Kilowatt Reactor Using Stirling TechnologY (KRUSTY) Experiment Update
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Outline

- Background on KRUSTY Experiment
- Objectives of the KRUSTY Experiment
  - Two experiment plans
  - Tests described in Experiment plans
    - Tests that have been performed with DU core at NASA Glenn Research Center
  - Criticality safety associated with hands-on operations
  - Other Issues (Safety Basis Challenges, Casting of the fuel, etc)
- Concluding Remarks

Background

- For more than 30 years, NASA has relied on Radioisotope Thermoelectric Generators (RTGs) to produce electricity that is used to power instrumentation in spacecraft or Rover vehicles

- In the 2000's, NASA decided to explores other sources of energy to produce electricity for spacecraft that will be used for a deep space exploration mission

•In 2012, NCERC conducted a successful test where electricity was produced using the Flattop assembly

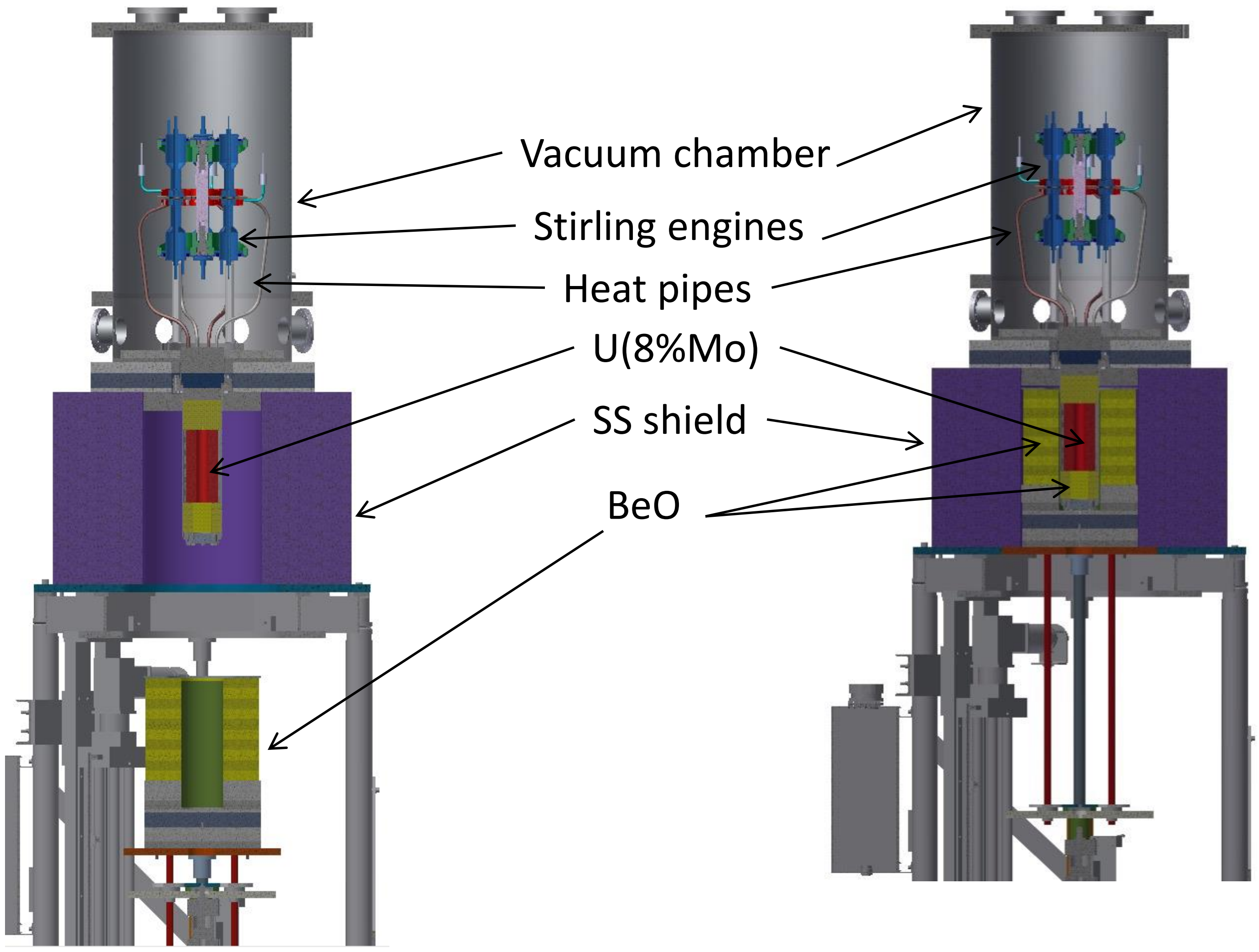
U. S. Department of Energy
Nuclear Criticality Safety Program

Objectives

- The main objective of the KRUSTY experiment is to evaluate the operational performance of a compact reactor that closely resembles the flight unit NASA will use for deep space exploration missions.

