Neutronics Analysis of Molten Uranium Breeder Reactor with a Code-to-Code Verification

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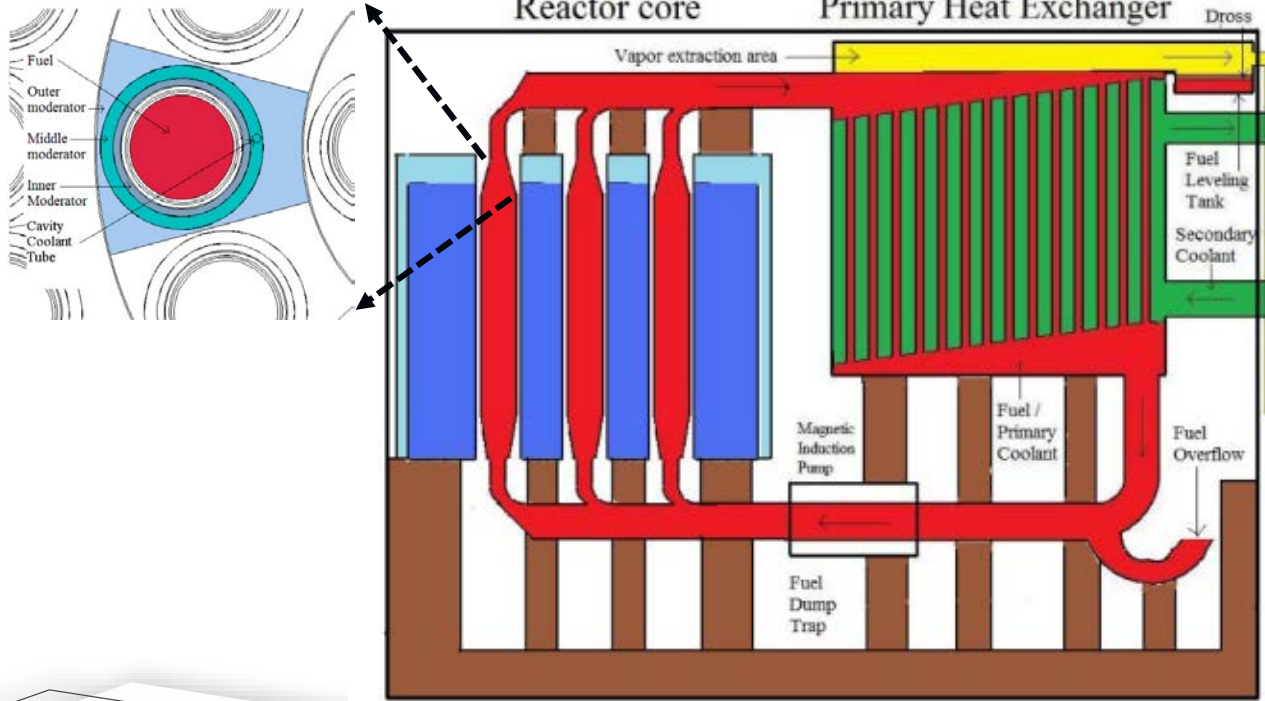Virginia Commonwealth University, Richmond VA*

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Mihai (Mike) Pop, *Areva College of Experts (Retired), Alexandria VA*

