Physical Property Measurements of Glassy Metals

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Measuring Thermal Properties

Data Processing

LIGO-G020443-00-R

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The Quantum Design Cryostat

- Temperature Range: 1.9K – 400K
- Pressure: 8.9 x 10^{-5} Torr
- Samples: Metglas, MoRuB

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Thermal Transport - Theory

1. Generate Heat Pulse
2. Measure $\Delta T = T_{hot} - T_{cold}$
3. Estimate Corrections
4. Calculate Thermal Conductivity!

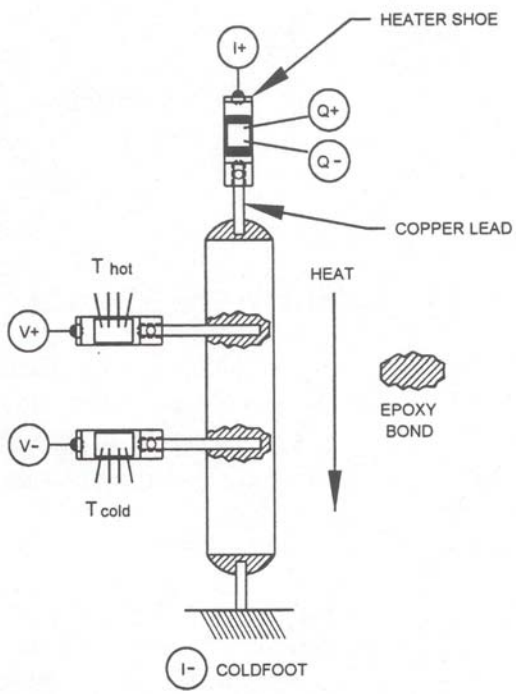

Figure 1-1. Thermal and Electrical Connections for an Idealized Sample

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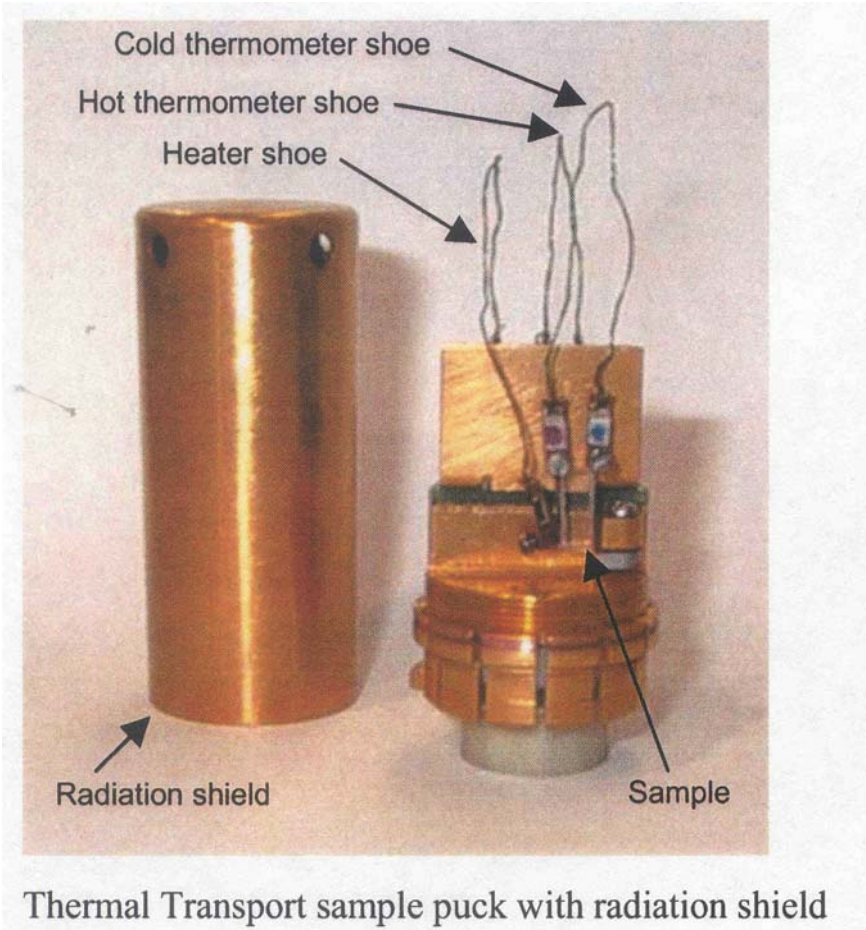
Thermal Transport - Hardware



