ATR Experiment Lead Experiment Design

ATR NSUF User Week 2011
Experimenter Course

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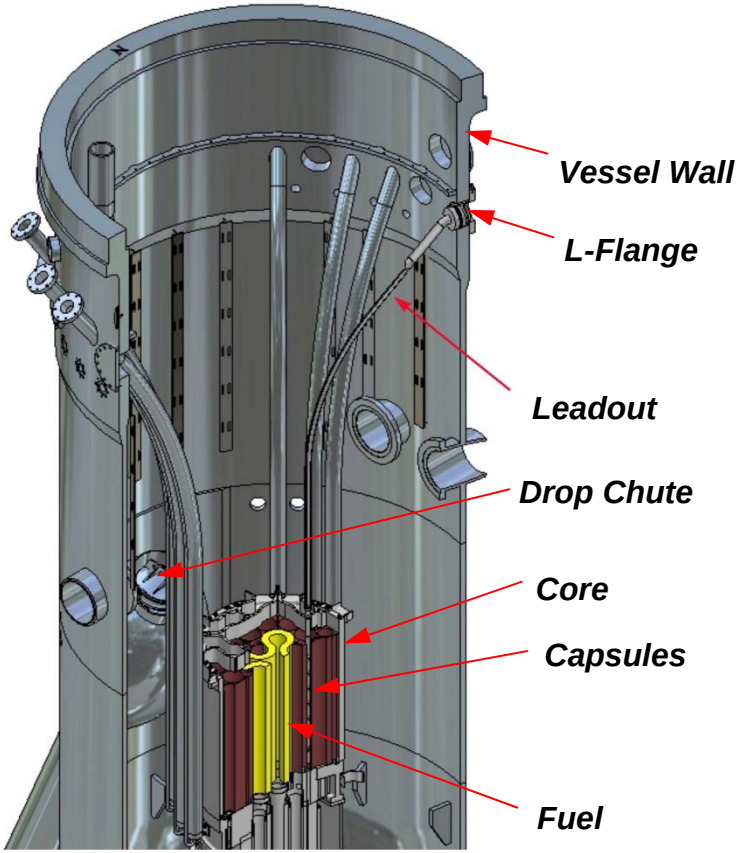
Idaho National Laboratory

Presentation Agenda

- ***Experiment Considerations***
- ***Design Considerations***

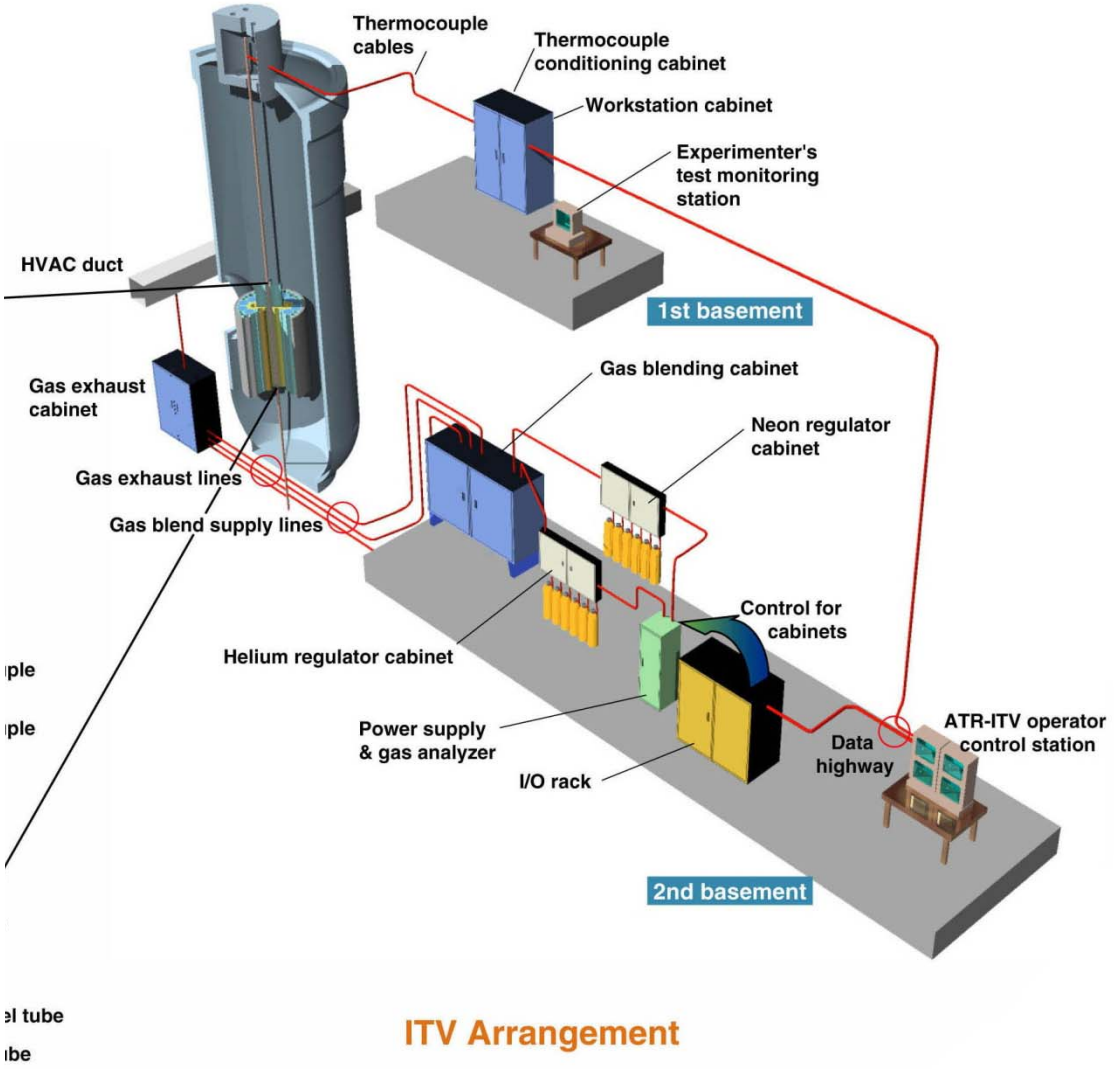
Instrumented 'Lead' Experiments



- *On-line instrument measurements (typically temperature)*
- *With or without active temperature control*
- *Irradiated in reflector positions or flux traps*
- *Lengths up to 1.2 m & diameters up to 12.7 cm*
- *Structural materials, cladding, fuel*
- *12 to 18 month lead time for design and installation*

Lead Experiment Control

- *Use neutron capture and gamma heating for heat source*
- *Insulating gas jacket from reactor physics and thermal analyses for control band*
- *Manipulate temperature by mixing conducting and insulating gases*
- *Irradiations use He and Ne or Ar to maximize control band in gas control system*
- *Methodology used at ATR to control:*
  - *Temperatures at TCs from 315ºC to 1000ºC*
  - *Specimen centerline temperatures exceeding 1300ºC*



