Brookhaven National Laboratory

Report # BNL-230125-2026-INRE

2025 CSEWG Meeting Minutes

6 - 9 January 2026

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

U.S. DEPARTMENT OF ENERGY

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Meeting presentations are available at https://indico.bnl.gov/event/29405/

Special Thanks

Meeting Organization

Cat Dunn (BNL)
Letty Krejci (BNL)

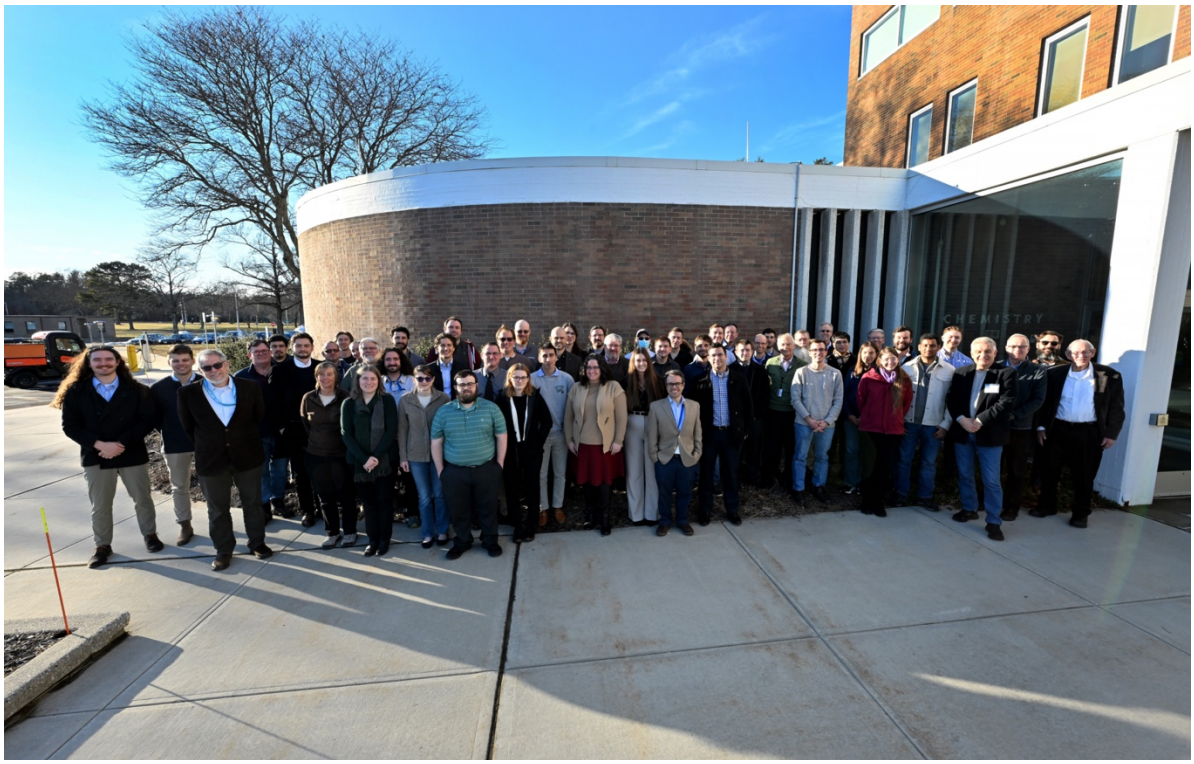
Meeting Rapporteurs

Julian Driebeek (RPI)
Alec Golas (RPI)
Ian Parker (RPI)
Ben Wang (RPI)

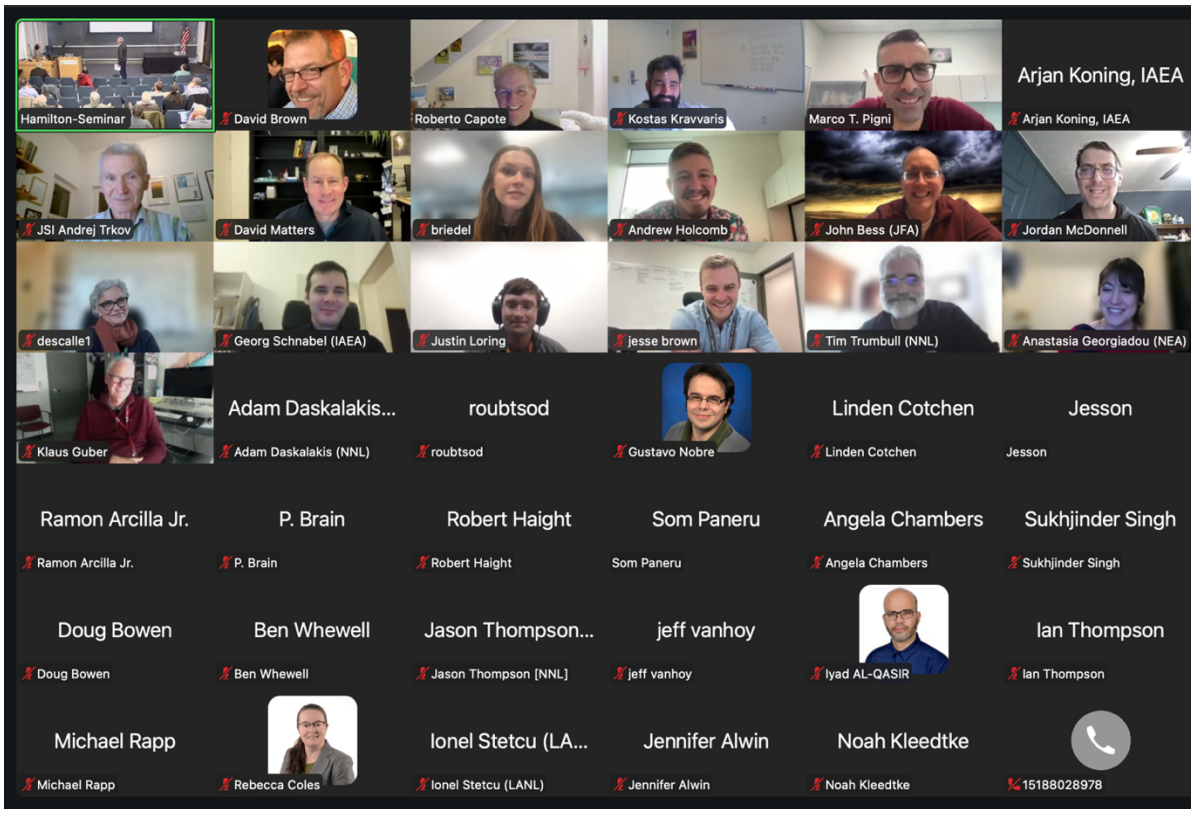
CSEWG Committee and Subcommittee Chairs

Evaluation: Mark Chadwick (LANL) and Roberto Capote (IAEA)
- FPY and Decay Evaluation Subcommittee: Toshihiko Kawano and Amy Lovell (LANL)
- TSL Evaluation Subcommittee: Ayman Hawari (TAMU)
- 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)



In person attendees of Nuclear Data Week 2025 (held in 2026!)



Remote attendees of Nuclear Data Week

Side Meetings

Both the Nuclear Data Advisory Group (NDAG), chaired by Mike Zerkle (NNL) and the Analytical Methods Working Group (AMWG), chaired by Jen Alwin (LANL) were held on the morning of Tuesday, January 6, 2025. Findings from both meetings were communicated to meeting attendees separately.

CSEWG Executive Committee Meeting

Chair: David Brown
Date: Thursday, January 8, 2025

Major changes to the Executive Committee:

- Amy becomes fission product chair.
- Chadwick to step down as evaluation chair and Roberto become the new evaluation chair.

If you want to join NNDC git repo let them know. Invitations may get stuck in spam filter.

Welcome Talks

Chair: David Brown
Date: Tuesday, January 6, 2025

Welcome

Speaker: David Brown, Alejandro Sonzogni

Overview: ENDF/B-VIII.1 is out! Work on the next ENDF (ENDF-B/IX) is underway. Note and be conscious of the rules set forth by CSEWG, including the multiple codes of conduct. Be kind and professional. Pre-order your lunch to make the amazing cafeteria staff happy.

Discussion Items: None.

CSEWG 101

Speaker: David Brown

Overview: Presented the history of CSEWG and the group that produces the ENDF/B Library. Reviewed sponsors, participating groups, and nuclear data pipeline. Introduced CSEWG leadership structure and those who are chairs on the executive committee. Introduced the new CSEWG membership agreement and CSEWG's first ever traceable membership list. Note that this is linked to BNL gitlab access, so renewal is needed every two years. For members who are on the executive committee or already have BNL gitlab access, it should be done via docusign. Members will be removed if they violate any of the listed codes of conduct, data distribution restrictions, or other limitations listed in the document.

Discussion Items:

- **QUESTION**: [D. Neudecker] – How does one get gitlab access in order to register for membership?
    - [D. Brown] Reach out to Gustavo Nobre (gnobre@bnl.gov) or David Brown (dbrown@bnl.gov). They will work with you to a) get the Docusign issued, b) establish a BNL visit (including cyber security training), and c) get you on gitlab.

ENDF Library Update

Speaker: Gustavo Nobre

Overview: The ENDF/B-VIII.1 library was released in 2024. The big paper is now released on preprint, available on arxiv, and is currently awaiting feedback responses from references. The revised manuscript has been submitted. There are now DOIs for each sub-library (Library DOI: https://doi.org/10.11578/endf/2571019). Lib81x was released and is now available on the LANL website.

ReGra Recap: Covered the Reactor Graphite workshop – over all the response was positive and the meeting was very productive! The meeting report is available at https://doi.org/10.2172/2998877.

An ENDF git repository-based data release system is being developed. Release distribution through gitlab was found to be a better system than the current OneDrive solution. The repository scheme gives full control of final release while also allowing everyone access to different phases of development. The purpose of repository scheme is to enhance the review process and make it more user friendly.

Encourage everyone to bring up with their program manager the importance of the review effort as an efficient and cost-effective way to improve the quality of the final product!

Beta1 release planned for the Spring. There won't be any changes to standards yet, so it'll be ENDF-B/VIII.2b1. Currently Looking for reviewers!

Discussion Items:

- **QUESTION**: [M. Pigni] – About Cl-35, mentioned Los Alamos, ORNL merged the file, in beginning of October to use and test process. Our point of contact checked the cross section. The covariance data still has open problems.
    - [G. Nobre] The ORNL branch has a file and we will merge it into phase1.

R-Matrix Meeting Announcement

Speaker: Marco Pigni

Overview: Workshop will be held **July 13-17, 2026.** Registration will open in February – Please spread the word!

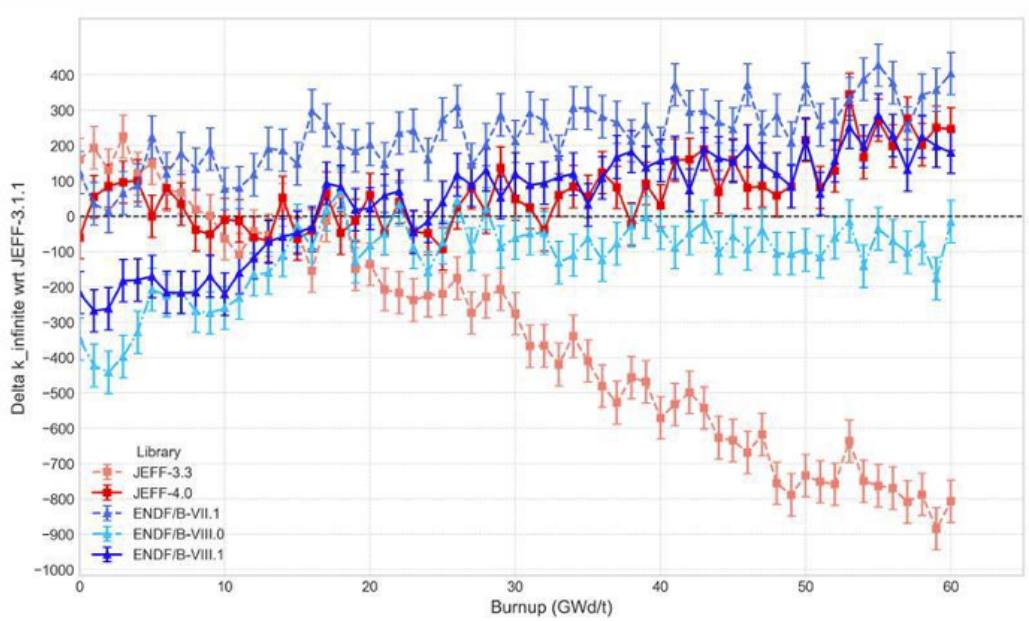
Discussion Items: None.

JEFF-4.0

Speaker: Antonio Jimenez-Carrascosa

Overview: Presented new library contents and examples of how the updated library performs. Introduced planned next steps and potential synergies between JEFF and ENDF development. JEFF-4.0 was released in June 2025, and included new data for neutron induced cross section, thermal fission yields, TSLs, proton transport, decay data, and induced particle cross-sections (TENDL). Data can be found on the NEA Data Bank (https://databank.io.oecd-nea.org/data/jeff/40/).

Benchmarking: criticality benchmarking 3191 shows clear improvement compared to JEFF-3.3. Similar performance to ENDF/B-VIII.1.



Beginning to use CI/CD infrastructure for JEFF library testing, allows for auto-generation of libraries in different formats.

Data available in multiple formats such as ACE file for multiple temperatures, PENDF 0K, GENDF, HD5.

Next steps: Work on GNDS translation of JEFF-4.0, include covariance testing and verification, compare JEFF with ENDF and JENDL in automatic way. Add more formats to meet the user community's needs. Main paper release. JEFF nuclear data week (13-17 April 2026). Stakeholders meeting in fall 2026. Synergies with ENDF/B-IX.0: New Cl evals, WPEC/SG-51 on URR, GNDS format conversion, INDEN collaboration.

Discussion Items:

- **QUESTION**: [D. Neudecker] – What format did you use for fission correlations?
  - [A. Jimenez-Carrascosa] Hot topic – GNDS translator crashes when using covariances – Regarding FY covariances, didn't check covariances – providing independent community FY correlations – working on a human readable format
  - [D. Neudecker] Covariance testing format is not fully developed – let's catchup on that
- **DISCUSSION**: [D. Neudecker] - Reach out to discuss testing for covariances, people have been making a program for testing the data and there are chances for collaboration.

Fission and Decay Data

Chair: Toshihiko Kawano (LANL), Amy Lovell (LANL)
Date: Tuesday, January 6, 2025

Update on the FY compilation effort at BNL

Speaker: Andrea Mattera

Overview: We created a new format to include data used to better represent fission yield experiments. Results in simpler data, modern database-ready format, can store additional information, keeps history of changes, etc.

Next steps will be updating old data to better match units. Old data sometimes doesn't include units, rendering it useless for this method. Significant cleanup of some FY data of major actinides.

Found case in which FY measured at same facility and stored in different energies, these energies were "dummies" to specify a region.

Data uploaded to NNDC database, developed FY dashboard which is now available.

Discussion Items: None

LANL FPY Summary

Speaker: Amy Lovell

Overview: Recent work on cumulative prompt and delayed fission product yield for minor actinides ($^{237, 238}$Np and $^{241, 242m, 234}$Am) and rigorous V&V for major actinides.
Significant amount of data for ^{237}Np (when compared to other minor actinides) can be included in optimization. Limited ^{238}Np experimental data to compare to, but model parameters can be constrained by ^{237}Np.

Most Am isotopes have limited experimental data, especially as a function of energy. They use ^{239}Pu(n,f) parameterizations to make predictions for FPYs on ^{241,242m,243}Am. Good agreement with available experimental data for average prompt neutron multiplicity. Less data available to compare to for delayed yield.

V&V efforts identified non-physical values in ENDF files which induced non-linearities
Working on updated optimization techniques to better take into account non-linearities
Covariance demonstrations and formats discussed in talk later in the week.

Discussion Items:

- **ACTION**: [A. Lovell] - Looking for friendly testers!
- **QUESTION**: [M. Zerkle] – You are putting more detail in product yields than historically seen. When will you have a test file so we can see if it breaks codes?

    - [A. Lovell] We have files that are complete, although they are preliminary results. We do want to get stuff out to community for testing and use in applications. These files with a finer energy grid hopefully won't break anything
    - [M. Zerkle] Let's hope the pieces hold together. Can we get a ^{235}U file just to start?
    - [A. Lovell] Absolutely!
- **QUESTION**: [C. Wemple] I'm curious about ^{238}Np, because we're making ^{238}Np in HFIR. So, it could possibly break our codes, but we don't know what we don't know?

Updating GEANIE Experimental Data by Evaluated Fission Product Yields, and Los Alamos CoH-based Evaluation (LACE) Framework

Speaker: Toshihiko Kawano – Given by Amy Lovell

Overview: Tested evaluated FPY data at higher energies, including evaluated energy-dependent data in the fast region, inelastic scattering measurements at Geel included discrepancies possibly from measurement of prompt fission gammas, progress of fission modeling at LANL with BeoH, and revisiting GEANIE ^{239}Pu(n, xn) data reported in 2002. Fission gamma-ray background production calculations using CoH3 and BeoH can model gamma-rays coming from fission fragments. Cross sections (n, n'/2n/3n) can be inferred by GEANIE/CoH by applying corrections to subtract fission fragment gammas. This is a preliminary method and may be able to be applied further.

Los Alamos CoH3-based Evaluation (LACE), production of all nuclear data using the CoH3 and BeoH codes (with external resonance files). Library will facilitate production of evaluated data files automatically and provide less-commonly used data (i.e. beta-delay gammas). Examples shown include ^{233}U fission energy, spectrum, multiplicity, and cumulative FPY.

LACE currently includes all U and PU isotopes.

Discussion Items: None.

LLNL FPY Modeling and Evaluation

Speaker: Ramona Vogt, Nicholas Schunck

Overview:

First optimized FREYA in 2019, currently working on new optimization. 5 physics-based parameters that need optimization. They directly affect fission observables. Simulated annealing employed for optimization. More data are available, and a genetic algorithm is used to improve optimization. Similar to evolution in nature, this involves crossover (exchanging materials between parents) and mutations. This method is independent of the initial guess. Checking new method based on n-n correlations on ^{252}Cf spontaneous fission. Other results cannot yet be used until published by their respective owners. I.e. No nu(A) for ^{240}Pu(sf), but there is for ^{252}Cf (sf). They are checking the effect of including n-n correlations on the ^{252}Cf (sf) fit to see if this biases the fit. Finalizing a paper on spontaneous fission results along with fits to thermal neutron induced fission

Continuation of LLNL report on fission activities. LLNL develops and applies fundamental nuclear theory to provide inputs to physics-based fission event models. Takes static nuclear properties, time-dependent dynamics, to predict actual observables. Code FETA - Fission evaluation tools and analytics, LLNL counterpart of CGMF. Validated vs CGMF. Utilizes time-dependent Hartree-Fock-Bogoliubov

(TDHFB) theory to compute real-time fission events through quantum mechanical time evolution of a fissioning system. Predicts both TKE and fragment excitation energy, and pre-liminary results and very promising. TDHFB faults to reproduce TKE and excitation energies outside the most likely fission, many parameters have been varied but nothing will solve the problem.

Works great for symmetry restoration and large amplitude collective motion to give spin distributions for all fission fragments. Microscopic spin distributions reproduce PFNS and PFGS.

Discussion Items:

- **QUESTION**: [D. Neudecker] - I saw you evaluated ^{240}Pu, do you have data from CEA and Chi-Nu?
  - [R. Vogt] CEA data not published yet, cannot use it – Chi-Nu data has much bigger error bars – not very helpful – have data from CEA
  - [D. Neudecker] - Do you have Maxwellian data/pot?
  - [R. Vogt] No.

Fission product yield data for basic physics research and applications

Speaker: Anton Tonchev

Overview: Collaborative effort between LLNL, LANL, and TUNL. Measurement of the fission process through long-lived (standard), short lived (jackrabbit), and very short-lived (RABITTS) methods. Measurements at Triangle Universities Nuclear Laboratory are performed with mono-energetic neutron beams, and result in a method where the neutron flux and cross section do not need to be known. Gamma-rays are directly measured; therefore, they interfere with the measurement. Recent publication in Nuclear Data Sheets (202, 12 2015) of 18 standard long-lived product yields.

Presented results for ^{235,238}U and ^{239}Pu, fission product yield as a function of energy for neutron induced fission as a function of energy. At higher energies all is consistent with theory but at lower energies discrepancy are found.

40 product yields at 8 energies for short lived (jackrabbits– ½ life mins to hours), 50 FPY for very-short lived (RABITTS- Rapid Belt-driven Irradiated Target Transfer System).
FPYs to support reactor anti-neutrino anomaly. Isomeric fission yield ratio different from expected. The metastable is lower than expected. The yield goes to the ground state.

Discussion Items:

- **DISCUSSION:** [A. Songonzi] - We thought that we know everything about fission yields. But apparently not, but if yields are 30% larger than an evaluation, then we don't know enough. So, we need more work and funding. So, a quick fix would be to switch most probable masses for some isotopes. But that would be a patch, clearly, we need to put more work in to improve it.
  - [A. Tonchev] - Indeed like your favorite ^{92}Rb, you show more than 30 percent higher compared to evaluation. That makes difference indeed as pointed out, 20 percent makes big impact on hardening of anti-neutrino spectrum.
  - [A. Songonzi] - And these are not thermal, so critical work moves into thermal point – the message to funding managers means that we don't know as much about yields as we though – we know stable and can do extrapolations – but we need a lot more funding to do experimental and experimental work – this is fantastic, incredible work.

