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**Title:** We Should Pay More Attention to Covariance Updates!

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# We Should Pay More Attention to Covariance Updates!

Nathan A. Gibson, XCP-5  
CSEWG Covariance Session

Wednesday, November 15, 2023

# Bottom Line

## Covariances matter

- Real, impactful workflows use covariance data
  - Criticality safety (USLs), NRC licensing, national security studies
- Poor quality data affects future investments and credibility
- Best estimates are turning into BEPU for more customers

## Community engagement needed

- We need to discuss and debate covariances as much as mean values
- Lacking stability, agreement on methods, robust validation, etc.
- WANDA 2024 will have a session on this!



# Case Study: Pu-239 (fast)

## Why Pu-239?

- Among the highest profile updated evaluations
  - Experimental investments leading to data between VIII.0 and VIII.1 near \$100M
- Hybrid file solution
  - Easily shows differences in approaches between evaluators/groups
  - Creates questions about consistency and correlations
- Hybrid collaboration/competition model
  - Covariances not considered at decision points – what is the implication?
- Where my personal focus has been
  - Setting up internally high-profile LANL UQ effort
  - Assembly process put my attention there



## Important caveat:

This case study is to show how things have changed and how different approaches lead to different results. I am not trying to name winners and losers, right or wrong. Only trying to start a longer-term discussion!

# Assembly Issues

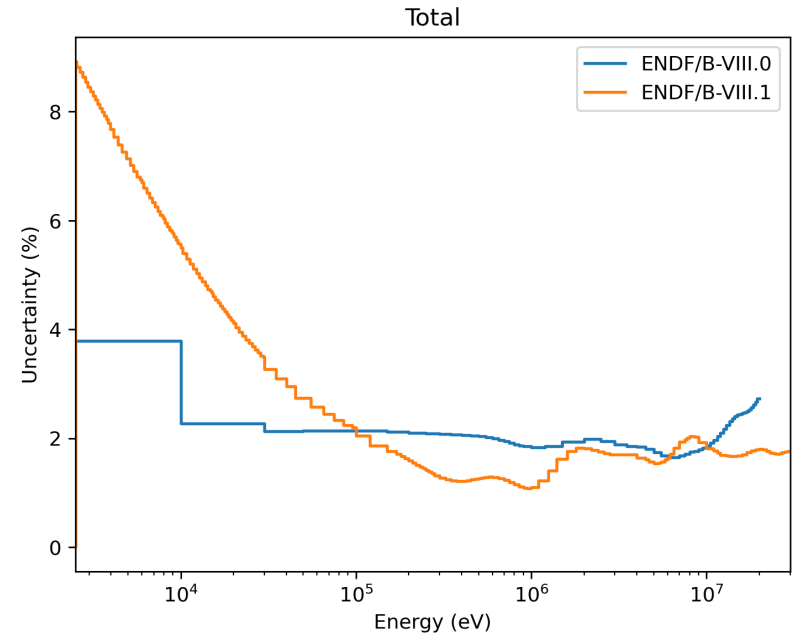
- Covariance components came from 5 efforts!
  - INDEN, Standards, LANL, ORNL, ENDF/B-VIII.0, ...
- Some moderate manipulation needed
  - Cutting off to appropriate energy bounds, etc
- Most of the bugs seem to have been fixed
  - Hole in nu-bar covariances, etc
- Still a few oddities to investigate before final release
  - Correlations in thermal nu-bar
  - Empty and unnecessary cross terms

