Molten Uranium Breeder Reactor - a Paradigm Change in Fuel Cycle

Zeyun Wu Ph.D.
Department of Mechanical and Nuclear Engineering, Virginia Commonwealth University, Richmond VA

Neal Mann
Neal Mann and Associates, Washington DC

Mihai (Mike) G. Pop, Dr. Eng.
Areva College of Experts (Retired), Alexandria VA

VCU College of Engineering

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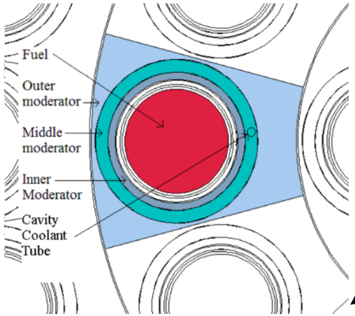
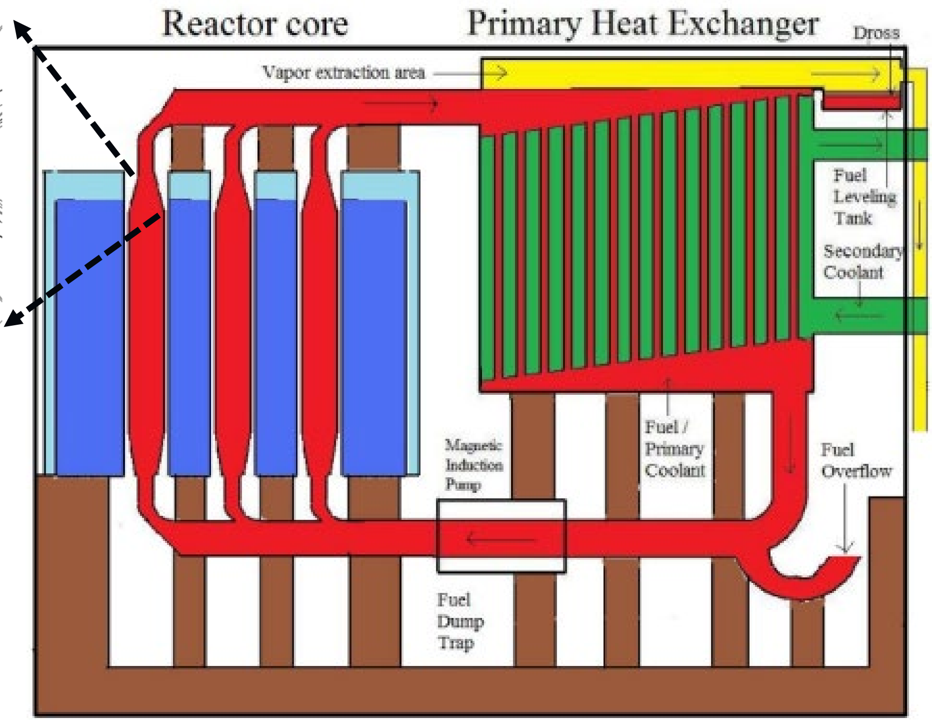
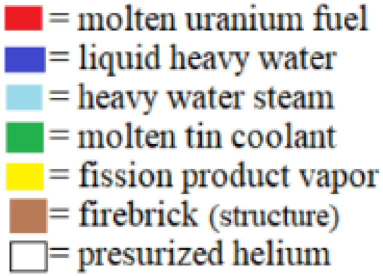
Molten Uranium Breeder Reactor (MUBR)



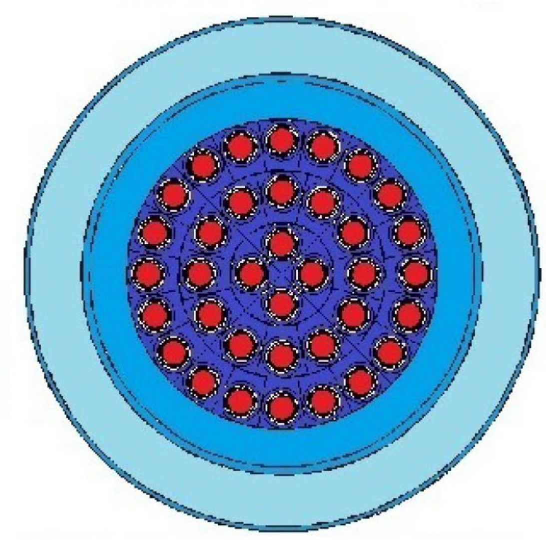


Key Characteristics

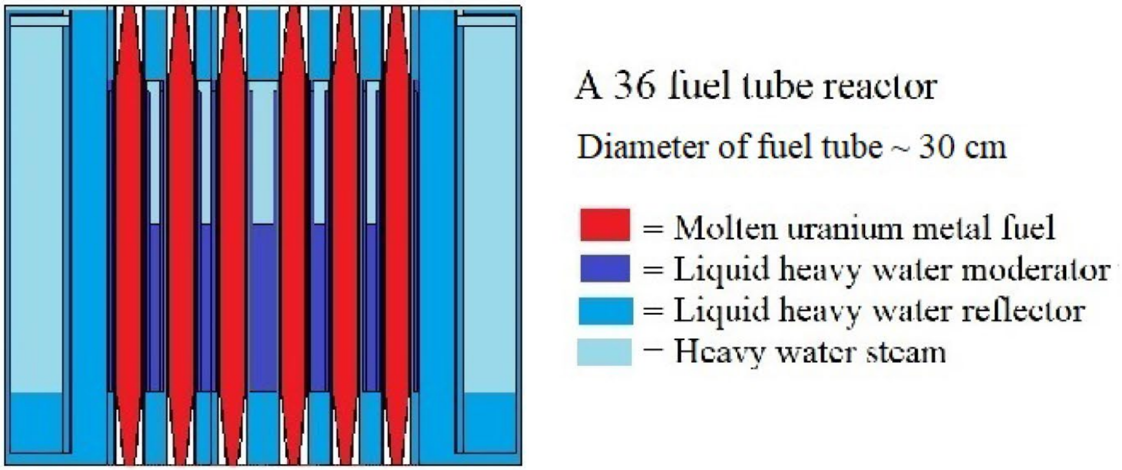
- Molten Uranium at 1475K
- Fuel type can be LEU or a mixture of UNF and LEU
- **Breeding ratio of 1.25**
- Majority of the fissions occur in the thermal range
- Fuel life of > 80 years
- Innovative control design



