



APPLIED SUPERCONDUCTIVITY CENTER
NATIONAL HIGH MAGNETIC FIELD LABORATORY
FLORIDA STATE UNIVERSITY



OP Furnace Update Renegade 2.0 Shakedown

Daniel Scott Davis

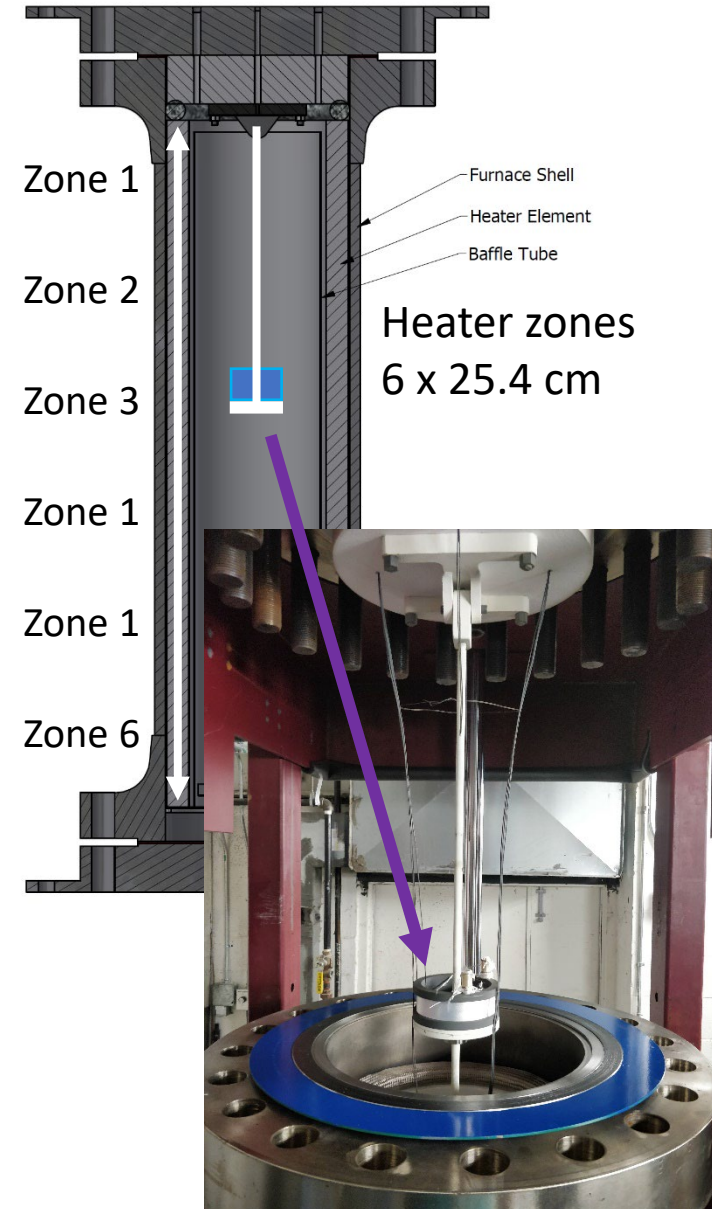
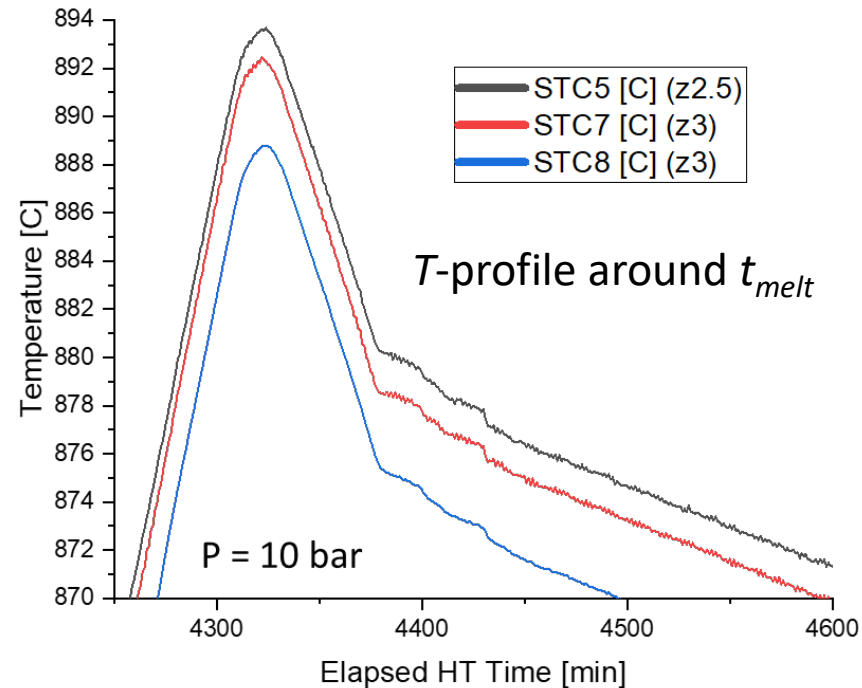
U.P. Trociewitz, Y. Kim, G. Miller, C.T. Brady, C.L. English, L. Marks, E. Arroyo, E.C. Martin, G. Bradford, E. Hellstrom, J. Jiang, L.D. Cooley, D.C. Larbalestier

MDP Meeting 11/6/2024

ASC-NHMFL is supported by US DOE-OHEP (DE-SC0010421, DE-SC0018683), US DOE-ARDAP DE-AC02-05CH11231/AWD00007176, NHMFL Core Grant (NSF 2128556), FSU special allocation for Bi-2212 commercialization, the State of Florida, and the US DOE-MDP for much context and many collaborations. The National High Magnetic Field Laboratory is supported by National Science Foundation through NSF/DMR-2128556 and the State of Florida.*

