ENERGY RESEARCH CENTER LLC

Advanced Isoperibolic Calorimetry in Brillouin's Reactor

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ERC LLC

Brillouin Energy Corp.

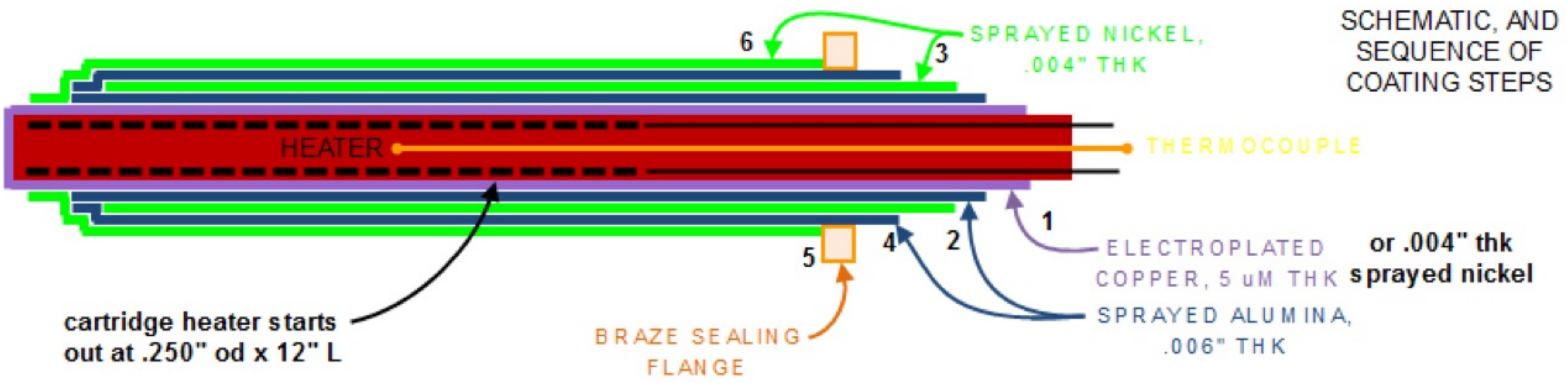
Outline

- Earlier results
- Existing reactor tube designs and pulse stimulation methods
- Isoperibol (IPB) calorimeter and existing methods
- Recent results from IPB reactor/calorimeter
- Mass flow calorimetry in IPB reactor
  - New calibration methods
  - Preliminary results
- Acknowledgements

Summary of Earlier Results

- Over 300 experiments performed on up to 100 reactor tubes
- Excess power seen in Ni/H_2 gas phase system
- Excess power has been shown to be reproducible and transportable
- Pulsed axial pulses gave excess power in this system
- Excess power depends on pulse voltage and power
- Experimental conditions and results are consistent with CEC hypothesis
- Changing pulse parameters yield 0 – 100% excess power which allows for switching power production on and off
- Very dependent on material chemistry and morphology

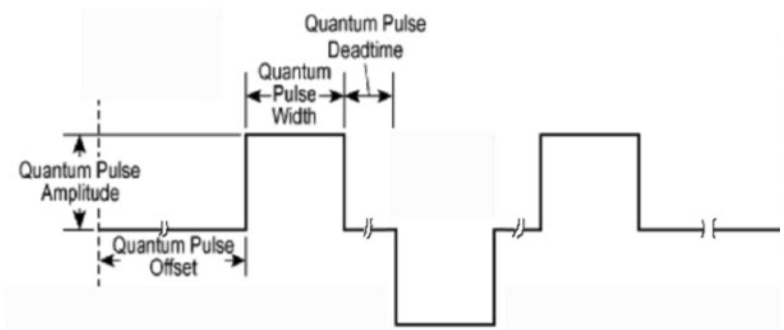
Brillouin's 4th Generation H_2 Hot Reactor Tube

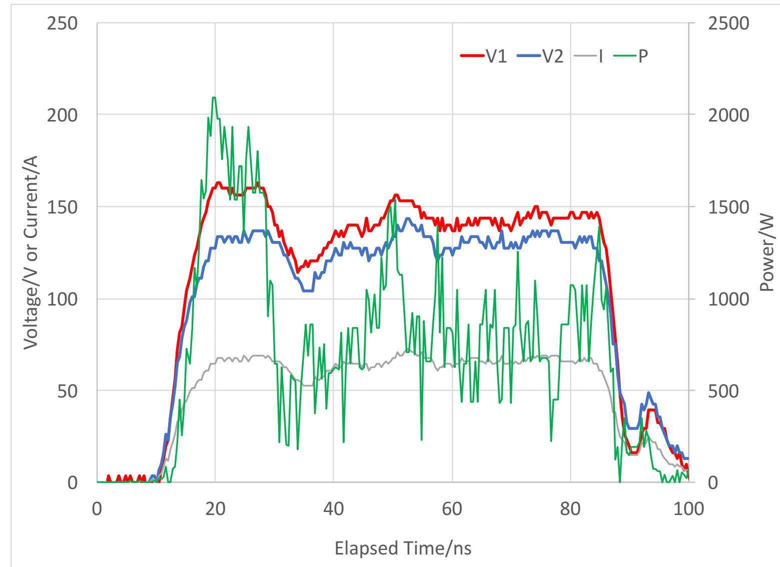


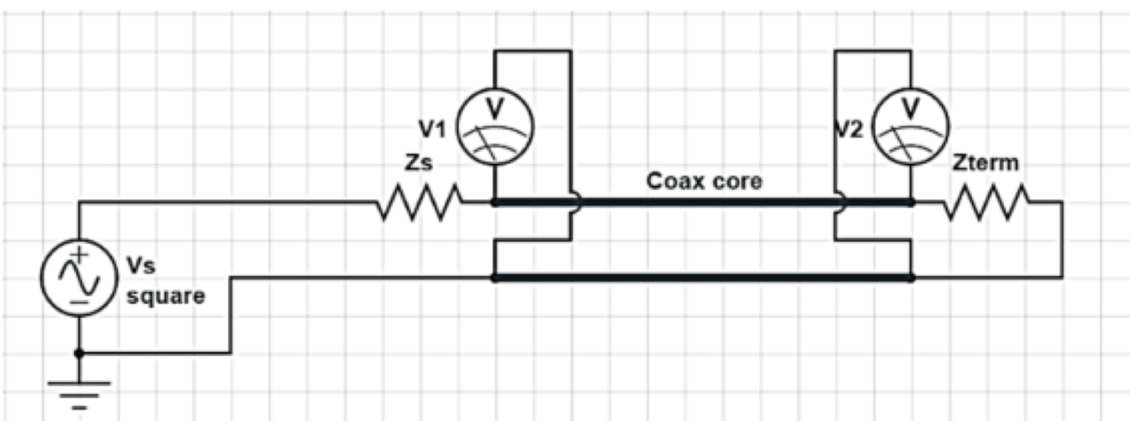
- One example of a spray-coated tube - some have more or fewer layers
- Metal and ceramic coatings are porous
- Pulse sent through outer Ni layer returns through inner Cu layer
- Fast rise-time pulse current is primarily at Ni-Al_2O_3 interface (skin-effect)

