Packaging Top-Loading Closed-Cycle Refrigerators for Beamline Research

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with extensive help from
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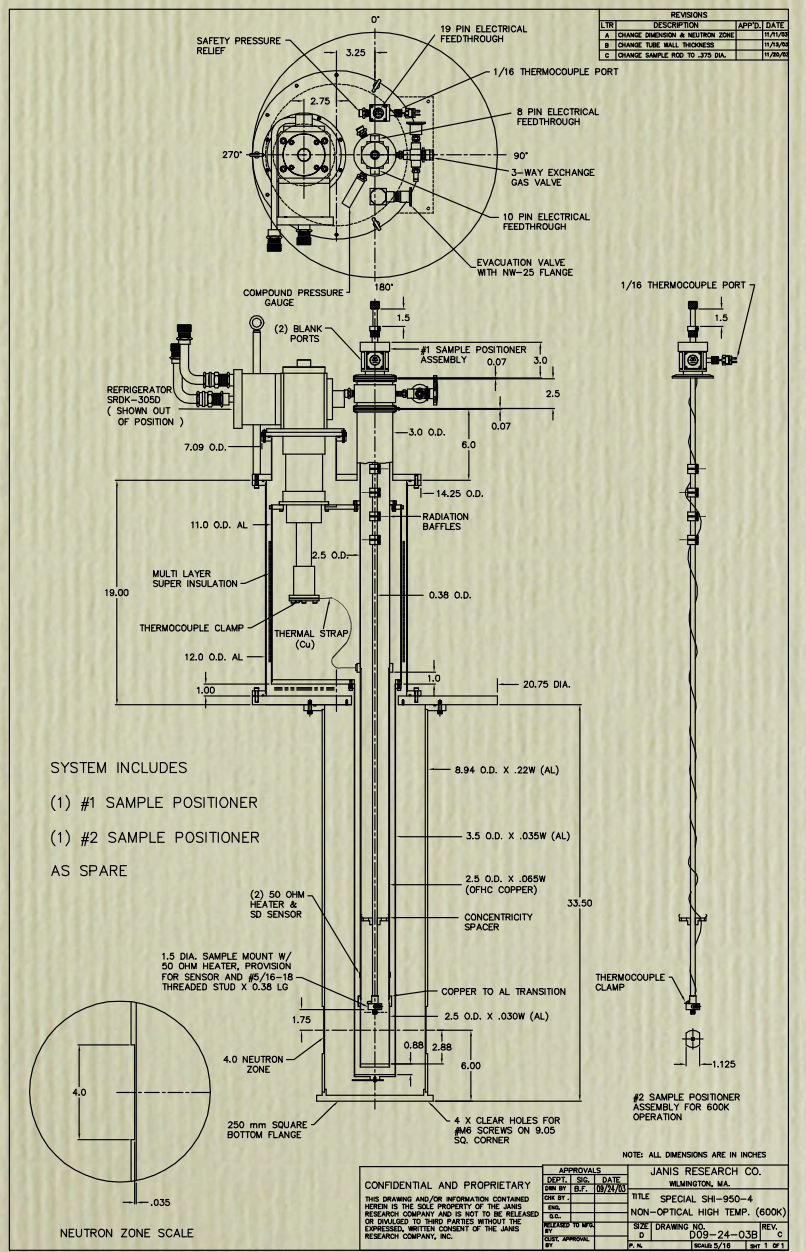
Overview of Topics

- Initial Configurations
- Specialized Tailsets
- Ease-of-Use and Reliability Enhancements
- User Manual
- PID Tuning
- Performance Enhancements
- Expanding Capabilities

Initial Configurations

- Initially procured in 2003
- 5-700 K (later upgraded to 5-800 K)
- Low temperature mode with exchange gas
  - heater on sample well
- High temperature mode with vacuum
  - heater on sample stick
- Modular so that configuration can be changed

Initial Configurations



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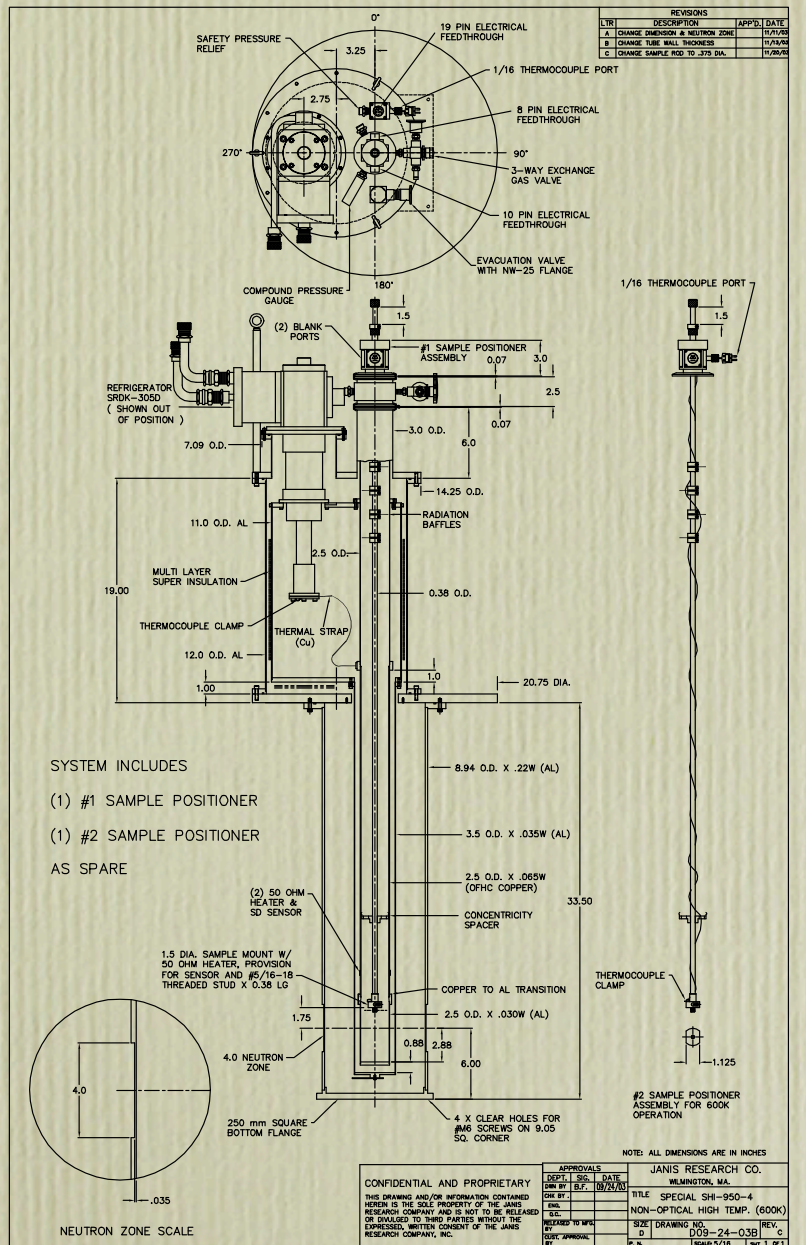