*I'm working on this, but it's hard to catch your own bugs!*



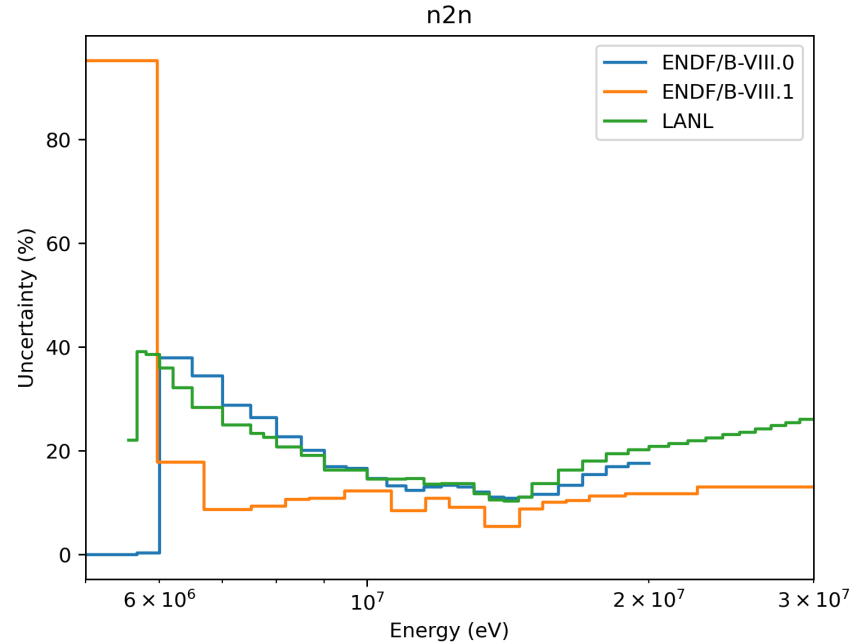
# Total

- VIII.1 evaluation from LANL
- Striking increase in reported uncertainty at intermediate energies
  - Consider all the values in ENDF we report < 9% uncertainties for...



# n,2n

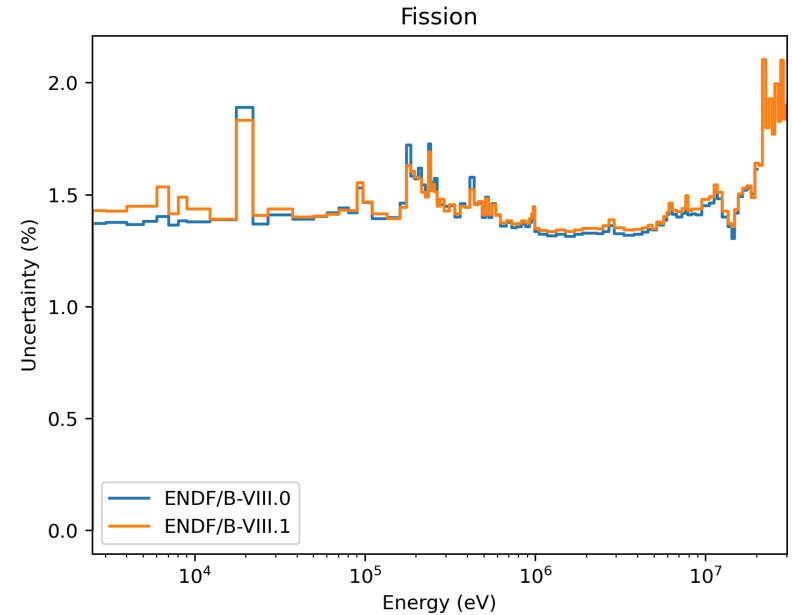
- VIII.1 evaluation taken from IAEA
  - New data from CEA/Meot, GLS with EMPIRE prior
- Greatly reduced uncertainties compared to VIII.0
- Discussions between LLNL, LANL, and IAEA started, but neither were completed nor lead to changes
- LANL evaluation candidate closer to VIII.0





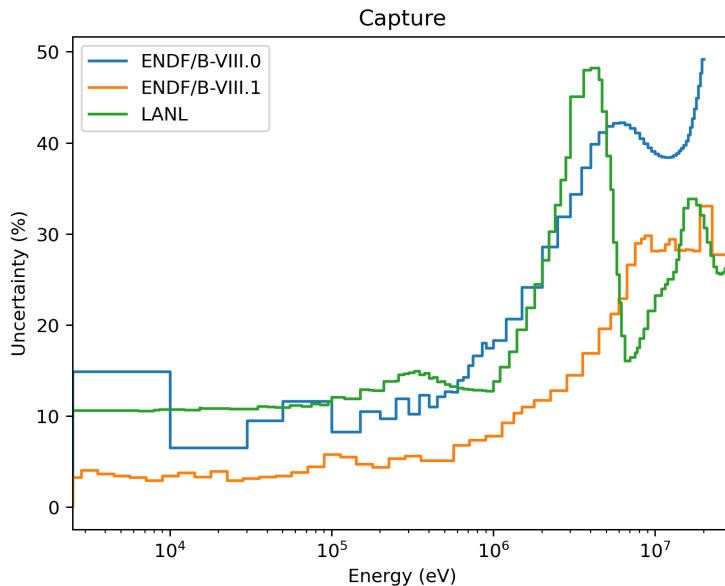
# Fission

- VIII.0 and VIII.1 both come from standards group
  - But we can't update the standards before IX.0!
- Overall similar uncertainty profiles
  - See Georg's talk for detailed discussion of how these are developed, USU, etc.



