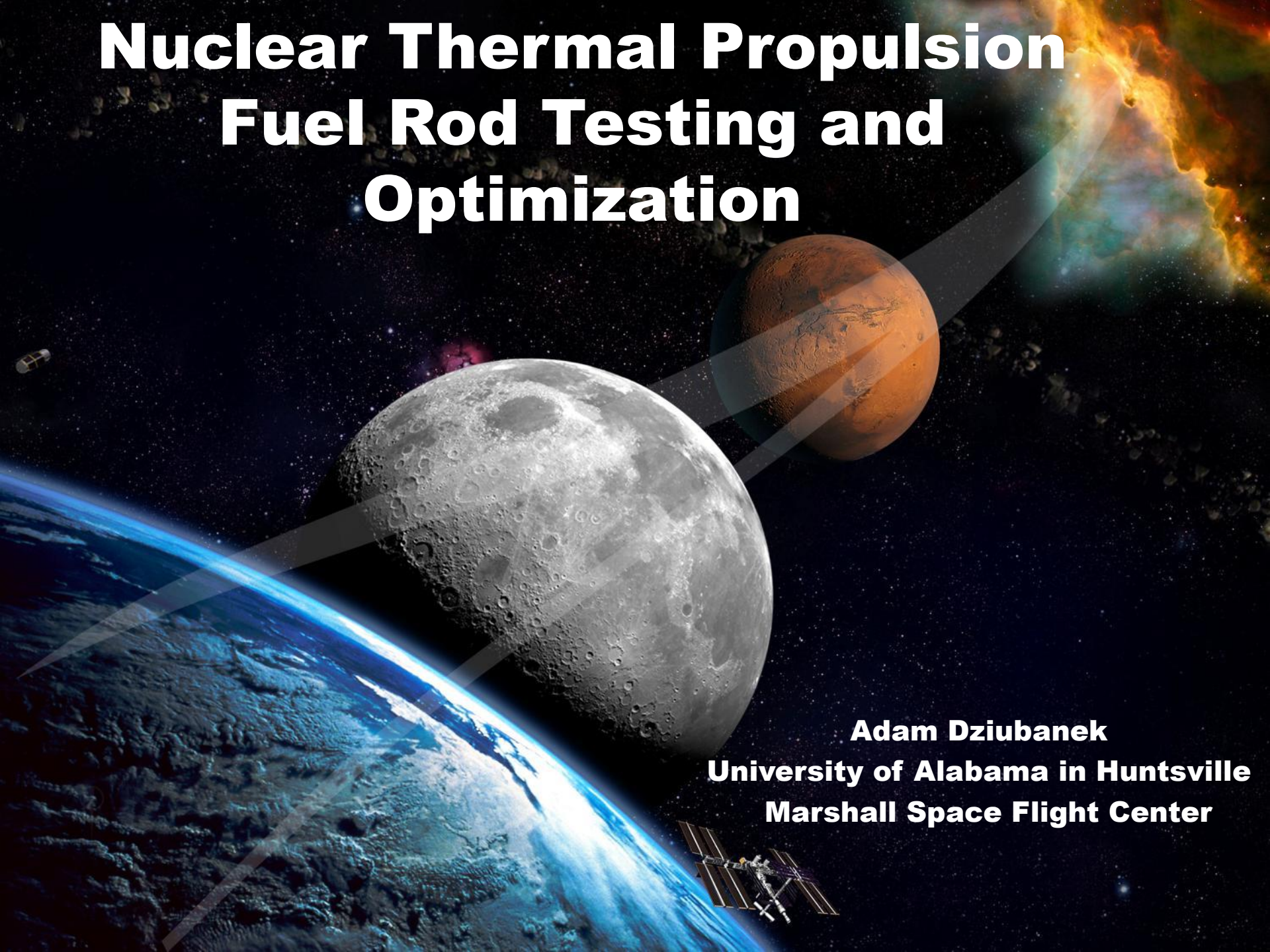
Nuclear Thermal Propulsion Fuel Rod Testing and Optimization



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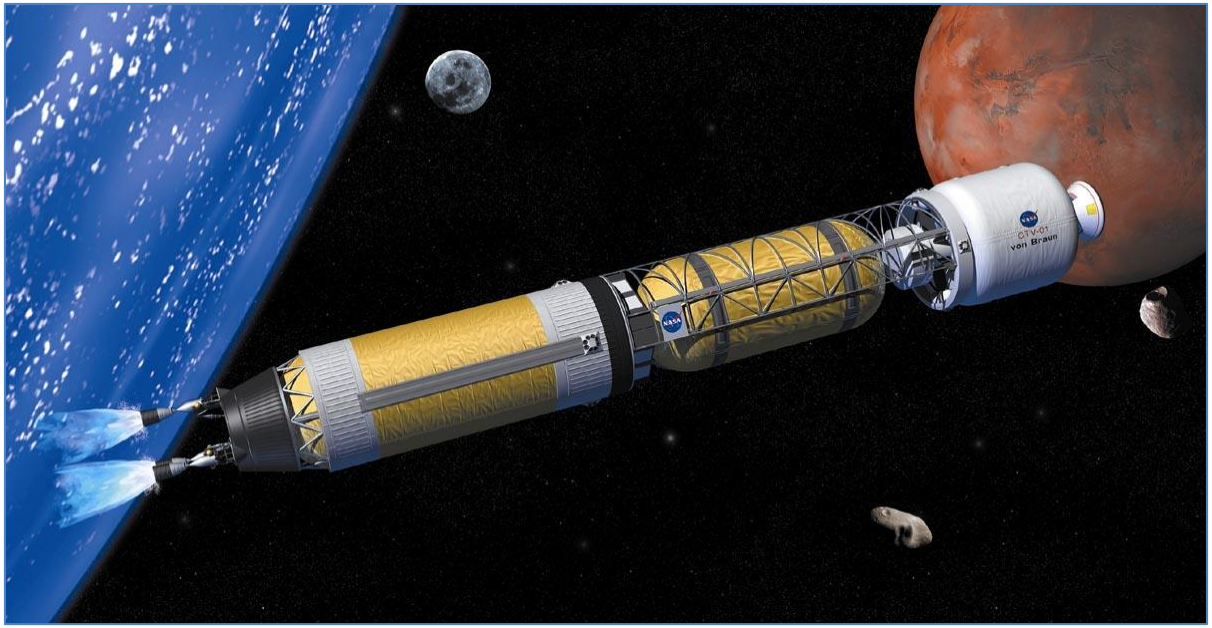
Nuclear Thermal Propulsion

