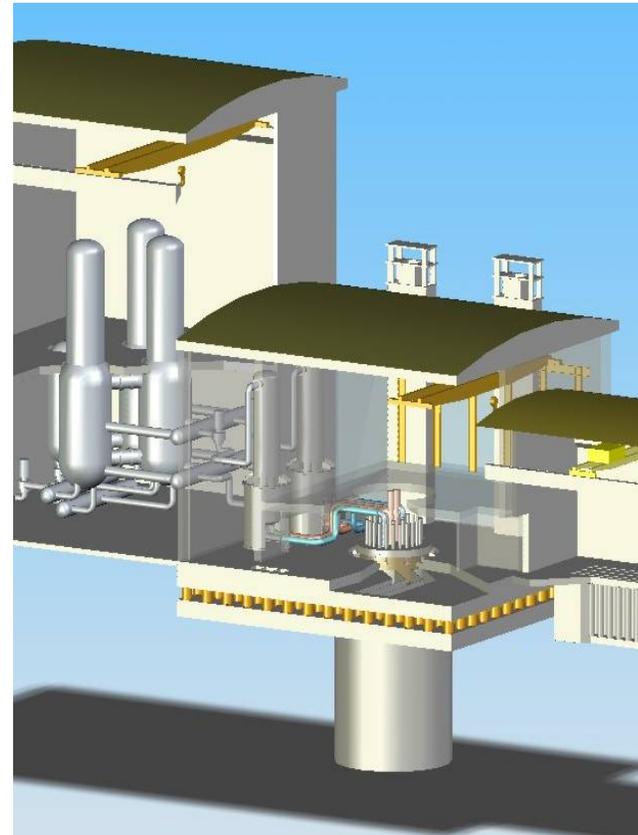
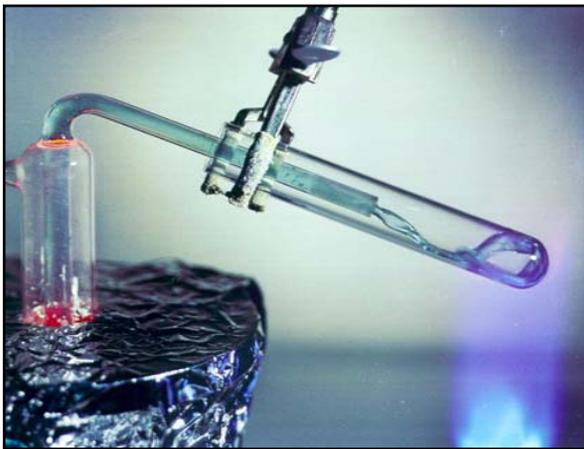


