

Criticality and Radiation Shielding Impacts of ENDF/B-VIII.0

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Outline

1. Criticality safety
 1. ENDF/B-VIII.0 performance summary for VALID
 2. List of published studies and results already available
2. Radiation shielding
 1. SCALE 6.3.0 validation plan
 2. Preliminary results for some models

KENO V.a results summary

Category	ENDF/B-VIII.0		ENDF/B-VII.1		Difference		
	Avg. C/E	Avg. C/E unc.	Avg. C/E	Avg. C/E unc.	(E8.0 – E7.1)	Unc.	Δ /Unc.
HMF	1.00179	0.00039	1.00198	0.00039	-0.00019	0.00055	0.3
HST	0.99824	0.00074	0.99774	0.00072	0.00050	0.00103	0.5
IMF	1.00061	0.00082	1.00289	0.00083	-0.00228	0.00117	2.0
LCT	0.99921	0.00018	0.99960	0.00018	-0.00039	0.00025	1.5
LST	0.99845	0.00083	0.99823	0.00083	0.00022	0.00117	0.2
MCF	0.99797	0.00157	0.99890	0.00157	-0.00093	0.00222	0.4
MCT	0.99811	0.00087	0.99916	0.00087	-0.00105	0.00123	0.9
MST	0.99354	0.00157	0.99839	0.00158	-0.00485	0.00223	2.2
PMF	0.99942	0.00062	0.99952	0.00062	-0.00010	0.00088	0.1
PST	0.99772	0.00055	1.00301	0.00056	-0.00529	0.00078	6.7
UCT	0.99818	0.00140	1.00080	0.00141	-0.00262	0.00199	1.3
UMF	0.99860	0.00051	0.99845	0.00051	0.00015	0.00072	0.2
USI	0.97945	0.00123	0.98275	0.00124	-0.00330	0.00175	1.9
USM	0.97546	0.00214	0.97901	0.00215	-0.00355	0.00303	1.2
UST	0.99750	0.00052	1.00016	0.00052	-0.00266	0.00074	3.6
Statistically significant bias reduction			Statistically significant bias increase			Bias change 1-2 σ	

Impacts of ENDF/B-VIII.0 on criticality safety calculations

- Many categories see only small differences
- Significant impact on thermal Pu systems
 - Reactivity reduction increases with thermalization
 - Over-correction for PST systems, causes worse performance for MCTs
- LCT performance slightly decremented, especially for harder spectrum systems
 - Caused by change in $^{16}\text{O}(n,\alpha)$ cross section
- Cumulative χ^2 for VALID higher with ENDF/B-VIII.0
- β_{eff} predictions may be slightly worse in ENDF/B-VIII.0

Published references for ENDF/B-VIII.0 validation

- Nuclear Data and Cross Section Testing Using ENDF/B-VIII.0, [ORNL/TM-2021/1868](#)
- Validation of KENO V.a and KENO-VI in SCALE 6.3 Beta 3 Using ENDF/B-VII.1 and ENDF/B-VIII Libraries, [ICNC-2019](#)
- Cumulative χ^2 Metric for VALID for ENDF/B-VII.1 and ENDF/B-VIII.0 in SCALE 6.3b9, [ANS Winter Meeting 2021](#)
- Validation of KENO Delayed Neutron Fraction Capabilities, [ANS Winter Meeting 2021](#)
- Bias between ENDF/B-VIII.0 and ENDF/B-VII.1 for LEU Pin Array Systems, [ANS Winter Meeting 2019](#)
- Recent Testing of ENDF/B-VIII.0 at ORNL, [CSEWG Validation Committee 2020](#)
- Energy-dependent Bias between ENDF/B-VII.1 and ENDF/B-VIII.0 for LCT Benchmarks, [CSEWG Validation Committee 2019](#)
- ENDF/B-VIII.0 Covariance Data Development and Testing for Advanced Reactors, [ORNL/TM-2018/1037](#)

Questions?

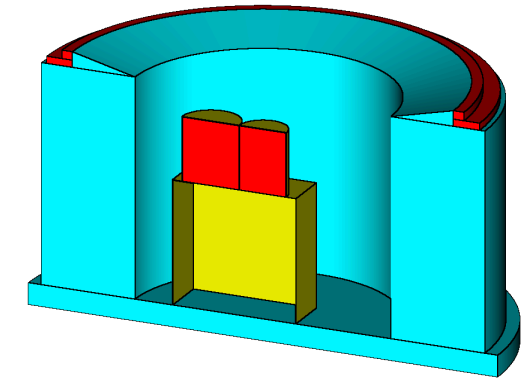
Otherwise, on to radiation shielding



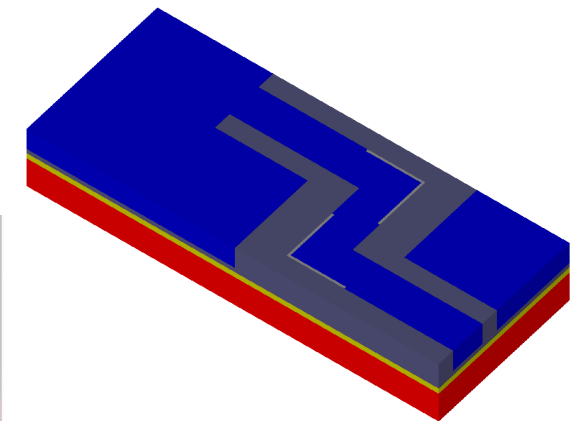
SCALE 6.3.0 Validation for Radiation Shielding Applications

