Kilopower Reactor Using Stirling Technology (KRUSTY) Nuclear Ground Test Results and Lessons Learned

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KRUSTY Test Objectives

- **Objective 1: Operate the reactor at steady state with a thermal power output of 4 kW_t at a temperature of 800° C**

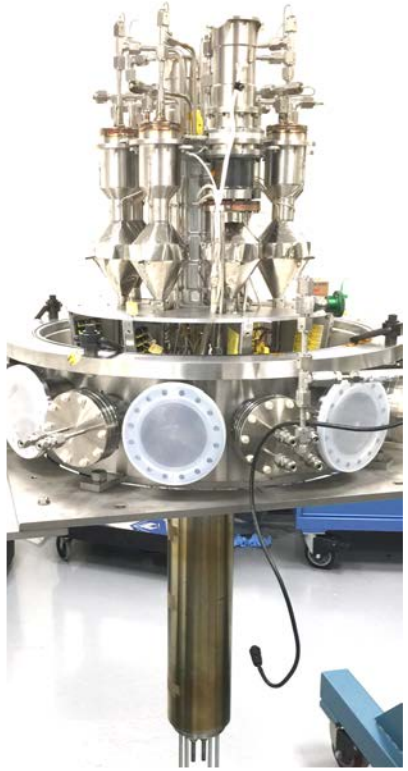
- **Objective 2: Verify the stability and load following characteristics of the reactor during nominal and off-nominal conditions**

- **Objective 3: Benchmark the nuclear codes and material cross sections using the test data**

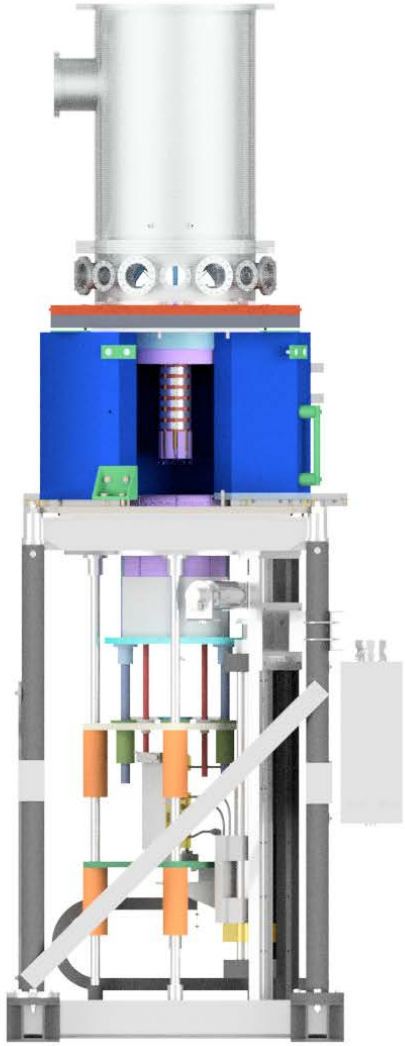
Kilopower Development and the KRUSTY Experiment