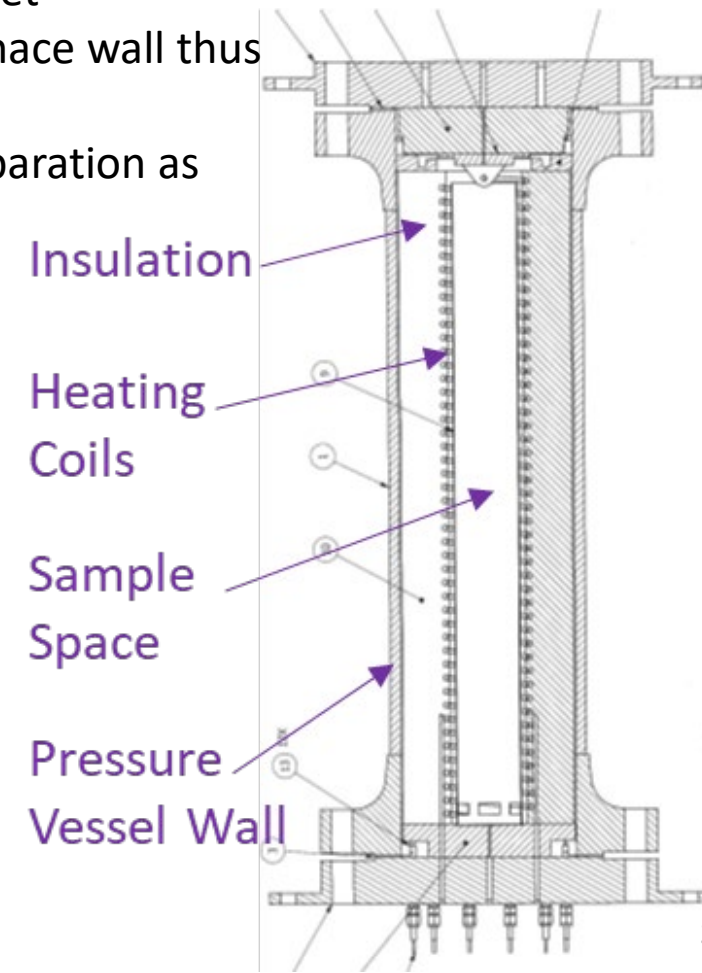
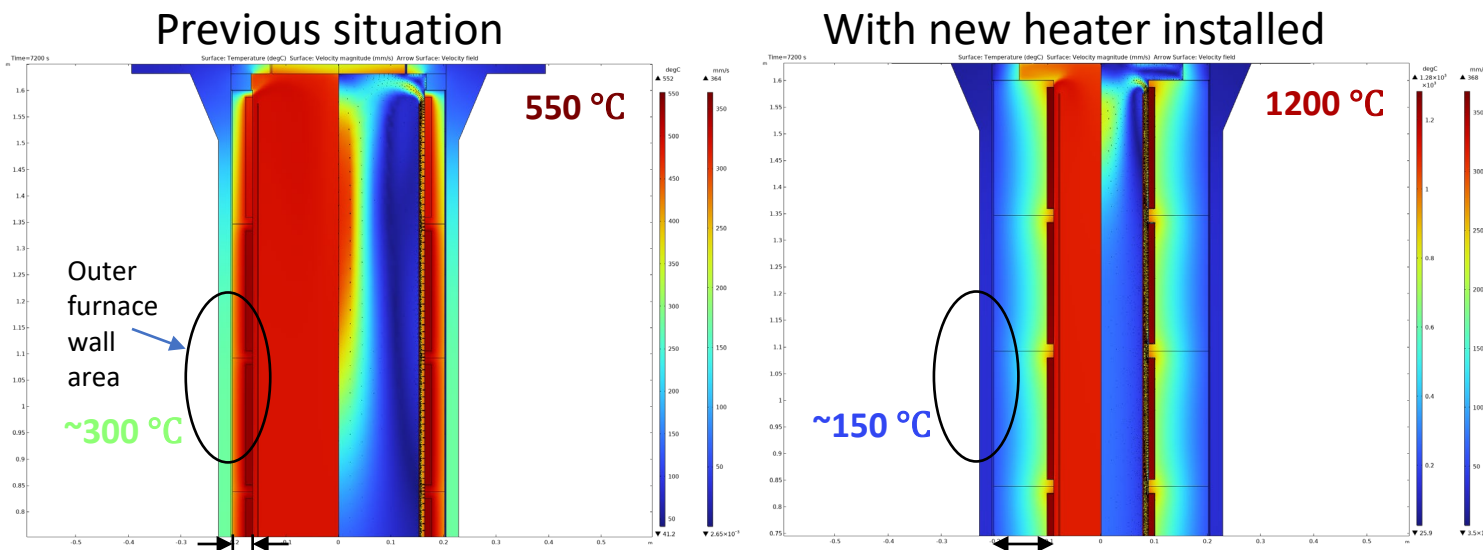
OPHT is essential for an efficient Bi-2212 technology

- **First Commissioning of the Large OP Furnace Revealed an Issue**
- **Our two OP furnaces are unique facilities to process Bi-2212 coils for us and our collaborators**
 - A homogeneous zone could be established with good rate controllability
 - However, only at 10 bar pressure...



Sustained Engineering Effort for Over Pressure Furnaces

- **Furnaces are critical infrastructure essential to the success of Bi-2212 coil technology**
- Two OPHT furnaces for Bi-2212 coil processing at ASC available
- These are unique systems that we and our collaborators in labs and industry depend on
- Larger furnace experienced a setback during commissioning phase: could not reach target temperature at 50 bar pressure (10 bar was ok but too high heat losses through the furnace wall thus not enough power reserve available for 50 bar operation)
- After successful recommissioning, an extensive upgrade of the smaller furnace is in preparation as well



Reassembly of the Large OP-Furnace with New Heater Complete



- Reassembly at the main Lab now finished and furnace set up again in our furnace room

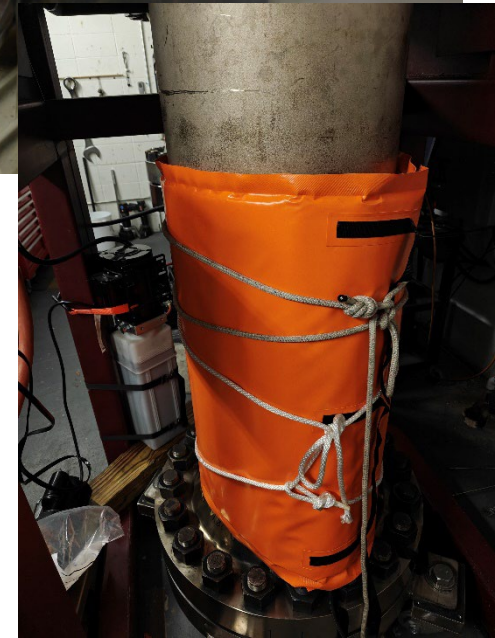
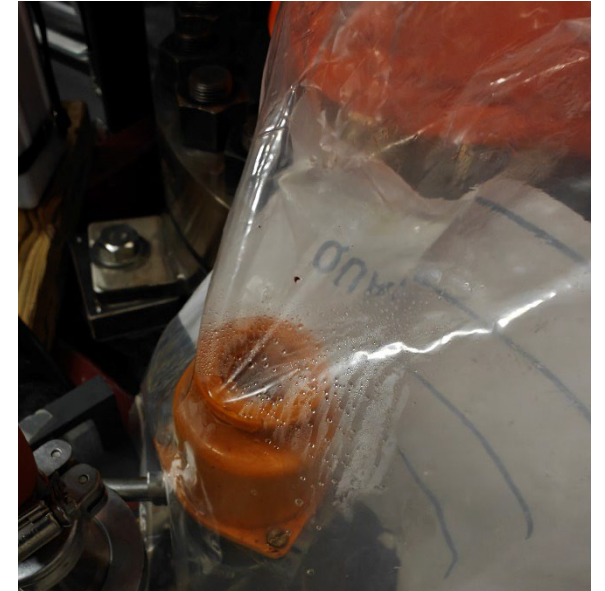
Furnace Assembly Complete