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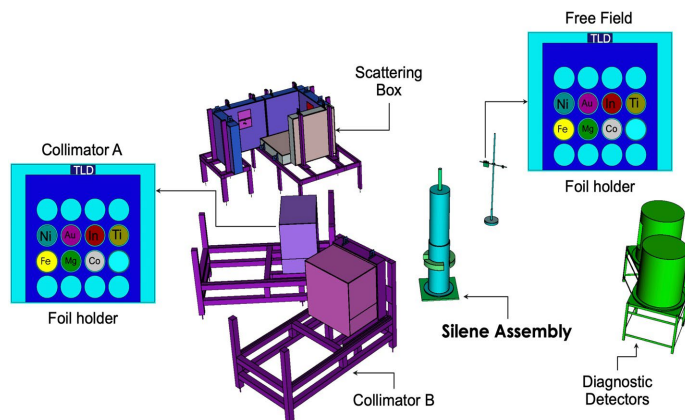
- MAVRIC is tested using various benchmarks from ICSBEP, SINBAD and/or peer-reviewed articles
- Measurements include neutron and gamma fluxes, foil activation rate, attenuation factors, and other metrics
- Wide range of materials including iron, polyethylene, water, cadmium, lead, air, soil, titanium, platinum, and others
- Good agreement of MAVRIC with experiments and other codes when available
- Comparison of result with using ENDF/B-VII.1 and ENDF/B-VIII.0 libraries
- Report will be published in 2022



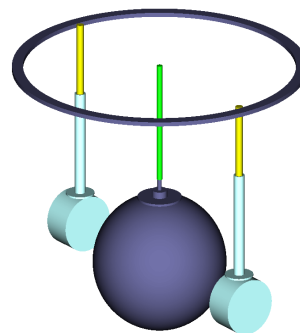
Photon Skyshine SCALE model overview



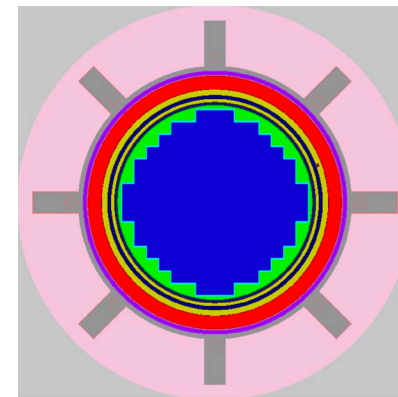
Concrete Labyrinth SCALE model overview



SILENE Critical Assembly SCALE model overview



Fission Rates SCALE model overview



H. B. Robinson Unit 2 model overview

Impact of ENDF/B-VIII.0 on Radiation Shielding Applications

- Most reaction rates, attenuation ratios, and dose rates are similar for ENDF/B-VII.1 and ENDF/B-VIII.0
- Significant reduction in reactor dosimetry results
 - Investigation continues to reveal underlying data for discrepancies
- All comparisons shown here used CE transport

Ratio of simulated to measured reaction rates for the SILENE assembly

Position	Reaction	Simulated/Measured					
		Bare		Lead Reflected		Poly Reflected	
		ENDF/B-VII.1	ENDF/B-VIII.0	ENDF/B-VII.1	ENDF/B-VIII.0	ENDF/B-VII.1	ENDF/B-VIII.0
Collimator A	$^{59}\text{Co} (n,g) ^{60}\text{Co}$	1.13	1.11	1.20	1.20	1.00	0.93
	$^{115}\text{In} (n,g) ^{116}\text{In}$	1.06	0.99	1.23	1.21	0.79	0.76
	$^{115}\text{In} (n,n'g) ^{115m}\text{In}$	0.97	0.93	1.17	1.18	0.65	0.81
	$^{54}\text{Fe} (n,p) ^{54}\text{Mn}$	1.03	0.99	0.97	0.93	0.88	0.81
	$^{56}\text{Fe} (n,p) ^{56}\text{Mn} + ^{55}\text{Mn} (n,g) ^{56}\text{Mn}$	1.04	1.04	1.17	1.16	0.87	0.94
	$^{24}\text{Mg} (n,p) ^{24}\text{Na}$	1.11	1.09	1.24	1.12	0.99	0.93
	$^{58}\text{Ni} (n,p) ^{58}\text{Co}$	1.02	0.98	1.12	1.09	0.99	0.91

Transmission ratio of iron sphere

Code and Dataset		Transmission Ratio
MAVRIC	ENDF/B-VII.1	0.971
	ENDF/B-VIII.0	0.970
MAVRIC-Shift	ENDF/B-VII.1	0.971
	ENDF/B-VIII.0	0.970

Ratio of simulated to measured skyshine dose rates

Code and Dataset	Simulated/Measured			
	50 m	300 m	600 m	
MAVRIC	ENDF/B-VII.1	1.057	1.193	1.030
	ENDF/B-VIII.0	1.058	1.189	1.033
MAVRIC-Shift	ENDF/B-VII.1	1.145	1.153	1.031
	ENDF/B-VIII.0	1.056	1.160	1.031

Ratio of simulated to measured specific activities for HB Robinson

Dosimeter	Simulated/Measured			
	Surveillance Capsule		Detector Cavity	
	ENDF/B-VII.1	ENDF/B-VIII.0	ENDF/B-VII.1	ENDF/B-VIII.0
$^{237}\text{Np}(n,f)^{137}\text{Cs}$	1.02	0.92	0.82	0.68
$^{238}\text{U}(n,f)^{137}\text{Cs}$	0.85	0.74	0.82	0.63
$^{58}\text{Ni}(n,p)^{58}\text{Co}$	1.00	0.85	1.11	0.81
$^{54}\text{Fe}(n,p)^{56}\text{Mn}$	0.96	0.80	1.10	0.79
$^{46}\text{Ti}(n,p)^{46}\text{Sc}$	1.02	0.88	1.23	0.93
$^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$	0.97	0.86	1.10	0.90

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Questions?