- Demonstrate how heat pipes coupled to Stirling engines can generate electricity from a “nuclear generated” heat source

KRUSTY Experiment



Experiment Plans

Two experiment plans have been written

- Operational Requirements for the 1st experiment plan
  - Excess reactivity shall not exceed $0.80
  - Peak temperature in the core not to exceed 600˚C
  - Electrically heated test not to exceed 850˚C (core surface)

- Operational Requirements for the 2nd experiment plan
  - Excess reactivity shall not exceed $3.00
  - Peak temperature in the core not to exceed 900˚C

Series of Cold and Warm Criticals (80 cents excess reactivity limit)

No vacuum chamber (Cold Criticals)

- **BeO Side reflector reactivity worth measurements**
- **BeO Axial (Top) reactivity worth measurement (Al replacement)**
- **B_4C rod reactivity worth measurement**

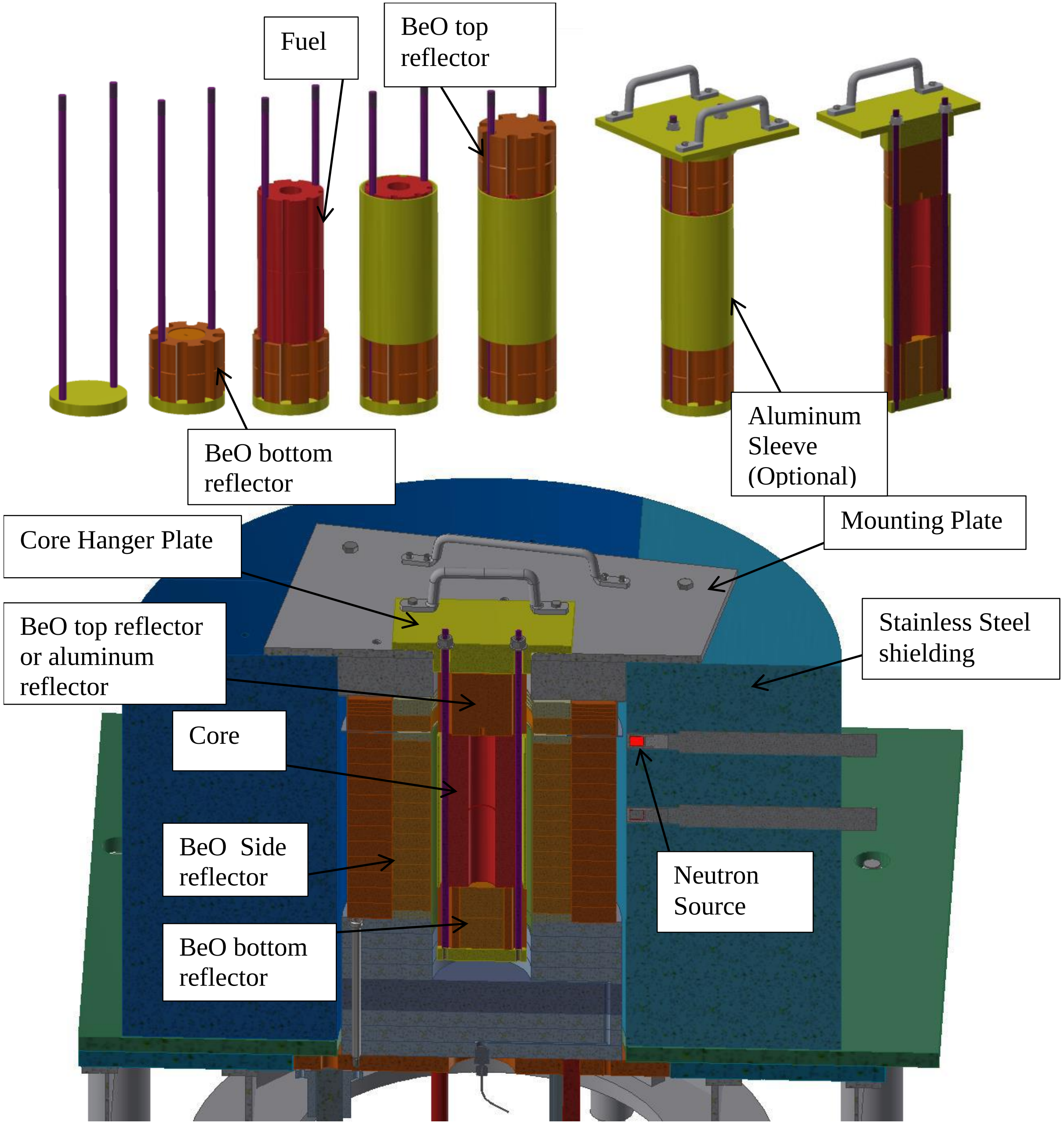
With vacuum chamber, heat pipes, and brackets (Cold Criticals)

- **BeO Side reflector reactivity worth measurements**
- **B_4C rod reactivity worth measurement**
- **Electrically heated test**