- Heater mounted
- TCs and electrical feedthroughs installed
- Furnace assembled
- Moved to Shaw
- Lid installed

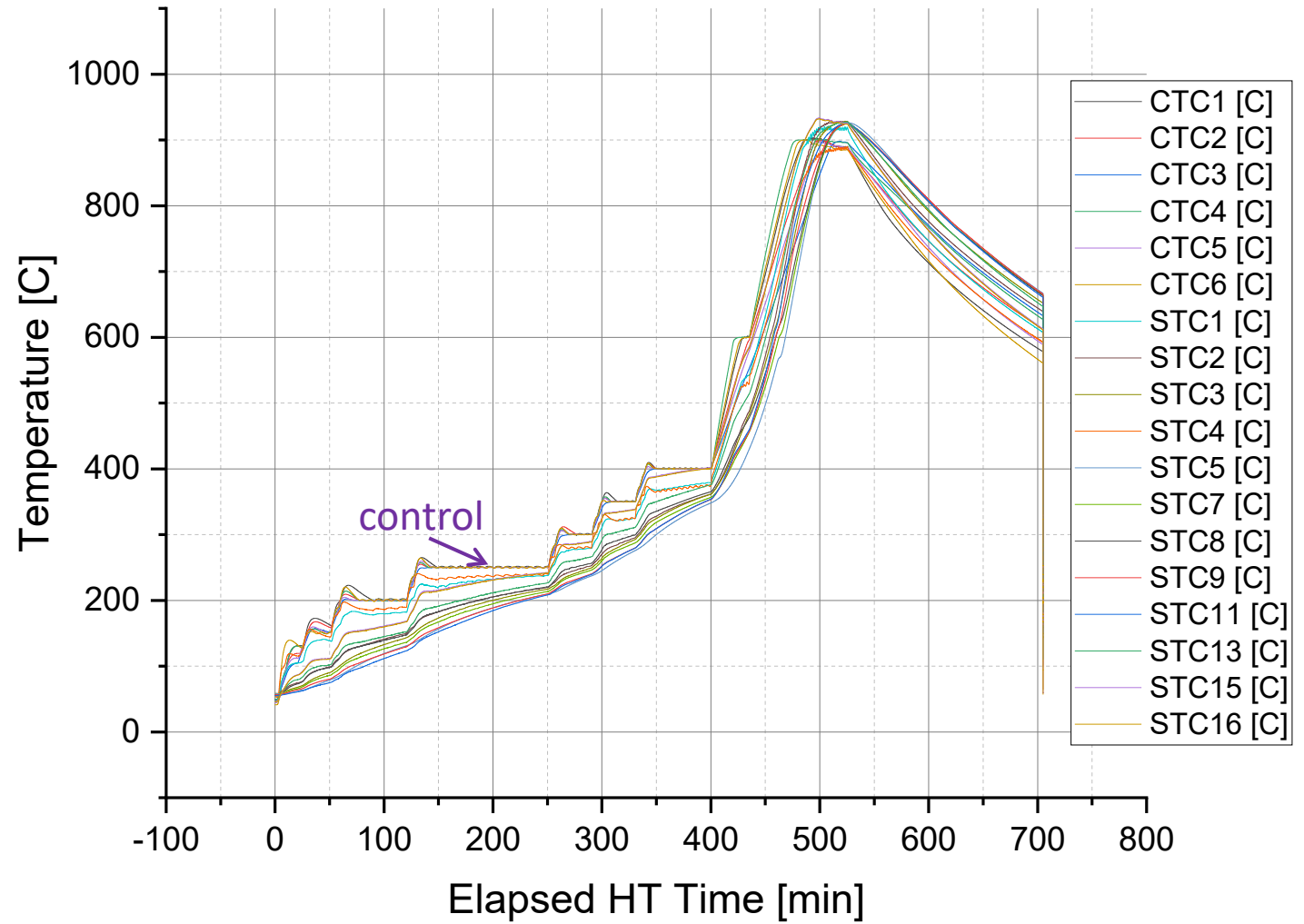
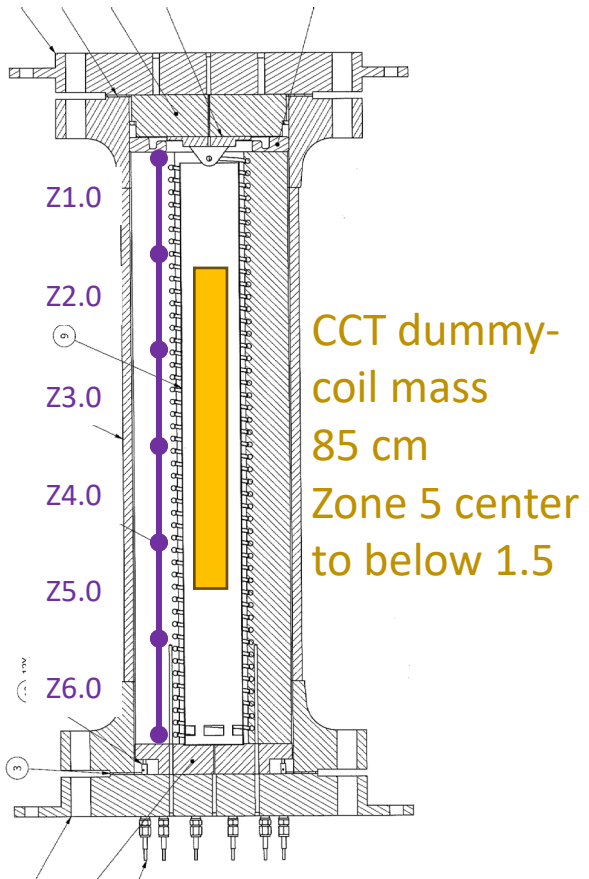


Drying with Rough Vacuum

- Furnace sealed
 - Top and bottom bolts torqued
 - Bottom gas feed in attached with valve
 - Sample TC lines blanked
 - Analog and digital pressure gauges monitored
- Roughing pump with ballast open used to extract moisture from insulation
 - periodic flushing using pure, dry Ar gas
 - Heater blanket used to warm wall to drive more moisture into gas and reduce condensation.



