Introduction to Multiphysics Applications Technical Area

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Multiphysics Applications Technical Area Overview

Reactor Applications

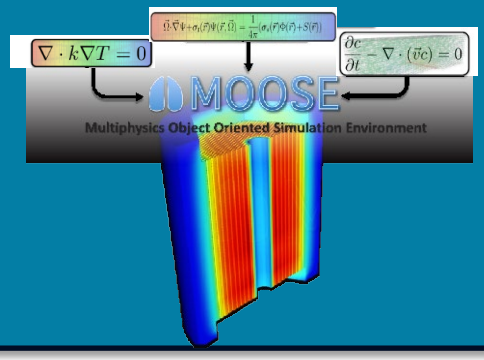
- Engage with stakeholders
- Apply tools to reactor technologies
- Identify code gaps
- Perform V&V
- Publish mature models on NRIC Virtual Test Bed

MOOSE

BLUECRAB

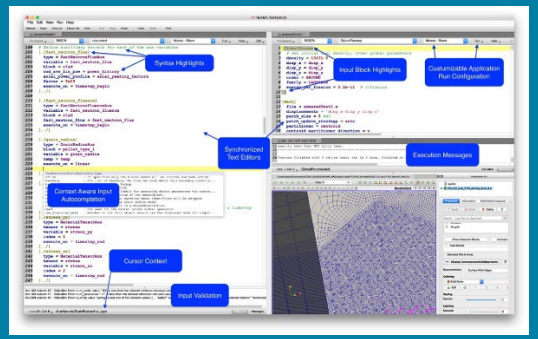
Multiphysics Framework Development

- Enhance MOOSE to provide a robust & efficient infrastructure for code developers and multiphysics users



Deployment & User Workflows

- Deploy software containers on INL HPC for easy access
- Enhance the NEAMS Workbench GUI for enabling user workflows



MOOSE Ecosystem

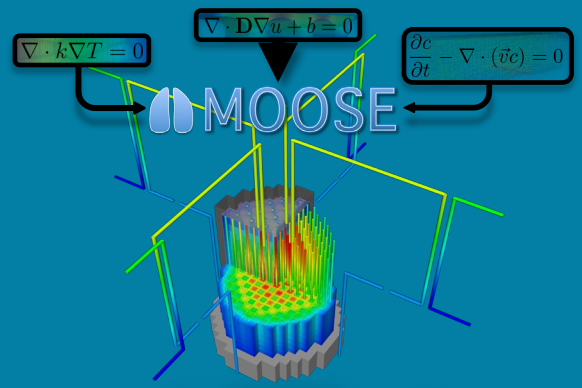
What is MOOSE?

- Open-source
- Massively Parallel
- NQA-1 Compliant
- Flexible multiphysics coupling options

Recent efforts:

- Physics/Component system (simpler input files)
- LSP integration for live syntax completion/validation
- Kokkos/MFEM integration for GPU accelerators

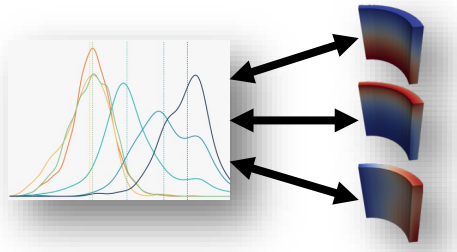
mooseframework.org



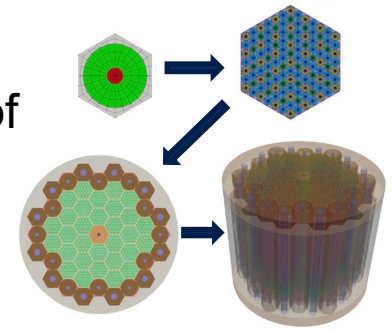
Chemical Reactions	Phase Field
Contact	Porous Flow
Electromagnetics	Ray Tracing
Fluid Properties	Reactor
Fluid Structure Interaction	Reconstructed Discontinuous
Function Expansion Tools	Galerkin
Geochemistry	Solid Mechanics
Heat Transfer	Solid Properties
Level Set	Stochastic Tools
Navier Stokes	Subchannel
Optimization	Thermal Hydraulics
Peridynamics	XFEM