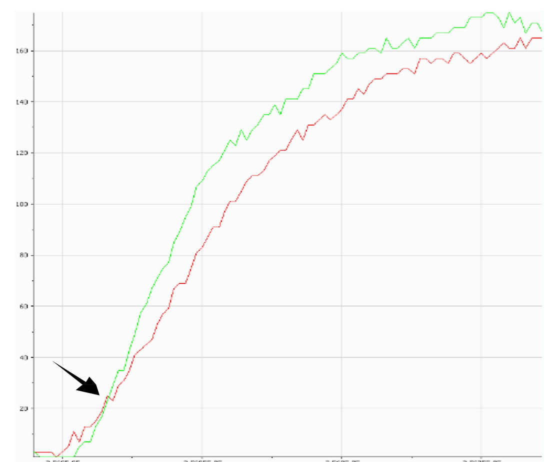
Brillouin's IPB Reactor Cores

Stimulation and Measurement

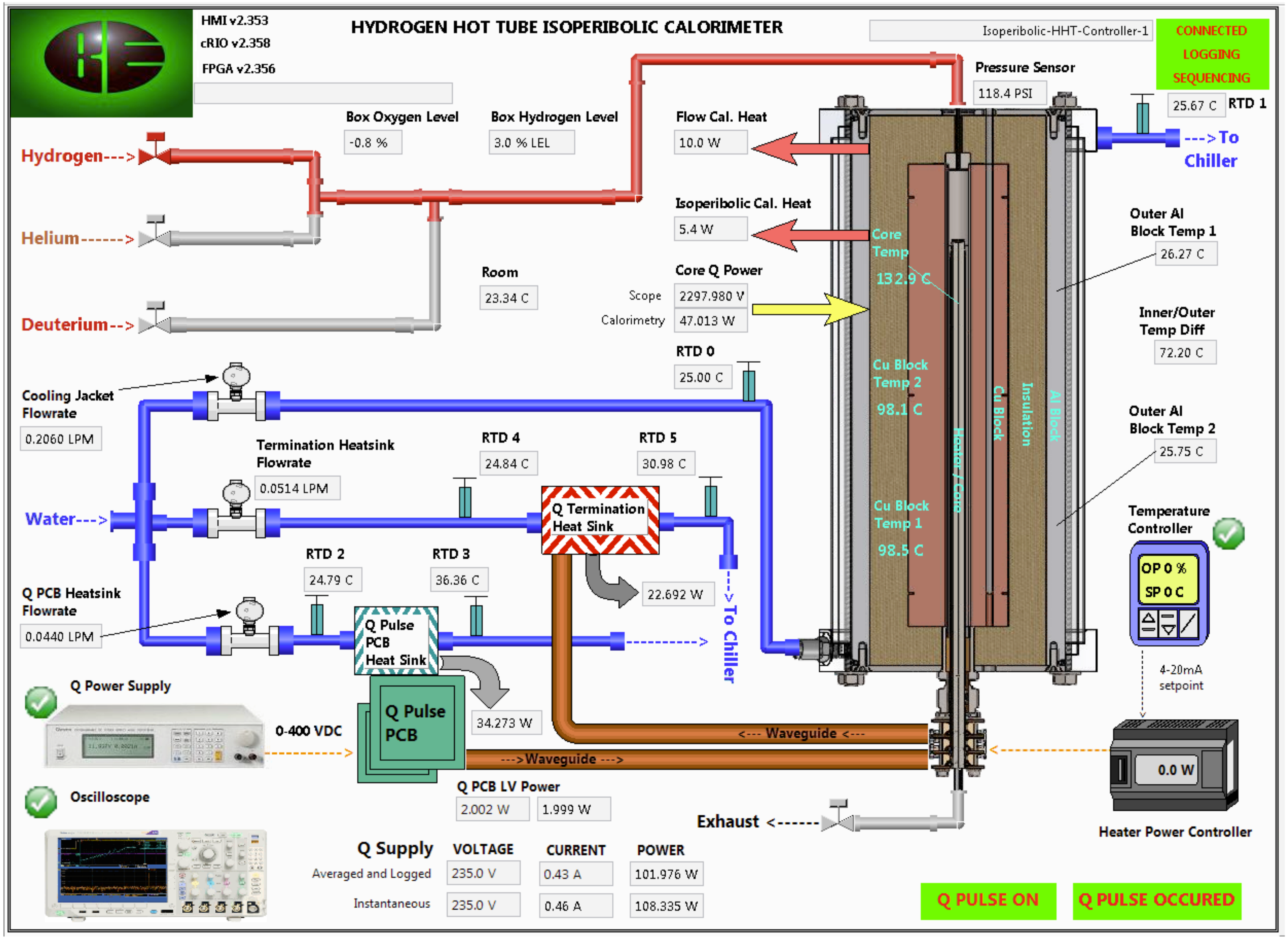




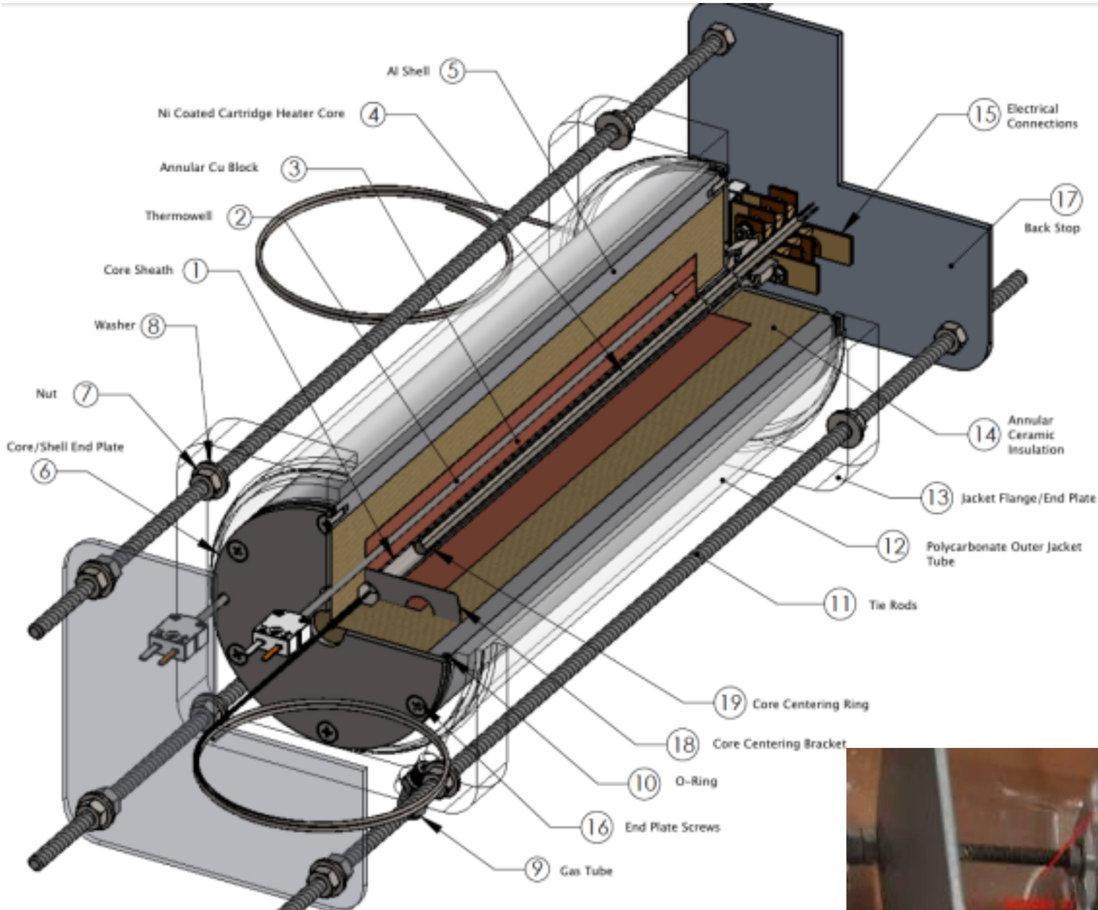




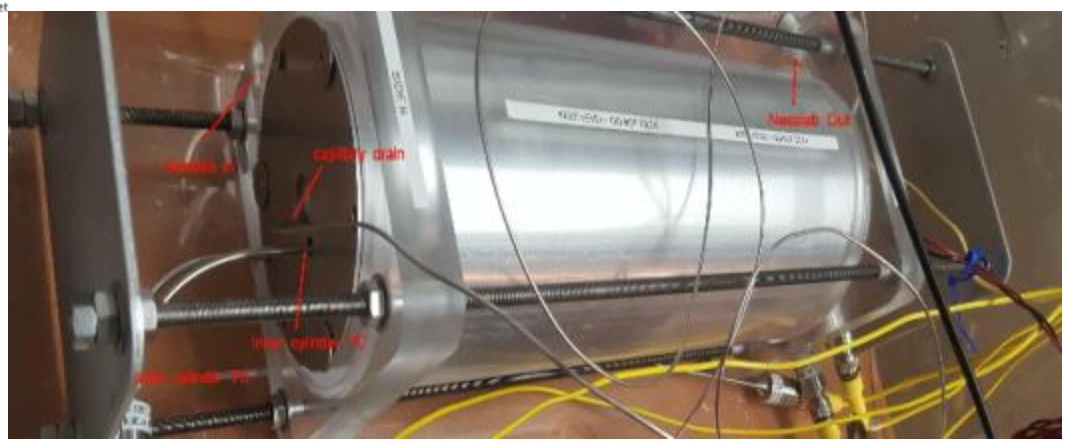
Brillouin's IPB Reactor/Calorimeter
Computer Interface



Brillouin's 4th-Generation H_2 Hot Tube Reactor (Isoperibol$_{ic}$)



- Heater inside tube or outside steel block
- Thermocouple inside tube
- Ni-coated reactor tube
- Core sheath inside steel block
- 2 T_{inner} sensors in steel block
- Ceramic insulation with Ar flush
- Al shell with 2 T_{outer} sensors
- Constant T flowing H_2O
- Pulses injected/returned at #15
- Ar flush outside reactor



Brillouin's Isoperibolic (IPB) Reactor

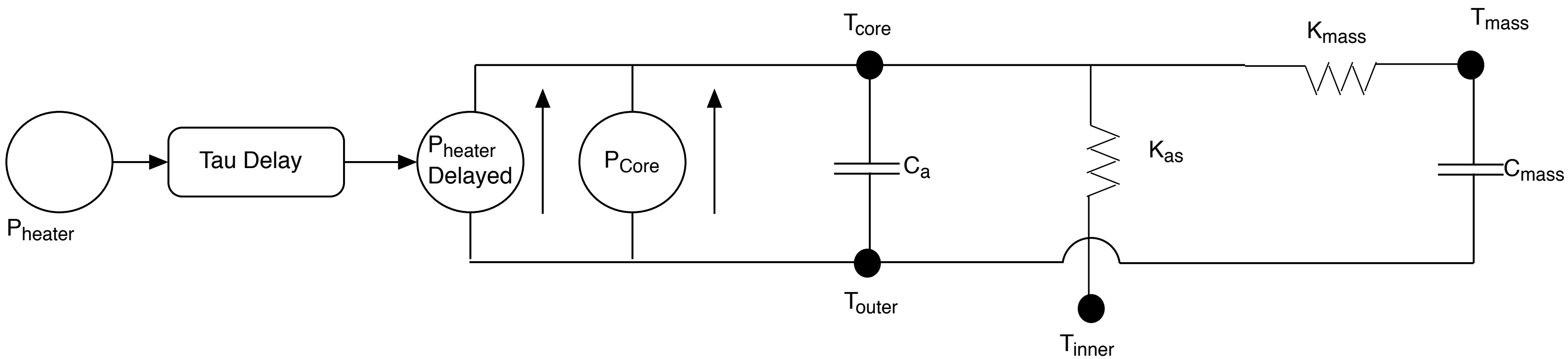
- Static ~9atm H_2 gas on high-surface-area Ni coating
- Reactor tube temperature varied from 200° to 600°C
- Outer block temperature
  - Constant temperature with high flow-rate chilled H_2O for heat flow calorimeter mode
  - Low flow-rate chilled H_2O for mass flow calorimeter mode
- Pulse power controlled at generator board
  - Fixed pulse widths and amplitudes
  - Pulse repetition rate changes to ramp input power
  - Actual pulse power imparted to reactor tube is measured directly
- Facility to control pulse or heater power
  - Constant reactor tube temperature
  - Constant inner block temperature

Brillouin's IPB Reactor: Heat Flow Operation

- Calibration: Using automated sequence and low-voltage pulses (LVP)
  - Two hour steps
  - Add heat to maintain 200° to 300°C
  - Adjust repetition rate for control pulse power at different heater power
- Stimulation: Using automated sequence and high-voltage pulses (HVP)
  - 5 minute steps
  - No heater necessary due to increased pulse power
- Measure and record 57 parameters every 10 seconds
  - Heater, pulse generator, and actual pulse powers
  - All temperatures, H_2O flow rates, and pressures
  - H_2 and O_2 concentration outside reactor
- Compare calculated output power with high-voltage versus low-voltage pulses