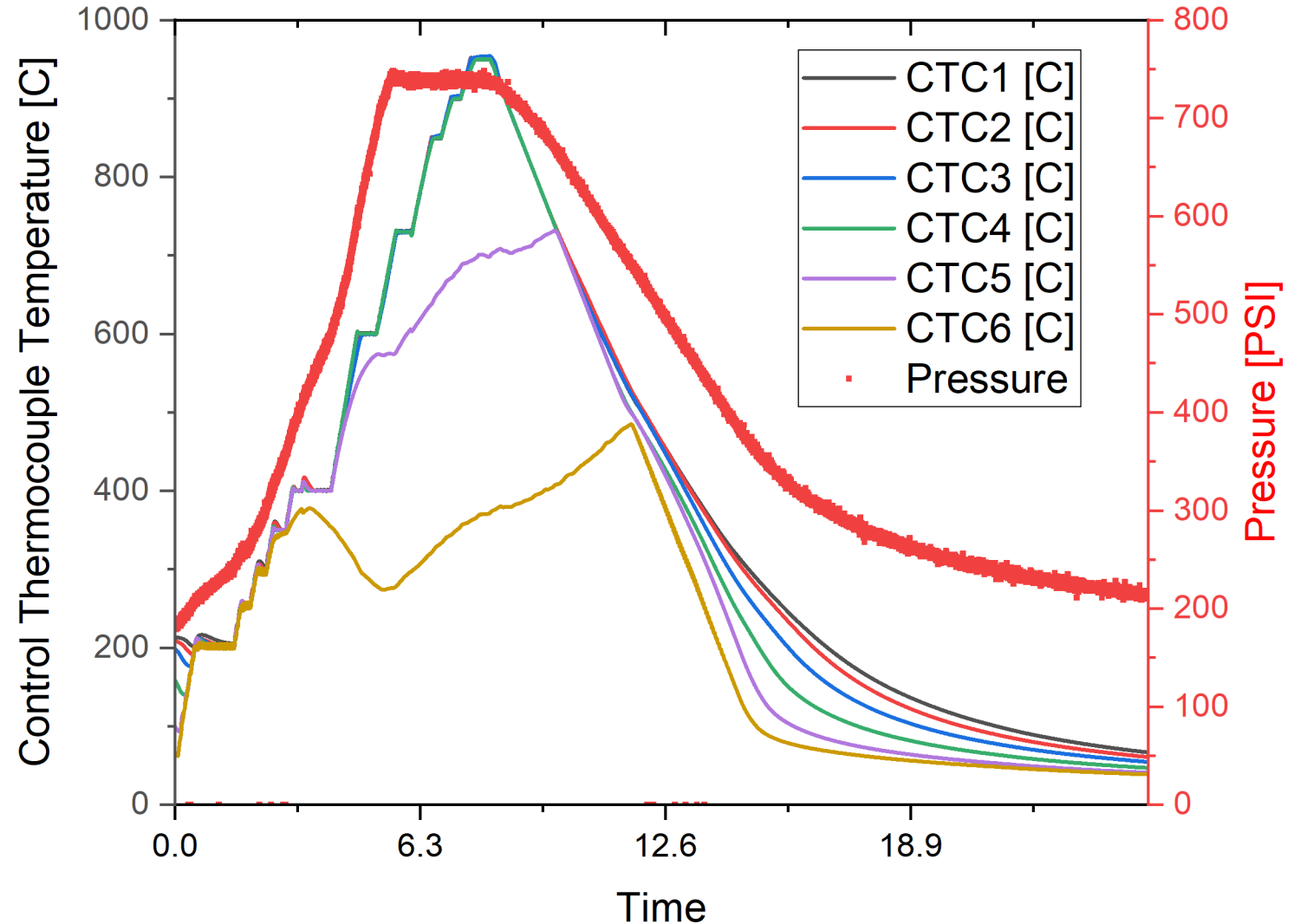
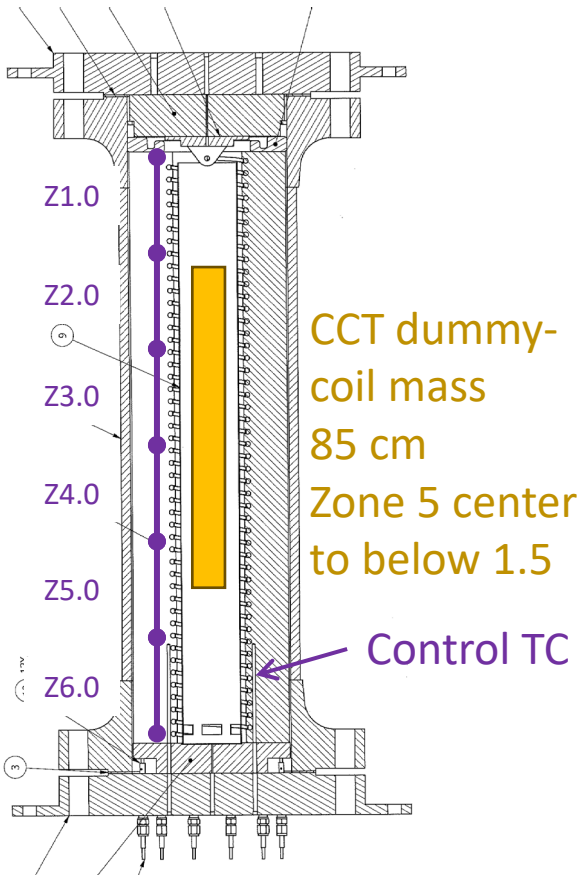
Fully Dry Heater Reaches Target 900 C with Large Mass



Temperature of thermocouples during 1 bar testing to full temperature.