Warm Criticals

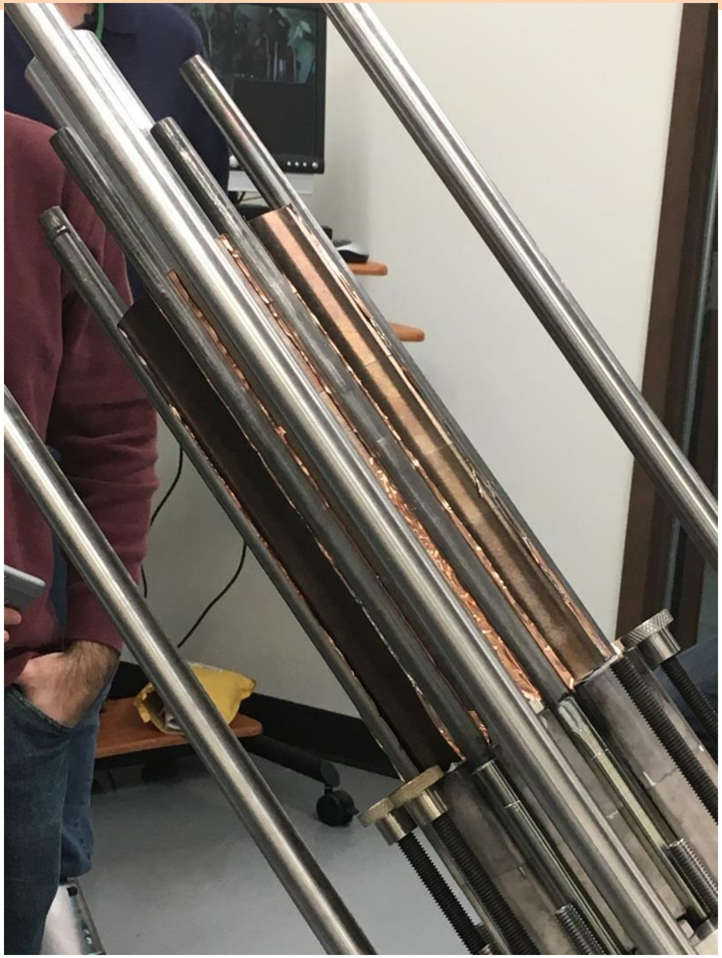
- **Reactivity temperature coefficient**
- **15 cent free run, 30 cent run, 60 cent run**

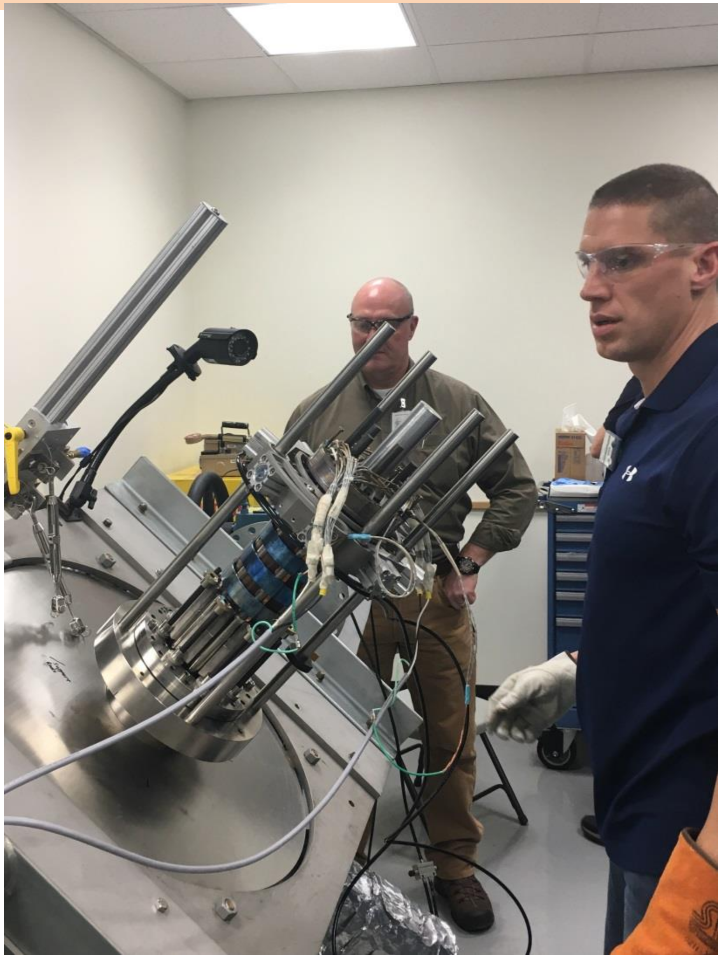
Excess reactivity:
80 cents
Temperature limit:
600° C as measured at the surface of fuel



