NEAMS Thermal-fluids Area Overview

Molten Salt Program - Annual Review

April 22nd 2026

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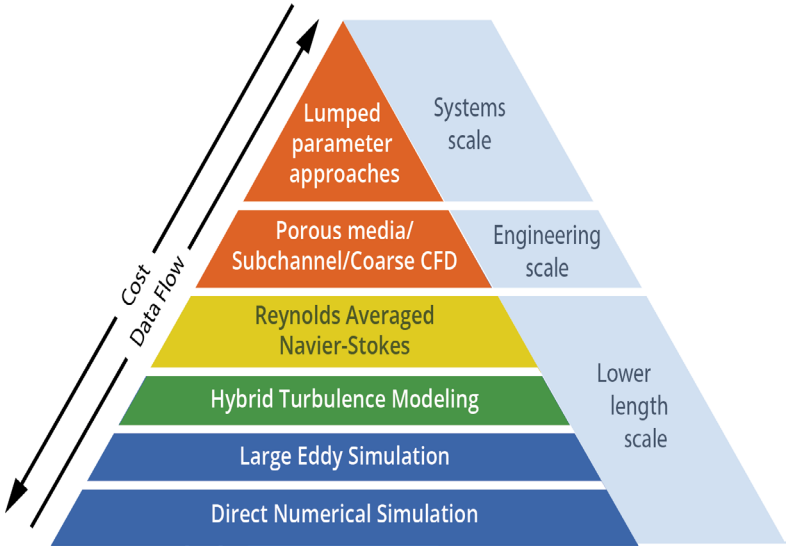
Thermal-hydraulics modeling in NEAMS - I

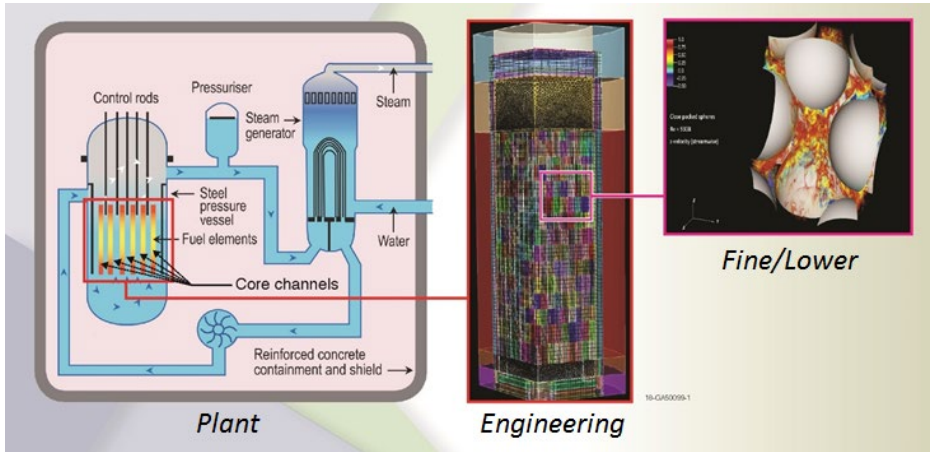
The thermal-hydraulic technical advances the state of the art of thermal-hydraulic simulations by researching novel new solution strategies for challenging real-world heat and fluid flow issues that affect advanced reactor designs or still affect the current fleet of deployed Light Water Reactor nuclear reactors.

- The economics of most advanced reactor designs relies on achieving higher temperatures that the current fleet.
- This poses severe challenges in terms of materials and puts an onus on thermal-hydraulic models to provide accurate assessment of hot spots.
- A reduction of uncertainty on thermal-hydraulic prediction has potential for a substantial economic benefit and to ultimately accelerate deployment.



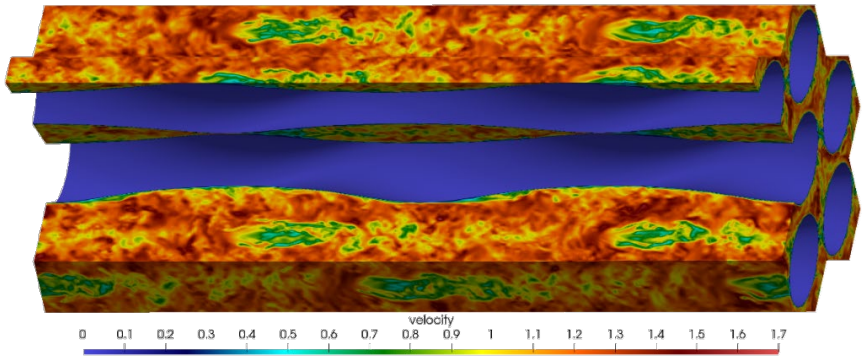
Thermal and Fluid Flow phenomena involve a wide range of length and time scales

- Resolving all scales for a realistic engineering system of interest is often computationally not feasible.
- On the other hand, if scales are not resolved, closures need to be provided to ensure reasonable accuracy, as all scales contribute to the dynamics.
- Multiscale/multi-resolution simulation hierarchy