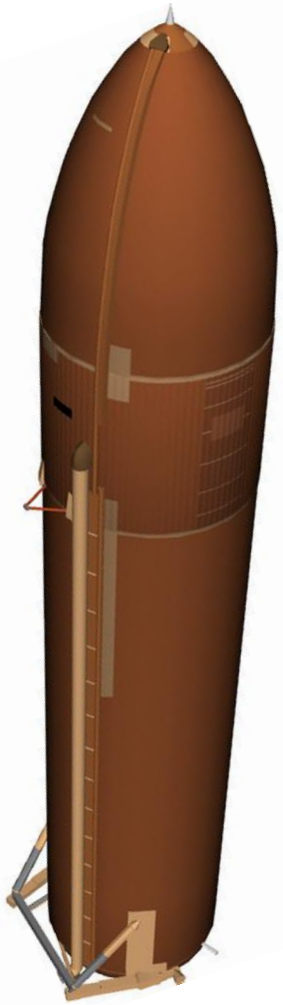
- **Viable concept for mars mission**
- **High ISP (~900 or more) roughly twice as much as chemical rockets**
- **Used for in space propulsion**



Nuclear Thermal Propulsion

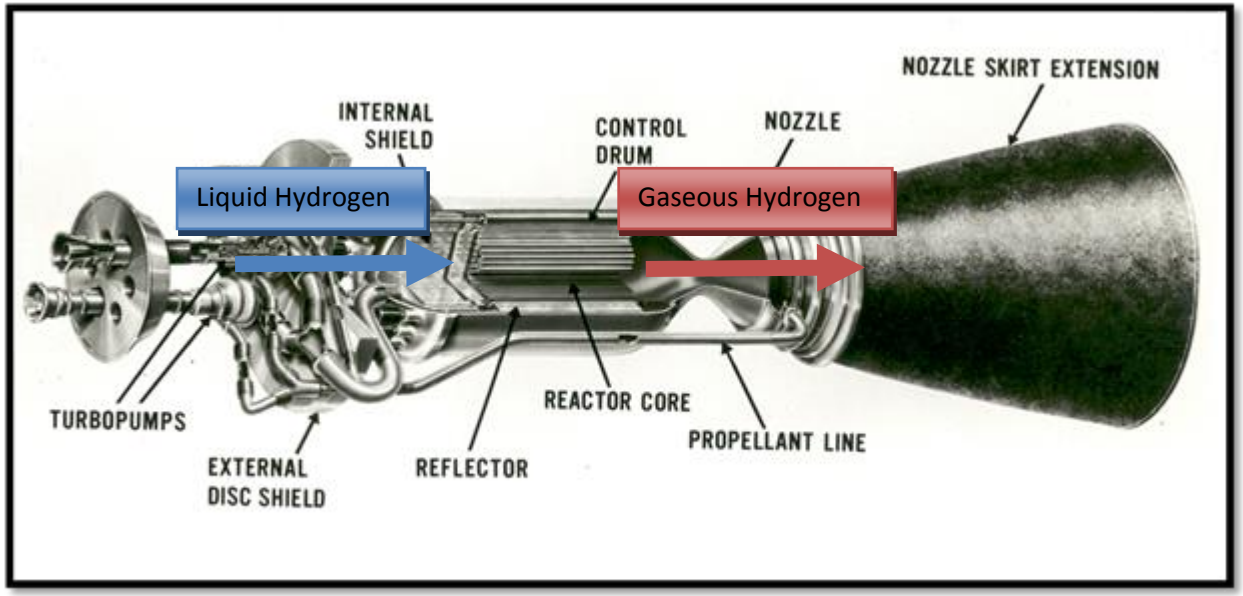
- **Nuclear fission reactions has a high energy yield**
- **12 fl oz of uranium fission**

= 50 x



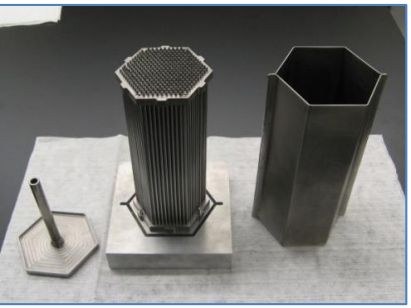
Nuclear Thermal Propulsion

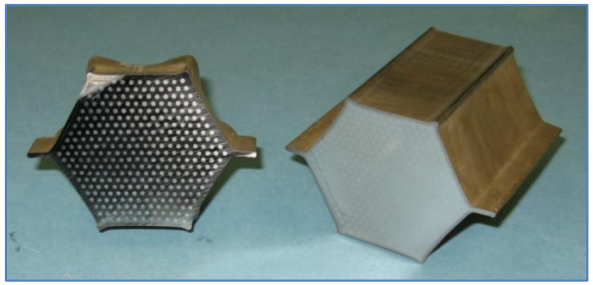
- **NERVA Rocket Engine**
- **High ISP**
- **Liquid hydrogen used for fuel**
- **Low Enriched Uranium (LEU)**