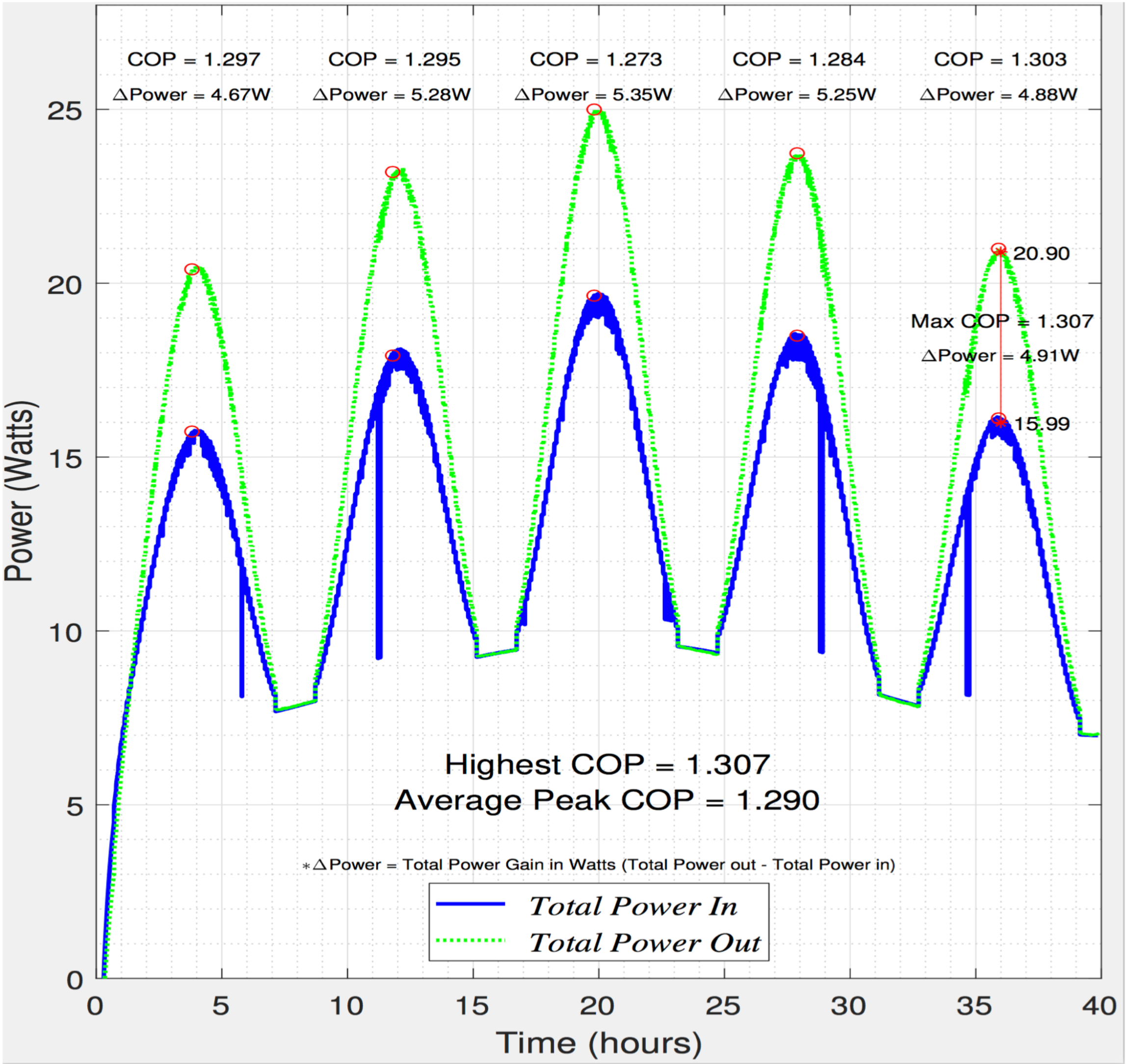
Brillouin's IPB Reactor: Heat Flow Calorimetry

Model used for Dynamic Stimulation Calorimetry



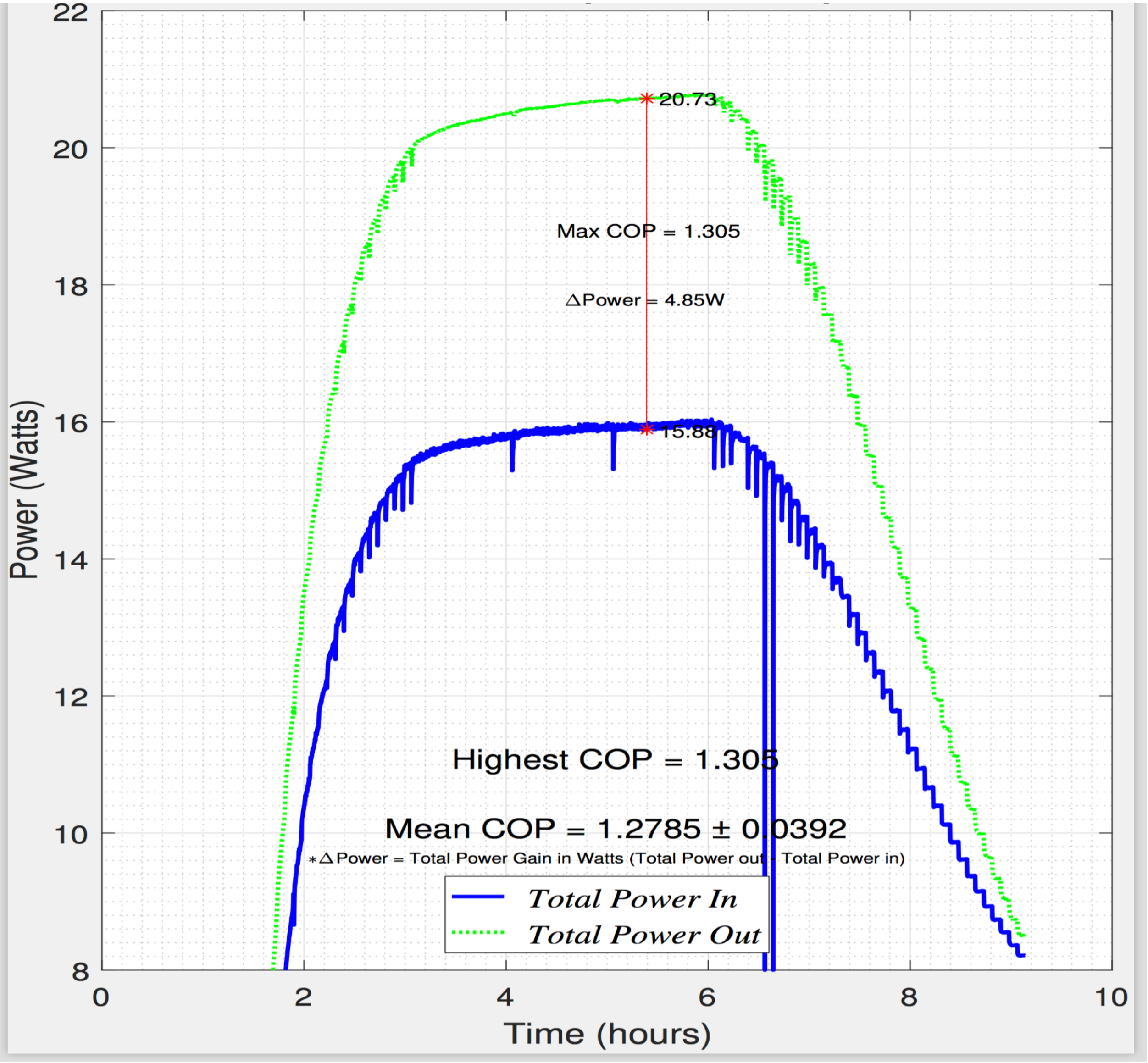
1) Each coefficient can be binomial
2) All binomial coefficients are found by fitting to LVP calibration data
3) Coefficients determine what percentage of input power is influencing reactor tube
4) Output power is calculated by applying those coefficients to outputs measured with HVP stimulation
5) Coefficient of performance (COP) = calculated power divided by input power influencing tube
6) This requires 100 hours of calibration and up to 40 hours of excitation, but allows testing of 12 parameter variations per hour versus one or two in the steady-state method.