ITV Arrangement

EXPERIMENT CONSIDERATIONS

Irradiation Requirements

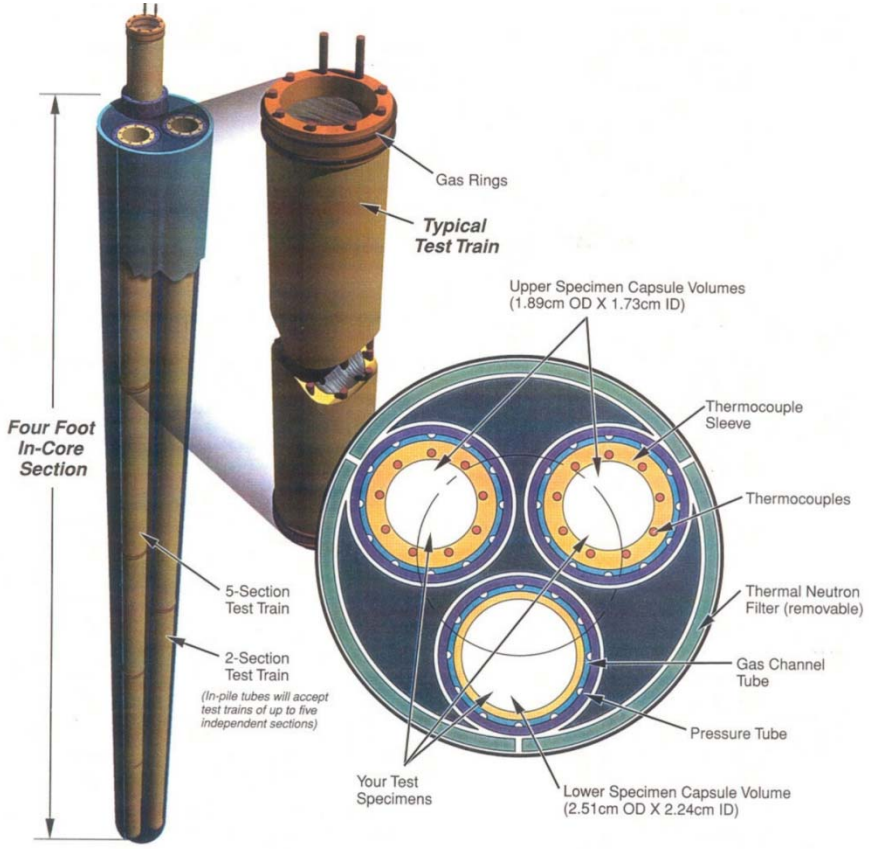
- *Specimen size & shape*
  - *Standard test specimen*
  - *Minimum grains across specimen diameter*
- *Desired fluence*
  - *Fast neutron damage level*
  - *Fuel*
    - *Burn-up level*
    - *Acceleration factor*
  - *Fast/thermal ratio*
- *Desired irradiation temperatures*
  - *Room for gas gap to provide adequate insulation*
  - *Control/monitoring*
    - *Active – gas mixtures & thermocouples*
    - *Passive back-up – melt wires, silicon carbide, etc.*

Irradiation Environments

- *Inert gas - temperature control selections*
  - *Insulator gas*
    - *Argon – good temperature range but activation issue*
    - *Neon – less temperature range but very limited activation - fission gas monitoring*
- *Non-inert gas*
  - *Utilize different temperature control gases*
  - *Utilize second gas boundary and specific cover gas*
- *Thermal Bonding – liquid metal*
  - *Reduced temperature gradients in specimens*
  - *Smaller gas gaps necessary to achieve desired temperatures*

Flux Tailoring

- *Irradiation position*
  - *Close to fuel to increase fast fluence*
  - *Flux trap or reflector to increase therma*
- *Fixed neutron absorption shroud*
  - *Integral with encapsulation design*
  - *More choices of absorption material if isolated from coolant*
  - *Consumable (e.g. Boron)*
- *Removable/replaceable neutron absorption shroud*
  - *Solid - chemistry compatibility with reactor coolant*
  - *Gas shroud – He3*
- *Booster fuel*



Miscellaneous Issues

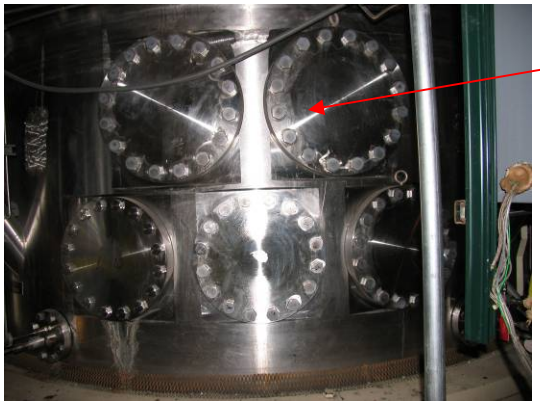
- *Material Selection*
  - *Compatibility with specimens or irradiation environment (particle fuel, catalyze reactions, etc.)*
  - *Thermal issues (expansion stresses & clearances, service & design temperatures, brazes)*
  - *Neutronic or activation effects (flux variations, heating, waste disposal, etc.)*
  - *Design code requirements*
- *Marking or features*
  - *Specimens or specimen holders for identification in hot cell*
  - *On capsules to provide orientation for installation in core & PIE*
  - *Cut lines for disassembly of test trains/capsules in hot cell*
- *Assembly & disassembly*
  - *Tolerances*
  - *Weld Joints*
  - *Etc.*

Design Considerations

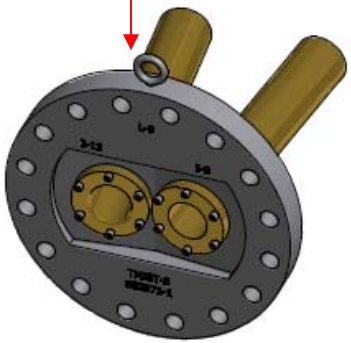
In-Reactor Systems

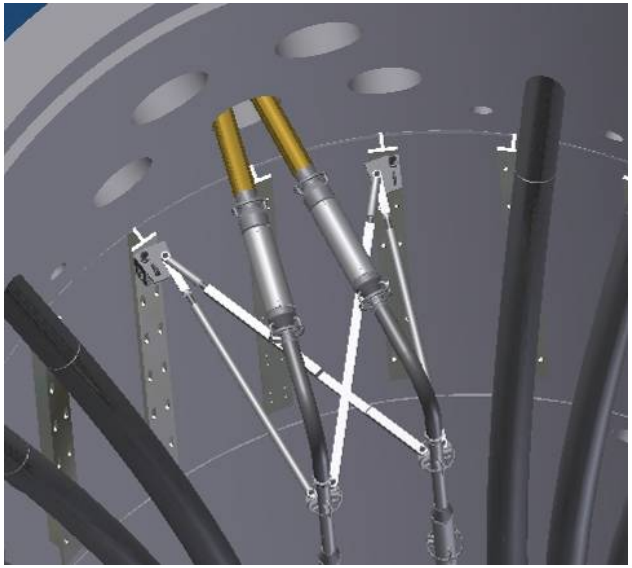
- Target Materials
- Capsule or Pressure Boundary
- Support Hardware
- Vessel Penetration Closure

