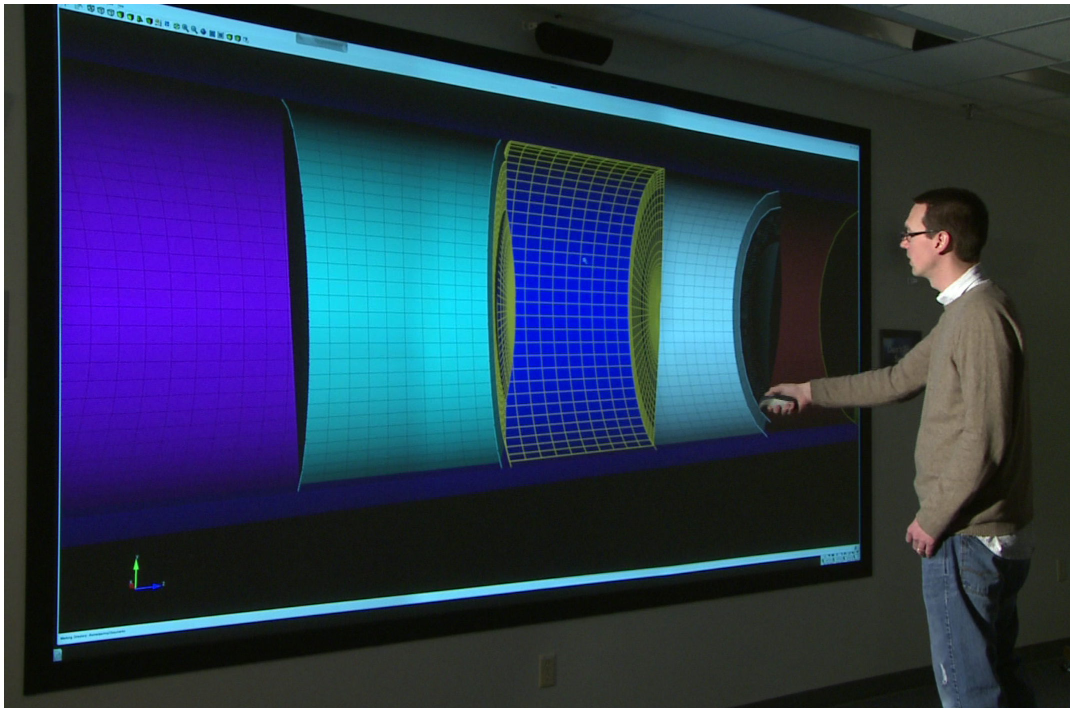

Scientists can advance understanding of everything from how radiation affects materials to how chemicals migrate through bedrock using MOOSE, which bestows simulation capabilities that simplify the process for predicting the behavior of complex systems.

The Energy of Innovation

Idaho National Laboratory

INL's MOOSE Computer Simulation Framework

The platform simplifies the creation of simulations for a myriad of model systems

The Multiphysics Object-Oriented Simulation Environment, or MOOSE, is a computer simulation framework that simplifies the process for predicting the behavior of complex systems ranging from irradiation effects on materials to groundwater physics and chemistry.

MOOSE makes it easier to create computer simulations from complex mathematical models. INL models that have been simulated using MOOSE include

- BISON, which has applications for nuclear reactor designers;
- MARMOT, which shows microscopic response of nuclear fuel to irradiation;
- RAT, which simulates chemicals reacting and flowing through bedrock; and
- FALCON, which simulates water and heat flow in geothermal reservoirs.

MOOSE can even run two or more related models simultaneously to reveal new insights. Such simulations can help inform real-world experiments, and researchers no longer have to be computer science experts to tackle state-of-the-art simulation.

Maximizing the output of models and simulation

Modeling and simulation have become indispensible research tools in many branches of science. Nuclear engineers studying how irradiation affects materials can build a mathematical model incorporating what they already know about radiation and material behavior, and then use that model to perform a computer simulation that predicts outcomes under new conditions.

But building simulations is a time-consuming task

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requiring a team of people with detailed understanding of everything from parallel code development to the physics of the system under study. Most scientists are not programmers (and vice versa), so tackling simulation often proved too daunting.