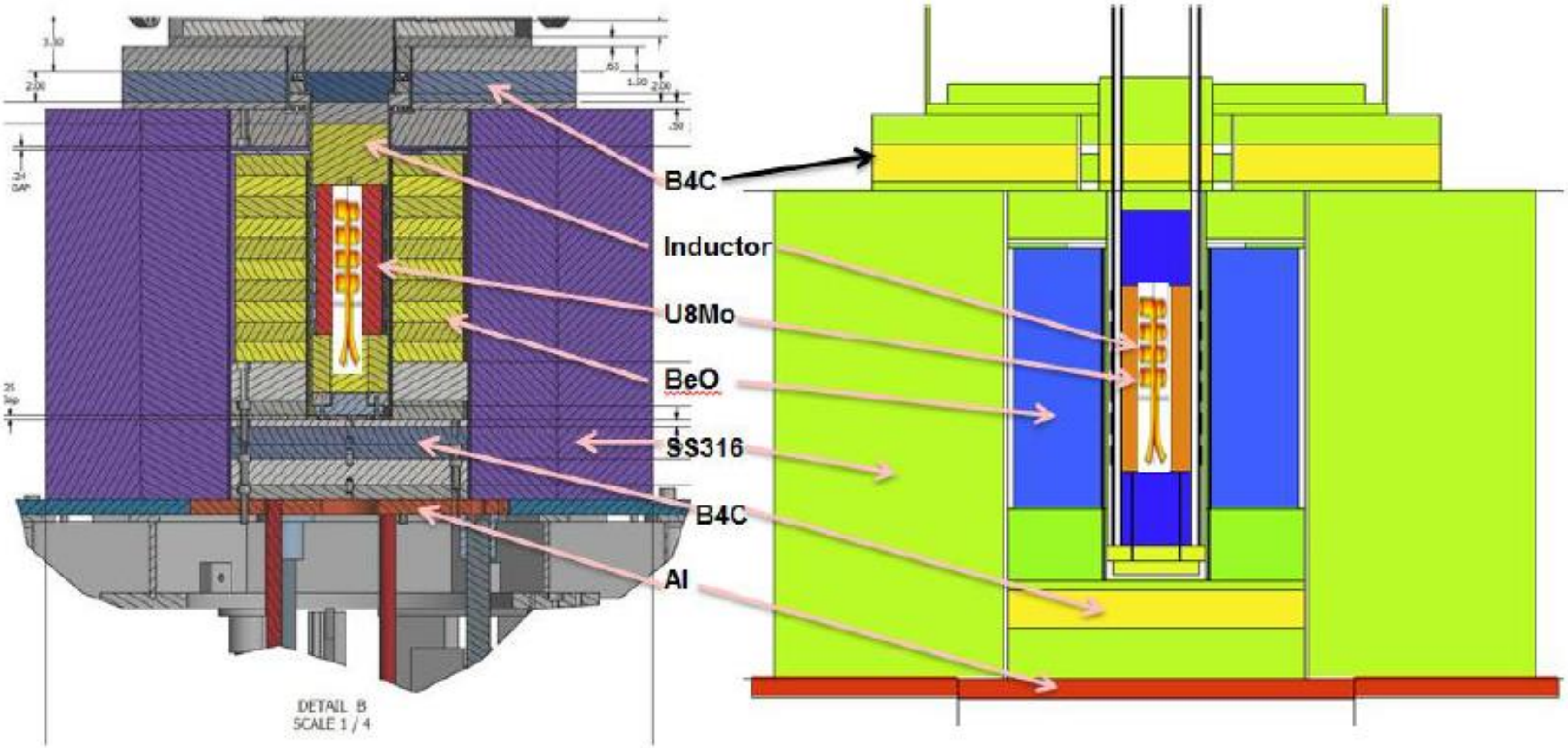
Electrical, Mechanical Interface

- **Enable the functionality testing of balance of plant (thermocouples, data acquisition system electrical heater will be used for testing functionality of instrumentation)**