Flight Concept

KRUSTY Design



KRUSTY
Hardware



KRUSTY
Experimental Design

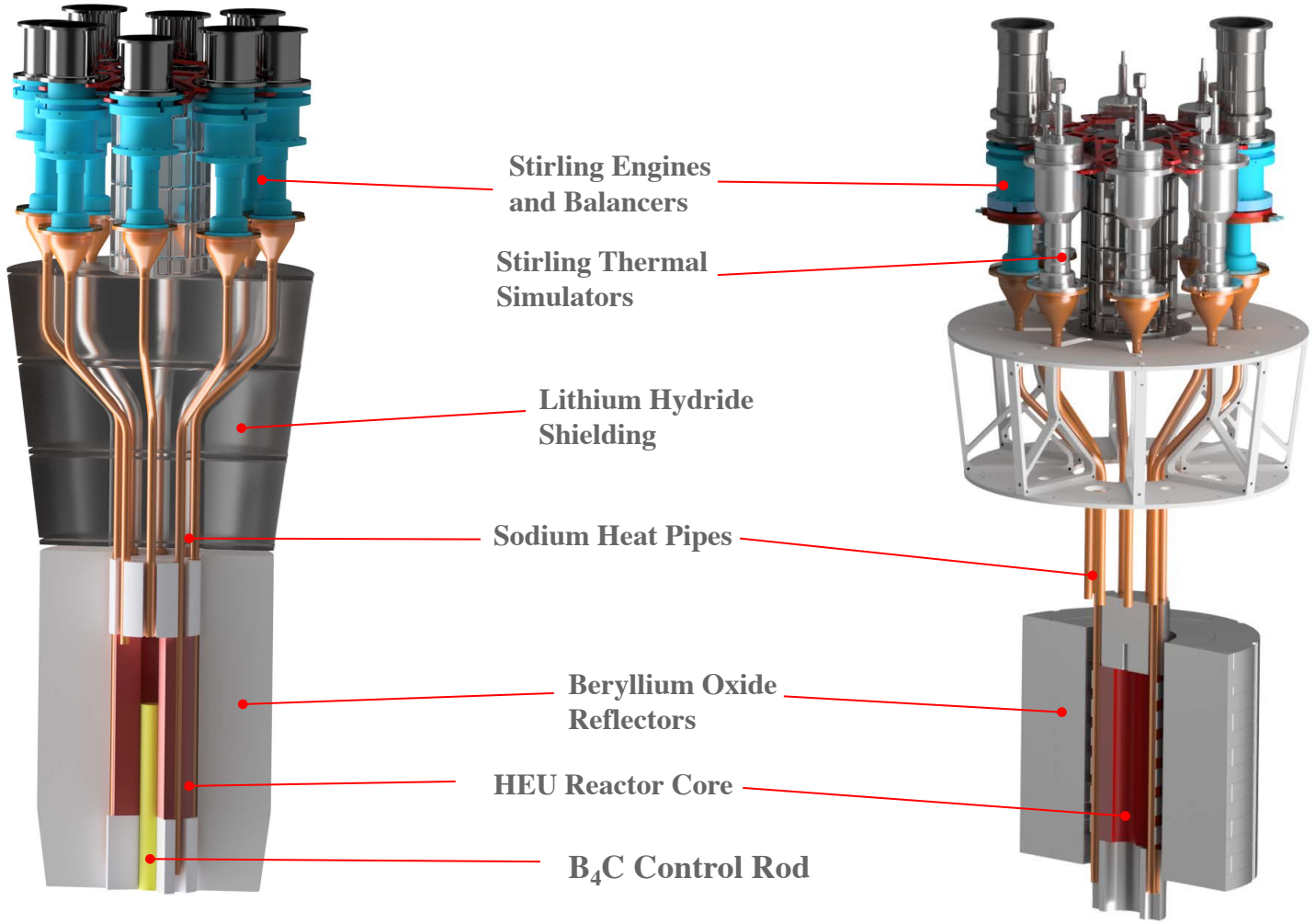
KRUSTY
Experimental
Hardware

Multi-mission Design

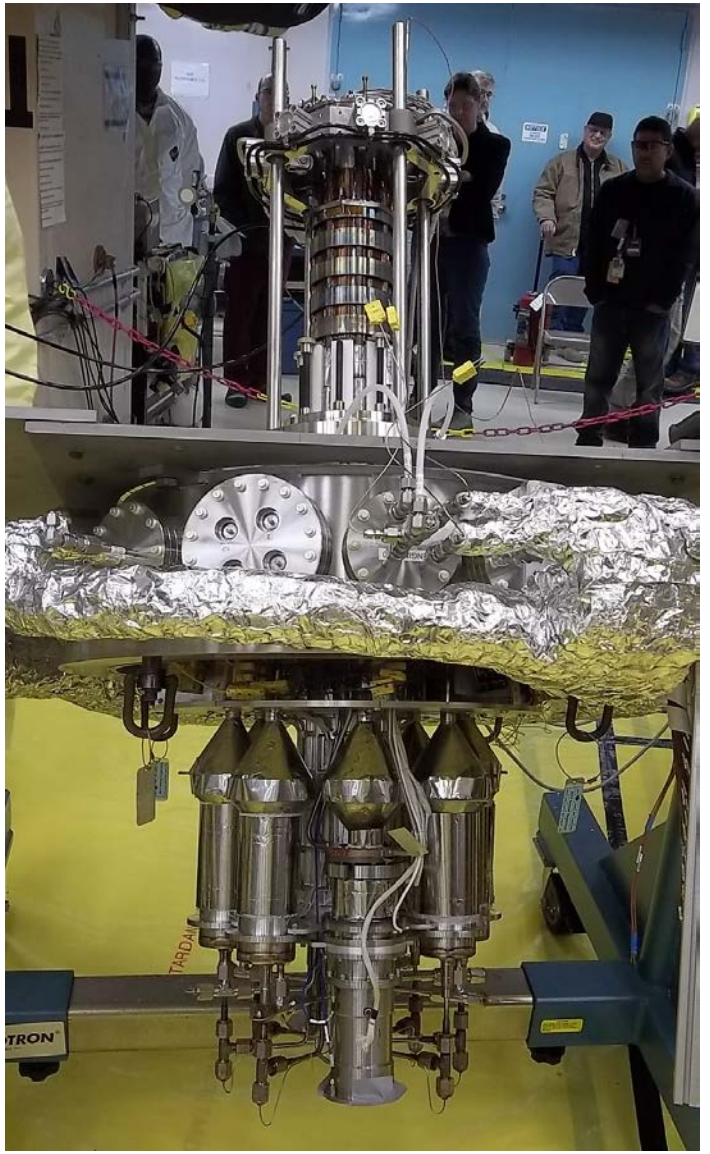
Kilopower 1-3 kWe Multi-Mission vs. KRUSTY Hardware