*ANS Student Conference 2023
University of Tennessee at Knoxville, Knoxville TN, April 15th, 2023*
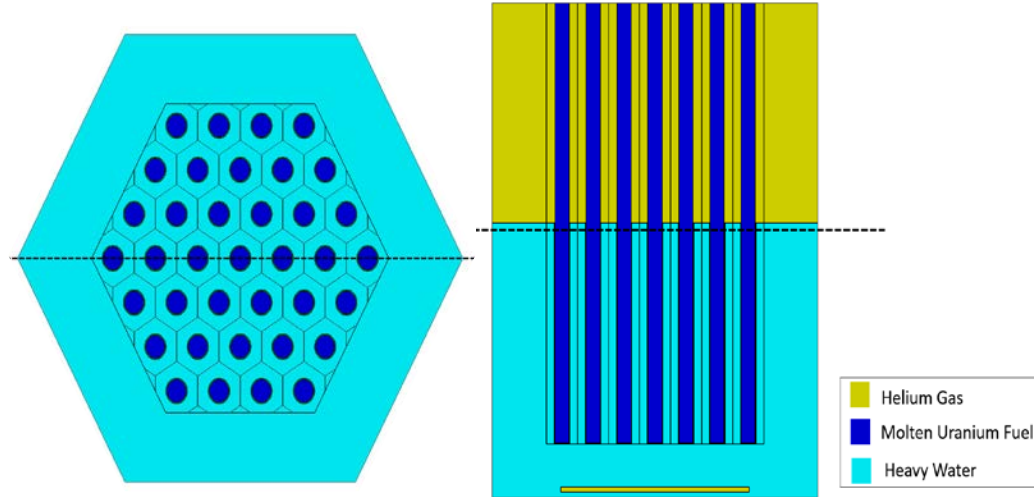
Molten Uranium Breeder Reactor (MUBR)

Key Characteristics

- Molten Uranium at 1475K
- Fuel type can be LEU or a mixture of UNF and LEU
- Breeding ratio of 1.25
- Majority of the fissions occur in the thermal range
- Fuel life of > 80 years
- Innovative control design

■ = molten uranium fuel
■ = liquid heavy water
■ = heavy water steam
■ = molten tin coolant
■ = fission product vapor
■ = firebrick (structure)
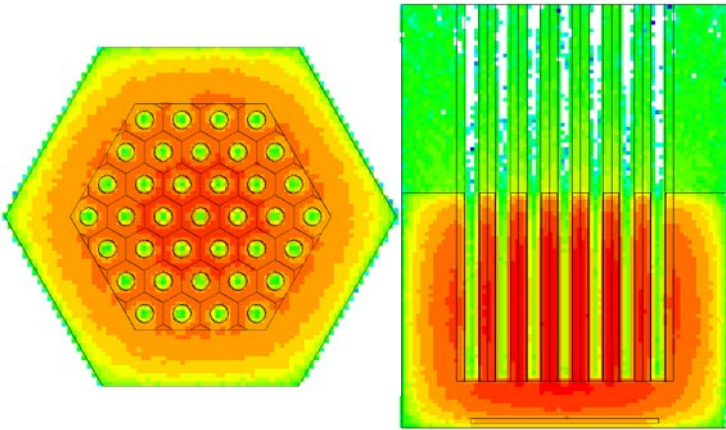□ = presurized helium