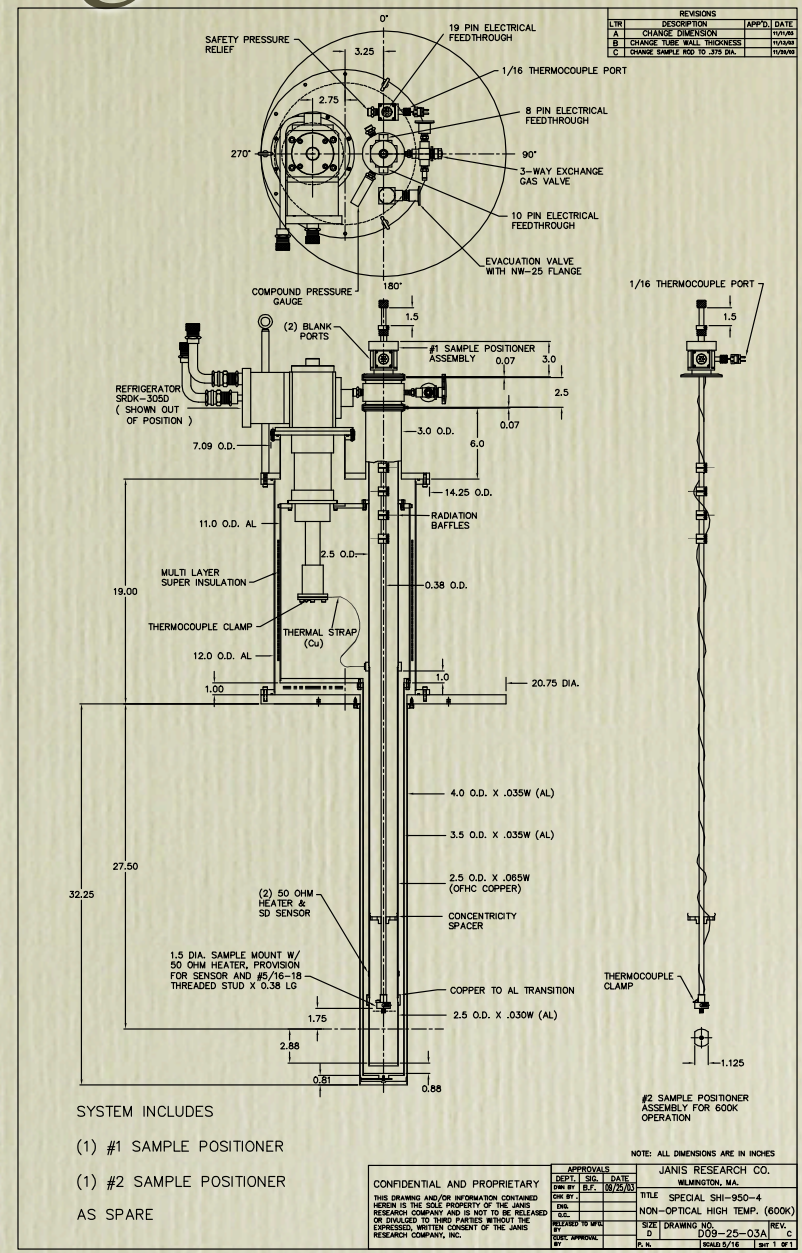

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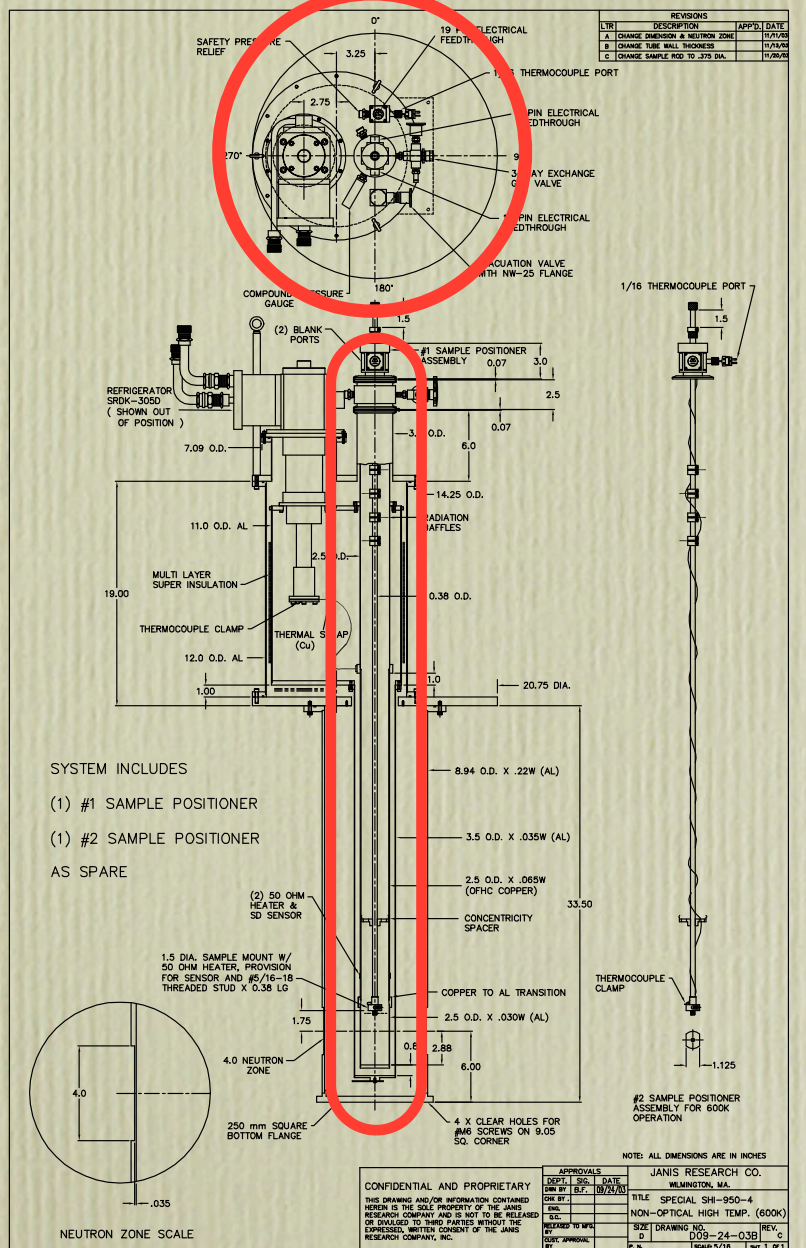
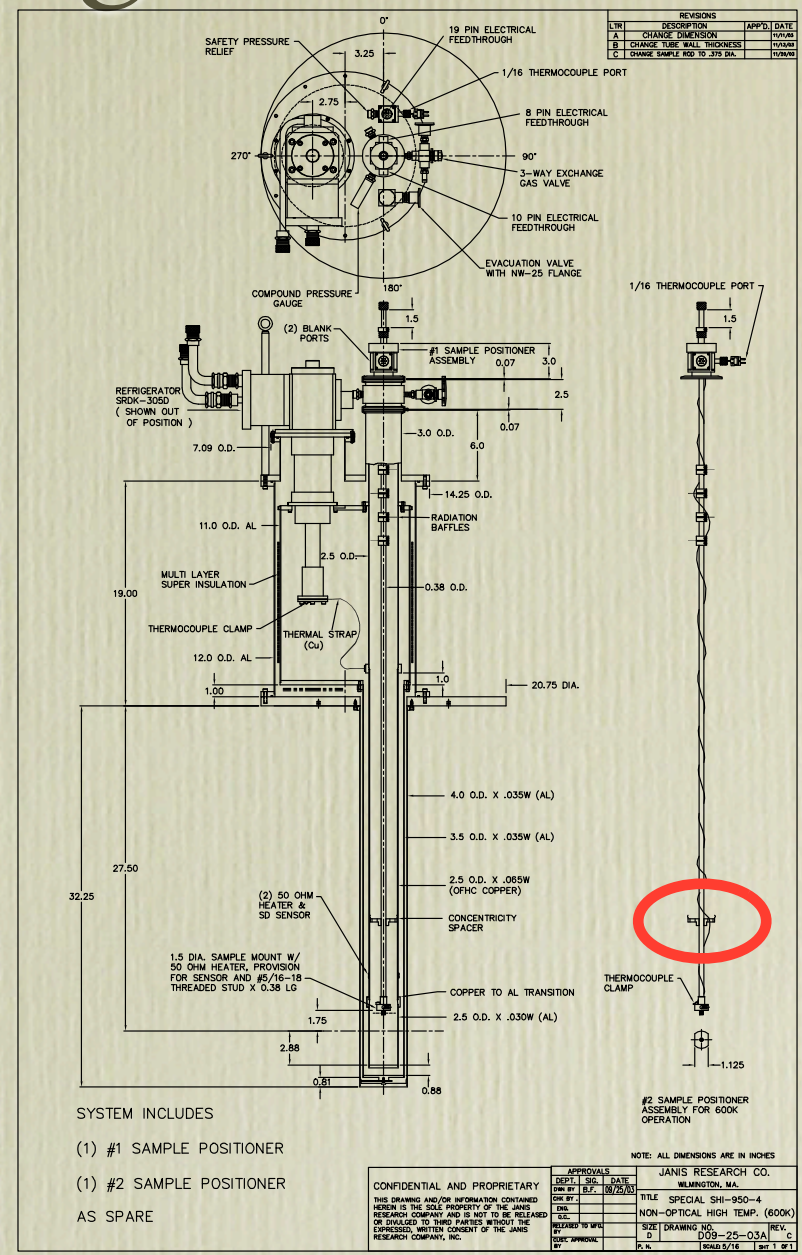
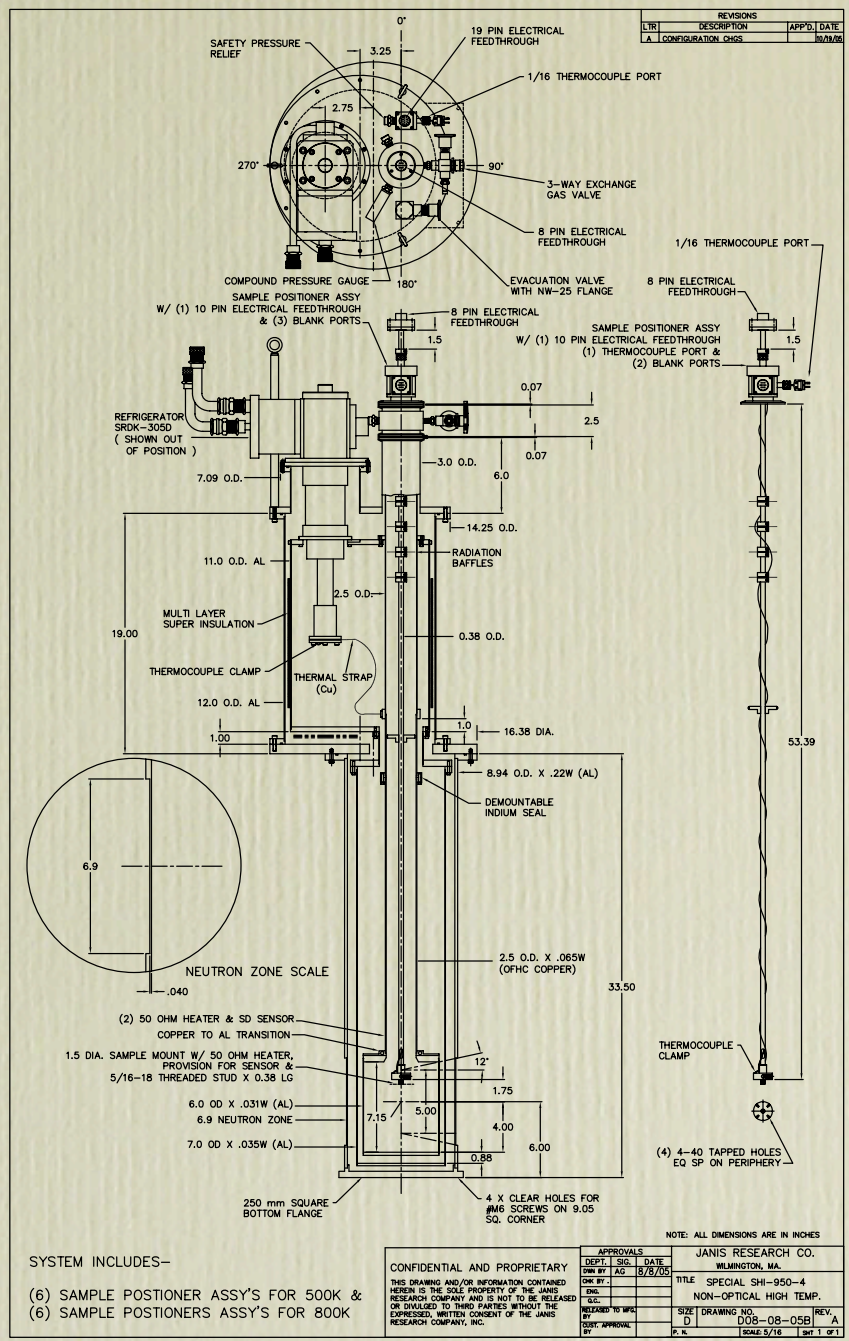




