



Computational Study of Critical Mass Curves for Various Ratios of ^{238}Pu to ^{239}Pu

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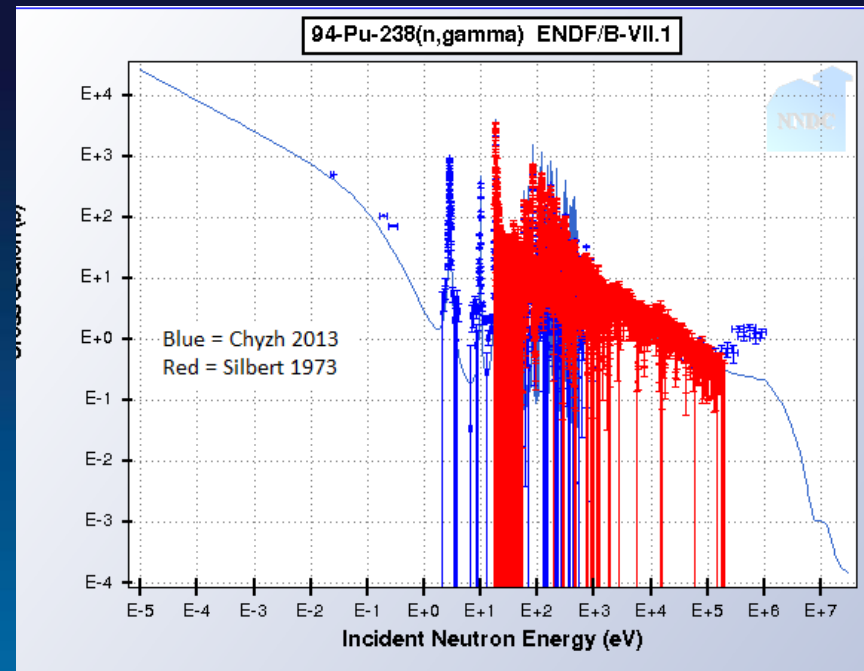
^{238}Pu Systems

- ^{238}Pu systems are outside of the Area of Applicability (AOA) of LANL's MCNP validation report and require additional margin of subcriticality (MOS)
 - No benchmark experiments contain significant quantities (<10 grams) of ^{238}Pu
- Many experiments have investigated ^{238}Pu cross sections
 - Most data from Silbert's 1973 time of flight experiment and Chyzh's 2013 4π γ -ray calorimeter experiments have a large data density between 1eV and 1MeV

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^{238}Pu systems continued

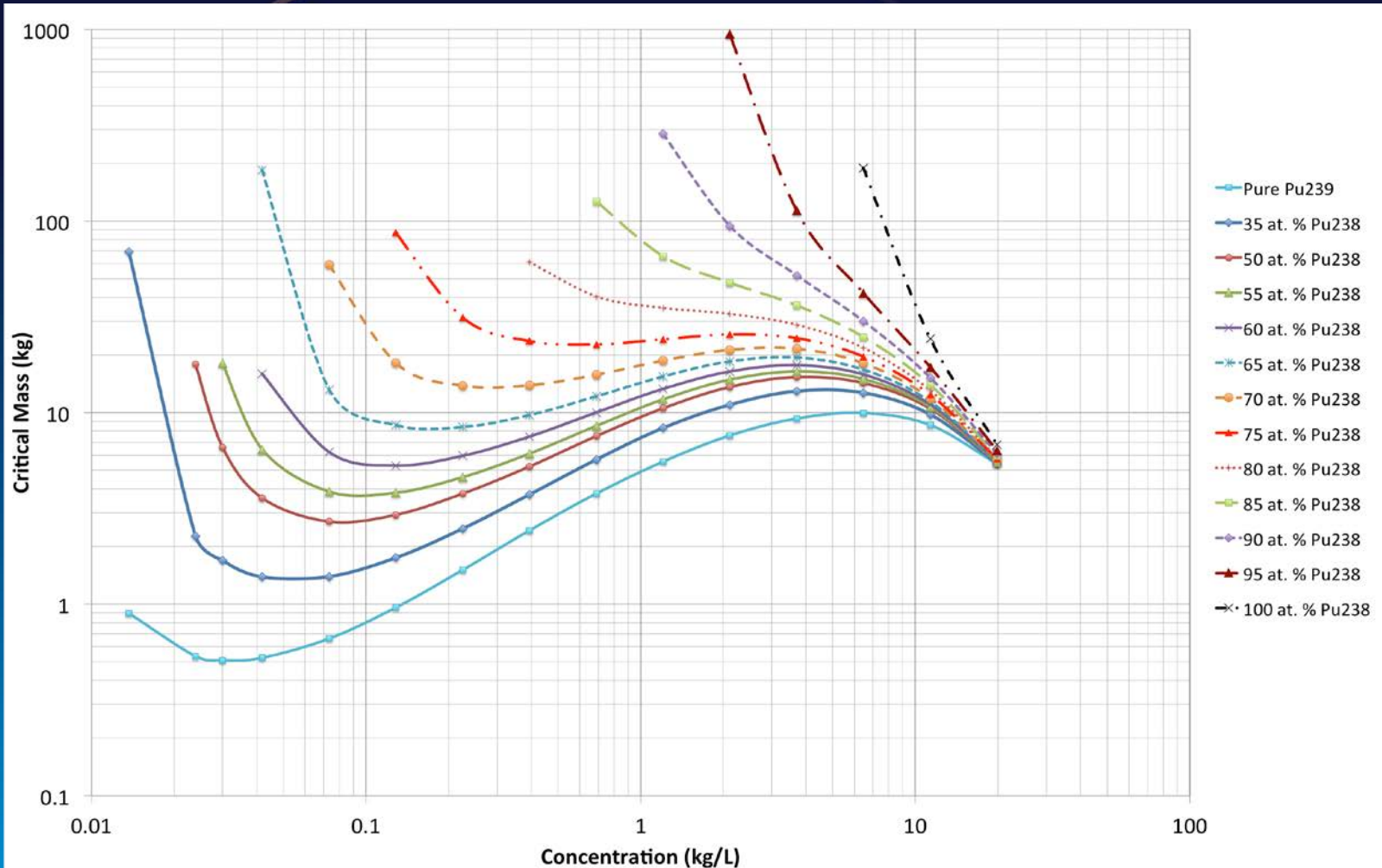
- Data contain area of interest for this study
- Additional MOS for being outside the AOA is not caused by the cross section data
- Lack of direct benchmark comparison capabilities drives additional MOS
- Whisper 1.0.0 was used to quantify impacts