Thermal Transport sample puck with radiation shield

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The Cryostat – HiVac System

- HiVac Pressure: 9×10^{-5} Torr
- Many Problems!!
- Result: Quantum Design is Redesigning Cryopump

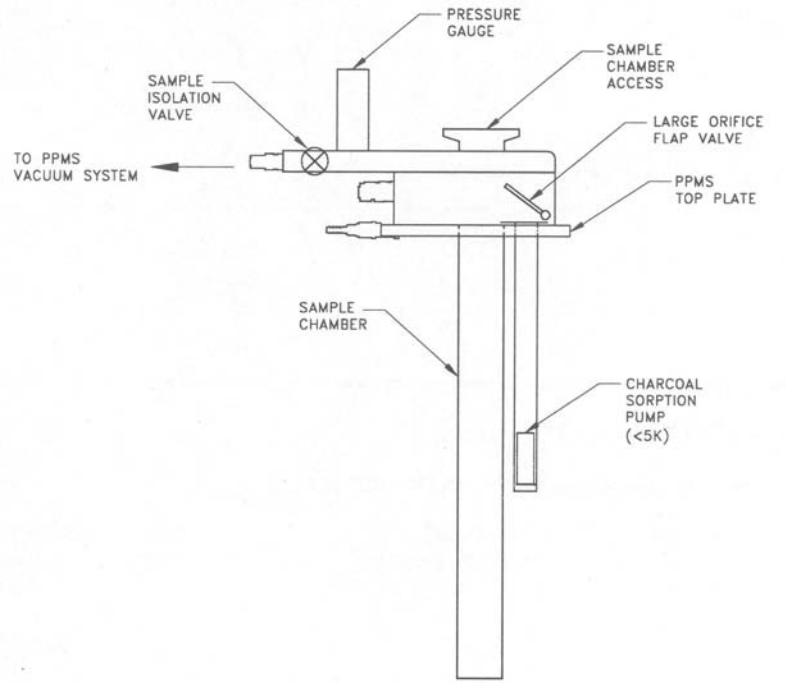

Figure 1-1. Cryopump Assembly

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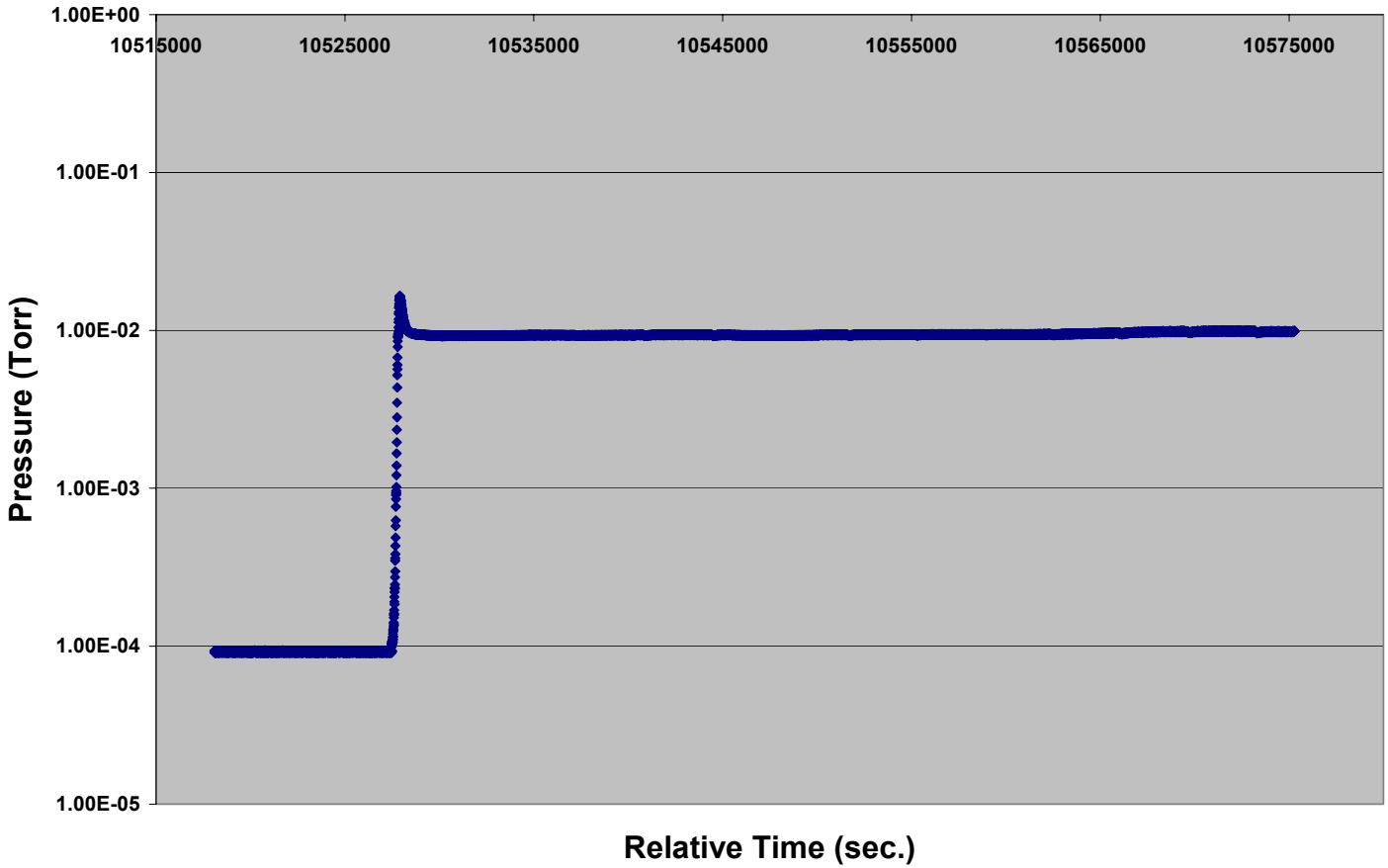
Cryopump Failure