Reactor Core Configuration



Top View

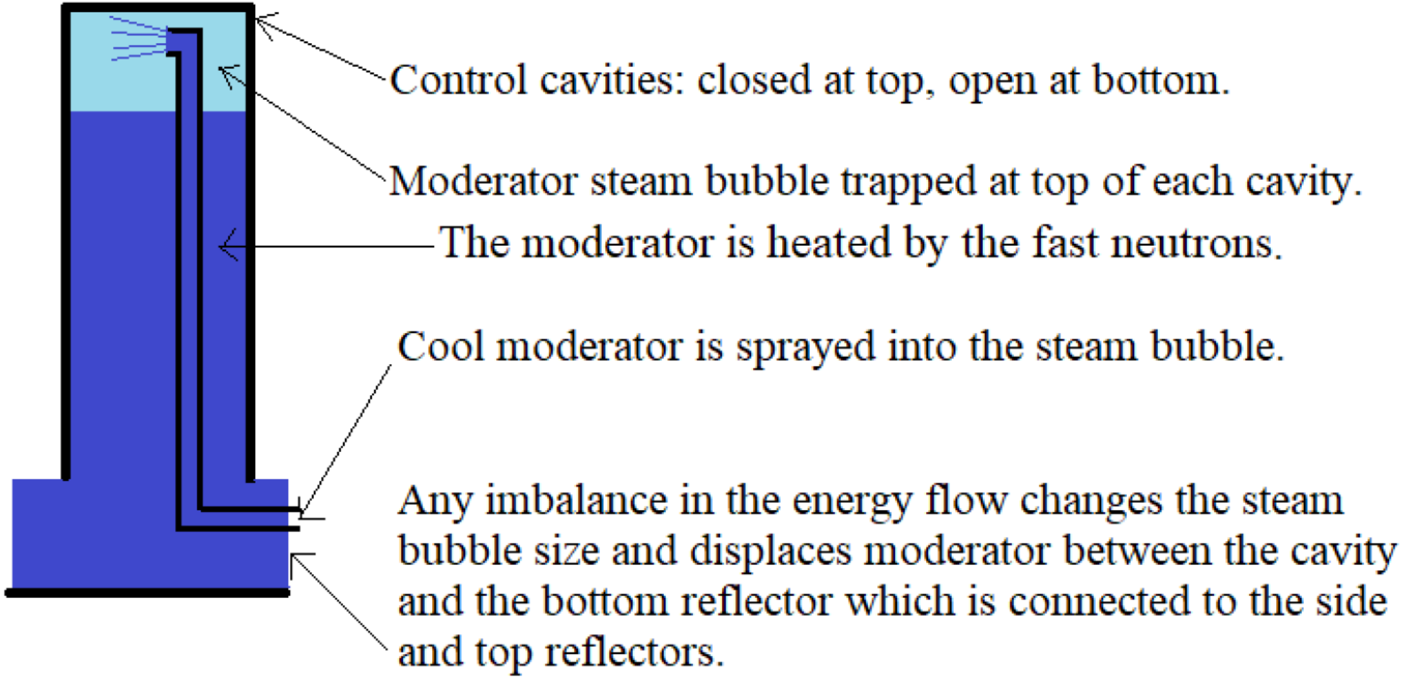


Side View

Unique Design Features of MUBR

- The fuel can be mostly LWR UNF
- Large fuel tubes, not fuel rods
- The fuel is circulating molten uranium metal
- Both the moderator and reactor are heavy water
- The reactor control is by negative feedback
- There is fission product removal from the circulating fuel

