Experiment Insertion in a High Power Test Reactor

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Topics

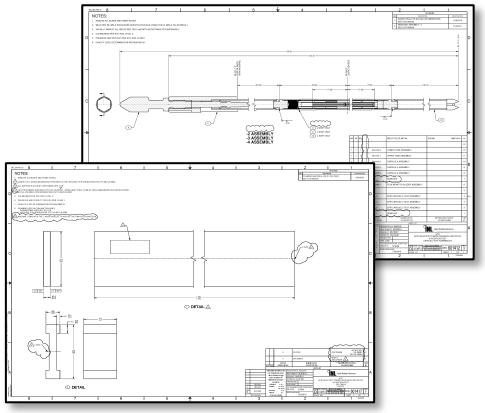
- Experiment Reactor Insertion Process
  - Defining the Experiment Objectives
  - Experimental Design Process
  - Required Analysis
  - Documentation Requirements
  - Typical ATR Experiments
  - Reconfiguration and Transportation

Experiment Objectives

- Experiment Technical and Operational Requirements
  - Balancing experimental objectives and reactor requirements
  - Experiment Objectives
    - Phenomena of interest (effects of irradiation)
      - e.g. Material defects, structural changes, fuel performance
    - Fluence (desired flux over total irradiation time [dpa/ wt.% burnup])
    - Parametric controls (temperature, pressure)
  - Reactor Requirements/Restrictions
    - Criticality safety (flux perturbations, reactivity)
    - Appropriate containment of materials to ensure no release
      - Materials incompatible with the reactor fuel element cladding, canal water or reactor primary coolant system (PCS) (i.e. mercury, gold, copper, silver and chlorides).
    - Generally Excluded Materials (may vary between reactors)
      - Explosive materials, cryogenic liquids, etc.
    - Material type (stainless steel, aluminum, titanium)
      - > 235 psig internal pressure – meet intent of ASME Pressure Boundary Code or demonstrate by prototype testing to withstand service conditions without failure.

Experimental Design

- Select Appropriate Experiment Type
- Select Suitable Reactor Position
  - Experiment Objectives
  - Flux
  - Lobe Power
  - Position Size
- Design of test specimen and components
- Scoping Analysis – desired as built configuration / nominal operating conditions
- Bounding Analysis – maximum configuration / accident conditions
  - Neutronic
    - Reactivity
    - Neutron/gamma heating rates
    - Heat Generation Rate
    - Fuel fission power density
  - Thermal/Hydraulic
    - Min. and max. temperatures as a function of gas gap/gas mixture
    - Appropriate Cooling
    - Effects of Coolant Flow on the Experiment Assembly
    - Departure from Nucleate Boiling Ratio (DNBR)
    - Flow Instability Ratio (FIR)
  - Structural
    - Effect on material during irradiation (temperature, pressure, etc.)
    - Structural integrity must be maintained



