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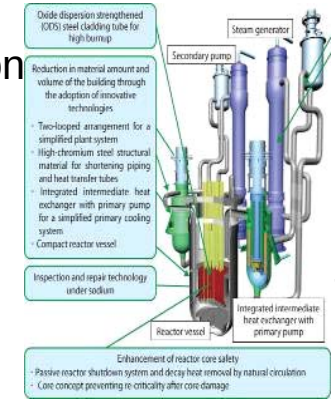
# Fast Spectrum Systems Scientific Research and Development

## Today's Technology Challenges

- Fast reactors have not been commercially deployed – perception of higher system cost of electricity
- Licensing regime is based on light water reactor technology
- Ability to design and assess other systems




## Grand Challenge

- Cost of fast spectrum systems less than current ALWR
- Risk to public health and safety prohibited by inherent safety

## Development Path

**Develop key cost reduction features**

- Modeling and simulation for optimized design and performance, and safety assurance
- Advanced materials for performance, reliability, longevity, and safety
- Energy conversion innovations for improved efficiency and component cost
- R&D facilities for validation of innovative features and exploration of options

## Transformational Result

- Revolutionary improvements in fast spectrum system performance (and cost) to enable transmutation and economic fuel cycle closure

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# Overview of AFCI Reactor R&D

- **For the closed fuel cycle, must develop and demonstrate the advanced recycle reactor**
  - Fast spectrum needed for final transmutation system
  - Sodium coolant technology chosen if near-term application
- **For future fast reactor technology deployment, a key research focus is capital cost reduction**
  - Improved design approach (e.g., compact configuration)
  - Advanced technologies (e.g., materials, energy conversion)
  - Advanced simulation for optimized design
- **Major technology R&D areas include:**
  - Advanced modeling and simulation *(separate talk)*
  - Advanced materials
  - Advanced energy conversion technology
  - Nulcear data *(separate talk*)
  - Reliability technology (e.g., undersodium viewing)

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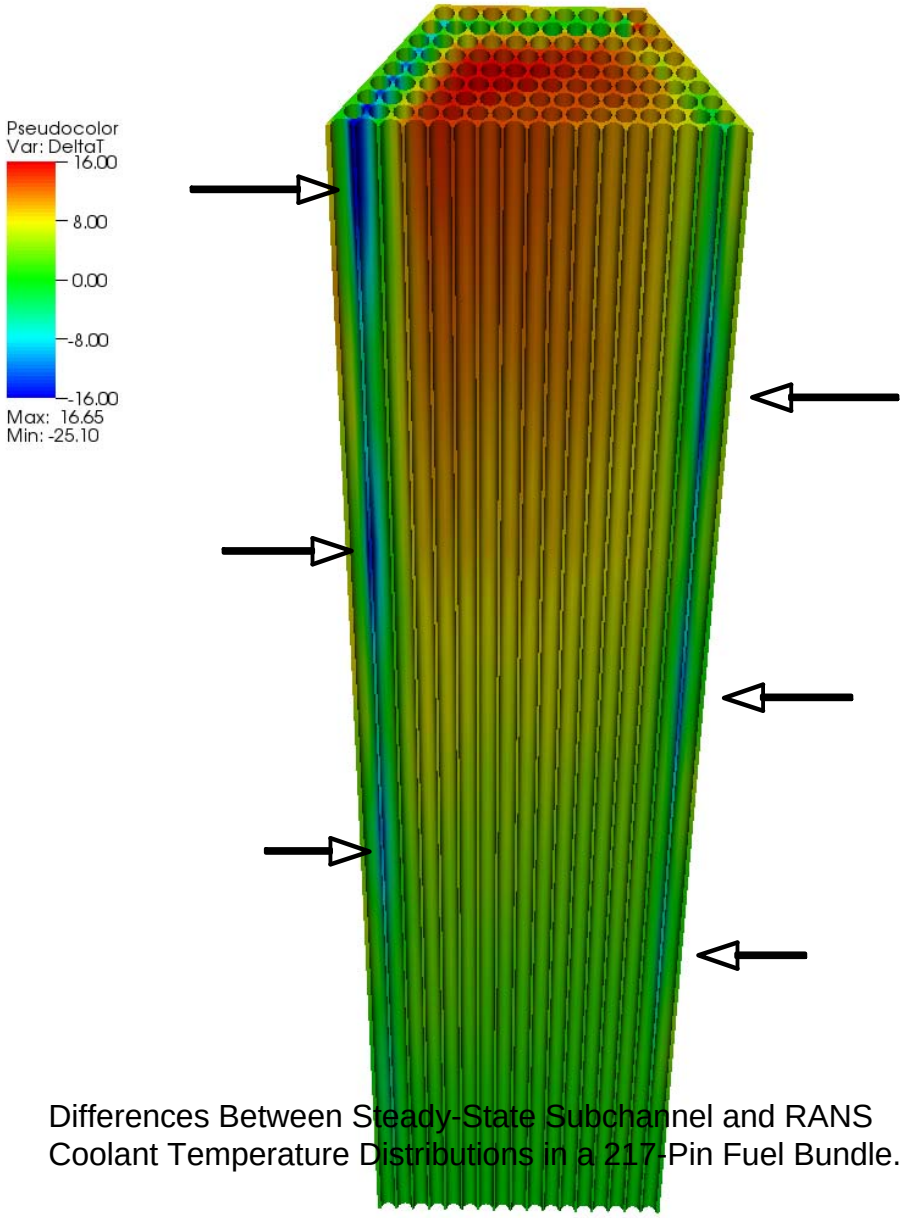
# Reactor Modeling and Simulation