Patented Reactivity Control Method



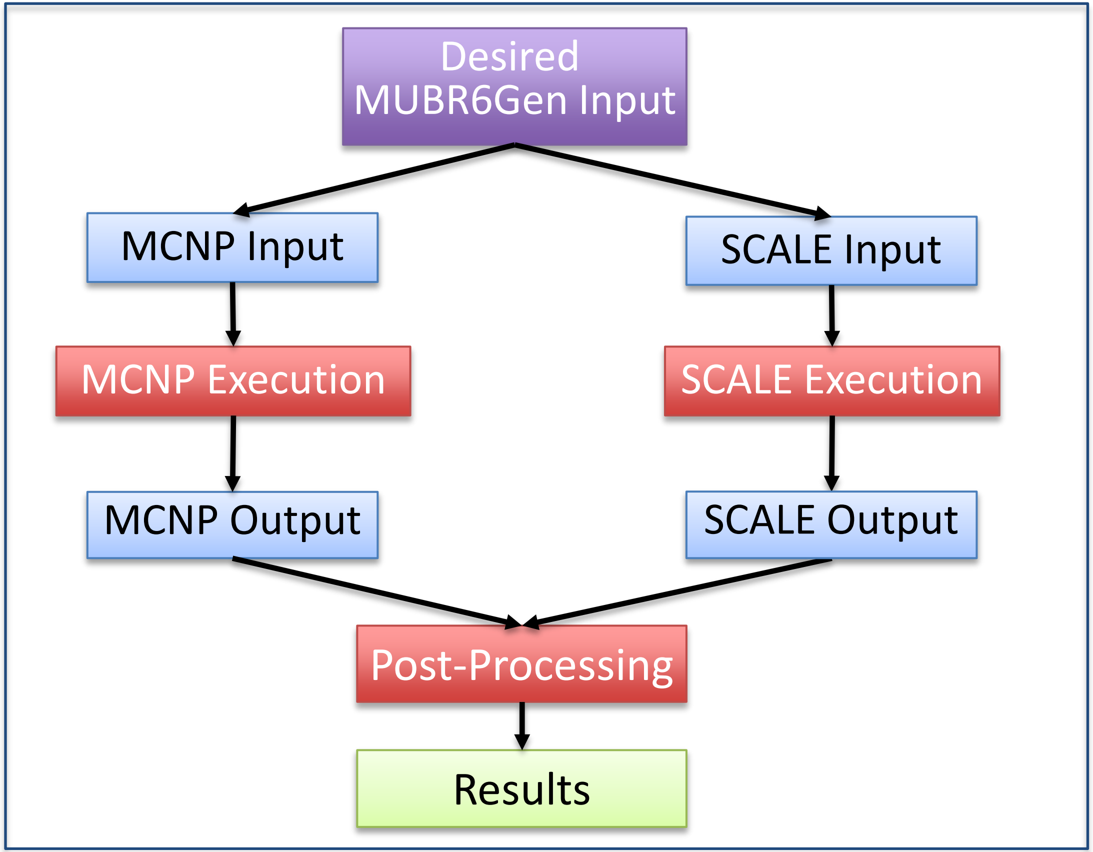
Fuel Cycle Advantages

- The fuel can be mostly LWR UNF
- The fuel lasts 50 to 100 years with no refueling or fuel shuffling
- The burnup is over three times the initial fissile content
- The ending fuel has a higher fissile content than LWR UNF
- The need to mine and enrich uranium is greatly reduced

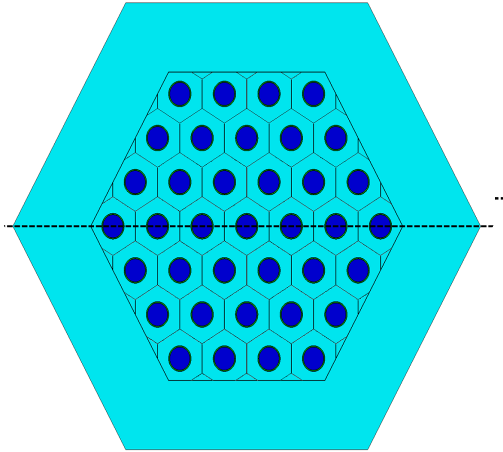
Small MUBR Design Parameters

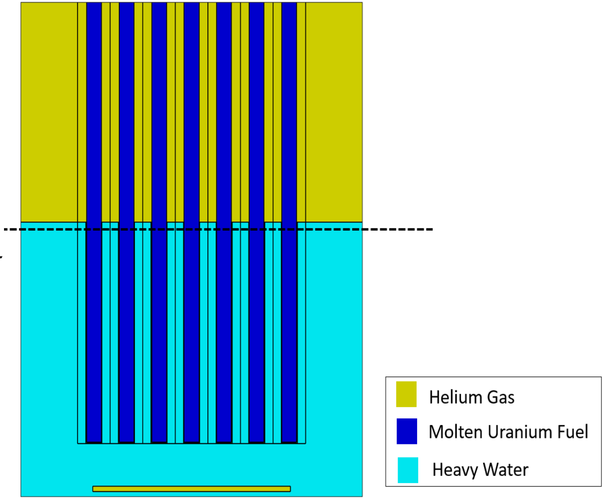
Parameter	Value
Reactor Power (MWe/MWth)	130/266
Average Power Density (W/cm^3)	36
Fuel Cycle Length (Years)	~80 as minimum
Number of Fuel Tubes	14
Fuel Type	LEU or 64% LEU + 36% LWR UNF
Fuel Inlet/Outlet Temperature (K)	1480/1680
Moderator	Heavy Water
Moderator Temperature (K)	440
Cladding (fuel tube wall)	Silicon Carbide
Gas Cap	Helium