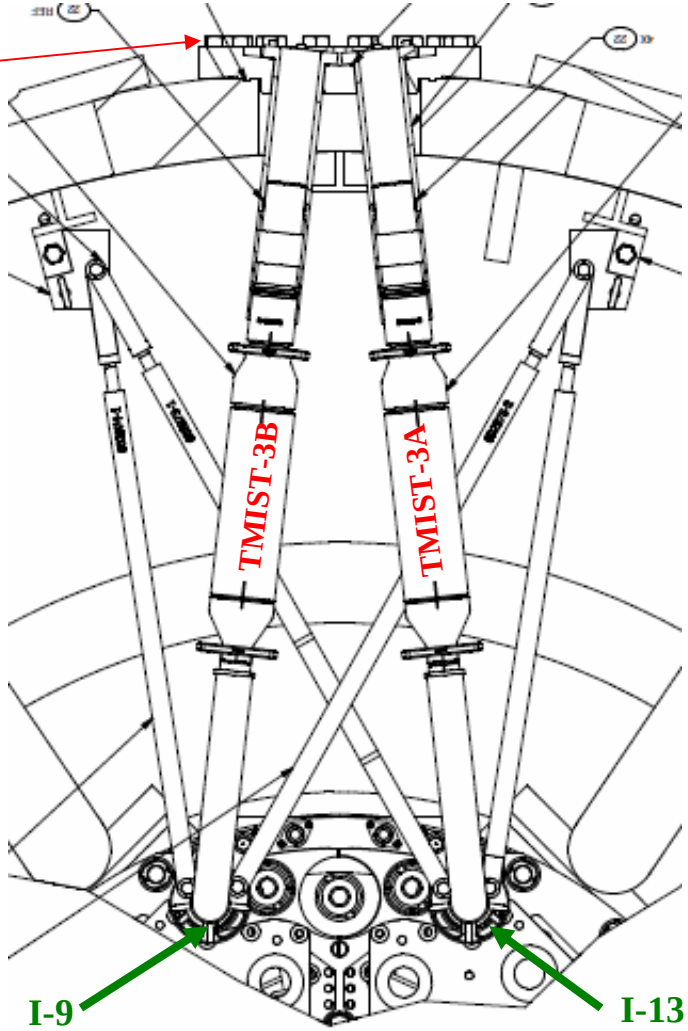
Interface with Reactor Vessel



L-9 Flange



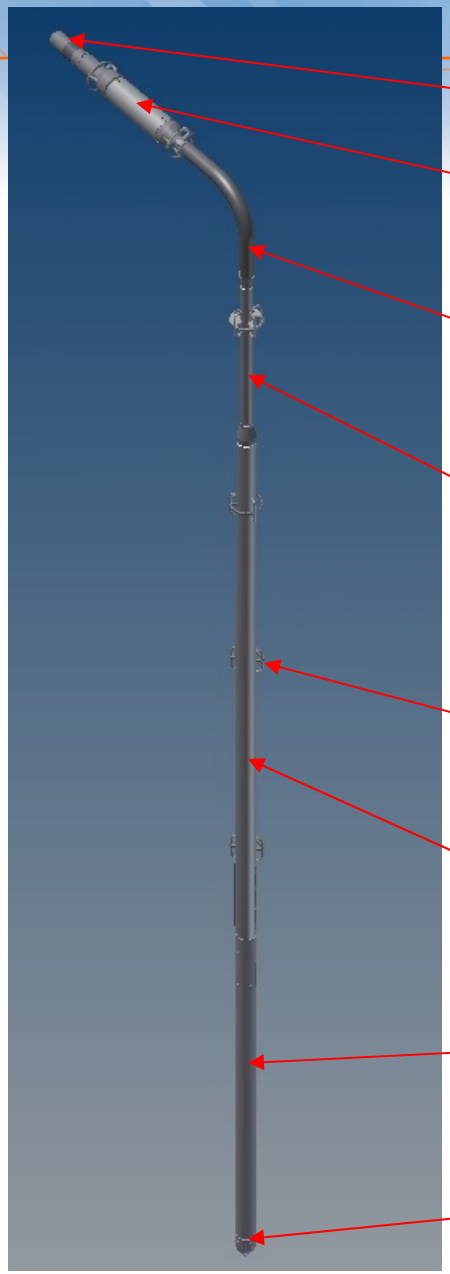




Leadout - General

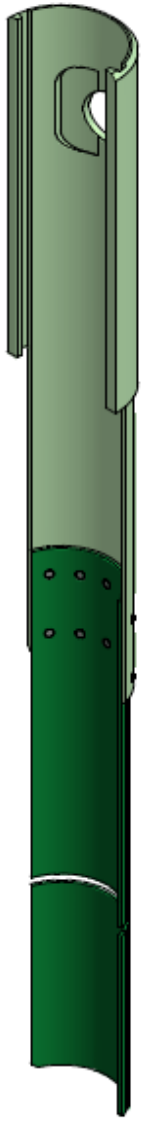
- 304L SST
- ASME Section III Class 1 at vessel closure area
- ASME Section III Class 3 for remainder of leadout
- Two internal helium purge systems which are monitored for moisture to verify the integrity of the pressure boundary is maintained

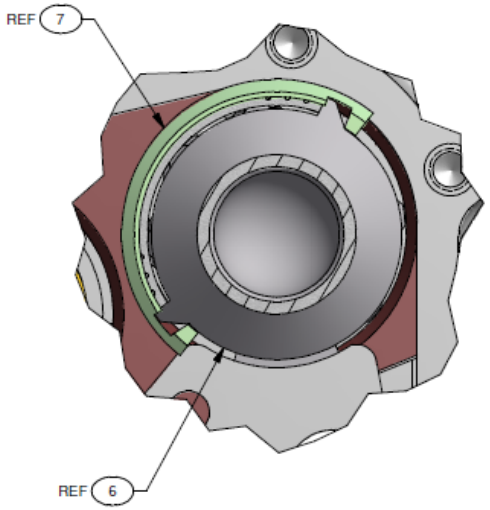
Leadout


Adapter
Horizontal Section
Flex Hose
Upper Vertical Tube
Handling Ring (6X)
Coil Tube
Core Tube
Bottom End Cap

Neutron Shield

- Shield material
  - 144° arc
  - Hafnium
  - Zirconium
- Shield material attached to SST top lifting bail with welded rivets
- Bottom supported by stepped nubs on bottom end cap
- Radially positioned by nubs on the Core Tube and the Bottom End Cap
- Edges interface with bore of I-hole