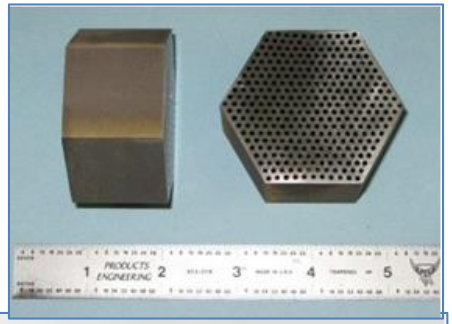


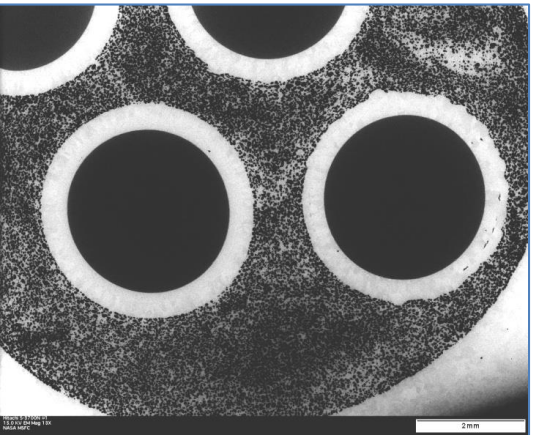
Fuel Rod Development

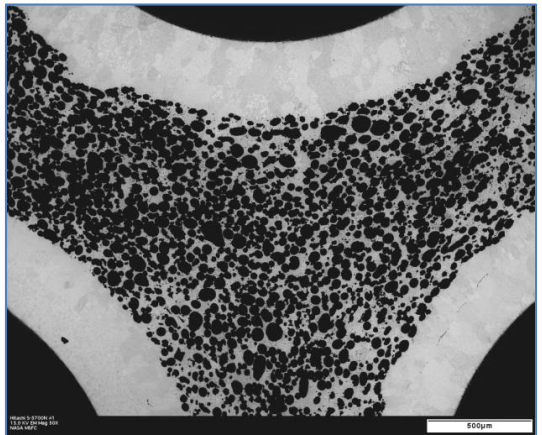
- Critical need for fuel rod development
- Reactor temperatures up to 3000K
- Hydrogen is highly reactive with most materials at high temperatures
- Limited data covering the effects of high-temp H2
- Cladded tungsten surface