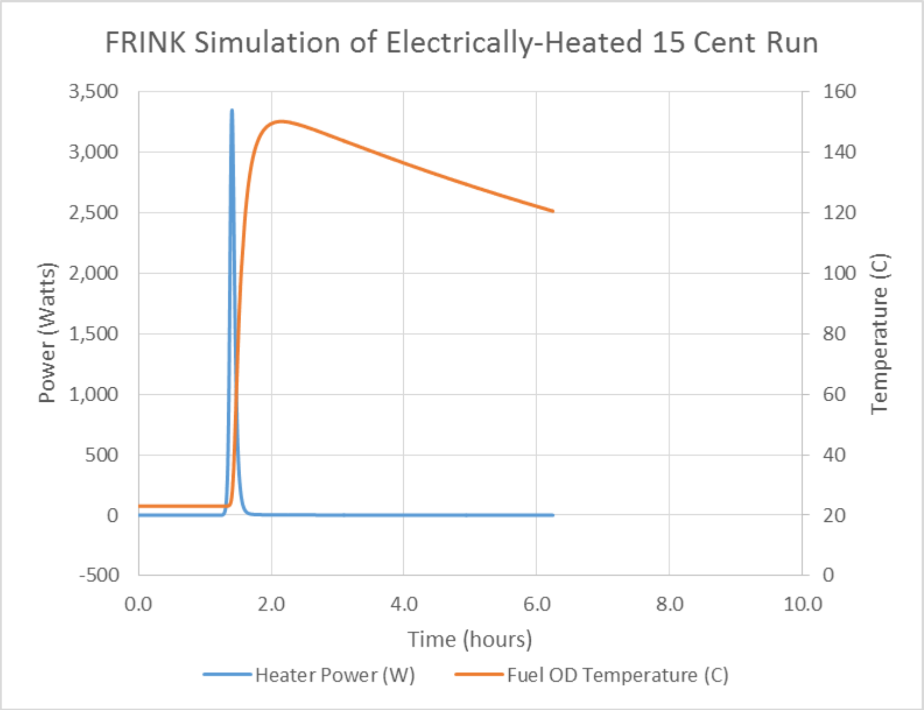


Electrically heated test

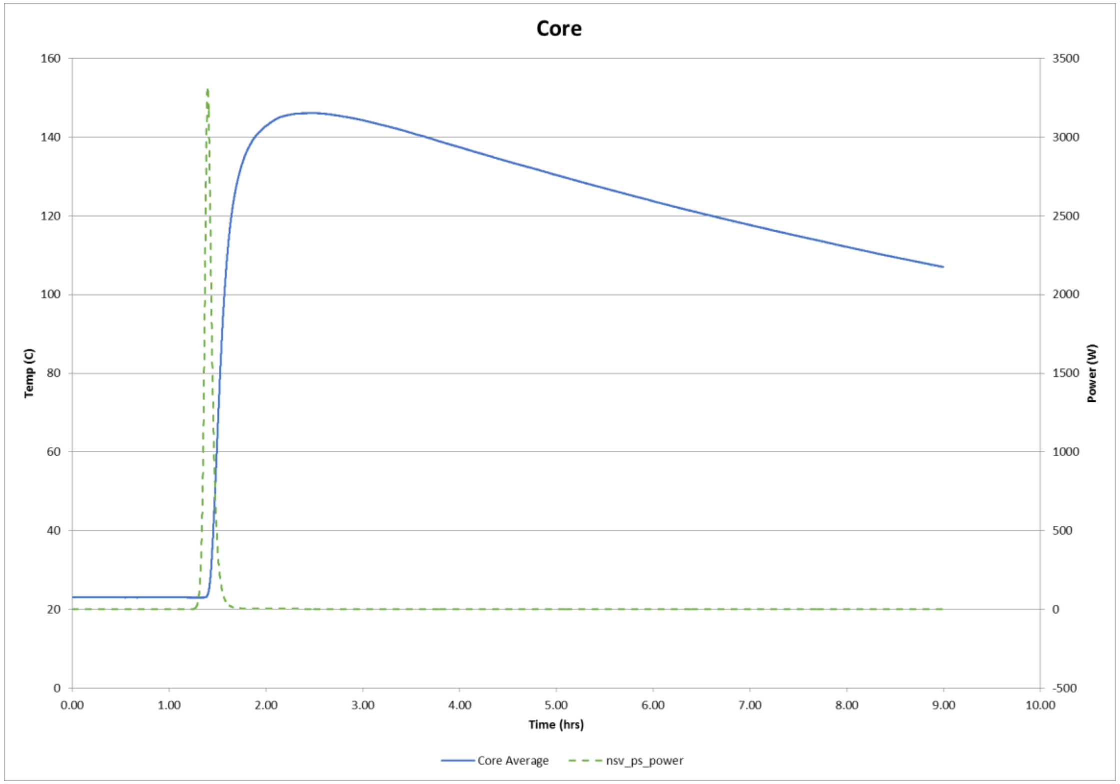


Warm Criticals
(Assembly loaded to 80 cents based on cold critical data)

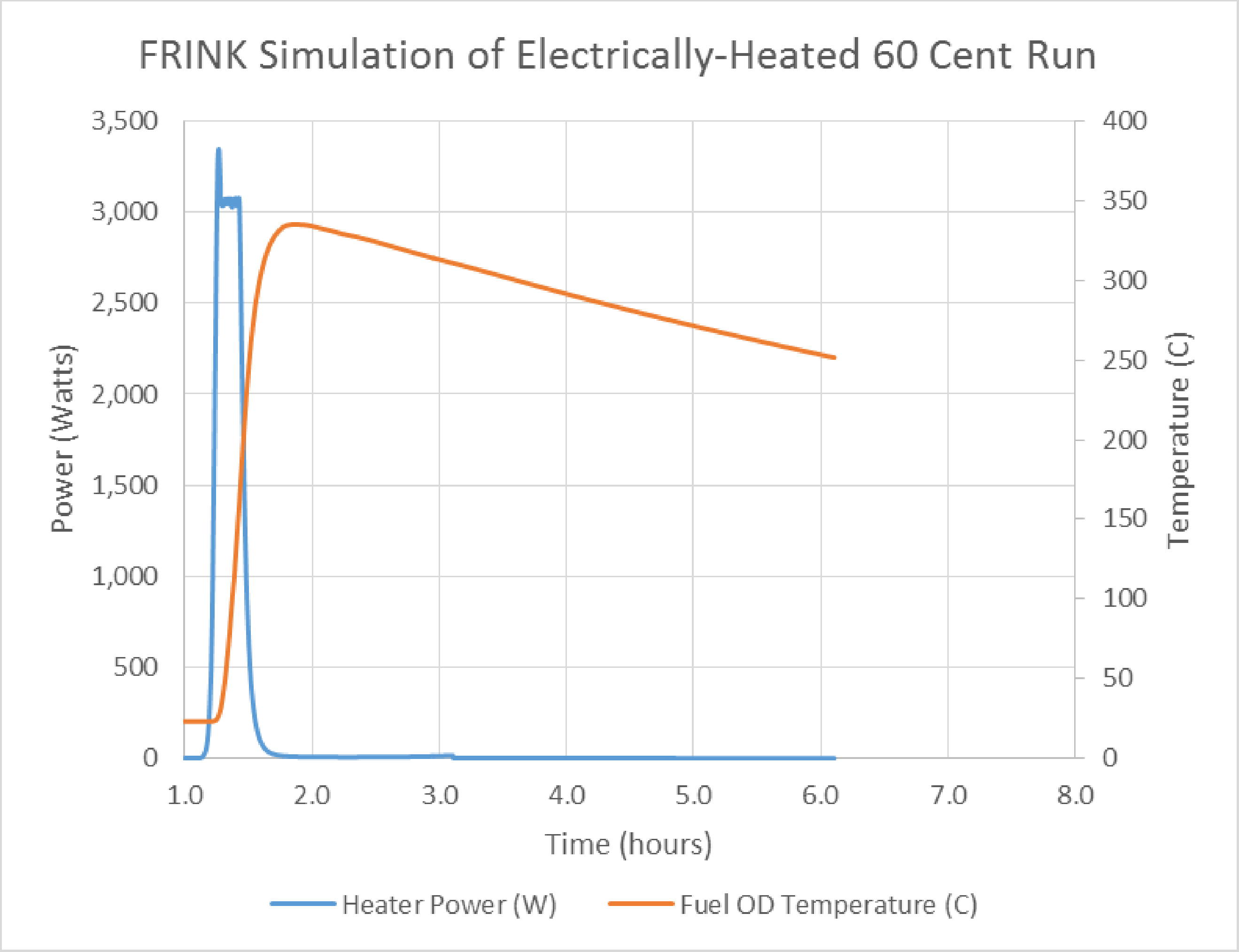
- 15 cents(Free run)
- 30 cents run
- 60 cents run