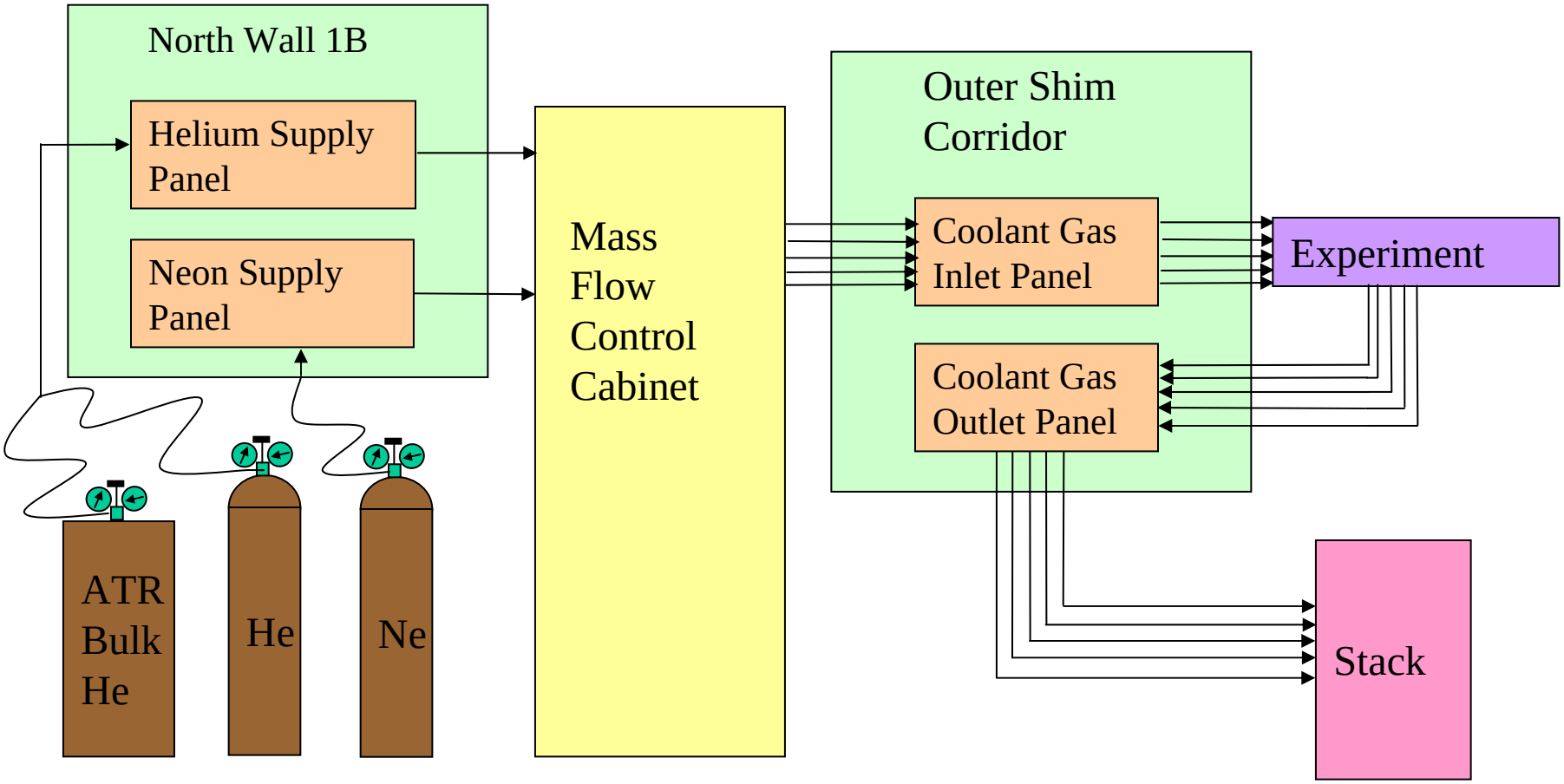




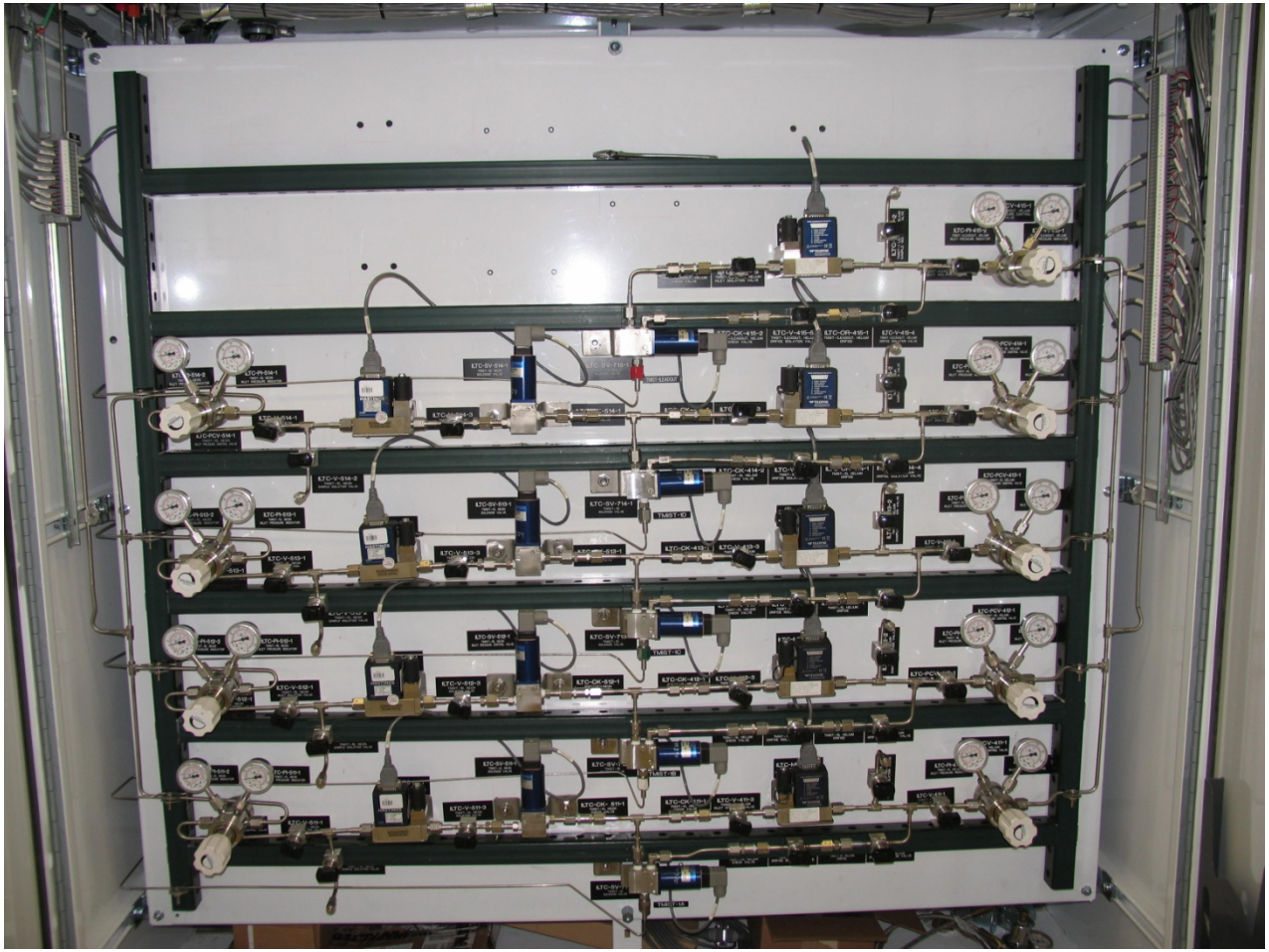
Ex-Reactor Systems

- Temperature Control Gas Supply Systems
- Sweep or Cover Gas Systems
- Gas Effluent Monitoring
- Gas Effluent Collection
- Data Collection
- Resizing
  - Wet
  - Dry
- Post Irradiation Examinations
- Shipping