Brillouin's IPB Reactor: Heat Flow Results



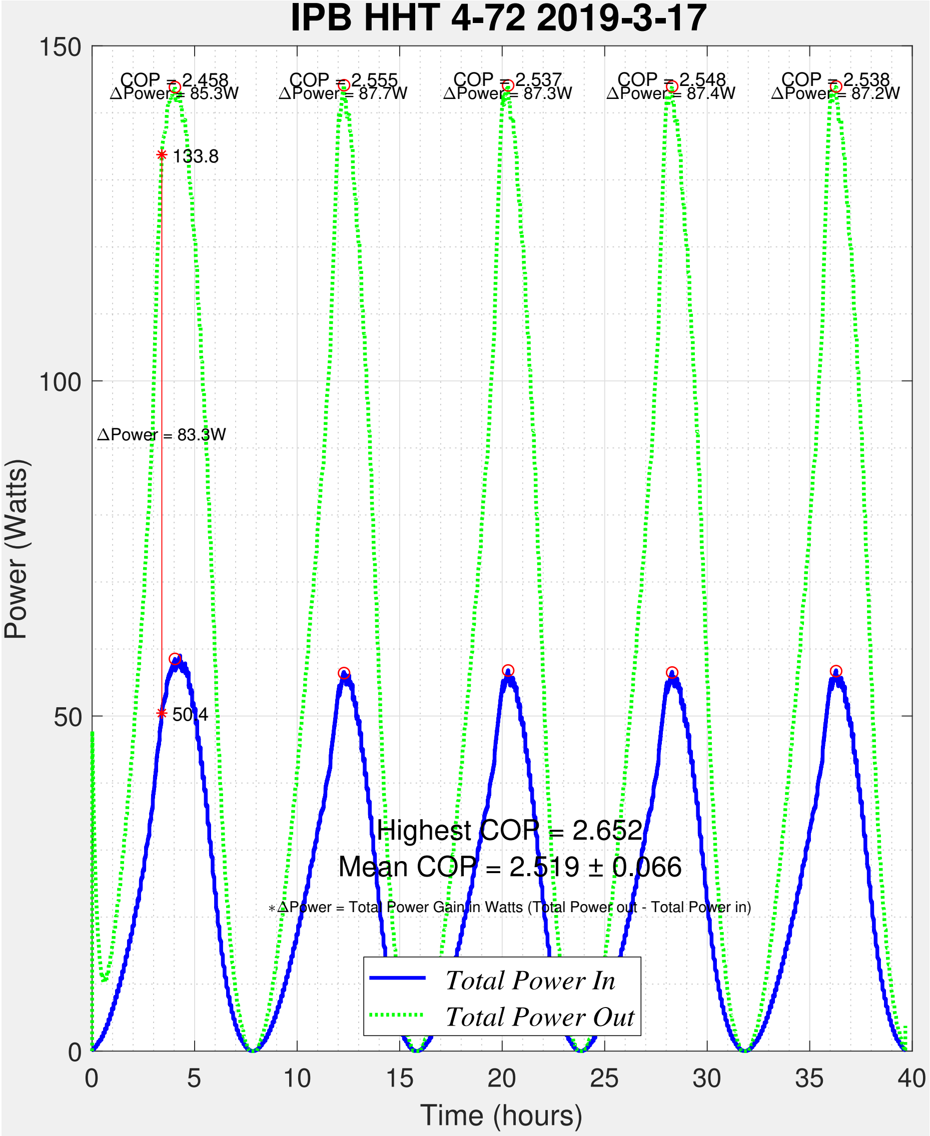
Instantaneous COP during dynamic stimulation

Brillouin's IPB Reactor: Heat Flow Results



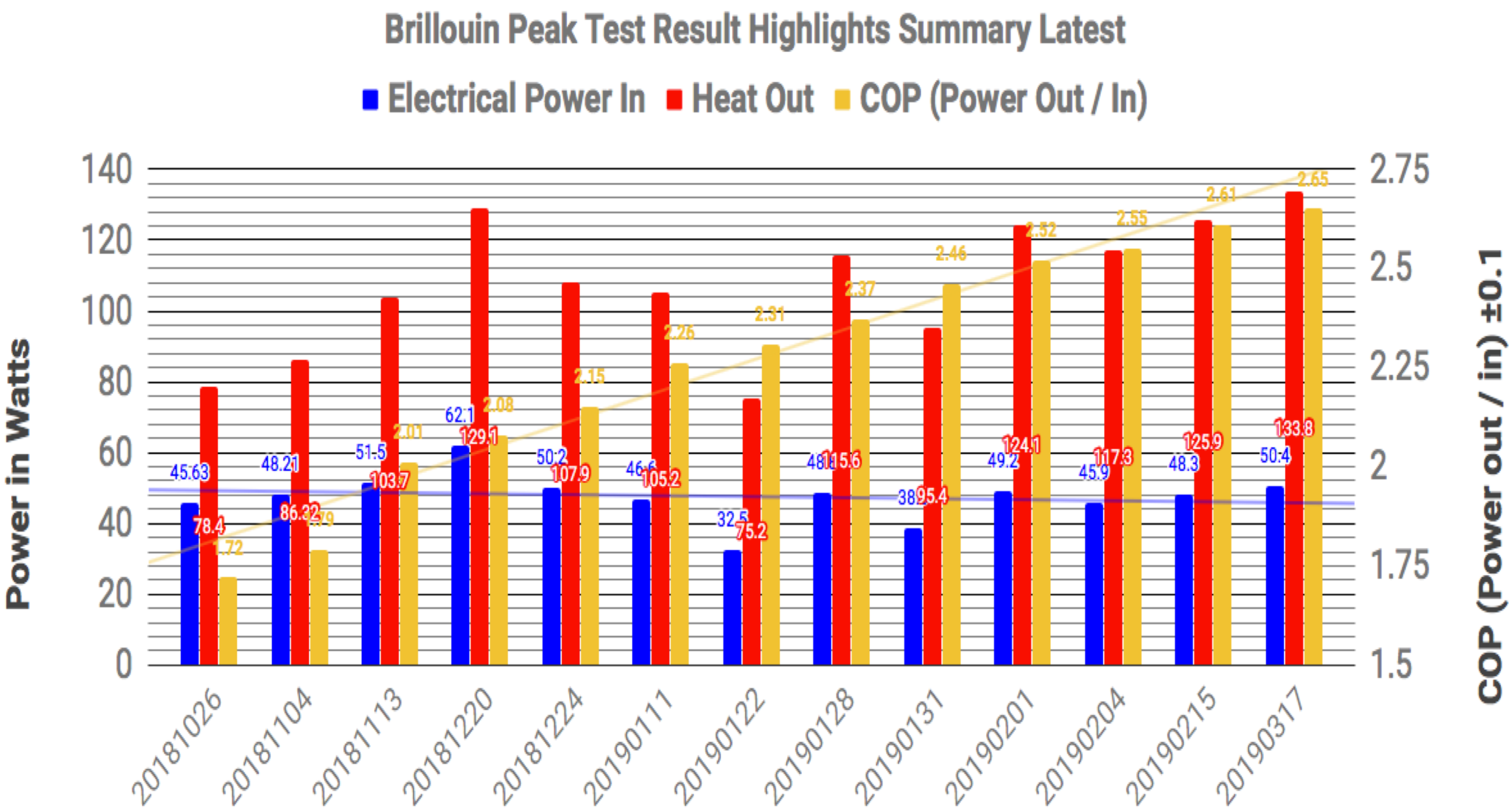
COP during 4 hours at maximum stimulation

