Validation of MCNP through Isotopic Analysis of LEU UO2

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Introduction and Motivation

- Test the accuracy of MCNP6.2 for isotopic accumulation. And experimentally measure nonproliferation signatures of foreign nuclear fuel cycles.
- Classic validation study of a neutronics modeling code. The MURR will be used for experimental and simulation work.
- This study also builds on the Maximum Likelihood Method for reactor-type discrimination developed by Osborn et al., 2019 [1].

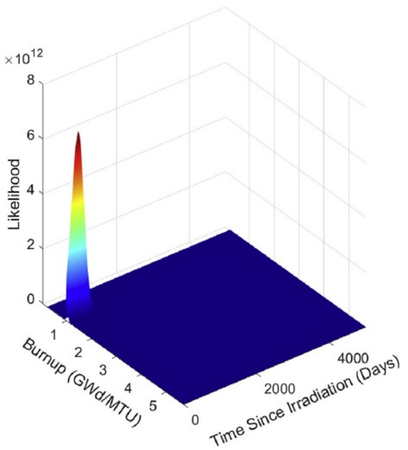

Figure 1. MURR 3-D likelihood surface map [1].

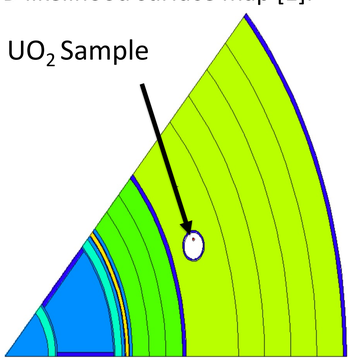

Figure 2. Vised image of 1/8 slice of MURR core with UO_2 sample.

Technical Approach

- Two small LEU UO_2 pellets will be placed in the MURR for 1-month effective irradiation to a burnup of 1 GWd/MTU.
- The study can be broken into two sections: Simulation and experimental.
- Simulation: MCNP was used to simulate the neutron irradiation of the pellets.
  - R = 1.5 mm, H = 0.33 mm, m ~ 20 mg, Enrichment ~3.44%
- Simulation: Intra-element Ratios were measured: $^{137/133}$Cs (1), $^{134/137}$Cs (2), $^{135/137}$Cs (3), $^{154/153}$Eu (4), $^{136/138}$Ba (5), $^{150/149}$Sm (6), $^{152/149}$Sm (7), $^{240/239}$Pu (8), $^{241/239}$Pu (9), and $^{242/239}$Pu (10)
- Experimental: In Progress.

Results

Ratio	1	2	3	4	5	6	7	8	9	10
End of Irradiation	1.18	4.31E-04	0.590	4.23E-03	5.56E-04	9.09E-01	0.608	4.25E-03	2.32E-05	0
1- month Cooling	0.953	4.20E-04	0.605	3.96E-03	8.41E-04	7.98E-01	0.533	3.96E-03	2.15E-05	0

Expected Impact

- Point-validation of reactor database used for nuclear forensics work and nonproliferation.

Mission Relevance

- This work falls under Thrust Arear 2: Signals and Source Terms for Nuclear Nonproliferation.

MTV Impact

- Human capacity building in radiochemistry and reactor physics to support nuclear forensics and nonproliferation work.
- Opportunity to collaborate with national laboratories
- Technology transfer to national laboratories.

Conclusion

- Simulation work is complete. Experiment work is currently in progress.
- This work builds upon and add new data to support nuclear forensics and nonproliferation signatures for LEU material.

Next Steps

- Physical LEU UO_2 samples will be irradiated in the MURR.
- Radiochemical analysis will be done to validate the MCNP results.
- Use Maximum Likelihood method with experimental data.
- Supply data for Machine Learning method

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National Nuclear Security Administration

[1] J.M. Osborn et al., "Experimental Validation of a Nuclear Forensics Methodology for Source Reactor-Type Discrimination of Chemically Separated Plutonium", *Nuclear Engineering and Technology*, 51, 2 (2019).