- [A. Tonchev] - and just for comment checked isomeric from thermal to 2 MeV can compare to French work and are not much changed on isomeric ratios. Therefore, there is not a need to do measurements between thermal and 5 MeV.

Nuclide Inventory Sensitivity to a Fine Resolution of Fast-Energy Fission Product Yields

Speaker: Friederike Bostelmann, et al.

Overview: Libraries provide FPY for specific energy points but fission happens at other energies. Depletion codes may interpolate FPY differently. This work investigates the relative impact of FPY energy resolution on nuclide inventory predictions. Small test models of different reactor types simulated to investigate nuclide inventory. Use GEFY for fission yield library. 2 sets of calculations run, in one there were 4 energies, in the other thermal plus fine resolution between 10 keV and 30 MeV. Shows examples of different interpolation schemes used in SCALE/ORIGEN and Serpent, and how they can affect subsequent calculations. Additional FPY energy points are located in the fast energy range so are most relevant to fast reactor simulations. SERPENT shows larger difference between all yields and 4 energy simulations compared to SCALE.

Discussion Items:

- **ACTION**: [F. Bostelmann] Need additional FPY energy points in thermal and intermediate range, FPY interpolation based on appropriate weighting with fission reaction rate, and analysis of the impact of these interpolation schemes with respect to validation data.
- **QUESTION**: [M. Zerkle] - Slide 8/9. Slide 8 shows different spectrum for different reactors. There is a big hole but, could we get more energy detail?
  - [A. Lovell] - Would it be helpful to have more points even if the energy dependence doesn't change? Or would it be more helpful to know if there's structure
  - [M. Zerkle] A point every decade
  - [R. Bostelmann] - Right now if I use ORIGEN, I'd love more info in energy range of interest – Just based on the way that ORIGEN works, by just using adjacent points, it's not clear if interpolating something in fast range is good – improving code and interpolation, then additional points will be always valuable, assuming that's what you want.
  - [M. Zerkle] Sanity check with points every decade would be great for testing
  - [A. Lovell] Can put more points in lower and code can then be tested to see if every dependence or structure matter more
  - [R. Bostelmann] Agreed, could use code to make own fission yields but not in scope but if someone could generate data in all fission yield ranges. For thermal systems there is validation data that could increase sponsor interest.
  - [M. Pigli] – if we have more points there would show structure but we want to determine what is the best interpolation rules we should use.
  - [R. Bostselmann] Need someone with the time and funding
- **QUESTION**: [Unidentified person] - In the validation set that we have has anyone looked at void history to see burnup trends.
  - [R. Bostermann] - What I remember from validation reports we have not done any trending.
- **QUESTION:** [A. Trkov] - Wondering if your details of energy depend on yield are consistent with fast energy range compared to four group fission yield – wondering if difference is due to the fission yield or just evaluation? See slides 17/18.

- [A. Trkov] - Comparing details with different fission yields – you have Serpent which shows 4 energies and detailed energies. Are detailed fission yields consistent with principle from library?
- [A. Trkov] - Comparison of all of them vs 4 -
- [R. Bostelmann] - Still GEFY library, just picked out the 4 data points. Didn't use ENDF data, just GEFY.

Formats and Processing

Chair: Doro Wiarda (ORNL) and Mike Dunn (Spectra Tech.)
Date: Wednesday, January 7, 2025

Disallowing interpolation on the current fission product yield data

Speaker: Wim Haeck, Amanda Lewis

Overview: NJOY uses a variety of interpolation schema, but most evaluators recommend not interpolating at all when using FPY at energies not evaluated. A new flag was added in HEAD, with 0 not recommended interpolation, 1 recommends by the law described by another flag.

A GNDS format change is also necessary since no current interpolation attribute exists. Options exist, but one could add interpolation attribute to <Incident Energy> or have it become a XYs2d.

Discussion Items:

- **ACTION**: [A. Lewis] - If any previous evaluations are not effective energies representing a spectrum, please let Amanda/Wim know.
- **QUESTION**: [D Brown] - ENDF has flat interpolation scheme for histograms – more in spirit with fission yields?
    - [A. Lewis] – Not sure of that is because you have thermal, 1 MeV, or 5 MeV but that means that at lower energies you should be using the thermal, and you have no info about what is happening at for example 2 MeV.
- **QUESTION:** [D. Wiarda] – Interpolation is still needed in transport codes, right? what do you recommend? At least interpolation gives information.
    - [M. Zerkle] - Transport codes do use it, like fast reactors.
    - [A. Lewis] – should be applied when relevant
    - [W. Dawn] - Problem is how do you pick one, we cannot choose so we interpolate.
    - [A. Lewis] - I'm not sure what transport codes *should* do. The point is we've been miscommunicating what's going on. This will at least communicate intent
    - [W. Dawn] - Also to Rike's point yesterday, evaluators can't agree how to interpolate so its left to transport people to make their own choices.
- **QUESTION:** [C. Wemple] - We've got 4 energies for plutonium isotopes – we just choose an appropriate effective energy – we don't have true thermal or true fast, working in middle realm – trying to generalize fission change – things get twitchy when we need to handle alphas at some energy (1 kev, 1 Mev, etc).
    - [A. Lewis] – I think that new eval that LANL is going to put out will help with that a lot since they truly are interpolate-able. but the question is how to differentiate from older data.
    - [W. Marshall] – This should be the responsibility of the user. If it's not recommended or able to do something, then they should go figure it out. We need to give more information to users though. We have a great set of data at thermal

representative in which we have effective energy, then a set of data of all crits. Things like Big 10, Godiva, Jezebel, etc., weren't just being used for crits but used to determine spectra. The usual method used over years is to just pick one and say it's the most representative. That's not something you'll automate. We had initially assumed that histogram is better, but I worry about interpolations on this. When interpolating data, you end up removing its normalization. This is especially relevant with fission product data, where it won't be off by percents, but sometimes off by orders of magnitude. It would be bad if they tried yield sets, so it's important for checking how these sets are used.

- [A. Lewis] - Yeah that is a good point. Maybe we could currently support any sort of interpolation, so you put whatever you want into the flag. We might want to do different ones for different products and look into new case and see ones in which normalizations fail.
- [W. Marshall] - FP might be something where we have to put in interpolation scheme where we need a normalization applied- you won't get 100% and we'll need to apply factor.

Energy dependent fission yield covariance

Speaker: Wim Haeck, Amanda Lewis

Overview: Energy Dependent FPY covariance format needs to be addressed. JEFF-4 places the data in a CSV file, which is liked, and is considered better than ENDF format currently. For ENDF, File 8 holds FPY & uncertainty but can't hold covariance. It is the only non MF30 file that holds uncertainty. Some considerations to take into account: Backward compatibility with uncertainty from MF8, it is not a compact format, it does allow cross correlations between energies and MTs, and does hold incremental energy grouped covariance like in MF33.

At a later meeting, expect a proposal draft including to leave uncertainty in MF8 w/ point-wise structure, allowing linear interpolation on absolute uncertainty values, placing correlation only in MF38 in grouped structure – needed because it only wants correlation not full covariances, requires same list of nuclides in both for all energies and MTs. For the GNDS proposal, the FPY already holds covariances with single incremental energies.

A test/example has been constructed for ^{235}U with 3 energy groups. The file was large (144 Mb), which is on the scale of TSL files. This could be decreased by only storing limited sets of eigenvalues and eigenvectors or the covariances matrices, but this would make the evaluators choose how many are needed per evaluation. It could also be decreased by relaxing the requirements for the list of nuclides in MF8 and MF38 being the same. Also, backward compatibility needs to be implemented so that users are not guessing what the evaluators mean.

Discussion Items:

- **DISCUSSION:** [M. Dunn] - This is very reminiscent of when we had to deal with storing resonance parameters. Originally, they were very large, on the order of 1 GB. This will be useful to get feedback.
    - [C. Mattoon] - like idea of same list of products for each incremental energy, need to handle diff yield at each energy, would be able collapse to 2d array

- [A. Lewis] - Working on putting together sample file – hopefully will cut down the size.
- **QUESTION:** [D. Neudecker] - if too big, could go to eigenvalue decomposition?
  - [A. Lewis] - It's one potential solution if files are too big
- **QUESTION:** [D. Neudecker] - if values aren't correlated it won't buy you much – so are they strongly correlated?
  - [A. Lewis] Not exactly correlated – when you take full flat matrix, a lot of correlations along diagonal – with traditional Eigenvalue decomposition you get a lot of zeros – also forgot to say if subblock is all zeros, then it won't be included
- **DISCUSSION:** [D. Wiarda] - Don't want to have compact format, but without don't have compression and only have 2 digits, might be okay to have correlated matrix and only 2 digits, but not have the compact format had in MF32.
  - [M. Dunn] - One recommendation with MF32 is that we had a WPEC subgroup focused on its development. That helped refine a lot of things as format was developed
  - [D. Brown] - Covariance realization format would have same normalization issues but 10x as angular distribution in spectra, because it has to sum to two fission products, but we know from past experiences we know how painful it is in angular distributions, and now we are going to hit much bigger problems for many isotopes in complicated and interconnect of just mean values. I have no idea what to do but this should be mentioned.

Standardization of reaction identifiers for GNDS and linking to ENDF MT nomenclature.

Speaker: Wim Haeck, Amanda Lewis

Overview: Wrapped into previous talks.

Discussion Items: None.

TSL Format discussions

Speaker: Chris Chapman

Overview: Discussing the format for storing covariance data needs to be addressed. MF37/MT4 have incoherent, inelastic covariance S(α,β) data. There are options for storing two quantities, covariance of phonon density states (PDOS) bound scattering cross-sections OR covariance of S(α,β) bound scattering cross-section but does require an effective temperature. As of now, this will be left up to the evaluator to determine best implementation for each isotope – best practices for evaluator will hopefully be distributed or published in the future.

In current work, there is 1 temperature for MF37/MT4. The goal is arbitrary temperatures for MF37/MT2 & MF37/MT4. However, there are open questions. Temperature effects for incoherent elastic scattering are straightforward, coherent elastic scattering is possible, but has choices that need to be made, and incoherent elastic scattering is difficult and may rely on effective temperatures. Things left to-do include: MF37/MT2 1 temperature light water covariance work near completion and multi-

temperature work is ongoing. MF37/MT2 need to identify potential candidate materials, which is contingent on the aforementioned work.

Discussion Items: None.

Depletion Data (or the Lack Thereof) in ENDF Data Files

Speaker: Charles Wemple

Overview: Most fission product cross section data has not been re-evaluated in the past 100 years, many others have not been looked at since the 1980s, and some shorter-life ones still don't exist at all. There are some important branching reactions pairs that are missing from ENDF: ^{147}Pm (up too 500pcm impact on depletion), ^{126}Te, ^{134}Xe. These influence the top 50 absorbers, so the get good depletion chains we want additional branching chains for these three. We have to use TENDL since there is limited data. We think it would be better to have branching fractions instead of branching cross-sections.

In ENDF7.1, (n,4n) for ^{238}U got rolled into MT5. This is not a huge issue but for depletion calculations it means something goes missing. It is preferred not to have this occur.

Discussion Items:

- **QUESTION**: [M. Dunn] - Only part where format failed was MT5, so have a large need for data. Have you submitted a high priority for WPEC groups for these needs
  - [C. Wemple] - No and should, will get on that
  - [M. Dunn] DOE NE has been hard for getting data work funding, but may be a good place to request
- **QUESTION**: [D. Wiarda] - There are some JEFF data that could use, ORIGIN is implementing JEFF as ENDF data since there is more
  - [C. Wemple] - Yes and that is something we have not explored yet with JEFF 4.0
  - [D. Wiarda] - ORNL is using those
- **QUESTION:** [G. Arbanas] - Do you have any understanding about sensitivity to branching ratio, is it ranges, ratios, other?
  - [M. Dunn] Our concern is thermal reactors. We get what we can yet. Alot of branching rations are not significant until the keV range. A lot of this is not just a lack of data it also is an inconsistency in data where things are going. And I don't think NJOY can handle branching data.
  - [N. Gibson] - NJOY has some but little capability to handle 8/9/10, GROUPR will do some, but not much.
- **ACTION**: [D. Brown] - need to make trackers on neutron sub-library to fix some issues
  - [D. Wiarda] - Yeah that is where the JEFF data is.

Minor ENDF manual changes

Speaker: David Brown, Dorothea Wiarda, Gustavo Nobre

Overview: ENDF-"102" updates: Not many changes in the last year, and all happened on Sunday. Went through all open issues in tracker and tried to do what he could.

He merged some without permission, feel free to yell at him or send strongly worded emails (dbrown@bnl.gov).
Brief list of changes detailed below:

- MR 42 – incorrect URL replaced by corrected URL.
- Issue 161 – IREV reference updated, IREV version control since late 60's had not been updated in many years
- Issues 166/158 - related to sum rules in manual, fixed/clarified text and supporting tables

Open Issues:

- Issue 162 – tabulated phase shift KPS=1 description (proposed changes, however no one uses this), will only make format internally consistent
- Issue 155: Propose multiplying max number of data points allowed in MF=5
- Issue 136: Remove LTP=15 from section 6.2.7 - some weird options no one uses or understands, so he is recommending removing this. Also uses incorrect capitalization, which was fixed. See MR 47. LTP=12 & 15 are the same, recommend removing LTP=15.

Discussion Items:

- **ACTION**: Vote passes for Issue 162 to be merged.
- **ACTION:** Vote passes to increase Issue 155 (number of energy points) by 10x.
- **ACTION**: Vote passes to do MR 47
- **QUESTION**: [D. Wiarda] - Ignore what the max number of energy points is, but do we need a max?
    - [D. Brown] – there is in the format manual, and in some of the checking codes, so
    - [Y. Danon] – any code uses to process in advance?
    - [D. Brown] – not anymore, everyone has their own work around, no one uses for any memory management at this point
    - [N. Gibson] – This is also present in NJOY, but not used

File 32/File 33 covariance mixing

Speaker: Dorothea Wiarda, Jordan McDonnell, Marco Pigni

Overview: The new evaluation from Marco for n+^{35}Cl, now opens in RRR. This is difficult because File 32 has resonance parameters and LRF=7 allows more open channels than LRF=3 for covariances for 600, 601, and 800. File 33 has 600, 601, 602, and 603. The result is File 33 and File 32 are now separately processed, summed up for individual covariances by reaction or redundant cross-section. Problems then arise and will require future proposals for changes.

Propose manual to specify File 32 and File 33 to be generated for all explicit matrices before calculating File 33 as NC sections that specify sums. Easiest change will be format, and for example will need to calculate MT=103 as NC section up to energy range covered by MF32. Other possible solutions are possible, however have more redundancies due to specific isotopes being able to resolve into reaction channels, with or without covariances matching.

Discussion Items:

- **QUESTION**: [N. Gibson] - First to point out this is not first time seeing this issue – PUFF and NJOY were doing different processes with Ta and MF51 was having issues. The problem was

processing codes were not consistent. Do we actually have a format problem, or is it just processing codes?
    - [D. Wiarda] - Marco was especially annoyed by not putting it right in Cl.
    - [N. Gibson] - Not the 600 its the 103
    - [D. Wiarda] - I think we have a formatting/guidance problem in so far as we need to state in the manual. Not doing NC section, which is used when doing ^{235}U fission.
    - [M. Dunn] – lets propose an update to the manual that specifies the issue

Unifying the ENDF free text documentation formats

Speaker: David Brown

Overview: Took part in 1000 scientist AI jam. Basically sucked in by administration to play with ChatGPT. His goal was to clean up ENDF documentation, specifically it needs to be:

- Human Readable
- Capture look and feel of well written documentation
- Structured so it was machine readable
    - Deterministic formatting
    - Unified metadata
    - Bibliography
    - Written reaction/class of reactions, including descriptions and change log

However, there were a bunch of challenges. Random seed leads to lack of predictable results. This can be controlled in a desktop installation of an LLM, but not ChatGPT. Tried a variety of LLMs using prompt engineering, but did not work as expected. Open gitlab project to anyone who wants to work on writing AI prompts.

Ran into inconsistencies for ^{1}H, worked for deuterium and tritium, because they are small. Hydrogen was inconsistent, ^{3}He was okay, ^{4}He worked well, ^{16}O was too large and went poorly. Theorizes could not get past Li because of many comments. The solution proposed by ChatGPT was to chunk the prompt.

See project on: git.nndc.bnl.gov/endf/tools/doc-fixer.git

Discussion Items:

- **QUESTION**:[M. Dunn] Did you try it on GNDS?
    - [D. Brown] I tried feeding it ENDF directly and it went badly. But once I had it in GNDS, I could use documentation and this tree from LLNL with layout of the file structure. With the outline and tables, it can generate the documentation.
- **QUESTION**: [Y. Danon] - do you ask to move to predefined template or let it just go wild
    - [D. Brown] - I tell it to use restructured text – told it the structure of the metadata I provided it – other than the use restructured text, had to describe sections of what documentation should be – led to very long discussion regarding excitations that was not sorted out yet – still a work in progress – never tried it on anything other than a neutron file – not sure if other charged particle would work or if too much neutron specific language in prompt

- **QUESTION:** [D. Neudecker] - very interesting and two questions, can you automate this? As an eval, can we somehow have a template as to how we put this in with ChatGPT to make this more standardized?
    - [D. Brown]Hoping that we could get API access for automation – even without being able to automate can still autogenerate prompt – have additional set of scripts that check the file produced – automation was the original goal, but tweaks necessitate improvement, although leads to a style-guide that would be useful in general – the fact that it's restructured text means it's machine readable – revision history includes information about what's been changed – goal was primarily to make sure it's both machine and human readable – style-guide would provide this
    - [D. Wiarda] - could possibly add to manual as to this is how it should be structured and done?
- **DISCUSSION**: [G. Nobre] - Hopefully end up with a place where an LLM can use this with evaluators to check if their documentation is sufficient
    - [W. Marshall] -if we can't do oxygen, forget anything more complicated

NDEX

Speaker: Jason Thompson

Overview: NDEX enhancements completed, all nuclear data needed by MC21 and generated independently of NJOY. Reanalyzed previous/common assumptions and approaches – but does not include multigroup data.

Some issues that were identified:

- KERMA calculations – Processing codes choose how to handle situations differently and the evaluation assembly structure matters. Cases where MT=3 contains all secondary photons lose accuracy at low incident energy.
- Different approximations in how resonance integrals are calculated – Different mathematical assumptions are implemented in different processing codes and causes small inconsistencies in linear sigma vs linear sigma/E calculations. No recommendations on how to address but just wanted to be noted.
- Support for Blatt-Biedenharn formalisms – Have more structure than what in provided in File 4, excited to start seeing sensitivity of models to structure. Will not make changes in many critical benchmarks, but may have some impact in others

No significant progress was made on supporting GNDS.

Discussion Items:

- **QUESTION**:[A. Trkov] - Regarding the use of Blatt-Biedenharn distributions, angular distributions from ^{56}Fe are based on measured data – ones reproduced from measured data would be okay if measured distributions were produced from experimental data but that's not the case – your results may not be more accurate than what's present in the file
    - [J. Thompson] - That is fair, I am not suggestion to move all calcs to reconstructive distributions. We want to see the impact and verify it before production calculations.
    - [A. Trkov] - Trying to point out two sets of angular distributions are entirely inconsistent – it's not that it lacks details

- **QUESTION:** [R. Capote] - we expect any processing code to produce what the evaluator intended. .... IN some sense people for a long time relied on the choices made by NJOY... Regarding angular distributions, the intent of evaluators is to use measured data... as far as he knows there are no evaluations where the evaluators are recommending using reconstructed angular distributions
    - [J. Thompson] - There is a flag in evaluation file that says if data in MF2 can be used to reconstruct the data – some evaluations turn flag on – plot of iron is just an example, not necessarily to show that Blatt-Biedenharn reconstructed distributions is more correct – good to know that what's in evaluations is not necessarily just what's grounded, but instead that they're backed by experiment – looking to see if there is more theory backed by that structure, and to see what evaluations need in order to represent that structure more than current evaluations
    - [R. Capote] - In general I would disagree, I would say that it is not possible to tell what is the best and to say why things break down. Warning that many times the evaluator needs to be considered in terms of what they intended inside the evaluation.
    - [M. Zerkle] That's fair, but the idea of providing feedback to evaluations is the evaluator pipeline, there are some cases where there is a need for more information that Blatt-Biedenharn provides, not present in current evaluations

NJOY

Speaker: Wim Haeck, Amanda Lewis

Overview: NJOY2016 updates, Lib81 and ENDF81SaB, and modernization efforts.

Latest release in Feb 2025 (NJOY2016.78) - see git docs for full updates:

- Increased to 999 tapes
- Add message to signal malformed resonance data

Know of large number of user comments and some file size issues.

New Pt and ^{180m}Ta evals have over 1000 gammas each when outgoing, causing MCNP to crash when mode p – Look for update from LANL MCNP team. First evaluations with capture primary gammas in MF6, fine with MF6 format description, JENDL puts discrete primary gammas in MF6 with the binding energy, ENDF just puts emitted gammas.

An erratum for lib81x is bring produced

Format divergence needs to be addressed, no progress currently listed but will be addressed before the next release. Not a format proposal, but just a conversation starter. Could possibly change format to match JENDL -> Easier to go toward JENDL style or just make a flag and use two different formats and just add in documentation. May not be best to have divergence.