# LS-VHTR Refueling, Inspection, and Maintenance (RIM) Instrumentation

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# LS-VHTR Instrumentation



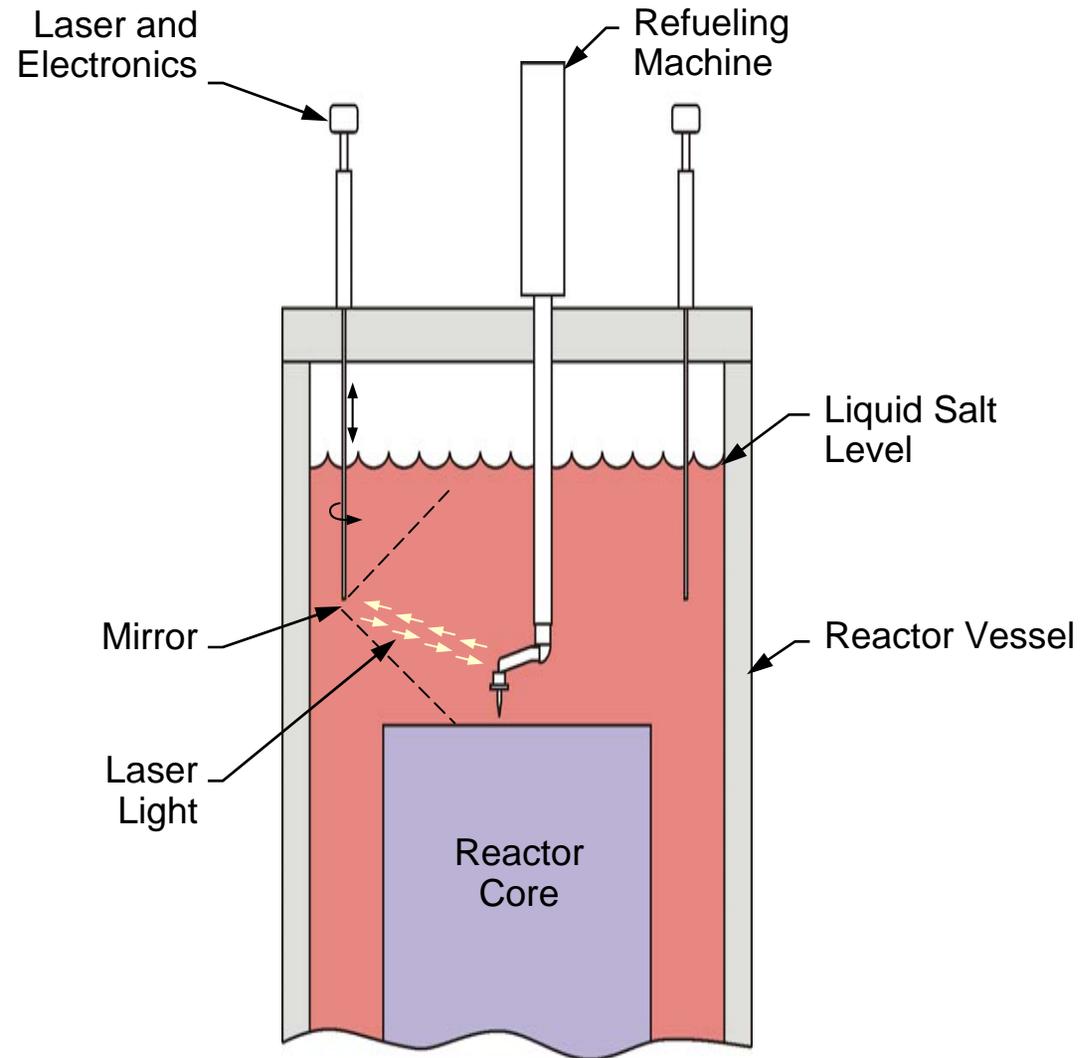
- **The LS-VHTR will have the traditional instrumentation of other high-temperature reactors**
- **Salt properties enable the use of optical techniques that offer unique capabilities**
  - **Transparent from 200 to 2500 nm (from ultraviolet through visible into the infrared)**
  - **Greater transparency than water**
  - **Frequencies for optical systems chosen for maximum transparency and avoidance of thermal signal**

# Optical Instrumentation Options

- **Metrology: Laser range finding**
  - 3-dimensional image of reactor interior
  - Fluid flow velocities (in some, but not all, systems)
  - Surface levels
- **Spectroscopy**
  - Measurement of light transmission and emission versus frequency
  - Properties that can be measured
    - Temperature
    - Salt impurities and composition
    - Density
- **Television/Fiberscope**

# Metrology and Spectroscopy Signals

- **Laser and sensors outside of reactor**
- **Laser light in and signal out by mirrors**
  - Periscope with diamond or sapphire window
  - Polished noble metal mirror immersed in the salt
- **Maximize performance by choice of laser frequency, light polarization, and power level**
  - Maximize signal-to-noise ratio
  - Avoid interfering thermal signals



# Metrology: Laser Survey Techniques and Computer Imaging

- **Technique**
  - Measure distance and angles from several points using lasers
  - Use computers to create 3-D image for viewer or refueling machine
- **Commercial off-the-shelf technology**
  - Widely used
  - Typical wide-scan commercial system accuracy ~5 mm



