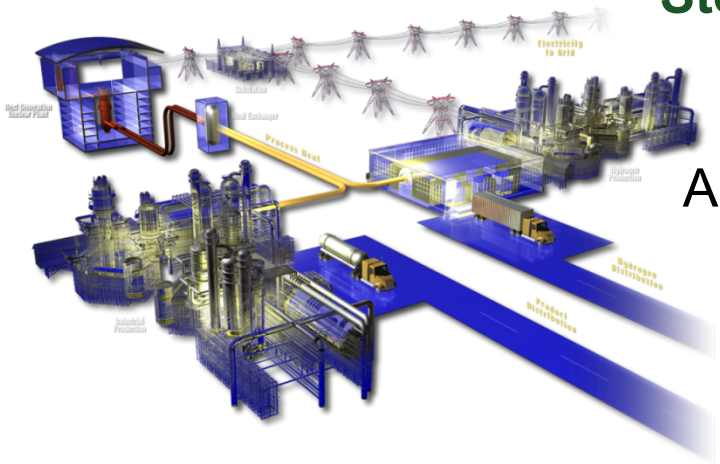
U.S. DEPARTMENT OF ENERGY | Nuclear Energy

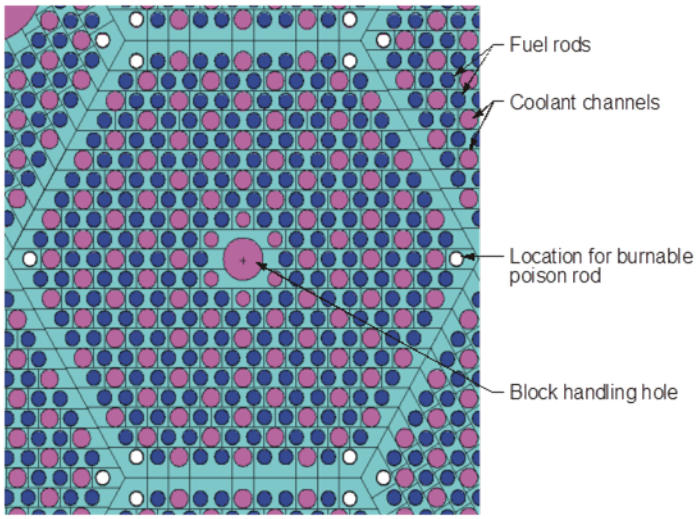
Nuclear Energy University Programs (NEUP) Fiscal Year (FY) 2016 Annual Planning Webinar

RC-1: Computational Methodologies

Steven Reeves



August 2015



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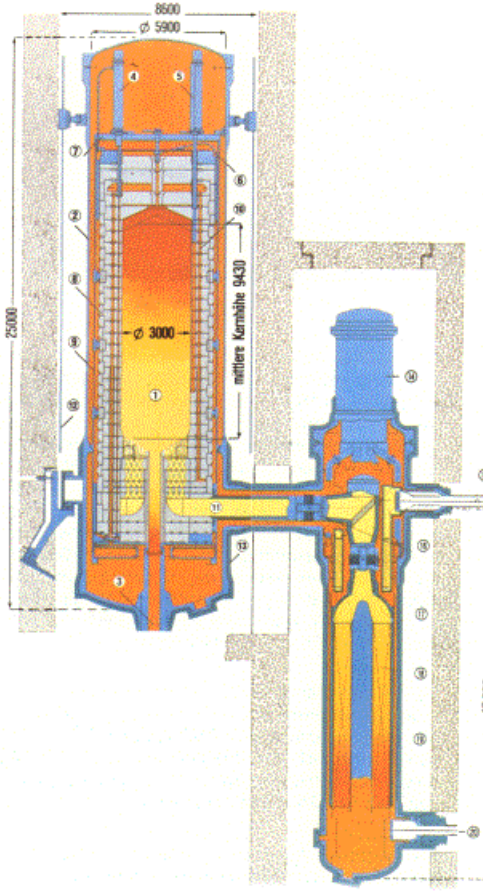
Gas-Cooled Reactor – Validate Simulation