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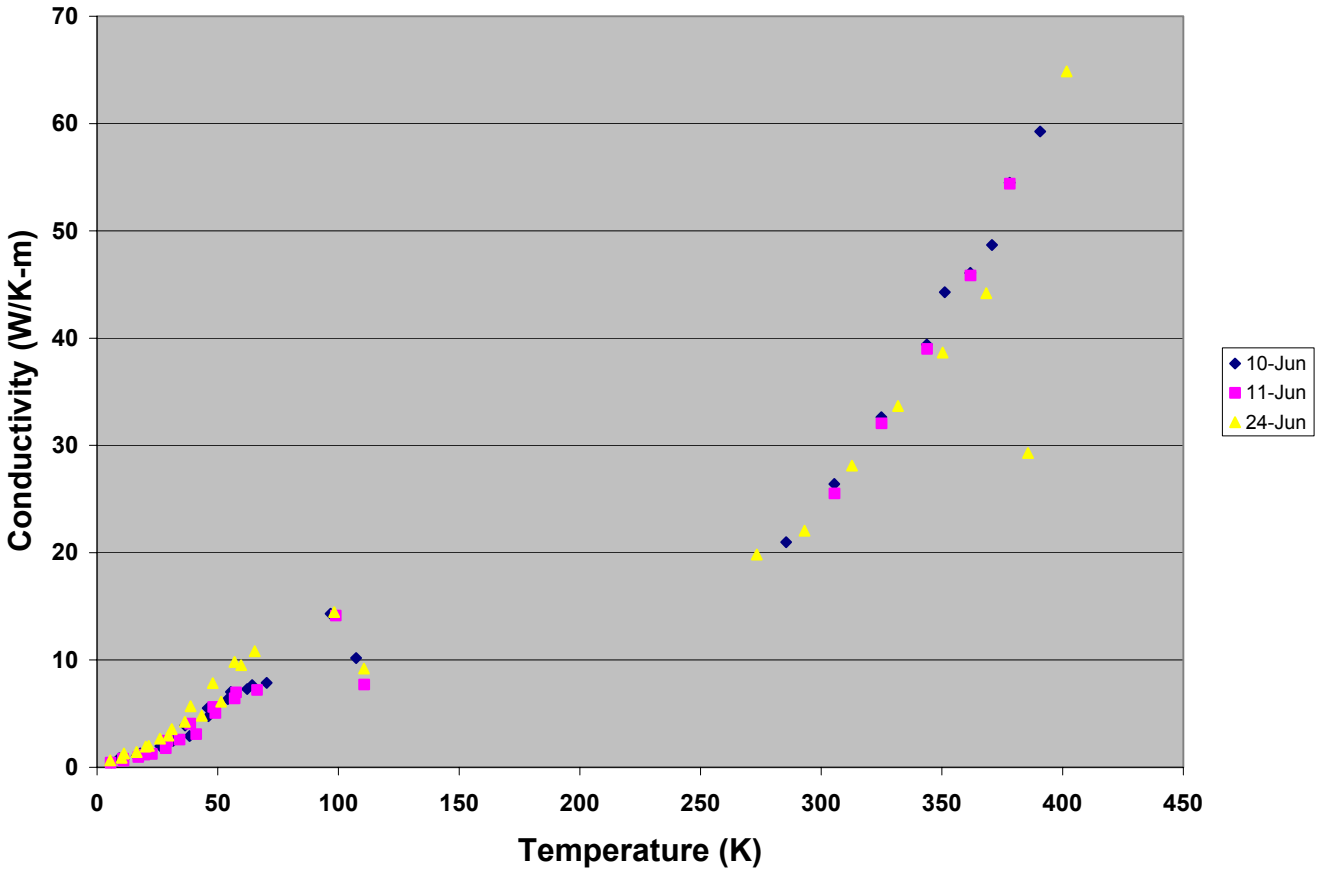
Continuous Measurement