MUBR Conceptual Core

Legend:
- Helium Gas
- Molten Uranium Fuel
- Heavy Water

MCNP	SCALE	Δ keff
1.00053±0.00014	0.99955±0.00017	0.00098

- A simplified conceptual core was used to compare MCNP and SCALE results
- This simplified core allowed for:
  - Easier comparison of MCNP and SCALE input
  - Faster running times
  - Easier implementation of burnup, filtering, and flux inputs
- Several versions were created and refined to obtain a final design with a **98 pcm** difference between SCALE and MCNP
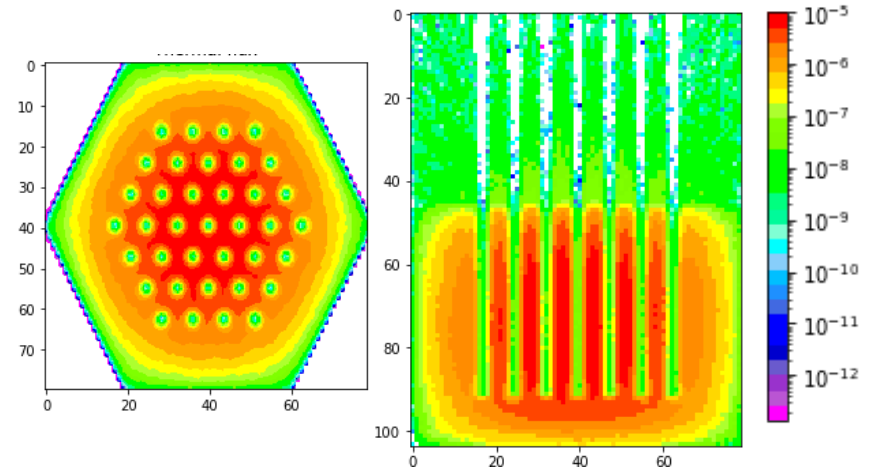
Flux Comparison – Thermal Flux
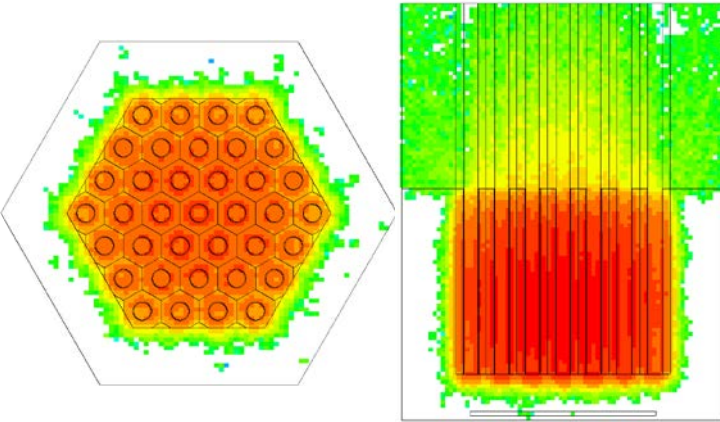
SCALE Thermal Flux

MCNP Thermal Flux

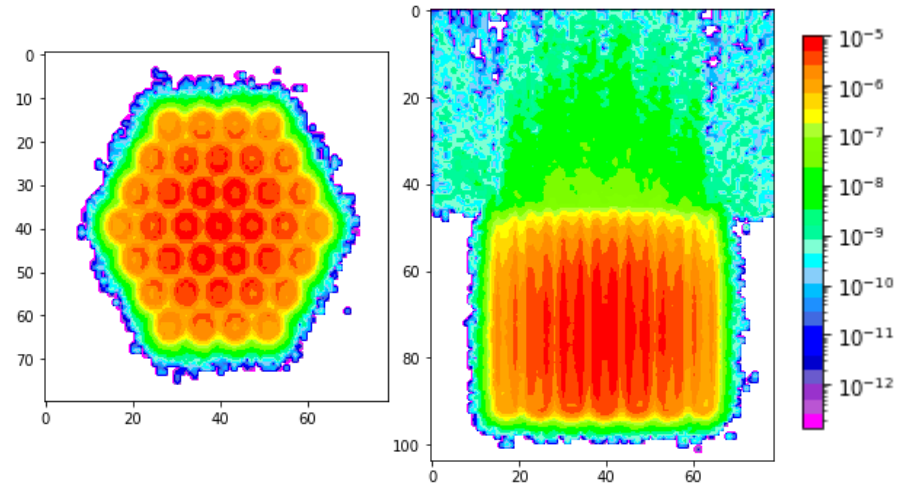# Flux Comparison – Intermediate Flux
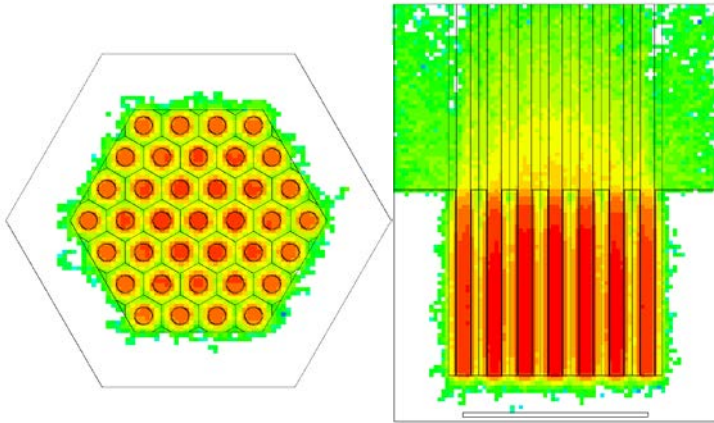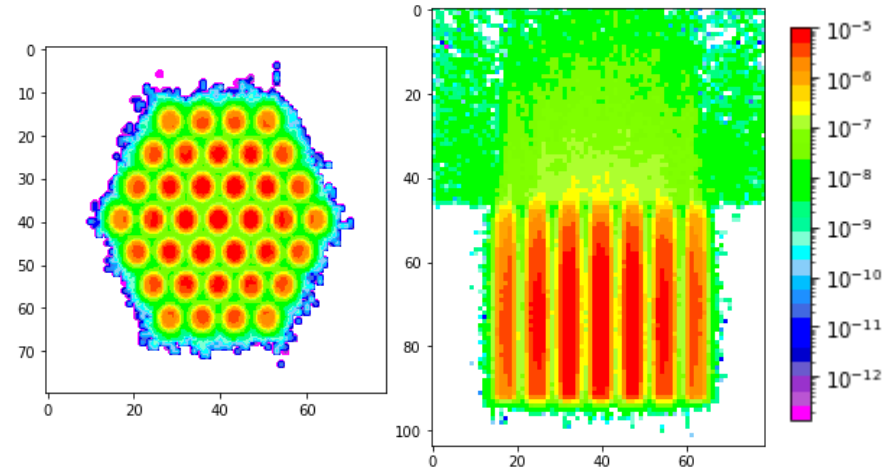

