OAK RIDGE National Laboratory

# Safety-significant covariance?

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# Outline

- Safety case for validation gap
- Brief summary of a case study*

* Taken from W.J. Marshall, "Lost and Found Opportunities Around the Chlorine Worth Study," ICNC 2023, Sendai, Japan, Oct. 2023.

# Safety case for a validation gap (1/4)

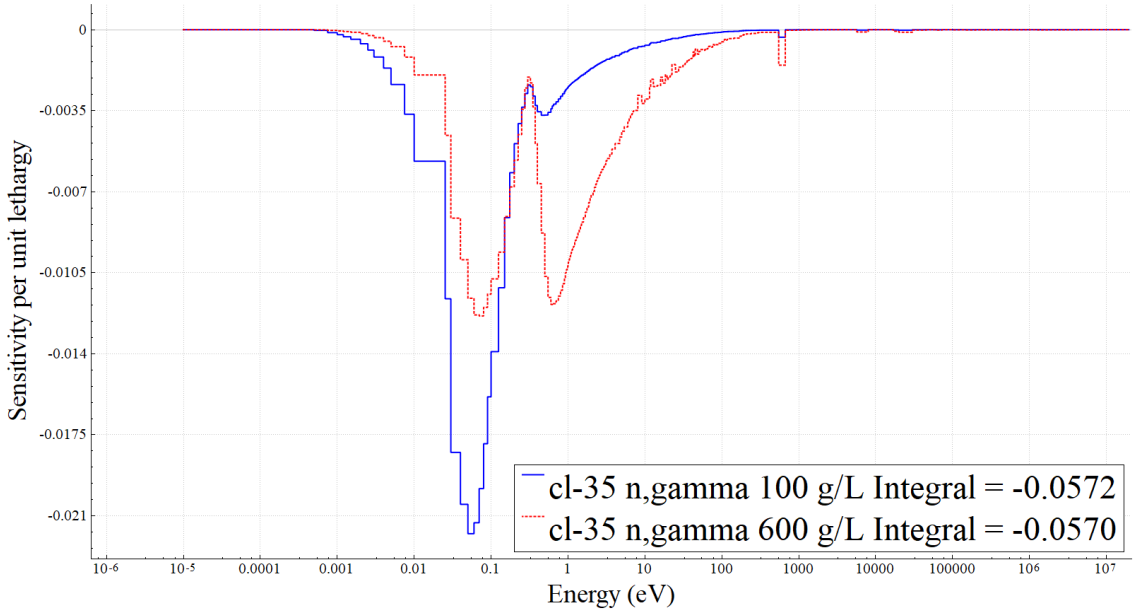
- Validation gap or weakness:
  - Material present in safety analysis model and
  1. Absent from validation benchmark set **OR**
  2. Not well represented in validation benchmark set
- Could neglect presence of material if absorber
- Could perform additional experiments to fill gap
- Could assess a reactivity margin to apply to the upper subcritical limit (USL) to account for gap

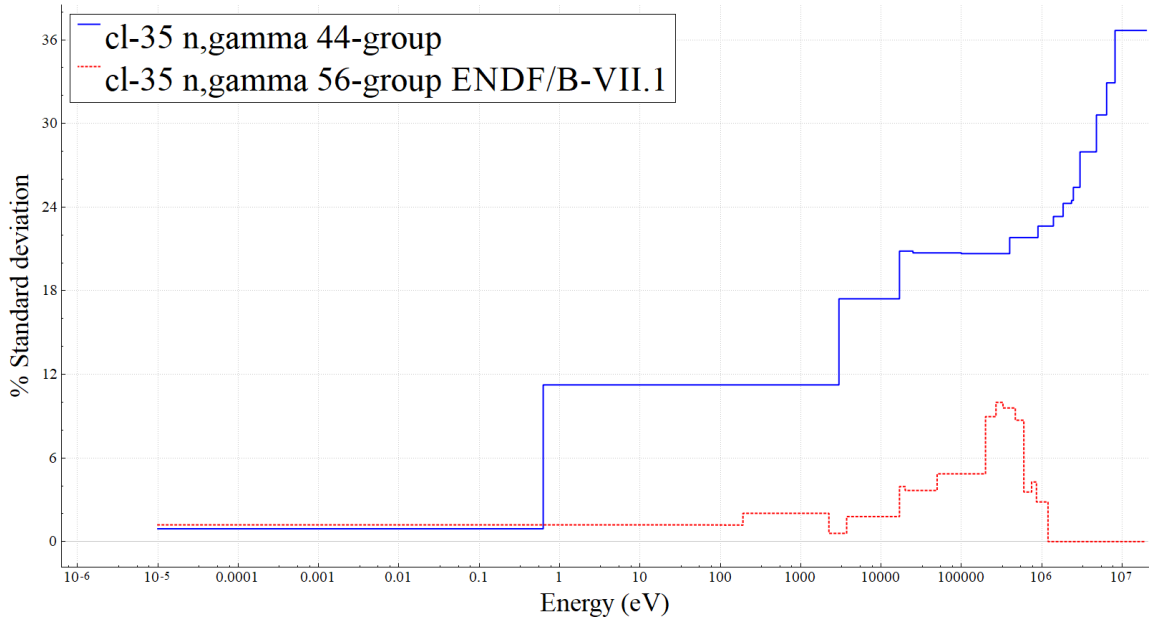
# Safety case for a validation gap (2/4)