Specialized Tailsets

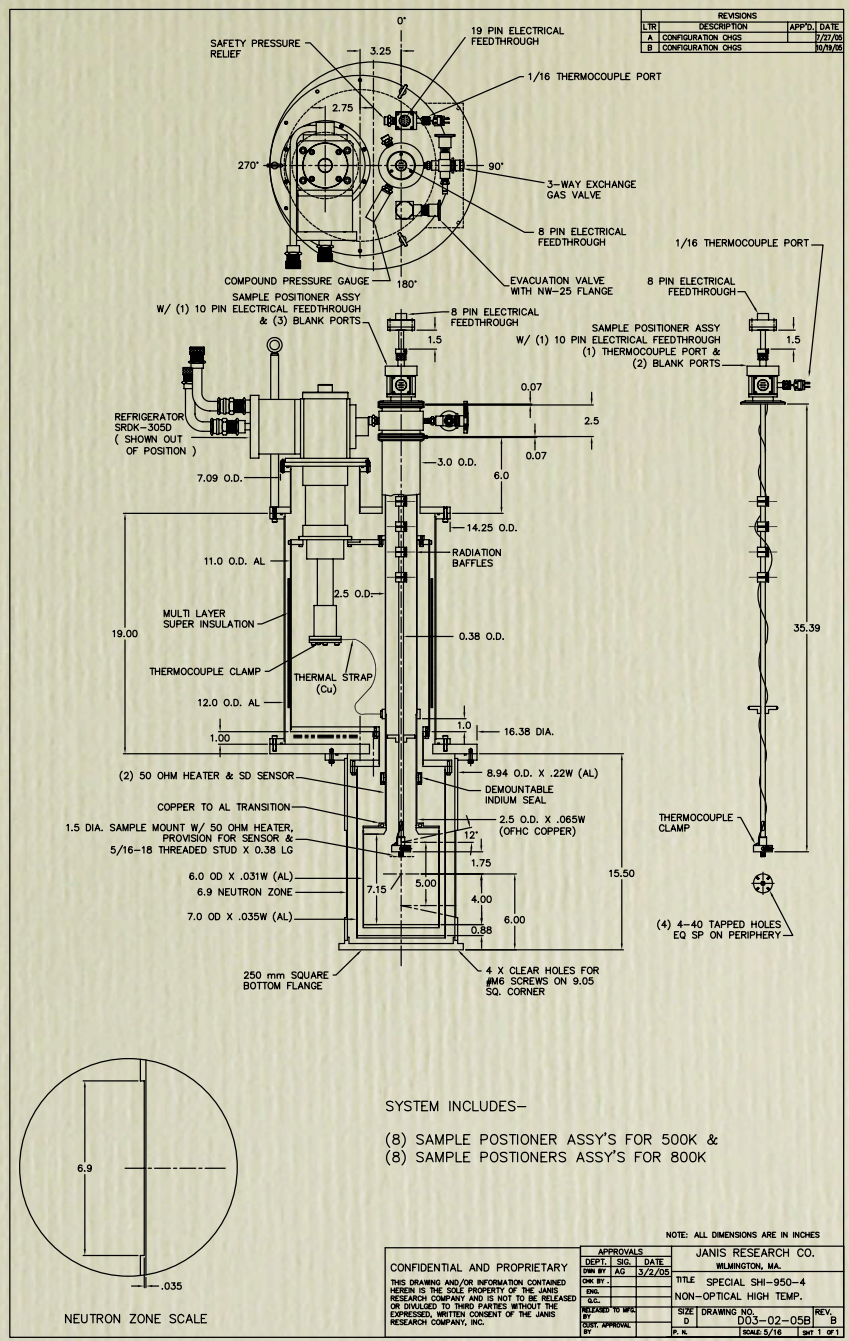
Specialized Tailsets

- **Tall**
  - Fits most instruments



Specialized Tailsets

- **Tall**
  - Fits most instruments
- **Short**
  - Convenient Size



Specialized Tailsets

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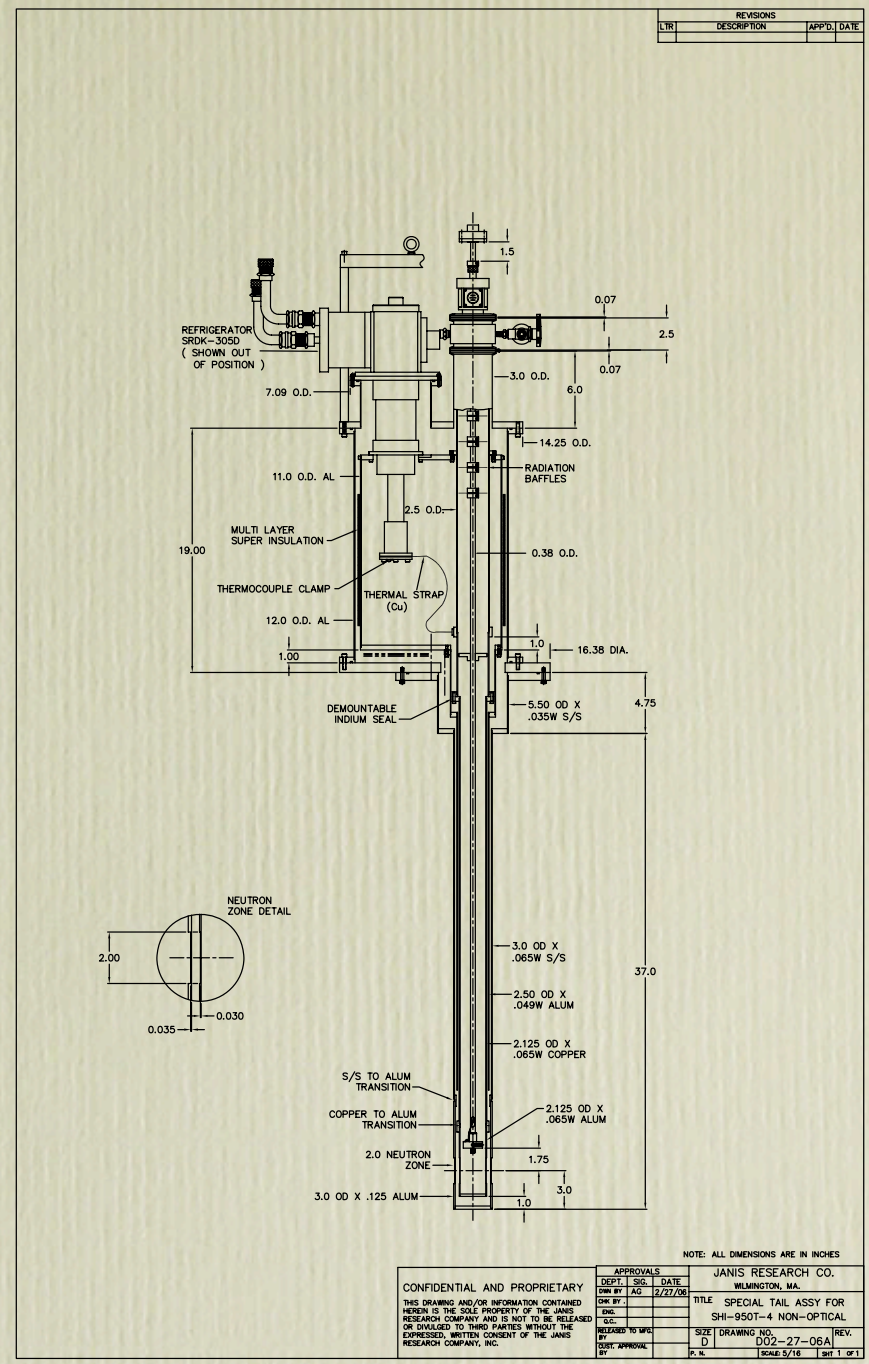
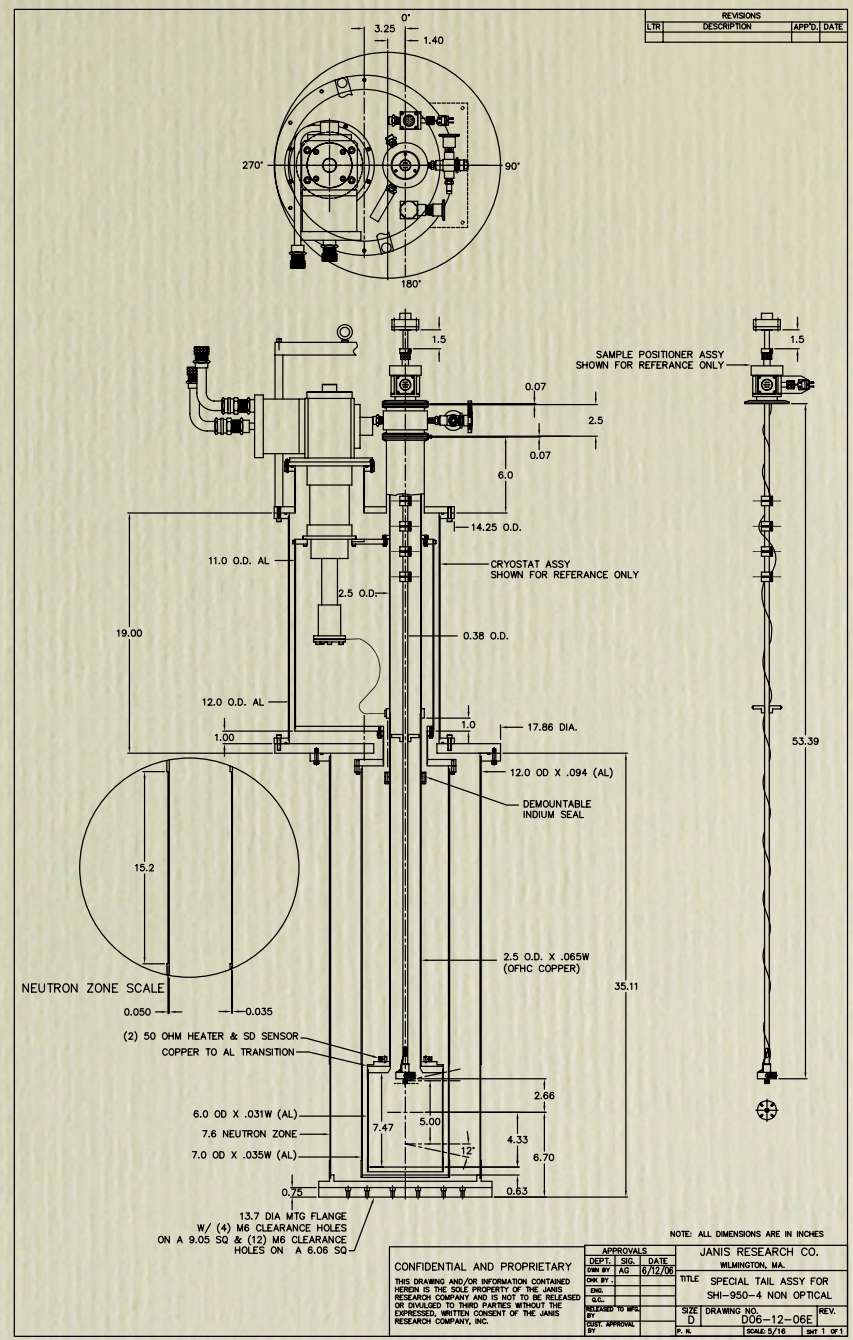
- **Short**
  - Convenient Size
- **7 Tesla Magnet**
  - Potential for High Temp.



Specialized Tailsets

- **Tall**
  - Fits most instruments
- **Short**
  - Convenient Size
- **7 Tesla Magnet**
  - Potential for High Temp.
- **DCS** (Disc Chopper Spectrometer)
  - Low Background



Ease-of-Use and Reliability Enhancements

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- Change to Lakeshore 340 controller

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- Cart for Mobility

Ease-of-Use and Reliability Enhancements