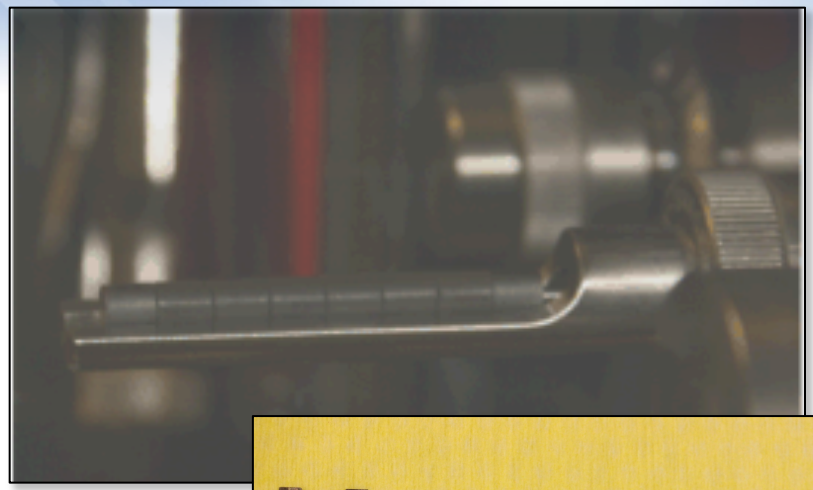
Documentation Requirements

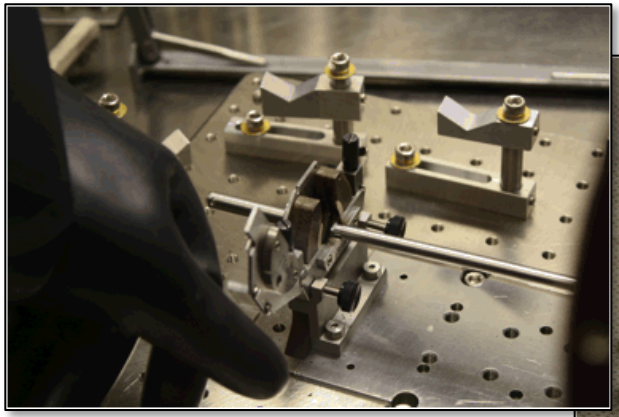
- Project Execution Plan
- Technical and Functional Requirements (T&FRs)
- Design Drawings
  - Test specimen, Capsule, Basket, Assembly
- Engineering Calculation & Analysis Report
  - Neutronic, Thermal, Structural
- Fabrication and Inspection Plans
- As-built Data Packages
  - Work orders
  - Lab notes, etc.
  - Material certifications - No Unknown Materials with the exception of trace constituents
- Experiment Safety Assurance Package
- Design Acceptance

Fabrication and Assembly

- Fabrication of Test Specimen
- Pre-irradiation characterization
- Fabrication of Components
- Acceptance testing of components
- Assembly of Components