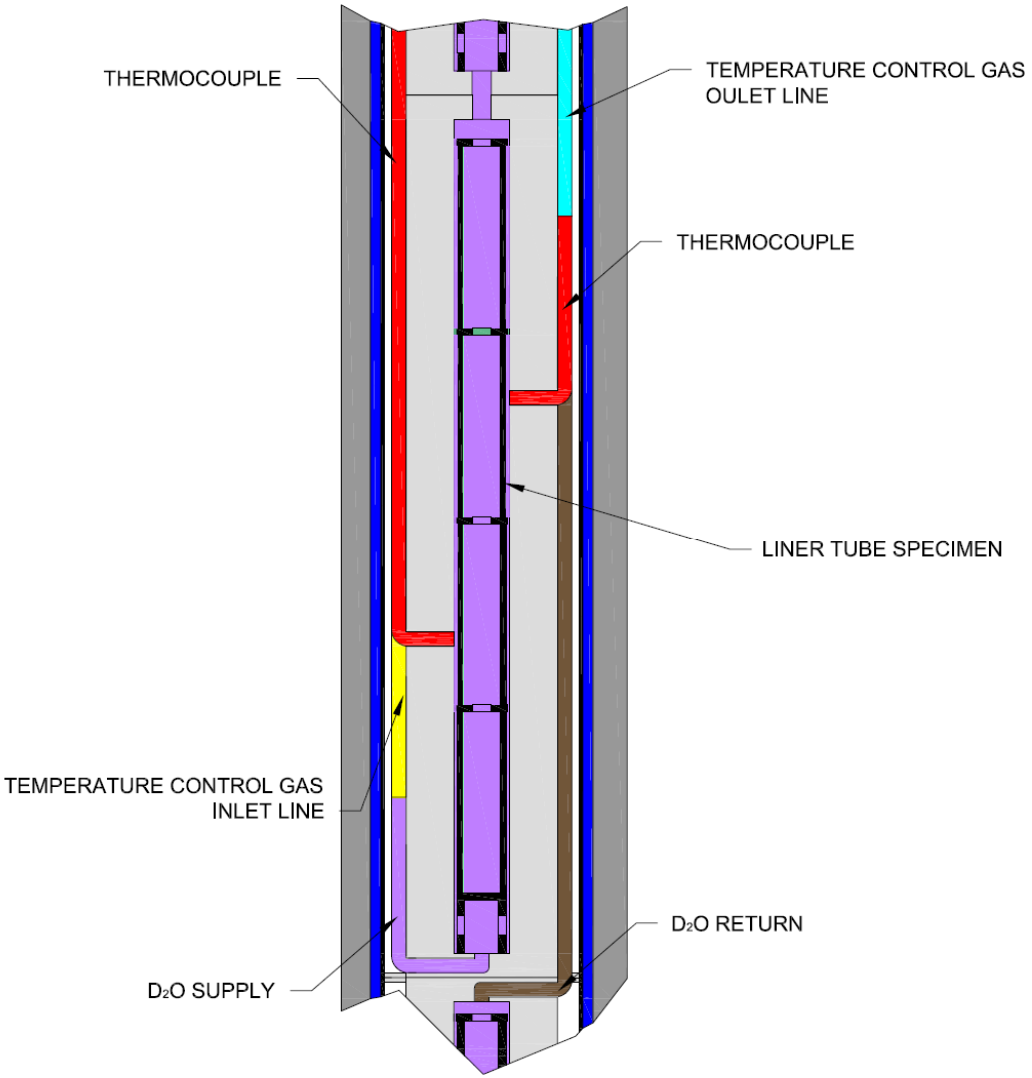
Temperature Control Gas System



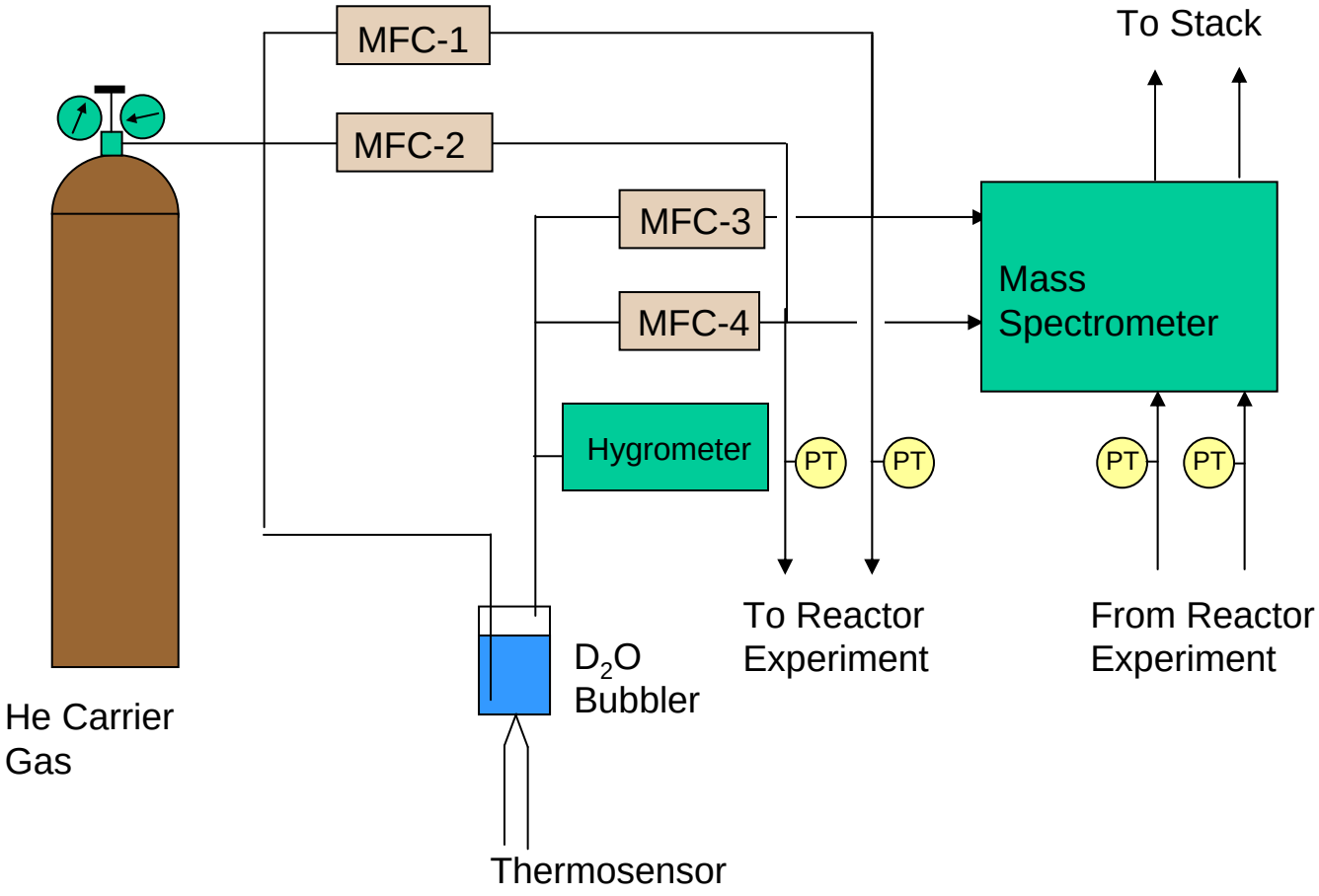
Mass Flow Controller



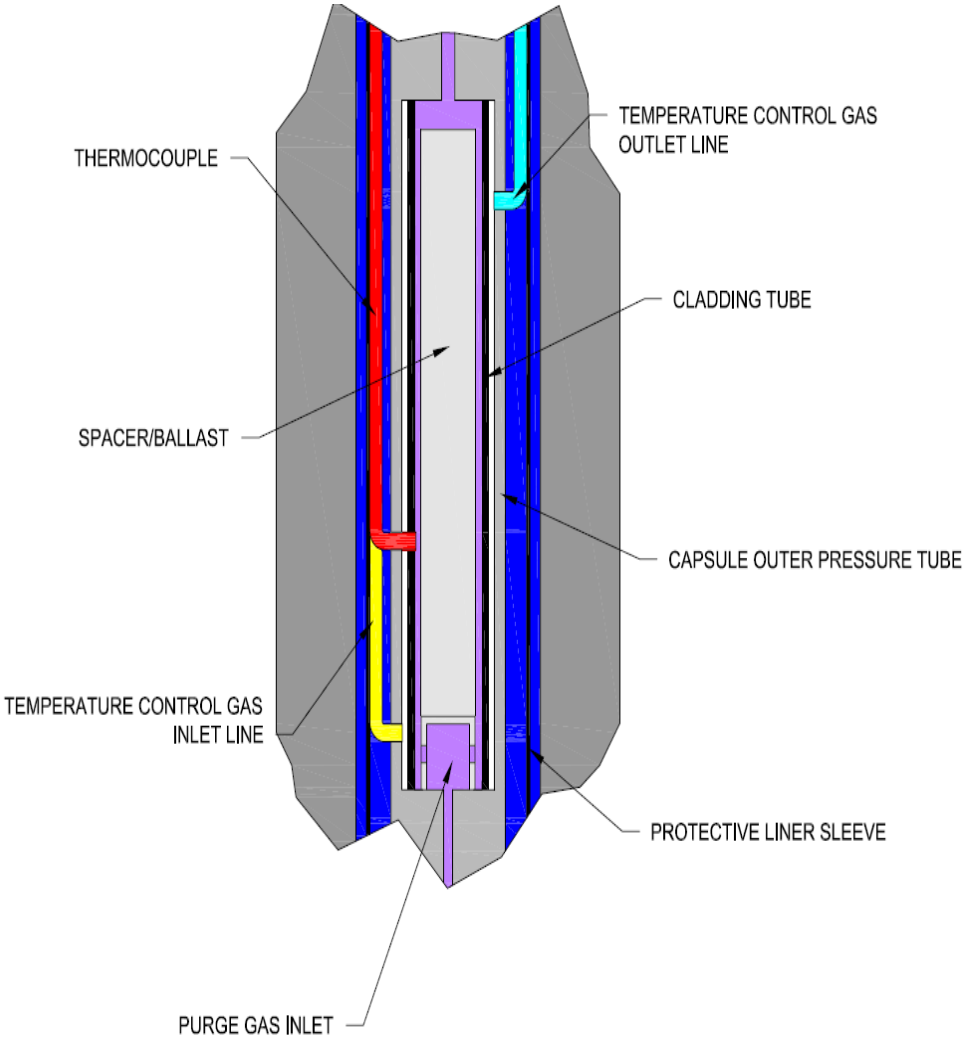
Oxidizing Cover Gas



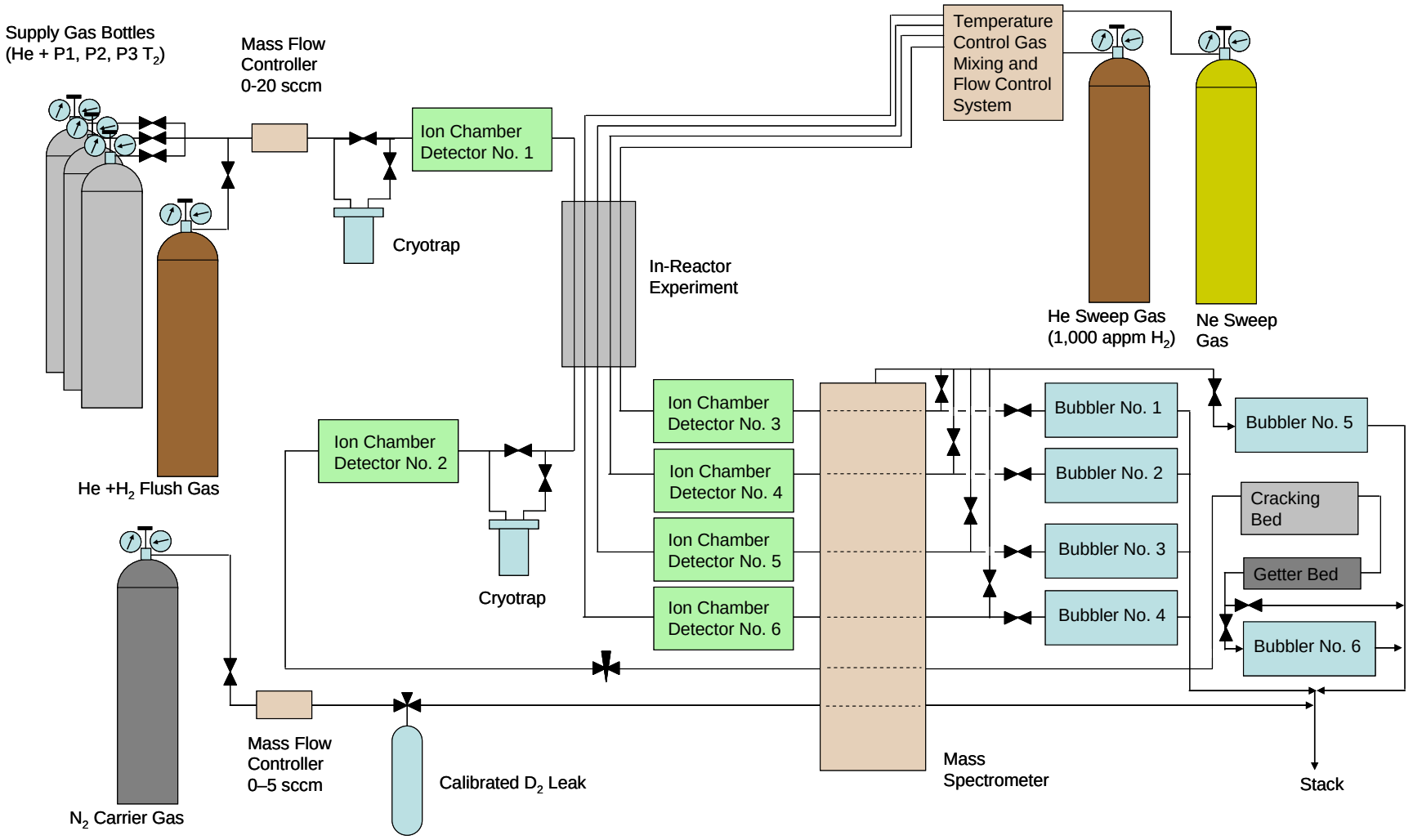
Oxidizing Sweep Gas System



Permeation Sweep Gas

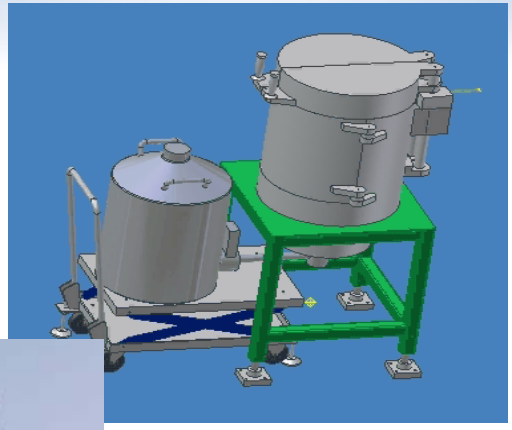


Permeation Sweep Gas System



Effluent Monitors

- *Fission product monitors*
- *Gross gamma detector*
- *Gas chromatograph*
- *Mass spectrometer*
- *Ion chambers*
- *Fourier Transform Infrared Spectroscopy (FTIR)*
- *Tritium scintillation collection*