Modernization – NJOY 2016 is very dependent on the ENDF 6 format but want to get away from looking for one value in one place. Time is a sink, where making the change is just temporary. Better to start from the ground up. Trying to make component based (not module based) new version. Format components ENDFtk, ACEtk, NDItk, etc. Users will only need to interact with python, C++ written. Based on similar data structures that can be interacted with in the same ways.

Reaction identifies – Moving away from MT numbers to reaction ID, which is just a combination of particle IDs.

Resonance reconstruction – redesigning previous reconstruction work, added python bindings, etc. Partially implemented, tested, and in development currently. Based off LRF=7 structure. Intermediate structures are available to user. 7 test cases are available. Time comparisons are approximate, but optimizations are being investigated to decrease the time necessary to run RECONR

Covariance Data structures – Want to be as general as possible, flat structure ideal, want to take all covariance and put into structure. I.e. X1 has Y and Y has Z. Need to hold independent and cumulative covariance; this fixes that problem. Basic capabilities are available, able to create structure, and can calculate anything missing. Extraction of submatrices by slicing is also available as well. Working on populating and writing to ENDF and GNDS.

Continuation integration – previously done on GITHUB, limitations are present, now doing most work on a LANL internal github, Wim and Joe setup good continuous integration with more compilers, and major changes are pushed to external github.

Test Results for Resonance Reconstruction:

- Differences between ^{54}Fe Dryad/NJOY resonance reconstruction is statistical – very good performance
- ^{57}Fe has poorer performance near higher end of resonance region
- ^{239}Pu has multiple duplicate energies in file, produced some issues and required special handling
- ^{35}Cl proton emission also has poor performance at high end of RR
- Dryad actually fixes bug in NJOY when processing ^{40}Ca

Discussion Items:

- **ACTION**: NO DIVERGENCE for handling primary gammas
- **QUESTION**: [M. Dunn] - We'll probably use the rest of the time of the session to discuss this change – we could move this to a whole CSEWG (next year's)
    - [A. Lewis] - I really don't want to wait to solve this until the next year, even with providing this information in the errata
    - [M. Dunn] - If we have an executive session/mini-CSWEG that could work

- **QUESTION**: [C. Mattoon] - Reaction specifications – two ways to define elastic scattering (Slide 15) ^{235}U->n(0)
    - [A. Lewis] - Yes when ^{235}U it is in its ground state, unless you specify meta, so we want it to be consistent. So nus35 to nus35 is just elastic scattering, so you would need to use all for all states.
- **QUESTION:** [A. Holcomb] - Mentioned something about emitting an error message about not having error messages?
    - [D. Wiarda] – Was a strange thing, should be error
    - [A. Lewis] – When there's something NJOY can't handle it should output an error message
    - [D. Wiarda] – those extensions should be there [formatting w/o resonances] - They're there, they should be there, and they should be allowed
    - [A. Lewis] – the point is when they're malformed, not necessarily that there needs to be an error in all cases – NJOY crashes when this happens
    - [D. Wiarda] – sometimes needs to be there, will write out empty list,
    - [A. Lewis] – Not that that is incorrect physics, but rather it crashes when not supported in NJOY

    - [M. Dunn] – Tying back to Jason's comment – Red and Bob used to discuss this all the time
- **QUESTION**: [W. Dawn] As a user for crystalline graphite, they use same name but different identifier. Difficult for trying to update temps on the fly.
    - [A. Lewis] Will note and look into.
- **QUESTION**: [A. Holcomb] - Late comparing two version of NJOY smells like there is something wrong with coulomb wave function solver?
    - [A. Lewis] - Also shows up in inelastic but not all charged particles
    - [A. Holcomb] - Another thing to do with stability –something with the matrices, so there's an issue in cancelling with small numbers.

AMPX

Speaker: Jordan McDonnell (Speaker: Jesse Brown)

Overview: AMPX Development highlights: updated continuous energy (CE) library format for SCALE now accommodates a table of Bragg edge energies and structure factors. Pont data and covariance data have been benchmarked using ENDF-6 and GNDS-2.1 formats of ENDF/B-VIII.1. Major effort towards validating the modern C++ implementation of CE library modules. Making efforts to streamline library production with more automation. SCALE and SCALE-data are export controlled. A public version of SCALE is available, recipes for CE libraries will be made public. CE recipes depends on ExSite utility. A C++ implementation of the ExSite capabilities has begun. Looking ahead: completion of GNDS-2.1 support and validation, multigroup library optimizations for SCALE 7, enhancements/ bug fixes to support ORIGEN, increased code-sharing with SAMMY, performance enhancements such as improving TSL processing times and URR/probability table treatment.

Discussion Items: None

FUDGE

Speaker: Caleb Mattoon

Overview: At LLNL we don't use ENDF-6 directly. We use FUDGE and GIDI+. FUDGE was made for using the ENDL format, but was modified to support GNDS. FUDGE consists of classes that mirror GNDS. FUDGE is available on GITHUB, and LLNL tries to update it every quarter.

Recent effort working on ENDF <-> GNDS translator now raising more error messages for errors in evaluations. Expanding error messages to help pinpoint underlying causes.

In terms of other libraries, URR covariance problem impacts over half the TENDL library.

JEFF-4 29 evaluations have problems mostly in the un-resolved resonance region, many inherited from TENDL. 27 have been fixed since release. Hope to make a superset of checker codes within FUDGE. GIDI+ is a C++ API for reading and sampling processed GNDS data. Now more efficient MC sampling on both CPU and GPU. GNDS <map> files combine evaluations into a library. Easy to create hybrid or test libraries. Newest GEANT-4 includes an updated version of GIDI+ in the G4LEND package

Goals: Faster processing turn around and improved thermal up scattering model. Update to GNDS 2.1

Developments in FUDGE/PoPs can translate ENSDF JSON to GNDS. FUDGE/GIDI+ training courses were held in 2024 and 2025 more are to come

Discussion Items:

- **QUESTION**: [W. Dawn] - I am interested in your physics checking and ENDSF data. Is that something you are checking for when doing merging?
    - [C. Mattoon] We, Vince you can jump in if you want, the way I see it going is we have a faster route to jump into ENSDF but they do get out of sync... my big complaint is about MF6 gammas.
- **QUESTION**: [Unidentified person] - Page 2 if you take that plot and make it for gammas you will see that different libraries and evaluations will generate different responses. It dates to issues built up over decades and it is haphazard. As people do new evaluations they should replace gamma production and fix that.
    - [C Mattoon] I can only second that suggestion.

ADVANCE (REQUEST FOR WORKING GROUP)

Speaker: Gustavo Nobre

Overview: Change to discussion about what we want from an evaluation review platform. The best approach is to assemble a formal working group to address this issue. So please reach out to Dave, Gustavo or Rebecca. If there are no volunteers, then Dave will make some. The more input we get, the better.

Discussion Items: None.

SAMMY

Speaker: Dorothea Wiarda

Overview: Improved the reading of ENDF files, but you could only read one file and covariance. Now you can read more than one ENDF file. For say natural Iron to pull all isotopes at once into SAMMY. You can also attach covariances to each ENDF file or let SAMMY write you a par file. You can also limit numbers of spin groups. RRR is working but URR is very different, ENDF file reading not implemented for URR.

We created a better C++ API. Not that you cannot run them in parallel with the base code but you can use it to read the file and set and retrieve parameters. You can also read before or after adjustment and decide what to adjust or not adjust. You can look at the resonance parameters before adjustment.

Can now use this new SAMMY model for use in fitAPI and for use with Minuit and a Metropolis-Hasting algorithm

Made a SAMMY model that can take several SAMMY runs for use in Dakota. Runs are performed sequentially.

Changes to internal program flow. All resolved range formalism now fills in the cross section for each energy for a given spin group. After than the same code can be used for resonance reconstruction. AT that point you can specify what abundance you want to use. Before you would have to do this in

reconstruction code but not it is done here. The only code that can do angular reconstruction is R-matrix and is unlike to get to the older codes.

Upgrade to internal program flow. It was convoluted, but now it is streamlined to be controlled by a C++ class.

Improved calculation of integral experiments. The manual always said you calculate for individual isotopes, in practice it never worked. Now it does.

We have any early Python interface. It is very new and might now work. Please test it and provide feedback.

Future plans. Make the URR more calculable in SAMMY. We have new developments from Alec Golas to incorporate this. Yaron asked for text format but we want something more flexible to be able to add new features in the future. We also want to add more robust numerical diff in the resolved range. This way you don't need the analytical. We also want to write all covariance and theory info to an HDF5 file.

Discussion Items: none

GNDS Updates

Speaker: Caleb Mattoon

Overview: GNDS 2.1 published December 2025 as an NEA Working Paper, minor changes and fixes to documentation. Introduced section for storing TNSL. Code support for GNDS is expanding. AMPX demonstrated ability to process recent ENDF lib in ENDF-6 or GNDS format. NDEX supports reading from both. Galilleé-1 is being updated to support GNDS, they have reported issues which point to necessary GNDS clarifications. For example, not currently clear enough how many L-values needed for reconstructing angular distributions. GNDS-2.2 will address these issues. For primary gammas in MT=102 considering if they should allow capture in discrete final states or just a single capture reaction. Beyond GNDS-2.2 considering better support for decay data from ENSDF, new ways of storing photon decay cascades and photo-atomic data, add more containers for storing derived/processed data

Discussion Items:

- **QUESTION**: [G. Arbanas] - A tangent, regarding scattering length. What is being done to take into account the direct capture component. The hard sphere radius, but there was some talk to add them if they were complex.
    - [C. Mattoon] - Yes, the idea is to store the partial widths? I don't remember that discussion
    - [D. Wiarda] maybe GNDS should consider if values could be complex if noted.
    - [C. Mattoon] - Is the idea for both energy dependent and constant radii to be complex?

- **QUESTION**: [D. Wiarda] - If you go back to the 999 primary gammas. If you can release it in GNDS it should be nice to have this new feature but have both, the new release but in the ENDF it is not there. Have the 999 primary gammas in the GNDS but not in ENDF?
    - [C. Mattoon] Yes, I think we would then treat MT102 as a summed cross section. The one thing to watch out for is how to handle specific capture effects and resonance channels

Measurements Committee

Chair: Yaron Danon (RPI)
Date: Wednesday, January 7, 2025

Measurements with DICER at LANSCE

Speaker: Thanos Stamatopoulos

Overview: New neutron spallation target as of 2022 which resulted in higher flux.

Device for Indirect Capture Experiments on Radionuclides [DICER], allows for minimalization of sample size, 1- and 0.1 mm collimation allowing for simultaneous in-out sample measurements. Ideal to measure radioactive samples you can only get very little of (<1g).

10 mL ^{88}Zr target created and measured, results are published in Phys. Rev. C and available on EXFOR --> Next ENDF! ^{147,149}Sm transmission data collected alongside DANCE to allow for 215 resonances to be resolved and for spins to be resolved for many isotopes. Resulted in significant in gamma-gamma distributions, results are available and Thanos can be contacted as well. ^{239}Pu results favor ENDF/B-VIII.1 evaluation, expecting to go to PRC in the near future. ^{191,193}Ir also measured.

New measurements and status: ^{63}Cu(n,tot) measured, showcases new nuclear data pipeline alongside AI/ML. ^{133}Cs first ever metallic Cs measurement, taken sub-thermal to 10s keV. Published early 2026 (hopefully). Development of DICER64, exploring simultaneous transmission and capture measurement and changeable field of view. ^{88}Y planned for Fall 2026, needs many developments.

Discussion Items:

- **QUESTION**: [R. Capote] When you showed ^{239}Pu is it ENDF VIII.0 or VIII.1?
  - [T. Stamatopoulos] - Figure has it correct, but that's a typo.
- **QUESTION**: [G. Arbanas] What methods do you use to be able to see oscillations?
  - [T. Stamatopoulos] - This is not even our data. In our case in the evaluations, if you bin them 10x coarser than the level spacings, not just in ^{235}U, but also other nuclei
- **QUESTION**: [Y. Danon] - With new system of 0.1 micrometer collimators are you still going to use two beams?
  - [T. Stamatopoulos] - We have the ability to align the system to 10 micro-meter accuracy in XYZ and few milli degrees in rotation. Yes, will still use two beams.

Update on Recent ^{35}Cl(n,p) LENZ Measurements into the RRR

Speaker: Kenneth Hanselman

Overview: Motivated to investigate ^{35}Cl by TerraPower – specifically, they needed ^{35}Cl(n,p_0) data, which is both a neutron poison and emitter of radioactive products. The energy range of the reaction is

relevant to fast reactors. The result significantly reduced the absorption in the fast region, increasing activity of the reactor, and having a better C/E agreement for the region. Chlorine Worth Study and TEX-Cl benchmarks have been run. Discrepancies between benchmarks were observed. The fast evaluation is well uncertainty-constrained so re-evaluation can proceed into RRR and thermal. Three different foil targets used. Need to calibrate beam intensity for proper TOF measurement. Preliminary yield spectrum lines up with previously reported results. Further analysis is ongoing for extracting resonance parameters and cross sections.

Future work: Making resolution function to more directly translate measured time of flight observation to cross-section – result intended to be applied to ENDF-IX release (^{39,40}K stable isotopes)

Discussion Items:

- **QUESTION**: [Y. Danon] For the NaCl how do you deal with the Na?
  - [K. Hanselman] In energy range, sodium has no impact – not for (n,p), at least
  - [Y. Danon] - What about attenuation by Na?
  - [K. Hanselman] - We have extremely thin targets, so it's negligible

Recent measurements of ^{235}U, ^{238}U, ^{239}Pu, and ^{240}Pu photofission cross sections in the region of the Giant Dipole Resonance

Speaker: Anton Tonchev

Overview: Reaction channels extracted from photoneutrons can be sorted by multiplicity at two facilities, Saclay and Livermore. A systematic discrepancy exists between the two labs. This forced evaluators to choose between discrepant data, i.e. JENDL used LLNL for low energies, Saclay at high energies. The modern approach of photofission just detects fission events without neutrons. Dedicated chambers are used for these measurements, with four chambers with pairs of foils of the same isotope in one chamber, and a fifth chamber for beam characterization. The LLNL experiment is located at HIGS (High Intensity Gamma-ray Source). Can have less than 100 microgram targets since they get $5x10^8$ gammas/s.

Need to measure flux in an absolute way and it is done in 2 ways. ^{235}U(g,f)/^{238}U(g,f) ratio general agreement between ENDF JENDL and data, ^{235}U(g,f)/^{239}Pu(g,f) has disagreement between evaluations. For ^{238}U(g,1n) HIGS data follows more closely Saclay than Livermore. Analysis is being finalized for ^{235}U, ^{238}U, ^{239}Pu, and ^{240}Pu cross sections.

Discussion Items:

- **QUESTION**: [D. Fritz] Do you plan to also look at fission yield distribution as a function of incident photon energy?
  - [A. Tonchev] - Yes, we did for ^{238}U and but need to prepare thick foils which they did not do this time. Plan to do that measurement in future.
- **QUESTION**: [C. Percher] You mentioned all the work to bring down experimental uncertainties – mentioned that experimental uncertainties were 2-3x historical values – do you trust historical uncertainties?
  - [A. Tonchev] - We hope that this data in absolute scale will be between 3 to 6 percent uncertainty overall, reason is because of deconvolution procedure, never put uncertainty on that process. Did that in past, but it is a model, and need to record kinetic energy, efficiency, etc. Not very straight forward to get uncertainty.
- **QUESTION:** [R. Capote] Why not compare to most recent IEA libraries?

- [A. Tonchev] I should have. Will do in the future.

Thermal Transmission measurements

Speaker: Kemal Ramic

Overview: Conducted measurements at the Spallation Neutron Source's VISION experiment. They used a He3 detector and designed a special Boron carbide polymer collimator. Initial results from the first collimator was poor. By adding Cd, the response improved but still had a way to go. They moved the experiment to SNAP beamline. They still needed collimation but got a better response. Issues apparently are due to sample. Addition of new beamline VENUS. VENUS has additional flexibility of temperature dependent setups.

TimePix 1 and 3 detectors were used because of high ~70% efficiency for neutrons.

Due to stresses in the metallic samples, they are not that great for validation purposes.

Why not use powder samples? They have SANS scattering due to pores. So how to correct for SANS? Experimental methods from Egelstaff involve measuring the sample as close and possible to detector. By selecting a region of interest, SANS events can be discriminated. This only seems to work for systems with low SANS cross sections. For strong SANS, this method is not enough of a correction. So, they tried picking the whole region but that didn't work either. SANS can be corrected analytically, but you need to figure out the scattered neutron acceptance and use it for certain angles. This can generate an analytical correction for the cross section. They were able to use this process for correcting Ni metal cross section. The final method is using neutronics codes to generate a correction. This method may even be better than analytical since you need less experimental information.

Discussion Items:

- **QUESTION:** [B. Wang] If you are generating this neutronics correction with cross section or codes, then what happens if the reference data for the calculation changes? Like say angular distributions.
  - [R. Kemal] Angular distributions mainly depend on inelastic and incoherent – above first Bragg edge they're all exactly the same – once you actually determine SANS, it falls off very quickly – The inelastic cross-section and total cross-section above that are independent of SANS,

Recent Work on Neutron Standards

Speaker: Allan Carlson

Overview: New work on $^{1}H(n,n)^{1}H$ standard was presented in ND2025 for 2 energy ranges. Measurements of $^{6}Li(n,t)$ have been published by a number of groups. If experimental data and R-matrix results are consistent, it is hoped that the energy range of the $^{6}Li(n,t)$ standard can be extended. Measurements have been completed and are underway that may impact C(n,n) standard. New measurements are needed for Au(n,g) in the standards energy region. Present standard for $^{235}U(n,f)$ is limited to 200 MeV. There is a strong need for these measurements to higher neutron energies. New results of Pu fission cross section measurements were published by a number of groups recently. In

conclusion need improved experimental work for all standards with an emphasis on using different experimental methods to improve our understanding of uncertainties.

Discussion Items: None.

Recent Zr-88 and Xe-135 measurements

Speaker: Will Flanagan

Overview: In 2019, ^{88}Zr was found to have an 800,000 b capture cross-section while 10 b was expected. It is found to be the only absorber above 10 kbarns with an even neutron number. This was due to a resonance. This results in a 1.5% difference in ^{89}Y produced. Unknown gamma-cascades and efficiency from gamma-energy cuts, create normalization problems for getting the absolute cross section, since relative is measured.

We don't measure direct capture – we only get a ratio for the direct capture cross-section. However – still agree with Thanos measurement

Measured at ILL FIPPS, 88 clovers. Preliminary analysis – 23 primaries measured and 26 new states found. This improved the transition from relative to absolute cross section.

The ^{135m}Xe cross-section is theorized to be 4x that of ^{135g}Xe. Very important than molten salt reactors, even though for ^{135m}Xe is $T_{½}$ = 15 m and ^{135g}Xe $T_{½}$ = ~9.5 h. Results at Texas reactor show there is sensitivity to the equilibrium concentration. The isomeric ratio of ^{135m}Xe to ^{135g}Xe is only known to 20%, planning to improve statistics in most recent measurement. Missing ^{126,132,134}Xe(n,g) prompt gammas are unknown, giving a background contribution that cannot be solved compared to gamma-ray heating spectra from ^{135}Xe.

Upcoming FIPPS campaign for all Xe isotopes Summer 2026.

Measurement of ^{130}Xe(n,g)^{131}Xe have been demonstrated in preliminary work.

Discussion Items:

- **QUESTION**: [A. Tonchev] Congrats on ^{88}Zr, would you be able to resolve spin parity from ILL measurements for these transitions?
  - [W. Flanagan] So I would have to look at stats available to see if we can do the correlations. So, I cannot say how many spins we could assign. Too preliminary.

- **QUESTION**: [G. Arbanas] the low energy capture cross-section, does it ever get away from 1/v?
  - [W. Flanagan] In terms of n-tof not too much data left of the resonance. One measurement in mind is at NIST reactor. When it is next available, it would be nice to test.

Hafnium High-Energy Quasi Differential Scattering

Speaker: Adam Daskalakis

Overview:

Presentations at CSEWG 2024 highlighted discrepancies for Hafnium elastic vs inelastic scattering. The speaker provided an overview of high energy scattering system and experimental methods. The speaker's team used 3 to 4 cm thick 7.62-cm cylindrical samples. Data collected from graphite sample

were compared to MCNP simulations to produce normalization and analyze background. Collected data were compared to MCNP results using different libraries and this analysis is ongoing. In future work a more complete model of the room and hafnium sample impurities will be included in the final MCNP simulations.

Discussion Items: None

Zr measurements at GELINA

Speaker: Klaus Guber, Chris Chapman

Overview:

Measured Zr-^{92} transmission – Metallic ^{92}Zr samples are difficult to create (either through enrichment or ^{91}Zr absorption) and therefore are expensive to produce.

^{90,91}Zr measurements completed already, being used to reduce ^{92}Zr measurements.

Decent agreement with current ENDF evaluation for ^{92}Zr , but still obvious discrepancies

Once ^{92}Zr data is finalized, will move on to ^{94}Zr. An overview of the status of NCSP experiments at EC-JRC Geel was shown.