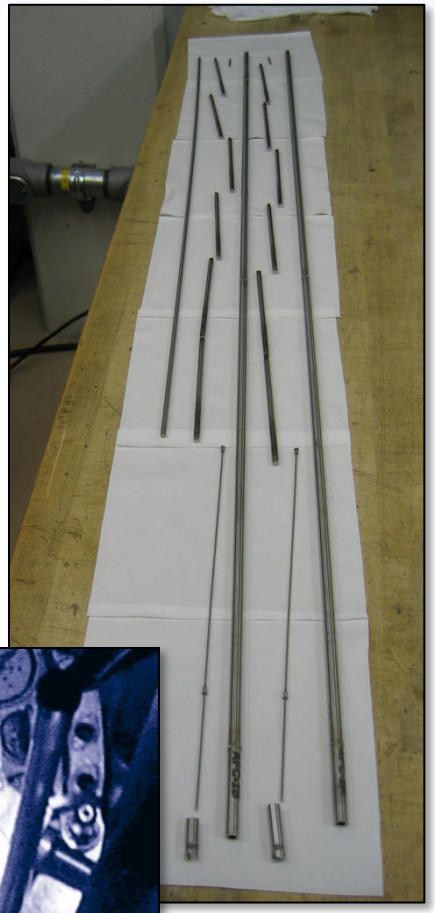
- Approval for Reactor Insertion





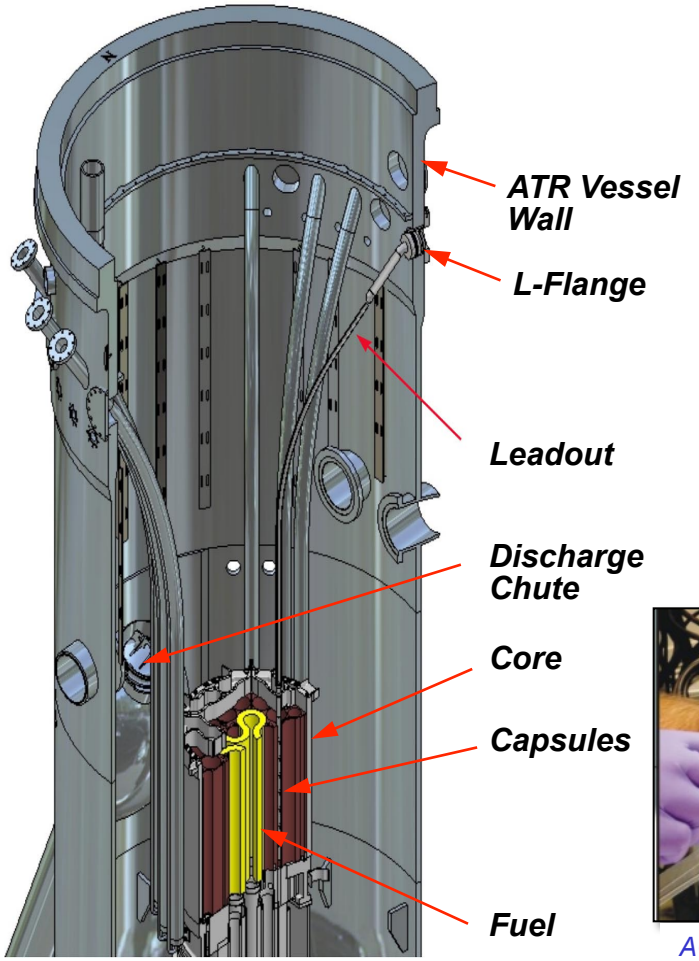
ATR Experiments
Typical Static Capsule

- "Drop-in"
- Fill gas to maintain desired temperature
- Reflector positions or flux traps
- Isotopes, structural materials, fuel
- 6 – 8 Months to prepare

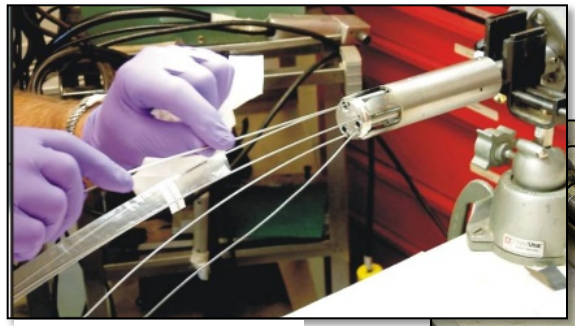


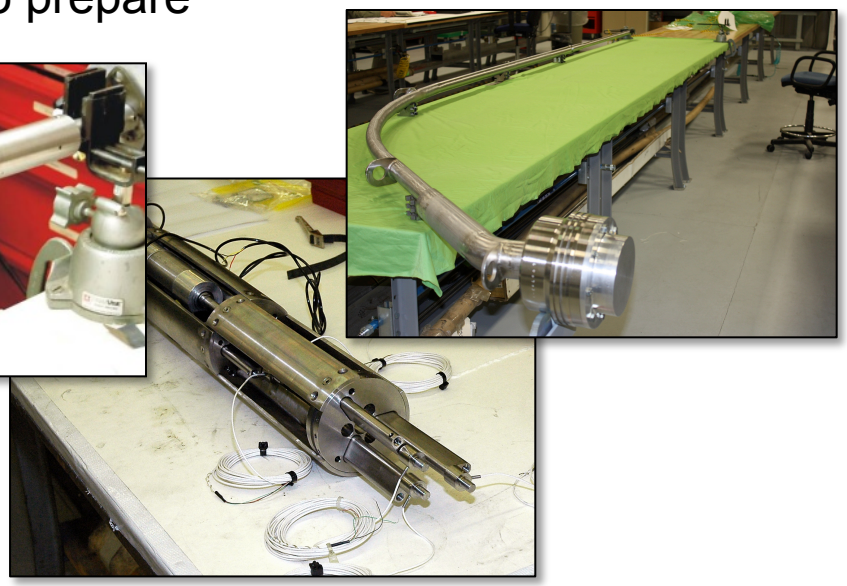
Top view of capsule basket with flux monitor wires inserted

ATR Experiments
Typical Instrumented Lead



- Specialized gas environments to control temp. (helium, neon, argon)
- Temperature control range 250-1200°C, within +/- 5°C
- Application of mechanical forces
- Monitoring of exhaust gases for experiment performance (e.g., fission products, leaking materials)
- Reflector positions or flux traps
- 1.5 years to prepare