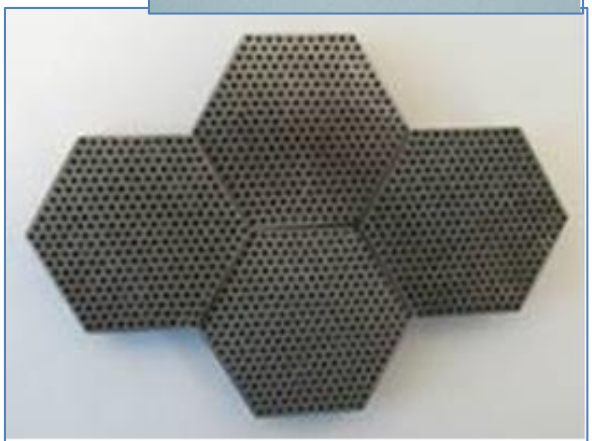




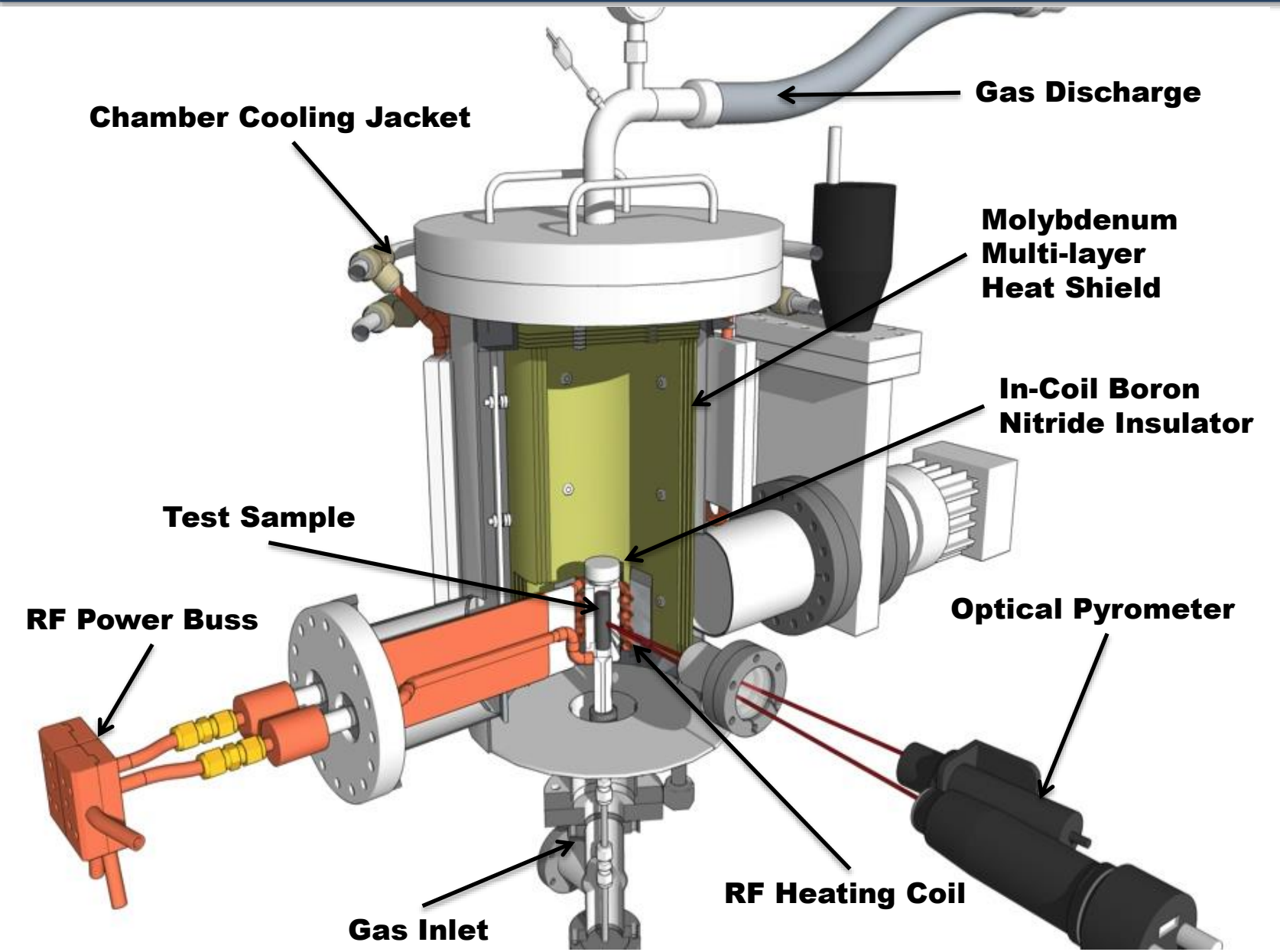






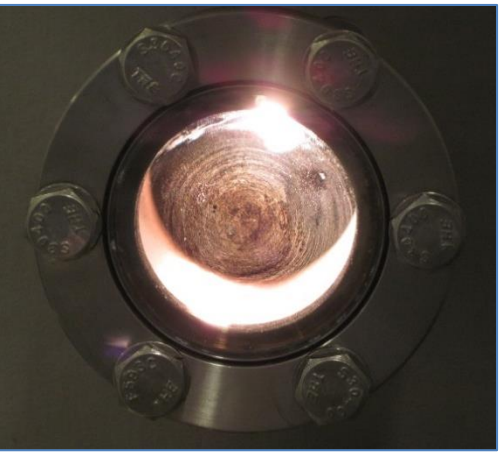


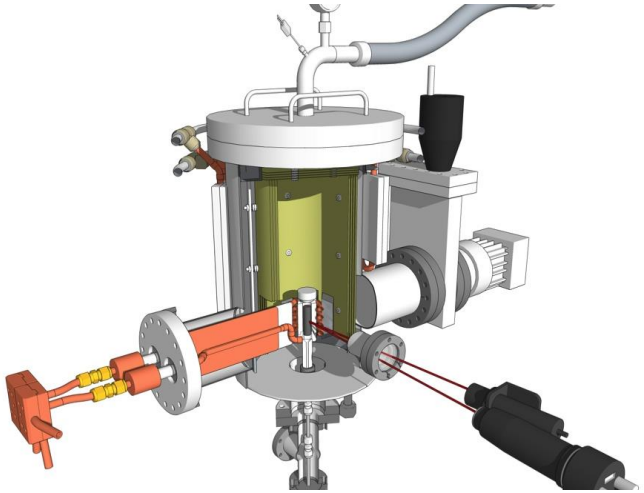
Compact Fuel Element Environment Tester (CFEET)

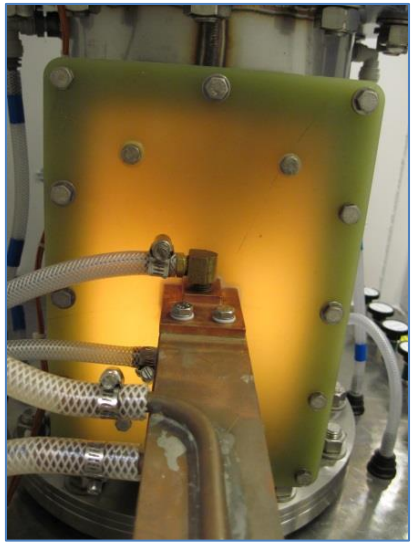


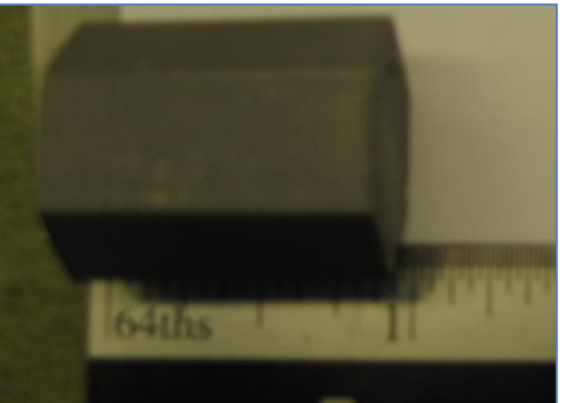
CFEET Optimization

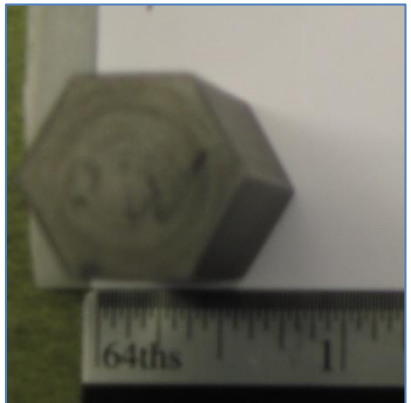
- **Verify Pyrometer readings**
- **Material used with known melting point**