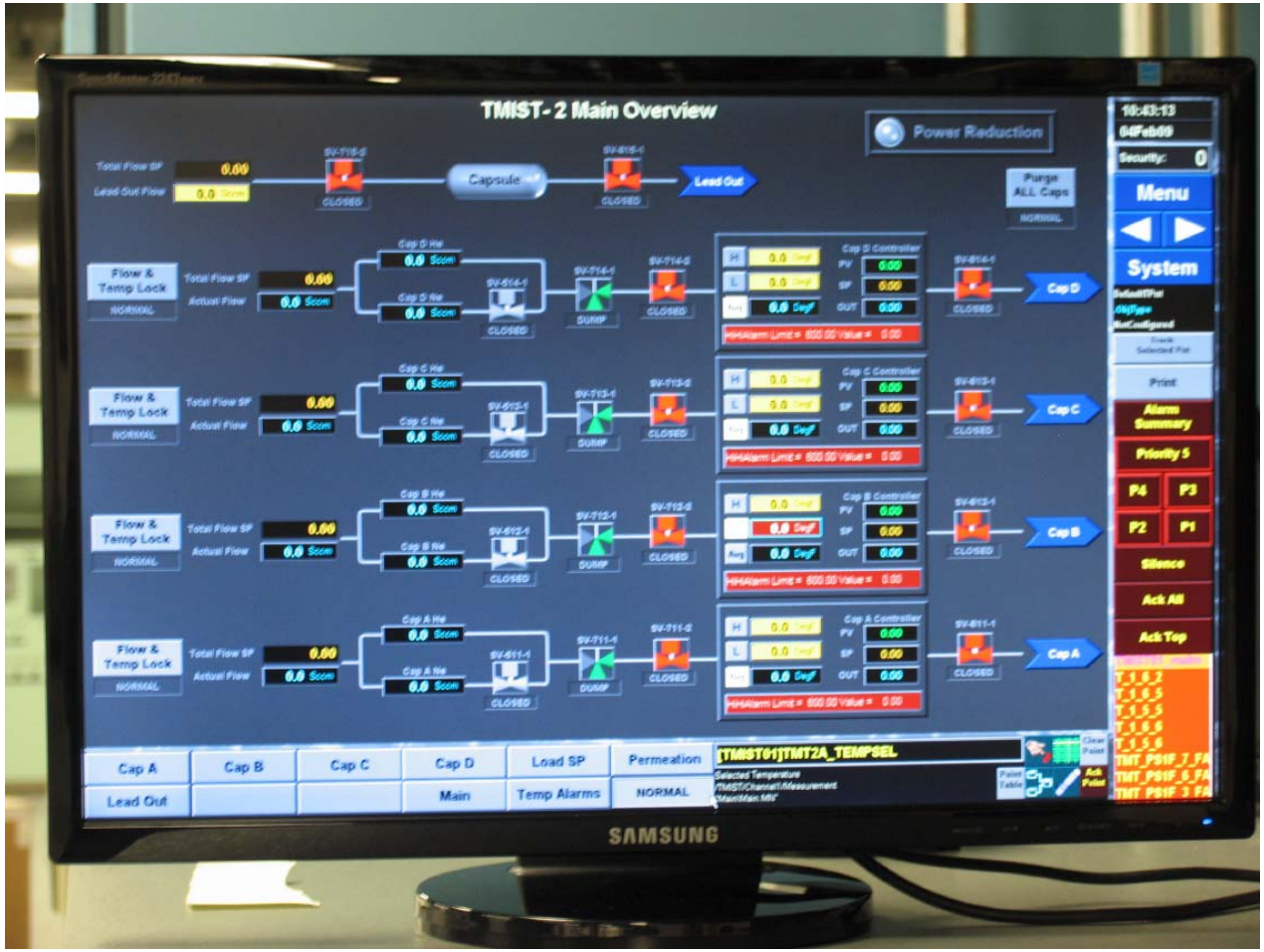


Bubbler Cabinet

Ion Chambers and Mass Spectrometer

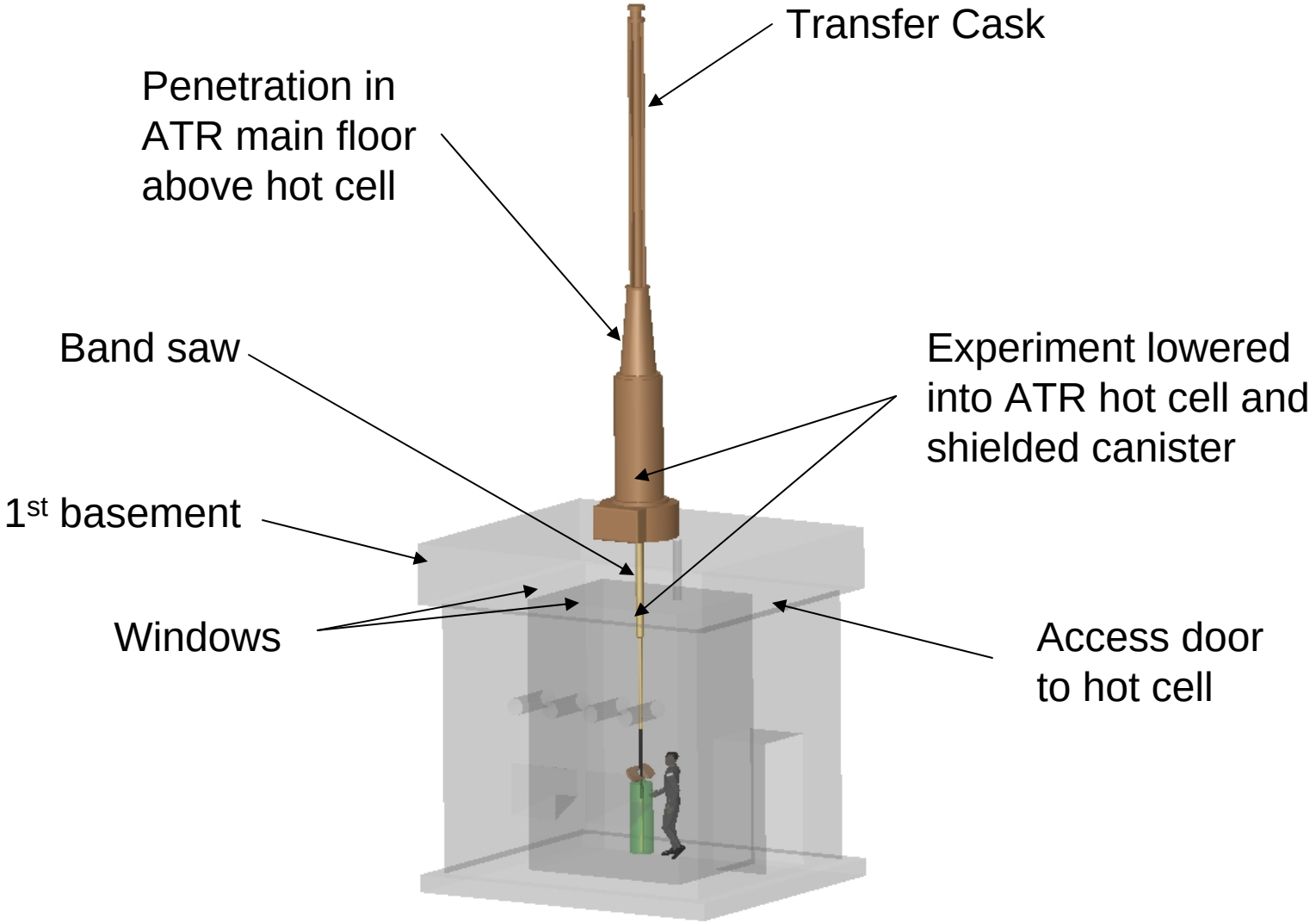
Distributed Control System

DCS Operator Interface