Experimental data for ^{238}Pu (n, γ) cross section

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^{238}Pu Spherical Critical Mass Curves



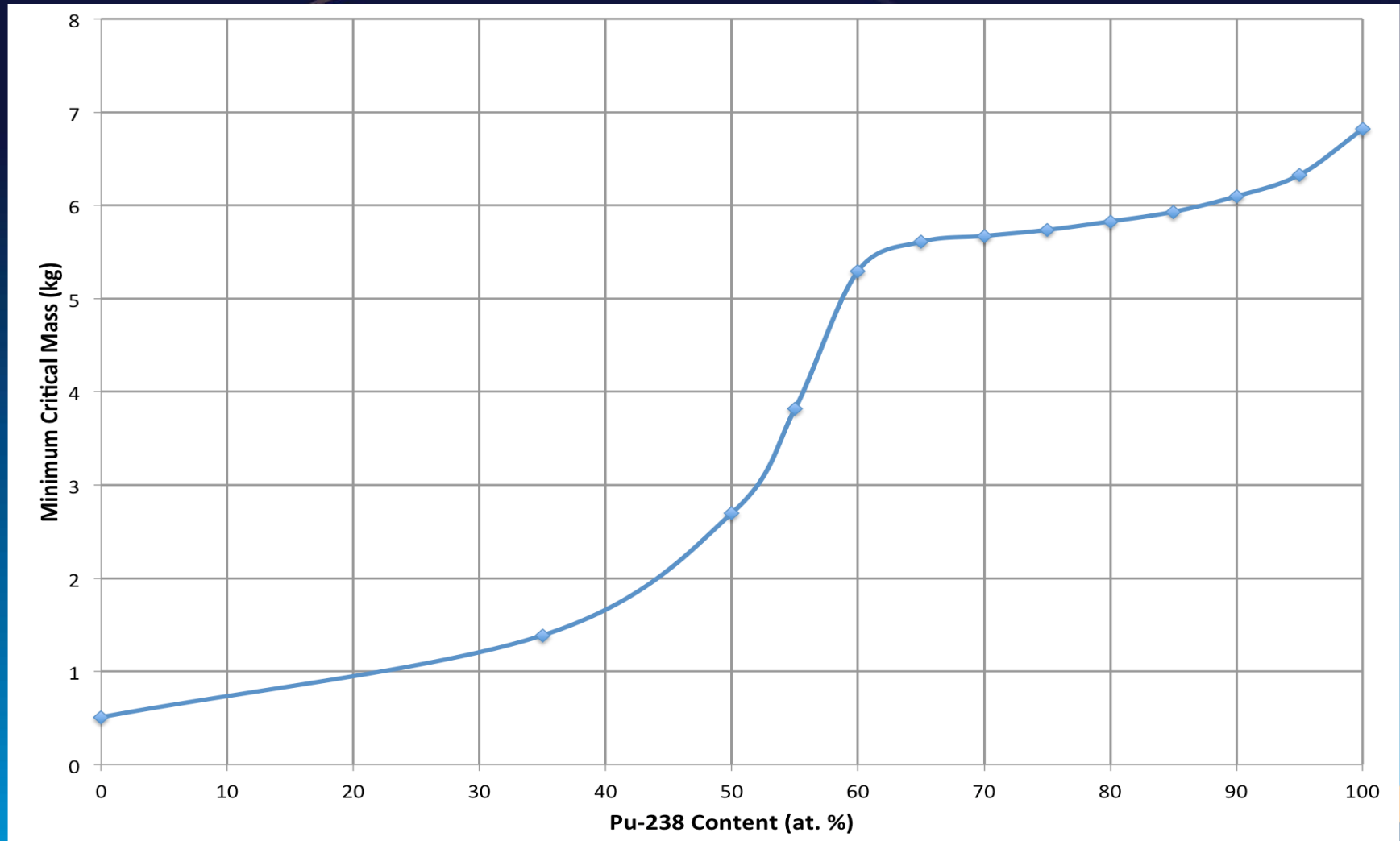
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Quantifying Additional MOS