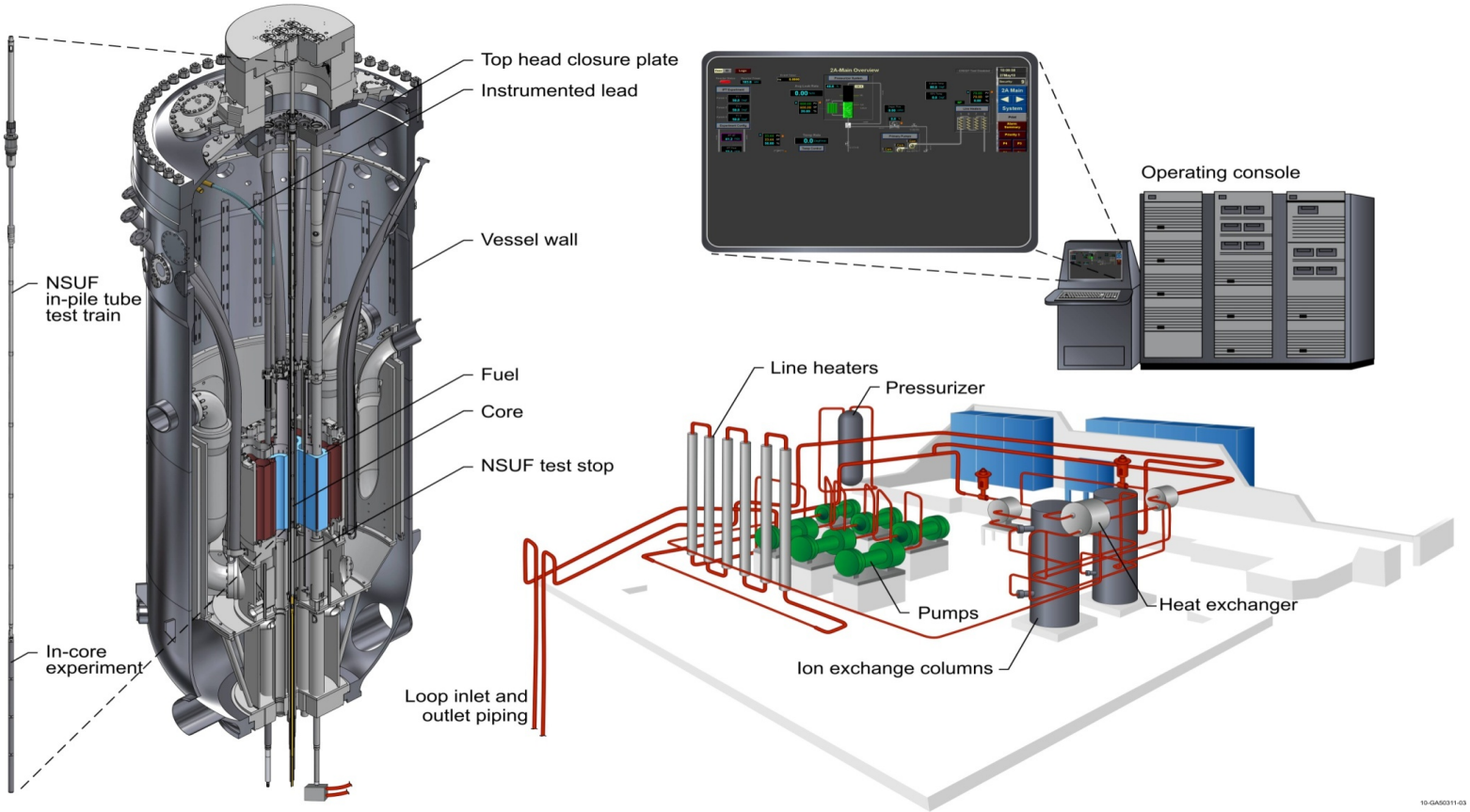




AGR-1 Test Capsule installed in ATR with INL HTIR-TCs

ATR Experiments Typical Loop

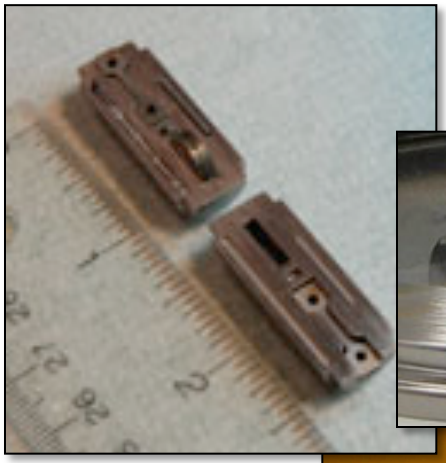
- Five Loop positions currently in flux trap positions; 6th loop is planned for center flux trap
- Independent from ATR primary coolant system
- Each loop has temperature, pressure, flow, and chemistry control systems
- Transient testing capabilities (cycle/seconds)
- 1 to 1.5 years