HDS 3000 Laser Scanner

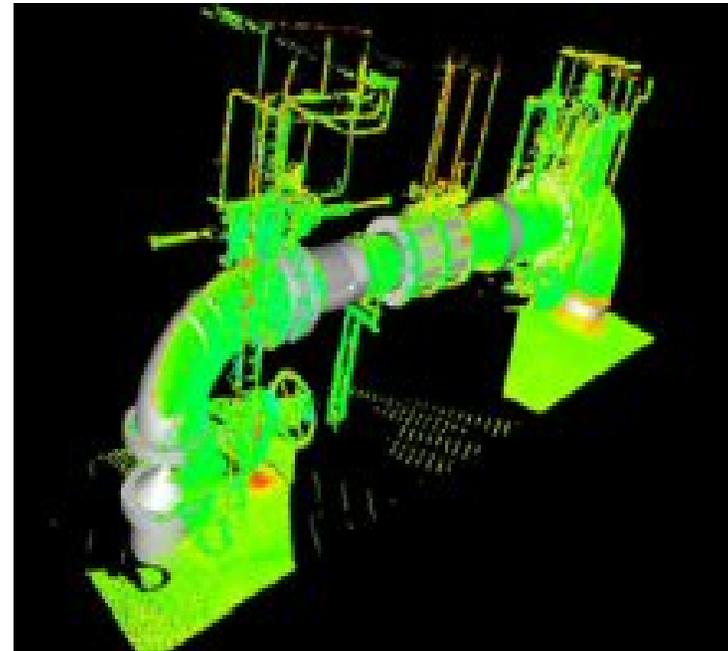
Courtesy of ScanTech International Ltd.

# Typical Industrial Applications



**Railway Right-of Way**

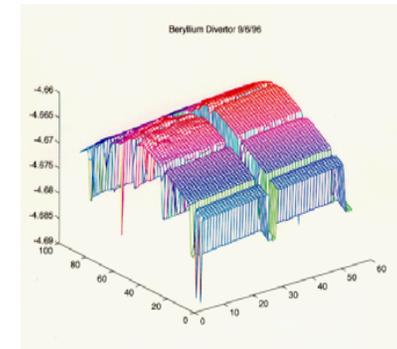
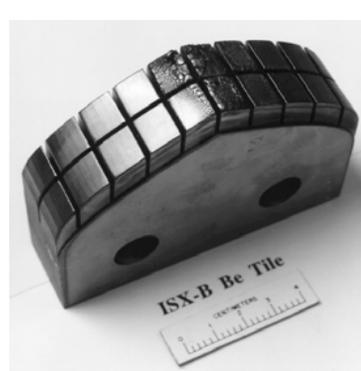
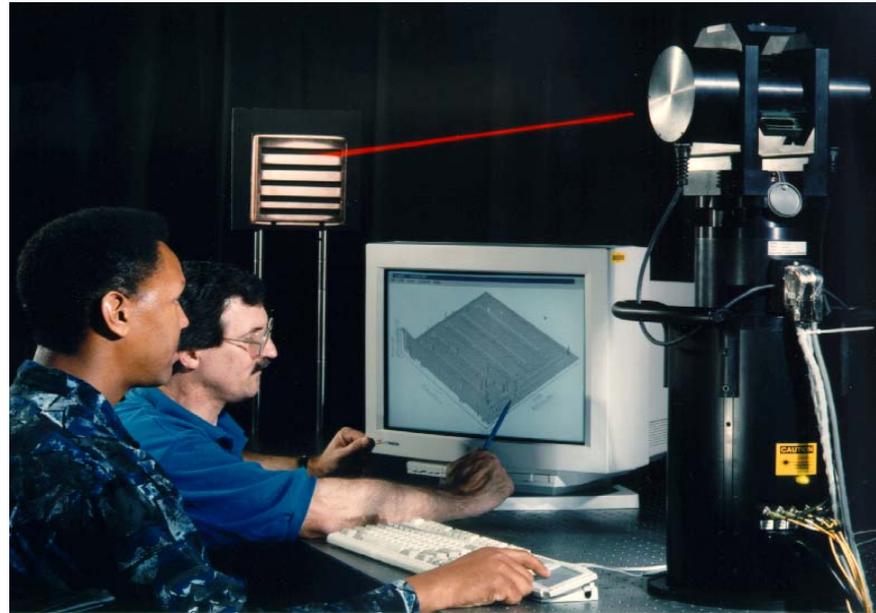
**Industrial Equipment for  
As-Installed Prints**