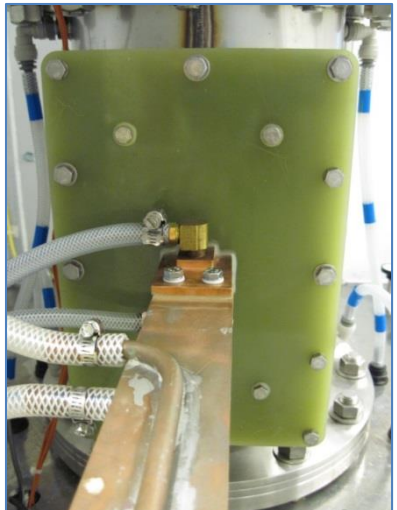






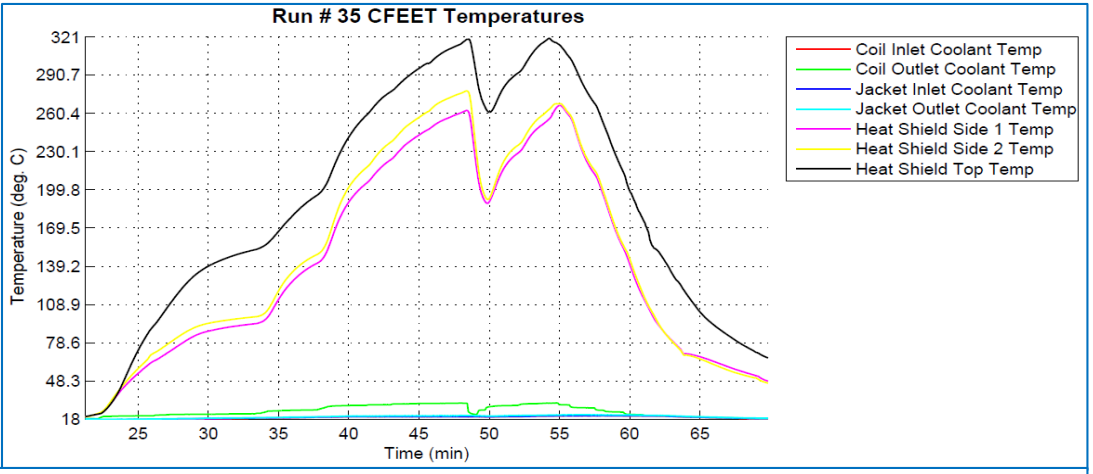


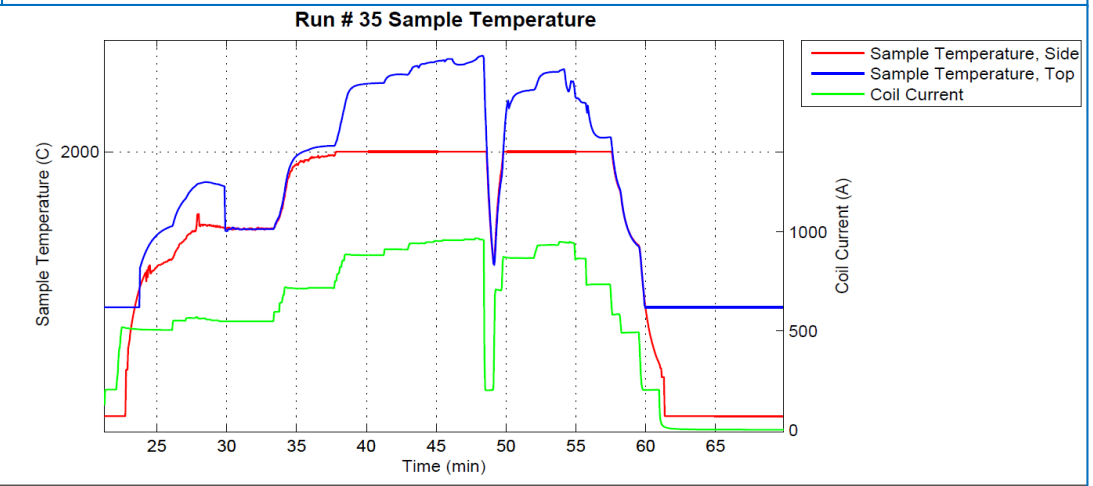


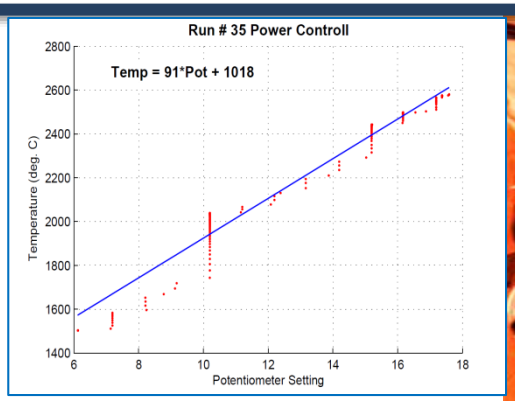


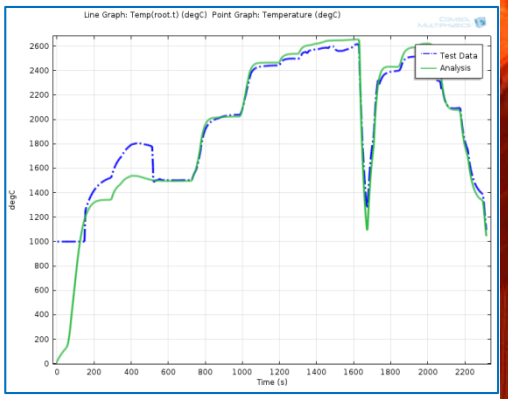
CFEET Optimization

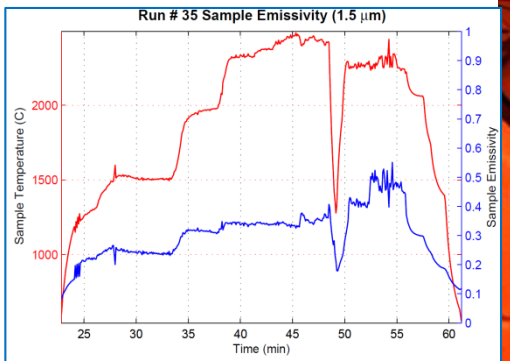
- **Data and analysis**





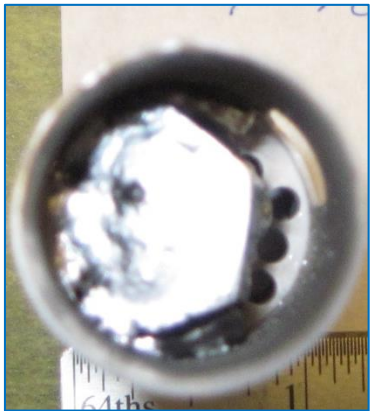






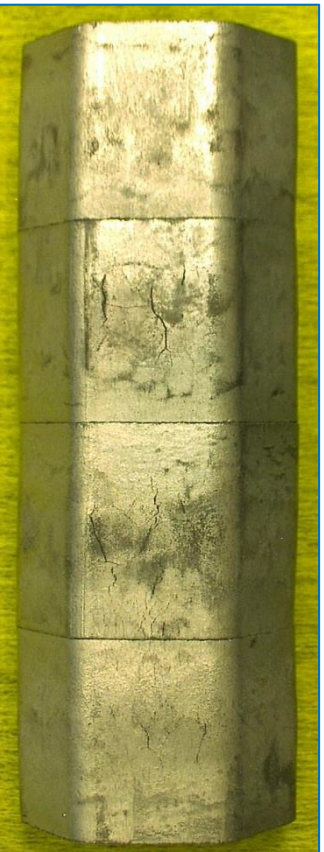