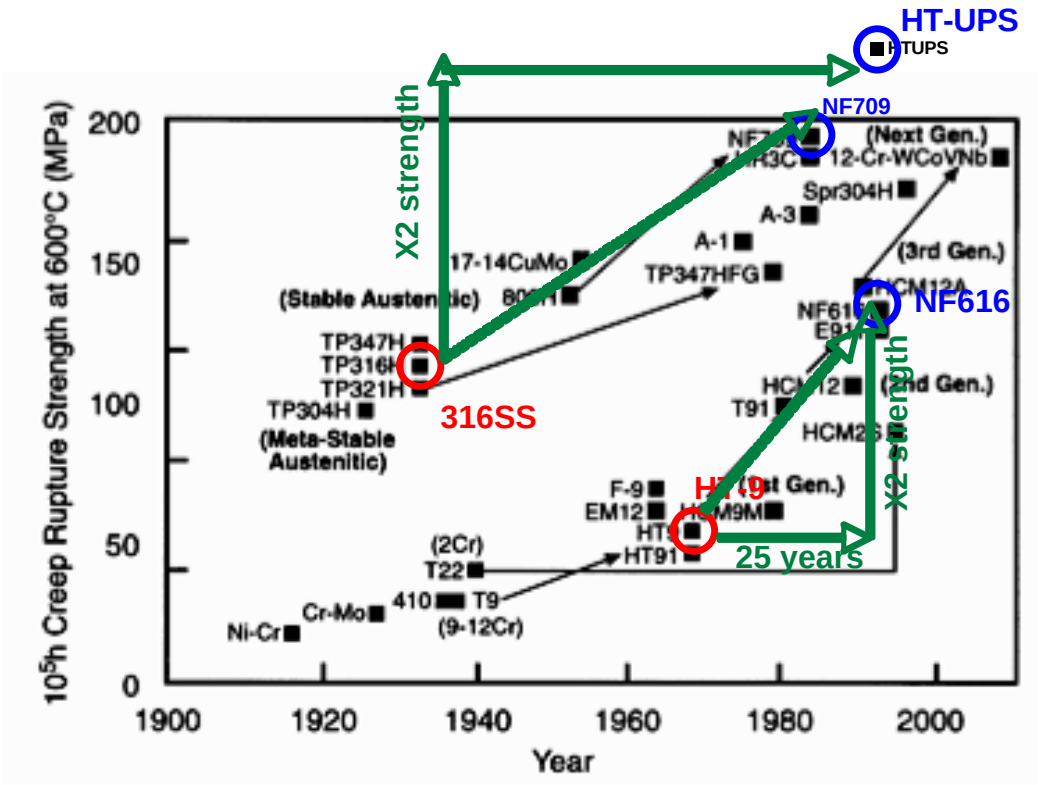
- High fidelity simulation allows:
  - Improved performance by reducing conservatism of existing models
  - System optimization by more detail and multi-physics integration
  - Exploration of design approaches outside the existing database
- Advanced modeling accomplishments in key physics areas
  - Significant improvements in fluid thermal dynamics methods
  - Greater geometric and energy detail for neutronics methods
  - Application of reactor simulation codes to high-power computers
- The final product will be an integrated performance and safety code




Differences Between Steady-State Subchannel and RANS Coolant Temperature Distributions in a 217-Pin Fuel Bundle.