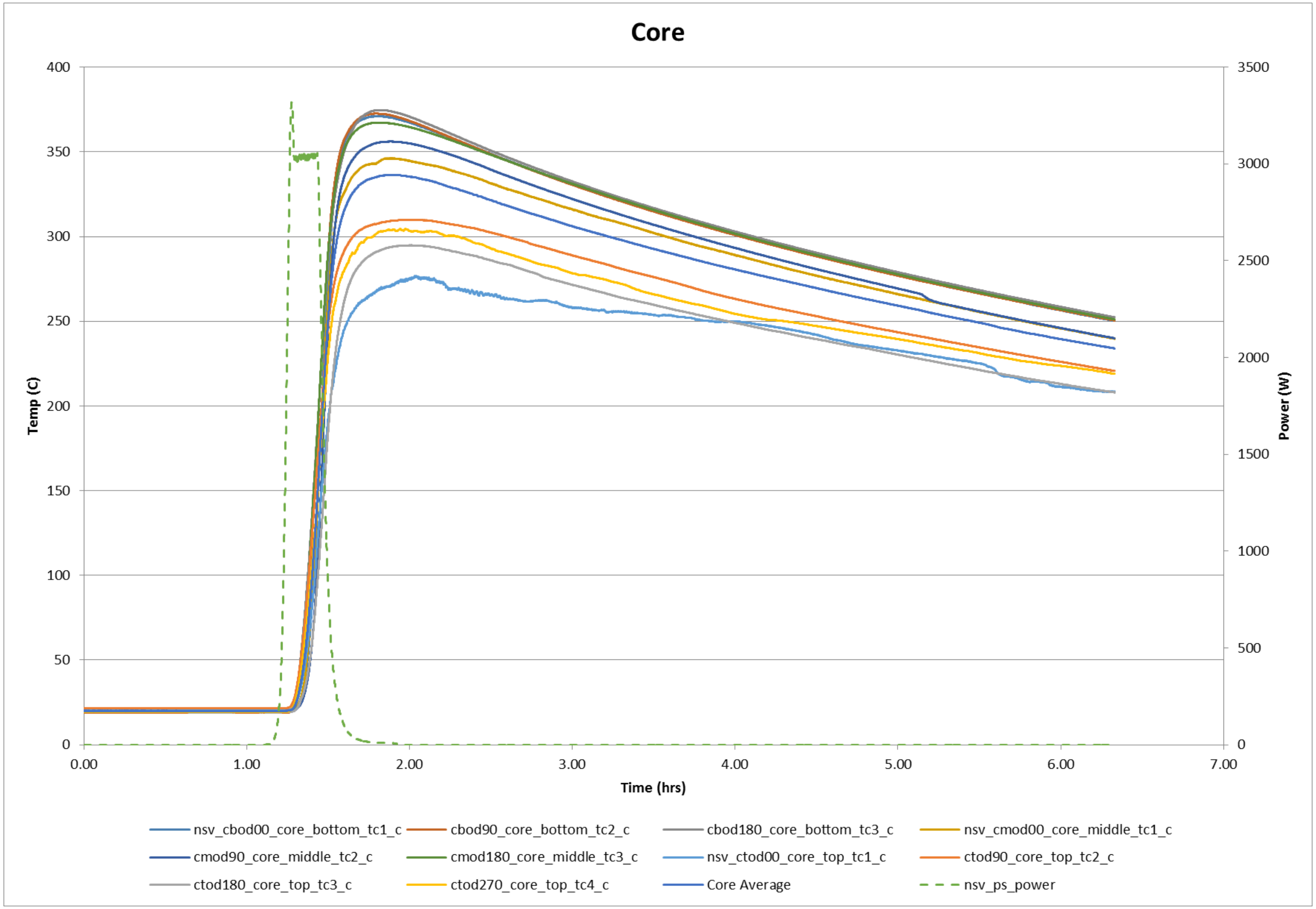
Depleted Uranium Core (15 cents)



Simulation (60 cents)