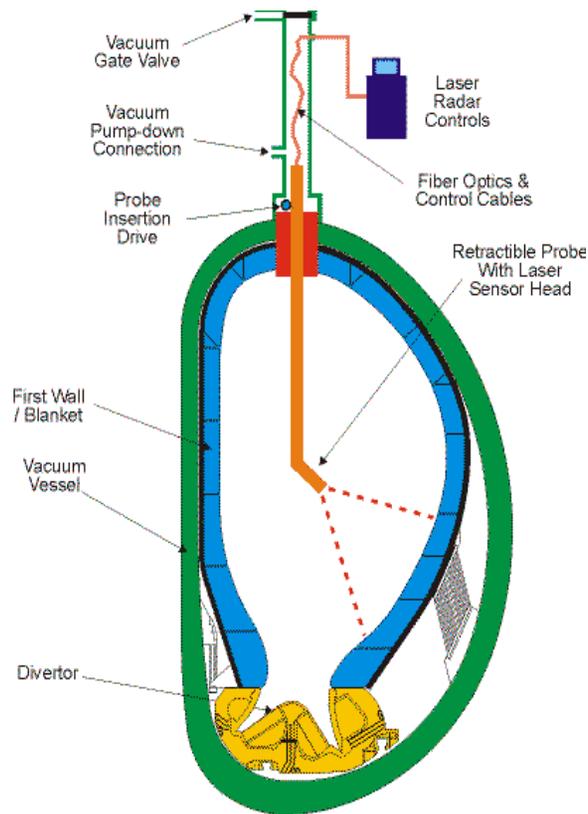
Courtesy of ScanTech International Ltd.

# Precision Metrology for Hazardous Environments

- **Example: ORNL is developing a Coherent FM Laser Radar (CLR) device for fusion metrology applications**
- **Measurements over range of values up to 20 m were performed with submillimeter accuracy**
- **Key components of the CLR are being tested for operational compatibility in severe fusion system environments**
  - Radiation ( $10^6$  rad/h)
  - Temperature ( $200^\circ\text{C}$ )
  - Vacuum ( $10^{-8}$  torr)
  - Magnetic field (6 T)



# Precision Metrology has been Used in Various Fusion Test Machines



Schematic of the CLR Inspection Scheme

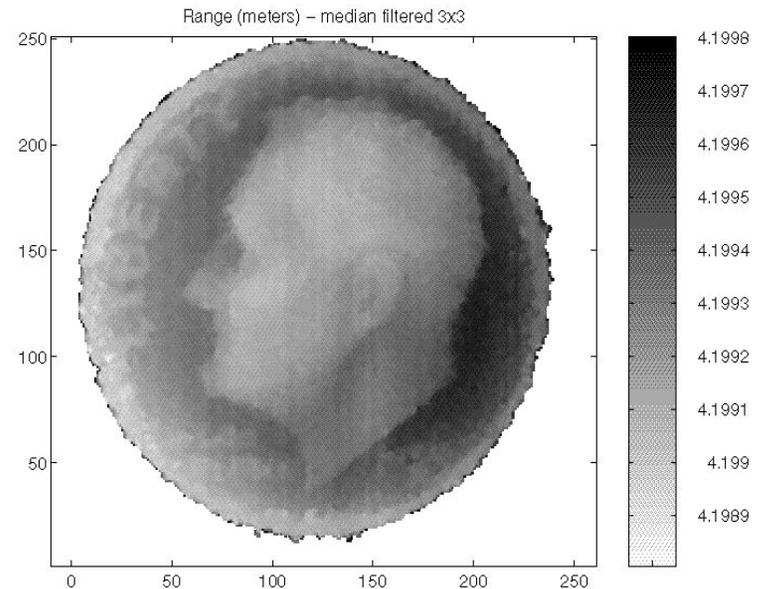


Image of a dome obtained by laser scanning the surface from a distance of 4.2 m .