Analysis Toolset: *MUBR6gen*



MUBR Conceptual Core



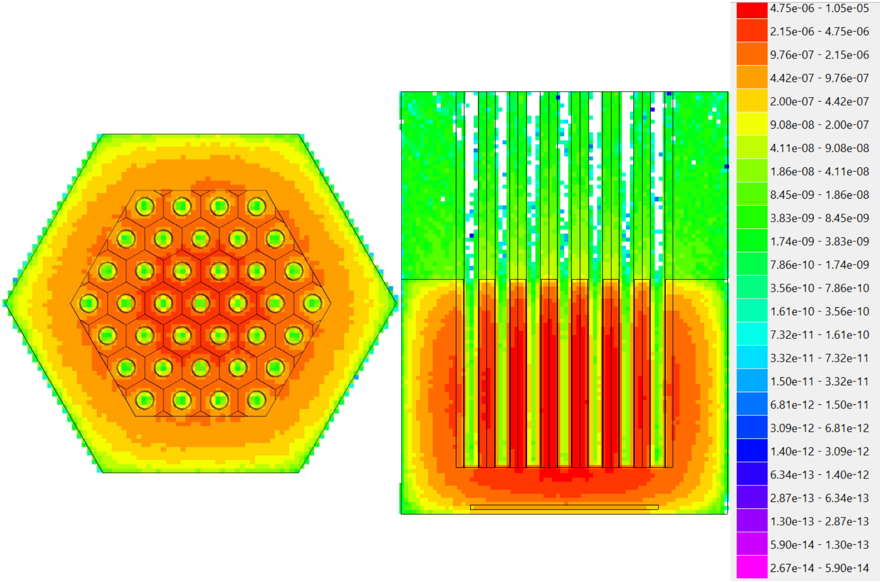


MCNP	SCALE	Δ keff
1.00053±0.00014	0.99955±0.00017	0.00098

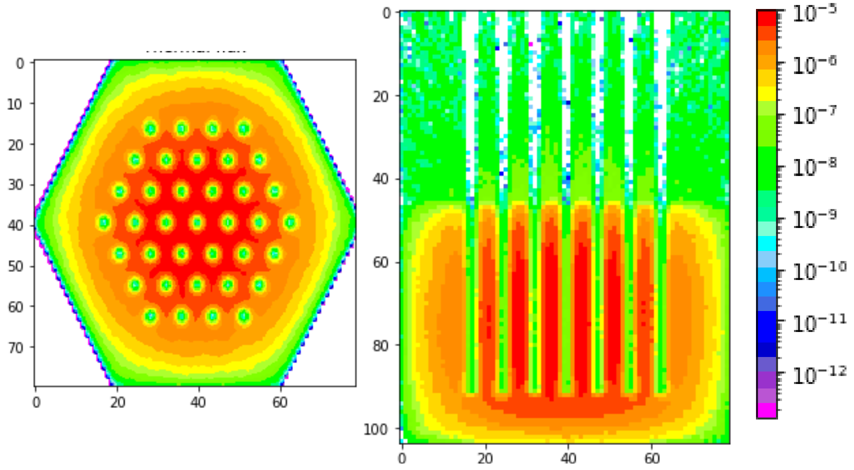
- A simplified conceptual core was used to compare MCNP and SCALE results
- This simplified core allowed for:
  - Easier comparison of MCNP and SCALE input
  - Faster running times
  - Easier implementation of burnup, filtering, and flux inputs
- Several versions were created and refined to obtain a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

Flux Comparison – Thermal Flux

SCALE Thermal Flux



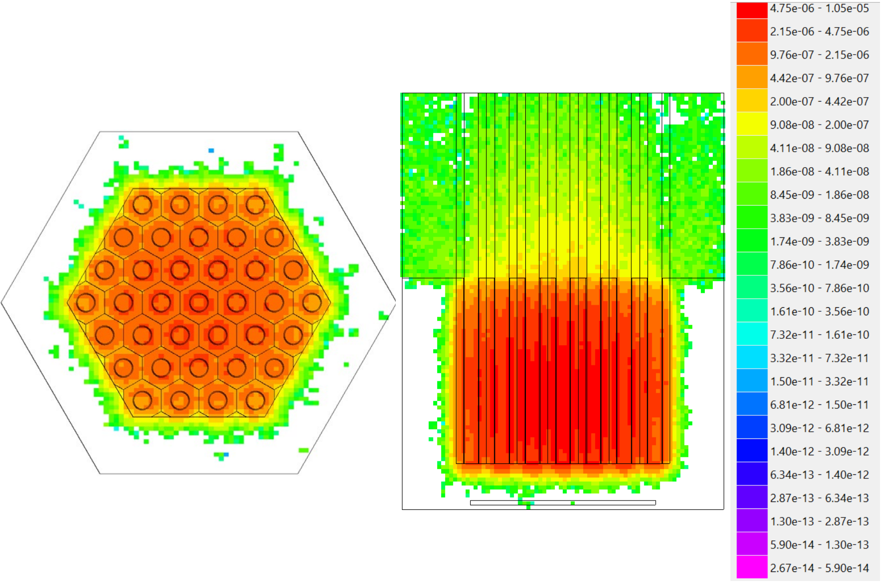
MCNP Thermal Flux



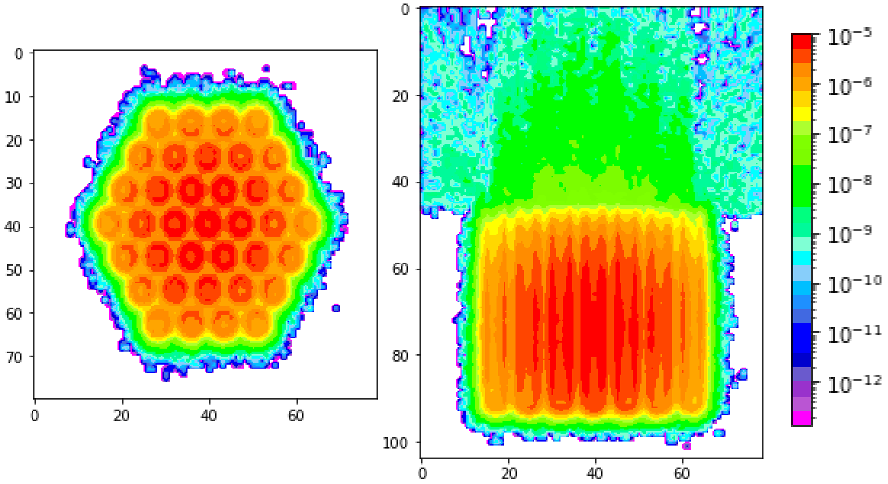
The thermal flux is high in the moderator and near the outside edges of the fuel tubes and very low in the large centers of the fuel tubes.