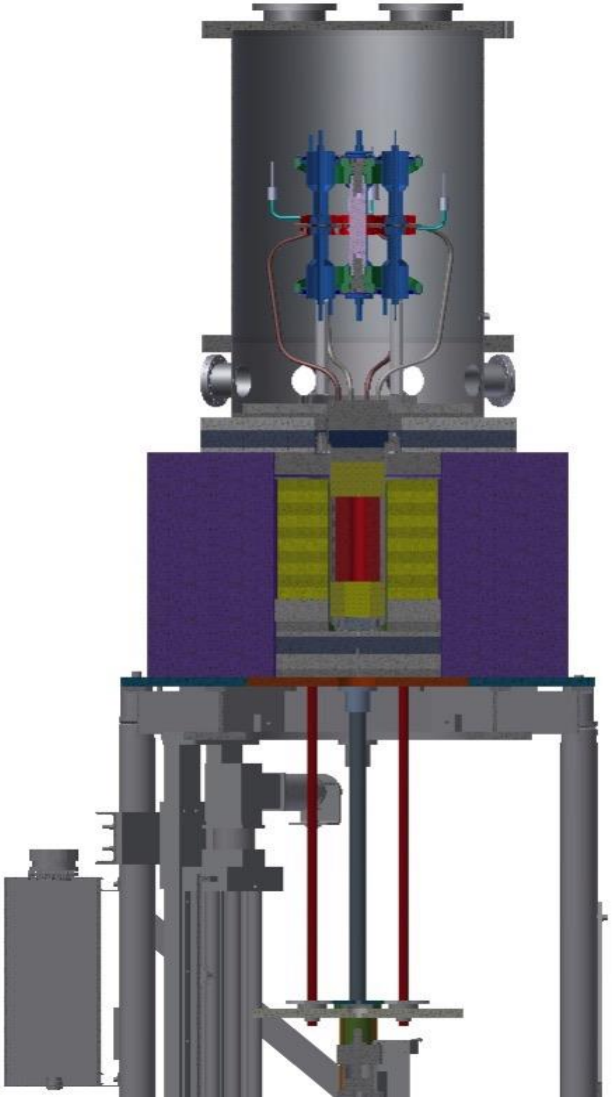


Depleted Uranium Core (60 cents transient)



Full power demonstration (2^{nd} Experiment Plan)

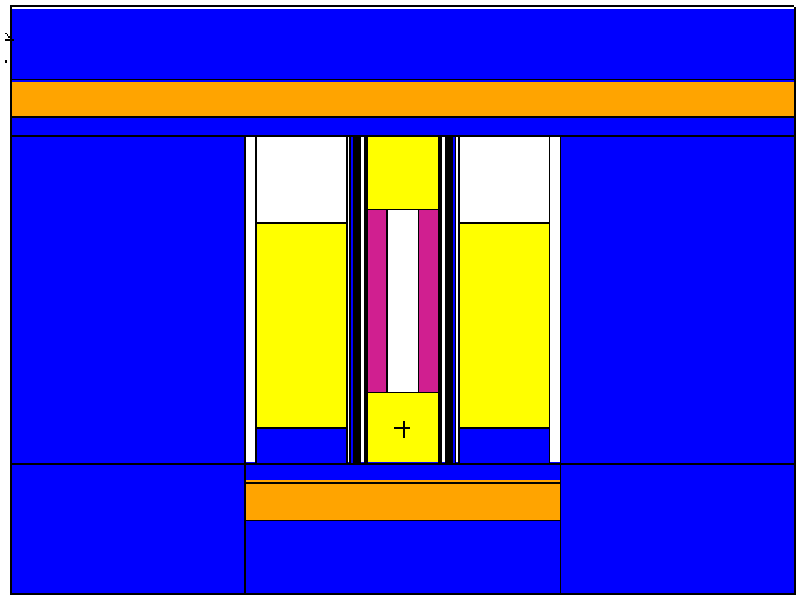
- Experiment Plan (3.00$ excess)
- Temperature Limit at the surface of the fuel: 900°C
- 20+ hour run
- Transients to look at
  - Load following (cutting power to Stirling engines)
  - Failure of a heat pipe



Criticality Safety for hands-on operations

- MCNP Simulations
  - ENDF/B-VI neutron cross sections
  - 3 million histories
  - Height of BeO: 28 cm

