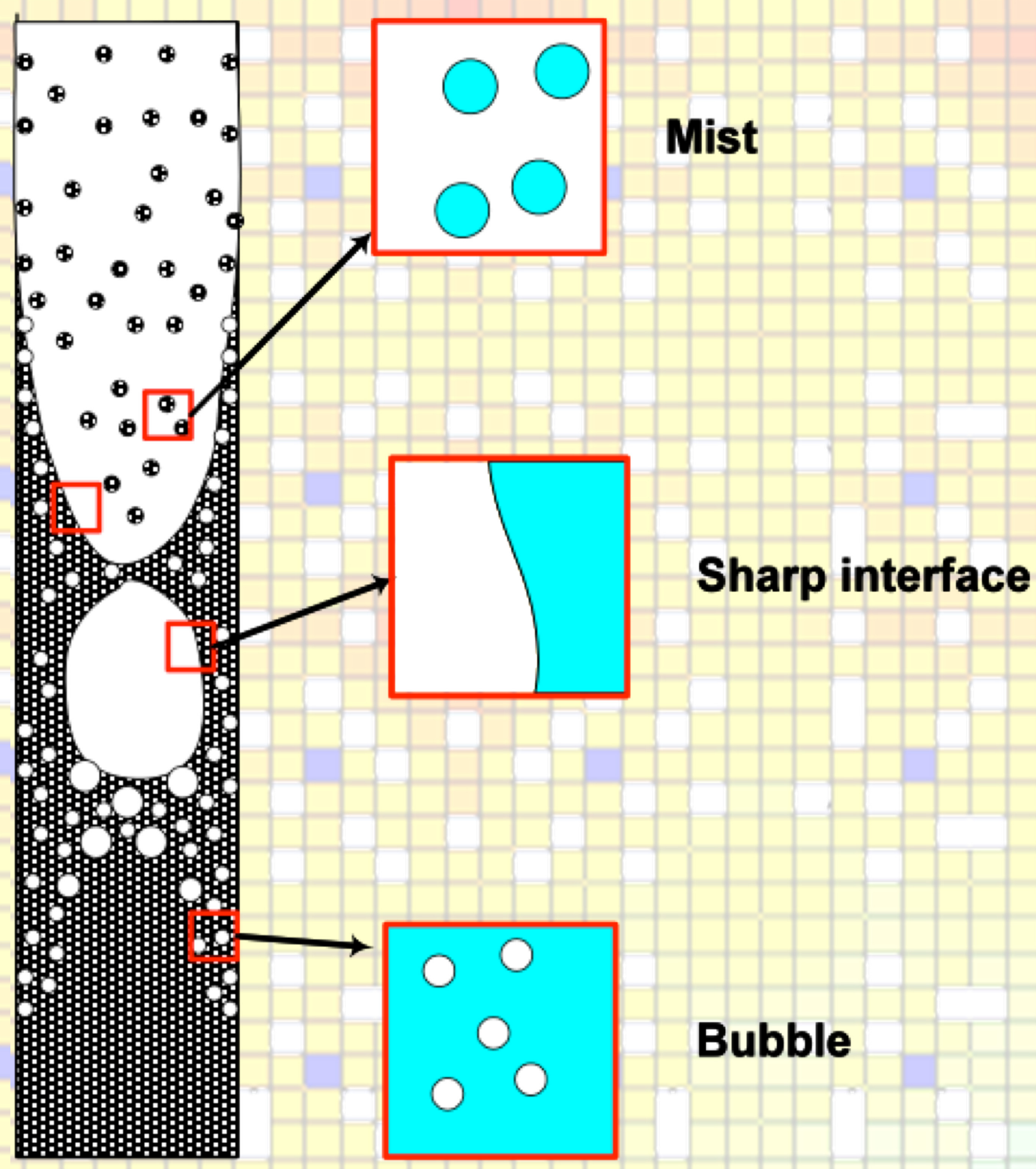
Argonne NATIONAL LABORATORY

Nuclear Engineering Simulations

Advanced Simulations for Today's Nuclear Power Plants

Argonne is working to develop and apply advanced simulation tools that will enable current generation nuclear power plants to safely produce more energy using less fuel than they do today. The advanced tools leverage the power of high performance computing to provide detailed predictions of the nuclear physics, fluid dynamics and heat transfer within the plant. One key enabling technology provides the ability to predict the complex behavior of boiling water.



Simulation of Boiling: Predicting a Familiar and Complex Process

Today's nuclear power plants use nuclear energy to heat water until it boils and turns into steam. This steam is used to turn a turbine which drives an electric generator.