- ***Focused on providing high quality data* for *validation of system and computational fluid dynamics codes and models of high temperature gas-cooled reactors***
- **Data needed to support validation matrix in the following areas***
  - **air and water ingress,**
  - **core heat transfer,**
  - **plenum-to-plenum heat transfer,**
  - **heated two-component stratified flow,**
  - **bypass flow,**
  - **dust and fission product transport in the primary loop, and**
  - **performance of reactor cavity cooling systems**



*** NGNP PIRT v. 4 -** http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6944/v2

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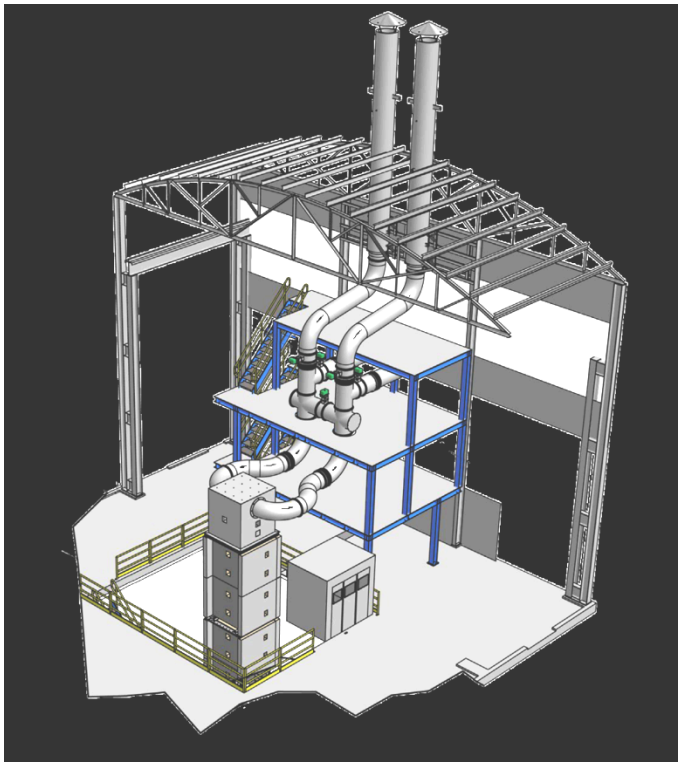
Code Validation – Coordinated Testing

- **Scaled separate and mixed effects tests of coolant mass flow and heat transfer under prototypical conditions and specific geometries**
- **Integral tests to reproduce thermal fluid conditions bounding gas-cooled reactor under nominal and accident scenarios in existing facilities such as**
  - **High Temperature Test Facility**
    (Oregon State University)
    http://ne.oregonstate.edu/content/high-temperature-test-facility-httf
  - **Natural circulation Shutdown Test Facility**
    (Argonne National Laboratory)
    http://www.ne.anl.gov/capabilities/rsta/nstf/index.shtml
  - **Matched Index of Refraction Facility**
    (Idaho National Laboratory)
    https://inlportal.inl.gov/portal/server.pt/community/mir_home/624/mir_home/7326



