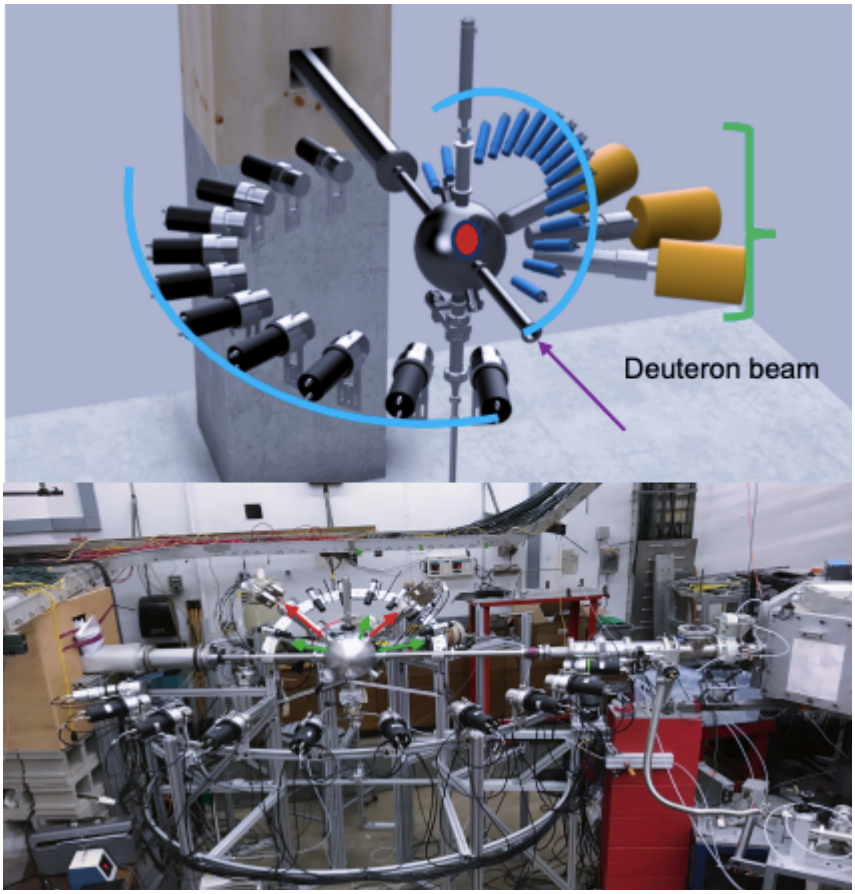
Discussion Items:

- **QUESTION**:
  - (Marco Pigni) When File 6 is generated from EDA are there any internal conversions or do you need to convert anything from EDA to File 6.
    - (Mark) Yes, so that is lRF7, KRL1 that is what we are still debugging.
    - (Marco Pigni) Is there a translation done in EDA?
    - (Mark) at the evaluation code in EDA, yes we calculate any of the observables with MF6 and fit them as part of the normalization procedure.
    - (Marco Pigni) I am interested in converting from resonance parameters to File 6
    - (Mark) There is an auxiliary code that does this.
    - (Marco Pigni) Is this fixed to EDA or can it be used for any set of resonance parameters.
    - (Mark) No it is not, it can be done with any set of resonance parameters.
    - (Mark) Yes, we have N4 and that converts it to Legendre coefficients.
- **RESOLVED**:
  - (p, alpha) and (t, alpha) have been submitted to phase 1 for He.

R-matrix Analysis of ^{8}Be System (including new ^{6}Li+d experimental data)

Speaker: Son Paneru (LANL)

Overview: Deuterium induced reactions on ^{6}Li are important for nuclear structure and nuclear astrophysics. ENDF/LANL includes only (d,n0) and (d,p0) partial cross sections. LLNL-2010 is consistent describing ^{6}Li(d,n0+1) but their ^{6}Li(d,p) calculation seems to be only ^{6}Li(d,p0). The inconsistencies in the R-matrix evaluations from literature demands new measurements and new R-matrix evaluation of 8Be system including more channels. Experiments were performed at University of Notre Dame using FN Tandem in collaboration with ORNL and LANL. Neutrons were detected by Deuterated Liquid Scintillator Array (ODeSA), charged particles were detected by silicon detectors and gammas were measured using 3 HpGe+GEANIE detectors. Experimental setup shown below. Preliminary results from R-matrix analysis of 8Be system with AZURE2 (open source code to fit charged particle systems) was compared with EDA calculations. We used AZURE2 parameters as a reference while updating EDA evaluations for 8Be system. Sensitivity studies were done for channel radius and background level dependence and an estimate of the uncertainty bands was done. Checks need to be made for overfitting to determine if the parameters are constrained by the data. Angular distribution data for ^{6}Li(d,n)^{7}Be from the new measurement will be added to the fits.