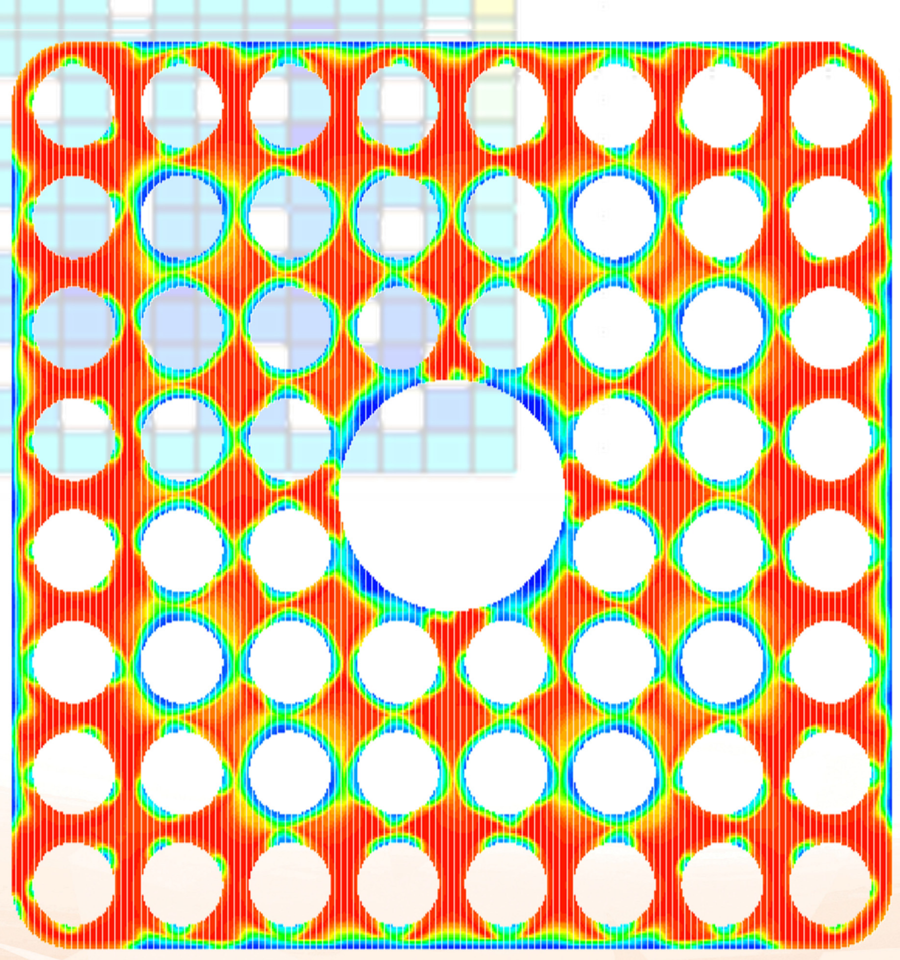
Accurate predictions of the detailed 3-D distribution of steam and liquid water in the core using computational fluid dynamics methods will enable the development of more efficient fuel assembly designs.

(Image Left) The two-phase boiling is based on an extended boiling framework which enables the simulation to model the local topology as bubbly flow, droplet flow or a sharp interface between steam and water. All of the boiling regimes that commonly occur in reactor systems can be reconstructed from these three local topologies.

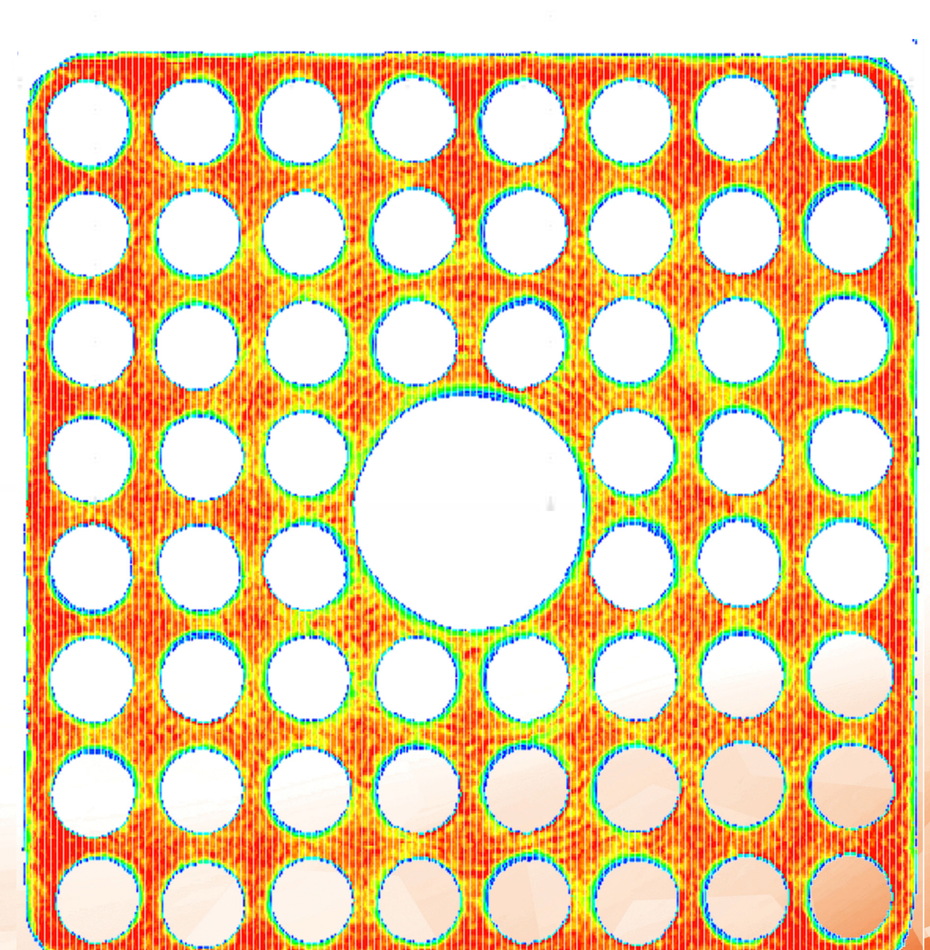
How do we know if it is right?

Simulation results are compared to measured data from experiments to validate that models correctly predict the system behavior. Validation of predictions to ensure that models accurately predict the real world behavior of the system is an important part of the development of any computer model. The two-phase boiling models are being validated by comparing simulations of an international benchmark experiment with detailed measured steam/water distributions, as shown below.

(Background Image) Predicted pin-by-pin power distribution in a current generation Light Water Reactor (LWR) core from simulations using the Numerical Nuclear Reactor.



Predictions



Measurements

(Image Left) Comparison of predicted distribution of steam (red) and water (blue) in an international benchmark experiment simulating a Boiling Water Reactor assembly. The experiment is electrically heated and detailed void distributions are measured using CT scan technology.

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