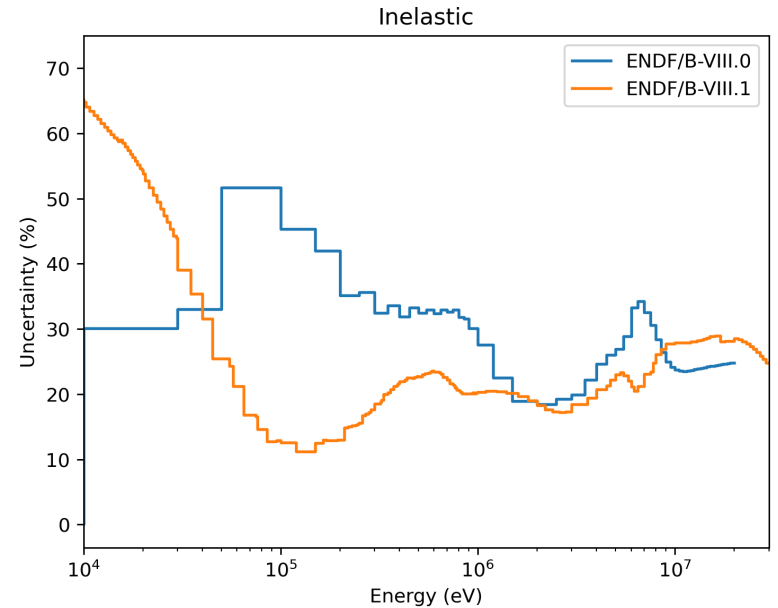
# Capture

- VIII.1 coming from GLS approach from IAEA
  - New data from Mosby/LANSCE
- Uncertainties greatly reduced from VIII.0
- LANL analysis kept uncertainties closer to VIII.0



# Inelastic

- VIII.1 evaluation from LANL
- Uncertainties reported for lumped MT4
- New uncertainty shape almost a mirror image of VIII.0



# My questions

- Are reduced uncertainties stemming from trustworthy newly acquired data or differences in evaluation approaches?
  - GLS vs Kalman, etc
- Do increased uncertainties imply VIII.0 was overly optimistic?
- If two evaluators come up with similar means but different covariances, and CSEWG does not consider covariances in selection process, how can we trust our data and our processes?
- If major actinide covariances are changing so much, what does this imply for the rest of ENDF?
- Would we accept a file with this level of inconsistency and deviation from previous work in mean values?



# A few scattered thoughts

- An incredible number of covariances were added between beta1 and beta2
  - Mostly IRDFF dosimetry reactions, some the only reaction with reported uncertainties in a file
- R-matrix fits, GLS fits, Kalman filter, ... -- all seem to give very small uncertainties by default
  - Are mathematical models being applied correctly? Are we handling inconsistent differential data appropriately? How do we decide how much to rescale? Are experimental uncertainties trustworthy?
- Formatting and processing are causing a lot of headaches
- Correlations are at least as important as uncertainties
- Adjusting to integral data requires good priors
- Lots of effort going on to get the best covariances we can have before VIII.1
- I'm not *that* crazy – we'll have plenty of follow on work for IX.0! 😊



# Not all doom and gloom!

- We're catching things before the final library is released, thanks to lots of community V&V
- Many more rounds of iterations -- testing throughout betas
- Templates of experimental uncertainties are changing how we interpret experimental data and evaluate covariances
- More coverage than ever of ENDF nuclides
- User community is growing (which ties back to challenges, of course!)



# Topic for mini-CSEWG / IX.0 and beyond

Can we develop “a Vision, a Strategy, and a Plan” for talking about uncertainty?

*Needs to be a community effort!*

## Step 1: Community **Vision**

- What UQ use cases are we supporting?
- Do we need a major change of course or a small pivot in our procedures?

## Step 2: Community **Strategy**

- How can we leverage our institutions and funding sources to enable the vision?

## Step 3: Community **Plan**

- Develop a challenge problem to compare across different evaluation strategies
- Define meaning of uncertainty in ENDF and communicate to collaborators and users
- Robust V&V beyond mathematical checks
- ...