Discussion Items:

- **QUESTION**:

- (Boris Pritychenko) Anytime when you see problems in data, if data was taken in US or Canada or Western Europe pass it to Boris
- (Allan Carlson) Did you try any tests using the exact same database for EDA for both?
  - (Son) In the future, yes. There are a lot of data sets missing.
  - (Allan Carlson) If you used the same database then the results would be comparable
  - (Mark Paris) What he means he is comparing different evaluations to the same data but not that the evaluations are fit to the same data.
- (Gustavo Nobre) you shared data for some reactions. Is your expectation for this for 8.1 or 9.0? No Christmas miracles!
  - (Son) 9.0

Overview on (a,n) reaction measurements on light nuclei

Speaker: Hye Young Lee (LANL)

Overview: Long counters were used for measurement, lacking neutron energy details 2. Differential/total cross-section data are limited, with some reactions measured only below 2 MeV and no comprehensive coverage across a broad energy range 3. Limited angular distribution measurements for complete analyses 4. Underestimations in uncertainties, particularly from branching ratio implementations for secondary gamma-ray measurements 5. Energy-dependent neutron efficiency contributes to overall normalizations from populated different final states and angular distributions 6. Some final states are closely spaced, necessitating high-resolution spectroscopy data and improved signal-to-background ratios. Multi-channel R-matrix analysis on the 8Be system constrained the discrepant normalization (due to identical particles) among data sets and different calculations, based on the simultaneous fitting of other reaction channels.

There are planned experiments on (a,n) reactions at Ea = 2 – 9 MeV using FN and 5U accelerators at U. of Notre Dame. Target samples include ^{13}C (to test systematics – will focus on higher energy), ^{10}B, ^{11}B, ^{19}F (real goal of project, also most challenging), ^{7}Li. HPGe + neutron detectors will be used to obtain (n2,3,4) and more. For boron oxides, there may be background from O17,18. For F19(alpha, n), there are many narrow resonances, many excited states, and activation can be used for efficiency and normalization checks. Expected comprehensive self-consistent data will be shared with the community includes cross sections of total & partial channels, angular distributions of neutrons, gammas, and charged particles, secondary gamma-ray yields, neutron spectra, multi-channel R-matrix analyses with all measured channels for ENDF evaluators, and an impact assessment using Source4C, MCNP, and Geant4.

Discussion Items:

- **QUESTION**:
  - (Allan Carlson) I am concerned about producing the ^{13}C target- can you make absolute measurements? This is very interesting since making targets of ^{7}Li for determining the boron standard (by reciprocity with ^{7}Li(a,n)) have problems with making targets.)
    - (Hye Young) Yes with activation.
    - (Hye Young) air-free transport method but it can be improved. We are aware of the difficulty

- (Mark Chadwick) nice to see collaboration between the labs. Can we get old Van de Graff going, or is it old and locked up? Do you discuss this at all in your group?
  - (Hye Young) You know better than I do that is exists. I don't know the cost to restore it, but if we need to, we can.
  - (Mark Chadwick) with charged particle beams, Van de Graaf can be important
  - (Yaron Danon) We made samples using charged particle reactions and measured them in the lead slowing down spectrometers. This is a good idea!
  - (Hye Young) I invite all help – Ben Hayes and you, Yaron.
- (Roberto Capote) The region of the (n, 3), (n,4) we see differences and discrepancies because of a lack of data.
  - (Hye Young) Exactly that is the goal to provide better (n,1), (n,2), (n,3) and (n,4).
- (Mike Zerkle) When should we expect the first files for ENDF testing?
  - (Hye Young) The test file could come out in middle of project, going to be a few years.
  - (Mike Zerkle) we have (alpha, n) capabilities that could be used to test when they have data.
  - (Mike Zerkle) Sealed source measurements would be interesting as well
  - (Hye Young) This is going to be at ND, but we can think about it.
- (Mark Paris) Charged particle detection in coincidence?
  - (Hye Young) yes, we have it but only at 2 angles.

INDEN for light elements and meeting and preliminary results on ^{19}F(a,n) reaction

Speaker: Paraskevi Dimitriou (International Atomic Energy Agency)

Overview: Vivian could not present this talk but it is posted on indico for reference (https://indico.bnl.gov/event/18701/contributions/82738/)

R-matrix analyses for light elements with the SAMMY code towards the foundation of the charged-particle libraries

Speaker: Marco Pigni (ORNL)

Overview: New updates to the SAMMY code. It was originally designed to work on neutron induced reaction but for light nuclei we need more incident channels. Internal conversion of resonance parameters is done by SAMMY based on kinematics according to the dataset that was desired to be fit by SAMMY. This feature is not yet released but has been tested extensively. Be7 is being fit using SAMMY. Available data for fitting are mostly angular distributions or excitation functions for a fixed angle. Proton induced reactions were also fit using SAMMY for different data angles. Gamma emission for alpha induced reactions were fit using particle pairs for two primary gammas up to the first excited level. For light nuclei evaluations sometimes, a strong normalization is needed between different experiments, ideally an on-the-fly normalization for different experiments is desired and within the normalization factor correlations between the experiments are accounted for. However, it is not desired

to create correlations between experiments and models. This implementation is expected to be completed within the next fiscal year and should be an easy implementation. The delivery of the final evaluated data file is also important – the contents of this file are important and the best solution may be to couple file 6 and 3. Reviews were also completed for ENDF/B-VIII.1 library for He3+Li7.