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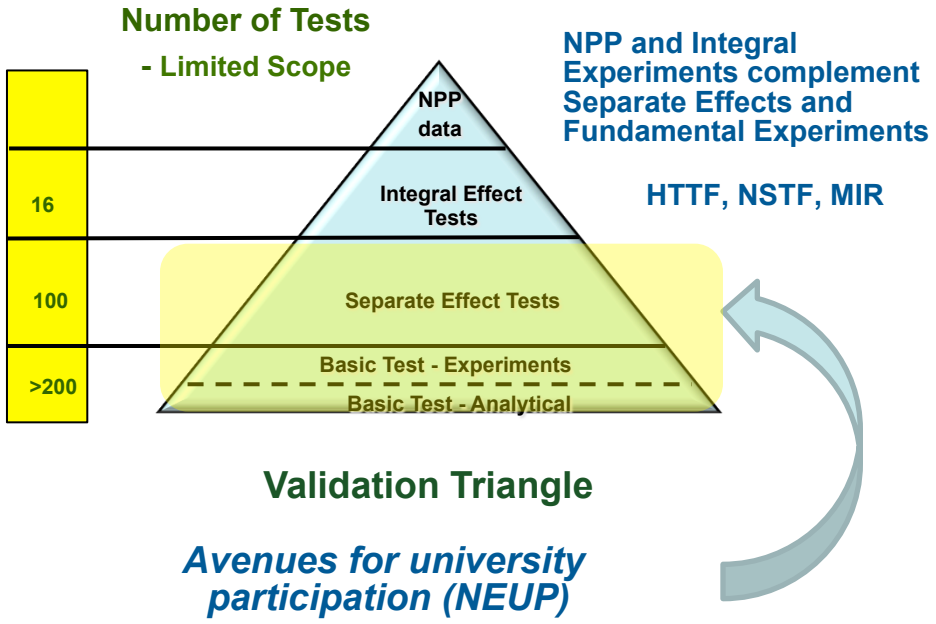
Proposals Needed – Fill the Gaps

- Appropriately scaled fundamental and separate effects experiments that complement tests at integral testing facilities, or
- Extend and enhance experiments at those facilities or other suitable integral facilities not identified here



Note: Investigators who wish to propose new experiments using one or more of these facilities are strongly urged to coordinate with the Principal Investigators at those facilities before submitting the final proposal to obtain guidance on costs, schedule, and quality assurance (NQA-1).

Instabilities in Natural Circulation

- **Air & water based RCCS are the leading considerations for passive decay heat removal in GenIV gas cooled reactors**
- **Natural circulation systems are inherently sensitive**
  - Existing work with both air and water have observed instabilities in several forms
    - Air: major instabilities can impede RCCS flow -> performance degradation
      - Unique to air is strong meteorological and geometric sensitivity
    - Water: major instabilities can induce strong vibrations -> structural concerns
      - Unique to water is dependence of instabilities on water inventory (time into accident)
- **Additional work towards the greater understanding of the impact on heat removal performance would be beneficial**
  - Expand on high fidelity instrumentation to capture phenomena and support modeling efforts
  - Flow instability envelope, triggers, influences, and impact on performance
  - Dynamic structural concerns from water vibrations

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Current State of Air RCCS Testing