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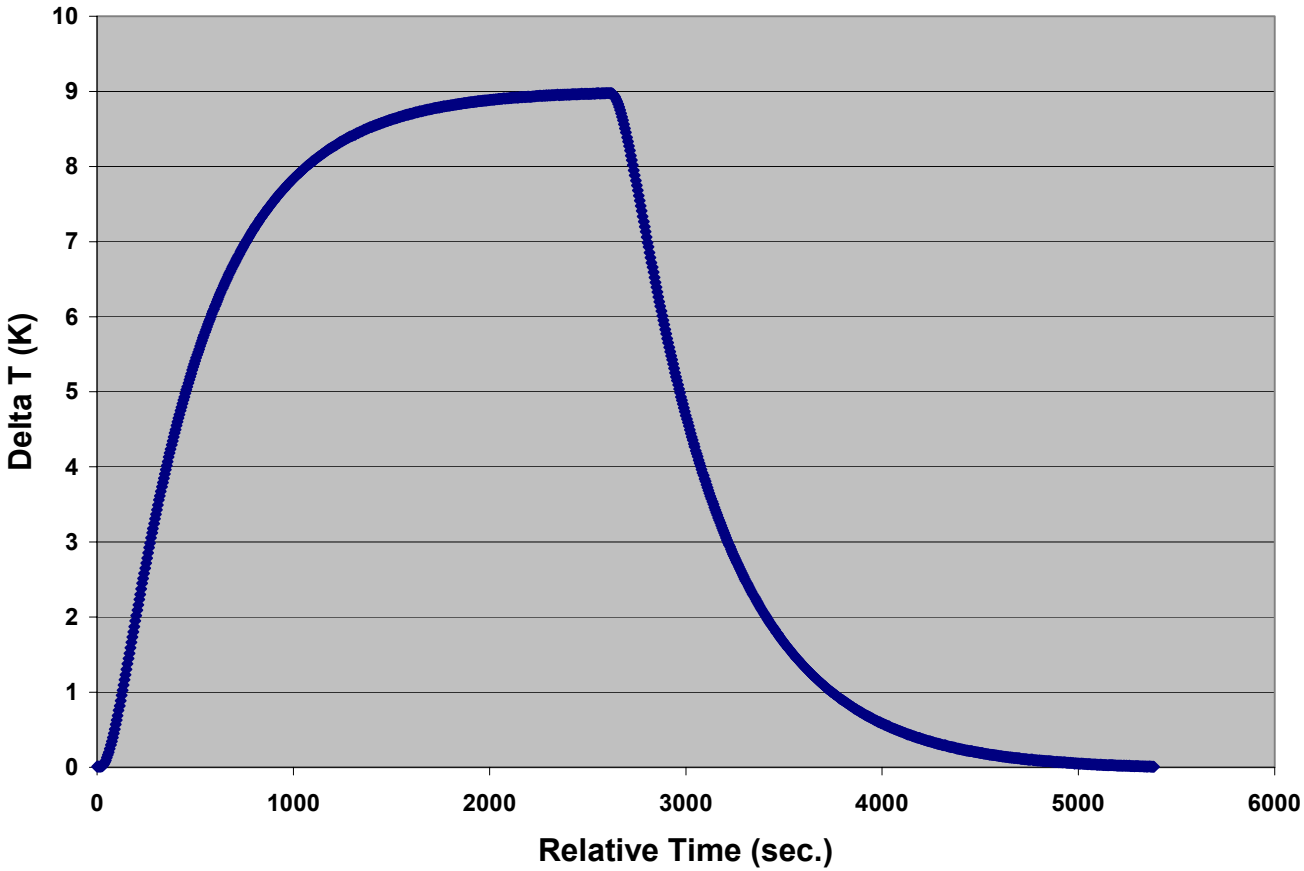
Ideal Data Acquisition