# Advanced Materials

- Fast reactor capital costs is dictated by the commodities; improved materials offer better performance, reliability, durability, and safety.
- Downselect process to choose candidate materials has been completed
  - Both austenitic (HT-UPS and NF709) and ferritic steels (NF616)
- Testing of the advanced alloys has been initiated
  - Mechanical properties
  - Sodium compatibility
  - Creep fatigue
  - Thermal aging
- Future work will consider joining and code qualification aspects



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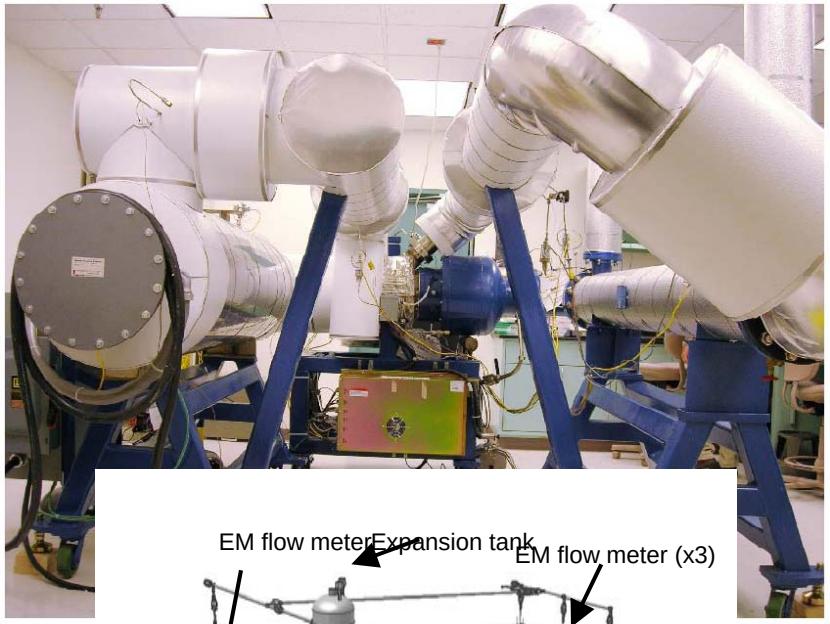
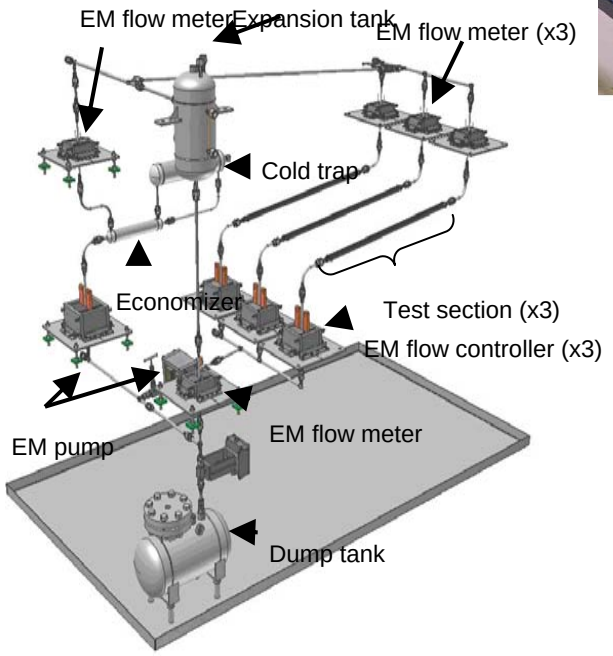
# Energy Conversion Technology

- Advanced energy conversion technology may improve thermal efficiency at SFR temperatures and reduce cost
  - A promising alternative being investigated is the supercritical $CO_2$ Brayton cycle
- Supercritical CO2 turbomachinery is being developed and tested
  - Small-scale 1 MWt loop at Sandia
  - Control strategies being investigated
- Innovative heat exchanger technologies also being explored
  - Compact heat exchangers for sodium-$CO_2$
  - Investigation of plugging phenomena for sodium in small diameter tubes
  - Heat exchanger testing facility design
- Future work will scale-up testing of complete energy conversion cycle to verify the feasibility and performance





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# University Solicitation Topic – *Tentative*

## Fast Spectrum System Innovations

- **Fast Reactor Educational and Training Materials**
  - Shrinking base of expert engineers and scientists
  - Develop communication tools (e.g., short course on either fast reactor and/or liquid metal technology) with National Lab experts
- **Transformational Concepts**
  - Radical changes to conventional fast reactor
  - Definition, performance, and R&D identification for new ideas

## Nuclear Data (*details in later session)*

- **Theory and Modeling**
  - Especially important for new measurements (e.g., inelastic scattering)
- **Improved Measurement Techniques**
  - New techniques and/or measurement types

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# University Solicitation Topic – *Tentative*

## Advanced Materials

- **Aging and Stability Testing**
  - Microstructural stability at extended life and severe conditions
  - Evaluate candidate alloys in existing facilities
- **Lifetime Modeling**
  - Predictive tool to assess degradation and behavior of key properties; synergy of multiple phenomena is required

## Advanced Energy Conversion

- **Heat Exchanger Testing**
  - Innovative compact heat exchanges being investigated
  - Fundamental phenomena and reliability testing needed
- **Supercritical $CO_2$ Brayton Cycle Modeling**
  - Initial testing at small-scale being conducted currently
  - Evaluation of off-normal behavior and dynamic/control strategies is required to refine performance