- To quantify the additional MOS needed for ^{238}Pu , Whisper was run
 - Whisper provides a comparison between the neutronic properties of MCNP process models and the neutronic properties of MCNP models of benchmark experiments
 - Whisper suggests a baseline Upper Subcritical Limit (USL) based on this comparison and an uncertainty/sensitivity analysis of the data used
- 65% $^{238}\text{Pu}/^{239}\text{Pu}$ case was used
 - 65% is where the minimum critical mass transitions from a solution to a metal system

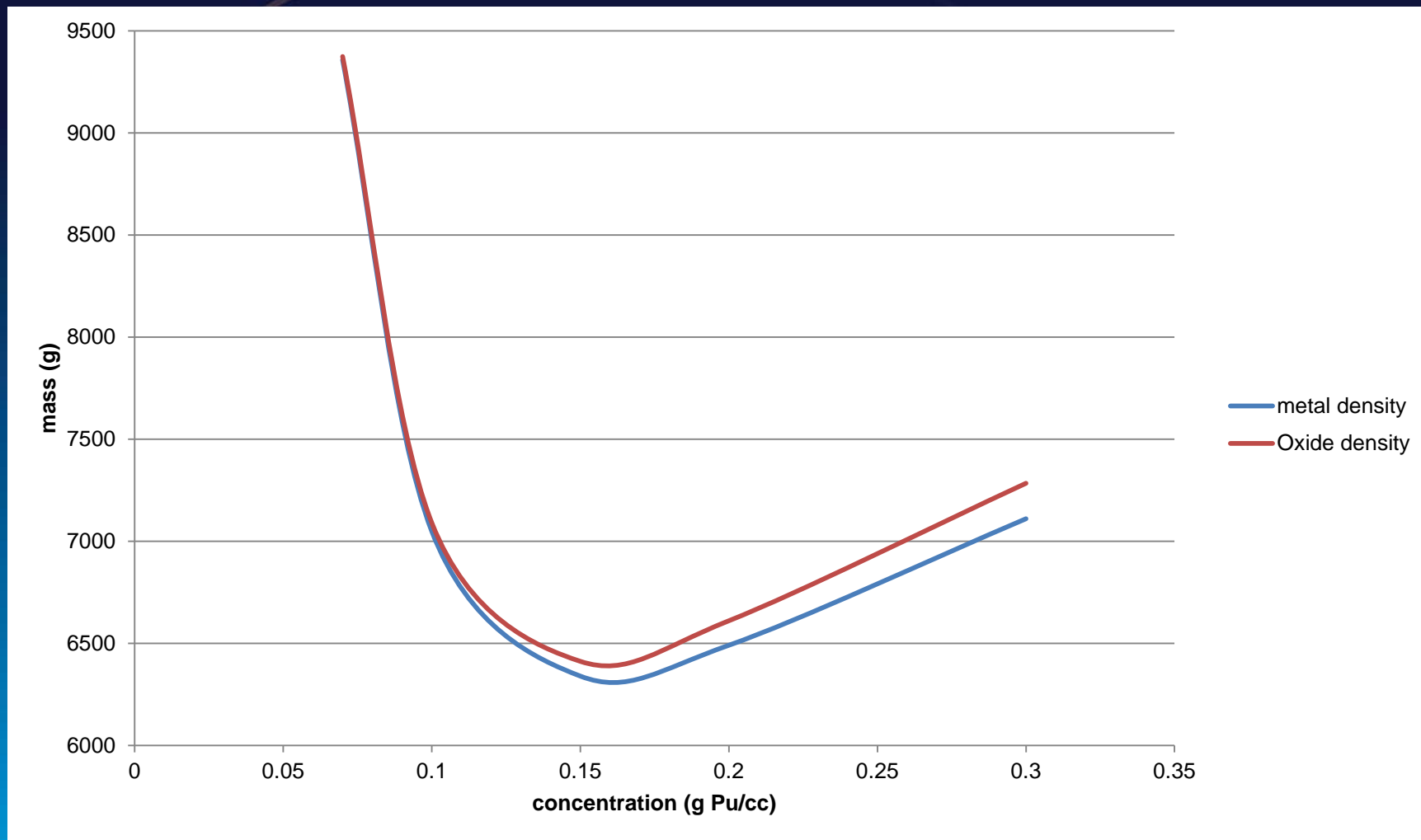
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^{238}Pu Spherical Minimum Critical Mass



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Subcritical Mass Curves for 65% ^{238}Pu



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Whisper Results

- The highest recommended USL is 0.96601 for 40 g/L and the lowest is 0.69928 for 19859 g/L
 - Lower USLs produced low correlations to benchmarks, resulting in more benchmark sampling
 - USLs are not statistically valid
- Benchmarks analyzed for four process models bracketing the curve minimum
 - 6 kg Pu at 0.15 and at 0.20 kg/L, 8.5 at 0.15 and 0.02 kg/L