- Change to Lakeshore 340 controller
- Cart for Mobility
- Heater Selection
  - Protection circuit in-line with selected heater
  - Required manually swapping heater on controller and two connectors on thermal relay box
  - Replaced with single switch, still manually operated

Ease-of-Use and Reliability Enhancements

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  - Required manually swappi
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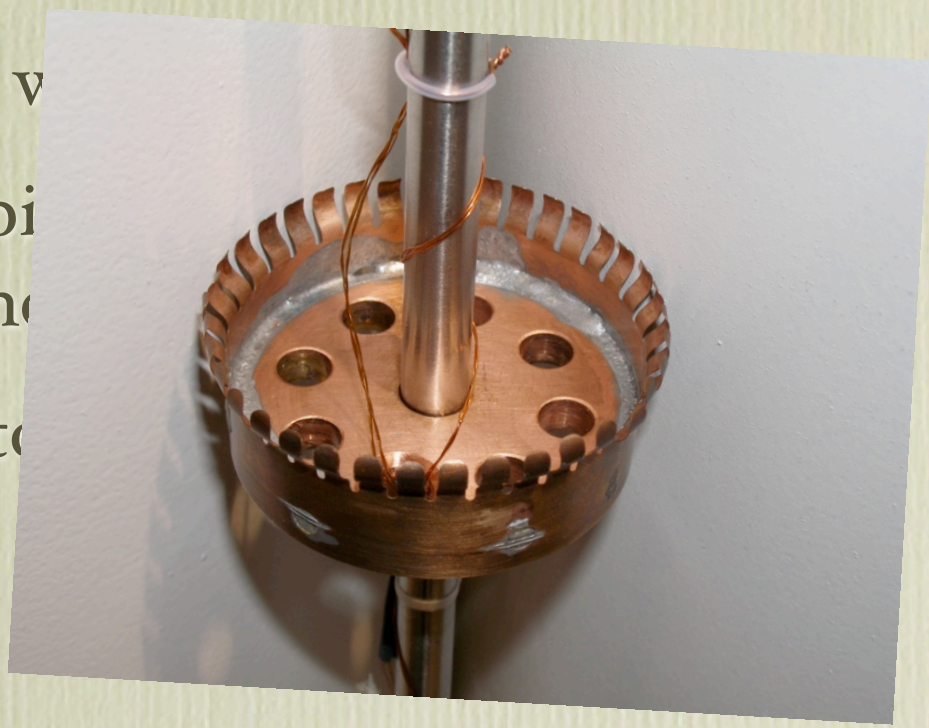
  - Replaced with single swit
    operated
- Concentricity Spacer
  - Copper Finger Stock degraded rapidly
  - New baffle uses ball plunger for concentricity



User Manual

- One page for any specific activity
- Step by step, numbered instructions
- Simple English
- Pictures to complement descriptions

User Manual

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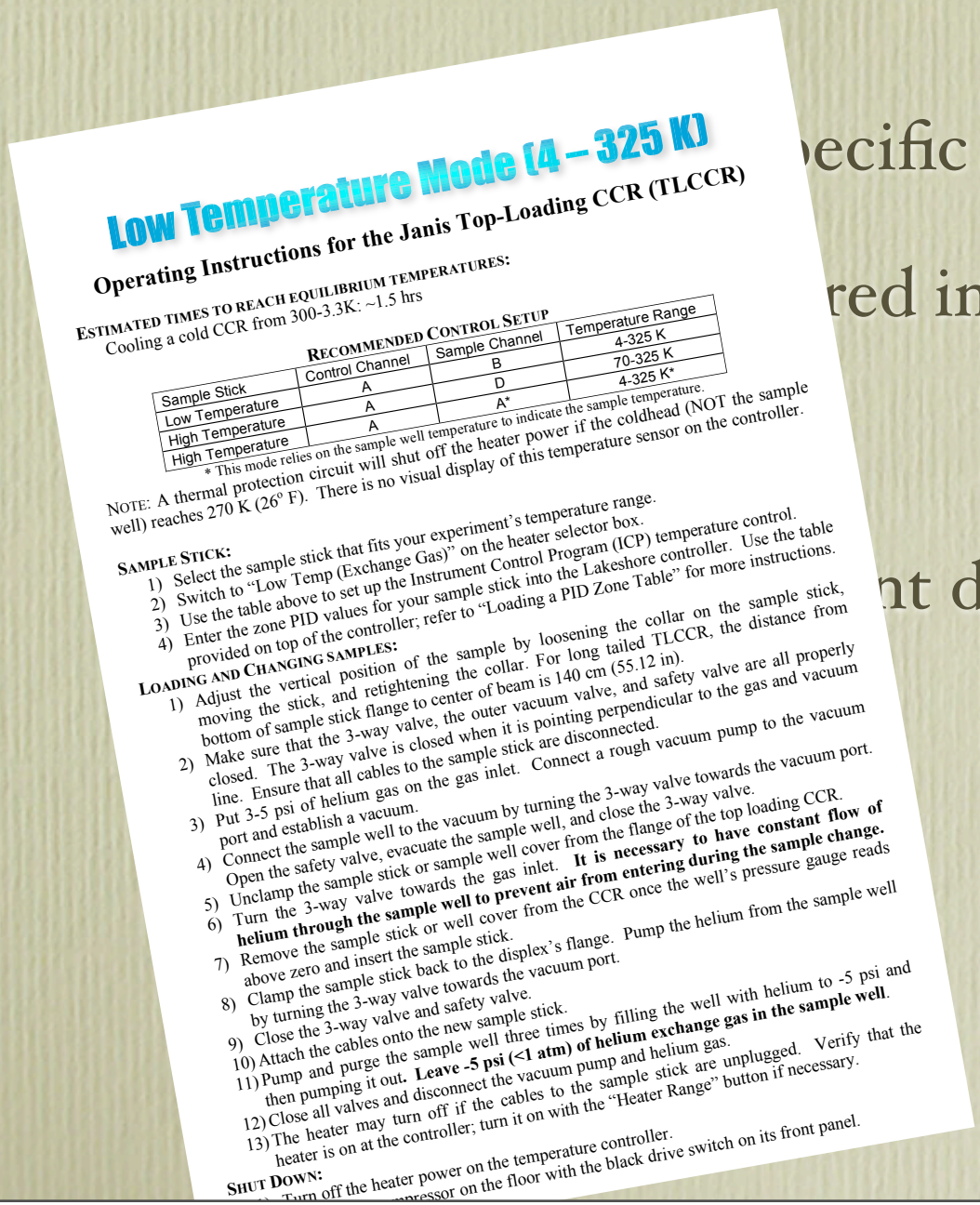
red instructions