Upper 4 Zones Heater Reach Target 950 C @ 50 bar

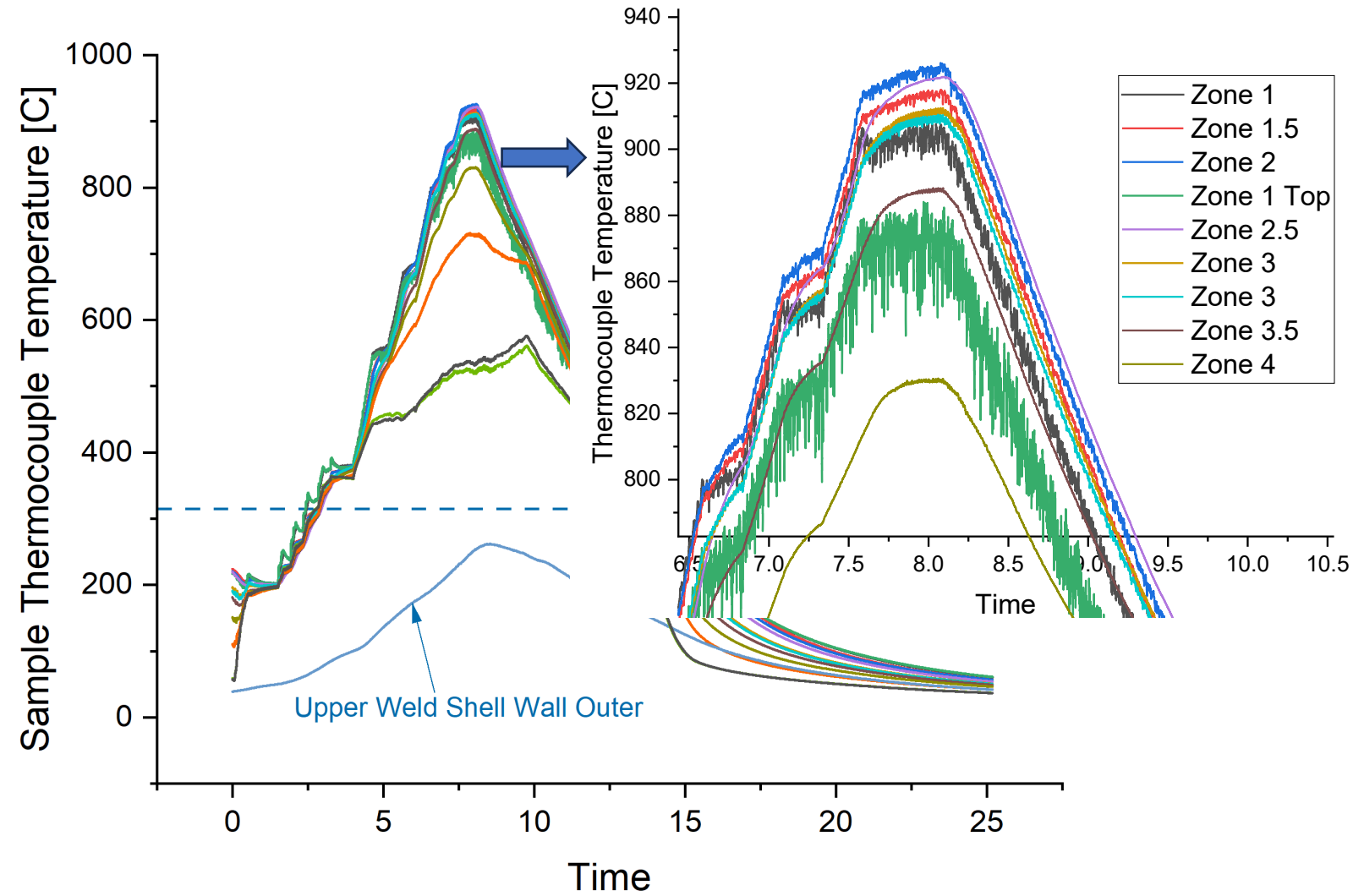
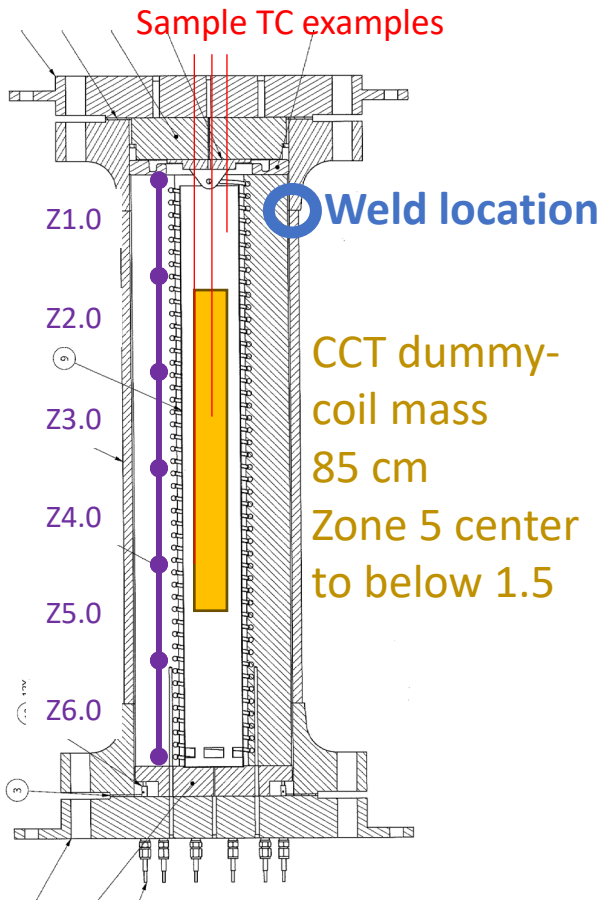
At approximately 400 C and 550 C respectively zones 5 and 6 reach maximum power while the upper zones follow the setpoints resulting in the stepwise increase until sample thermocouples reached ~900



Internal furnace pressure and temperature of control thermocouples adjacent to heating coils in the center of each heating zone.