Brillouin's IPB Reactor: Heat Flow Results



Recent results using dynamic stimulation

Brillouin’s IPB Reactor: Heat Flow Results

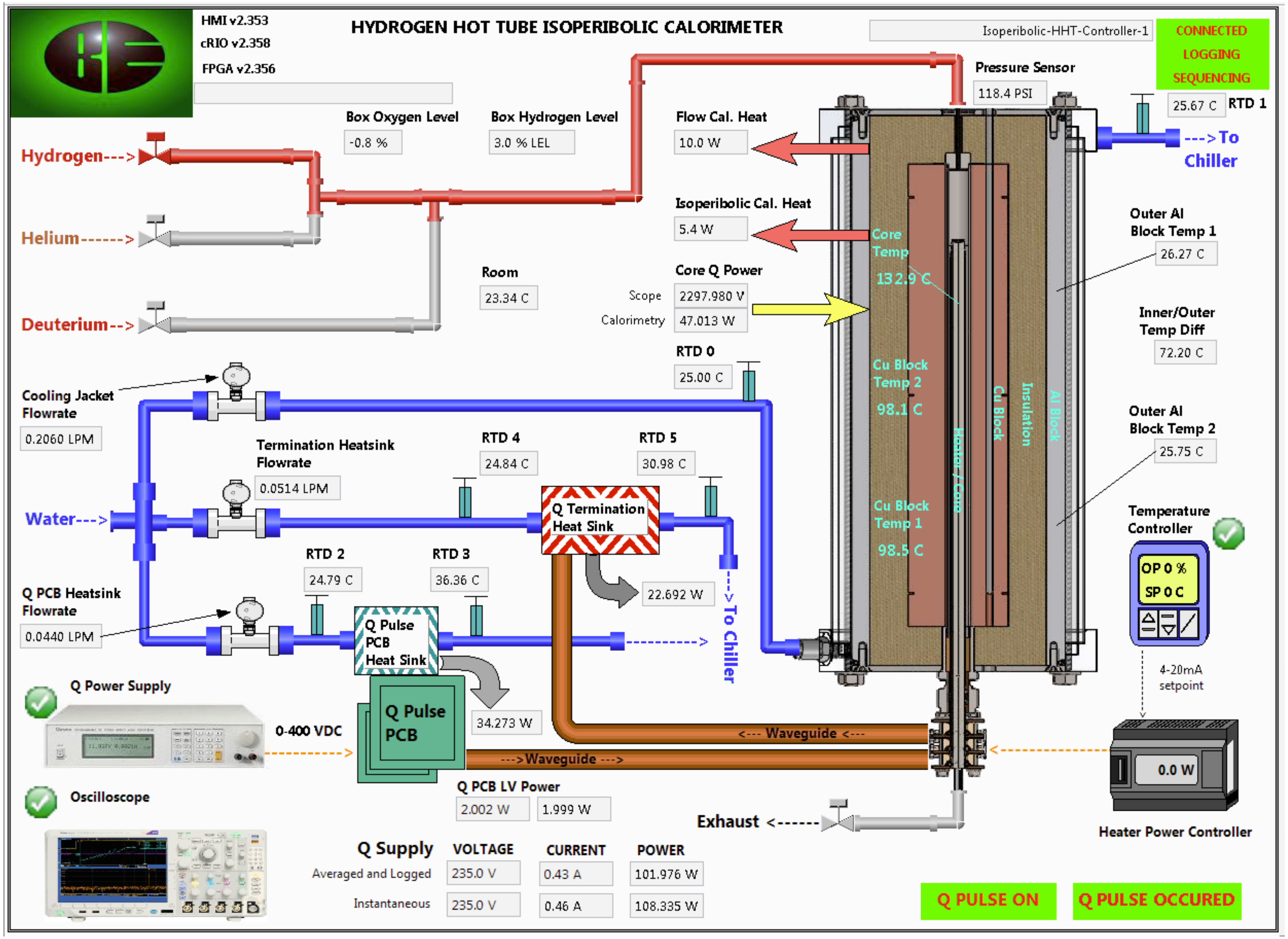


Recent results using dynamic stimulation

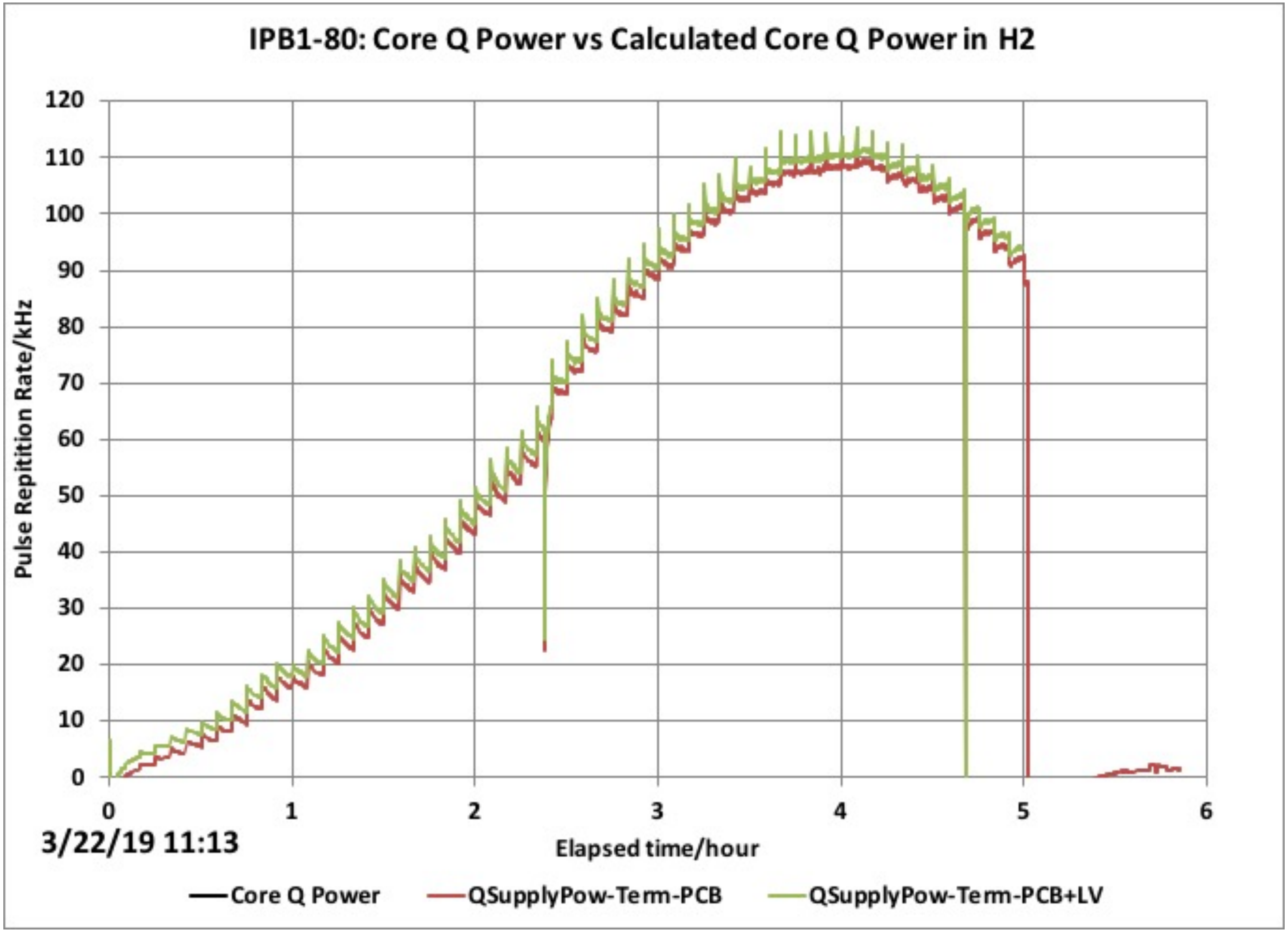
Brillouin's IPB Reactor: Mass Flow Operation