Discussion Items:

- **ACTION**:
  - Updated SAMMY will be made available soon
  - Discuss adding (alpha, gamma) reaction data with Doro Wiarda
  - Work on better visualization of the library
- **QUESTION**:
  - (Mark Paris) Do you have an automated process to make the tables at the end?
    - (Marco) I still need to automate. I also need to rework the visual format I am not content with its current form.

LANL FPY Evaluation Report

Speaker: Amy Lovell (Los Alamos National Laboratory)

Overview: The evaluation methodology is described as a combination of experimental data and model calculations through a Kalman filter optimization. This includes new experimental data, including recent effort to measure short-lived FPY and energy-dependent values. BeoH is a LANL-developed, Hauser-Feshbach fission fragment decay code (PRC 103, 014615 (2021) and references therein). Updated experimental FPY data with most recent structure information and updated decay data (consistency between independent and cumulative FPY with decay data). Covariances are calculated consistently from the Kalman filter. R-values are not currently included in the fitting procedure but are instead being used for validation. Optimization techniques were also detailed, this is a work in progress but we are forming a complete energy evaluation instead of splitting between first, second, third fission so this increases optimization.

FPY evaluations are still under development. The new covariance format will be pushed to ENDF-8.1. In conclusion, independent and cumulative FPYs are being re-evaluated, with covariances, for 252Cf(sf), ^{235,238}U(n,f), and ^{239}Pu(n,f). Adjusting of BeoH pre-neutron emission mass distributions (input parametrization) is underway to account for stiffness in the model that currently doesn't consistently calculate important FPYs. Parameter and nuclear structure investigations are also in progress to better compare to isomeric ratios (discussions ongoing with LLNL, A. Tonchev and collaborators). We are continuing work on calculating R values from critical assemblies beyond R147. Preliminary calculations for ^{233,234,236}U have been performed.

Discussion Items:

- **QUESTION**:
  - (Hye Young Lee) 15 MeV data coming from...?
    - (Amy) This is a collection of all the available data. I did not label individually, but they are all from different groups.
    - (Mark Chadwick) Yes, if you look at thermal on the lefthand side there might be ten or more measurements to get the evaluation. We looked at all experimental data. It was an assessment on what we wanted to trust

- (Andrew Holcomb – *online*) cool stuff. I think they were trying to do something similar at CEA for JEFF. Have you been able to compare with them? Ask Daniela for a point of contact
  - (Amy) Yes we have been communicating with JEFF and JENDL but we have not done that comparison yet.
- (TerraPower) Did you fold these into delay neutron precursors groups and look at that?
  - (Amy) We have information for the 6 group structure of the delayed. I think they do relatively well. I can look again and we can chat
- (Roberto Capote) there are 5 or 6 recommended CFPY in IRDFF-II. It would be nice if you compare to them.
  - (Amy) I have the plots just didn't include them here
- (Mike Zerkle) incident energies for fission yields?
  - (Amy) Every 1 MeV and below 5 MeV every 500 keV
  - (Mike Zerkle) Great, we (the reactor community) will need to think about changes to our depletion methods to use the increased incident neutron energy detail in reactor calculations

LLNL Fission Evaluation Report

Speaker: Ramona Vogt

Overview: Symmetry restoration techniques from nuclear structure theory can be extended to predict initial conditions of fission fragments at the point of scission. Fission yields are related to the probability to populate scission configurations. For each scission configuration, particle number projection gives dispersion in Z and N (no need for Wahl systematics) angular momentum projection gives spin distribution of fission fragment (no adjustable parameter), and TDGCM gives probability of being populated. We computed the primary (pre-neutron emission) charge and mass distributions odd-mass fissioning nuclei by combining fission models and reaction theory description of the entrance channel. We are deploying a new Python framework called PESO (Potential Energy Surface Optimizer) to simplify, automatize and accelerate the determination of potential energy surfaces.