# Applications of Metrology

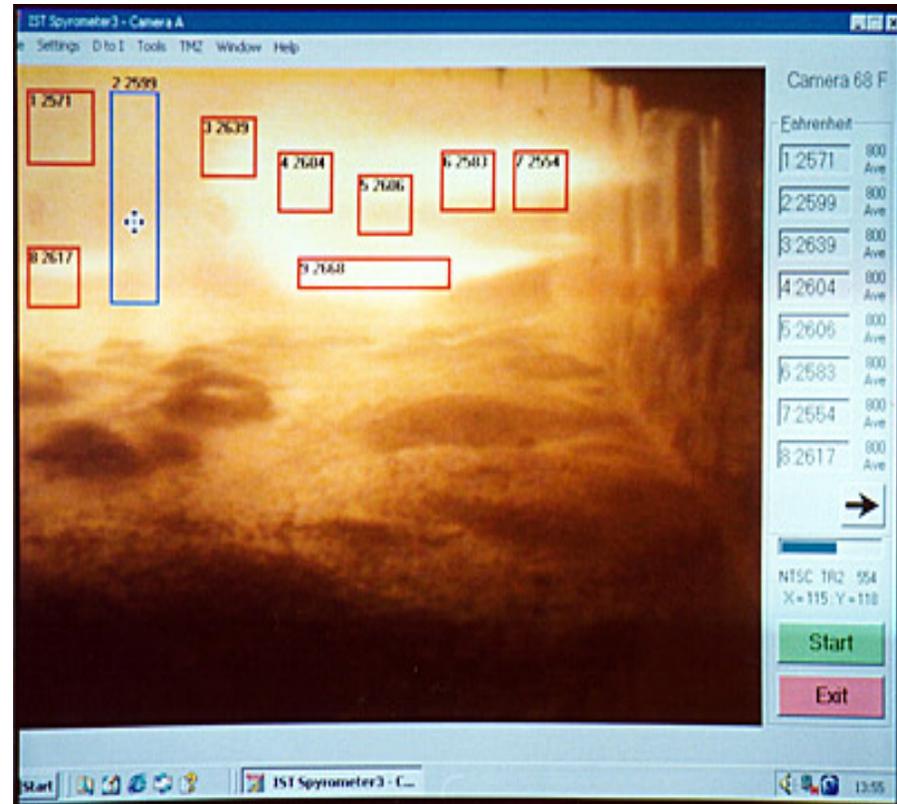
- **3-D vision**
  - Aids refueling
  - Enables monitoring for loose parts
  - Position of equipment (control rods, etc.)
  - Inspection (including surfaces to high resolution)
  - On-line monitoring of core status
- **Vibration monitoring**
- **Fluid flow velocities**
  - Requires small nanoparticles in fluid
  - Used in the chemical industry

# Spectroscopy

- **Traditional applications**
  - R&D
  - Chemical-plant process monitoring
- **Physical measurements**
  - Temperature
  - Density
- **Chemical analysis: transition metal concentrations**
  - Uranium
  - Actinides
  - Iron/Chromium/Nickel
- **Chemical valence state**
  - Corrosion control parameters (like oxidation potential in water systems)

# Video Systems

- **High-temperature video systems are common in industry**
- **LS-VHTR temperatures are low compared with those of glass furnaces and other high-temperature systems**
- **Directly applicable to LS-VHTR**



Imaging and Sensing Technology Corporation  
High-Temperature Video System View  
of Glass-Melting Furnace

# Conclusions

- **Transparent liquid-coolant allows the use of optical systems with unique capabilities**
- **Major improvements relative to sodium cooled reactors**
- **New technologies now becoming available**
  - **Metrology for 3-D vision**
  - **Advanced spectroscopy**