Multi-mission Design

KRUSTY Design



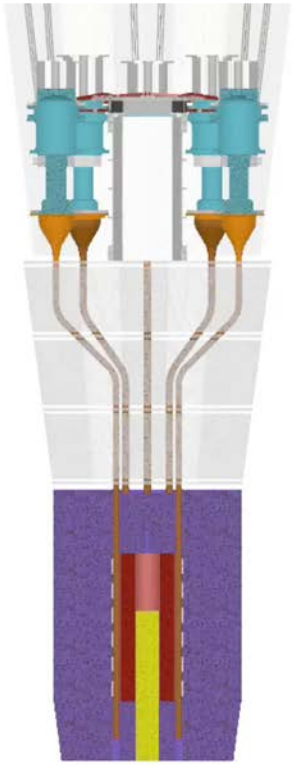
Reactor Assembly



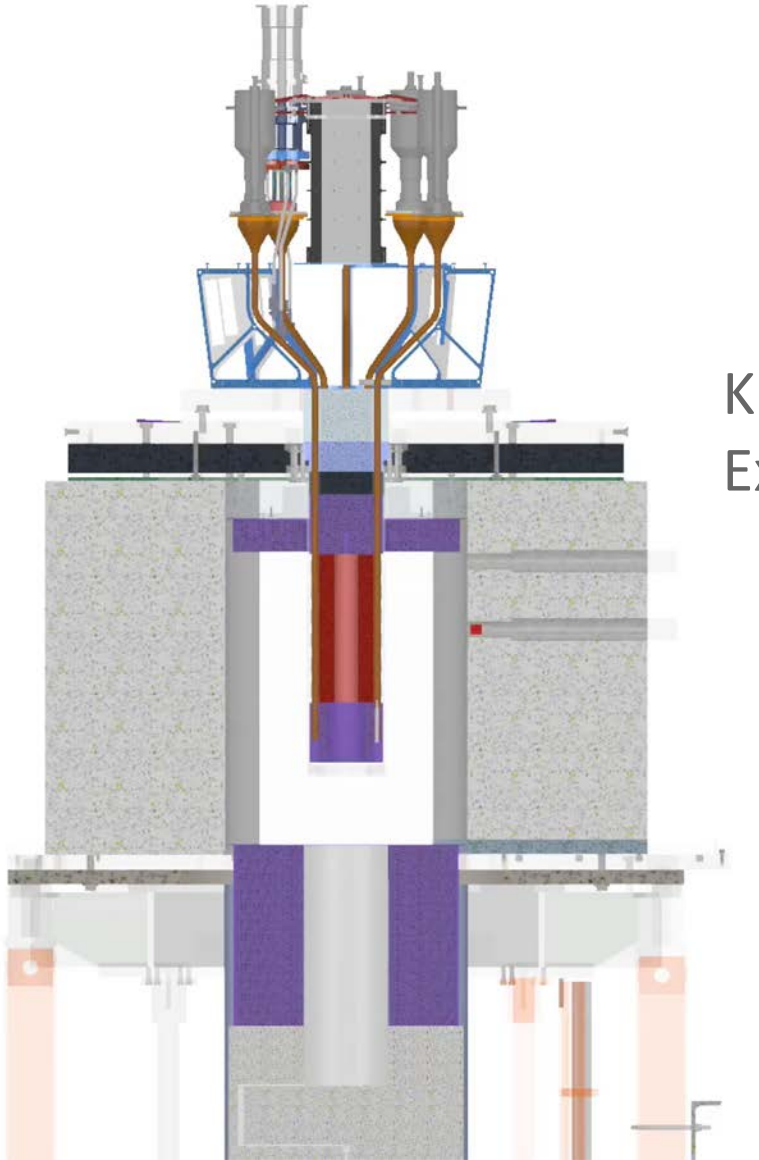