- Calibrations: Using heaters and/or DC power along Ni coating
  - Ten-hour steps
  - Add heat to maintain 200° to 300°C using heater inside reactor tube
  - Add heat to maintain 200° to 300°C using heaters outside block
  - Apply DC joule heating power steps along Ni coating
  - Calculate efficiency using mass flow calorimetry (MFC) on outer block
- Stimulation: Using same automated sequence as dynamic stimulation (HVP)
  - More efficient pulse generator board increases % of power reaching tube
  - Replaced termination resistor with transmission line to allow more pulse power into tube
- Measure and record same 57 parameters every 10 seconds
- Use DC joule heating calorimeter efficiency and measured MFC power to calculate actual output power
- Subtract PCB MFC power and transmission line MFC power from power supply power to determine reactor tube input power

Brillouin's IPB Reactor/Calorimeter
Computer Interface

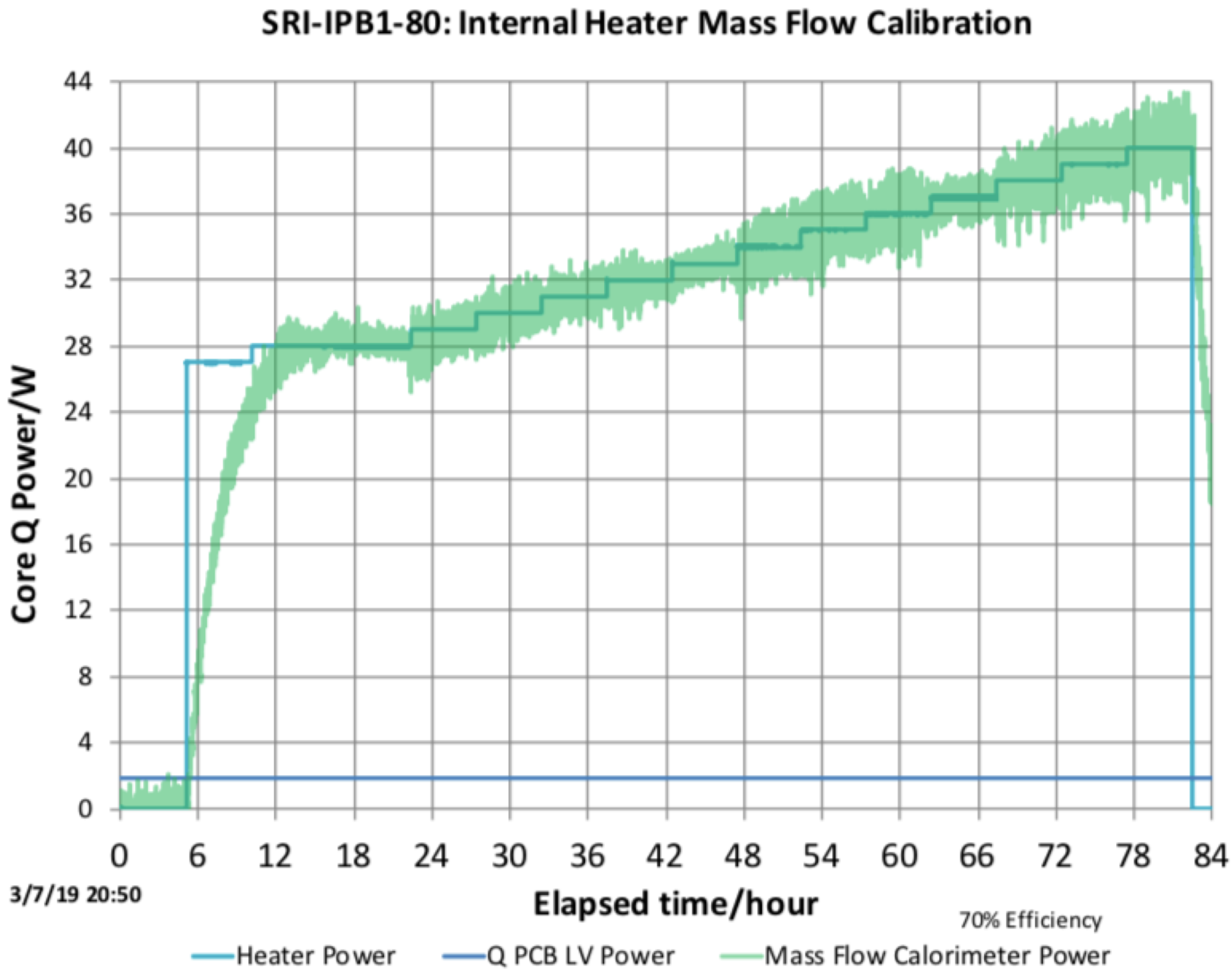


Brillouin's IPB Reactor: Mass Flow Calibration



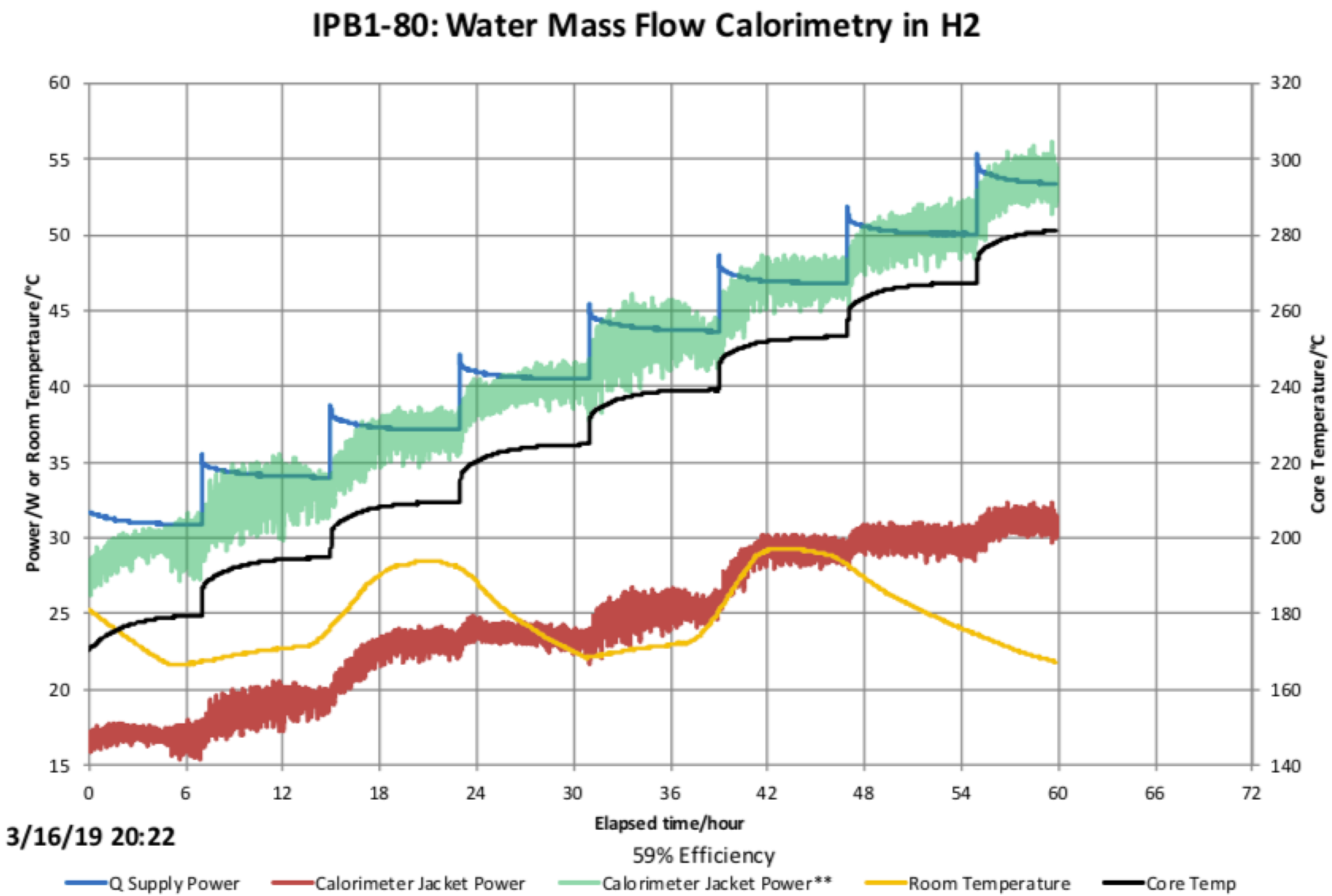
Calibration using heater inside reactor tube