Discussion Items:

- **QUESTION**: [T. Stamatopoulos]– Jesse, is AGL code accessible for others to use? Pt 2 – about samples, typically Zr comes with Hf, but didn't see Hf references, where did you get samples from.
    - [J. Brown] I doubt it (AGL) will be available, but I've worked on a replacement in python – if you have GELINA listmode binary data, I already have a reader I wrote that you could bin in time-of-flight data.
- **QUESTION**: [Unidentified person] About samples – typically it comes with Hf but didn't see those resonances- where did you get the samples from?
    - [K. Guber] The samples used are from ORNL as of now I don't remember any Hf impurities.
    - [M. Zerkle] There should not be any since they were generated by Y-12 – – there won't be Hf
    - [G. Siemers] - With these measurements, these are in the keV so it is insignificant.
    - [K. Guber] - The measurements basically stop at 100 keV so we wouldn't see it
    - [T. Stamatopoulos] – Is it available for use by me?
    - [Y. Danon] - You can lease from ORNL
    - [A. Tonchev] - What is the enrichment?
    - [Multiple people] - they all have high enrichment expect for the Hf - which is 95%
    - [T. Stamatopoulos] - I don't plan to use the sample, I plan to destroy it (evil smile)
    - [S. Singh] How does ENDF compare to the data for capture
    - [K. Guber]- That analysis has not been completed.

Nuclear Data measurements at RPI

Speaker: Yaron Danon

Overview: Developing a test suite for gamma ray spectra data. NaI detector array can measure capture spectra. Validated methods with ^{56}Fe. Multiple other measurements completed. Next step is uncertainty quantification.

Observable gammas attributable to fission which are not modeled in library – need to use modified MCNP w/DICEBOX to better represent gamma spectra - began correcting gamma spectra with CGMF PGFS increased in 4-8 MeV in RPI measured fission spectra – consistent with other measurements similar to this one.

Integral measurements for validating TSL in a non-critical system. DT source, detector isolated from ambient neutrons. Water density decreases between 4 deg C and 0 deg C the impact of this is being investigated.

Capture gamma measurement was performed on natural Zr – measurement ran into significant difficulties: out-of-spec Hf contamination, and machine failures led to only a couple hours of usable runs – still produced valuable data for analysis, but longer run needed to validate that

Nuclear data for validation of isotope production. Integral validation of ^{237}Np photonuclear and fast neutron data related to ^{236}Pu production. Significant difference between photonuclear evaluations and experiments for some produced isotopes. Measurements were compared to evaluations from IAEA/PD-2019 and TENDL-2023.

Discussion Items:

- **QUESTION**: [A. Tonchev] Question about fission gammas – Can you distinguish gammas between ^{235}U and ^{238}U?
  - [K. Keparutis] No. Our incident neutron energies are not high enough.
  - [Anton] Are there any plans to measure Plutonium?
  - [Y. Danon] No. Too difficult to procure quantities needed. (Mike Z. also shakes his head no)
- **QUESTION**: [G. Nobre] - Are you comparing photonuclear rxn directly to IAEA or what?
  - [D. Fritz] Yes – But cannot separate out measurement from metastable state

Recent Results from GENESIS

Speaker: Bethany Goldblum, Thibault Laplace

Overview: Gamma Energy Neutron Energy Spectrometer for Inelastic Scattering (GENESIS) Experiment at Berkley's 88-inch cyclotron. Deuterons hit target to produce neutrons for GENESIS. Past GENESIS array spectrometer used to find energy by TOF

Motivated to improve inelastic (n,n') - Seth McConchie et al. Tech report.

Possible amplitude offset of GENESIS carbon inelastic data compared to 2 previous data sets.

Forward modeling starts with reaction model this produces cross-sections, this is convolved with system response to make predictions for experimental quantities. These are then compared to measured quantities. X^2 fed into minimizer which then modifies the initial reaction model. For ^{56}Fe(n,n') gamma ray data, the inverse (traditional method) and forward models using GENESIS gamma-ray production cross section for 1.238 keV exhibit good agreement. They do not agree for other gamma energies.

Discussion Items:

- **QUESTION**: [D. Brown] If you are concerned that if you model does not describe reality, are you encoding incorrect physis into what you report and a measurement? It's difficult to reconcile if there is a model or data shortcoming.
    - [B. Goldblum] That's concerning, but what we're doing right now is look at the limit of applicability right now and incorporation of additional reaction modeling code – Such as each different level can have a different parameter set to describe it – So maybe there is missing physics but by first applying it to well-understood datasets
    - [Y. Danon] isn't that the method being used to generate TENDL
    - [B. Goldblum] The difference here is we take the output of TALYS and convolve with our system response – we're applying it to "raw" data, rather than a processed cross-section

The present status of the EXFOR project

Speaker: Boris Pritychenko

Overview: EXFOR is experimental nuclear reaction data. It is a way to everyone to access everyone's data. EXFOR control center allows for you to access who is contributing what from all over the world. Most recent entries of A. Stamatopoulos on ^{88}Zr, J.M. Brown on ^{181}Ta and A. Daskalakis for ^{92}Mo and ^{94}Mo. What happens when you have data but no publication, you can submit to us for data archiving and access for others. Data sets from experiments that are not recent can also be added if they have sufficient documentation.

EXFOR is more than 75 years old. There are some issues both new and legacy. It would be nice to update EXFOR using new technologies. There is a focus on a new curated EXFOR that utilized more modern storage and organization techniques.

Discussion Items:

- **QUESTION**: [M. Herman] I would like to know how does the compilation work now in the databank.
    - [B. Pritychenko] Whole compilation effort was based on contractors from Russian federation – in last few years, all those contracts became impossible – membership has been suspended – most recent meeting, very big backlog – Mike Flemming is working on behalf of the databank.

Thermal scattering measurements from graphite

Speaker: Kemal Ramic

Overview:

Multiple grades of graphite with a range of porosity and grain size have been measured. During ReGra it was suggested that the reason there is no observed influence of pores on the measured S(α,β) is

because samples were too thin. The wavelength of a neutron at thermal energy is much smaller than the scale of pores so pores act as macroscopic boundaries. Thin refers to neutron optics, the same sample is macroscopically large compared to the crystal structure. The goal of the TSL is single scattering, multiple scattering should not be represented in a TSL. That is what the transport code is for. ARCS measurements of two samples in two orientations. Measurements present no difference on the thickness of the sample of the orientation on the measured phonon spectrum.

Discussion Items:

- **QUESTION**: [M. Zerkle] From the workshop is to do additional transmission measurements on thicker samples.
  - [K. Ramic] Yes, I am but you have to also understand that at 10, even 20 cm was talked about, there is no transmission.
  - [M. Zerkle] It would be useful to address some of these issues to do the transmission.
- **QUESTION**: [Y. Danon] You say if I treat porosity by removing atoms you say it is as if I am removing porosity.
  - [K. Ramic] If there is porosity then using the porosity TSL is incorrect. It is Crystalline but with less density, i.e. pores.

Nuclear data measurements of Ni and Cr capture gamma-rays

Speaker: Shuya Ota

Overview: CapGam is one tool to visualize capture gamma-rays. ENSDF is another tool. There is a need for thermal neutron capture gamma-ray data. Applications include PGAA – Prompt Gamma Activation Analysis, non-destructive assay to determine isotopic concentration of materials, planetary science, oil finding, etc. The need led eventually to the GRIN project - Gamma-Rays Induced by Neutrons. Work to fill in missing primaries. FAIR at UMass Lowell Research Reactor of Cr, Ni, and Cu. FAIRRAY HPGe Array. 2 more HPGe coming alive in next months. Recent publication in Phys. Rev. C by M. Jandel with more experimental setup. ^{152}Eu and ^{35}Cl used to normalize Mn, then $MnCl_2$ and subsequently MnNi can be measured and Ni gamma-rays can be determined. Nat-Ni was later measured. ^{58}Ni results normalized and matched well to ENSDF, agreement within 20%, some low intensity gammas are contaminated, and no increase (decrease?) in lower limits.

Insufficient known thermal neutron capture gamma-ray data for A>60 isotopes, Preliminary results show some success, but normalization still has issues,

Discussion Items:

- **QUESTION**: [W. Flanagan] simple question - are the HPGe detectors in coincidence?
  - [S. Ota] Yes, we can do coincidence, but statistics can be very low.
- **QUESTION** [Y. Danon] Is the main goal after you overcome issues a new list of primaries to update ENSDF? What about gammas that are not primaries?
  - [S. Ota] Primaries is just one example – we want to measure as many gammas as possible. Primaries are the highest energy and provide the most useful information. We might be able to do something with other gammas but I don't know

- [Y. Danon] Are the middle gammas there or can you not get them? You can get gammas that are high energy and some that are low energy but not many in the middle.
- [S. Ota] Trial and error with each example – but I don't know at this time

Mn, Cu, Fe capture gammas at thermal

Speaker: Marian Jandel

Overview: Measurements of capture gamma rays for multiple isotopes are planned at UMass Lowell reactor. One year worth of data has been collected. There is ongoing work with ^{56}Mn in order to use as a normalization for future measurements. Both Mn and $MnCl_2$ are measured. ^{35}Cl has well known capture cross section that can be used for normalization. Need to subtract scattered neutrons producing background signal in HPGe. Spectrum measured with carbon target to measure ambient and scattering background. After background subtraction peaks are identified with ROOT-TSpectrum and a final normalization is performed. Neutron capture experiments for Fe isotopes and other nuclei being planned.

Need coincidence in order to model full level schemes. Third detector will solve this problem.

Discussion Items:

- **QUESTION**: [D. Neudecker] - I assume when you speak of Cu you actually mean elemental Cu and what energy range
  - [M. Jandel] Elemental, in Thermal energy.
  - [D. Neudecker] - Would be interesting above.
- **QUESTION**: [Anton Tonchev] - nice work and capabilities have you been surprised thus far by new transitions measured, have you seen anything you are surprised by?
  - [M. Jandel] So far I have seen things in coincidence. We have not done triple, double coincidence is sufficient.
- **QUESTION**: [Anton Tonchev] - And you hope to do triple coincidence?
  - [M. Jandel] - No just double
- **QUESTION**: [Y Danon] – You want to measure electrons from Gd?
  - [M. Jandel] We are thinking about Micro channel plates and breaking Electrostatic field. That's why capability of making very thin plates is very important to us – you can excite Auger electrons

Covariance Committee

Chair: Denise Neudecker (LANL)
Date: Thursday, January 8, 2025

Introduction

Speaker: Denise Neudecker

Overview: In 2026 neutron standards will come out, if you are an evaluator, please implement and update accordingly. Real push for AI, please use, test, and adapt for UQ.

Discussion Items: None.

Ta181 Covariances and Integral Experiments

Speaker: Jesson Hutchinson

Overview: ^{181}Ta sensitive benchmarks are necessary, specifically for applications that are not met by current ICSBEP benchmarks. Currently, there is a goal to create new benchmarks with ^{181}Ta sensitivity. This will provide additional validation PMF-45 and PMM-3 are the only two benchmarks currently sensitive to Ta. Covariances in ENDF/B-VIII.1 have added reactions and more cross reaction correlations than previously implemented. Issues were also found, with the min and max being greater than –1 and 1 – Could also be an issue in the processing. Reductions of relative uncertainties were also found.

THALES is current work, on a v3 build, and applications/experiments with thick Ta are very sensitive to ^{181}Ta . A lot of the targeted designs do match the sensitivities well. The uncertainty decreased significantly. Ta uncertainty is still > 700 pcm. The similarity coefficient, Ck, is generally lower for 8.1.

^{181}Ta, while improved, is still a large contributor to the total nuclear data uncertainty. Final design document details other investigated configurations, but the choice is currently down to 4. As a last side note, with covariances as large as they are, codes like WHISPER are useless.

Discussion Items:

- **ACTION**: Add Ta-181 covariances where greater than |1| to issue tracker.
- **QUESTION:** [R. Capote] 2 questions: Are you considering angular distributions, for reflector criticality? this is important. For total cross sections, sensitivity to elastic and inelastic are both positive, do you need to change total?
    - [J. Hutchinson] So related to the angular distribution I would say that we are looking into what the sensitivity is on the other hand we don't have covariance associated with it, so we are not propagating it. So you are correct that it will be sensitive to angular. Regarding your second question, Total does matter and it is important.
- **QUESTION**: [W. Marshall] Going to be disappointed if expecting covariances to go down with a new eval – that's not been the case in general

- [M. Chadwick] - That is absolutely true, we would hope over time actual mean values get better with time, do you have any evidence done from other experiments that things have got better?
- [J. Hutchinson] - That's a good point – limited data – has been some comparison for C-E for existing experiments – Don't know immediately if they've immediately improved.

Neutron Standards Project Developments

Speaker: Georg Schnabel

Overview: DATP is Fortran code that reduces a computational mesh to one that is significantly smaller than the full database, with collapsed cross sections, which can then be used in the GMAP code to create an evaluation. These codes have been modernized with modern JSON rather than positional text files. Code modernization also occurred, going to datpy and gmapy – Python. TensorFlow and TF Probabilities extensions were also implemented. This modernization increased flexibility in method choices. Support for statistical model extensions, specifically cut posteriors (cut-Bayer) and Bayesian Hierarchical Modeling "Uncertain Uncertainties".

This will be discussed within standard committee, and next IAEA technical meeting on Neutron Data Standards, 26-30 Jan. 2026. See presentation for list of GitHub repositories.

Discussion Items:

- **QUESTION**: [G. Arbanas] - how do you deal with inconsistent data sets? Should it be done before using these tools, or can this be handled within?
  - [G. Schnabel] - We have several ways there –historically a preprocessing step – used to be point by point, test sigma away from point – New approach is the uncertain uncertainties – adding components to covariance matrix
- **DICUSSION**: [R. Capote] Code is open source so can be used by everyone
  - [D. Neudecker] standards are reproducible and are available on GitHub, they can be used by everyone, thank you Georg

Using ML to find root causes for discrepancies in experimental data underlying the new ^{252}Cf PFNS Standard

Speaker: Denise Neudecker

Overview: ^{252}Cf(sf) PFNS is used as a relative for all other fission spectrum measurements, so it is influence in all other data measurements. Previous standards are unable to be used since the input data was lost/destroyed. New evaluated data uncertainties below 3 MeV and above 8 MeV were decreased. Between 3 and 8, there is less trust in the data.

Looking to implement AI/ML processes to resolve PFNS based on sound physics bases. Looking to see if it can find root cause between discrepancies between trustworthy experiments, and which experiments/simulations can be performed to best reduce the scattering in experimental data. AI can identify trends but the scientist needs to determine if effects are real. ChatGPT and other tools can be used to get data into a format where ML can be better used. Then a sparce Bayesian model can be used to identify potential sources of bias. This code is open source (github.com/lanl/sparse_bias) from N. Walton. ML clues indicated the major open issues in the spectrum, and guided toward new experiments.

Impact assessment shows that without ML clues, there is a strong bias in the evaluation, but with the ML, the uncertainty is decreased by 25%.

New PFNS standard will be released for ^{252}Cf(sf), and there is a new ML tool that can help identify the root for discrepancies (USU).

Discussion Items:

- **QUESTION**: [C. Percher] What is the minimum number of data sets needed to find these issues?
  - [D. Neudecker] 2 and 3 is too little, this needs decent coverage. It depends on the number of data points in the data set. If you are interested in an energy range, I'd say 3 to 4 cover the energy range but 4-7 is ideal, the standards are useful for that
- **QUESTION**: [M. Chadwick] Can you remark on how good Manhart's work is?
  - [D. Neudecker] - Manhart knew what he was doing - I wish he left his computer there – this shows how important it is to make work reproducible, because it took a lot of effort to try to reproduce it

A Data-driven Approach to Credible Uncertainty Quantification in the RRR

Speaker: Vladimir Sobes

Overview:

RRR should be limited to a 10% lower bound in cross-section uncertainty (for good data) - Using synthetic data, which is cleaner than real data to determine uncertainty on known cross-sections – AutoFit can perform as well as a human evaluator. Using synthetic data without any experimental uncertainty fits to 10% error – 10% error is irrespective of cross-section value (if it's in a resonance or not) - Testing with a synthetic criticality benchmark – applied non-differential data (URR-like) and had 300 pcm uncertainty – applying HQ differential data reduced it by 37% - ...ENDF has 95% confidence interval.

Resonance parameters with equivalent fits are outside of each other's error bounds – not good!

Discussion Items:

- **ACTION**: Additional discussion at Mini-CSWEG on this topic.
- **QUESTION**: [A. Carlson] - If you work with smooth cross sections would not have this problem? Can you get realistic uncertainties from smooth cross sections?
  - [V. Sobes] - The results I show are for the resonance region. I am not making a statement on high energy. I would like to use this method on higher energy.
  - [A. Carlson] - I think you should build this technique on smoother cross sections
- **QUESTION**: [C. Percher] - Are you sure that you're using the same differential data that the evaluator used? Because that could contribute to the difference in the spread
  - [V. Sobes] To the difference in spread to be specific what we did, in this case the evaluator had 6 data sets we looked at 5. We took that evaluation and fit to 5. Consider this to be another evaluator.
  - [C. Percher] You are not passing judgment on these data sets.
  - [V. Sobes] That's true but I would argue passing judgement on data should increase uncertainty. If we have clean data we can generate we cannot find the cross section within 10%.

- **DISCUSION:** [Y. Danon] - Related to the previous talk – Current covariances don't propagate systematics on parameters – These uncertainties fit the model, so I'm not surprised that there are differences since it's dependent on the model – proof in pudding is that when we do benchmarks, we fit them very well – so even though the datasets are fit differently and there are artifacts, but that is still fit well.

Covariances in the URR

Speaker: Cole Fritsch, Noah Walton

Overview: ARIADNE code used to perform UQ across energy regions – With ToF need physics model of uncertainties – physics don't exist to propagate uncertainties down to RR – not feasible to always have exact resolution function, but not totally necessary – Approximating source channel width broadening would make resonances disappear in some cases, so it's not totally generalizable, i.e., resolution contributes to uncertainty but isn't totally correct.

Averaging XS in URR is essential for proper modeling – Use weighted averaging with larger bins to get good averages – Due to self-shielding cannot do simple averaging.

Simple averaging fails when data is highly stochastic and when there is non-linearity with respect to the count data. Weighted averaging fails when the cross section fluctuates.

Probability tables with covariance can be generated from more complicated methods – however no ENDF format for probability table uncertainties

Discussion Items:

- **ACTION**: [D. Neudecker] If anyone has information or processes for analysis it should be available on the NNDC page for all to access and contribute.
- **QUESTION**: [R. Capote] - I think that you have to keep in mind that URR there are a lot of ongoing developments. One is that is what is in file 3 is inconsistent with data and that makes the URR very different from everything else. We can't even compare file 3 in URR and expect it to agree with high resolution data. I fully agree that uncertainty is there, but the mean values as well.
    - [N. Walton] - Yeah, I completely agree and I think the takeaway is that we are going to smooth this data to get this uncertainty source so MF3 will look like a probability table.
    - [R. Capote & N. Walton] Agree there needs to be more talk about fission standards and how this will be applied for that data.
- **QUESTION**: [Y. Danon] I think your approach to averaging is wrong I think you need to take it from the integral. Like from transmission.
    - [C. Fritch] All we have is the data.
    - [Y. Danon] Even with the data you can take the integral instead of the pointwise data.
    - [N. Walton] The ideal case it to use the data with defined bins and we should know those.
- **QUESTION**: [K. Beyer] - averaging in points of energy vs far cutoff?
    - [N. Walton] - Moving filter averages – it's not a Lorentzian, but a polynomial – because it doesn't account for uncertainty in data, it's a problem.

Bayesian Model Mixing and the Bayesian Analysis of Nuclear Dynamics (BAND) Software Framework

Speaker: Daniel Philips

Overview: Looking at how model uncertainty limits prediction capabilities in key problems. Goal is to build a framework that is generally useful for full uncertainty quantification in nuclear physics. There is a public github repo (github.com/bandframework/bandframework) which is a publicly available framework that can be used. Also allows for push requests, looking for improvement and feedback from users. BAND Framework V0.5 has 11 software tools implemented, and they can all be used for their specific use. Examples are surmise, provides a surrogate model interface for emulation, calibration, and sensitivity analysis, Taweret a Generalized Bayesian Model Mixing package, and BRICK (Bayesian R-matrix Inference Code Kit).

Discussion Items:

- **QUESTION**: [R. Capote] we have been dealing with issues for a long time since 04' and looking at how to combine experimental uncertainty data and models. For applications what is required is uncertainty of quantities not parameters; in order to differentiate, you can start from uncertainty of model parameters, but this is not the case. I am really very curious because there have been many methods and I am unsure, even the language sometime is misleading.
    - [D. Phillips] I agree with everything, if I take an example, I am familiar with, if I take samples of parameters, forward modeling is relative straight forward. Many times, we look at parameters which are a gateway to find what we are actually interest in, I know the community struggles with this, so he is thankful and looks forward to continuing discussions. Need to sit down learn language and find points of common interest.

The BAND approach to optical potentials

Speaker: Kyle Beyer

Overview: UQ on optical potentials – ubiquitous to nuclear reactions but intractable frequency – limitations in datasets, forced to extrapolate well outside of experimental ranges, need to quantify that uncertainty – In general we have some uncertain parameter we want to fit to uncertain data (construct likelihood) - Global optical potential parameters would be a very large input-space, previous piecewise (data-sparse) analyses might be biased systematically – developing models for different reactions – Suite of tools written to perform this UQ: EXFOR_tools, rxmc

For standard models, this UQ fitting doesn't make much difference

Concluding with propagating uncertainties to final cross-sections

Discussion Items:

- **QUESTION**: [R. Capote] - Fitting optimal model potentials, very impressive and important, but need to use optical model data. No one will fit PFNS.
    - [K. Beyer] - Yes so that is an example of forward propagation. What we are fitting on is optical model data.