Flux Comparison – Intermediate Flux

SCALE Inter. Flux



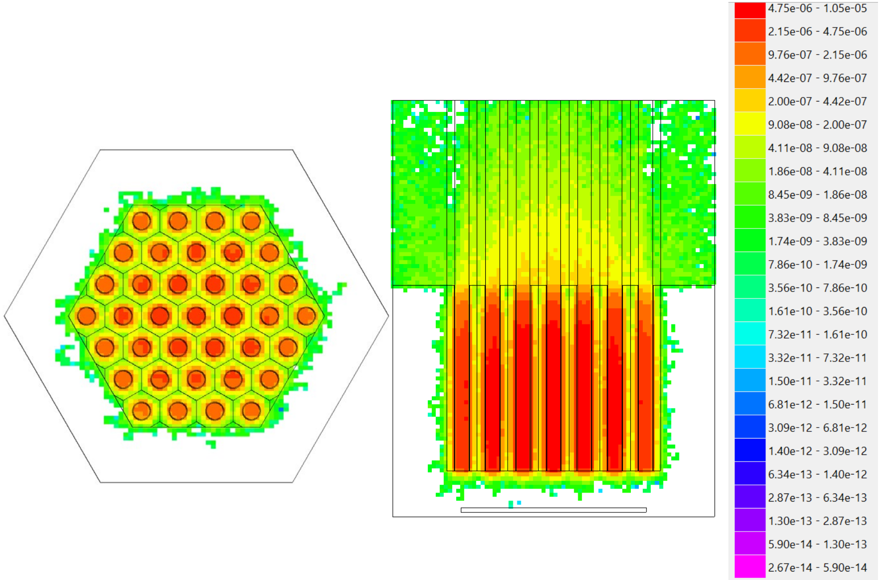
MCNP Inter, Flux



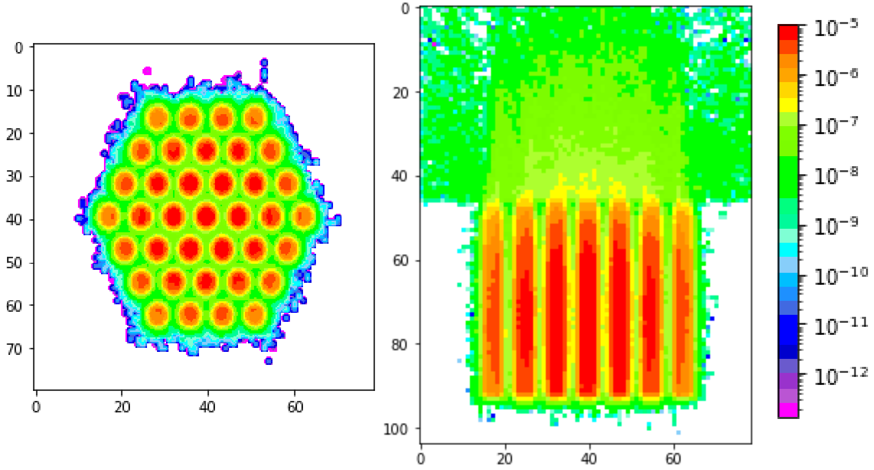
The intermediate flux is relatively evenly distributed.