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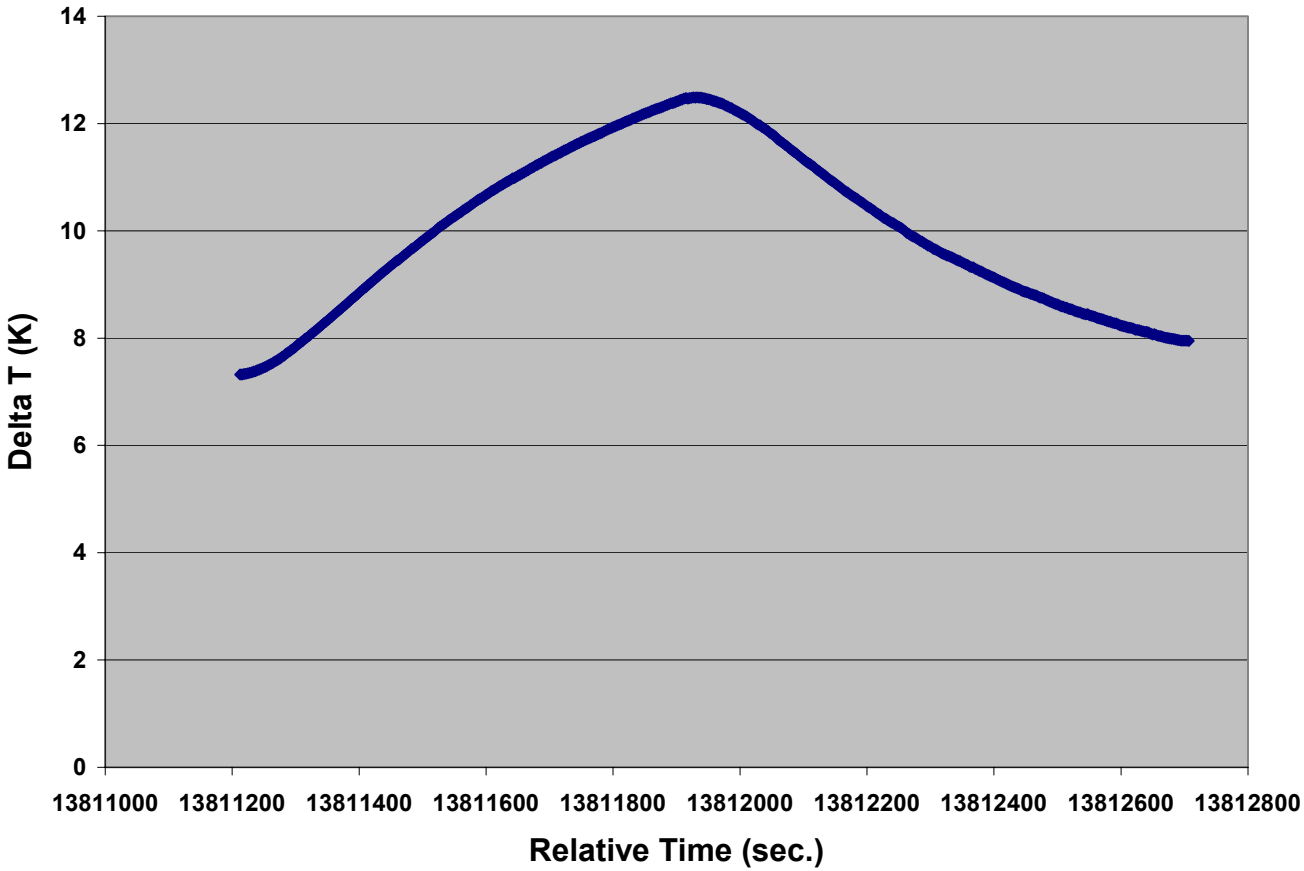