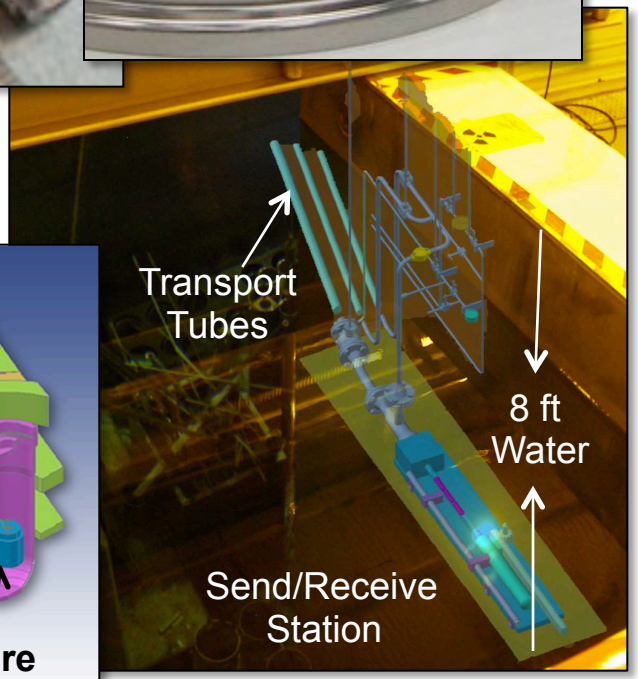


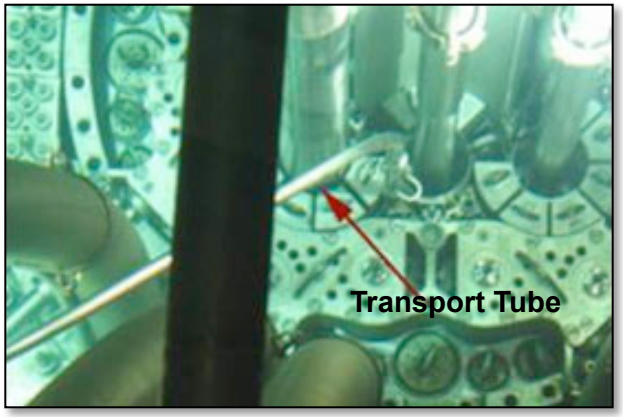
ATR Experiments
Hydraulic Shuttle Irradiation System (HSIS)

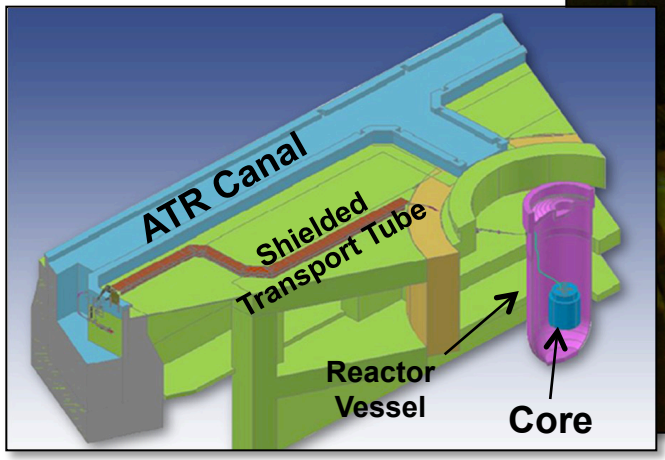
- Inserted and Removed During Reactor Operations
- 14 Capsule Train
- Flux (at 110 MW total Rx power)
  - Thermal: 2.5E14 n/cm^2-s
  - Fast (>1MeV): 8.1E13 n/cm^2-s
- Dimensions
  - ~ 0.55-inch ID, ~2-inch L
  - ~ 7 cc useable volume
  - ~35 g Contents depending on density