CFEET Optimization

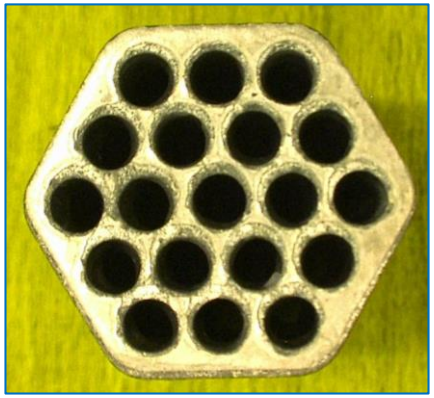
- **Post test**
- **Molybdenum melted**
- **Pyrometers successfully calibrated**



CFEET Testing

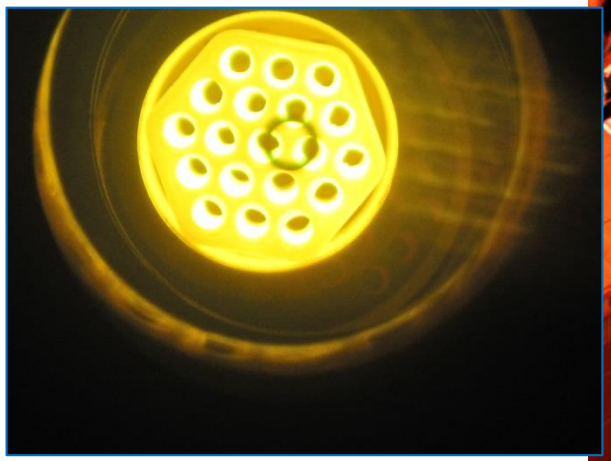
- **Pre test pictures of LEU sample**

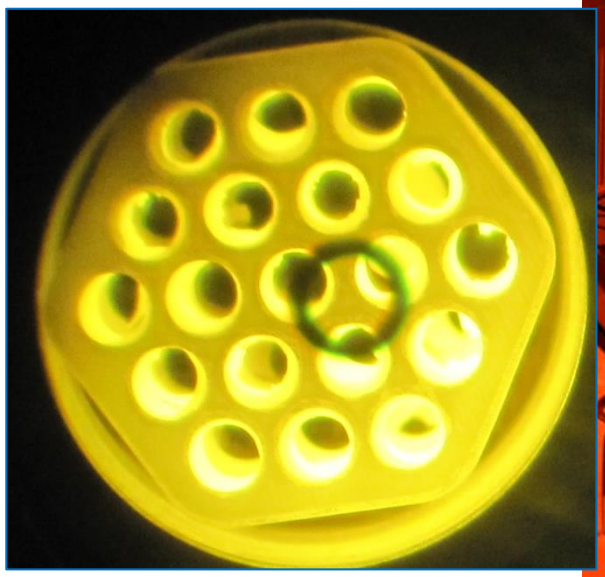




CFEET Testing

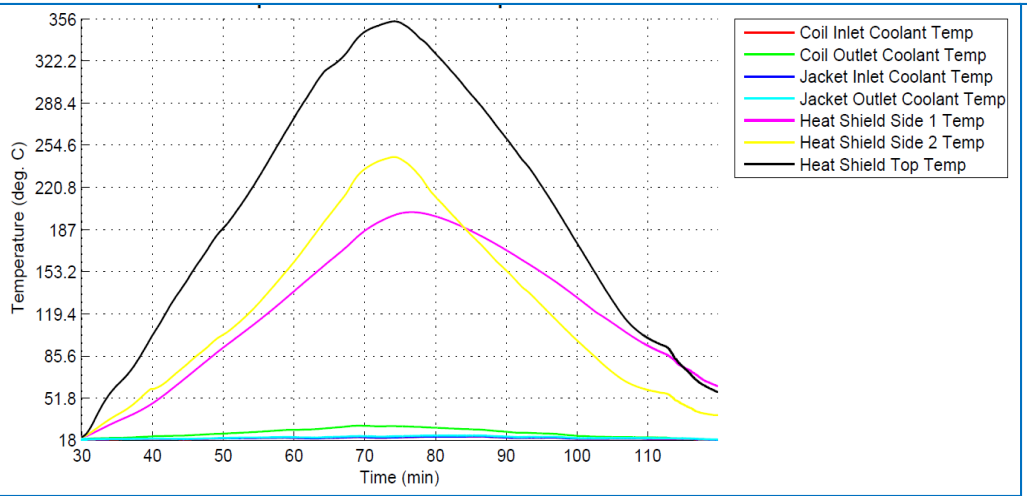
- Green flame during testing
- Pyrometer reading up to 2800°C