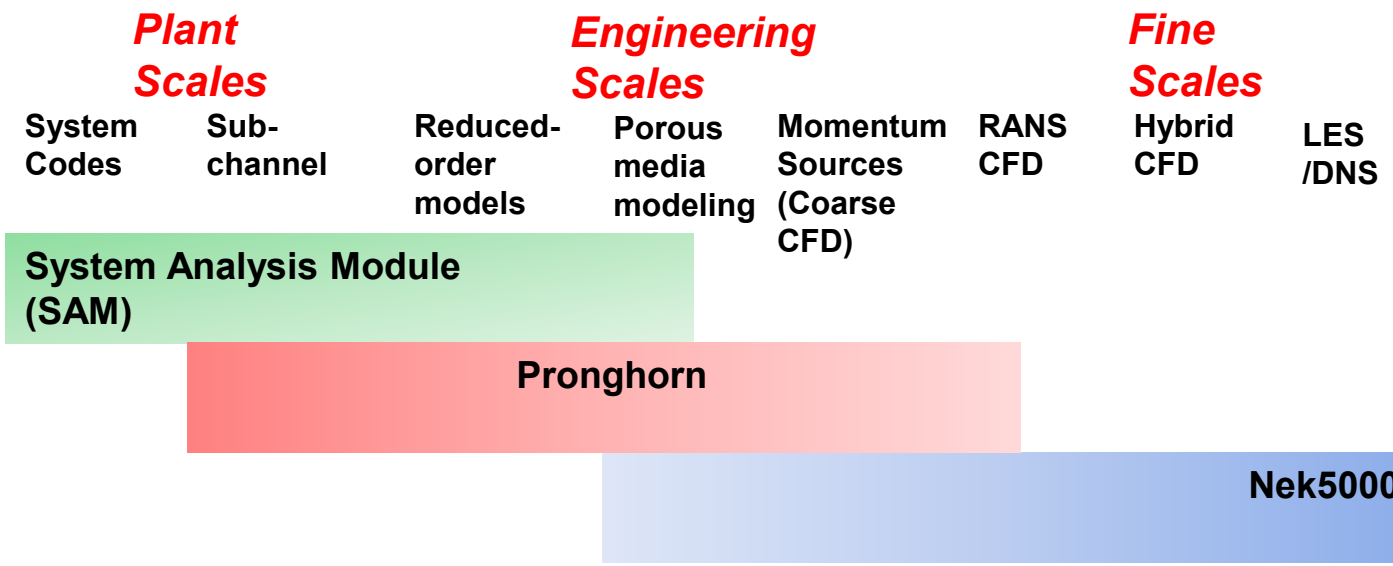


Thermal-hydraulics modeling in NEAMS - II

- **SAM**
  - Trustworthy and practical plant-level system analysis tool for advanced reactors
  - Advances in software environments and design, numerical methods, and physical models thanks to **MOOSE**.
- **Pronghorn**
  - Engineering scale environment build on **MOOSE**
  - Coarse CFD, subchannel and distributed resistance
- **Nek5000/NekRS/Cardinal**
  - Open Source, Spectral element high-fidelity code
  - Proven scalability beyond a million MPI ranks (Gordon Bell prize). Now GPU-capable (NekRS).
  - Extensive code verification and validation
  - *Couples to MOOSE and OpenMC through **Cardinal***
- **Sockeye**
  - Engineering scale heat-pipe heat transfer code.
  - Relies on THM module of MOOSE.
- **CTF**
  - LWR subchannel code.
  - Part of VERA.



Flow in a twisted tube HX.