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Top Benchmarks for each model

| Modeled Configuration | Benchmarks | ck | weight |
|-----------------------|-------------------------|--------|--------|
| 6 kg at 0.15 kg/L | mix-sol-therm-001-009.i | 0.9307 | 1 |
| | pu-sol-therm-034-003.i | 0.9299 | 0.879 |
| | mix-sol-therm-001-010.i | 0.9296 | 0.8427 |
| | pu-sol-therm-032-006.i | 0.9294 | 0.7995 |
| | pu-sol-therm-032-007.i | 0.9294 | 0.8026 |
| 8.5 kg at 0.15 kg/L | pu-sol-therm-034-003.i | 0.9275 | 1 |
| | mix-sol-therm-001-010.i | 0.9273 | 0.9733 |
| | mix-sol-therm-001-011.i | 0.9271 | 0.9508 |
| | pu-sol-therm-034-004.i | 0.9269 | 0.9324 |
| | pu-sol-therm-032-008.i | 0.9262 | 0.8486 |
| 6 kg at 0.2 kg/L | mix-sol-therm-001-009.i | 0.9306 | 1 |
| | pu-sol-therm-034-002.i | 0.9304 | 0.9628 |
| | pu-sol-therm-034-003.i | 0.9302 | 0.9481 |
| | mix-sol-therm-001-008.i | 0.9284 | 0.7121 |
| | mix-sol-therm-001-010.i | 0.9284 | 0.702 |
| 8.5 kg at 0.2 kg/L | pu-sol-therm-034-003.i | 0.9294 | 1 |
| | mix-sol-therm-001-010.i | 0.9274 | 0.8431 |
| | pu-sol-therm-034-004.i | 0.9271 | 0.8227 |
| | mix-sol-therm-001-009.i | 0.9269 | 0.8014 |
| | pu-sol-therm-034-002.i | 0.9264 | 0.7676 |

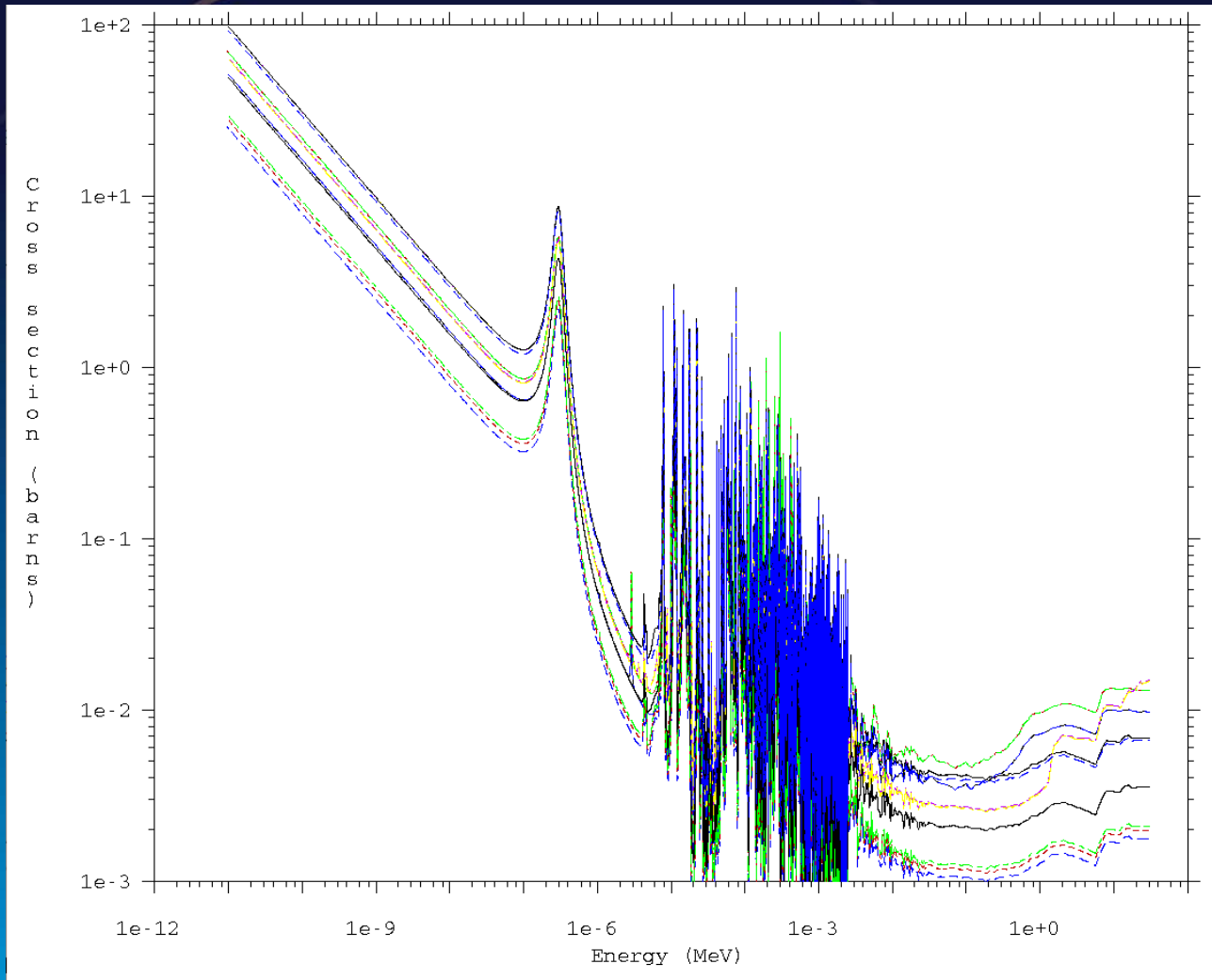
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Cross Section (XS) Analysis of Benchmarks