Discussion Items:

- **ACTION**:
  - **Nothing to do with the slides but we are collecting signatures for the LRP... APS Division of Nuclear Physics (DNP) please sign!! Link: https://engage.aps.org/discussion/show-your-support-of-the-2023-nsac-long-range-plan#bm7faeba70-7880-4aa2-8e34-e2a7e8e9d3fd**
    - **Last day to sign is today (11/16/2023)**
- **QUESTION**:
  - (Mark Chadwick) plot of the spin states. Is it real data? Distribution Monte-Carlo?
    - (Ramona) No, These are calculations. The line is an eye guide. Not sure on what the differences are driven by.
  - (Toshihiko Kawano) You showed even-even targets only... how about odd?
    - (Ramona) The odd targets were not included in this work, as it is ongoing

Summary of BNL activities for ENDF/B-VIII.1 FYSL Evaluation

Speaker: Andrea Mattera (BNL)

Overview: A correction was applied to all NFY and SFY files, at all energies. Changes have been reviewed and included in ENDF/B-VIII.1-beta1 BNL-220804-2021-INRE. The dCY in ENDF/B-VIII.0 reflects the uncertainty on the IYR (50%), but the dCYs of 90YGS and 90ZrGS do not depend on their isomeric yield ratios (the IS decay by IT to the GS), and the largest contribution is from decay of precursors. we also removed isomers for ^{109}Ru and ^{109}Rh, that were added in ENDF/B-VI.0, but not confirmed in measurements since. We fixed the 'hole' in masses 162-167, and adjusted discontinuities in the yields at masses 67-71. Heavy/Light peak sums slightly worsen but are still an order of magnitude lower than differences accepted in other fissioning systems. A technical report will be coming soon to document the changes made.

Discussion Items:

- **QUESTION**:
  - (Mark Chadwick) when you say rescale, what do you mean?
    - (Andrea) We reassign/replace/repair the yields that were supposed to be there. No experimental data so not complicated. Since we changed the yield of some of the FP, we had to renormalize.
    - (Andrea) Submitted to b2
  - (Toshihiko Kawano) can be a very complicated issue... You also updated decay data. This is the first time we have FPY and decay data which are consistent with one another

Liquid hydrogen and deuterium evaluations

Speaker: Douglas Di Julio (European Spallation Source ERIC)

Overview: These materials are used for the production of cold neutrons of (2-20 Angstroms) via spallation of GeV protons. Evaluations are available at 20k and validated against data measured in 1970 by Seiffert and there are known issues within the community. New measurements were done in 2015 by KB Grammar and deviated from older measurements – not explained by temperature differences in the measurements. A different way to calculate the distinct term in LEAPR is implemented in a custom version of NJOY. The new evaluation combines NJOY-H2D2 with path-integral molecular dynamics techniques (published DOI:10.1051/epjconf/202328417006). An updated evaluation shows good agreement with JEFF3.3 and experiments for para hydrogen and ortho deuterium. This new evaluation is under phase 1 review.

Discussion Items:

- **QUESTION**:
  - (Allan Carlson) Is it still true that early next year the ESS will start?
    - (Douglas) No, It will not be ready by early next year. We are still in the commissioning phase.
  - (Caleb Mattoon) I have some issues in File 7. It the intent to have log-lin interpolation for S?
    - (Douglas) Yes that is the intent. Is there something specific we can discuss offline?

    - (Gustavo Nobre) You modified NJOY to process your file. Have you interacted with Wim to make the needed changes to NJOY so that when the evaluation releases the result remains the same?
        - (Douglas) I have not discussed that with him, but we could be interested in doing that.
- **RESOLVED**:
    - JEFF-3.3 includes new, updated evaluation

Measurements Committee

Chair: Yaron Danon (RPI)
Date: Friday, November 17, 2023

R-Matrix analysis of Sm-149 + n in the resolved resonance region

Speaker: Thanos Stamatopoulos (Los Alamos National Laboratory)

Overview: Capture and transmission measurements of ^{149}Sm were performed with DANCE from 8 eV – 1 keV and DICER from 1 meV – 1 keV. There were also additional measurements of ^{147}Sm but there was a contaminant in the samples with a strong 3.4 eV resonance. The data and R-matrix analyses are complete. 163 resonances were resolved up to 521 eV with average uncertainties of about 3.5% and 4.8% for Γg and Γn, respectively. A new target was developed at the Lujan center at LANSCE for better flux in the energy region of interest. Resonance parameters and spins were assigned using SAMMY R-Matrix code, and corrections were applied to account for missed resonances that could not be resolved.