Experiment Assembly

Flight vs. KRUSTY

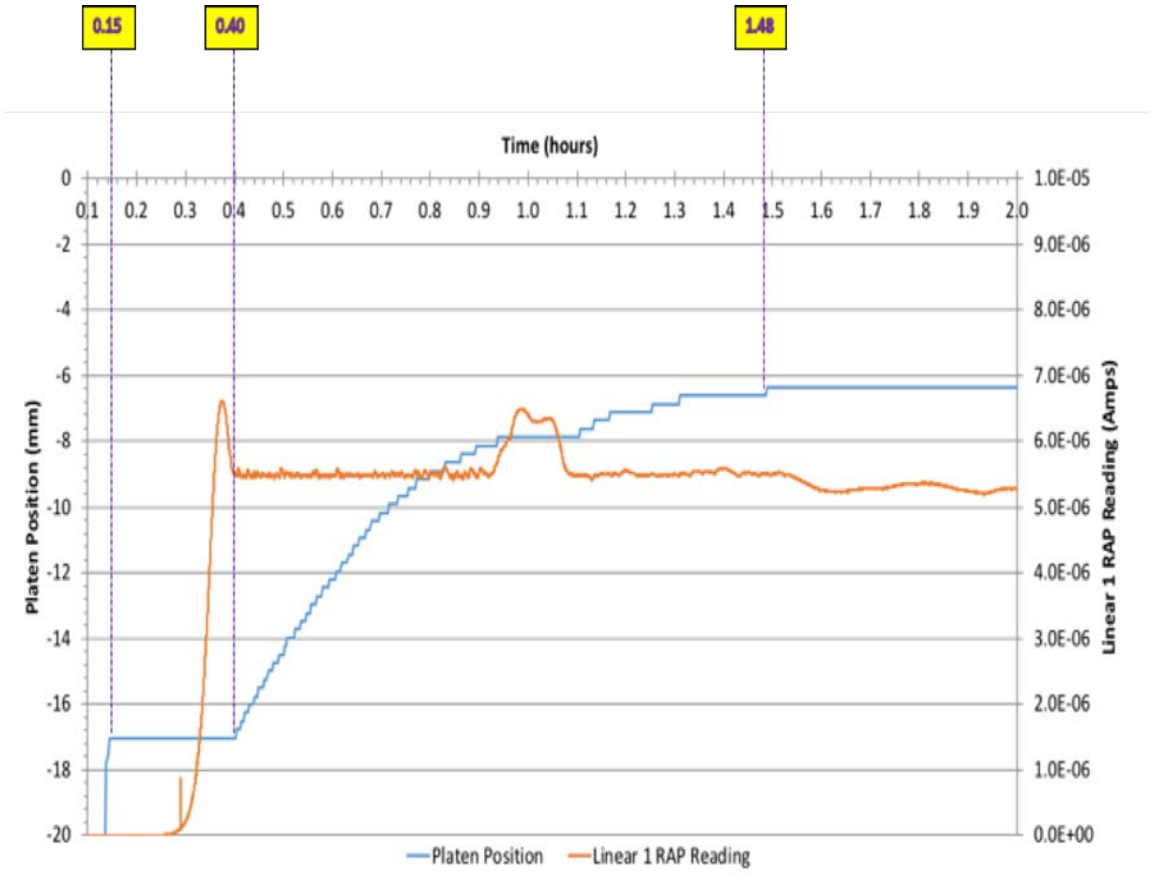
Flight Unit

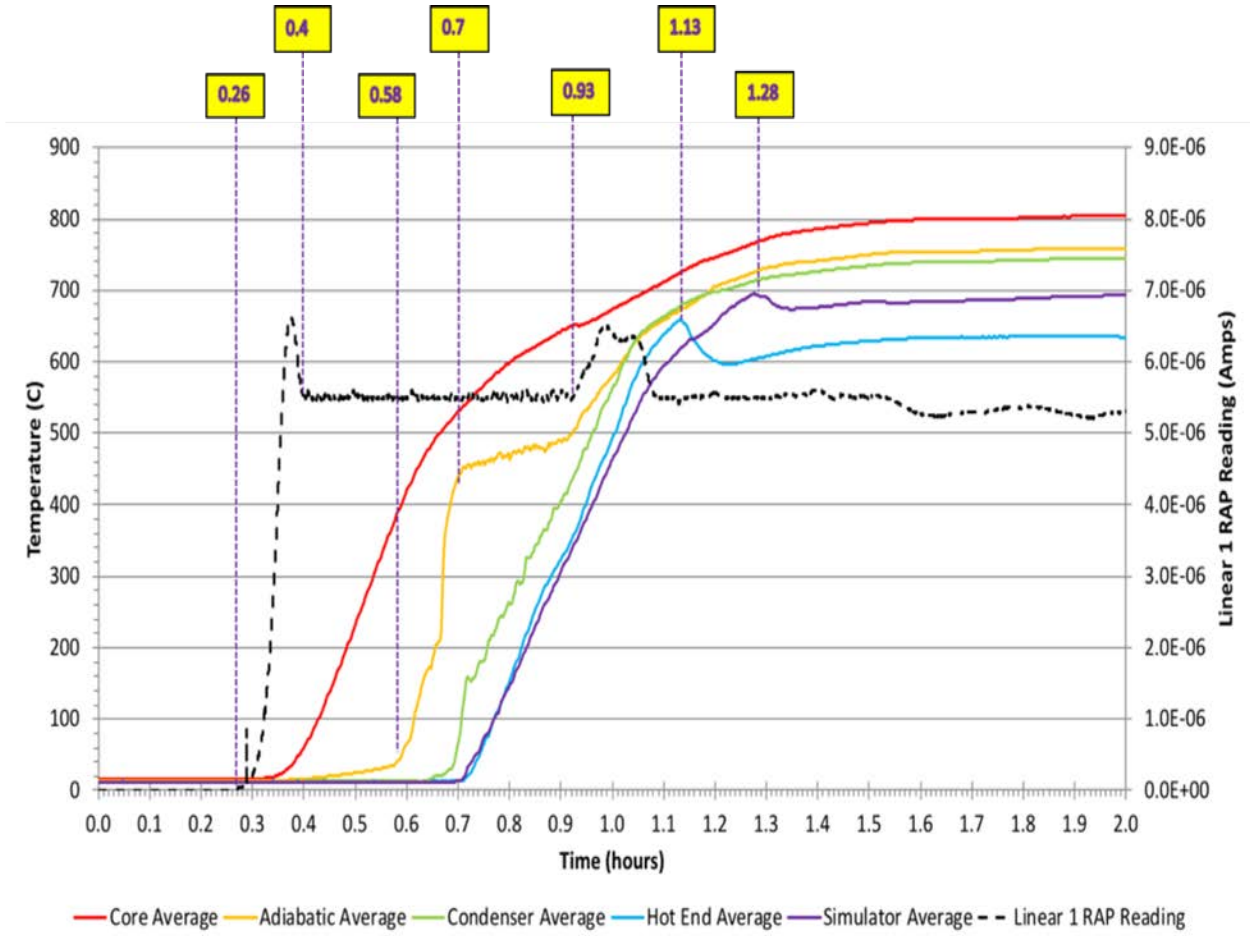