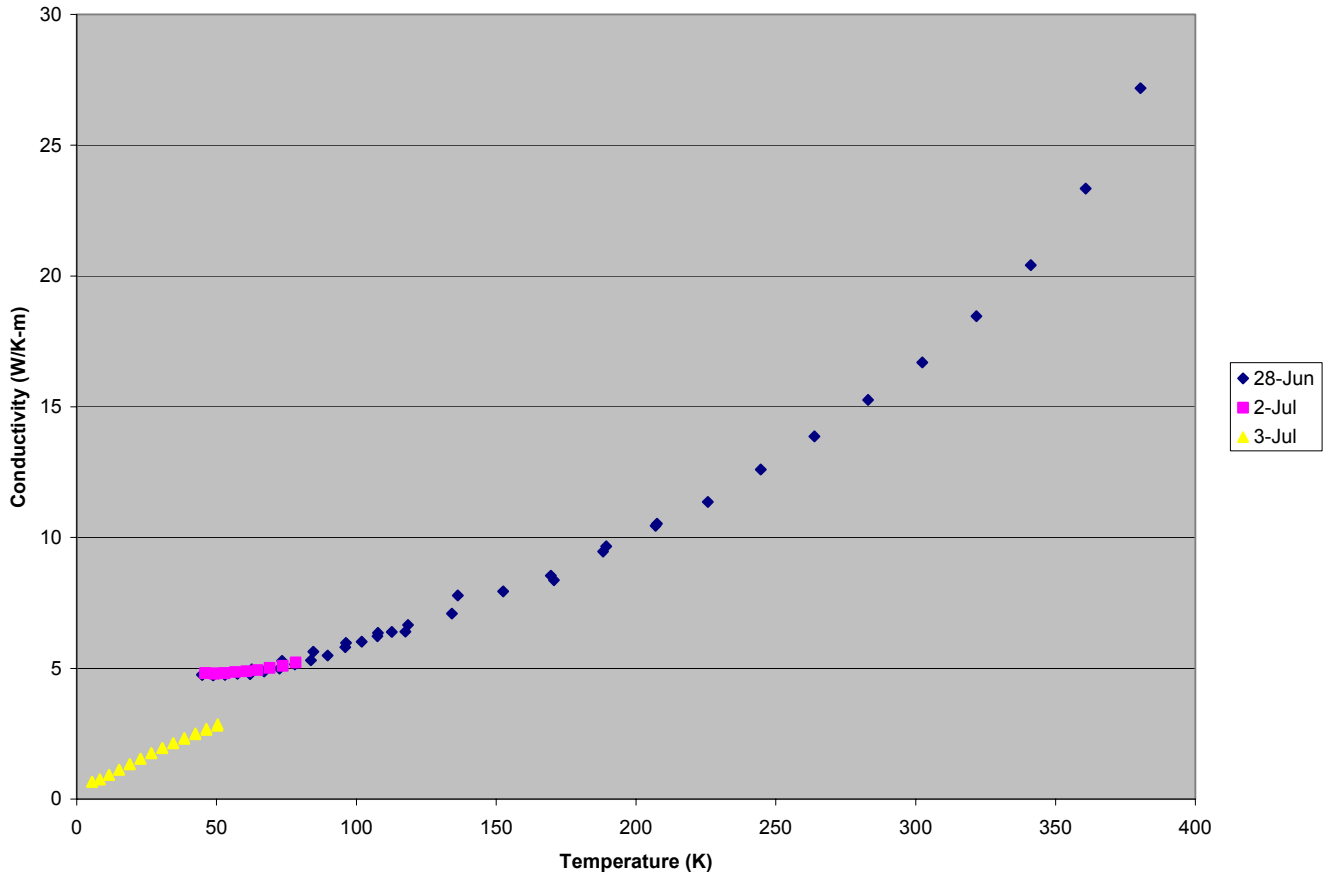
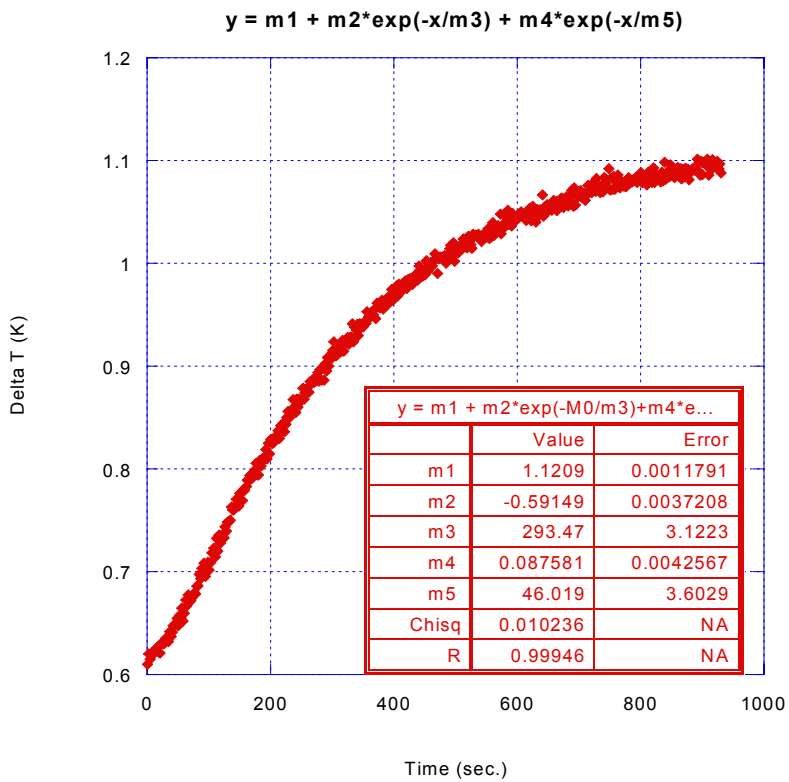
Poor Data Acquisition