Discussion Items:

- **QUESTION**:
  - (Klaus Guber) Very nice measurement paper, do you know anything about the history of the samples and how they were treated?
    - (Thanos) I made the samples. It was powered I put in a vacuum and measured, after a month I re-measured again to check for any water absorption. There was no difference.
    - (Klaus Guber) How high in temperature did you go?
      - (Thanos) Didn't go as high to 1000 but I'd be surprised if there was issues with water.
  - (Nathan Gibson) Were uncertainties previously reported on the parameters that are changing by 400%? 400% changes with 3% new uncertainties seems pretty drastic!
    - (Yaron Danon) no time – discussion should be taken offline
  - (Jesse Brown) natural or isotopically enriched?
    - This is isotopically enriched
  - (Roberto Capote) provide the measured data so someone can repeat the evaluation
    - (Thanos) This is not an evaluation, it's an r-matrix analysis. Capture yield and transmission will be available in EXFOR when the results are published.
  - (Yaron Danon) Statistics at the end of the resonance? For J=4, how do you explain that you have more levels than the level spacing? Probably too many resonances
    - (Thanos) This line is not a fit of the data. If there is a resonance with a big neutron width

Update on New Cl-35(n,Z) Fast Reaction Measurements to Guide Data Evaluation

Speaker: Ken Hanselman

Overview: $^{35}Cl(n,p)^{35}S$ is dominant in fast-spectrum molten salt reactors (chloride salts = coolant). Previous evaluations did not have sufficient experimental data from 100 keV to 14 MeV, and many measurements have been added in addition to a new STATISTICAL part of the evaluation performed at LANL in conjunction (CoH3). The current working evaluation is a work in progress, and they are anticipating new data from Ohio, Berkeley, and U. Mass Lowell. There is in-house validation efforts using measurement and simulation of CLYC (Cs_2LiYCl_6:Ce) detector. Preliminary results show improvements and TerraPower is also working on validation. The end goal of this work is to have a final updated evaluation for TerraPower and future ENDF/B.

Discussion Items:

- **QUESTION**:
  - (Klaus Guber) There seems to be a dataset missing (Wagemans?), why is it missing?
    - (Ken) We are not focusing on that region right now... only 300 keV upward... less focus on the data but how we are stitching the data together
    - (Klaus Guber) Evaluations rely on measurements and you should include all measurements in your evaluations.
  - (Tom Bohm) chloride salts as a blanket for fusion applications? We would be interested in ^{37}Cl
    - (Ken) All the data show has been taken with enriched Chlorine 35. But we could.

Updates on (n,z) reactions on K-40, Ti-44, Al-26, and O-16 at LANSCE

Speaker: Sean Kuvin

Overview: Similar studies to the experimental setup as the previous talk. Isotope production, target fabrication and characterization was very important to this work and some target fabrication techniques have been developed. Directly measured (n,p) and (n,α) cross sections on ^{40}K (T1/2 = 1.3 Gy), calculations and reaction rates are being derived for astrophysical applications. Measurements on $^{26}Al(n,z)$, $^{44}Ti(n,z)$ and $^{16}O(n,a)$ are planned for 2024.

Discussion Items:

- **QUESTION**:
  - (Yaron Danon) like all this development – very promising!
    - (Sean) hopefully next time next year we will have preliminary results to show

LANSCE CoGNAC and Chi-Nu Experimental Updates

Speaker: Keegan Kelly (Los Alamos National Laboratory)

Overview: $^{238}U(n,f)$ PFNS results were published in PRC (DOI:10.1103/PhysRevC.108.024603) and delivered to D. Neudecker. ^{240}Pu results were delivered to D. Neudecker and A. Lovell and an iterative process to understand covariances is underway before the data is final. CoGNAC n-g approach to measure scattering (DOI:https://doi.org/10.1103/PhysRevC.108.014603, DOI:https://doi.org/10.1103/PhysRevC.104.064614) as each detector is a n and y detector, which are separated via PSD algorithms as well as kinematics (CLYC and EJ309 are both being used). Kinematic

patterns can be observed by plotting incoming and outgoing neutron energies. ^{56}Fe, ^{12}C, ^{28}Si and ^{16}O (most difficult) were measured using this method and preliminary results were presented. LANL/LLNL PFNS measurements have been completed – NCSP funded Pu240 data are delivered to ENDF evaluations. More results will be presented next year.

Discussion Items:

- **QUESTION**:
  - (Allan Carlson) You talked about Carbon scattering – how is the normalization completed and please be aware that carbon is only a standard up to a certain energy region. Up to 1.8 MeV you don't need to worry about other channels opening up.
    - (Keegan) for ^{12}C elastic scattering I'm aware of the level of belief. I want to make sure the results are final before commenting on it. The two channels that we extract are not the only contributions to the total so this will be informative but possibly not as interesting as you might want.
  - (Roberto Capote) question about ^{56}Fe, the data may miss some transitions but I think your data may support better the new evaluation.
    - (Keegan) resonance feature wise, we agree well for ^{56}Fe(n,n1'g). I would argue that Ramirez matches better in some regions. There is a neutron energy threshold that would require extrapolation.
    - The CLYC detectors have good gamma energy resolution, and it will allow us to pick out specific gamma rays.
  - (Denise Neudecker – *online*) Keegan, I assume nuclear data is used for unfolding? Is some of the nuclear data (and their uncertainties) limiting the precision / accuracy of your scattering experiment? Anything CSEWG could help with better nuclear data for your exp. Analysis?
- **DISCUSSION**:
  - Angular distributions for ^{56}Fe
  - ^{16}O(n,n'g) has three data sets that disagree