KRUSTY Experiment

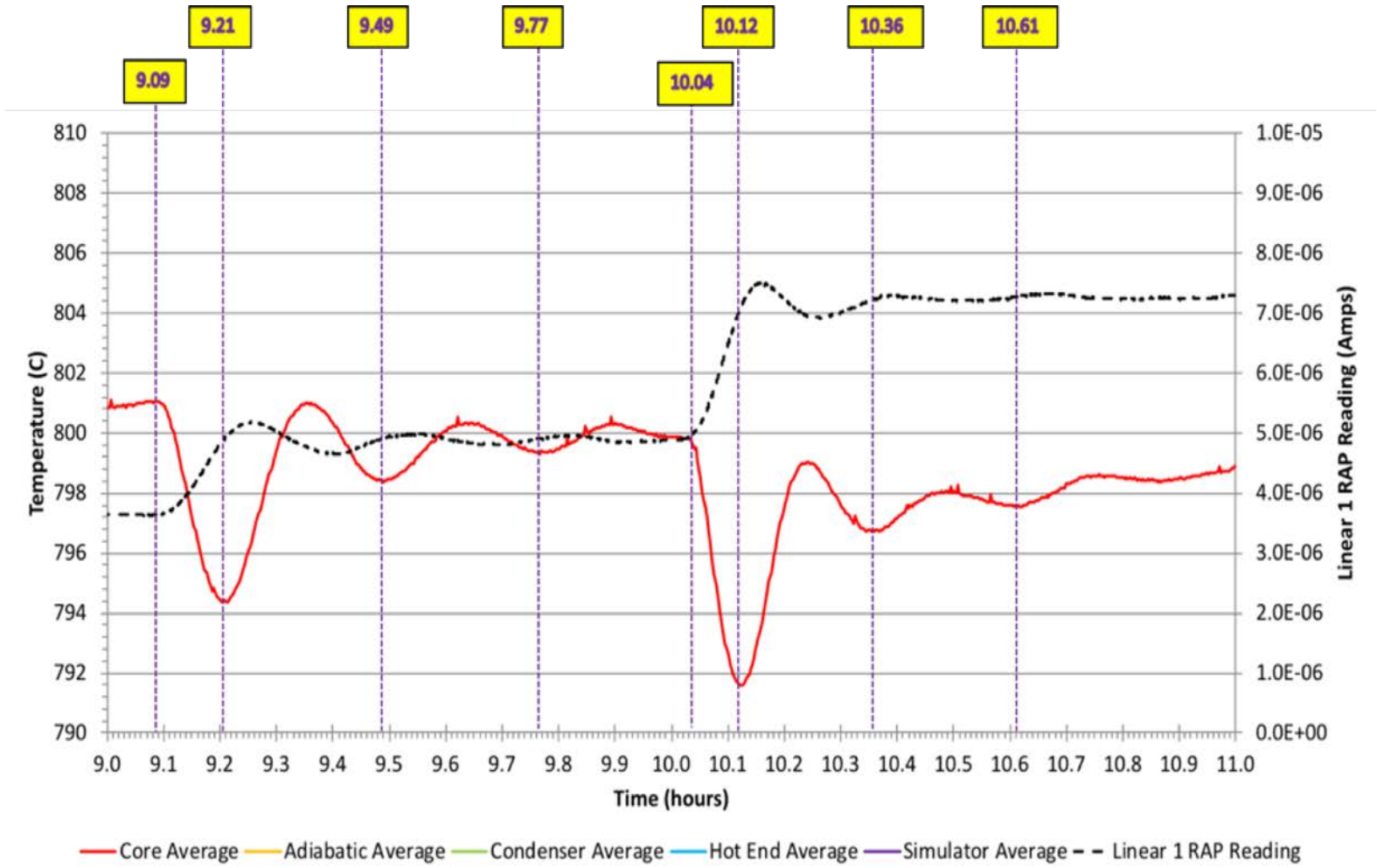


Reactor Startup



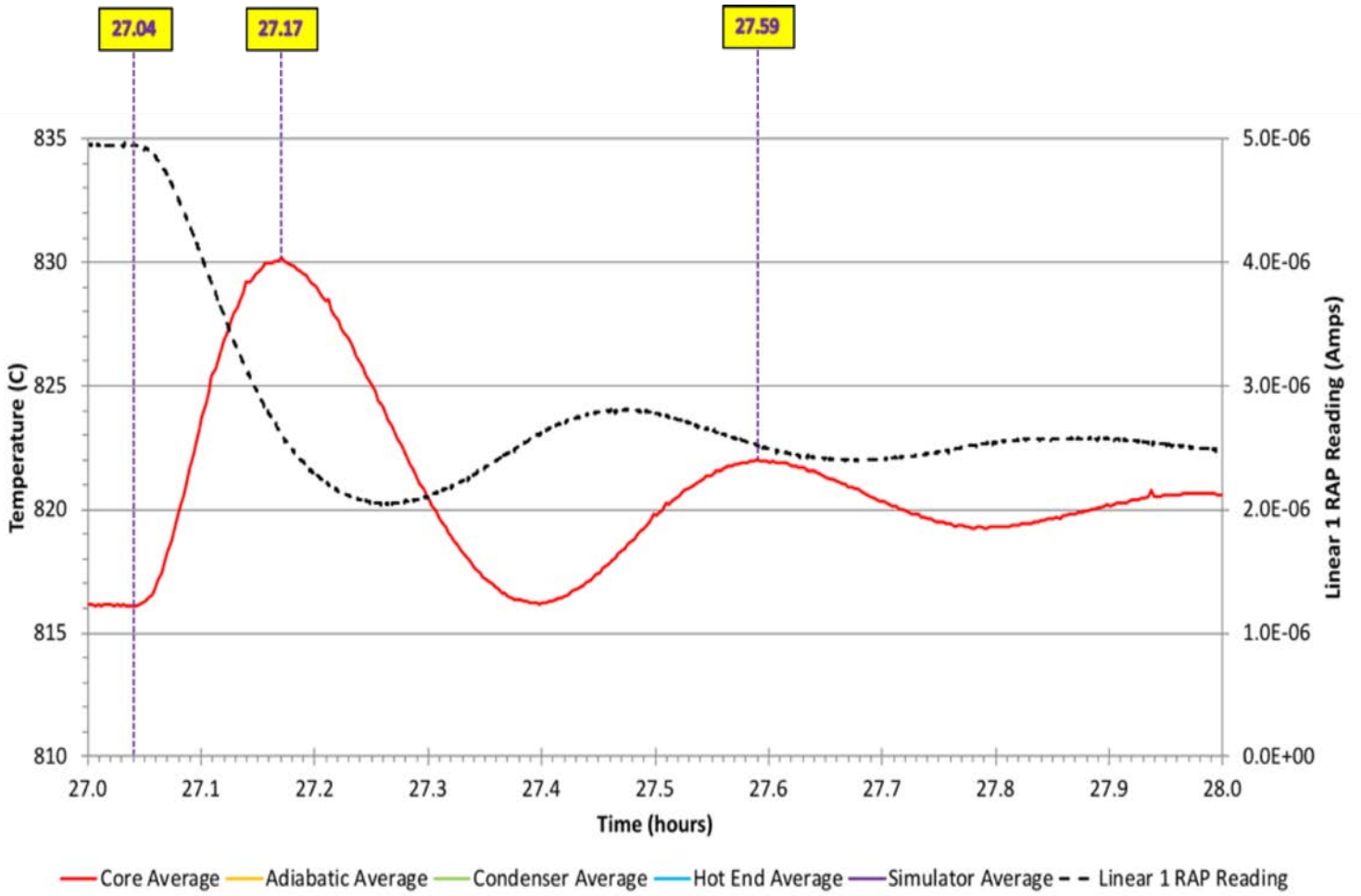


Maximum Thermal Draw