Upper Sample Mass Reaches 900 C @ 50 bar within Wall Limit

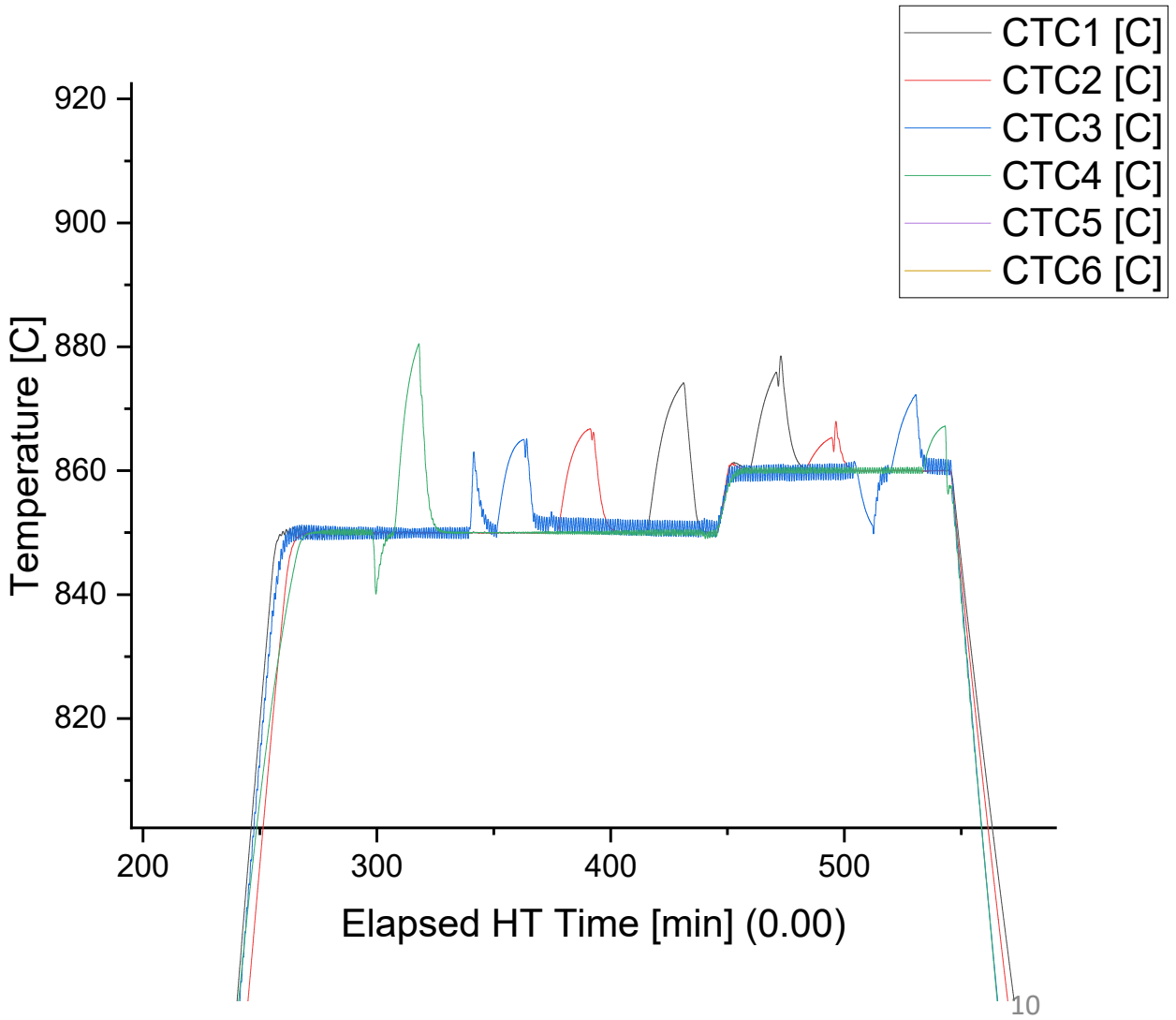
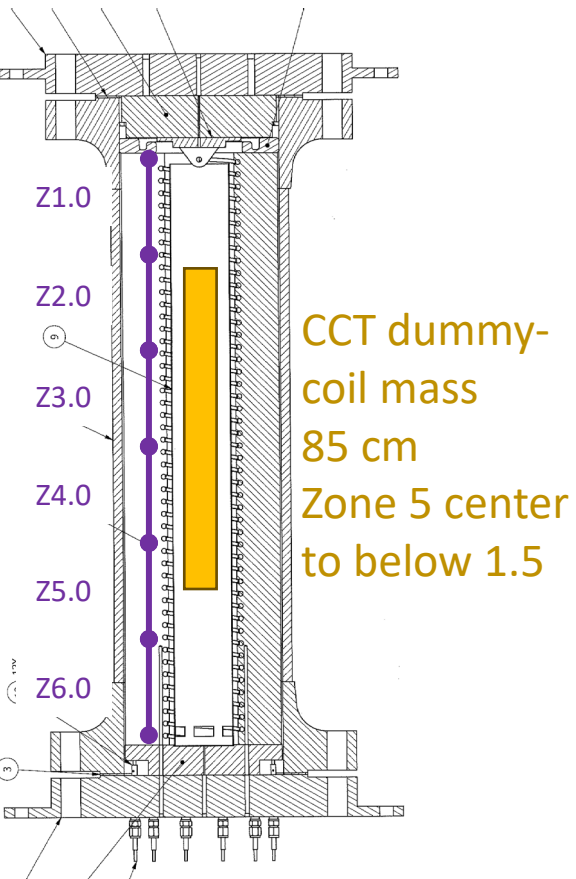
The rest of the furnace shell is much cooler ~150 C



Temperature of sample thermocouples, some attached to dummy-mass hanging between zone 2-5, and a thermocouple attached to the upper shell weld on the outer wall of the furnace precisely identified as the hottest location to monitor.

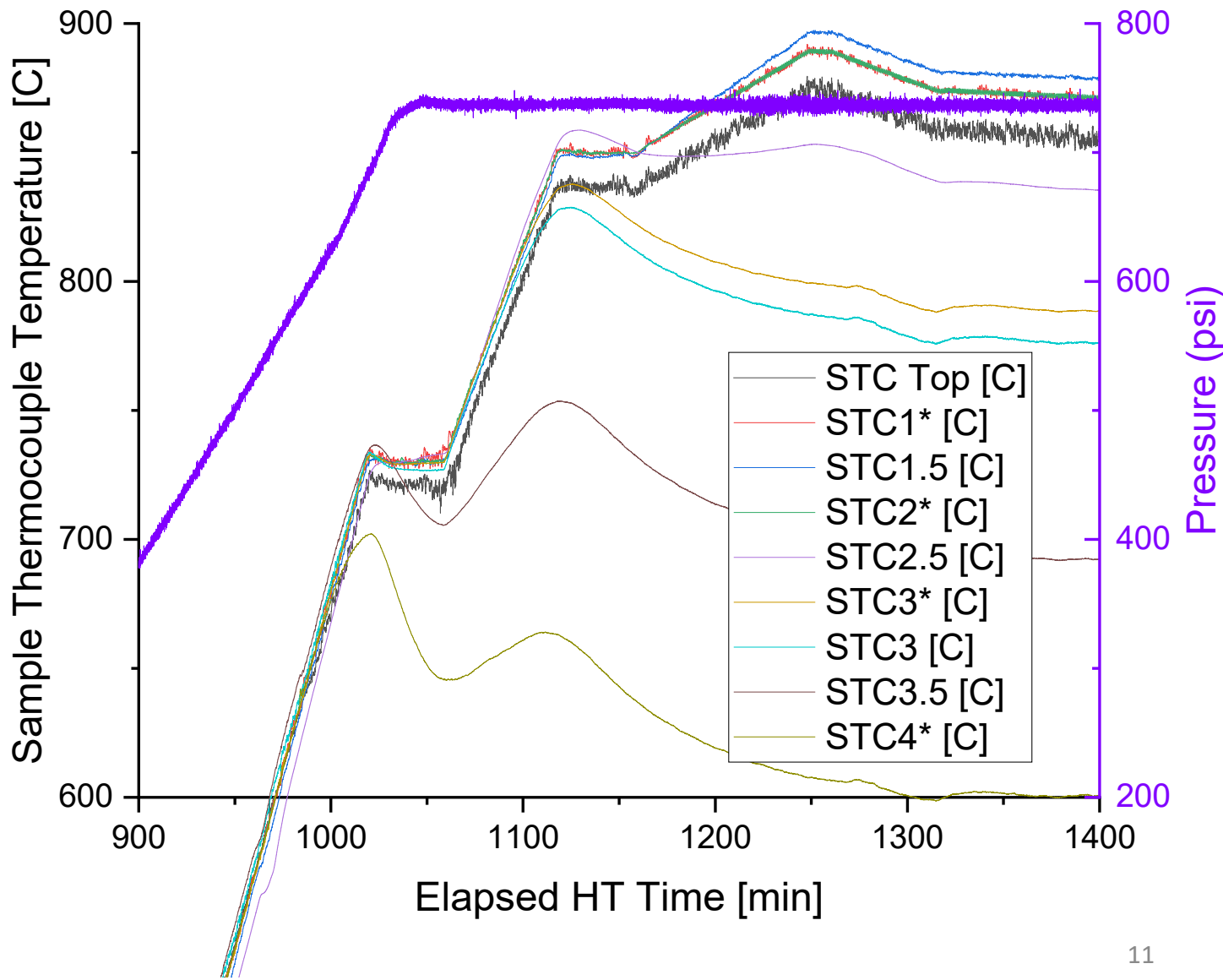
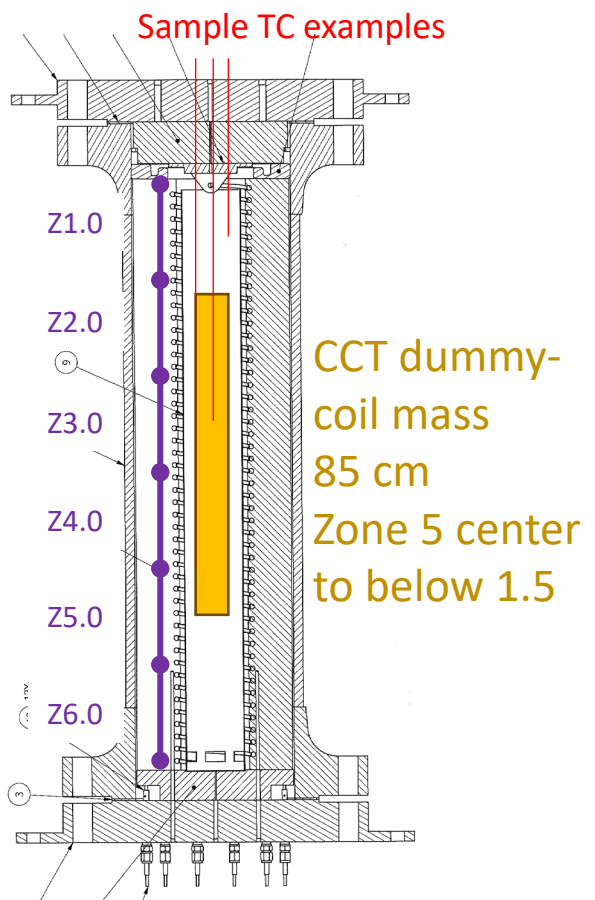
Open-loop Step PID Auto-Tuning Produced Baseline PID