Capabilities of the University of Kentucky Accelerator Lab

Speaker: Jeffrey Vanhoy (US Naval Academy)

Overview: There is a lot happening in the university of Kentucky, including some staffing issues. A new lab director has been chosen at Kentucky (Erin Peters from the chemistry department), and opportunities exist for two postdoctoral positions. A digital DAQ system has been used for recent experiments, which expands capability but also increases time needed to reduce digital data. We are planning some scattering experiments with ^{13}C, ^{7}Li, ^{27}Al, ^{51}V, ^{19}F, ^{20X}Pb, ^{24}Mg, ^{9}Be. ^{13}C is being worked on, we've run into some difficulties but will get it. For ^{7}Li, there are discrepancies between IRMM/GELINA and UKAL measurements being investigated. ^{19}F(n,n'g) measurements from UKAL and GELINA both had problems. There are issues with using ^{51}V(n,n'g) as a normalization as well. We are looking to return to (n,n'gg) coincidence measurements. Various side projects were also discussed (see slides) including measurements at the LANL DANCE facility.

Discussion Items:

- **QUESTION**:
  - (Allan Carlson) ^{7}Li(n,n') is a reference cross section and it looks like there is a problem with it... are you looking into it?
    - (Jeff) Yes, we have the data, Danielle from MSU is looking into it. Its just better to measure neutron directly than perform the subtraction.
    - (Dave Brown) situation of UKAL: there is a mini-petition to sign for Kentucky's administration to encourage efforts to stabilize the director position. FRIB is also wanting the facility to stay so hopefully we can make an impact.
      - (Gerry Hale – online) Will those of us online get a chance to sign onto this UK petition/letter of support also?
      - (Dave Brown) I can email the word doc to anyone on line to sign & scan if you are interested - dbrown@bnl.gov
    - (Jeff) I have heard some people have called the dept. Head and shared their options. The accelerator is in the physics department.
  - (Denise Neudecker) how easy is it to get isotopic cadmium samples for some of these measurements? How high in energy will these measurements go?
    - (Jeff) For neutron we can use lithium (p,n) and get low energies. We can do protons on tritium, deuterium on deuterium, deuterium on tritium to get 14.2 MeV. I am not qualified to answer on the isotopes.
  - (Sally Hicks – *online*) The lab has been part of the Department of Physics and Astronomy Department for its history. Steve Yates had a joint appointment (CHEM and PHY), but is primarily considered a nuclear chemist. With Steve's retirement, the chemistry department has worked to provide a method to continue by reducing Erin Peter's teaching load to be the lab director for the interim.
- **RESOLUTION**:
  - The petition was submitted to the department chair before Thanksgiving. The chair, Dr. Plaster, thanked us and will use the petition to demonstrate that there is a large external (to UK) community who care deeply about the UKAL.

Overview of Nuclear Data Measurements at RPI

Speaker: Yaron Danon, Suk Singh, Katelyn Cook, Ben Wang, Alec Golas (Rensselaer Polytechnic Institute)

Overview: General overview of the graduate work being done currently at RPI. ^{54}Fe capture and transmission measurements have been completed and a re-evaluation is underway in the RRR using RPI and EXFOR data. Full data covariances will be made available with ^{54}Fe capture and transmission measurements and work is underway to quantify the effect on R-Matrix analysis. Work is being done using the RPI multiplicity detector to benchmark gamma cascade information. Additionally, the design of PNDA experiments is underway. Initial exploratory measurements show promising results. Initial testing presents results involving different geometries and temperatures that correlate with simulations. SESH is being integrated into SAMMY. Gradient of transmission does not incorporate correction factor dependence – matches previous evaluations. Fitting URR transmission in SAMMY will be pushed to public branch soon.

Discussion Items:

- **ACTION**:
  - Release ^{54}Fe data and covariances to EXFOR and publish measurement paper.
- **QUESTION:**
  - (Roberto Capote – about capture measurements) it was nice to not compare to the current ENDF data, but I'm assuming they do not do a very good job.
    - (Yaron) it was not explained in the talk but for the gamma spectra, the bottom curve shows the individual detectors (for a typical nonproliferation measurement that would only use one detector) and the top curve shows the total gamma energy deposition in all 16 detectors (coincidence data) so both types of measurements can be validated using this system. To answer your question, Unmodified MCNP does not do well on the total energy deposition because it does not model event-by-event coincidence events but the comparison to the individual detectors is better.
- **DISCUSSION**:
  - (Denise Neudecker – *online*) Just a comment (no need for a question): Great that we are getting a new Fe-54 RRR eval! Right now, we have no covariance in the RRR in beta2.
    - (Suk) Yes, Suk is working on experimental and evaluated covariances.
    - (Denise Neudecker) When would that evaluation be available? For IX.0?
    - (Suk) the evaluation should be ready for ENDF-9 (don't want to ruin Gustavo's Christmas 🙂)