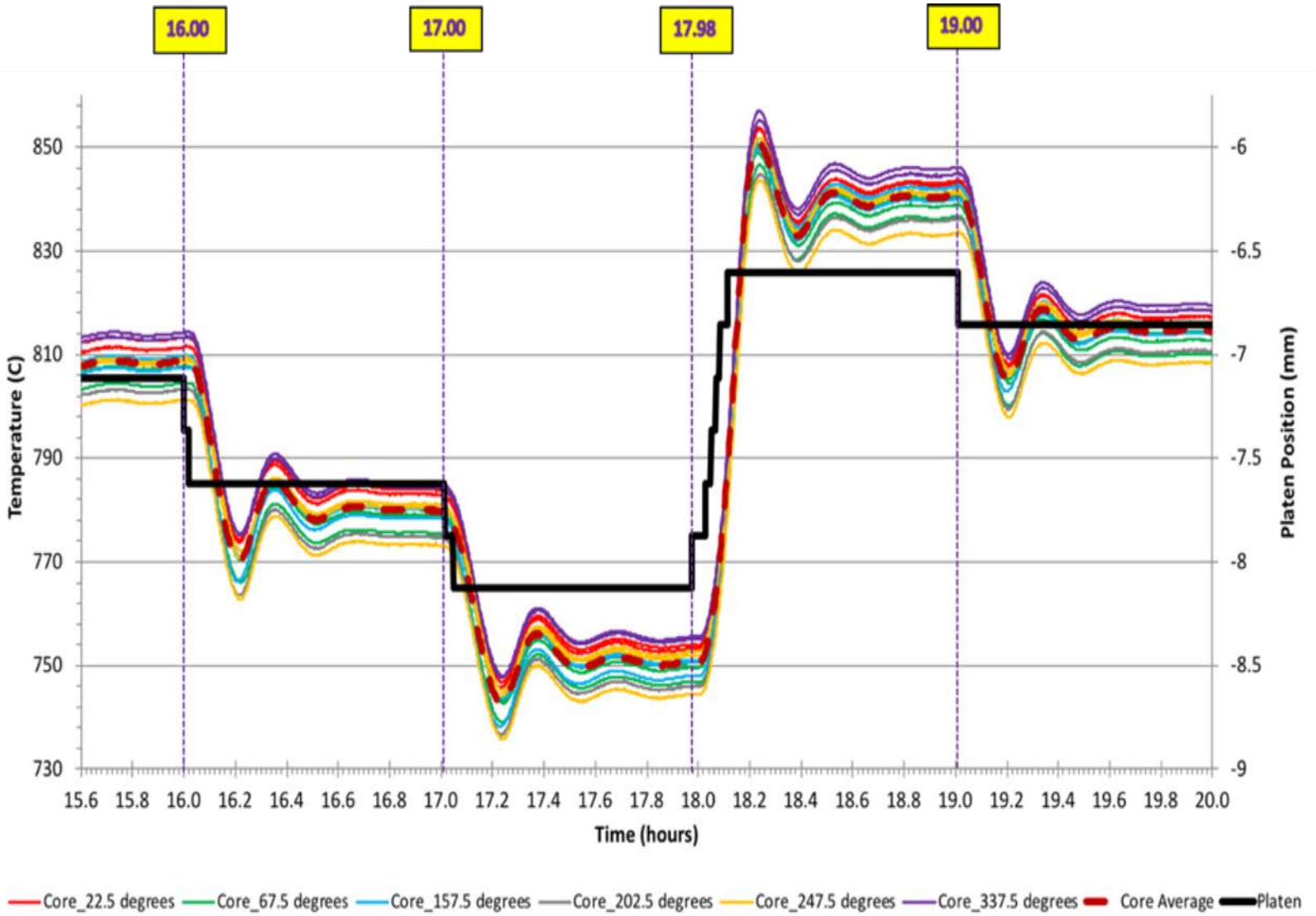
- 10.04 hours: Stirling engines and simulators turned up to maximum thermal draw
- 10.12: core thermal power increases enough to reverse core temperature
- 10.36: First period of oscillation shows controlled dampened response