SCALE Inter. Flux

MCNP Inter, Flux
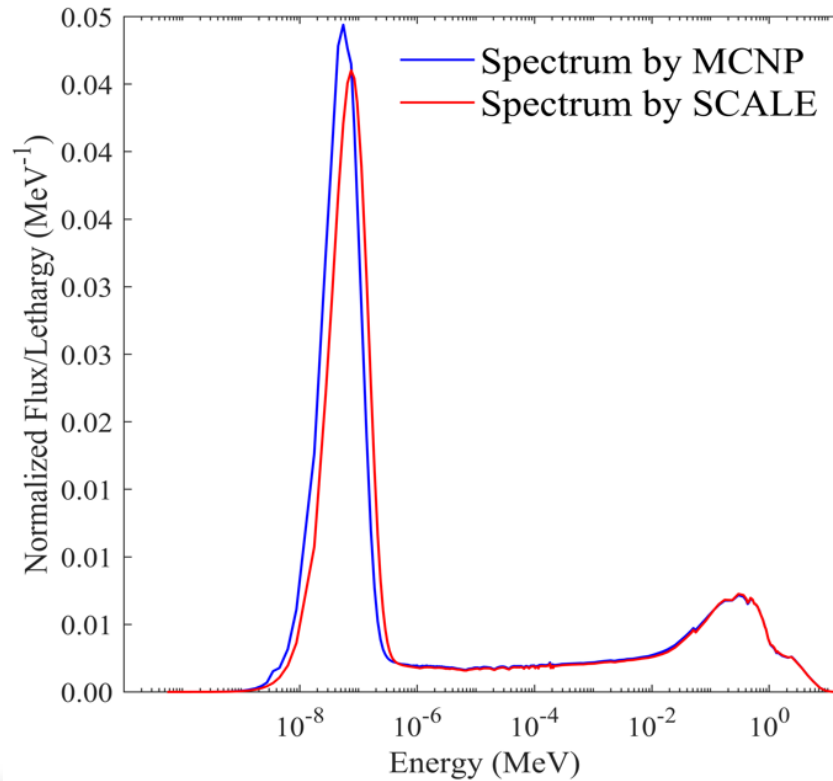
Flux Comparison – Fast Flux
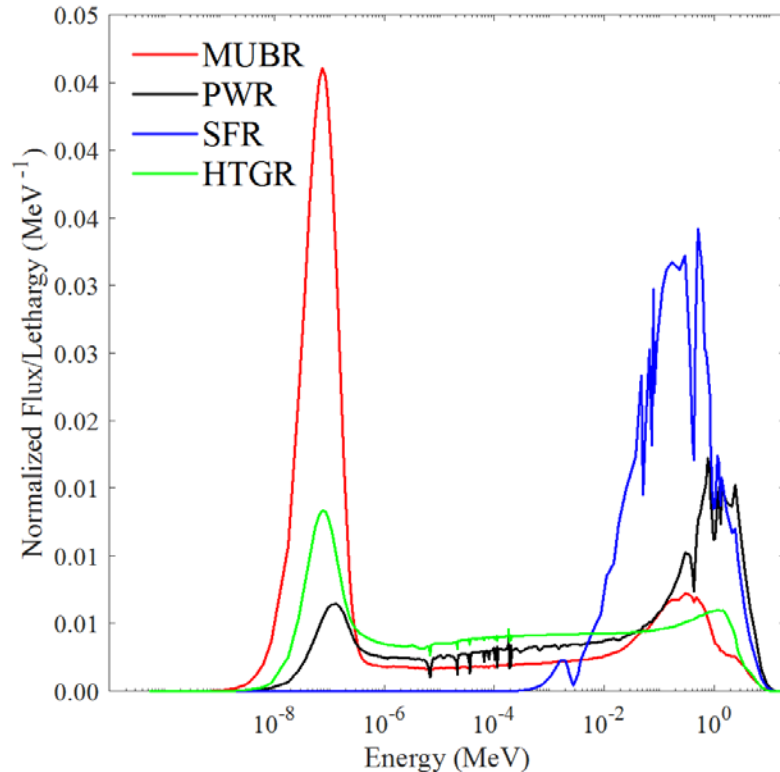
SCALE Fast Flux