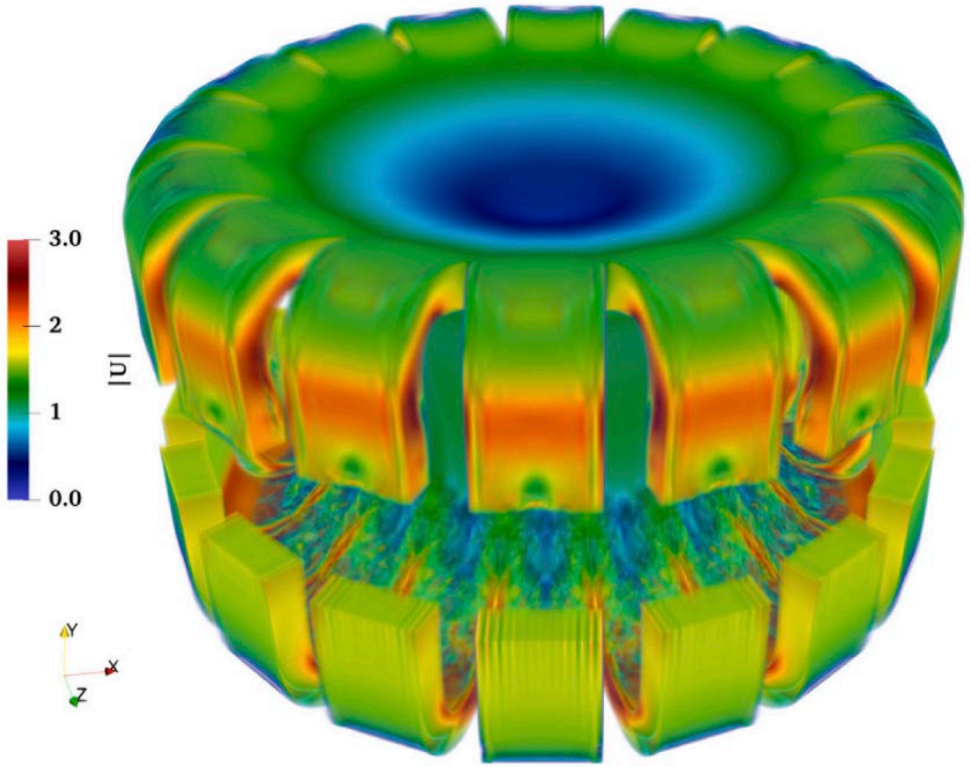


Unique High-resolution Capability

CFD modeling capability for MSR cores at high fidelity

- Example: MSFR
- Comparisons against available data and correlations.
- Can be used to assess applicability of correlations, turbulence models and improvements to both (see presentation today)
- **Electrochemistry integration through MOSCATO**

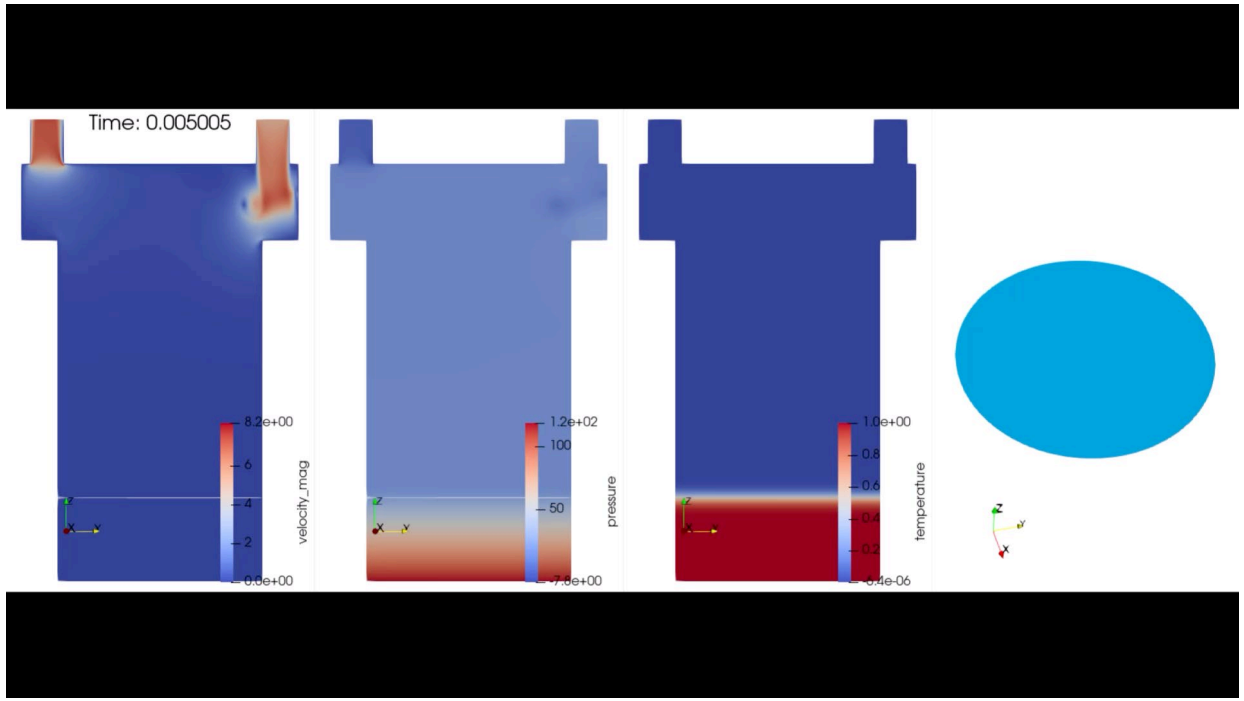
Excellent scaling and performance on leadership class computing architectures (Aurora, Frontier).



Flow in a MSFR core (Large Eddy SImulation).

Thermal-fluids presentations today

- Recent SAM enhancements for MSR applications (Travis Mui)
- Pronghorn enhancements for MSR applications (Mauricio Tano)
- For questions contact me at rhu@nal.gov or ebm5351@psu.edu



CFD Simulation of Air-jet impaction on molten-salt surface. Subsequent application: O_2 ingression in molten-salt

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