Now MOOSE can carry much of the programming burden, making simulation tools more accessible for a wide array of researchers. Plus, the MOOSE platform is a general problem solver that can accommodate many mathematical models. It essentially lets researchers "plug-and-play" by entering the mathematics describing their system — whether it's irradiation effects or groundwater movement — and letting MOOSE execute the simulation.

INL's multiphysics methods group began developing the MOOSE framework by utilizing code and libraries from existing massively scaling numerical tools developed elsewhere in the Department of Energy complex and academia. The result is a framework with a number of high-level features including a hybrid parallel mode and mesh adaptivity.

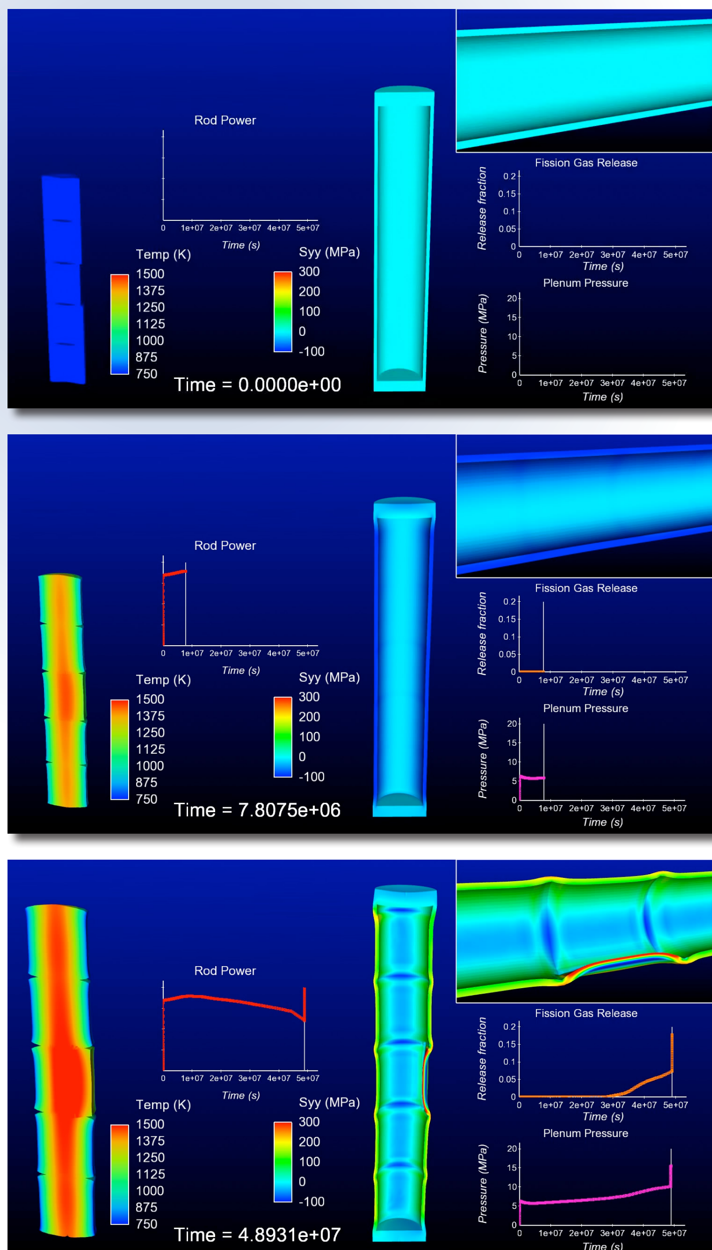
Plus, researchers don't have to access a supercomputer because MOOSE can also function at personal workstations.

New pairings, increased teamwork

MOOSE is helping bring materials scientists and nuclear engineers closer by making it easy to merge their respective mathematical models into a single simulation. For example, MOOSE is able to run both BISON and MARMOT simultaneously to create a simulation that shows how microscopic radiation effects evolve into fuel or cladding failures at the macroscopic scale.

In the future, MOOSE, BISON, MARMOT and a herd of associated programs can enable materials scientists to work hand-in-hand with nuclear engineers to achieve new insights far more quickly than was possible in the past.

Three screen shots from a BISON missing nuclear fuel pellet surface simulation (credit: Richard Williamson), which can help inform nuclear energy industry safety margins by showing how a tiny fuel pellet defect (top panel: middle pellet on left) could cause stress in the nearby cladding (bottom panel: center and upper right).



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