MCNP Fast Flux

252 Group Spectrum

MUBR Spectrum vs. Others

- PWR – Pressurized Water Reactor

- SFR – Sodium Fast Reactor

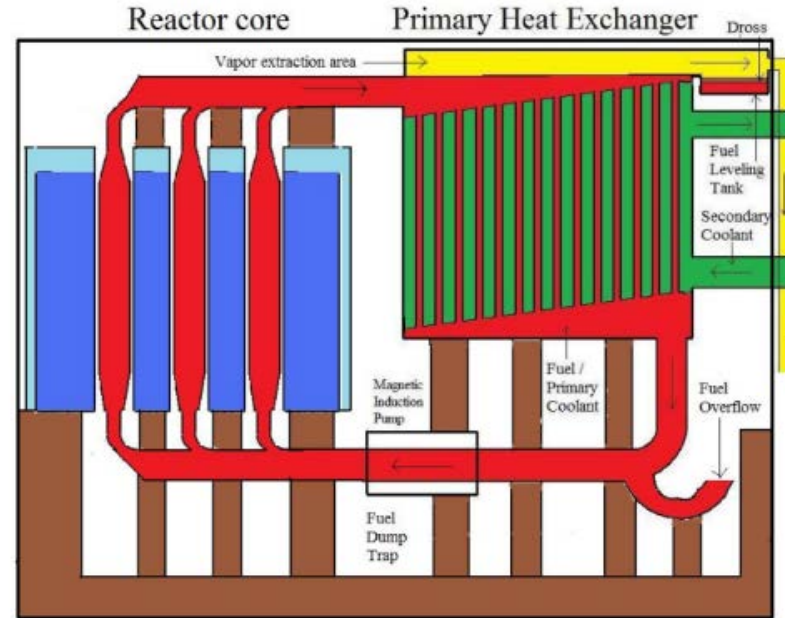- HTGR – High Temperature Gas-cooled Reactor

Future Work

- Fission product evaporation and removal capability

- Fuel & moderator temperature coefficient calculations

- Fuel cycle and waste burning analysis

Thank You, and Questions?

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ANS Student Conference, Knoxville TN, April 13-15, 2023

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