– 6 – 8 months to prepare







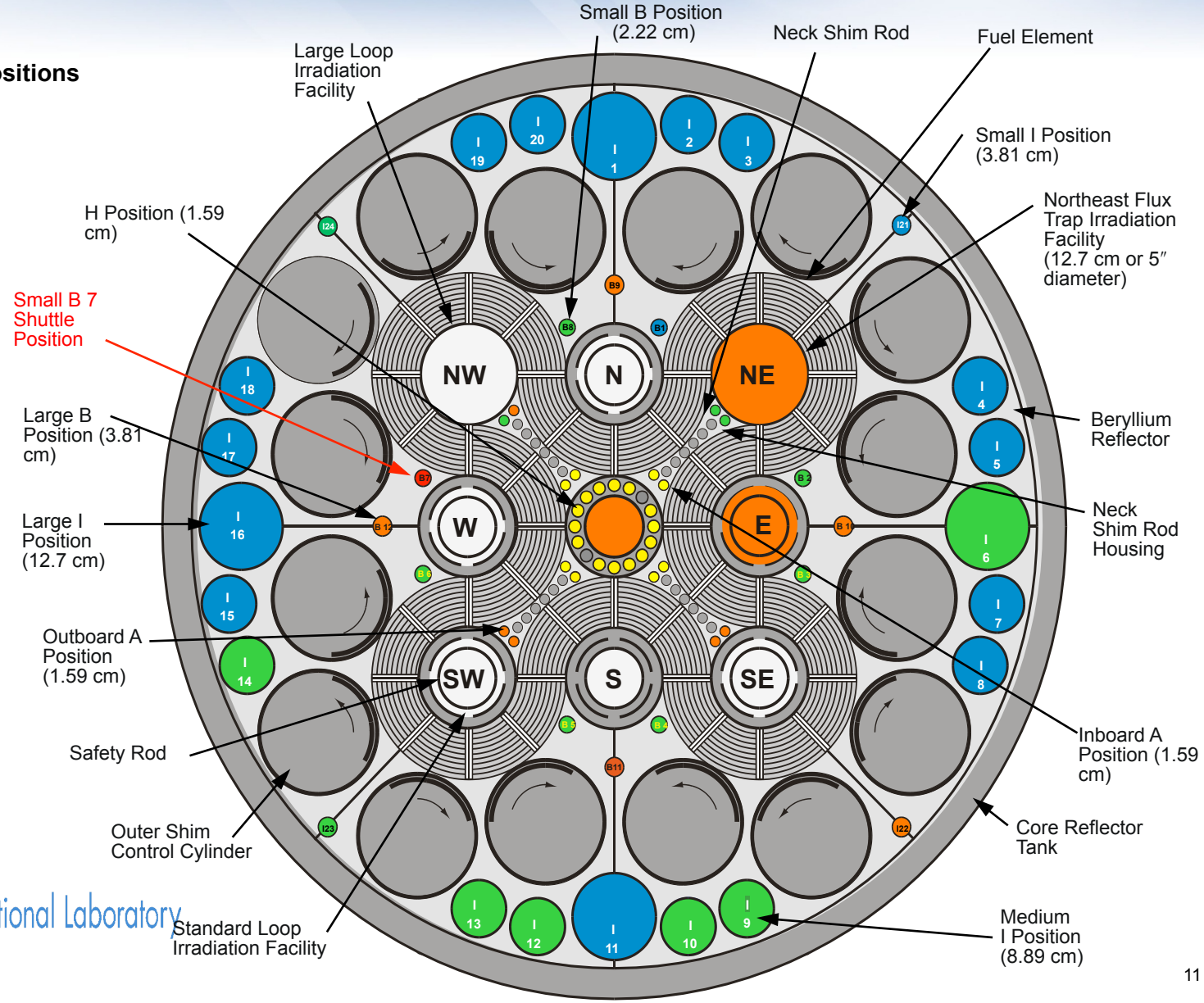


Selection of Reactor Position

ATR has 77 irradiation positions
- **4 flux traps**
- **5 in-pile tubes**
- **68 in reflector**