nt descriptions



Low Temperature Mode (4 – 325 K)

Operating Instructions for the Janis Top-Loading CCR (TLCCR)

ESTIMATED TIMES TO REACH EQUILIBRIUM TEMPERATURES:
Cooling a cold CCR from 300-3.3K: ~1.5 hrs

	RECOMMENDED CONTROL SETUP		
Sample Stick	Control Channel	Sample Channel	Temperature Range
Low Temperature	A	B	4-325 K
High Temperature	A	D	70-325 K
High Temperature	A	A*	4-325 K*

* This mode relies on the sample well temperature to indicate the sample temperature.

NOTE: A thermal protection circuit will shut off the heater power if the coldhead (NOT the sample well) reaches 270 K (26° F). There is no visual display of this temperature sensor on the controller.

SAMPLE STICK:

1) Select the sample stick that fits your experiment's temperature range.
2) Switch to "Low Temp (Exchange Gas)" on the heater selector box.
3) Use the table above to set up the Instrument Control Program (ICP) temperature control.
4) Enter the zone PID values for your sample stick into the Lakeshore controller. Use the table provided on top of the controller; refer to "Loading a PID Zone Table" for more instructions.

LOADING AND CHANGING SAMPLES:

1) Adjust the vertical position of the sample by loosening the collar on the sample stick, moving the stick, and retightening the collar. For long tailed TLCCR, the distance from bottom of sample stick flange to center of beam is 140 cm (55.12 in).
2) Make sure that the 3-way valve, the outer vacuum valve, and safety valve are all properly closed. The 3-way valve is closed when it is pointing perpendicular to the gas and vacuum line. Ensure that all cables to the sample stick are disconnected.
3) Put 3-5 psi of helium gas on the gas inlet. Connect a rough vacuum pump to the vacuum port and establish a vacuum.
4) Connect the sample well to the vacuum by turning the 3-way valve towards the vacuum port. Open the safety valve, evacuate the sample well, and close the 3-way valve.
5) Unclamp the sample stick or sample well cover from the flange of the top loading CCR.
6) Turn the 3-way valve towards the gas inlet. **It is necessary to have constant flow of helium through the sample well to prevent air from entering during the sample change.**
7) Remove the sample stick or well cover from the CCR once the well's pressure gauge reads above zero and insert the sample stick.
8) Clamp the sample stick back to the displex's flange. Pump the helium from the sample well by turning the 3-way valve towards the vacuum port.
9) Close the 3-way valve and safety valve.
10) Attach the cables onto the new sample stick.
11) Pump and purge the sample well three times by filling the well with helium to -5 psi and then pumping it out. **Leave ~5 psi (<1 atm) of helium exchange gas in the sample well**.
12) Close all valves and disconnect the vacuum pump and helium gas.
13) The heater may turn off if the cables to the sample stick are unplugged. Verify that the heater is on at the controller; turn it on with the "Heater Range" button if necessary.

SHUT DOWN:

1) Turn off the heater power on the temperature controller.
2) Turn off the compressor on the floor with the black drive switch on its front panel.

User Manual

Low Temperature Mo

Operating Instructions for the Janis T

ESTIMATED TIMES TO REACH EQUILIBRIUM TEMPERATU

Cooling a cold CCR from 300-3.3K: ~1.5 hrs

RECOMMENDED CONT

Sample Stick	Control Channel	Samp
Low Temperature	A	
High Temperature	A	
High Temperature	A	

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SAMPLE STICK:

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LOADING AND CHANGING SAMPLES:

1) Adjust the vertical position of the sa
moving the stick, and retightening the
bottom of sample stick flange to center
2) Make sure that the 3-way valve, the
closed. The 3-way valve is closed w
line. Ensure that all cables to the sam
3) Put 3-5 psi of helium gas on the ga
port and establish a vacuum.
4) Connect the sample well to the vacu
Open the safety valve, evacuate the
5) Unclamp the sample stick or sampl
6) Turn the 3-way valve towards th
helium through the sample well
7) Remove the sample stick or well
above zero and insert the sample
8) Clamp the sample stick back to
by turning the 3-way valve towa
9) Close the 3-way valve and safe
10) Attach the cables onto the new
11) Pump and purge the sample
then pumping it out. **Leave -**
12) Close all valves and disconne
13) The heater may turn off if
heater is on at the controller

SHUT DOWN:

Turn off the heater power on the
pressor on the floor with the

High Temperature Mode (70 – 800 K)

Operating Instructions for the Janis Top-Loading CCR (TLCCR)

ESTIMATED TIMES TO REACH EQUILIBRIUM TEMPERATURES:

Warming from 300K-600K: ~30 min
Normal cooling down from 600-300K: ~4 hrs

RECOMMENDED CONTROL SETUP

Sample Stick	Control Channel	Sample Channel	Temperature Range
Low Temperature	B	B	4-500K
High Temperature	D	D	70-800K

SAMPLE STICK:

1) Select the sample stick that fits your criteria and switch to the "High Temp (Vacuum)" on the heater selector box.
2) Use the table above to set up the Instrument Control Program (ICP) temperature control for your sample stick choice.
3) Enter the zone PID values for your sample stick into the Lakeshore controller. Use the table provided on top of the controller; refer to "Loading a PID Zone Table" for more instructions.

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3) Put 3-5 psi of helium gas on the gas inlet. Connect a rough vacuum pump to the vacuum port and establish a vacuum.
4) Connect the sample well to the vacuum by turning the 3-way valve towards the vacuum port. Open the safety valve, evacuate the sample well, and close the 3-way valve.
5) Unclamp the sample stick or sample well cover from the flange of the top loading CCR.
6) Connect the sample well to the helium gas line by turning the 3-way valve towards the gas inlet. **It is necessary to have constant flow of helium through the sample well to prevent air from entering during the sample change.**
7) Remove the sample stick or well cover from the CCR once the well's pressure gauge reads above zero and insert the sample stick.
8) Clamp the sample stick back to the displex's flange. Pump the helium from the sample well by turning the 3-way valve towards the vacuum port.
9) Close the 3-way valve and safety valve.
10) Attach the cables onto the new sample stick.
11) Pump and purge the sample well three times by filling the well with helium to -5 psi and then pumping it out. **When finished, be sure to leave on a turbo pump and continuously pump on the sample well to maintain an adequate vacuum**.
12) Disconnect the helium gas.
13) The heater may turn off if the cables to the sample stick are unplugged. Verify that the heater is on at the controller; turn it on with the "Heater Range" button if necessary.

SHUT DOWN

1) Turn off the heater power on the temperature controller.
3) Once the temperature at channel D is 300 K or lower, turn off the compressor on the floor with the black drive switch on its front panel.