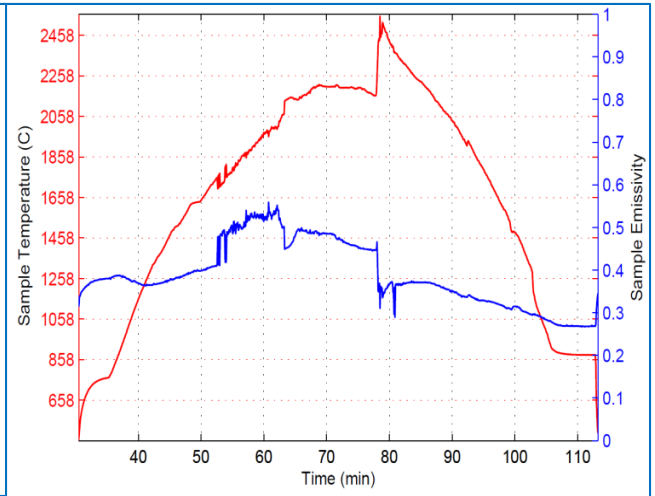


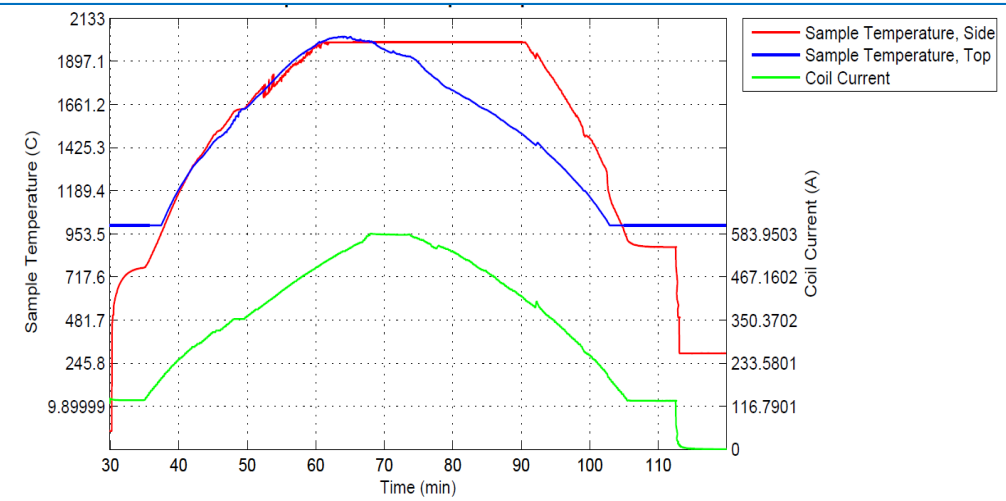


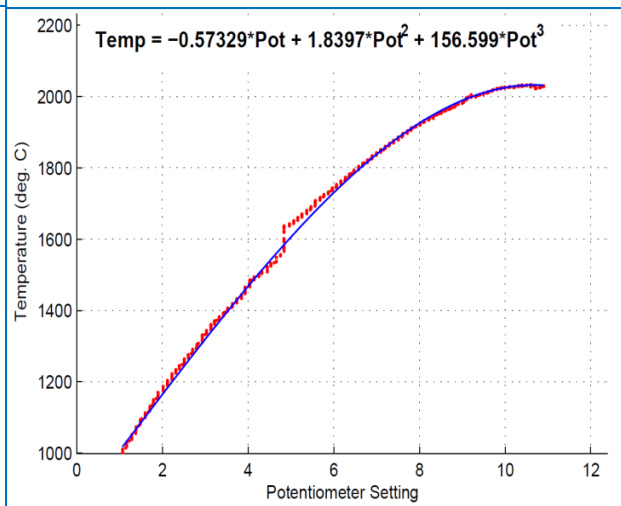
CFEET Testing

- **Data and Analysis**



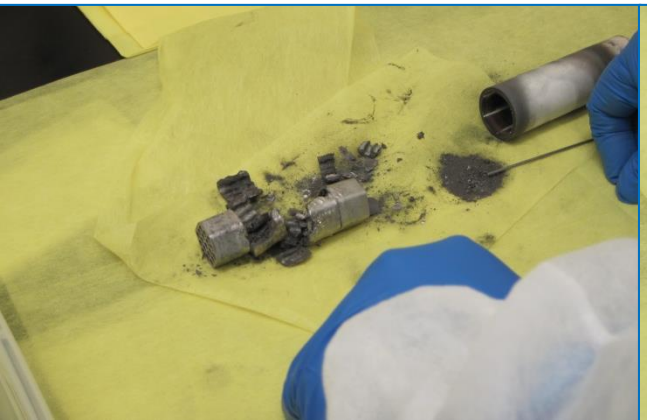


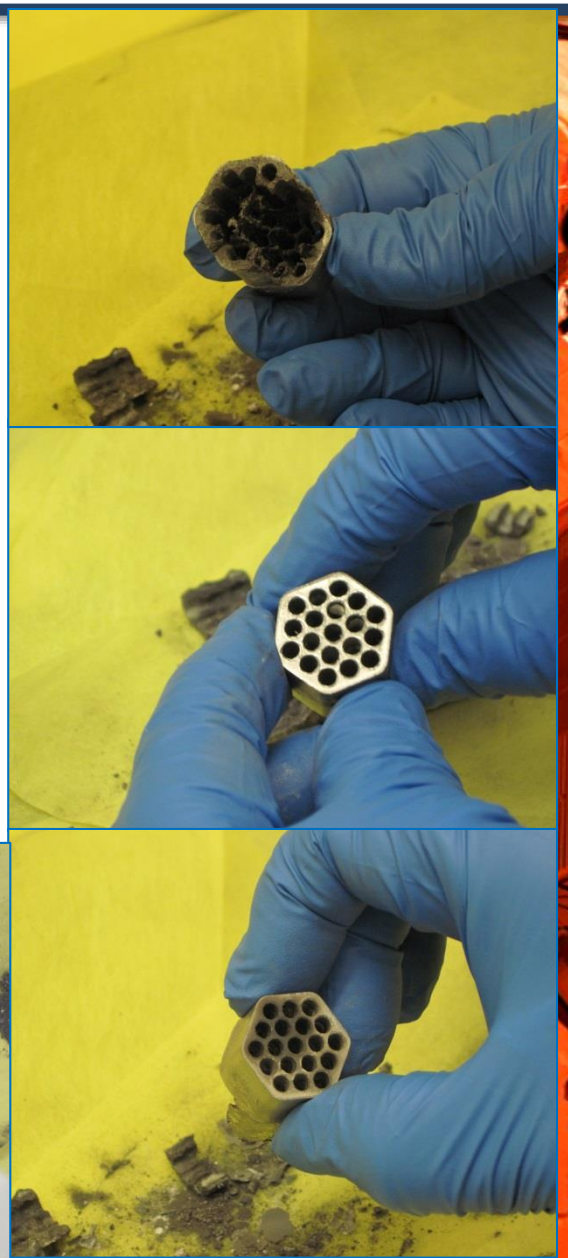




CFEET Testing

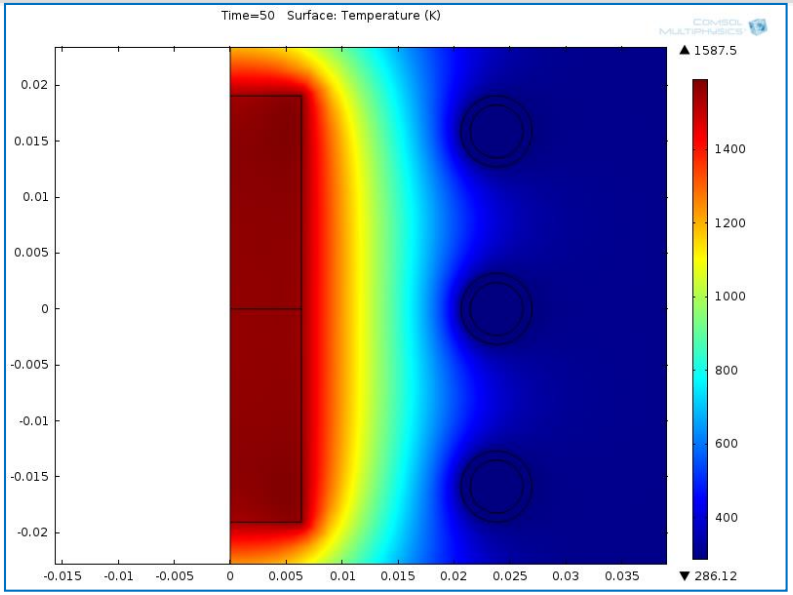
- **Post test pictures of LEU sample**
- **Possible causes?**
- **Failed before final temperature was reached**
- **Fuel rod designed to withstand temperatures of 3000K**

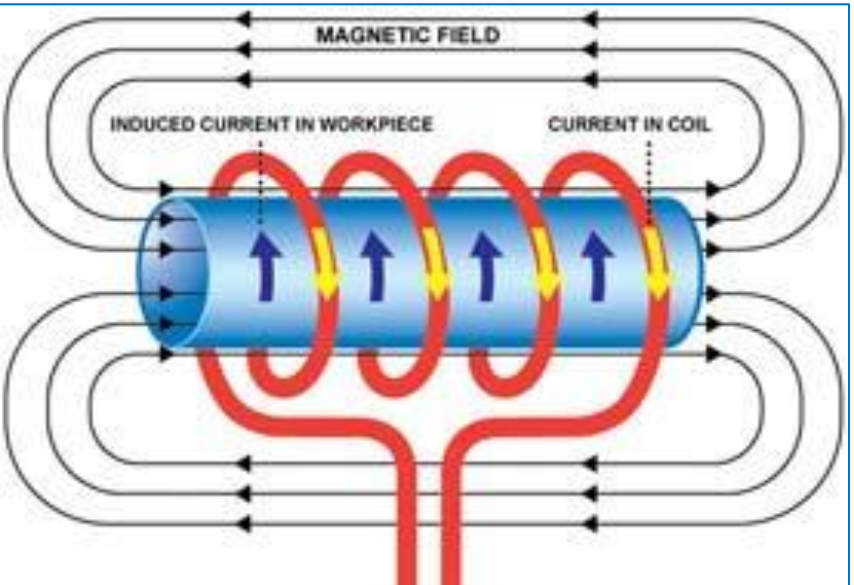


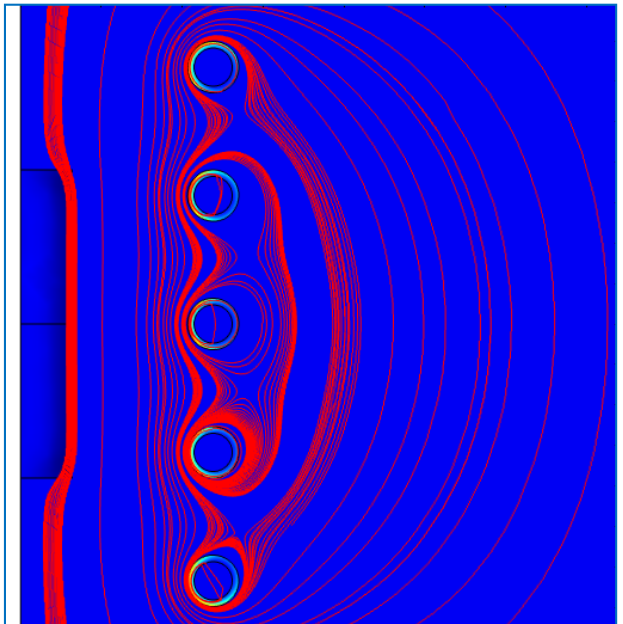



CFEET Testing

- **Focal point theory**
- **RF power supply creates an AC current on the sample**
- **The current flows against the resistivity of the metal, generating heat**







CFEET Testing

- Possible solutions
- Tungsten susceptor
- Coil sizing

Figure 9. 308 stainless steel sample before and after melting at 1500°C.

Conclusion

- **NTP offers a safe and effective way to get to Mars**
- **CFEET is a reliable test bed for NTP fuel rod design**
- **Acknowledgements: Carolyn Russell, Robert Hickman, Doug Trent, Dr. Mireles**

Appendix

- Protection from Radiation
  - Time
  - Distance (Crew at the front, fuel tanks, space trusses, then engine)
  - Shielding (Shadow Shield)
- What if it explodes?
  - Water could activate the reactor