- **QUESTION**: [R. Capote] Of course very important what you're doing – even if it's state of the art, only the case for stable nuclides – need to extend the model to coupled channels and that's what's most important
    - [K. Beyer] I am glad you brought that up. I have a student that is extending EML model to other states of nuclei. We are taking a couple channel solver into a multi-channel solver.
- **QUESTION:** [D. Neudecker] – Related to experimental data – pulling straight from EXFOR – I would encourage you to be careful – you will be faced with discrepant data – are you filtering the data in any way?
    - [K. Beyer] - Right now manual and boring and no fun process. Query EXFOR, go through manually and remove discrepant data points. Simple outlier and rejection identification. Also has issues with error reporting, each subsequent EXFOR release improves the error reporting. The main piece of this tries to take all sources in one evaluation and synthesize to statistical and systematic errors.

Covariances for the LLNL ^{239}Pu Evaluation

Speaker: Andre Sieverding

Overview: Our eval starts at 30 keV to 20 MeV for ^{239}Pu. Our main motivation is the new measurements predicts a higher cross-section ratio than previous evals. In addition to cross-sections, we added new data sets from fissionTPC. We got an increase of 0.5% compared to previous evals. To generate covariance data, we used backward-forward MC method. These methods let us get an evaluation with fewer datapoints vs other methods. Applied Hauser-Feshbach and OMP parameters separately, explored how to account for cross terms and overlap between HF and OMP. Taking fissionTPC ^{239}Pu ratio with 2017 ^{235}U fission standard makes benchmarks hard to achieve.

Discussion Items:

- **QUESTION**: [R. Capote] - What was the last evaluation? There was issues with the last one I saw in Oct 2024. There are limits with differential data. We should discuss online.
    - [A. Sieverding] - 2024? That probably could be this one. But I guess what you have is that one, but I have not sent it to you. The capture in the data is not that great.
    - [R. Capote] This has a huge impact on criticality. It may be true, but your differential data is very poor.
    - [A. Sieverding] - We did not fine a large sensitivity between the capture and the crit
    - [R. Capote] - Capture was very sensitive.
    - [D. Neudecker] There are two data sets. It looks like you only used one data set.
    - [A. Sieverding] -For the analysis we used both datasets and are both handles. We also assumed they are uncorrelated but that is likely incorrect as it is the same setup. I applied preliminary correlation, and it did not change the outcome. The actual impact on the cross section is only half a percent.
    - [D. Neudecker] That is still a lot.
    - [A. Sieverding] Yes, it is.

Adjustment of ^{239}Pu Evaluation Using Bayesian Inference

Speaker: Marc Salinas

Overview: Calibrating criticality benchmarks using both integral and differential data. Would be idea to calibrate to fissionTPC data. Prior samples taken from ENDF using EMU [LLNL code] which draws samples entire ENDF covariance for sample and target, returns weights. Sampling is very computationally expensive, but importance sampling reduces this cost by weighting each sample appropriately. First calibration done by adjusting the fission cross section of ^{239}Pu to fissionTPC data caused large discrepancies with Pu-based critical benchmark data. Bayesian inference is used to infer other ^{239}Pu degrees of freedom to match Jezebel benchmark again. When using fissionTPC explicit calibration yielded small changes to many channels, but no major changes when looking at benchmarks, all less than one standard deviation change.

Discussion Items:

- **QUESTION**: [D. Neudecker] - Very hard to see k_{eff} change, would help to see in PCM. Changing ^{235}U XS by ½ percent is significant. No justification due to the huge amount of work thus far.
    - [A. Sieverding] if you want to really fit to fissionTPC data, takes many changes, many of which are already constrained extremely tightly.
    - [M. Salinas] - 1 std is 2% because USU was added.
    - [D. Neudecker] 1% change you disagree with a lot of data. From a standpoint of within sigma but there is a lot of nuances. We need to think more about this data
    - [A. Carlson] There was mini work with JPI that could take into account spectrum average that had a lot of work on ^{239}Pu/^{235}U ratio, maybe we are talking about a problem that is not really there.
- **QUESTION**: [R. Capote] We have a lot of data and we to make sure everything is considered. It is a lot of data, but we need a wide approach.
    - [M. Salinas] My concern with diff data I don't know how the eval was done but it that included in a Bayesian approach I would be concerned with double counting.

Inference of Photonuclear Theory Parameter Covariances Using ML-Enabled MCMC

Speaker: Noah Walton

Overview: Almost no covariances for evaluated covariance for incident photon data. For this data, composite observables are more common and are harder to implement into covariances. Developing a global photonuclear reaction neural network emulator. It uses CoH3 theoretical modeling code. Breakdown into training, testing, and holdout sets, and performance at median is almost perfect. Worst test cases primarily miss height of peaks, but there is not significant difference. Emulator can make predictions for isotopes it has never seen data for. MCMC framework allows clean simultaneous evaluation across channels and isotopes. MCMC framework gives posterior parameter samples with very flexible output.

Discussion Items:

- **QUESTION**: [K. Beyer] - On the final slide, funky looking posteriors, bimodality, can you speak more?

    - [N. Walton] This is one of those diagnostics from a MCBF that maybe there is a discrepancy between model and parameters. This can mean maybe we don't have enough GDR pars. OR maybe there is something in the experiment not described properly
- **QUESTION**: [G. Schnabel] I have a question about deep neural network emulator. Was there a lot of trial and error about the number of layers, or was it straight forward and you took something that was already there?
    - [N. Walton] - It wasn't too difficult using Keras TensorFlow package, has a nice way to random walk around a network design. Varies a few parameters and it started to perform really well
- **DISCUSSION**: [M. Chadwick] It seems like this NN emulates the XS well. What is the uncertainty on these cross sections. But if you look at data from other labs in general this process is much more complicated than it first seems.
    - [N. Walton] - I agree completely and we don't have all the terms accounted for. In the future we are looking to explicitly capture more terms.

Impact of cross section and fission yield uncertainties on the fuel inventory in a high temperature fluoride salt-cooled reactor

Speaker: Friederike Bostelmann

Overview: Propagate cross section and fission yield uncertainties to the fuel inventory during operation and spent fuel inventory. Want to identify which cross section observables are the main drivers of uncertainty. Fuel pebbles at target burnup are continuously replaced by fresh fuel pebbles, the average condition in each zone is approximately constant. Axial slices taken through the FHR core. Generated a random sample of XS and FPY then performed 1000 calculations using these random samples. Fission product yield uncertainties have minor impact, with few exceptions. Cross section uncertainties are the major drivers for spent fuel inventory uncertainties. Impact of BLO uncertainties for some key fission products point to missing covariance data. Sensitivity analysis comparing ENDF/B-VII.1+BLO and ENDF/B-VIII.1+BLO reveals missing covariance data influencing important neutron absorbers and reveals missing and updated covariance data impacting burnup indicators.

Discussion Items:

- **ACTION**: Missing covariances in ENDF/B-VIII.1 seen as action items: ^{148}Nd(n,γ) and ^{155}Eu(n,γ)
- **DISCUSSION**: [D. Neudecker] It's a case-by-case basis on how good the covariances are.
    - [D. Brown] - Uh so I want to point out the BLO stand for BNL-LANL-ORNL, when created, I was at LLNL so... meant to be low fidelity, placeholder/stopgap. BNL contribution was Kernal contribution (if I remember right), poor but quick and dirty and what was possible at the time. If can be improved, please do.
    - [F. Bostelmann] Is it better to include them since they have large uncertainties or better to just not do but leave out the uncertainties?
    - [R. Capote] – In JEFF they have been doing assessment of problems, probability use uncertainty coming from there, very comprehensive and well for inventory calculation. Low fidelity works better for educated guess, but not as well for high fidelity. We will not be able to do any quantitative assessment with low fidelity.

- [M. Zerkle] Low covariance data was developed by NCSP to test UQ tools to see if they'd break – so make sure you understand the application they were developed for.
- [J. Brown] - When using 7.1 BLO or 8.1 BLO, we can only assume we're adding here- that's been our approach for years – have not looked at JEFF data in years – assuming that JEFF hasn't updated covariances but could be wrong.
- [R. Capote] - You're wrong.

Gaussian Mixture Models (GMM) for data and covariance evaluations: a phonon density of states case study

Speaker: Goran Arbanas

Overview: Gaussian Mixture Model (GMM) as a framework for evaluations of non-normal PDFs. GMM PDF is a weighted sum of normal PDFs. GMM parameters may be made to obey normal PDF and enables use of General Linear Least Squares (GLLS) for such GMM. Phonon Density of States (PDOS) as a scaled symmetric GMM with scaling and symmetry enforced enables derivation of NJOY TSL analytically. Development of GLLS is relevant for thermal neutron because there is no current GLLS framework for thermal neutron scattering. With this formalism can propagate parameters to evaluation and covariance. Nuclear data models beyond thermal are functions of many parameters in contrast to the S(α,β) a functional of one PDOS. GMMs may, in principle, be useful for nuclear data evaluations, but the multivariate aspect of models makes it complicated. A simpler alternative may be to reduce GMM to a histogram (weights only).

Discussion Items:

- **QUESTION**: [G. Schnabel] I think it's a great idea to use mix models. Why does using the GMM create complexity? How should we assign to the covariance matrix?
  - [G. Arbanas] - It's not impossible in principle but it's not nearly as simple as what it is for phonon density of states when there's a single phonon PDF – that sort of technical complication that led to suggest histogram model – each step in the histogram is essentially a fixed weight gaussian with a fixed width.

Progress on Light Water TSL Covariance

Speaker: Chris Chapman

Overview: A previous covariance was generated with 4000 samples of S(α,β). Then fitted to double diff and total scattering cross sections. Linear weights were used to get covariances of variables of interest. This thing is huge, over 37 GB, even after optimization it is 8.5 GB. Our main focus is reducing file size. Looking at matrix decomposition, group strutting and manual entry removal. Manual removal involves removing any value below a certain threshold.

How to test covariance? Direct comparison, compare sampled cross sections, compare efficacy of sampled cross sections and applications (running through benchmarks). We performed tests on two cases. Created simple tests to verify response, a PST like and HST like system. Simple geometries of homogenous materials. Run in SCALE and got uncertainties down to 5pcm. Over 1000 sims with have the mean k_{eff} and the change in k_{eff} over the runs. There is some slight change in the change in the average, but it not significant. Needs some wiggling. The other is that there is a different between the

two system in the spread of the eigenvalue. We will do more internal testing before releasing the data to the wider community for external testing.

Discussion Items:

- **QUESTION**: [D. Neudecker] What you are doing to compare values to benchmarks is good. I don't understand the delta k_{eff}.
  - [C. Chapman] That is the change in the spread of k_{eff}.
  - [D. Neudecker] So this is the difference between the two methods. So this looks bad.
  - [C. Chapman] Yes. I agree. You are correct, that is bad. It might be linked to the sensitivity of the PST trials. It's possible with the uncertainty in that region is important vs a broader system. There is going to be very extensive to see if that is the cause of the issue.

New LANL FPY Evaluation Covariances

Speaker: Amanda Lewis

Overview: Hoping to take information and feed back into the evaluation process. Performed on a 21-energy grid, covariance is grouped into three files, there are cross nuclide and cross energy – Too large to include. Examples are included. New LANL energy-dependent covariances in FLATTOP-OY R-value calculation introduce new challenges. @ 1 MeV, there is correlation between products, which directly influences the uncertainty of non-reference isotopes. ^{99}Mo examples detailed in presentation.

Ideally this information will improve FPY evaluations prior to releasing. CINDER API used for decay heat calculations. Work toward ANS Decay Heat Standard with new LANL ^{235}U Yields. Done with brute force sampling, not the sandwich approach, which regardless would not be ideal. Correlated samples create issues when comparing, so arbitrary cut was made, which is not ideal. A new standard will need to be introduced.

Correlated sampling gives higher standard deviation at lower times. Also, large error bars at low time creates differences. No convergence study was completed thus far, planned as future work. Will allow for adjustment for independent FPY. At time studies, there is a oscillatory behavior in correlated data. In decay heat, independent sampling has a large correlation with times close to the current value. In correlated sampling, there is other correlation found.

New LANL FPY has covariance with cross-energy and cross-nuclide terms. Has significant impact on R-value and decay heat calculations. Future work will contain non-linear sampling.

Discussion Items:

- **QUESTION**: [W. Marshall] - Do you have a decay heat person? There is a lot of work going on, and he is unaware of the ANS standard if it is binding or not.
  - [M. Zerkle] discrepancies greater than 7% are troublesome
  - [A. Lewis] No. I am not trying to do that. I am getting yields to match better.

Evaluation Committee

Chair: Mark Chadwick (LANL)
Date: Thursday, January 8, 2025

Nuclide Inventory Sensitivity to a Fine Resolution of Fast-Energy Fission Product Yields

Speaker: Friederike Bostelmann, Marco Pigni

Overview: Talk given in earlier session.

Discussion Items: None.

Introduction

Speaker: Mark Chadwick, Roberto Capote

Overview: Many issues need to be addressed in induced reactions (specifically neutron induced).

Discussion Items: None.

Neutron standards

Speaker: Allan Carlson

Overview: Brief history of ENDF libraries, and how standards and methods evolved over time. In 2006 the IAEA provided a Coordinated Research Project with participants from several countries to evaluate neutron cross section standards. ENDF/B-VII addressed how inaccuracies and inconsistencies were handled by introducing additional uncertainty. In 2017 new evaluations were obtained for all the standards except ^{3}He(n,p) which was carried over from the last evaluation. Presently work continues on R-Matrix analysis for hydrogen and ^{6}Li standards.

Discussion Items:

- **ACTION**: "We need to figure it out."
- **QUESTION**: [M. Chadwick] - When will standards be finalized? I think we have time to go beyond this spring
    - [A. Carlson] - The hope was spring but maybe Robeto has something.
    - [R. Capote] - I think that realistic schedule will be within the year.
    - [M. Chadwick] - Some *nasty* things to figure out such as fissionTPC data
    - [D. Neudecker] - Roberto knows this very well, we looked at fissionTPC data, had discussions, etc. Have a new input deck. Conclusion – increase uncertainty of fissionTPC data for now.

New INDEN Pu-239 evaluation: Improving scattering cross sections

Speaker: Roberto Capote

Overview:
INDEN changed fission, capture, and (n,2n) cross sections. Still large inelastic cross section in n+^{239}Pu. There is also a noted disagreement with the evaluated nubar and CEA/LANSCE Marini data - 1% is too much for criticality. More than 1 sigma disagreement in some measurements and evaluations. Better physics/data leads to better performance.

Discussion Items: None.

Actinide nubar and PFNS evaluations

Speaker: Denise Neudecker

Overview: The point is that we have new experiments for Pu and U. We have new experiments lined up and it would be good to incorporate them into the library after they are complete. We need new ^{235}U PFNS because the crits have issues. We will eval nubar for Pu and U. Plutonium 240 has some strange structures. We will work on Uranium and try to understand nubar's through cross correlations. We will release ^{240}Pu and ^{242}Pu when ready.

Discussion Items:

- **ACTION**: Denise can work toward releasing PFNS for certain actinides – list not recorded. If interested, express interest to her.
- **QUESTION**: [M. Chadwick] - you mentioned ^{238}U in 8.1 already is out, is it only for neutrons of certain energy?
    - [D. Neudecker] – I misspoke, its in beta for 9.0, still open questions for nubar.

New ^{240}Pu evaluation in the fast range

Speaker: Nathan Gibson, Amy Lovell

Overview: Previous PFNS evaluations are from 7.1. Are going to reevaluate capture where URR and Fast regions connect. Uncertainty is lower than ^{239}Pu in some measurements but since it is compared to the ^{239}Pu, this is impossible. There is also missed data, overfitting, and updated data that can inform evaluation status. Using unpublished DANCE data to guide evaluation. Chi-Nu data and updated simulations are also being used.

Discussion Items:

- **QUESTION**: [J. Wemple] Are you targeting beta2 for test releasing
    - [A. Lovell] We are planning on having a complete cross section evaluation by the end of the fiscal year and to have done complete testing of PFNS with recent Chi-Nu data

- [R. Capote] For ^{240}Pu similar to others, be very important to use data and reaction theory to update evaluations.
- [A. Lovell] We are looking at reaction theory as well

URR challenges: Update to the ^{56}Fe evaluation

Speaker: Andrej Trkov

Overview: Report "Resonance Self-Shielding: Why it is so Important", LLNL-TR-2011238 by Red Cullen states that all evaluations should have a URR. JEF-2.2 includes URR from 863 keV to 3 MeV. Question's to be addressed: Is URR necessary? Does it cause double-counting of self-shielding?

In the final version (Slide 12 – e81_URR3q) kept unresolved resonance parameters with reduced s wave width by factor of 1000 with increased elastic, up to 1.75 MeV. Now agrees with measured values, above that just use XS as they are in evaluated data file.

Discussion Items: None.

Motivation for New Stable Zirconium Isotope Evaluations

Speaker: Greg Siemers

Overview: Interest in reevaluating Zr for a variety of applications. New data from ORNL/GELINA was collected and can be utilized. Working on RRR and Fast Region of 90 and 91. New/tweaked optical model parameters, and currently curating final data sets. Large DOE collaboration – RPI, NNL, BNL, ORNL.

Discussion Items:

- **ACTION**: [D. Neudecker] Before you leave your PhD work, don't forget to also provide covariances!
  - [G. Siemers] I promise there will be covariances.
- **DISCUSSION**: [G. Nobre] Just a comment Greg found interesting inconsistencies between natural and isotopic zirconium – can reach out for more information.

Zr-90/91 URR evaluations

Speaker: Alec Golas

Overview: Evaluation being performed concurrent to RRR and fast region evaluations of 90 and 91 – Primary issues are that the isotopic file 3s are sourced from natural – ^{90}Zr structure is visible in current ENDF-8.1 evaluation of ^{91}Zr – clearly not observable in experiment. The file 2 parameters don't model isotopic transmission well. Natural transmission is better modeled by file 2 parameters- indicating compensating errors. New Self-shielding URR functionality in SAMMY provides capability to fit multi-isotopic self-shielded measurements.

Discussion Items:

- **QUESTION**: [D. Neudecker] - What do you mean with implement a physical model? Please elaborate.
    - [A. Golas] The structure that is present, Greg and I, have been characterizing it in Sammy using a basic approximation. It's nice that the new Zr eval will go to the top of the spectrum so I only need to get the tail end of that structure.

Recent and planned updates to neutron standards for ENDF/B-IX.0 from R-matrix evaluations

Speaker: Mark Paris

Overview: Unavailable, possibly will be inserted into later call.

Discussion Items: None.

n+ ^{14}N

Speaker: Jordan McDonnell, Jesse Brown

Overview: We are looking to provide res para and covariance. We plan to have files for testing by end of fiscal year. We are using new SAMMY features to incorporate data from multiple channels.

Discussion Items: None.

Chlorine Evaluation

Speaker: Marco Pigni

Overview: Current status: RRR eval up to 1.2 MeV. Still need covariance. Tests on file from ORNL and LANL. Validation with ICSBEP and Terra-Power. We have a lot of measured transmission data, the eval is up to 1.2 MeV but the Los Alamos has higher energy. There are some fit issues but as a preliminary it is looking good. More refinement is needed and addressing documentation.

Discussion Items: None.

Photonuclear evaluations of major actinides

Speaker: Kostas Kravvaris

Overview: LLNL evaluation was in ENDF 7. No covariances in any of the current data in the photon sub library. New ratio data for photo-fission cross-sections and more data in pipeline, and both IAEA and JENDL both have new evaluations, but only photofission and MT5? First results are already available in GNDS format.

GLS over ^{235}U, ^{238}U and ^{239}Pu simultaneously. Resulted in significant changes in ^{239}Pu, smaller changes in the Uranium, and differences are currently sensitive to the selected datasets.

Discussion Items:

- **QUESTION**: [D. Neudecker] - How do you calculate nubar, what model?
  - [K. Kravvaris] its not a model it's just a straight line
  - [M. Chadwick] Why is your black line a lower slope than the data seems to be. You said you are fitting the data but if I look at the plot the red line appears to be a better fit than the black one
  - [K. Kravvaris] It is modified by the neutron production not just nubar.
  - [M. Chadwick] Quite a lot of other data exists, part of this new update it will be useful to review that history and see how you would handle those previous results
  - [K. Kravvaris] I think Sofia Quaglioni? has a report on looking into past experimental data – OSTI Report
  - [R. Capote] You will have to check to format.

8Be CN evaluation

Speaker: Som Paneru

Overview: New R-Marix analysis for ^{8}Be compound system was found to be inconsistent during fitting of reaction channels with identical particles in exit channels (i.e. $^{7}Li(p, \alpha)\alpha$, and $^{6}Li(d, \alpha)\alpha$). New ongoing work includes new channels that were previously missing and additional high energy data previously missing. Proper treatment of systematic uncertainties was also focused on. Planned to be finished in next few months (~3) and submitted for ENDF/B-IX

Discussion Items:

- **QUESTION**: [M. Chadwick] Tell us a little about the data recently measured.
  - [S. Paneru] - Some data was measured in 2022. From LANL.

Impact of the temperature dependent lattice constants and extinction on keff

Speaker: Kemal Ramic

Overview: Using N-Crystal and OpenMC we looked at Be temperature dependance. Scaled the lattice of the crystal based on temperature expansion. This method has limited differences in k_{eff}. At best 20pcm. The other major effect is extinction. This is more significant impact on k_{eff}.