Flux Comparison – Fast Flux

SCALE Fast Flux

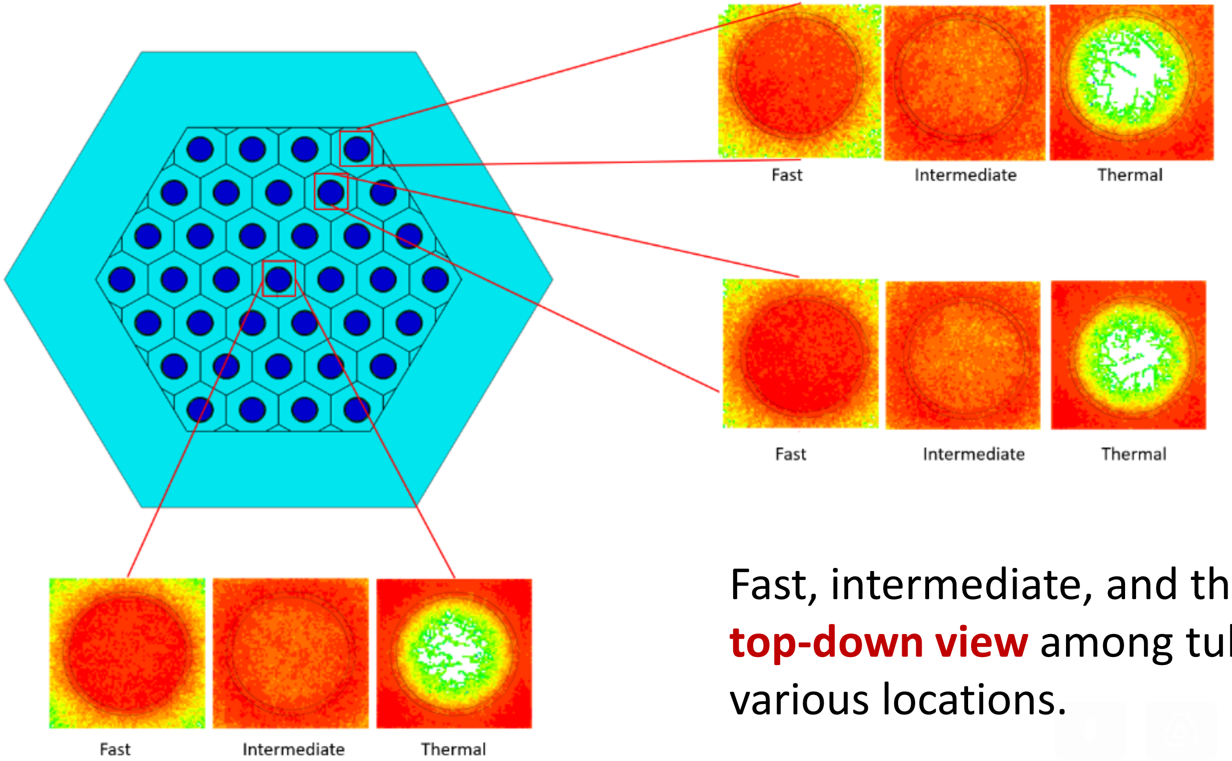


MCNP Fast Flux



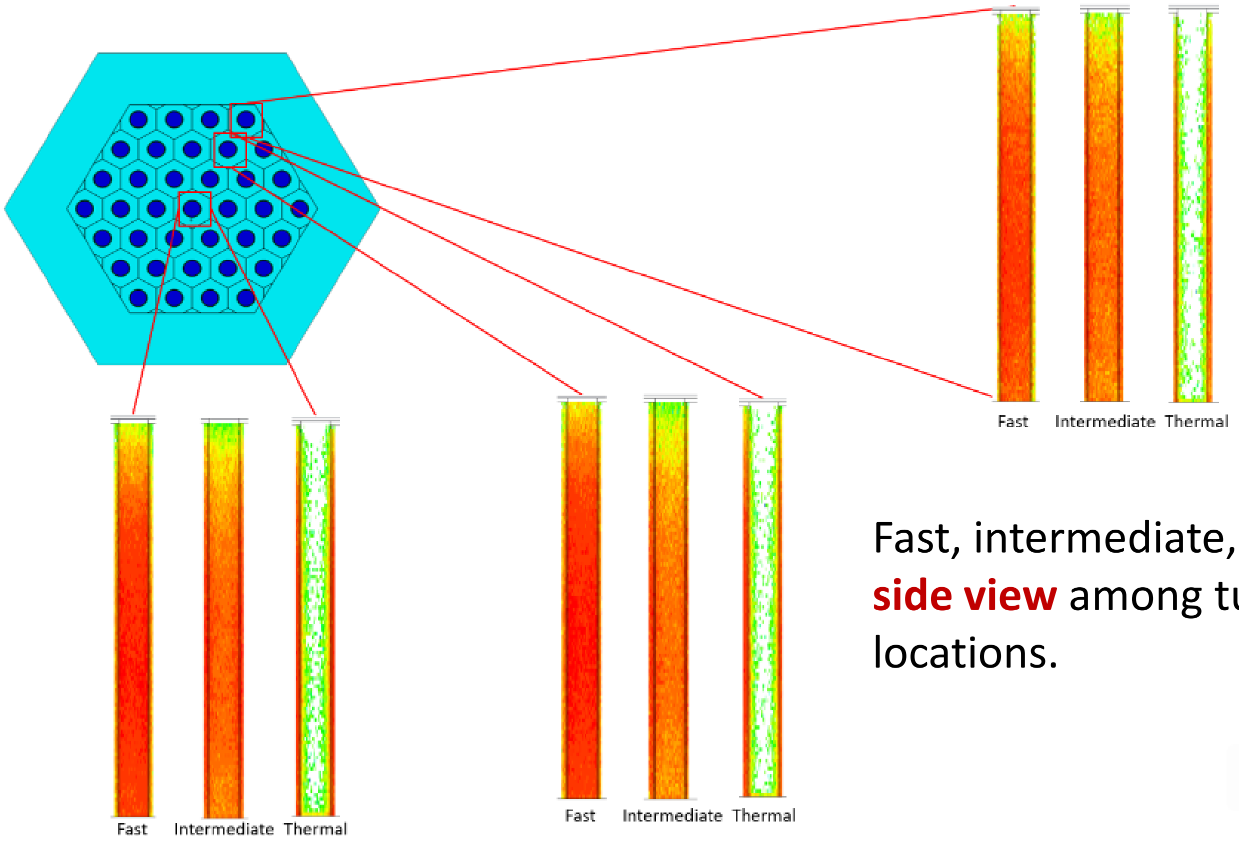
The fast flux is almost uniformly high throughout the fuel tubes in the core but fades off rapidly in the moderator and is low in the moderator except near the fuel tube walls.