Brillouin's IPB Reactor: Mass Flow Calibration



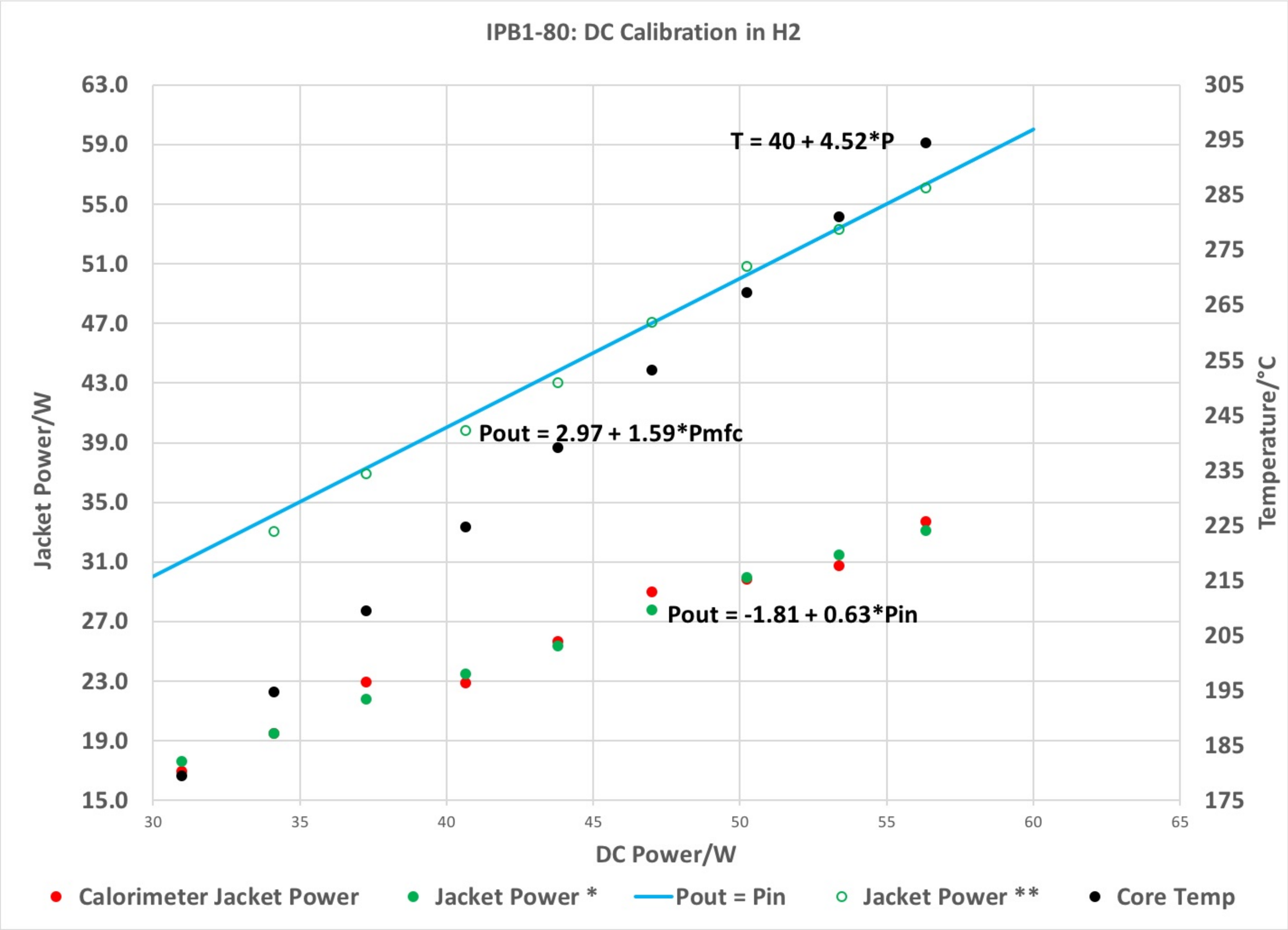
Calibration using heater inside reactor tube

Brillouin's IPB Reactor: Mass Flow Calibration



Calibration using DC joule heating along Ni coating

Brillouin's IPB Reactor: Mass Flow Calibration



Calibration using DC joule heating along Ni coating

Brillouin IPB Results Summary and Future Work

- LENR reactions stimulated by electrical pulses on coated Ni powders
- Experiments in static H_2 gas at 200 – 600°C
  - Comparison between low voltage and high voltage pulse power
- Isoperibolic calorimeter operated in heat flow or mass flow mode
- Over 500 experiments performed on 100 different Ni-coated cores in six different reactors
- COPs from 1.0 to 2.6 measured increasing with pulse power
- Core composition/metallurgy and pulse generation still being optimized
- Mass Flow Calorimetry to meet ”see it from across the room” analysis
  - 100% efficient on inner block heater
  - 70% efficient on tube’s internal heater
  - 60% efficient on DC joule heating

Acknowledgements

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Thank You