- Whisper provides a comparison of neutronic properties for the process models and the benchmark models
 - The XSs for the process models were compared with the top benchmark models from the Whisper results

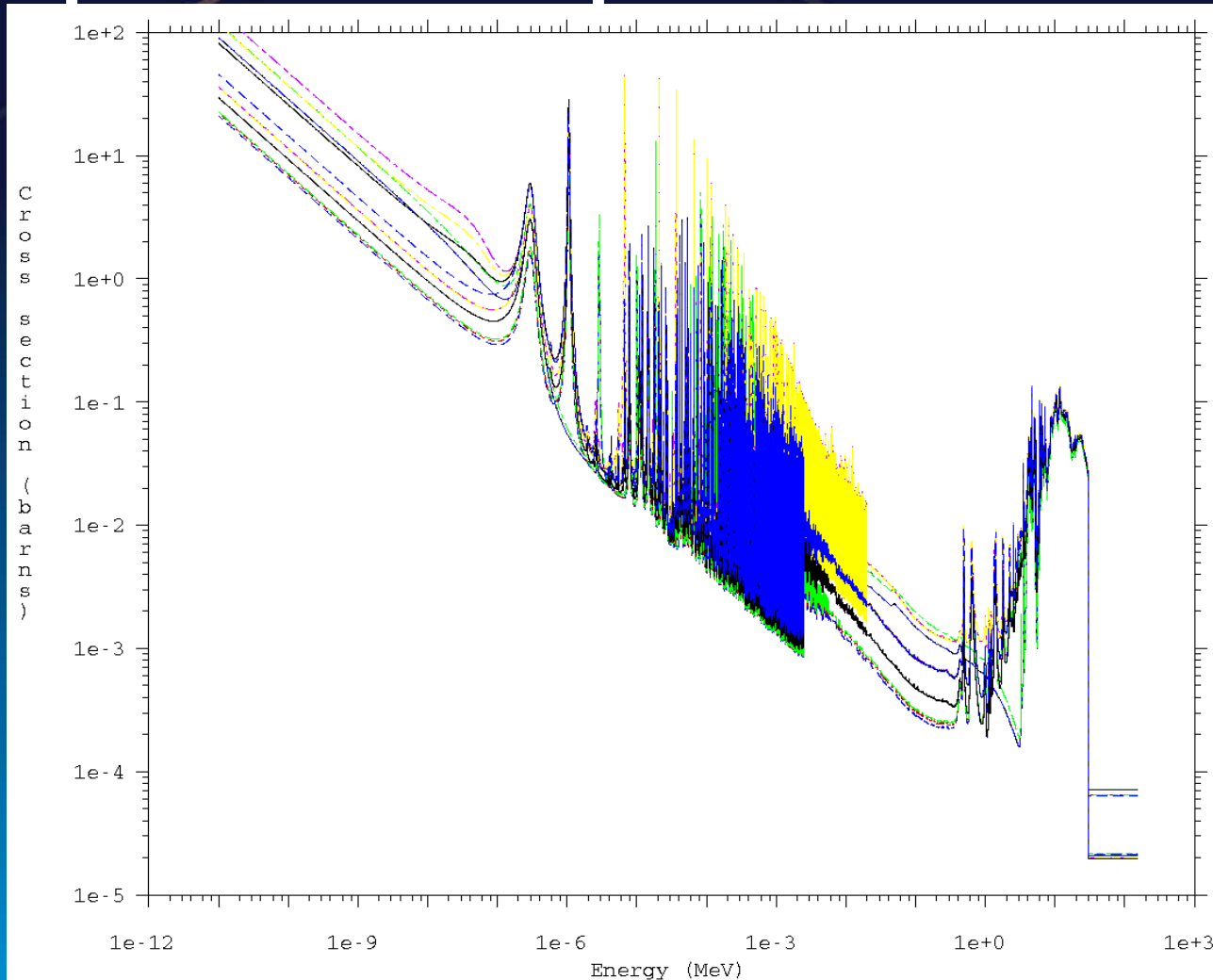
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Fission XS Comparison