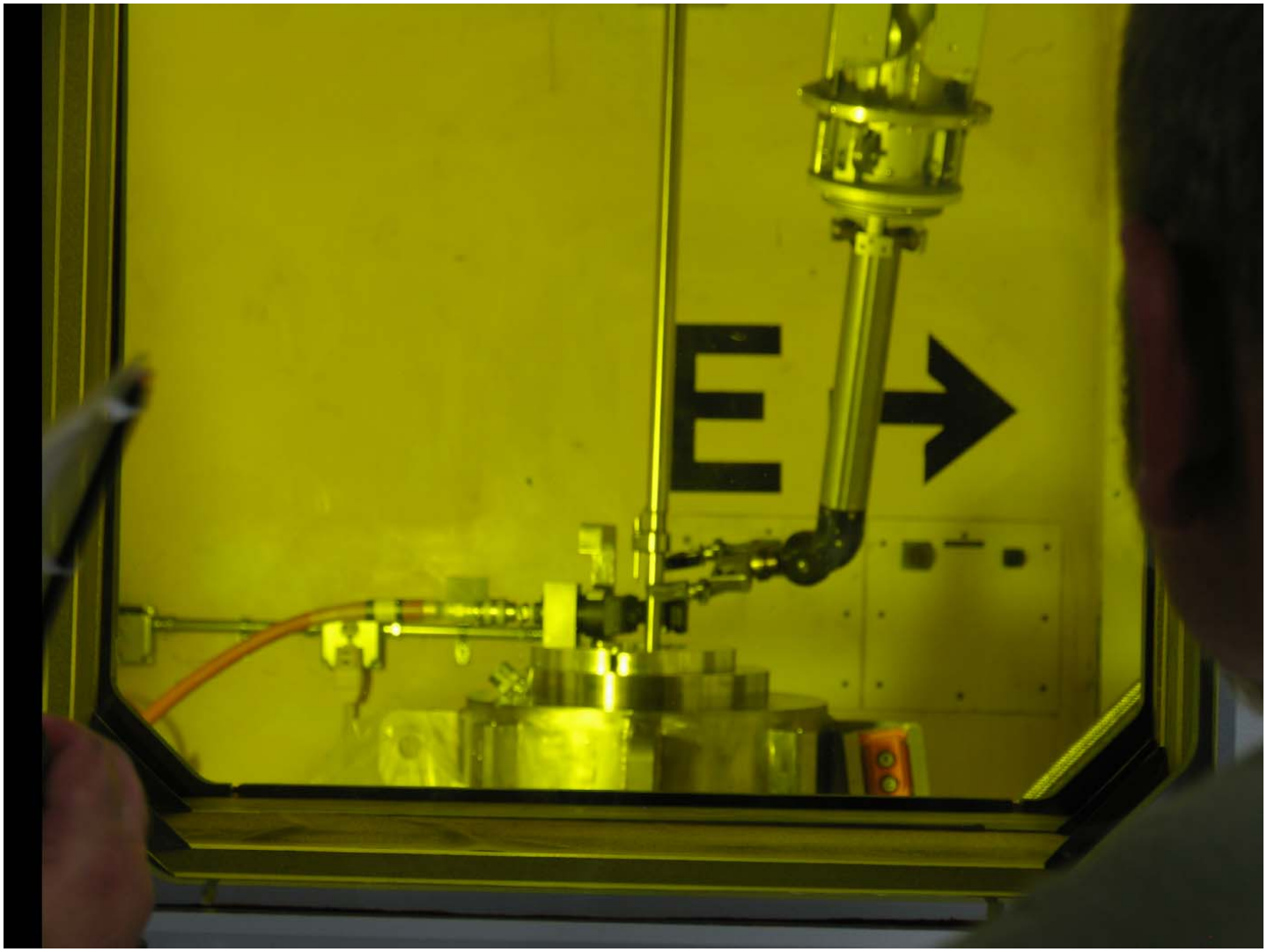
ATR Main Floor

Dry Transfer Cubicle



Dry Transfer Cubicle Outside Wall

Dry Transfer Cubicle Experiment Resizing



Loading GE-2000 Cask

GE-2000 Trailer

GE-2000 at MFC Hot Cell Truck Bay