Discussion Items:

- **QUESTION**: [M. Zerkel] - Transmission measurement on extinction measurement vastly overestimate the effect, and NCERC is also finishing measurements toward this, this summer.

Experimentally validated machine learned potentials for next ENDF release

Speaker: Kemal Ramic

Overview: TSL Evaluations to be submitted for next ENDF release, including temperature dependance on many materials and isotopes. See uploaded slide for list of material:

Cu, V, W, Ni, Mo, Pb,(already in NNDC git). Future work on SiC, ZrC, MgO, BeO, Be_2C, LiAlO2, Alloys, Molden Salts, FLiNaK, FLiBe, Propyl Glycol

Discussion Items:

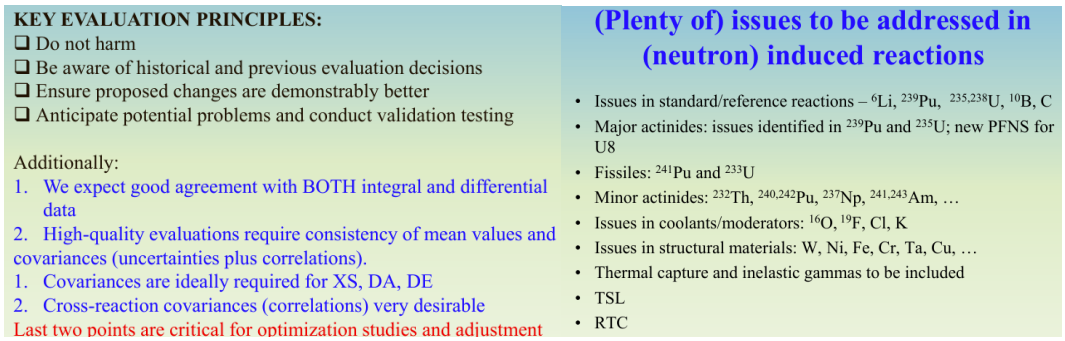
- **QUESTION**: [M. Chadwick] When will next more detail discussion on TSLs?
  - [D. Brown] I don't know maybe that is a reason for another mini CSEWG

Introduction – Panel Discussion: Toward ENDF/B-IX Evaluations & Addressed Issues

Speaker: Roberto Capote

Overview:

Two slides with many key points, see below:



For isotopes mentioned on slide 2, there are issues with either integral data, differential data, or both.

Discussion Items: None

Panel Discussion

Speaker: Mark Chadwick

Overview:

Note that Mark Chadwick also took notes during this session.

Introductory Statement: [M. Chadwick] If I think at a high level, let's look at fission and fusion, with regards to future reactors what sort of things might be coming up that have not been considered in recent decades. In the past there was more engagement with industry. Now with upcoming SMRs and other reactors what are some topics this community should discuss user communities topics for fission and fusion.

Fission Users and Applications:

- [C. Wemple] - One of the first this brings to mind is good handle on burnable absorber materials used in reactors, in their solid forms (not soluble) - deficiency is because until last decade most of data XS eval work has been NNSA and NCSP. Focused on depletions.
- [M. Chadwick] Why do you think there is a deficiency?
- [C. Wemple] So much data has been driven by NNSA or NCSP, so they don't care much about that.
- [M. Chadwick] Do you think it's just capture cross section
- [W. Dawn] If you want a headline these new reactors are targeting boron free operations
- [Will (next to Wemple)] - Why boron free?
- [C. Wemple] Plant chemistry. They want to get away from the acids using boron.
- [R. Capote] - assessment is true, but we should allow to happen un future release and have to engage user community to make sure evals are good for wide range of applications
- [M. Chadwick] Roberto that was specifically the ^{238}U capture issue?
- [R. Capote] - it was a combo it was the ^{239}Pu and ^{238}U was part of the but final solution involved Pu
- [M. Chadwick] We did end up with Pu testing that still looks not great for solution systems that is something we will want to solve over time
- [C. Percher] - might be benchmark issue
- [R. Capote] No but let's say that one of the things I wrote, reactivity temperature partition, this is closely related to depletion problem, everything is defined below 2 eV, but problem part for ^{239}Pu, you're right Marc that there's things we don't understand well so I hope that for ENDF9 we'll solve that problem.
- [C. Percher] - You just mentioned the Pu solution data that the new eval doesn't match as well as ENDF8 but in criticality community we don't know if we can trust it as well because it's very hard to characterize. Existence of acid changes solution of H, 4 valence state. In ICSBEP there are 800 Pu benchmarks but 670 are Pu solutions, don't have great coverage for thermal Pu besides solutions, fast crits are more metal systems. Unfortunately, Pu validation data isn't that great.
- [R. Capote] Still for uranium we have good agreement maybe because of chemistry we have issues, but they cannot be valid for uranium?
- [C. Percher] yeah so U is different. It isn't as chemically finnicky, we have a large amount of solid systems and have a lot of HEU and LEU, and have fuel like things in water and can also temper HEU solutions that do not have with Pu. TEX is one of only solid systems that is thermal, and TSL ones are also pretty good. I think it should be a priority on the experimental side for more that aren't solutions.
- [M. Zerkle] For (Cadmium and Gadolinium?) there is NR/NCSP work that should give us a better look at those nuclides to look at the deficiencies we have historically had. For the build out of the new fuel plants we should look at capture in cadmium. Should also be investigated for other non-reactor non-crit applications.
- [Vlad Sobes] So not directly on fission power gen. ARPA-E has several spent fuel transmutation projects currently, and in terms of evaluation, I'd just love to see some of the fission product stuff get cleaned up, so having continuous energy cross-sections that aren't discontinuous would be nice, since it could just be smoothed and not discontinuous
- [R. Capote] Just a comment on the fission products the main problem with the fission products is that we practically don't have data - I mean what is the caveat on the uncertainties let's say on the fast region is not clear to me

- [M. Chadwick] Do you mean fission products as target materials or?
- [R. Capote] Fission products are important because they capture neutrons, but the main capture happens on shortlived fission products. Because of the center point – so what's the point of improving on evaluations in which we don't have data?
- [M. Chadwick] - valid point but tangential to current talk
- [M. Zerkle] - do have new capability at LANL with DICER instrument, can do cross-section of selected activation products
- [R. Capote] - Does have value but for fission products it is not as simple. In 5 years will have many more fission products from DICER but may be over hopeful.
- [A. Trkov] I wanted to make a comment about the depletion problem – we heard that the VIII.1 is useless because the reactivity loss is still big, what we did was compare different evaluations but the VIII.1 reactivity loss was indeed bigger than VII.1, but the burnup scale is not so much – what it did for computer codes is good, but what it did for nuclear power plants is a different thing so there should be more attention paid to what's happening there rather than just what's happening from one library to another, have to take into account the energy contribution of different gammas, capture gammas, the decay of fission products, and that's something we have to study and identify issues. The reactivity loss depends not just on the cross section but also fission yield, decay data as well as assumptions, and approximations but that's something that's not addressed carefully.
- [M. Chadwick] when you said VIII.1 did you mean VIII.0 or VIII.1
- [R. Capote] it was VIII.0
- [D. Neudecker] I just wanted to bring something up on reactors from Rike Bostelmann– who looked at what isotopes are important for inventory study – cross section uncertainties cause changes for up to 25% in some isotopes [she's just reading the presentation; it's already been covered]
- [M. Chadwick] - Any other exotic fluorides and chlorides
- [C. Wemple] Not exotics but cycling back to vertical absorbers and primary absorbers as well, but one deficiency that's been propagated as well is that we don't have primary gamma emission from (Ag, Cd, In, etc.) isotopes which has been a problem for some time
- [R. Chadwick] That is the reason I wrote about thermal capture and needing a new evaluation.
- [M. Chadwick] I had raised the question about F and Cl because there had been experiments – would anyone like to add anything?
- [M. Zerkle] - Just finish up that work and leverage the measurements
- [M. Chadwick] What about plutonium? Chuck mentioned he's interested in ^{240}Pu – some companies are trying to make fast reactors to burn plutonium – is anyone involved in those discussions? At LANL we've been asked by Oklo to have some Pu to validate concepts – we did the first fast Pu reactor, but it had problems leaking coolant (lead or mercury) we were fine and we got good data.
- [C. Percher] - To your point Mark wasn't there an executive order about releasing Pu for fuel? Is MOX still on the table? I haven't heard anything myself. Right now OKLO's demonstration plans are going to use uranium reprocessed fuel.
- [J. Hutchenson] They are talking about MOX also
- [M. Chadwick] Aren't they also using HALEU in their plants? (OKLO)
- [J. Hutchenson] Less about HALEU more about MOX.
- [C. Percher] I visited their plant in Idaho and they're talking more about recycled Uranium.
- [M. Chadwick] Can you mention any work or is it all non-disclosure?

- [J. Hutchenson] - Non-disclosure about crit. experiments, world is aware recently we did BALOR atomics experiment. Mostly related to burnable absorber although design is so low in power. They are not burning them, same idea. Known collaboration with Westinghouse. Perhaps less relevant since the overall design it is based around is not being used anymore, still interested regardless.

Discussion on Fusion:

- [M. Chadwick] Shall we move onto fusion? IAEA is running fusion lead programs and are building upon that.
- [C. Percher] - I've been dragged into fusion – there are some more unique materials, I did a review of it for benchmarks and we saw tungsten, for basically all designs, doing neutron multiplication so in addition to tritium generation, they are needing to multiply neutrons (n,xn) reactions are important – Be and Lead are the most important – Titanium as well, and there's a lot of materials research going on as well as to what is able to withstand 14 MeV – but also a very wide spectrum of energy required throughout the reactor
- [M. Chadwick] - The in terms of materials, the concern is that if reactors work one day, but the damage level is 10x higher, so materials that can withstand flux is intense. Thought of creating neutron sources to test but hasn't invested yet. Europeans are building a facility, IFMIF-DONES, in Spain. It is probably decade out, deuterium-lithium source making intense neutrons. Sense is that will be a great source for nuclear science as well. Will be interesting to connect to that community. DPA will be important. LANL does fusion work, with MCNP for essential tritium economy calculations in terms of breeding reactions even ^{6}Li is used as principal neutron absorbed to make tritium, at 14.7 MeV the tritium XS is much, much, higher. If you have ^{7}Li you may be able to do even better. May be able to use Pb and Be, but another one, ^{238}U would give more neutrons per, and might get some fission products as well. If you look at economy, tritium is back, can get above 1 with MCNP with no losses, but there is hard work to make cycle work.
- [A. Carlson] Do you think that ITER will provide any information as to what's needed?
- [Y. Danon] - I published a paper about quasi-differential scattering using fusion relevant materials, we're funded to do that and Julian will do those measurements – first material is tungsten and the paper outlines the importance and the rationale is that the first wall and beyond is that the quasi differential models the shielding that the tungsten would provide
- [M. Zerkle] - will be important for radiation shielding analysis
- [M. Chadwick] ITER moved from beryllium to tungsten to the first wall and I heard from fusion friends that they always wanted to stick with beryllium and regret tungsten
- [RC] - Be is something that is missing, but should be there
- [M. Chadwick] - we know that last evaluation of Be from M. Paris and Gerry but too many questions needed resolving so wasn't accepted. Also Be scattering experiments are in pipeline.
- [D. Neudecker] Right on that topic the COGNAC array is relevant what we saw is that the angular distributions are not right for tungsten we saw the PFNS because the PFNS had structure and there's no explanation for that other than that the angular distributions are wrong
- [M. Chadwick] - And that as Roberto Capote pointed out that could impact performance in fast crits.
- [R. Capote] - there are two things, Chinese are making experiments for DT from Be, managed to separate (n,2n) and elastic, and also measured 6 angles. Have good info about what the evaluation should look like, also new data from LANL Be is important as reflector

and multiplicator, strongly depends on angular distributions and specifically back scattering will have large impact on crits, so do believe that we can really improve Be evals.

- [G. Siemers] One thing just to add on from Roberto about inelastic and gamma production, when I was working on quasi-differential, a big thing is elastic scattering, activation and inelastic states which will have some gamma coming out of the target and has impacts on shielding
- [D. Neudecker] - the other one is ^{27}Al it is good with XS but angular distribution has caused issues in PARADIGM and EUCLID. Seen it listed for fusion apps as well and if angle distributions are poor, they could be bad.
- [M. Chadwick] Reminders what is the data that indicates that the angular distributions are not good?
- [D. Neudecker] Toshihiko looked at data ND2024 looked at MF2 and shows they didn't fit together, will share with Mark later.
- [M. Chadwick] sure thank you that is interesting
- [R. Chadwick] That depends on the local resolution of experiments you have to be careful because I'm looking for somebody to indicate that the angular distribution is the most significant
- [D. Neudecker] – I can only say it mattered for PARADIGM, we did see a diff in k_{eff}
- [M. Chadwick] - Okay any more on fusion? Maybe I'll do a Q&A
- [A.Carlson] - ITER needs? Require improved cross-sections
- [M. Chadwick] - ITER's current plan is to have tritium production by 2036
- [J. Drieber] - ITER will be followed by DEMO, which will focus on applying the ITER concepts to a powerplant and will need tritium breeding. That group may be more likely to know nuclear data needs.
- [M. Chadwick] - This Commonwealth Company in Boston say they'll be doing plasma by (allegedly) 2027
- [C. Percher] - Someone said that anything with activation will be something they care about, that will go into shutdown margin and effect biological shield. Having this problem at NIF, structural material getting activated.
- [M. Chadwick] - I think my own sense is that this is one of the areas that materials will be massively important if fusion ever gets real – if indeed DPA's are 10x worse for reactors and we're activating everything, then it's going to be a massive issue for this community – I haven't seen anything for that yet, but I'm still waiting for it to take off
- [C. Percher] - they have a lot of problem's...
- [M. Chadwick] - Who here thinks that commercial fusion and tritium economy will be done by 30 years
- [some] - *raise hands*
- [group] - wrong way
- [some] - "50+ or never" *more raise hands*
- [C. Percher] - A gigawatt plant needs 50 kilo grams of tritium per year – our current storage is 20 kg – this is insane
- [A. Tonchev] - since we are talking about data for advanced reactors will you please tell energy that this reactor operates will you tell us about operating conditions and spectrum of advanced reactors. How different?
- [M. Chadwick] - do you mean for new advanced reactors being talked about?
- [W. Dawn] - Rike had some good spectra in her slides – sodium cooled fast reactors, 500 keV 1 MeV – for carbon you have like 10 eV, so this annoying in-between – we expect them to be very different

- [A. Tonchev] -that's different, so that's also a matter for the data we are thinking of
- [C. Wemple] - Advanced reactors were brought up - many molten salt reactors bleeding off volatile fission products, that's going to change beta, and they're not prepared for that – they're going to have to fundamentally re-evaluate their calculations
- [M. Zerkle]- For fluid fueled reactors of any kind.
- [C. Pecher] - Also thinking of using different reflectors too and they' think of – need more angular distributions.
- [M. Chadwick] - Final interesting fact on fusion. LLNL got over 18MJ and has a device Q value greater than 1 but the facility Q value is much less than 1. So, there is an example for how far is needed to go. First time fission was done we made 1e-4 joules – except for the big bang, 10^68 joules – let's be positive here
- [C. Wemple] - Yeah but that was uncontained.
- [all] - hahahhahaah

Discussion on Nonproliferation:

- [M. Chadwick] - two application that will be important, space detection and others, we did not go into much here. On non-proliferation side, any comments? NA22? No Money.
- [Matt Devlin] - I'll pass along for this – been a request for NA22 to add spontaneous fission to ENDF for a few cases at least.
- [D. Neudecker] - Do you mean PFNS or NuBar
- [M. Devlin] - All
- [All] - What nuclides?
- [Matt Devlin] - Cf, ^{242}Pu, ^{244}Pu?
- [NOTE] - Only prompt Cf is available in current ENDF.

Discussion on Fission Products:

[M. Chadwick] - Haven't gone into great detail on fission products – was there a session on the last few days? Never mind we can skip a big digression but are there any other comments? We have a piece of work that's been fantastic, but basically, we haven't put in updates for a long time into said work – what's the quick story on that?

- [A. Lovell] - There's been a push locally at LANL to put in new data that has been produced and put together formats and all MF8 and MF38, so great interest on Tuesday to test file formats to test continuous energy that would be put out and put our ORNL and much commercial interest, BNL, ORNL, NNL, etc. Test continuous energy.
- [M. Chadwick] - And by CE you mean not just thermal, .5, etc.?
- [M. Zerkle] - That's a big change to our analytical methods
- [C. Wemple] -A lot of getting the fission product cross sections themselves their very basic there is a minimum amount of data in there and many of them are very old
- [M. Zerkle] -It is time we to go beyond the lumped methods we have been using for decades
- [M. Chadwick] – Roberto, talk about fission products work done in Europe:
- [R. Capote] - While their evaluation produces energy dependence it would be my recommendation that the seminal point of interest is preserved correctly
- [M. Chadwick] - Have you, thinking on that Amy, specifically getting thermal right is very very important and need higher energy at more fidelity is crucial. See TUNL and other extrapolations to higher energies. We need that but thermal is dominated. {Discussion of historical data} LANL measurements that were never published, find agreement better than 2% but then was published in another paper. Looked Into Europeans doing better but particularly committed to doing better. Comments?

- [R. Capote] – The ^{235}U evaluation published, check data, can say they are using high flux reactors and new techniques and try to understand discrepancies. Very often those differences are in experimental corrections. For first time they include covariances. Reduce uncertainties. I think that whatever has been done keep an eye on what is there and compare with other evaluations.
- [M. Pigni] - Can I chime in? The point is easy to get but when I ask about the consistency between XS and fission product yields, in Rike's presentation, the energy is less than 1 MeV – so we are dealing with 500 keV, 700 keV, and we are dealing with a regime that is not very? But we are using HF modeling, and to me the consistency between FPY and energy dependence is not very clear – when we are calculating production cross-section in which the product is well – the mean is one of the major things in the FPY
- [R. Capote] - But my first comment was related, I didn't say anything about energy independent for energy independent for anything we do it needs to agree with TUNL. What I was pointing out was the Europeans are just doing thermal point, ICSBEP is not looking at energy dependence and the only statement we make is any new evaluation needs to agree with TUNL data.
- [M. Pigni] - What I am saying is that the seminal point is acceptable yes but when we do an energy dependent evaluation, we still have enough work to use do measured data that we don't have. I'm talking about XS that is highly resonant and if I'm talking about FPY in the RRR then I'd be struggling because I don't have data.
- [BJ Marshall] - In terms of FPY fuel reprocessing to harvest industrially or medically useful isotopes, could support that extract like ^{85}Kr from targets used to make Pu, will have more data to get FPY correct but with those will be commercial interests, but that doesn't always go well. Some of those things are needing of funding, more info and pressure upcoming. Harvesting Np targets would be great.
- [A. Lovell] - With regards to JEFF, we are aware the new one has come out, then we are doing our due diligence to compare ENDF to previous iterations to JEFF – historically there has been no agreement, but while we're going to take a look then we're going to do our own assessment to determine what to trust in addition to our historical knowledge and our conversations with the broader community
- [M. Chadwick] - This isn't a criticism, think of England and Rider in 1980's, probably pushing hundreds of years of human effort to make consistent.
- [D. Neudecker] - Because Roberto brought up covariance. I don't dare to bring it up in the evaluation section, but Rike brought up FPY and XS and several covariance is missing for several isotopes, would like to push beyond low fidelity. Overlaps with other sessions, with new list of new isotopes, we do need strong covariances or what do we do with this.
- [M. Chadwick] - Thanks

Standards Between Evaluations:

- [A. Carlson] new topic: I'm concerned that we don't have the same standards of the various datasets- these libraries don't have the same standards - what happens when one library is adopted by another?
- [M. Chadwick] - No
- [A. Carlson] -Why doesn't the IAEA make sure all laboratories have same standards?
- [R. Capote] - Generally the first point is that we have to find out what they are using. In JEFF-3.2, we have some evaluations that moved away from the standard – I told the Standards committee that this is nonsense – essentially they changed the evaluation. These days they are consistent with the Standards, but they still agree with the standards within one sigma.

Japanese have different standards and for some things they have been doing independent fits, but we have good agreement between what we do and what we have – it's getting much better.

- [A. Carlson] - we should talk about this at the end of the month.