Flux Distribution Within the Tubes



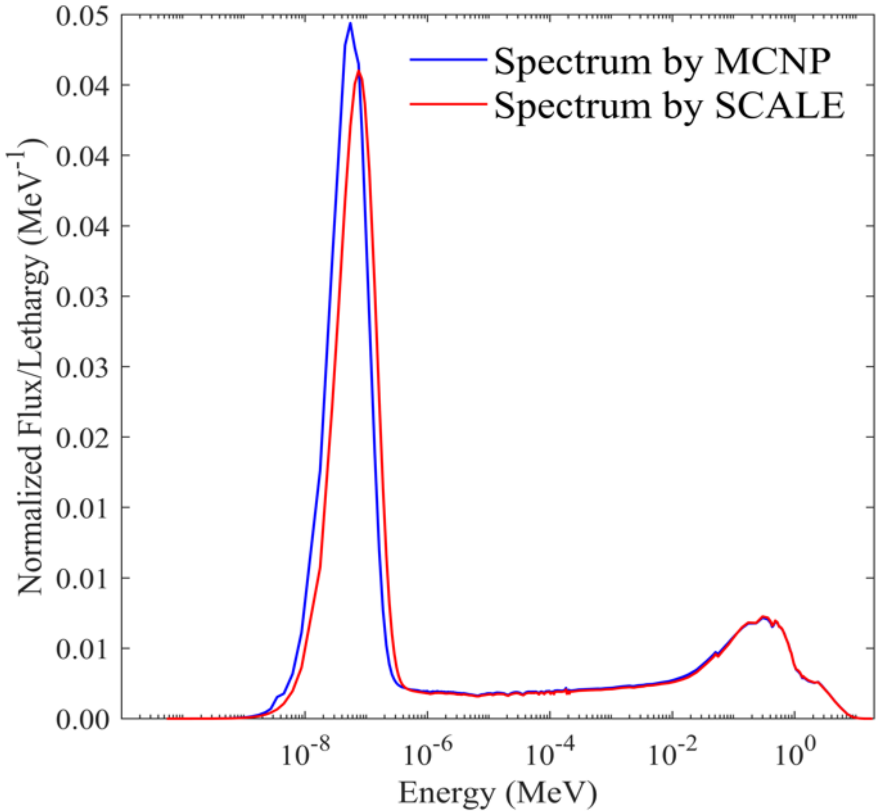
Fast, intermediate, and thermal flux **top-down view** among tubes at various locations.

Flux Distribution Within the Tubes

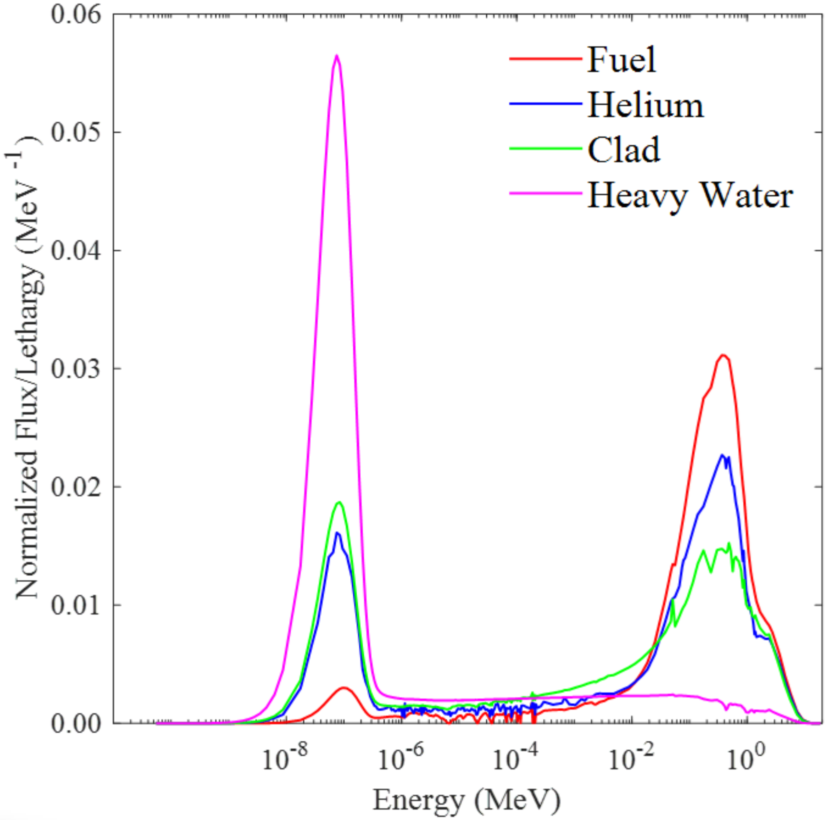


Fast, intermediate, and thermal flux **side view** among tubes at various locations.