RPI quasi-integral scattering for F and Ta

Speaker: Greg Siemers (RPI)

Overview: Ta and Teflon high energy scattering measurements were conducted using the RPI HES scattering system. The system was upgraded from an 8-bit digitizer to a Struck 10-bit SIS-3305 digitizer. The data were reduced to obtain preliminary comparisons to MCNP simulations and it is seen that for both Ta and F ENDF8.1b2 performs well when comparing to the preliminary quasi-differential scattering data obtained from RPI. Results obtained are still considered to be very preliminary and further work is underway to improve the pulse shape discrimination methods to see neutrons down to ~0.5 MeV.

Discussion Items:

- **QUESTION**:
  - (Mike Herman) Could you go back to the first Ta slide?
    - (Greg) The first slide is a slide with carbon measured in the Ta experiment.
    - (Mike Herman) – we are a bit high and lowering inelastic may help with criticality a bit.
      - For applications, there is more sensitivity for back scattering.
    - (Yaron Danon) If you raise it up it is more forward scattering.
  - (Roberto Capote) This is great, and F-19 needs more work. There is something that needs to be double checked to make sure that we understand the difference between the ENDF8.1b2 and INDEN (After CSWEG the problem was tracked down to the use of different versions of the INDEN evaluation in the comparison. E81b2 contains the latest and recommended INDEN version).

- (Gustavo Nobre) There are several versions of the INDEN evaluation – lets make sure we are consistent with our reporting
- (Roberto Capote) First carbon slide, why are there differences below 1 MeV, we really need to understand what is happening.
  - (Greg) We are very P.S.D sensitive below 1 MeV.

Nuclear Data Activities at UCB/LBNL

Speaker: Andrew Voyles (UC Berkeley / LBNL)

Overview: There are nuclear data needs for neutron inelastic scattering for different materials. Measurements are being done with the GENESIS array at UC Berkeley. Within the past year there are measurements to highlight including ^{12}C(n,n'g) which were done using 90 total hours of data. College of Engineering is providing $1 million over 5 years to expand the department under the nuclear technology initiative. DT-API generators allow for measurements that have not been completed previously (dpa measurements). Within the last year, nuclear medicine measurements have been conducted of proton induced reactions on different targets. Work has been done to play with modeling in TALYS to create good fits at high energy potential tails, with optical model changes along with other parameters. BEApR is also available – an online heavy charged particle database. Python libraries also exist to help process EGAF data.

Discussion Items:

- **DISCUSSION**:
  - (Yaron Danon) Great capabilities coming online soon!

Nuclear Graphite TSL Measurements

Speaker: Iyad Al-Qasir (Oak Ridge National Laboratory)

Overview: Nuclear graphite can be very different with different porosities, grain sizes, etc. G347A and PGA are two types of nuclear graphite. Phonon density of states were measured, there is a softening of the PDOSs if 20% and 30% porosity calculations of nuclear graphite. The phonon distributions show large differences between the modeling and the experiments. If 10% porosity of states is used, there is an overestimation that increases with higher temperature due to phonon excess in the lower energy region of the PDOS. When looking at Bragg edges, they are captured in both crystalline and nuclear graphite.

Discussion Items:

- **QUESTION**:
  - (Jonathan Wormald - *online*) The SANS cross sections is expected to be 1/E with the Porod model. Yet, the SANS calculations seem to show 1/v behavior expected for inelastic scattering. What SANS model are you using to compute cross section and how do you reconcile the discrepancy in cross section behavior?
    - (Iyad) Actually there are many models to calculate, these models are naive cause they assume porosity is spherical, we see
    - (Jonathan Wormald - *online*) -4 gives 1/E

Recent work on neutron standards

Speaker: Allan Carlson (NIST)