- Methods to determine magnitude of margin:

1. Guess a margin large enough to satisfy reviewers/regulators
2. Engineering judgement based on prior similar experience
3. Safety analysis model calculations to estimate impact of potential error in unvalidated material
4. S/U-based uncertainty propagation
   - Same as option #3 but way fancier

# Safety case for a validation gap (3/4)




Application system sensitivity to missing nuclide, generated by TSUNAMI in SCALE or KSEN in MCNP

Generic covariance data, here $^{35}Cl$ (n,γ) from SCALE 44-group library and 56-group ENDF/B-VII.1 library

**Uncertainty is believed to bound the bias, so propagating it to the system of interest estimates the potential bias from the unvalidated material**

# Safety case for a validation gap (4/4)

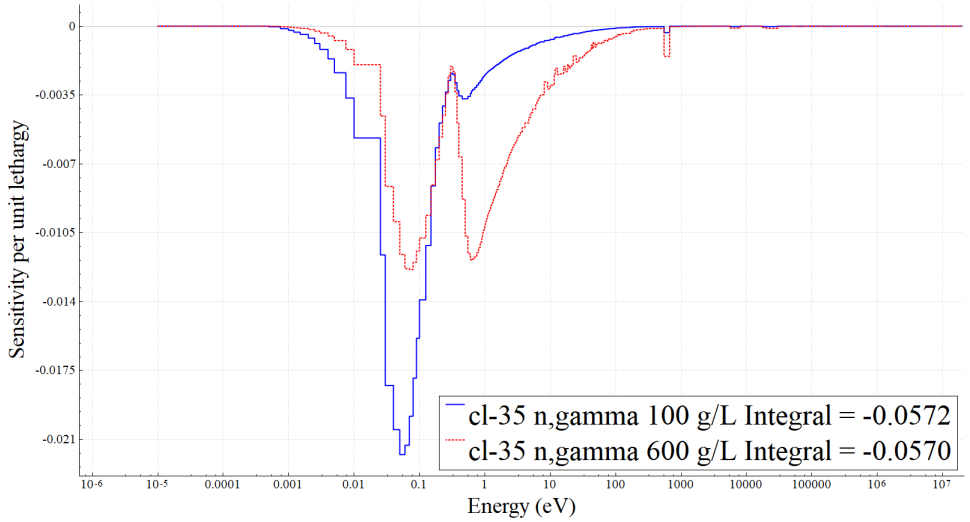
- Defense needed to accept margin based on covariance data
- Options:

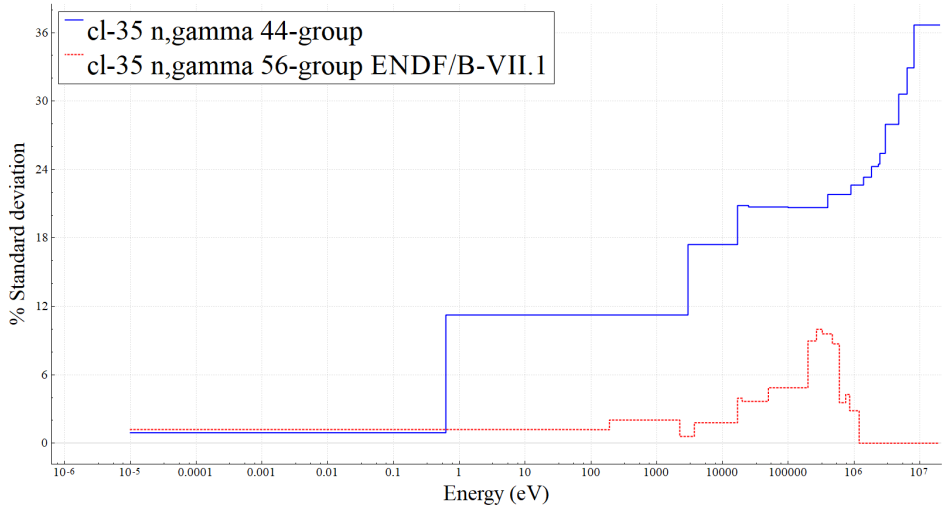
1. Argue it's better than arbitrary guesses or engineering judgment
2. Use different libraries to examine variability of margin
3. Look at different covariance estimates qualitatively
4. Find the evaluator and discuss

# Case study for option #2: Impact of multiple libraries

- Two $^{239}PuCl_3$ application systems:
  1. 100 g $^{239}$Pu/L
  2. 600 g $^{239}$Pu/L
- $^{35}$Cl (n,γ) sensitivities very different
- Covariance estimates very different:

| Library | 100 g/L model (pcm) | 600 g/L model (pcm) |
|---|---|---|
| 44-group SCALE 6 | 78 | 264 |
| 56-group ENDF/B-VII.1 | 68 | 66 |



# Now what?

- Magnitude of the difference is system dependent and will surely be nuclide dependent as well
- Large fluctuations between covariance evaluations do not inspire confidence with practitioners or regulators
- Need to identify rigorous tests of covariance data
- Must move towards passing these tests and providing basis for safety-significant use of covariance data

# Acknowledgment

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# Questions?