252 Group Spectrum

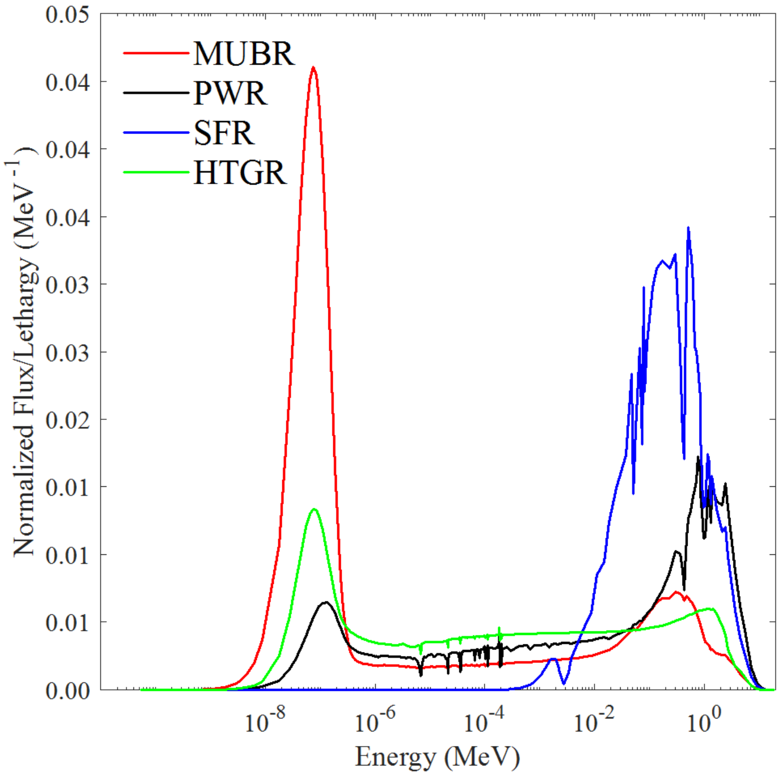


MUBR Spectra at Different Components



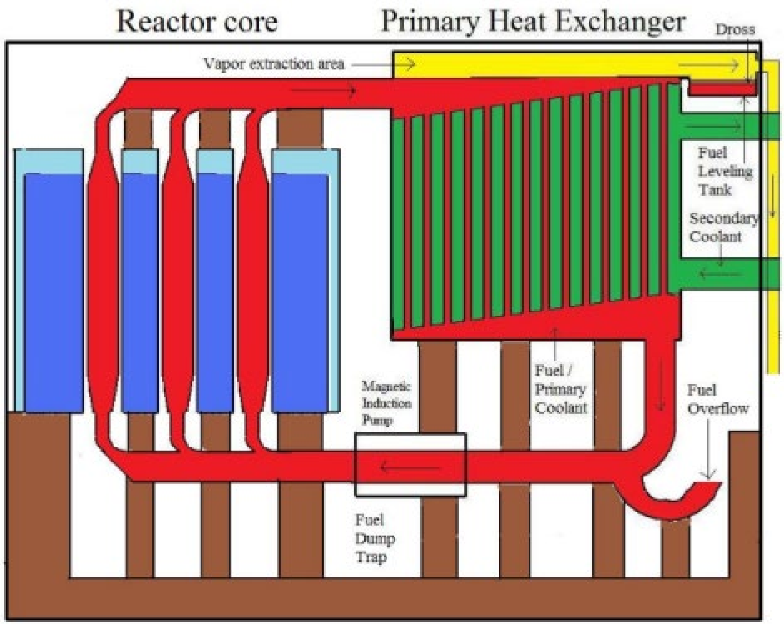
MUBR Spectrum vs. Others

- PWR – Pressurized Water Reactor
- SFR – Sodium Fast Reactor
- HTGR – High Temperature Gas-cooled Reactor

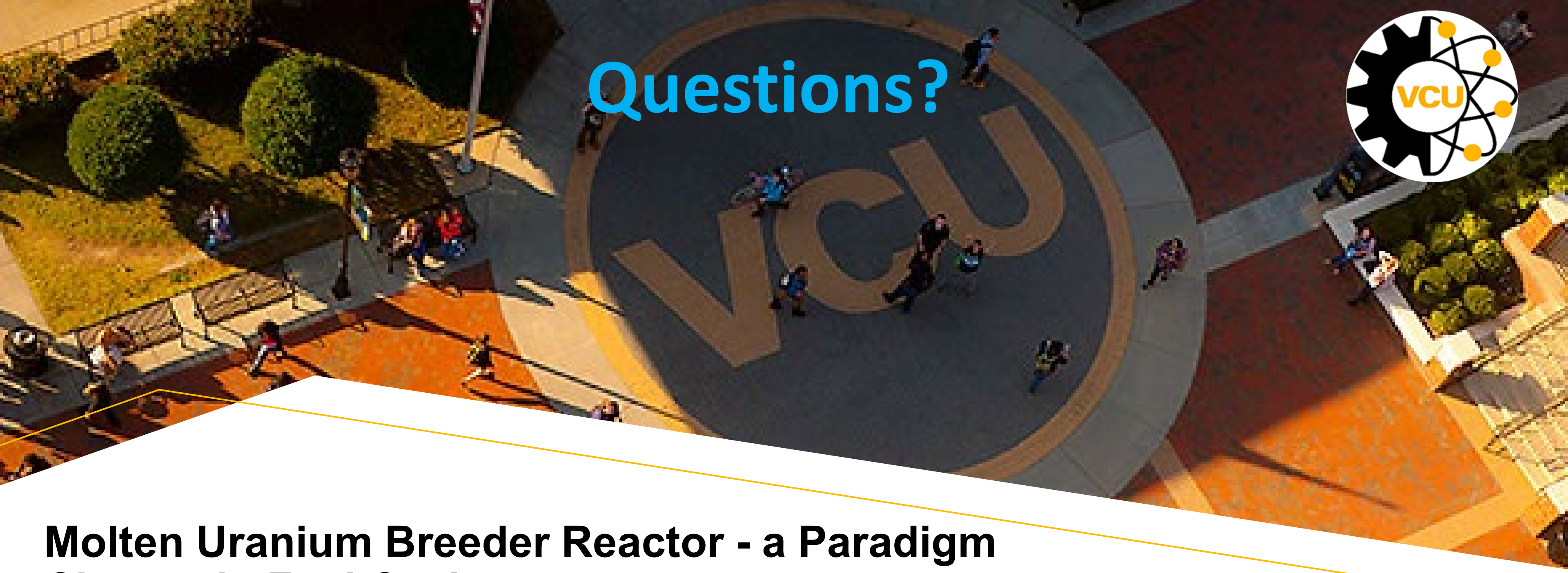


Ongoing and Future Work

- Fission product evaporation and removal capability
- Fuel & moderator temperature coefficient calculations
- Fuel cycle and waste burning analysis



Questions?



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