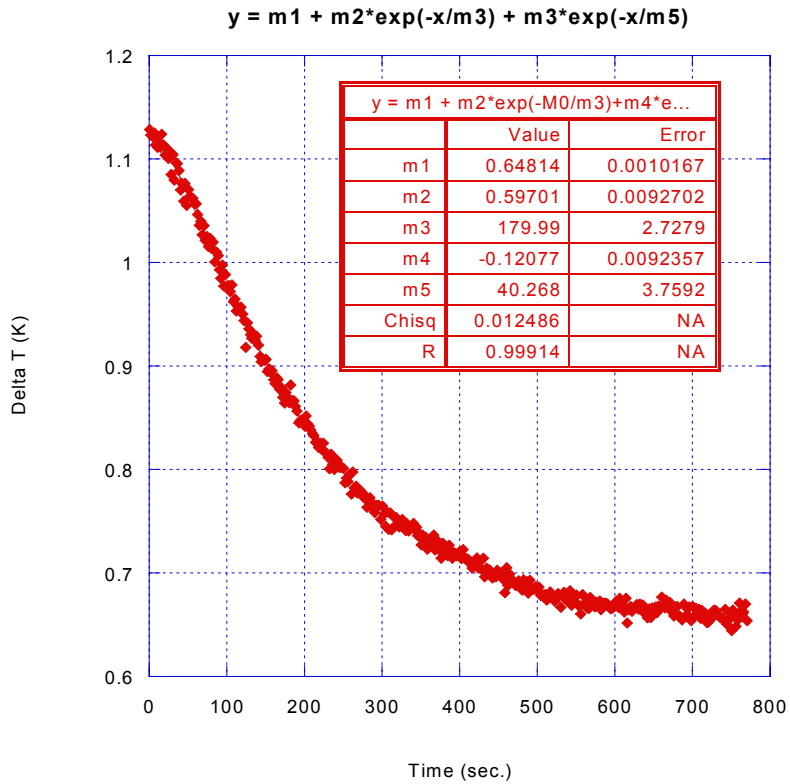
TTO – Stable Measurement



Data Processing



y = m1 + m2*exp(-M0/m3)+m4*e...		
	Value	Error
m1	1.1209	0.0011791
m2	-0.59149	0.0037208
m3	293.47	3.1223
m4	0.087581	0.0042567
m5	46.019	3.6029
Chisq	0.010236	NA
R	0.99946	NA



y = m1 + m2*exp(-M0/m3)+m4*e...		
	Value	Error
m1	0.64814	0.0010167
m2	0.59701	0.0092702
m3	179.99	2.7279
m4	-0.12077	0.0092357
m5	40.268	3.7592
Chisq	0.012486	NA
R	0.99914	NA