Photonuclear Reactions:

- [M. Chadwick] - Let's talk photonuclear because applications need it, I think of big issues, actinides, not lot data. Pu LLNL, 40/50 years ago all we got. Existing eval agrees well, done 30 yrs ago. Seems to be hints that that needs changed based on ratio and or absolute data. Remind me which channels.
- [A. Tonchev] - It's absolute
- [M. Chadwick] - Absorption, fission?
- [Anton] -just the photo-fission but it eventually effects multiplicity through channels like (g,3n), (g,f)
- [A. Tonchev] - So the biggest surprise was ^{239}Pu– it goes up then when you make the ratios make sense...
- [M. Chadwick] - I want to use the data from here and TUNL, and it's likely that the uncertainties will be bigger than our previous estimation
- [A. Tonchev] - if you are just want to add this country had most powerful facility to tackle this photofission, as i show, one can do for less than 70hrs beam time can measure photofission XS data at one HIGGS @ Duke university, tunable from 1 to 20 MeV, going to measure ^{242}Pu in few months. Will have all actinides, ^{237}Np being produced, anything can be measured if samples are had, very efficient and very fast.
- [A.Tonchev] - When I looked at last set of measurements, they call it Subaru something – based on quasi-monoenergetic – our data also agrees with NuSUBARU data
- [R. Capote] - Most of the data of photonuclear IAEA data was made using NuSUBARU data, applied to many elements but unfortunately didn't have good data for actinides.
- [M. Chadwick] - basically did adopt for 8.1 which was IAEA with exception of some actinides. Only if US put in lots of effort ourselves.
- [M. Chadwick] -one other thing that has come up is Be. In our community as a photoneutron source, it is a cool source because it is low energy
- [J. Thompson] - Don't have enough data, only one resonance, only little above threshold, good data doesn't even go up to high enough
- [M. Chadwick] - Currently Be evaluation from China - could be good could be not good
- [D. Fritz] - There is a significant increase in electron facilities coming online, ^{226}Ra is hot commodity, want to make ^{225}Ac, lot of primary channels but primary one is (g,2n)
- [N. Walton] - Last comment on uncertainty quantification, looking at experimental data systematic uncertainties will just be reported in free text format, but usually on observables that are not the actual XS, but the corrections are usually. Had a difficult time estimating correlation structures of deconvoluted data, having some work in documentation besides EXFOR would be great.
- [M. Chadwick] - Roberto back to you for any more comments?... Must be 11 PM over there
- [D. Neudecker] - This seems a step away, but we talked about what isotopes are needed – regarding the Genesis Mission, and I know this might not be of interest, but we want to discuss how to put the data out for AI/ML ready reading.
- [M. Chadwick] -I wanted to bring that up when you were talking about ML I wanted to say of course there is enthusiasm for AI and it is a big deal in our labs. If you are not talking that language you may not get funded. This Genesis will give funding across DOE a component of

that is data curation to make it AI ready and in some ways our community is ahead of that. At LANL we are trying to get all of our data into a consistent format to use in Genesis. I think we can get some fast progress because we have made progress and can get good PR. We have seen ways that AI can design new experiments for example an AI suggested us to do a crit. experiment which was the largest crit. experiment ever. Managed to do 110 kilograms slab the AI told us to not just do spheres. And when we made a slab it did not meet predictions which shows there is something new we have to work on. In ENDF/B-IX AI will help us get the data in the right place.

- [A. Daskalaskis] - Note about AI, standard format conversations are ongoing for data governance, so there is some presentation material out there from WANDA (i.e. SENDF), if there is any effort towards a standardized nuclear data format, he is all ears.
- [M. Chadwick] - As a closing remark I will be stepping down as chair. Roberto will be taking over my position.

END OF SESSION

Validation Committee

Chair: Mike Zerkle (NNL)
Date: Friday, January 9, 2025

Welcome

Speaker: Michael Zerkle, David Brown

Overview: [D. Brown] gives summary of executive committee. Amy becomes fission product chair. Chadwick to step down and Roberto becomes eval chair. If you want to join NNDC git repo let them know. Invite may get stuck in spam filter.

Discussion Items: None

LANL Validation Results of Recently Released Libraries

Speaker: Noah Kleedtke

Overview: Brief review of recent experiments at NCERC, including projects related to MUSiC, PFUNS, EUCLID, PARADIGM, and TRISO. Neutron multiplication benchmarks comparing libraries were shown.

ENDF-8.1 improvement across the board compared to ENDF-8.0. Gadolinium systems have significantly different performance compared to JEFF-4.0

Discussion Items:

- **QUESTION**: Not sure if this is fair – yesterday M. Chadwick suggested AI proposed slabs for ^{239}Pu – Any other applications for AI towards critical systems?
  - [C. Percher] He was talking about EUCLID
  - [M. Zerkle] There are results, but it has not been benchmarked yet
  - [N. Kleedtke] They're pretty good models but they have not been documented fully
  - [R. Capote] It is quite interesting that we are using the same Cu, Fl, and Cl as JEFF for fissile evaluations

NNL Validation Testing

Speaker: Linden Cotchen

Overview: Presenting validation of MC21 runs. New evals for ^{155}Gd and ^{157}Gd. They expand the RRR from 300 eV to 500 eV. Results of the new eval fall in line with expectation. There is an improvement in average agreement. ACL trends appear flatter with new eval as well ATF trend. There is some trending with the Plutonium benchmark.

Only one ICT case with Gd (and in oxide form) - within 1 sigma of benchmark – reasonably close. HST benchmarks have more interesting behavior. There is an increasing trend tied to increasing Gd. Something might be going on with materials in the benchmark itself. Based on a paper by W.J. Marchall they identify that the HTS series might be problematic. The HSTs seem to have an issue compared to the PST one which have an expected behavior. Unknown what may be cause.

^{233}U - Focused on light water breeder reactor – uranium oxide enriched to 98% ^{233}U – motivated by spent fuel management bill – UST benchmarks were highly discrepant, removed from validation due to questionable material characterization – very strong agreement between ^{233}U and crits otherwise

Discussion Items:

- **QUESTION**: [G. Arbanas] Thank you for this impressive work, I'm curious about uncertainties from nuclear data, can you explain about uncertainties in nuclear data and how they stack up to calculations and other uncertainties
    - [L. Cotchen] - The issue with looking at integral experiments, is that it's tough to separate uncertainties and propagate them properly
    - [M. Zerkle] - For some benchmarks clear issues its characterizations, could be driving uncertainties planning on driving work towards re-characterizing benchmarks – could be worthwhile to have a collaboration, at least to find ones we all trust

ORNL Validation Testing

Speaker: Travis Greene

Overview: Used VALID suite to test 810 cases with ENDF/B-VIII.0 and ENDF/B-VIII.1 in KENO V.a/KENO-VI. SCALE 6.3 used with both libraries. Limited number of cases tested with TSUNAMI. ENDF/B-VIII.1 provides total $\chi 2$ per degree of freedom values lower than ENDF/B-VIII.0. Improvements in all categories of experiments except IMF, LMT, LST, MCT, PST, UCT, and UST. Work is also being performed for advanced reactor applications and nuclide inventories.

Discussion Items:

- **ACTION**: [M. Zerkle] - Should focus on earlier specified materials, i.e Gd which is expecting a new evaluation, and other materials related to planned ^{233}U work.
- **QUESTION**: [J. Brown] - this is me not knowing – in $\chi 2$ plot, there's jumps in the HEU and U-233, and everyone just accepts it – but why is that the case in HEU?
    - [C. Percher] - There is other stuff in it.

LLNL Testing of ENDF/B-VIII.1 with the COG Validation Suite

Speaker: Jesse Norris

Overview: Running COG validation suite – Mosteller, Full suite, ^{233}U and Pu – Suite represents 3420 cases from ICSBEP – Cross-sections ere processed by PREPRO – Extended COG validation suite to very easily swap parameterizations, physics treatments, etc. Mosteller suite agreed strongly with 8.1 paper – consistent improvement from 8.0 to 8.1 - Improvements across the board except for two cases: UCT-

001, and IMF-001 – Pu had worse performance but will be discussed – ^{233}U switches from underpredicting to overpredicting k_{eff} – In Pu solutions, 8.1 matches 7.1 quite closely – will continue to use suite to test different flux, URR, and TSL treatments

Discussion Items:

- **QUESTION**: [D. Heinrichs] - Can you go back to slide 14. If you remove Pyrex cases 8.0 looks better. The main takeaway is that 8.0 if making Pu worse.
    - [M. Zerkle] - How sure are we that Pyrex is appropriately characterized?
    - [J. Norris] - Benchmark uncertainties are being taken account of, but it's not sure
    - [C. Percher] - We know a lot of the Pu solutions have issues – if we're trying to game the system, not sure what benchmarks we can really trust- if you look at the end, the non-solution ones, they're basically the same
    - [D. Heinrichs] - Sure but the general trend is you see a 4% spread
    - [W. Marshall] When we get the PST to look good depletion looks poor. The challenge is these 2 different signals from 2 different systems, and the problem is finding why they disagree
    - [M. Zerkle] Really dependent on the solution temperature – if that was taken months after the experiment, then you can't trust those a whole lot
    - [Unidentified person] Next Step is to curate these benchmarks

AWE Validation Testing

Speaker: Mark Cornock

Overview: Looking at 90 benchmarks, checking if any broke for fast metal critical systems. Using MCNP but also processed data from raw ENDF, did not use published ACE files. We also processed using an in-house code for pointwise data. It can be seen 8.1 does better than 8.0 in reproducing the Cu pulsed sphere. Ta also shows decent improvement over 8.0. Overall, there is not much change in fast test suite of 8.1 over 8.0. However, Be is slightly worse, JEFF library may show some insight as to why.

Comparing cumulative $\chi 2$, both JENDL and JEFF are slight improvements over 8.0, however 8.1 is slightly lower. Per case, ~10 pcm on average difference. JEFF is better for low Z reflectors (Be, Li, Water), 8.1 worse for Be. Roberto, LANL team for EUCHLID, and others are helping to see if changes in data show improvements. Roberto's file changes the elastic/inelastic, shows improvement in Pu Pulsed sphere. Was not wildly changed or different but does change criticality under 100 pcm.

Discussion Items:

- **QUESTION**: [Nathan] - Just a comment on the Be. ENDF 8.0 to 8.1 did not change Be. So, there should not be much difference. We do still need to look at Be.
    - [M. Cornock] -Yeah, I think it definitely something we should look into.

Nuclear Data Testing at Studsvik Scandpower

Speaker: Charles Wemple

Overview: Multiple codes Monte Carlo as well as multi-group transport used for SSP data testing.

PEACOCK, general geometry continuous energy Monte-Carlo code being developed by SSP. NQA-1 Quality Assurance compliant, 10 CFR Part 21 adherent. Designed to be easier to use on lower grade hardware. Comes with prebuilt cross section libraries with temperature dependance. Takes input process from a YAML file. Code allows for temperature interpolation in a Monte-Carlo code. Had shared memory parallelism via OpenMP. Has full available decay data from ENDF, with cross sections from TENDL. 16000 depletion reactions tracked and requires 10 GB for cross sections.

Code has been undergoing validation testing. Over 200 ICSBEP cases tested. We compare well to other MC codes. Will discuss 3 suites. HMI006 (ZEUS with Graphite) wt. Copper reflector. Good improvement between ENDF 7 and 8. Still has a dependence on core height. There may be more work needed in copper eval in secondary angular distribution or inelastic scattering.

Next, is LCT011 and LCT051. PWR spent fuel pool configuration. Cases with solid boron have large negative deviation from benchmarks, up to sigma 3 deviation. Liquid boron is fine.

Lattice depletions. Through burnup cycles Helios 2 and CASMO5 have similar trends but still show differences. Note: CASMO5 used the JENDL4 Pu-239 eval.

Discussion Items:

- **ACTION**: Looking for thoughts and test cases for LCT – Please contact.

MCNP6.3 and OpenMC testing of the ENDF/B-VIII.1 Graphite TSLs using FUND-ORELA-ACC-GRAPH-PNSDT-001 benchmark

Speaker: Kemal Ramic

Overview: During ReGra a list was selected for benchmarks to target Graphite TSLs. Determine potential deficiencies in the benchmarks. In the FUND-ORELA-ACC-GRAPH-PNSDT-001 experiment, a pulsed neutron source hits a graphite 70x70x70 cm block inside a borated polyethylene box with Li6

glass detector measuring the slowing down spectra. The benchmark evaluation has many potential deficiencies. To get the MCNP input running needed to fix issues with cell importance and tally times. To match benchmark results, changed source definition to replicate the pulse width and remove incorrect beam divergence. Using MCNP 6.3 we replicated the benchmark using the porosity TSLs. There is not poly TSL assigned to the borated box, it should have been. By applying this fix the crystalline TSL has better agreement over the porous TSLs. Checking uncertainties the uncertainty of the detector glass thickness has the largest impact, and this makes the benchmark more questionable.

Then testing in OpenMC. Results are similar with proper behavior, but small differences may be due to how tallies are calculated. So, care is needed when comparing results. Also, attempted to test the model using SCALE, uses Maverick so it is very slow with bad statistics.
All inputs and outputs are available at request on github.

Discussion Items:

- **ACTION**: The benchmark should be reevaluated to address potential deficiencies, call for evaluators to provide inputs.
- **QUESTION**: [C. Percher] - We have discussed this but one thing to tell Is that we don't review the input files are not part of the benchmark. The ICSBEP is an internation project. For example, the Russians had codes with Cyrillic input characters. So as a reviewer we build our own codes and models based on the geometry and data in the benchmark.

- [M. Zerkel] - Refer to chapter 3.
- [C. Percher] - The benchmark is chapter 3 so any user should start from chapter 3. So, make sure benchmark models match chapter 3.
- [K. Ramic] -I agree – OpenMC has been built from Chapter 3 and Travis built it from chapter 3, and he built the scale model from Chapter 3 as well. It's also up to evaluators to provide their input files.

CSU/ORELA Neutron Thermalization in Graphite ICSBEP Benchmark - LLNL COG Results

Speaker: David Heinrichs

Overview: Purpose of the benchmark is to be not only code agnostic but also data agnostic.

Discrepant behavior outside of benchmark range – NCSU vs LLNL; porosity calculations did well, free crystal didn't do as well. If you turn off TSL for polyethylene and the water in concrete it worsens the results.

Discussion Items:

- **QUESTION**: [K. Ramic] - How can you justify these differences.? You present this as you believe it supports these results.
  - [D. Heinrichs] It's not the benchmark – the benchmark is a certain range of time – that's outside the window
  - [K. Ramic] I am saying your model may not be correct as I have the same behavior.
  - [D. Heinrichs] You're using the same data in both codes- you should be getting the same result.
  - [K. Ramic] I am not using the same data.
  - [D. Heinrichs] ACE data coming out of NJOY. The ACE data is used in both OpenMC and others. We know there is a discrepancy between NJOY and other processing codes – need external validation from LLNL and NNL.
- **QUESTION**: [C. Chapman] - If we keep saying the time bins are outside the benchmark, then why do we keep including them?
  - [D. Heinrichs] Have to make sure every calculation has its own normalization – due to the problem being a shape problem, not an absolute problem.

MC21 Testing of the ENDF/B-VIII.1 Graphite TSLs in the ORELA PNSDT Benchmark

Speaker: Jason Thompson, Jason Thompson

Overview: Analysis of ORELA using MC21. Note I am not a TSL person, but I want to understand the problem. Took evaluations as series of black boxes. This is preliminary with no drawn conclusions. In the experiment, measuring neutron leakage out of graphite cube.

Initial comparison: The porous eval does have a different response to the crystalline. What I think is happening is the crystalline is leakier, so more neutrons have leaked faster resulting in lower detector response at longer times. Comparison of cross sections: There is not a major different in total XS but there are more differences in Inelastic.

MC21 sensitivity study: start with crystalline evaluation, splice in porous evaluation cross section. Based on energy distribution you need to use the porous to get the correct result.

By replacing the angular distribution with each file. We find that replacing the angular distributions does not have much impact on the result. Our current preliminary analysis appears to fall in line with the results in the benchmark but more analysis is needed to check everything.

Discussion Items:

- **QUESTION**: [K. Ramic] - SANS stuff I have tested in OpenMC and there is no appreciable impact.
- **QUESTION**: [A. Hawari] - I just want to say thanks - Wondering if you could test crystalline library without Sd effect – porous library does not include Sd effect- might want to compare the two
    - [J. Thompson] - I did choose sd+ evaluation because during ReGra everyone was aligned with using the one-phonon corrected one – but that's not an effect that was considered.

TSL Validation using HTR-PROTEUS

Speaker: John Bess

Overview: HTR-PROTEUS tests under review. We found in ENDF 8.0 that the free gas carbon results are flipped vs previous evaluations. In 8.1 the free gas flip is still there but we also began graphite mixed with U235. It does not matter what enrichment is used they have similar results. Most of results are within 2 Sigma, except free gas it is significantly off. Water ingress cores are much less sensitivity to graphite TSLs. Using 100% graphite TSLs. As evals libraries progress performance improves. Will need better benchmarks with tighter uncertainties with high amounts of graphite.

Discussion Items:

- **ACTION**: Need more benchmarks with large mass of graphite and tight uncertainty.
- **QUESTION**: [C. Percher] - I had question about biases, I see some of them are large. What is driving them?
    - [J. Bess] - Alot of them are measured biases. The computation biases are around 100 pcm or less. More is experimentally measured. And they had detectors and pulled each one out to make the core full. Cores 1 and 8 were heavy with instruments. Cores 5 and below just didn't have as many detectors so they didn't worry about accounting for those spaces. Older cores had a lot of channels and driver cores. PROTEUS is different as fuel is on inside. So early core had a lot of open or closed channels, this adds more bias impact.
    - [C. Percher] - Which ones were the random cores?
    - [J. Bess] - case 5 and 6, is core 42, 43. Core 41 was thrown out as a benchmark, issue with loading process. Maybe a physics benchmark but not for crits.
    - [C. Percher] - I know you are not done with the benchmark but are the uncertainties reflecting the random core calculations that you did?
    - [J. Bess] - Yes. I like how the capabilities have advanced for simulating the TRISO pebbles and how you drop the pebbles in and they randomly settle.

Update on New ICSBEP Evaluations

Speaker: Catherine Percher

Overview: Recap of International Criticality Safety Benchmark Evaluation Project – International effort under the Economic Cooperation and Development Nuclear Energy Agency under the Working Party for Nuclear Criticality Safety. Try annual released, 2024 released in Dec 2025 – Hoping to fix to correct year in future.

New 2024 content – 2 new evaluations, 7 critical configurations (HEU over many energy spectra), 8 fundamental physics (Pulsed Neutron Die-Away). One major revision, Flattop with HEU core. Uploaded presentation details updates.

New 2025 content – 8 new evaluations, 19 critical configurations, 4 fundamental physics configurations, and 2 ALARM/shielding configurations. Final files provided to NEA and expected to be published soon. Again, uploaded presentation describes new updates.

Next ICSBEP TRG meeting is at the OECD/NEA HQ in Boulogne Billancourt, France April 13-16 (M-Th) 2026. International Reactor Physics Evaluation Project (IRPhEP) will be Friday April 17. List of benchmarks currently expected at the next meeting is also described in the uploaded presentation. Many new experiments are being designed to fill validation gaps and target novel materials or neutron spectra.

Discussion Items: None.

Data Testing of ENDF/B-VIII.2 Beta Chlorine with ICSBEP

Speaker: Eric Aboud

Overview: Currently only five benchmark evaluations that utilize chlorine absorbers exist within the ICSBEP. The experimental setups and C/E results for these 5 benchmarks were presented. All but one configuration is predominantly thermal, with one in the intermediate to fast regime.

Discussion Items:

- **QUESTION**: [Marco] - I am confused about the file test. Are you sure you tested the latest file?
    - [E. Aboud] - I downloaded the most recent one available
    - [G. Nobre] - I assume the version you used was collaboration with Terrapower, this file in on separate branch and will be brought in in the beta release, then you will have new file.
    - [M. Pigni] - Someone tested the TEX benchmark at LANL, was hoping to see the results from that file. We have to clarify that we are testing the latest file because I was hoping to have some feedback. Also sent email to link of latest file.

- [E. Aboud] - I did run with ORNL eval as well, didn't make it to the presentation. Do have and will send. No significant changes seen.
- [G. Nobre] - I assume the version you used was collaboration with Terrapower, this file in on separate branch and will be brought in in the beta release, then you will have new file.
- [M. Pigni] - Someone tested the TEX benchmark at LANL, was hoping to see the results from that file. We have to clarify that we are testing the latest file because I was hoping to have some feedback. Also sent email to link of latest file.
- [E. Aboud] - I did run with ORNL eval as well, didn't make it to presentation. Do have and will send. No significant changes seen.
- [M. Pigni] - Just wanted to be sure of results, no big deal – Also wanted to see test of file itself.
- [G. Nobre] - One suggestion is to always make sure you're referencing the hash of the file, that way you know for sure it's the exact same file.
- [???] some of these evals that have Cl and non-Cl are you doing those as well? The setup with and without a cl absorber would be helpful to make sure you can attribute to Cl correctly.
- [E. Aboud] - That's exactly what we did with TEX-HU and TEX-Cl. There are ones that are similar, but they didn't do one with and without, they just did a vast suite of tests. A lot of them are included in the COG suite.

Source Modelling in the LLNL Pulsed Spheres

Speaker: Tim Gaines

Overview: Jake Land (UG) credited for this work.

14 MeV neutron source generated from a 400keV Deuteron beam onto Tritium Titanium target.

Updated simulations of neutron source in recent history.

New Monte-Carlo code allows comparison with ACE files. Does neutrons in MCNP and charged particles and neutrons in external code. Can model any type of charged particle interaction, protons to alpha particles. Limited documentation from historical references. When removing certain materials, the old and new source match, but the new imposed source is harder to model. There are agreements between experimental, MCNP, and external code, but not all 3 at once.

Since not limited by imposed source, can modify target to change D buildup, and see differences. Low energy PFNS of U and Pu match well. Future work is to continue to modify the source to see differences and continue to see effectiveness of this charged particle code.

Discussion Items:

- **QUESTION**: [D. Neudecker] - Two questions. When you say slow do you mean running source once or running every time?
  - [T. Gaines] - Yes, we are unfortunately running the source every time. The source itself, the target is always the same. But sometimes it's in a nice big hollow entry so you can just do the source but sometimes when material is right against a target like in this ^{6}Li one, neutron interactions are already happening before your source is built up so it's hard to decouple.
  - [D. Neudecker] - It would be good to know when we need to use a static source.