MOOSE also contains modules…

MOOSE Stochastic Tools Module enables parameter sampling, UQ and sensitivity analysis

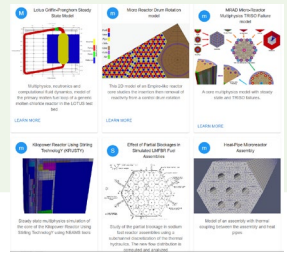


MOOSE Reactor Module enables rapid construction of reactor geometry finite element meshes



Reactor Cross-Cutting Highlights

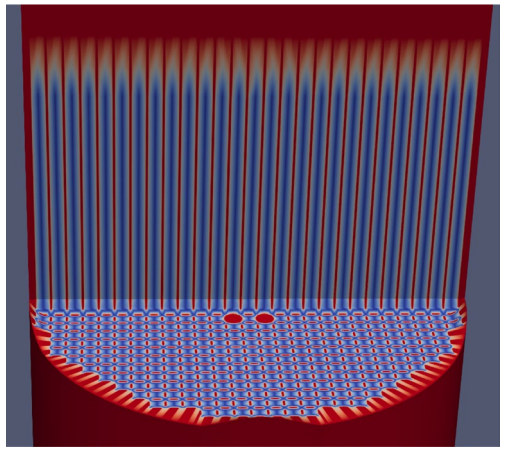
FY24 Milestones	FY25 Milestones
MOOSE and Workbench "front-end" improvements	
• Containerized deployment • Language server protocol (LSP) integration (link) • 2D & 3D reactor geometry meshing improvements (link)	• Initiate support for Constructive Solid Geometry (CSG) to improve Monte Carlo workflows • Improved MOOSE/Workbench integration
MOOSE "back-end" improvements	
• Flexible execution strategies, algorithms for transient solves, and modular system for encapsulating physics (link) • Physics application support (Griffin, BISON, etc) (link)	• Add support for polyhedral elements, AI input generation, hardware accelerators • Deployment of concise physics syntax
NRIC Virtual Test Bed Contributions https://mooseframework.inl.gov/virtual_test_bed/	
Selected model highlights: • High Temperature Test Facility (HTTF) TH model (link) • TRISO fuel failure analysis in a heat-pipe microreactor (link) • LOTUS molten chloride fast reactor neutronics & TH (link) • ABTR SFR cross section generation and reactor physics calculation (link)	*Recent and upcoming model highlights:* • KRUSTY microreactor experiment steady state and 15 cent reactivity insertion (link) • Fast reactor core bowing-related demonstrations



Molten Salt Reactor Highlights

FY24 Milestones	FY25 Milestones
Fast Spectrum Molten Salt Reactor Modeling (LOTUS-MSR)	
Reactor physics & thermal hydraulics *(link)* • Transient modeling (LOF, entrainment of cover gas, operational pump transient) • Depletion calculations	***Initial steady state core simulation capability coupling reactor physics, thermal hydraulics, and evolving chemistry***
Thermal Spectrum Molten Salt Reactor Modeling (MSRE)	
Reactor physics & thermal hydraulics *(link)* • Coupled depletion and redox potential calculations for chemistry control • Xenon transport calculation for Xe poisoning effect • **Code validation**: depletion, transient validation (pump startup/coastdown, reactivity insertion, natural convection, frequency test)	***Initial steady state core simulation capability coupling reactor physics, thermal hydraulics, and evolving chemistry*** • Stochastic perturbations for depletion calculations to capture experimental data removal rates • Reactor physics coupled with depletion including cross section generation • Continued work on Xe transport calculation with bubble flow • **Code validation**: Xe poisoning data

LOTUS-MSR solidification under cold shutdown conditions



MSRE power density

Multi-lab collaborative team:
INL: Mauricio Tano, Samuel Walker, Ramiro Freile, Rodrigo de Oliveira
ANL: Tingzhou Fei, Shayan Shahbazi, Jun Fang
ORNL: Eva Davidson, Donny Hartanto

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