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Absorption XS Comparison



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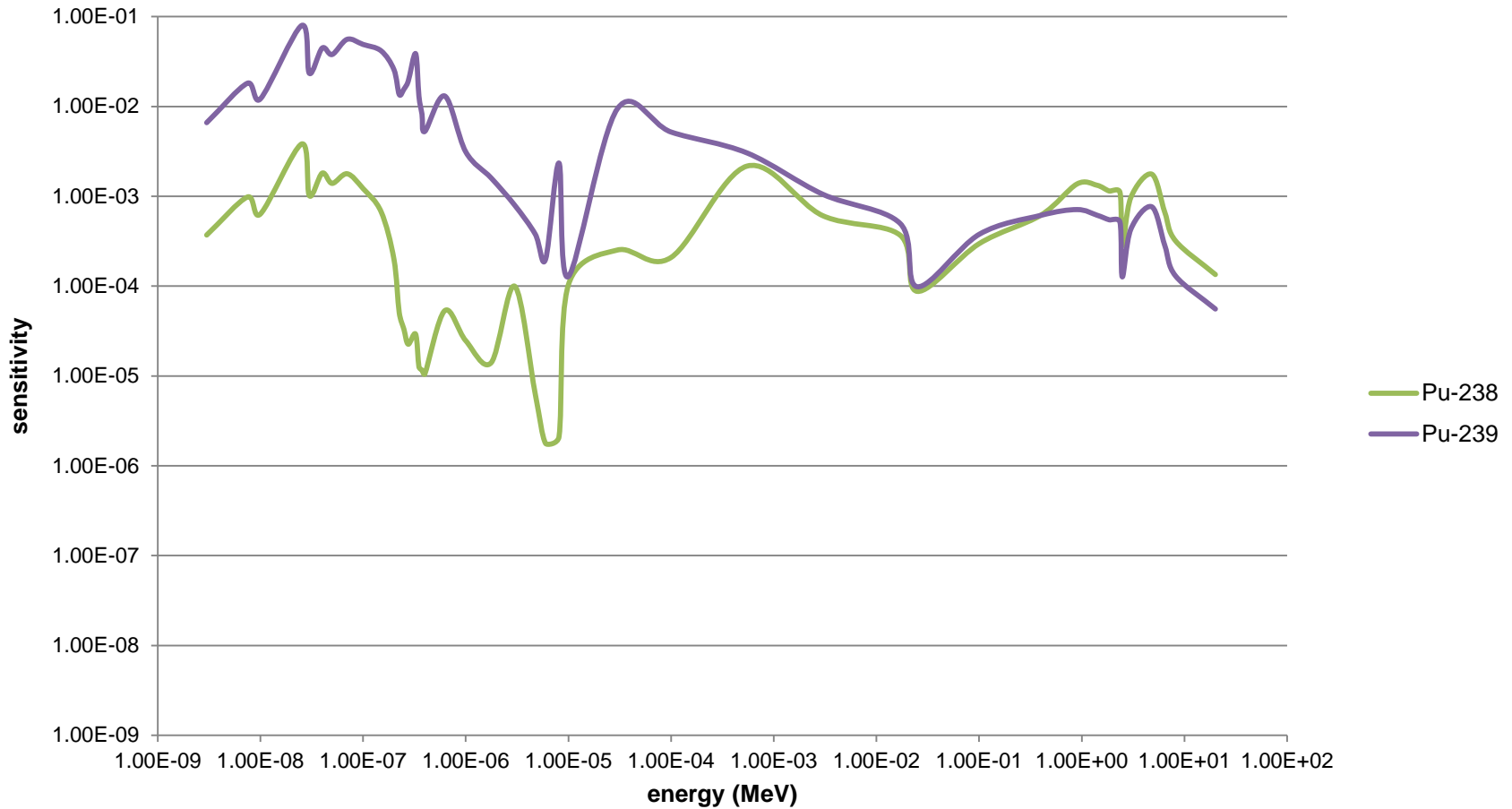
Sensitivity Analysis of Benchmarks

- 6kg Pu at 0.15 kg/L process model chosen for this analysis
 - This model was the closest to the suggested USL
- Process model was compared with the benchmark that had the highest c_k value (weight=1)

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Process Model Fission XS Sensitivities

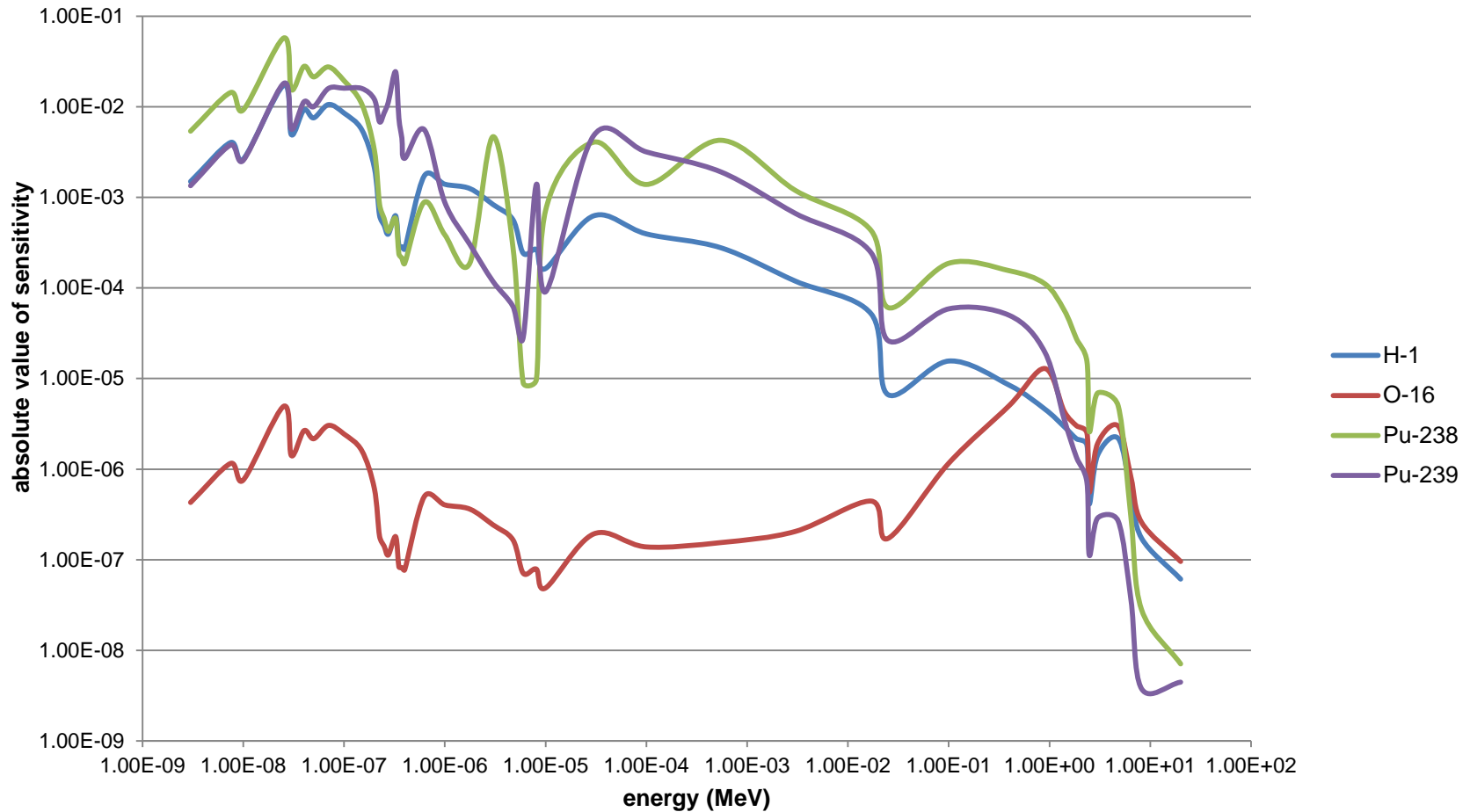
(n,fission)