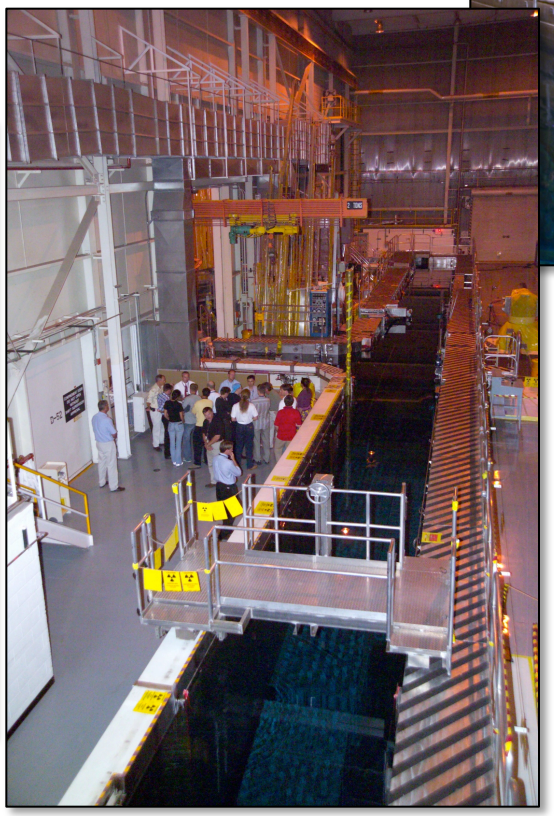
NR
Currently in use by NE
Planned future use (FY 2013, 2014)
Cobalt 60
Currently unplanned for 2012, 2013, 2014

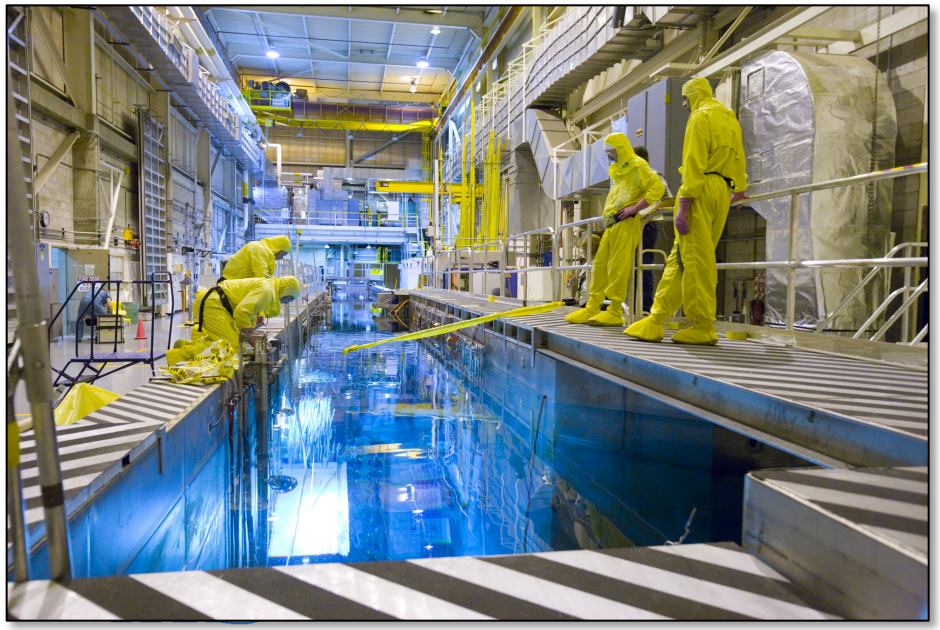
ATR Core Cross Section



Reconfiguration

- Experiments Planned for Multi-cycle Irradiations
- Performed in Canal Between Irradiation Cycles
  - Typically 2 week duration
- Provide Uniform Fluence Across Capsules
- Replace Capsules Reaching Desired Burnup/dpa





Cool Down and Transportation to PIE

- Assemblies stored in canal
- ~100 day cool down period
- Type A or Type B Shipment to PIE Facility