- PID values similar to previous Renegade heater
- Performed fast and slow PID fits
- Proportionally shifted to reduce oscillation while retaining good knee



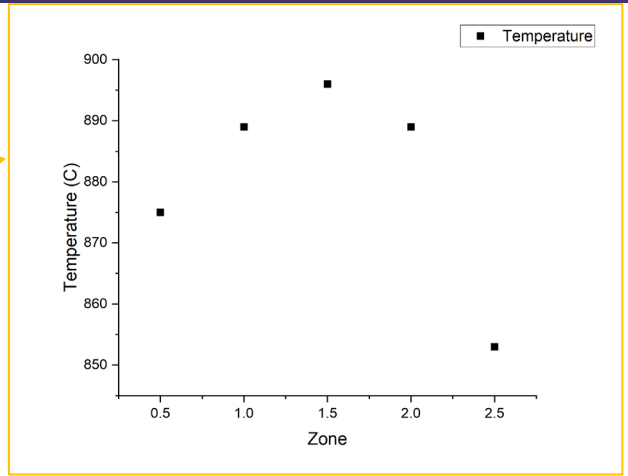
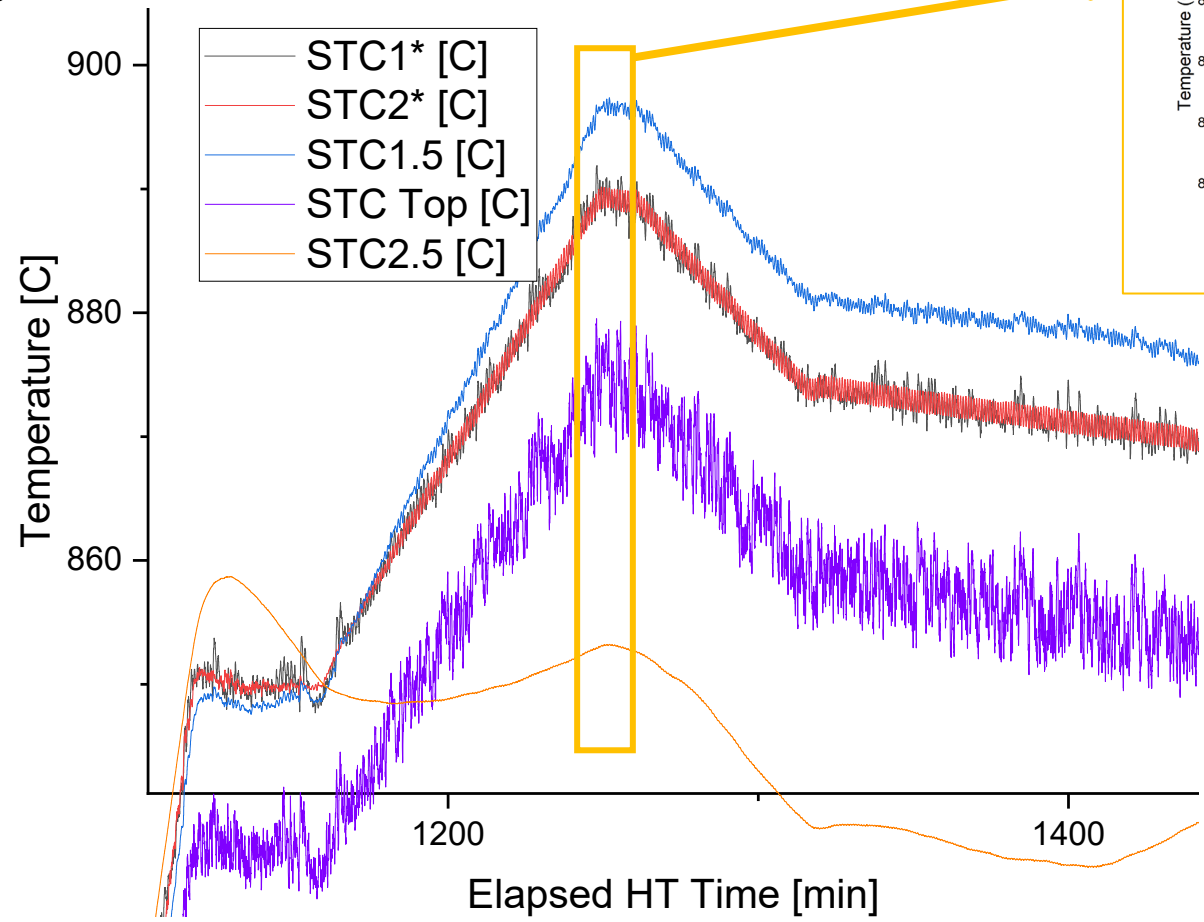
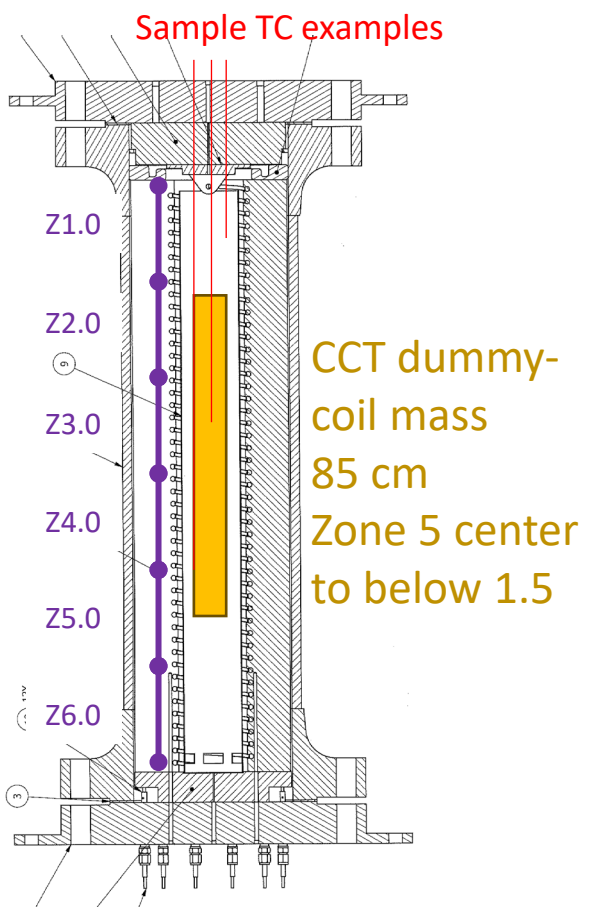
At OPHT rates (50 bar at >730 C) top 2 zones reach 889 C