- **QUESTION**: [D. Neudecker] - We had a student with Wim, Juan Dominguez, tried to simulate PT source, but could never get good comparison to the sphere, did you get that or only to the source?
    - [T. Gaines] - This one here (slide 16) we basically plugged it straight in and saw it matched nicely

Benchmarking and Validation of Gamma-Producing Nuclear Data For Well Logging

Speaker: Bor Kos

Overview: Baker Huges – Nuclear in-well logging, pulsed neutron well logging, simulations, gamma-producing nuclear data for well logging.

1. Passive: Measure natural occurring radioactivity emitting ionizing radiation.
2. Active: deploy radioactive sources in logging tools, measure scatter and secondary radiation from formation.

Looking at inelastic and capture (n,g) pulse height spectra. Pulse on – inelastic, pulse off – capture. Primarily done via CSG however does Unstructured Mesh as well. Need to make simulation reductions, using OpenMC and MCNP. Highly attenuating materials cause challenges. Many standards used, Rock formations, sulfur, Al_2O_3, and Glycol Calibration rebuilt in digital simulations and compared to physical experiments.

New sulfur standard ENDF/B-VIII.1 and JENDL-5 performed well. Aluminum alloy also performed well.

Dolomite $CaMg(CO_3)$ ENDF/B-VIII.1 has 2 deviation of oxygen peaks. Solution may have been found by LANL.

Copper simulations are missing 7.9 MeV line in ^{63}Cu.

Magnesium all libraries miss 3.9 MeV peak – open to suggestions.

MCNP cannot handle more than 1000 gamma-lines.

The libraries were compared for a number of other standards and solutions to identified issues were presented.

Discussion Items:

- **QUESTION**: [M. White] - I might have some info that may be helpful. I have some tribal knowledge. Back in the late 90's there was a project at LANL working on oil well logging. We created the capture gamma lines so when you are trying to do these simulations comes from this target. They never really reported the impact they made, because they were not engaged in CSWEG. We tried to keep it in ENDF7 but something might have happened. But I wonder if some issues come from that. Alot of this stuff does not count naturally so trying to put these in will require additional effort to get these in the library.
    - [B. Kos] - That's great- thanks for history
- **QUESTION**: [D. Brown] - To Morgan's comment – in 7.0 got rid of elemental evaluation completed, lots of elemental were model driven, so some got lost. In ENDF VIII.1, project brought some data back in, more work needs to be done. Appreciate testing and collaborating.
    - [M. White] - Other comment is that a lot of the work Phil Young did is that they cut lines off at 2 keV, weren't sure how to include that data – if you were here when I made that comment – someone had a nice plot of the multigroup data – if you did that for photon production data, you could see where gamma lines pop in and

disappear, you could see some beautiful gamma lines and if you have captures driven by higher energies, they go away – so just be aware of that too

Potential for Validation Data from Radioisotope Production at ORNL

Speaker: William Marshall

Overview: Pictures, allegedly ^{239}Pu and Ra.

HFIR central flux trap designed for trans-plutonium production. Beryllium reflector with numerous irradiation facilities and beam tubes for neutron scattering. High-fidelity modeling and simulation for radioisotope production uses a combination of MCNP and ORIGEN. The impact of typical assumptions needs to be investigated. Chemical processing losses and process variability are not well understood by radiation transport staff. They would need to be understood to compare yield to simulation predictions for yield.

Discussion Items:

- **QUESTION**: [M. Zerkle] -It does look like you were in secular equilibrium so that could be a new target for validation
- **QUESTION**: [Morgan] - HFIR is not a commercial reactor. So, you should be able to prepare deletion type benchmarks. I hope you would consider that?
    - [M. Zerkle] -It does look like you were in secular equilibrium so that could be a new target for validation
    - [W. Marshall] - The complicating factor in this in regard to HFIR, it's in the reactor and isotopes directorate, so there's organizational differences – the HFIR stuff itself probably isn't in GUI? Space – not being willing to come down on what's sensitive complicates that part. I feel like a mole – I can work with people to get more data

First Look at use of PARADIGM for ND Validation

Speaker: Annamaria McHugh, Peter Brain

Overview: The goal of the PARallel Approach of Differential and InteGral Measurements (PARADIGM) is to reduce uncertainty in nuclear data for ^{239}Pu in the 1-600 keV energy range by an aimed 50%. This region is the RRR through the fast range, encompassing the URR. Current integral measurements account for less than 5% of the ICSBEP benchmark suit. Two assemblies are used. Multiple responses are used from different data types, resulting in better constrained nuclear data and better assessment of compensating errors.

Leakage measurements are taken with 6 Bonner Sphere Spectrometers (BSS). For sensitivity studies, manual perturbations and the FESN tool are used. Both ENDF 8.0 & 8.1 are used and cause a shift in the simulation of mean energy of the neutron flux leaving the assembly, analysis indicates the existence of compensating error. Full nuclear data sensitivities are being generated.

Discussion Items:

- **QUESTION**: [R. Capote] - From the latest Pu eval it would be interesting to see the result? The INDEN Pu.

    - [A. McHugh] - a component of future work could be to use it
- **QUESTION**: [Unidentified person] - What's your prospect for getting the experiment evaluated?
    - [A. McHugh] - Maybe Jesson could give an answer?
    - [J. Hutchenson] - We are actively working right now – peter can comment on this – already done within the scope of the LDRD – once it's complete, we'll finalize the benchmark
- **QUESTION**: [R. Capote] - Did you characterize the response function of the Bonner sphere they are not usually used spectroscopy but dosimetry. It is kind of far fetching they can be trusted here
    - [A. McHugh] - Organic scintillators is what was used in EUCLID but those ended up failing – so that's why this spectroscopy tool was selected, but they're not the only ones used – foils were used as well
- **QUESTION:** [C. Percher] - You have uncertainties on the data -are those measurement uncertainties or are those data uncertainties?
    - [A. McHugh] - There are uncertainties, I just did Poisson error propagation - for the error bars. These were just taken from MCNP statistical uncertainty, probably could have done a better UQ job, but one issue is that manufacturers also gave just a 5% uncertainty without explaining where those came from.

Inventory Library

Chair: Andre Sieverding (LLNL)
Date: Friday, January 9, 2025

Welcome

Speaker: Andre Sieverding

Overview: What would an activation library look like? A nuclear sub-library for inventory, activation or dosimetry contains the nuclear data for processes that generally change the isotopic composition (transmutation) and lead to radioactive products as well as the reactions on the radioactive products themselves and their decay

Discussion Items: None

Activation Library Use in Target Design and Analysis for Radioisotope Production at ORNL

Speaker: William Marshall

Overview: They use activation libraries for isotope production, but new updated ones are desired. ^{252}Cf production was part of the original and still primary mission. ^{238}Pu heat sources for NASA RTGs are produced as well as anything else the DOE Isotope Program desires. There are tools designed for specific processes as well as general purpose tools such as MCNP used for depletion and activation calculations. Radioisotope production calculations would benefit from a new activation library, especially if it is consistent with ENDF data used in transport calculations.

Discussion Items:

- **QUESTION**: [A. Sieverding] - What is the shortest radioisotopes you can analyze.
  - [W. Marshall] - Probably a couple of days. There are some quicker facilities so maybe we could do minutes to hours. Not super-fast but not slow either.
- **QUESTION**: [R. Capote] - I wonder, I know in US for ling time people didn't bother with activation library – with JEFF they've been consistently moving forward – JEFF-0 has been accurate and they've gotten even better – at least look at what they have and verify what is already there
  - [W. Marshall] - I agree my understanding is the SCALE folks at least use JEFF.
  - [D. Wierda] - they are working on a new library and are testing with TRITON
  - [R. Capote] - This is good to know- the fact you have data you've been using according to your needs which are very specific – most of EU data has been for fusion or other use-cases they have no reason to produce actinides which is your use case – it could be convenient for both sides to look at each other's data
  - [W. Marshall] That is why I am here. To make those connections.
- **QUESTION**: [D. Heinrichs] - Is the latest released European activation data 2010?

- [R. Capote] - 2010 is certainly not the latest

Nuclide inventory validation: effect of nuclear data libraries

Speaker: Germina Procop

Overview: Goal is to assess the effect of ENDF/B cross section libraries on nuclides relevant to inventory validation for spent nuclear fuel applications. Looking to quantify the effect of nuclear data library for the C/E nuclide concentration ratio for actinides and fission products, use as a basis for measure nuclide concentrations from radiochemical assay (RCA) for four PWR spent fuel with burnup in range 30-70 GWd/MTU, and finally compare between ENDF 7,8,8.1.

RCA provides reliable basis for validating calculated nuclide inventories. Current resources are SFCOMPO, from OECD/NEA, and is publicly available. Challenges are in experiments, non-typical characteristics, aging data, and missing modeling data. The effect of the 4 PWR are from 2020-2021, making it less sensitive to limitations in the input data available for modeling. SCALE/TRITON was used for the nuclide inventory validation. C/E vs burnup for ^{235}U underestimates relative to measurement in ENDF 8.1, however ^{239}Pu agrees with different libraries. Other major actinides are predicted, with a variety of over and under estimations. Uncertainties in calculated nuclide inventory result from XS and FPY uncertainties. ^{154,155}Eu and ^{155}Gd has relative uncertainty greater than 5%. From ENDF 7.1 to 8.1, the XS data uncertainty is greater than 1% for ^{238}Pu, greater than 0.5% for U-234/236 and ^{237}Np, and less than 0.4% for all others shown. For fission products, >1% for ^{155}Gd and ^{154}Sm, >0.5% for ^{155}Eu, and less than 0.4% for all others.

^{155}Eu uncertainty differences in ENDF libraries may cause confusion and impact end users. SCALE uses Mark William's "special" ENDF7.1 file instead, ENDF8.0 is different but similar, and ENDF8.1 does not provide covariances. ^{155}Gd is one example of emphasizing the importance of reliable uncertainty data for reactor safety and end of fuel cycle.

There are significant impact and finding from an end user prospective, including change in cross-section libraries, and raise the question as to how we could better embed the user experience in ND generation, evaluation, and validation.

Discussion Items: See next Talk for any comments

Impact of cross section and fission yield uncertainties on fuel inventory for a molten salt fast reactors

Speaker: Germina Procop

Overview: Uncertainties in fundamental nuclear data—specifically neutron cross sections and fission product yields—affect predictions of fuel composition over time in a molten salt fast reactor (MSFR) model. Using a representative molten chloride fast reactor (MCFR) benchmark based on publicly available TerraPower specifications, employs uncertainty quantification techniques with the SCALE code system to perform random sampling depletion simulations. By perturbing nuclear data and running thousands of reactor burn-up cases, the study isolates the relative influence of cross section versus

fission yield uncertainties on calculated inventories of key actinides and fission products after irradiation. This analysis uses two generations of evaluated nuclear data libraries (ENDF/B-VII.1 and ENDF/B-VIII.1) to illustrate how choice of library impacts uncertainty magnitudes.

The results highlight that cross section uncertainties dominate uncertainty in predicted nuclide concentrations, particularly for major actinides (e.g., americium and curium isotopes) and certain fission products—often contributing several percent variation—while fission yield uncertainties generally have a smaller effect in the contexts studied here. Additionally, comparing ENDF/B-VII.1 and ENDF/B-VIII.1 shows that updates in evaluated cross sections can materially alter uncertainty estimates for specific nuclides. These insights are relevant to both nuclear data evaluators and reactor designers, as they underscore the importance of improving certain data sets to reduce predictive uncertainty in advanced reactor fuel cycle modeling.

Discussion Items:

- **QUESTION**: [A. Sieverding] - From what I hear you have everything you need in the ENDF library. There is nothing missing?
    - [G. Procop] - I already know there are things missing especially after hearing talks. Specifically looking at nuclides which have measurements from LWR space, cannot say we have everything we need in ENDF, will have to look more deeply
    - [D. Wierda] - Germina is right we use ENDF but we also use JEFF, TRITION uses JEFF
    - [G. Procop] - Misunderstood question - I noticed something missing in 8.1, but how we handle that data in scale is that for this coupled depletion simulation, we use ORIGEN the data from ENDF, but there are reactions and nuclides that may be important for nuclides which aren't in ENDF, and those we get from JEFF - JEFF-4 data complements our ENDF data - I don't work directly with it though, so I cannot give specifics

Reaction theory and workflow developments at LLNL

Speaker: Jeff Berryman

Overview: The object of this work is to provide uncertainty quantified predictions for neutron capture rates for species with weak r-processes. The reaction cross sections are calculated using the Hauser-Feshbach reaction framework. Uncertainties for nucleon-nucleus interactions are ready for use. The issue is there are massive numbers of calculation that are needed to work this out. We worked with Comp Sci individuals to help us develop optimal codes to make this calculation as fast as possible. Code developed called Maestro to break down a study into parts and performs a lengthy calculation. Merlin is based on Maestro but utilizes more parallel computation tasks, this can make it faster in some places but can be finicky and needs larger allocations. This new workflow has allowed for calculations for over 1500 nuclear species.

We have calculated the same astrophysics cross sections using the old and new method. And got comparable results.

From the purpose of an activation library if the correlation between species is not small?

Discussion Items:

- **QUESTION**: [G. Nobre] Great presentation - my concern is that it's based on Koning Delaroche potential, so it estimates well for nuclei in which the model was based on (spherical potential) but in nuclei in which the potential is deformed, how have you considered that? I was looking at germanium and that's the region of interest.
    - [J. Berryman] That is an excellent point there are no concrete plans to address that yet. We have no plans. This is trying to address the discrete energies. We are committed to working in spherical land - but this is a proxy for a much larger discussion on Koning-Delaroche. This is part of a larger discussion of modeling biases from sticking to a specific form. The question is why results change when more physics is added. We should consider spherical OMP in more detail. Cole and others on the team have been working on studying the modeling biases that occur when sticking to a specific form - so a concrete demonstration why the results change when more physics are added in are more important – other contributors have been developing UQ for optical model that does more. Cole and others on the team have been working on a new UQ optical model, but specifically deformation falls outside of the scope of this project. Potentially a future LDRD could address that. It is an excellent point but deformed, falls outside the range of this project. Maybe later though it could be looked at in a future LDRD, but it is not something we will be able to solve by the end of the present project.
    - [Unidenfied person] Global potential but you want to move far from the realm of stability but there you really need less ideal potential, so when you're doing your UQ it's very usable, but it has to be aware of your limitations
    - [J. Berryman] - My perspective is that all models are wrong but some are useful - can't argue that Koning-Delaroche is not useful – if we're able to more sharply quantify the deficiencies of our model, then that would be very useful, but we'd need additional apparatus. Let's be honest about our deficiencies, and hope that money falls out of people's pockets – at some point we'll figure it out.
- **QUESTION**: [Boris Pritychenko] – I'd like to ask about physics - the r-process is difficult beast because it happens on its own side we don't know decay rates or anything, and that will also depend on the astrophysical side where it happens, so something like arsenic, how do you deal with a lack of knowledge for those cases, and I've never seen those factors for those
    - [J. Berryman] We make well defined choices and stick with them when we can. When we have to make choices be upfront. We sometime use hybrid experimental masses and combine with FRD2012 values.

      [Technical difficulties led to missing some of this discussion]
    - [J. Berryman] In terms of beta decay rates we are deferring to the set of rates the astrophysical community recommends. You are correct the r-processes is difficult to tame what we are trying to do is report on the whole soup of numbers that enter this problem and hoping we can move the ball a little and at least solve a piece of the problem

Reaction theory developments at LANL

Speaker: Amy Lovell

Overview: LANL is focused on compound and pre-equilibrium reactions of medium to heavy nuclei in the fast to few tens of MeV. The CoH3 Hauser-Feshbach code is the central role. Recent upgrades were made to improve width fluctuation based on GOE, unified description of direct and compound reactions, and improved fission models. Statistical decay model was also expanded to beta-delayed neutron emission and fission fragment decay, using CGMF and BeoH. HF-BCS + QPRA with non-iterative FAM nuclear reactions are used for neutron capture and photo-induced reactions. Quantum mechanical direct and pre-equilibrium models for inelastic scattering without adjustable parameters is in PRC press.

Coupled channels and H-F CoH3 has many special features and can be found at github.com/toshihikokawano/coh3 . Spherical and deformed targets, including single channel optical model and coupled-channels optical model are included. Multi-particle emission and exclusive spectrum are now available. Beyond optical model and H-F, photon channel, fission channel, direct reactions, and pre-equilibrium emission are all being improved upon. Impact of initial spin/parity on inelastic scattering models, with examples from Pb-208 are described without adjustable parameters. In conclusion, LANL is tackling the high energy range efforts. Microscopic nuclear structure theory, maintaining model codes, and nuclear data file production are all top priorities.

Discussion Items:

- **QUESTION**: [G. Arbanas] - Thank you for the work. I am wondering what are the interference effects between various process?
    - [A. Lovell] - As Jeff put up we use the same Hauser-Feshbach. But for a couple of channels where you are getting a CRSS you will get all the interference in the calculation.
    - [N. Schunck] -Quick comment for microscopic theories in general. Often it is made the statement there are no adjustable params. But there are some they are tied to things like masses and ground states. You can consider generating a Bayesian distribution to get a family of E1 and M1 cross sessions. The params are still their you still need to do UQ but you can vary things
- **QUESTION**: [A. Lovell] - I know you have worked with Skyrme parameters; it would be interesting to use different functionals and see the effect
    - [N. Schunck] -It could be extended to cross section calculations which has not been finished yet but there is ongoing work at Brookhaven.

Discussion

Speaker: Andre Sieverding (LLNL)

Discussion Items:

- [A. Sieverding] - Activation session at Wanda.
- [D. Brown] - It be good to give users an internal consistent library. By internally consistent I mean allow transport or astrophysics from the same library.
- [J. Brown] - At max volume, still can't hear Dave Brown's usually great voice, note the compliment on his normal projection abilities

- [D. Wiarda] - I want to reiterate what Dave said – a backstop is good but even better is that the backstop is consistent with the whole ENDF library – because you have currently inconsistent levels and positions, and we should not have that
- [Unidentified person] - I would state that the various codes that have the ability to do produce these libraries have been asked to produce this before. Some of them may be hesitant because they are considered of the consequences if the information in the library is incorrect.....

  [rapporteurs had technical problems preventing note-taking]
- [Unidentified person] - Used and believed and have impacts and hopes and dreams and wishes and useful models
- [M. Zerkle] - We have three years or more of experience developing our activation files – would it be possible to collaborate on that at the next WANDA?
- [A. Sieverding] - At WANDA we have people scheduled to talk about activation library in FENDL and how they went about that. And Jean-Christophe's.
- [A. Sieverding] -I'm impressed from Tuesday based on the whole validation framework that JEFF is using for their whole library that we don't have to that extent, and ideally, we'd have that for the activation library as well
- [M. Zerkle] - US does have two high-performance test reactors - at least for reactor spectra to validate the activation lines - many other facilities have the capability to test that as well
- [A. Sieverding] - But doing to more on a large enough scale since you have so many isotopes
- [M. Zerkle] - So a part of that suggestion is to get lessons from Europeans to get lessons
- [J. Brown] - how long does it take to make this? Is there going to be a decision-making process? When?
- [G. Nobre] - One goal is to push for one or not, and the goal is to push for a library, and I suppose this is a very good time to start this discussion, since we just released VIII.1 and the next one is a few years away. When we start converging to the release, (5 years from now) then that should be feasible
- [G. Nobre] -Now is the right time to start planning these details we can aim the release is in 5 years maybe plus one or plus 2 years we should be planning those details how we should be following up
- [A. Lowell] - Golden rule of CSWEG - how much will this cost and who is going to pay for it? Do we want to put out every calculation? Do we want to just do this quickly as needs arise? Having the capability to very quickly put out a file would be great, but it's probably not necessary – and if it came out quickly that could be bad because it could distract us. We worry if we put out everything people will say this is bad and now, we have spent time on data that is not relevant to our day-to-day life.
- [A. Sieverding] - One of the first steps would be to have a candidate would could be produced - the key question is whether to say if this will be ready by 9.0, 9.1, etc., and maybe this should be several projects to build such a library and the framework around it. The thing at LANL is to develop these workflows and then very quickly put them into the formats that are commonly used - the point is at WANDA to use funding from a related project
- [A. Sieverding] - One idea would be to have a candidate or multiple candidates. Groups are working on this capability. But if it will be ready by 9.0 will depend on if we can get funding... One big thing at LLNL and LANL is to put these calculations into the formats that are commonly used
- [Unidentified person] - Longstanding debate as to whether there's really an ENDF-8 since it doesn't really get used by industry

- [M. White] - Recommends reading Jimmy Wales's book. People were skeptical when Wikipedia first came out but now although it is not always right, it is trusted. For libraries to be trusted they will have to be released so they can be tested. Just remember to through tomatoes at underlying issues not at people. Kudos to TENDL for releasing evaluations for us to test.
- [Unidentified person] - One library – same one for transport and activation – That will be extremely challenging, and just Frankenstein the libraries – with the data already existing in ENDF/B, they won't be consistent

  [Connection issues affecting Rapporteurs]
- [A. Koning] - this will increase the Frankenstein nature of the libraries if I make the data and there is current data that has been integral evaluated in working reactors. Every single reaction added to the - use files need to be tested 3,4,5 times to make sure it doesn't mess up reactions already there. You could either make a library combining activation and transport or keep them separate. In ENDF people are interested in specific isotopes but in TENDL we focus on all equally and update them at the same time. For high quality data needed for crit safety our approach is not sufficient. I have seen from the last 2 talks interest in automated generation, maybe this could be combined with the expertise currently used to generate ENDF.
- [A. Sieverding] - Can take libraries from other sources. My idea with the ENDF activation library is the merging can be done ahead of time rather than the users needing to do it on their own each time.

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