NSTF

Universities

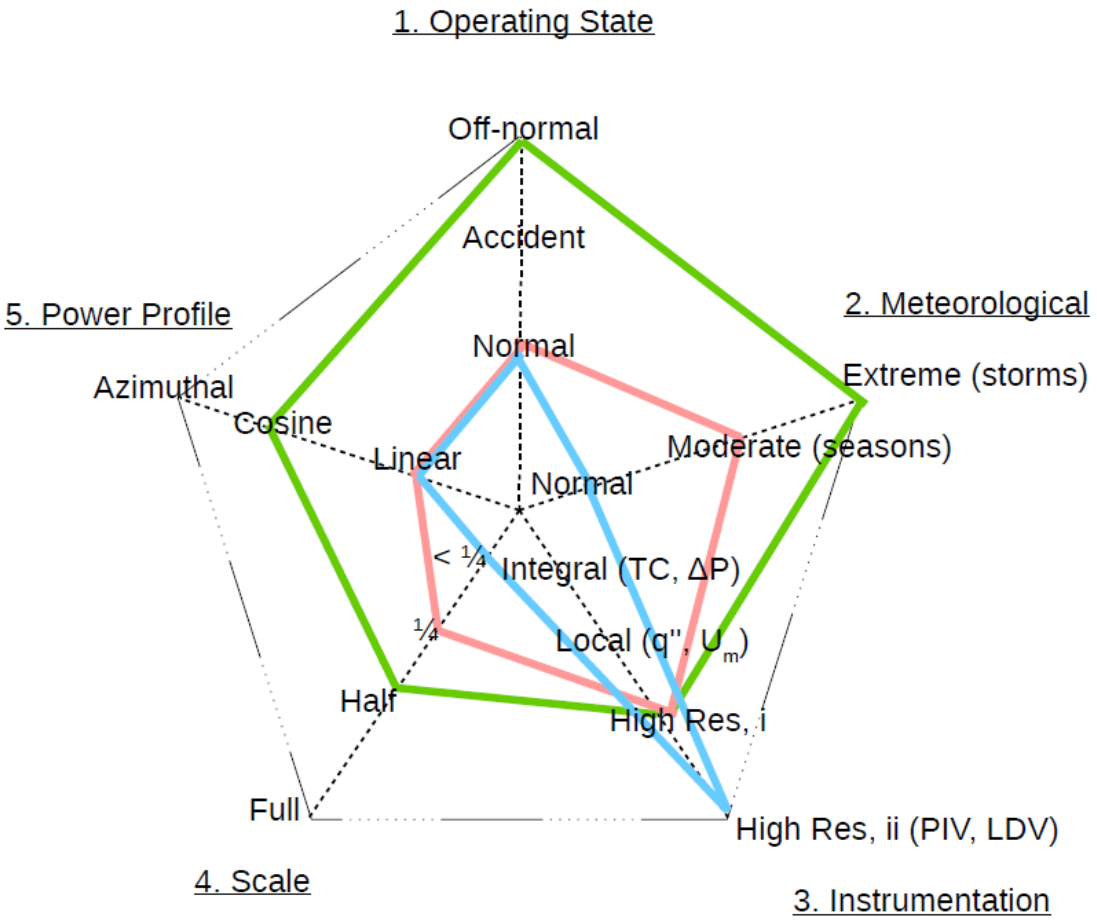
1) Operating State
1) Normal (700 kWt heat load)
2) Accident (1.5 Mwt decay heat)
3) Off-normal (blocked risers)

2) Meteorological
1) Normal
2) Moderate (summer, winter)
3) Extreme (storm)

3) Instrumentation
1) Integral (TC, Flow)
2) Local (heat flux, DP)
3) High Res,i (LUNA, hot-wire)
4) High Res,ii (PIV, LDV)

4) Scale
1) < ¼
2) ¼
3) ½
4) Full

5) Power Profile
1) Linear uniform
2) Cosine
3) Asymuthial Skew



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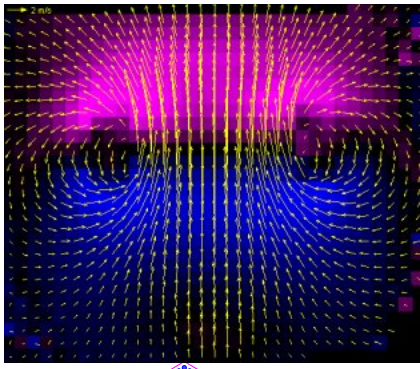
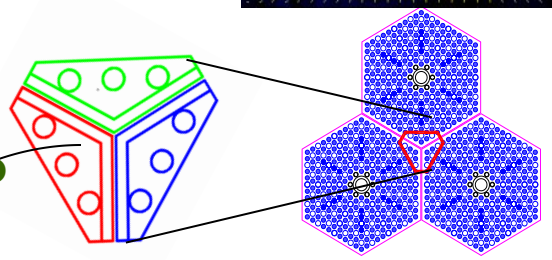
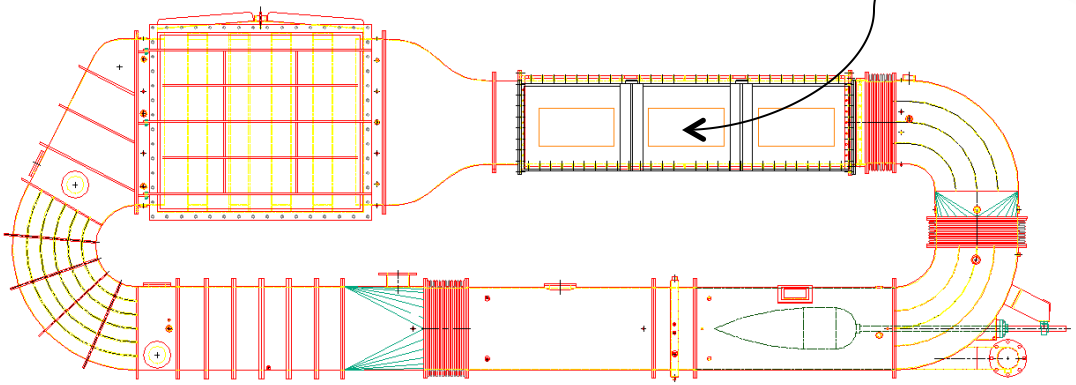
Code Validation – Verses Development