PID in zones 1-4 using Sample thermocouples to generate Control offsets for full OPHT



At OPHT rates (50 bar at >730 C) top 2 zones reach 889 C

Approximately second order curve around zone 1.5

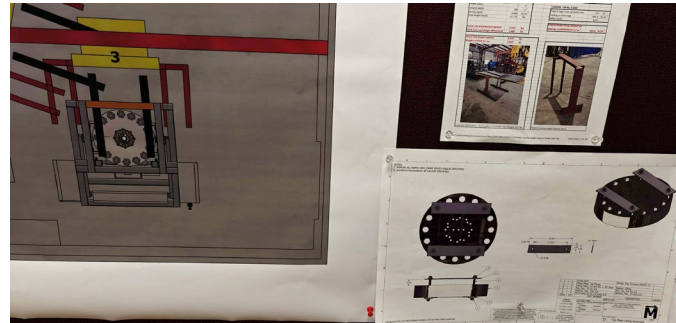
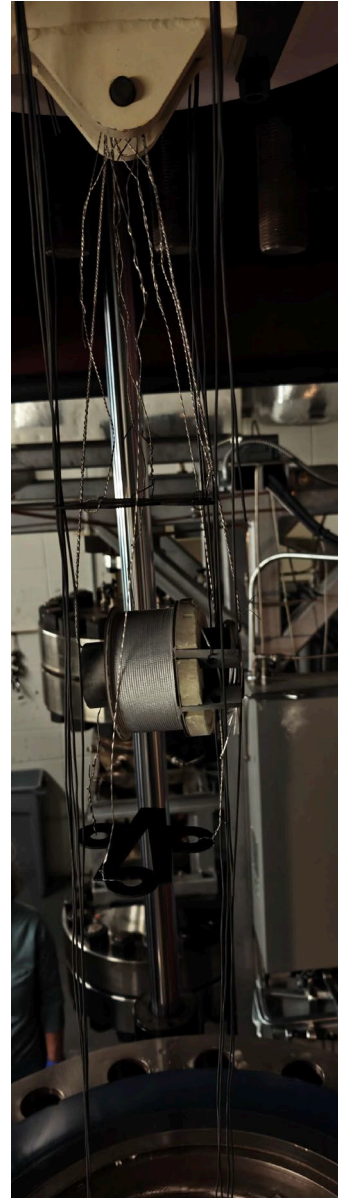
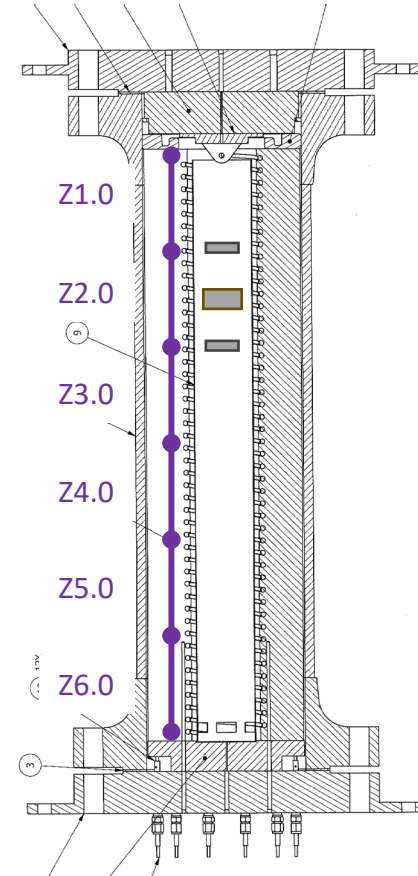


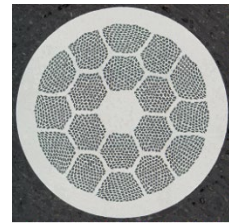
Noisier than optimized PID's because of control on sample thermocouples

Near roof insulation in gas so even noisier

Next Steps

- **Renegade Operational Readiness: IQM and ISM ongoing**
 - “describes the scope, purpose, configuration, safety features, and normal operations of the Renegade Overpressure Furnace (Renegade) at the start of normal operations”
 - Identified a required upgrade to AC power feeders to be addressed following yearly user program maintenance
- **Prepared for Initial OPHT**
 - Small processing test coil that does not need to be energized
 - Short samples around coil and in zones above and below
- **Deltech Zone 1 circuit open during warm up for Bin5E OL**
 - Assembly plans being finalized for lift replacement (pneumatic to hydraulic) and heater replacement (similar to Renegade)
 - Final parts manufacture (electrical leads and lifting hardware) and pallet stacker acquisition (allows replacement of top flange in the room)





Thank You!