User Manual

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Operating Instructions for the Janis T

ESTIMATED TIMES TO REACH EQUILIBRIUM TEMPERATU

Cooling a cold CCR from 300-3.3K: ~1.5 hrs

RECOMMENDED CONTI

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Low Temperature	A	
High Temperature	A	
High Temperature	A	

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10) Attach the cables onto the new
11) Pump and purge the sample then pumping it out. **Leave -**
12) Close all valves and disconne
13) The heater may turn off if heater is on at the controller

SHUT DOWN:

Turn off the heater power on the
pressor on the floor with the

High Temperature Mode

Operating Instructions for the Janis Top-Load

ESTIMATED TIMES TO REACH EQUILIBRIUM TEMPERATURES:

Warming from 300K-600K: ~30 min
Normal cooling down from 600-300K: ~4 hrs

RECOMMENDED CONTROL SETU

Sample Stick	Control Channel	Sample Channel
Low Temperature	B	B
High Temperature	D	D

SAMPLE STICK:

1) Select the sample stick that fits your criteria and switch t the heater selector box.
2) Use the table above to set up the Instrument Control Pr your sample stick choice.
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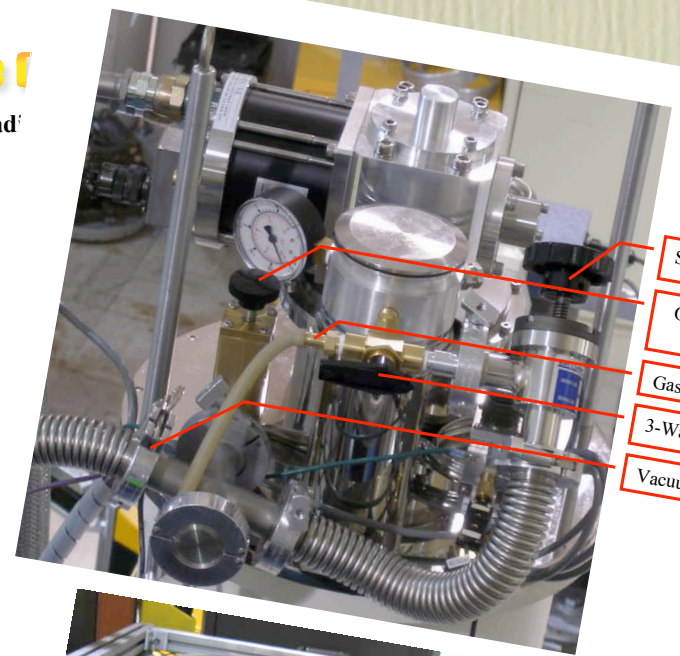
SHUT DOWN

1) Turn off the heater power on the tempe
3) Once the temperature at channel D is with the black drive switch on its front panel.



PID Tuning

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- Procedure developed to avoid manual tuning

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- Start by recording system's thermal time constant
  - input known heater power & record temperature
  - takes about two days of data collection

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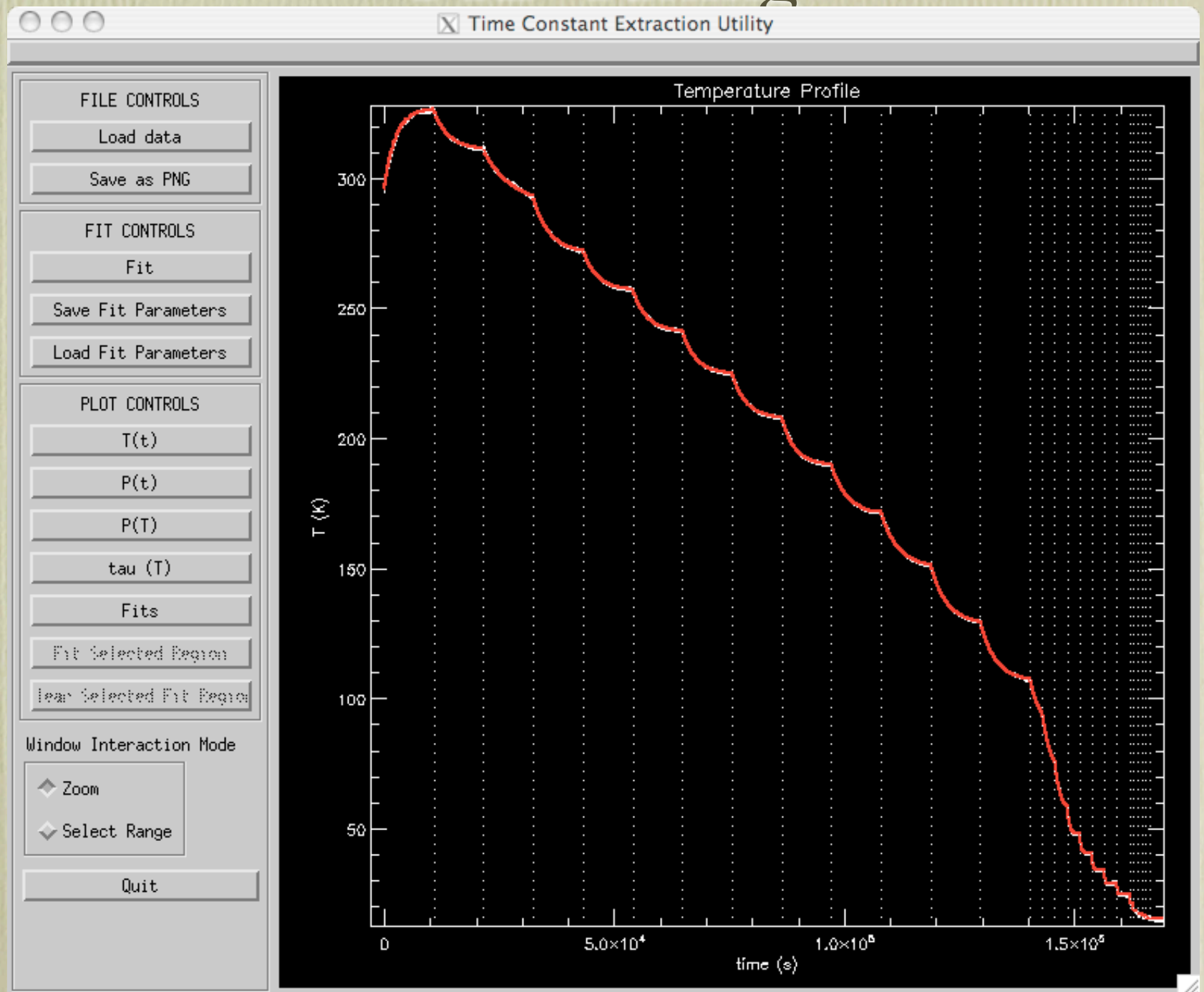
PID Tuning


Time Constant Extraction Utility
FILE CONTROLS
Load data
Save as PNG
FIT CONTROLS
Fit
Save Fit Parameters
Load Fit Parameters
PLOT CONTROLS
T(t)
P(t)
P(T)
tau (T)
Fits
Fit Selected Region
Clear Selected Fit Region
Window Interaction Mode
Zoom
Select Range
Quit
Temperature Profile
T (K)
300
250
200
150
100
50
0
5.0×10⁴
1.0×10⁵
1.5×10⁵
time (s)

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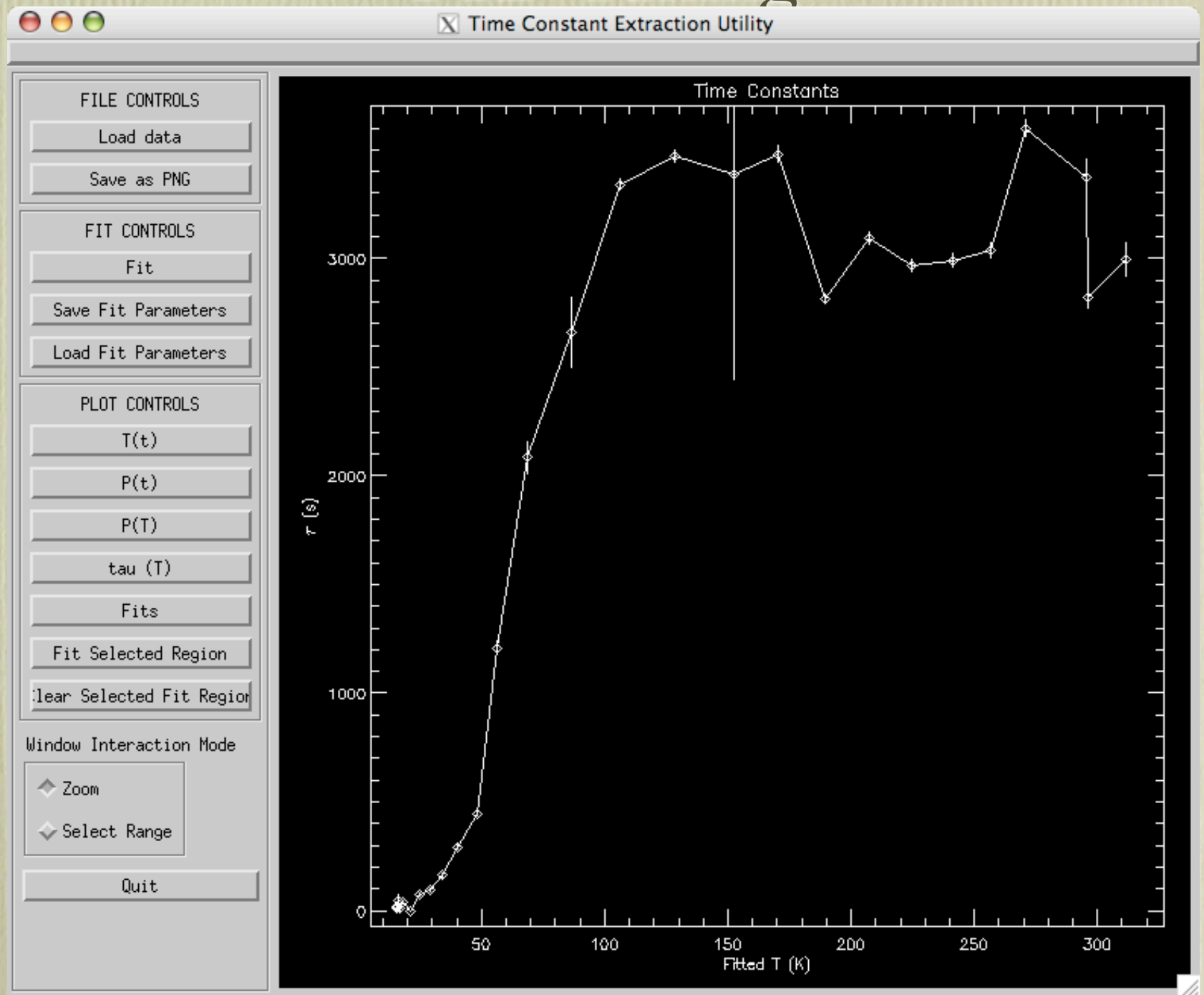
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T(t)
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P(T)
tau (T)
Fits
Fit Selected Region
Clear Selected Fit Region
Window Interaction Mode
Zoom
Select Range
Quit
Time Constants
τ (s)
0
1000
2000
3000
50
100
150
200
250
300
Fitted T (K)