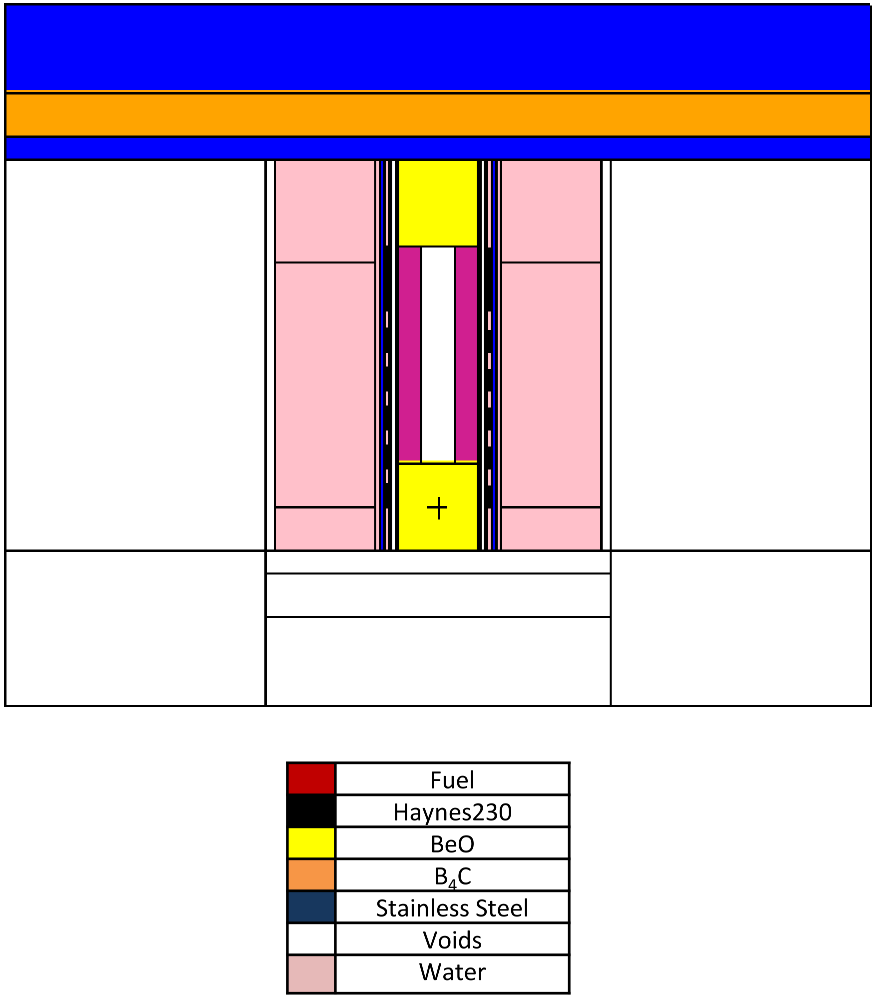
- Reference Case
  - $k_{eff} = 1.00103 \pm 0.00037$



	Fuel
	Haynes230
	BeO
	B_4C
	Stainless Steel
	Voids

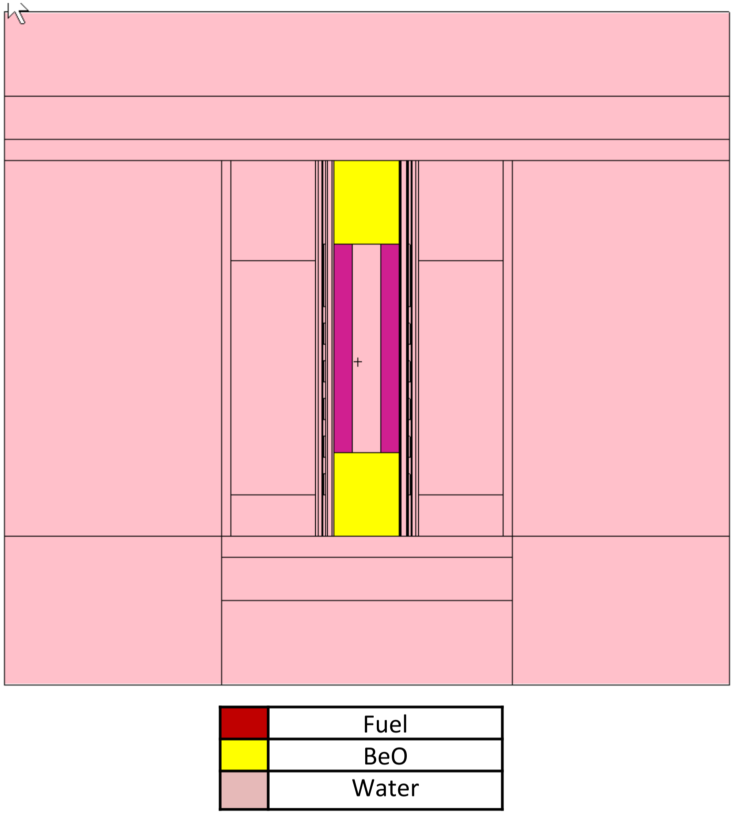
Criticality Safety for hands-on operations (Cont.)

- k_{eff} = 0.84796 ± 0.00036
- M of about 6.6
  well below the nominal
  hands-on limit of 10.
- -$23.12 assuming a
  β of 0.0078.



Criticality Safety for hands-on operations (Cont.)

- k_{eff} = 0.97679 ± 0.00040
- M of about 43
- -$3.18 assuming a
  β of 0.0078.



Other Issues

- **Kilopower Reactor Using Stirling TechnologY (KRUSTY) Experiment Amendment to the Device Assembly Facility Documented Safety Analysis Addendum for the National Criticality Experiments Research Center (NCERC)**
  - **90% completed**
  - **Submitted to DOE for review**

- **Casting of the fuel is proceeding according to the schedule**

- **Experiments Plans (One of them is in the process of being approved, the other will be submitted to the CESC (Criticality Experiments Safety Committee) in the near future)**

- **Heating test (at Glenn Research Center) using depleted uranium was a great success.**

Conclusions

- A lot of progress has been made to accomplish the goals for this experiment
- The casting and machining of the fuel will be completed May 2017
- KRUSTY experiment addendum will be approved April 2017
- Experiment plans (both approved in May 2017)
- Cold Criticals (June or July 2017)
- Warm Criticals (September 2017
- High Power Run (Oct-Nov 2017)