- Experiments in-conjunction with pre-test and post-test simulations:
  - Computational fluid dynamics, or other suitable codes.
- Emphasis:
  - Generation of high quality experimental data
  - Used for the validation of different analysis codes
  - Not the development of those codes.
- All data and simulation results are to be:
  - uploaded to and archived in the INL's NGNP Data Management and Analysis System (NDMAS.)
- Investigators - Coordinate with INL personnel to link to the NDMAS.







Interstitial Block Flow Model to be inserted into the MIR Flow Loop

Flow field captured with Particle Image Velocimetry

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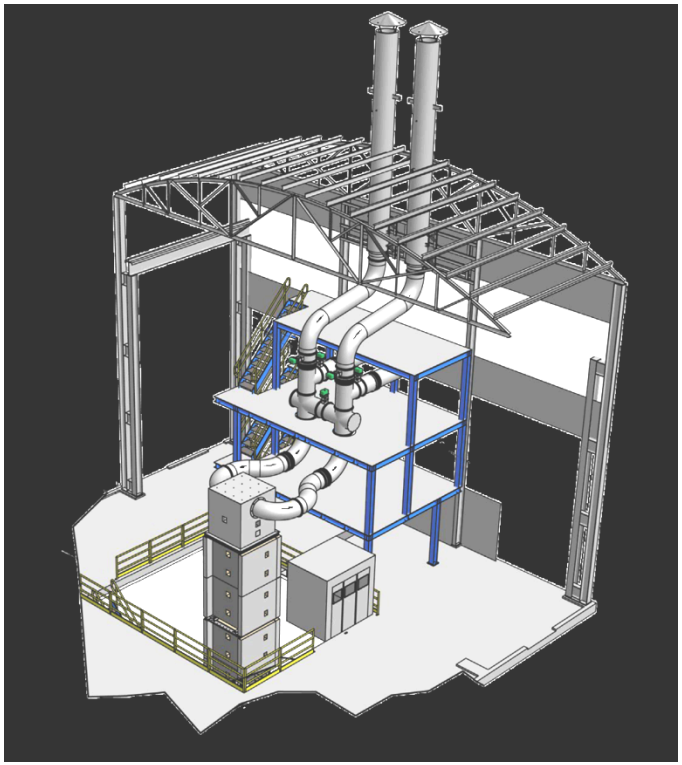
Summary

- A range of supporting scaled fundamental, separate, and mixed effects experiments are needed
- Experiments:
  - Must be scaled to reproduce anticipated conditions in reference system (e.g. MHTGR 350) and
  - Must complement past or current experiments at:
    - High Temperature Test Facility (OSU)
    - Natural Convection Shutdown Heat Removal Test Facility (ANL) and
    - Matched Index of Refraction Facility at INL or others
  - Can be accompanied by pre- and post-test analyses
- New measurement techniques encouraged
- Conform to NQA-1



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