Total Coolant Loss Scenario

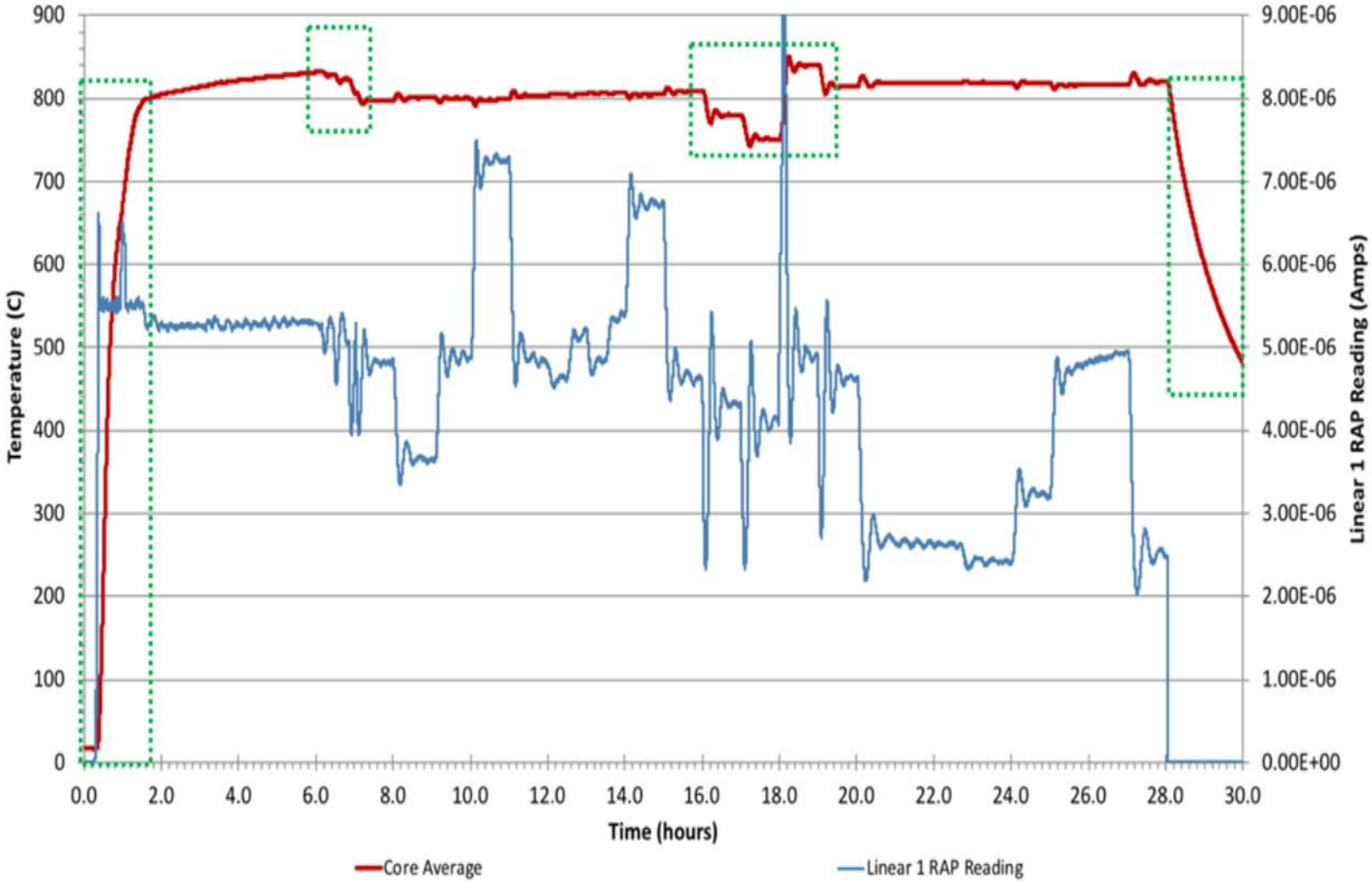


- 27.04 hours: Stirling engines and thermal simulators are shut off to simulate worst case reactor coolant loss condition
- 27.17: Local maximum is reached when reactor thermal power decreases to the point where core temperature reverses
- 27.59: First period of oscillation showing damped response converging to steady state

Setting the Reactor Temperature



Overall Performance



KRUSTY Performance Metrics

Event Scenario	Performance Metric	KRUSTY Experiment	Performance Status
Reactor Startup	< 3 hours to 800 deg. C	1.5 hours to 800 deg. C	Exceeds
Steady State Performance	4 kWt at 800 deg. C	> 4 kWt at 800 deg. C	Exceeds
Total Loss of Coolant	< 50 deg. C transient	< 15 deg. C transient	Exceeds
Maximum Coolant	< 50 deg. C transient	< 10 deg. C transient	Exceeds
Convertor Efficiency	> 25 %	> 30 %	Exceeds
Convertor Operation	Start, Stop, Hold, Restart	Start, Stop, Hold, Restart	Meets
System Electric Power Turn Down Ratio	> 2:1 (half power)	> 16:1	Exceeds

Conclusions

- **KRUSTY test complete!!**
  - First real space reactor test in over 50 years
  - Less than 20 million dollars invested
  - Completed in just over 3 years
  - All objectives were met or exceeded
- **What does this mean for NASA?**
  - The ability to move forward towards a flight mission
  - A proven design capable of providing multiple kilowatts of electrical power for several years or decades