Overview: Almost all measurements are done relative to neutron standards – improvements to the standards improves ALL measurements made relative to the standards. Only the most recent work on neutron standards will be included. Due to time limitations, prompt γ-ray production reference cross section measurements (^{7}Li(n, n') and ^{48}Ti(n,n')) will not be discussed. Measurements on the hydrogen standard have been made by Jiang et al. Work on the ^{6}Li(n,t) standard was done by Anastasiou et al. through the ^{235}U(n,f)/^{6}Li(n,t) cross section ratio measurement. Preliminary results agree well with the standards evaluation and suggest a rise in the ratio above 1 MeV. Also work by Bai et al. has been made on that standard. Measurements on the boron standards have been made by Jiang et al. and Massey et al. Measurements on these light element standards can be used in R-matrix fits to improve the ^{6}Li(n,t) and boron standards where increases in the maximum neutron energy are needed. The most recent evaluation of the carbon standard by Hale was done by combining ^{12}C and ^{13}C R-matrix evaluations to obtain the elemental cross section that is the standard. That evaluation, the ENDF/B-VIII standards evaluation (the 2017 standard), is somewhat higher than the ENDF/B-VII standards evaluation (the 2006 standard). The difference is most noticeable at the highest energies. Recent Improvements in that evaluation by Hale show good agreement between the 2 evaluations. Plutonium and Uranium Fission Cross Section Measurements were also discussed (see slides). In particular the ^{239}Pu(n,f)/^{235}U(n,f) measurement by Snyder et al., though the normalization is not settled, appears as though it will agree well with the standards evaluation. To summarize, improved experimental work is necessary for all the standards (especially the boron and lithium standards so the upper energy bound can be increased). Additional work is needed for gold capture because it has some of the largest uncertainties for the standards. Extension of the hydrogen standard to about 150 MeV and possibly higher is underway by Hale and Paris (it currently goes to 20 MeV but there are cross section ratio data to much higher energies). Note that changes to a standard are not allowed for a given version but extensions are allowed. Further work needs to be done on unrecognized sources of uncertainty; specifically gaining an understanding of the energy dependence of it. Also more use of integral data for simple systems should be pursued. Finally, we need to consider improved evaluation techniques for the standard cross sections.

The Neutron Cross Section Standards

Reaction	Energy Range
H(n,n)	1 keV to 20 MeV
^{3}He(n,p)	0.0253 eV to 50 keV
^{6}Li(n,t)	0.0253 eV to 1 MeV
^{10}B(n,α)	0.0253 eV to 1 MeV
^{10}B(n,α$_1$γ)	0.0253 eV to 1 MeV
C(n,n)	10 eV to 1.8 MeV
Au(n,γ)	0.0253 eV, 0.2 to 2.5 MeV, 30 keV MACS
^{235}U(n,f)	0.0253 eV, 7.8-11 eV, 0.15 MeV to 200 MeV
^{238}U(n,f)	2 MeV to 200 MeV

Discussion Items:

- **QUESTION**:
  - (Roberto Capote) The results by Snyder that were presented were preliminary but are moving slightly lower, so I think they are within uncertainties with the evaluation now. When absolute measurement was done, it appears the normalization works out.
    - (Allan) Was more documentation by Snyder available? We might have agreement but we won't know until the normalization gets worked out.
  - (Yaron Danon) Is the C(n,n) the same as the total?
    - (Carlson) That is the total cross sections since capture is very small.
  - (Adam Daskalakis – *online*) The source that's being passed around, the underlying data, will that be collected into a common format or just final values?
    - When data are finalized they will be available as final values with uncertainties.

Status of the EXFOR project

Speaker: Boris Pritychenko (NNDC, BNL)

Overview: NNDC EXFOR compilation efforts are complex and well-organized by B. Pritychenko (BNL), O. Schwerer, S. Hlavac, O. Gritzay (Under contract with BNL), V. Zerkin (IAEA). The IAEA EXFOR compilation control system is a tool used for this effort. THe AIACHNE (AI/ML Informed cAlifornium CHi Nuclear data Experiment) Project was introduced (led by D. Neudecker). The goal of the project is "Designing Nuclear-data Measurements that Resolve Discrepancies in Existing Data." EXFOR modernization proposal was reported to NDAC. Modernization includes new data formats including JSON lightweight data interchange format for EXFOR is now in progress at the NNDC and IAEA-NDS. Additionally, implementation of uncertainty templates have been developed by Denise Neudecker et al. (LANL) for resolving issues with missing uncertainties and covariances. U.S. government funding issues may have a negative impact in FY 2024.

EXFOR	FY2022	FY2023
New Compilations	158	152
Updated Compilations	210	181
Preliminary Transmissions	29	19
Final Transmissions	31	22
Database Updates	41	40

Discussion Items:

- **QUESTION**:
  - (Yaron Danon) Is there a number that describes submissions you cannot compile due to issues with formatting?
    - (Boris) I will have it next year.
    - (Yaron Danon) if we can't compile, we can have it in different places.
  - (Roberto Capote) For the record, the IAEA is against any change that will affect the compilation process. The key of EXFOR is the capability to compile, and we have no tools to compile into a new format.
    - (Boris) Perfect is the enemy of good.
    - (Toshiko Kawano) The IAEA is not going to make any changes. But an update is requested from international users.
    - (Boris) not planning to destroy existing stuff
    - (Roberto Capote) The IAEA considers all stakeholder opinions. Then the network NRDC decides the best course of action. The IAEA advisory body - the INDC - makes suggestions.
  - (Allan Carlson) Why did we switch from Sigma to EXFOR
    - (Boris) In the 60s we had Sigma center storage. That was in journal format. In 1970s 4 major centers meet and standardized data format. To allow for data interchange between major labs. Other internal formats were abandoned and accepted EXFOR.

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