PID Tuning

- Procedure developed to avoid manual tuning
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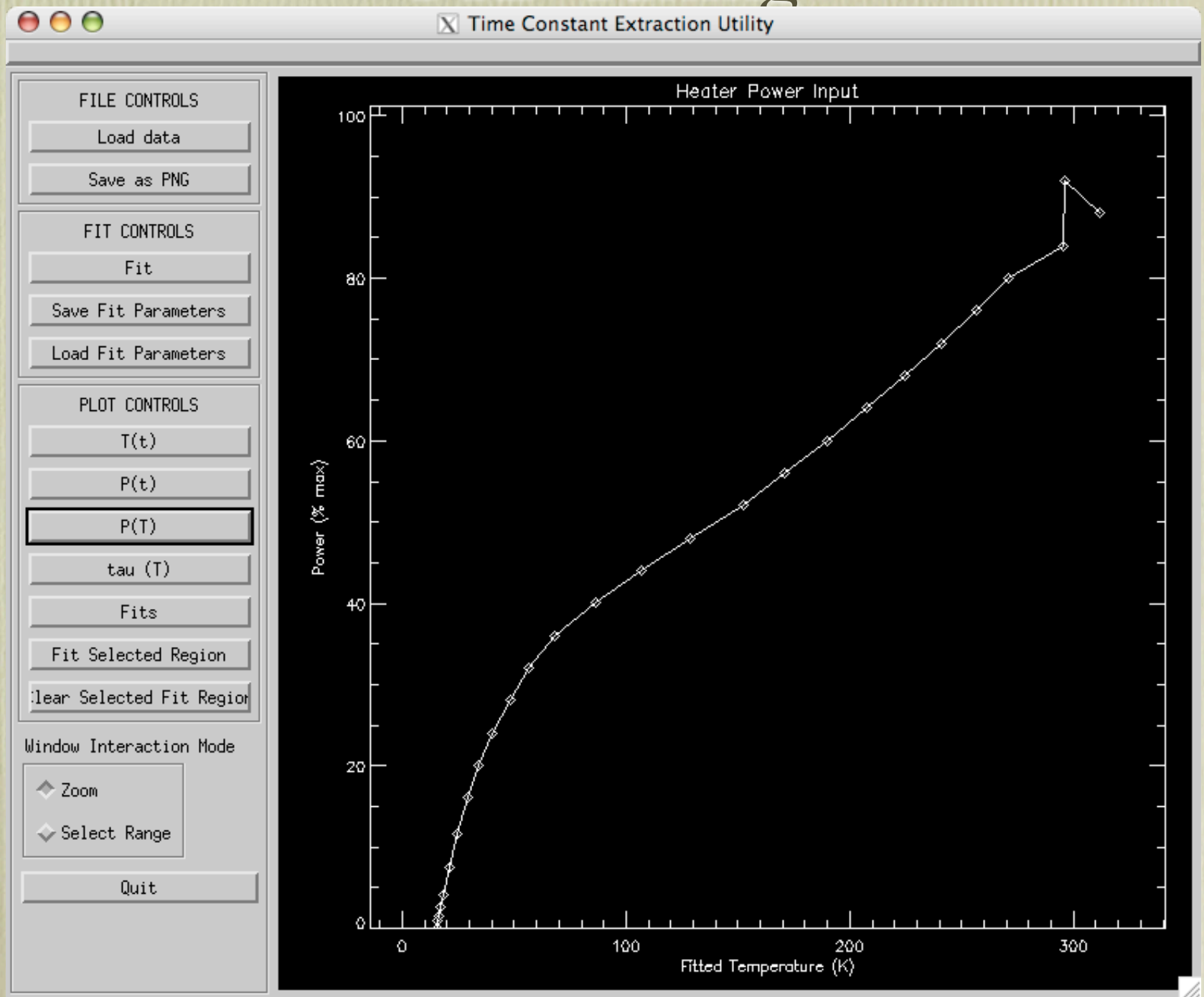
  - input known heater power & record temperature
  - takes about two days of data collection
- Fit data to get time constant *vs.* temperature
- Get cooling power *vs.* temperature as bonus!

PID Tuning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PLOT CONTROLS
T(t)
P(t)
P(T)
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Fits
Fit Selected Region
lear Selected Fit Regio
Window Interaction Mode
Zoom
Select Range
Quit
Heater Power Input
Power (% max)
Fitted Temperature (K)
0
20
40
60
80
100
0
100
200
300

PID Tuning

- Procedure developed to avoid manual tuning
- Start by recording system's thermal time constant
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- Fit data to get time constant *vs.* temperature
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- Determine zone temperature limits, I, D, and heater power from curves generated

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PID Tuning

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- Start by recording system's thermal time constant
  -
  -
- Fit
- Ge
- Determine zone temperature limits, I, D, and heater power from curves generated
- Manually determine P with system

CCR-H03 PID Settings

Zone #	Zone Limit (K)	P	I	D	Manual Output	Power
1	34	32	33.3	8	0	14W
2	37	32	11.1	23	0	14W
3	42	64	5.3	30	0	14W
4	47	64	2.7	30	0	14W
5	60	64	1.3	30	0	14W
6	120	120	0.7	30	0	71W
7	220	90	0.2	30	0	71W
8	300	90	0.2	30	0	71W
9	400	90	0.3	30	0	71W
10	650	60	0.7	30	0	71W

8/29/2005

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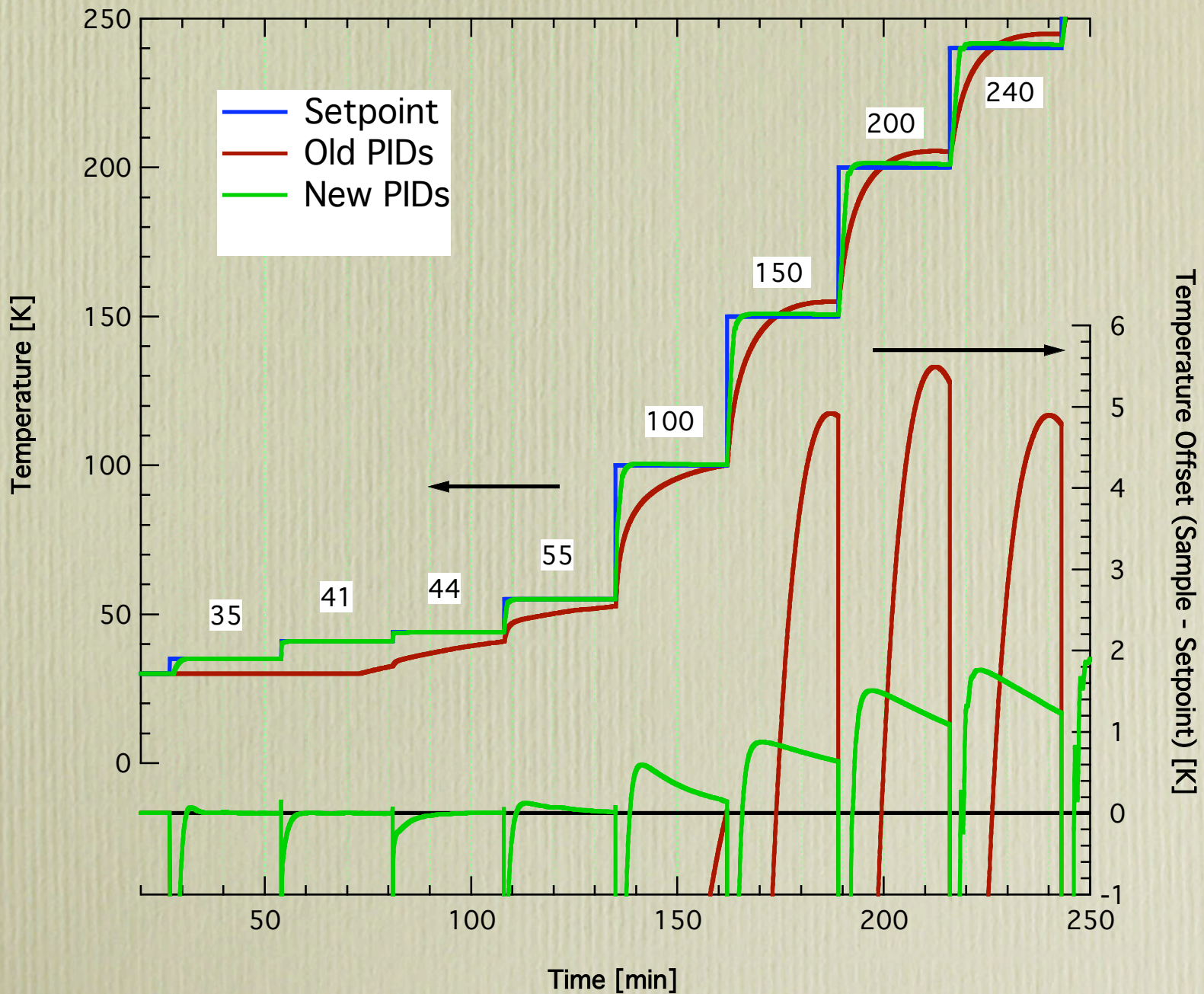
- Fit data to get time constant *vs.* temperature
- Get cooling power *vs.* temperature as bonus!
- Determine zone temperature limits, I, D, and heater power from curves generated
- Manually determine P with system
- May be used for diagnostic purposes over time