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Process Model Absorption XS Sensitivities

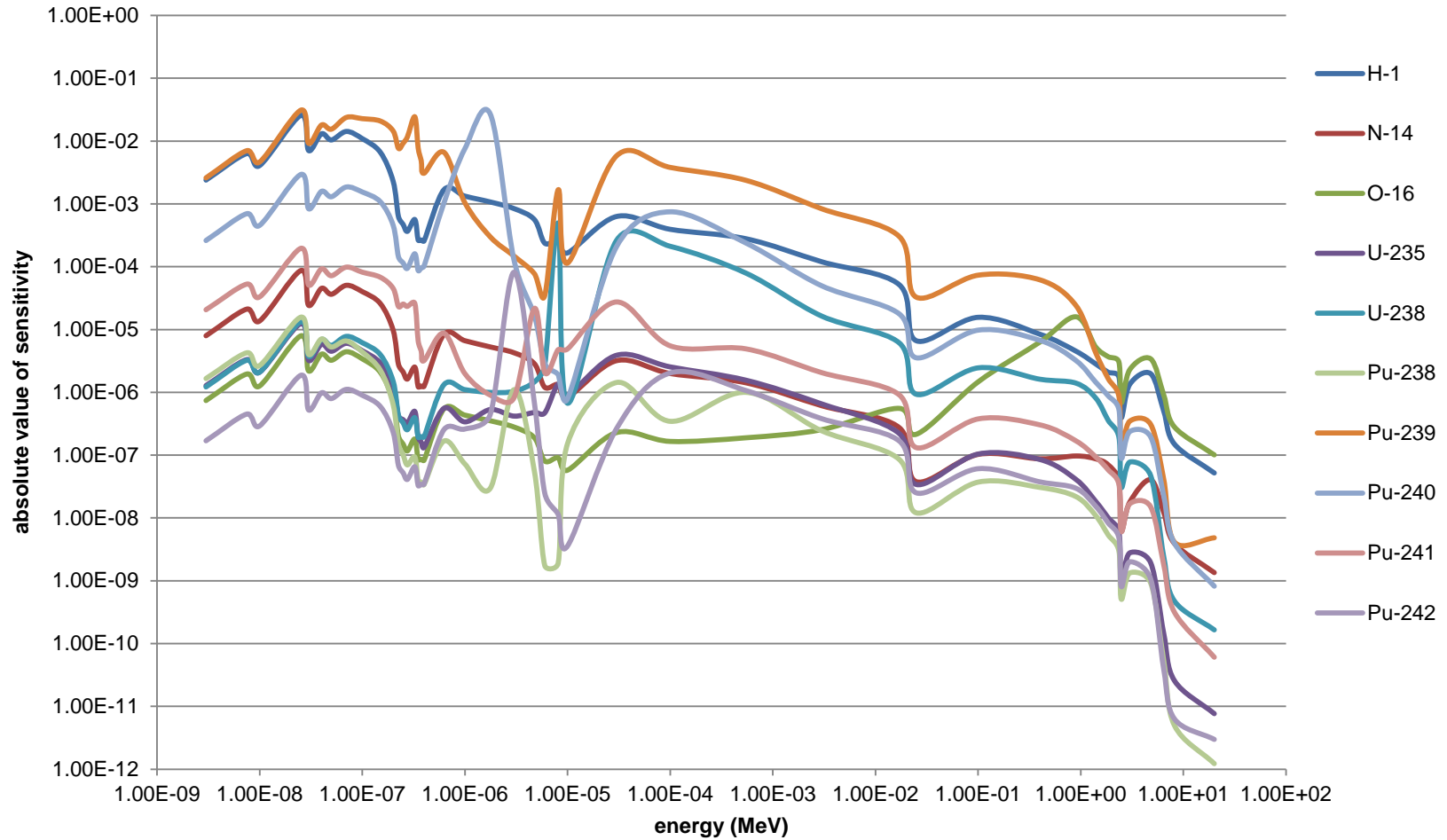
(n,γ)