PID Tuning Comparison for High Temperature CCR



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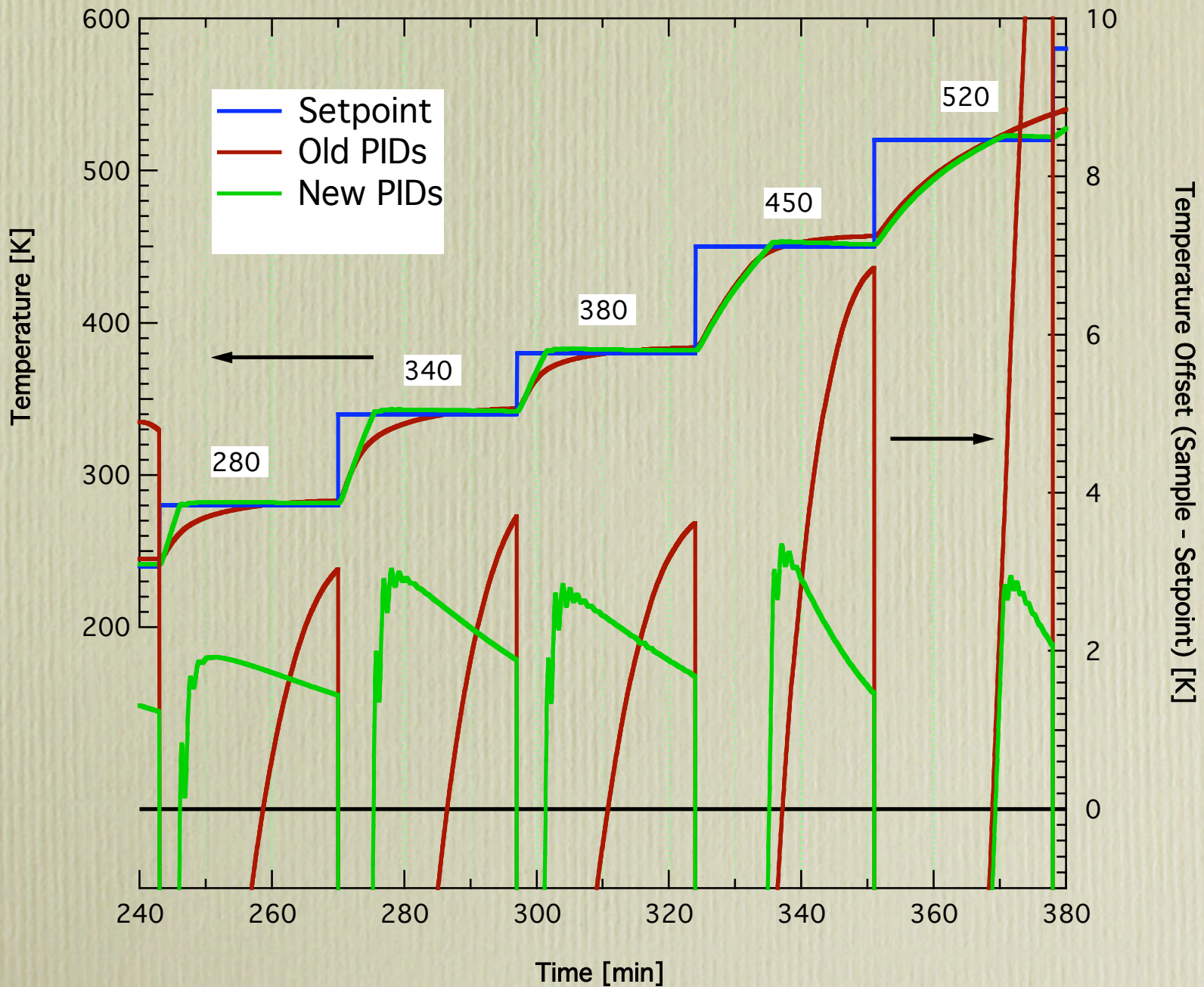
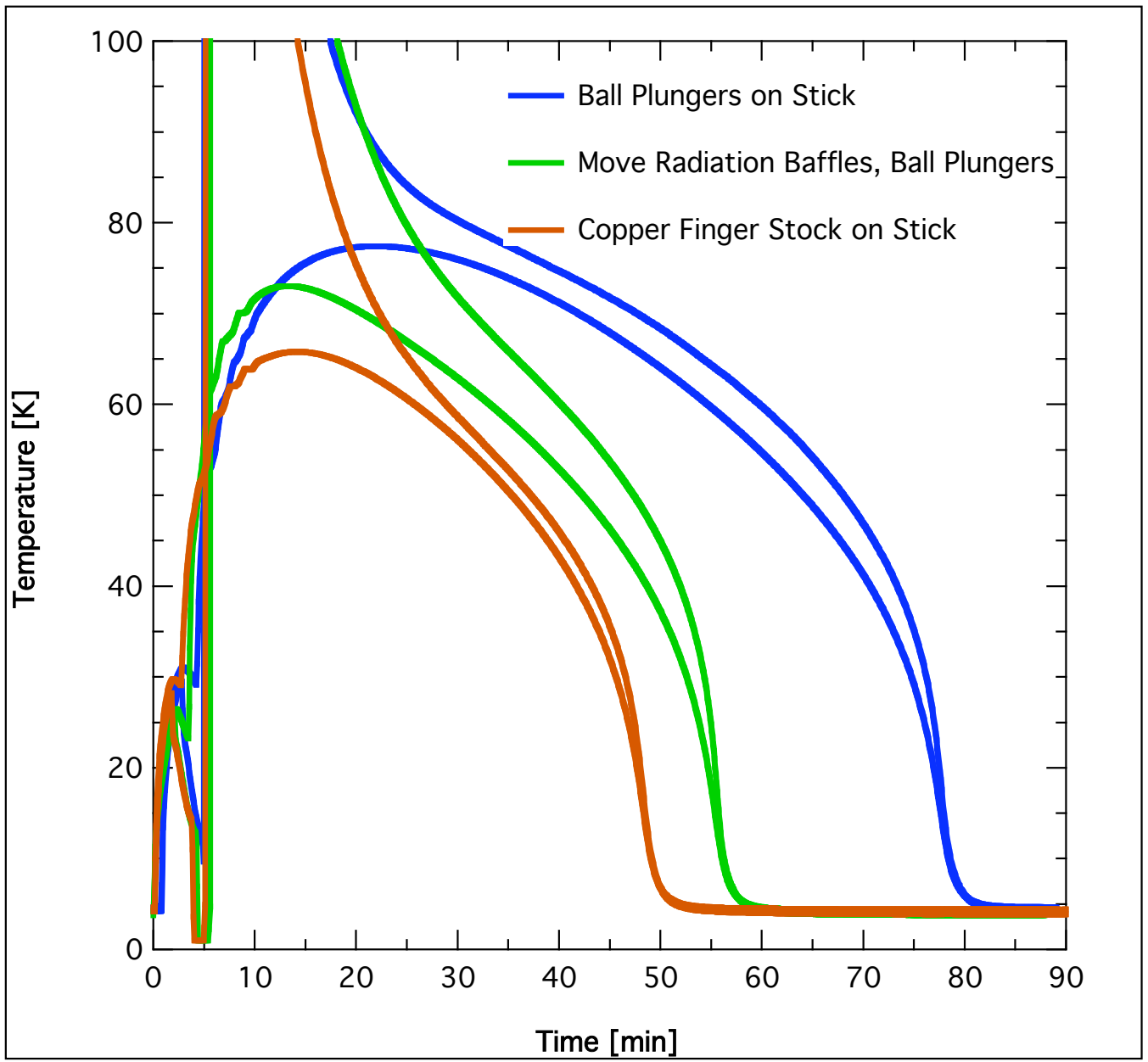


Performance Enhancements

- Temperature gradients in high temperature mode
  - attach an aluminum or vanadium heat shield
- Change 50 ohm heaters to 25 ohms to get 100 Watts
- Move radiation baffles
  - thought we needed better thermal contact
  - found that radiation baffle location made all the difference
- Add a heat switch between 1st and 2nd stage?

Performance Enhancements

- Te
  -
- C
  W
- M
  -
  -
- A



Expanding Capabilities

- Additional sample sticks purchased in long and short versions
  - Duplicate capabilities in these sizes to avoid conflict
- Adding special environment capabilities which will not be dismantled
  - Gas loading with temperature controlled inlet tubing
  - High pressure (hydrostatic gas, low temperature)
  - High Voltage (vacuum only)