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Benchmark Absorption XS Sensitivities

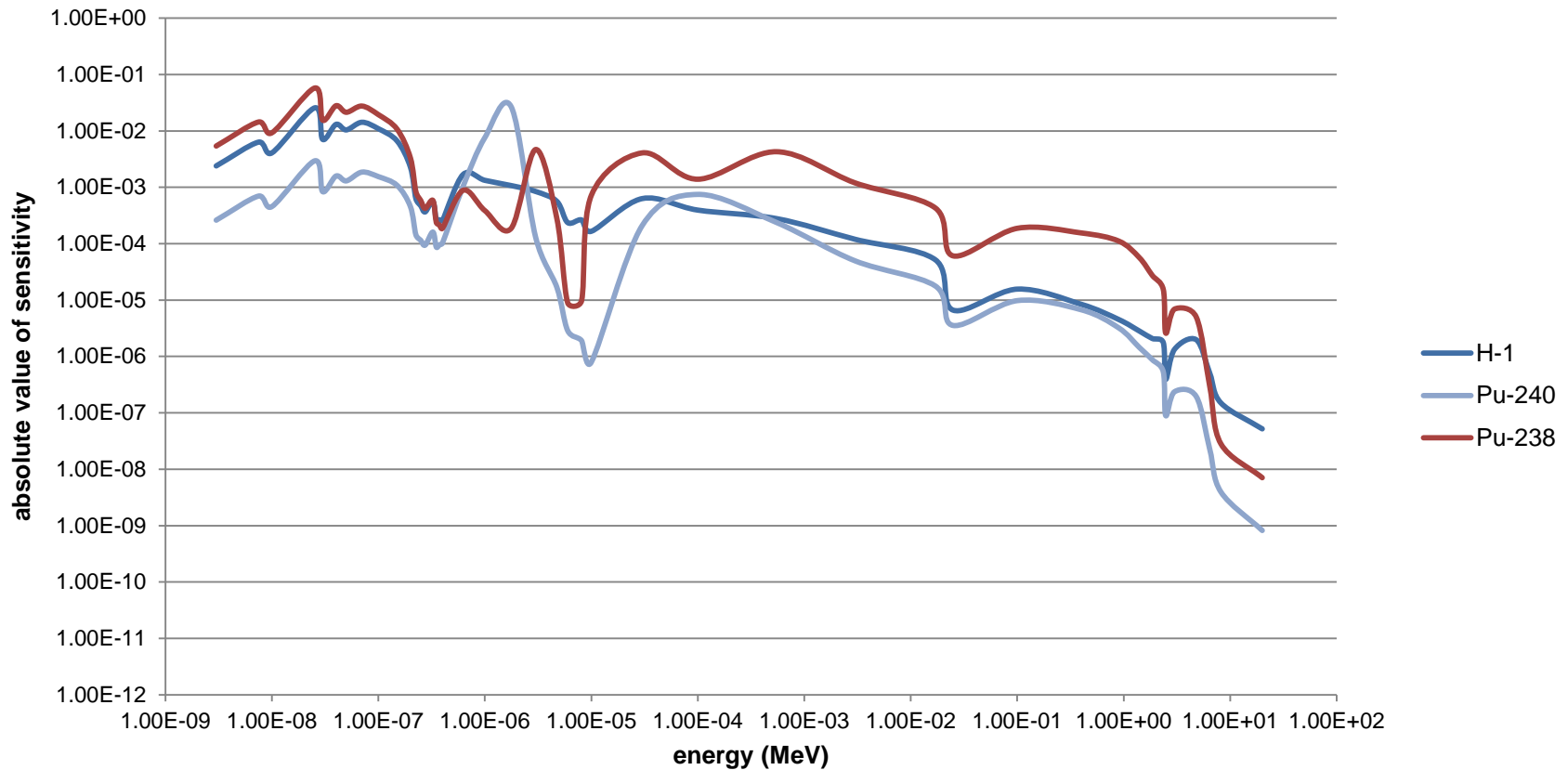
(n, γ) for mix-sol-therm-001-009.ik



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Absorption XS Comparison

(n,γ) Comparison



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Conclusion

- At a 65% ^{238}Pu composition, the moderated systems correlate well with mixed (Pu/natural U) solution benchmarks
 - Correlations confirmed through examination of XSs and sensitivity profiles
- Subcritical Mass limit for 65% ^{238}Pu suspended in water is 6.30 kg for metal and 6.35 kg for oxide
- Unmoderated systems should refer to subcritical limits of the ANSI-ANS 8 series standards
 - Analytical techniques in this report do not have sufficiently strong correlations

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Questions?

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