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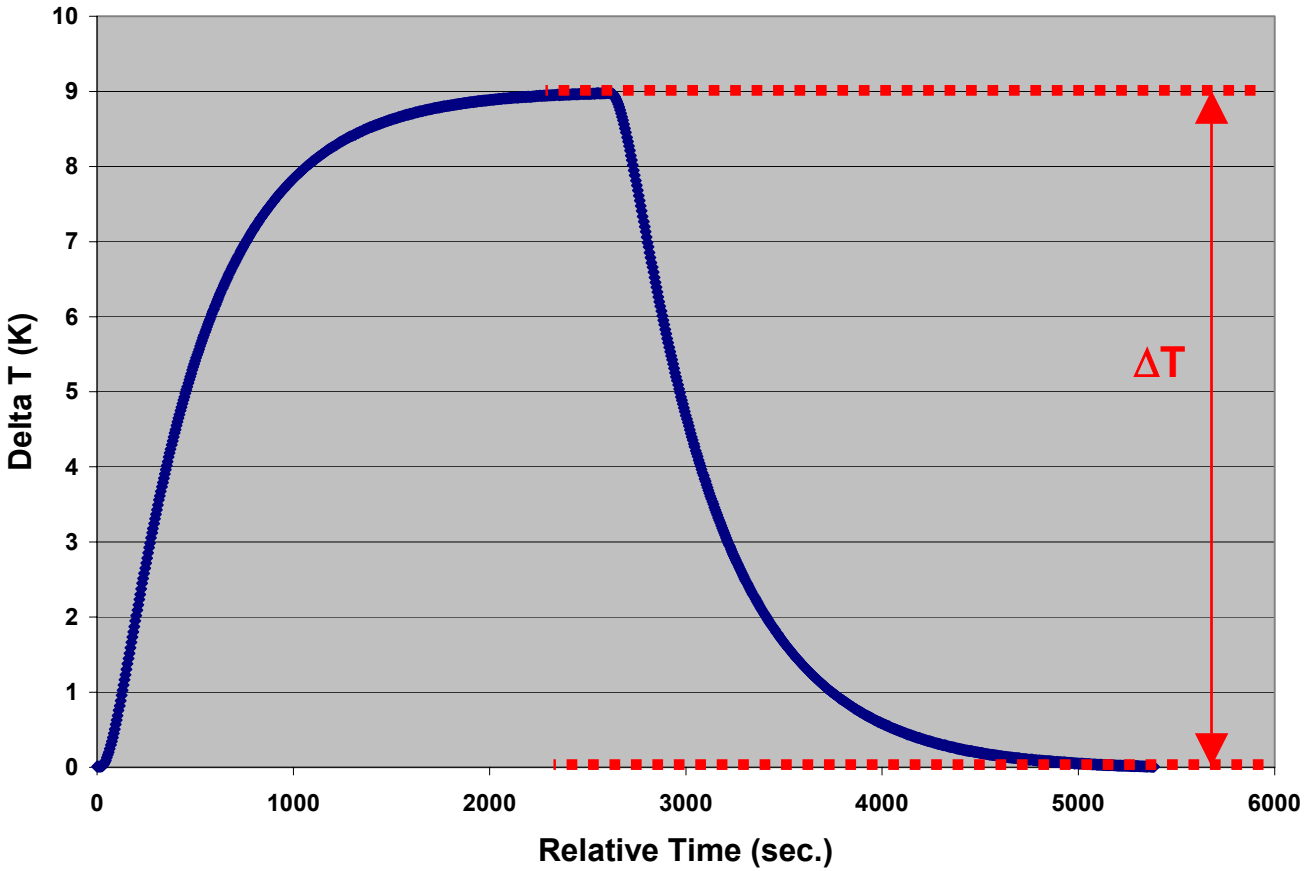
Data Processing



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Thermal Transport Formulas

- Conductance
- $K = P/\Delta T$

- Conductivity
- $\kappa = [(P_{IN}-P_{RAD})/\Delta T-K_{WIRES}](L/A)$

- $P_{RAD} = \sigma\varepsilon(S/2)(T_{HOT}^4-T_{COLD}^4)$

- K_{WIRES} is Measured Directly!

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Measurement Adjustments

1. Stable Measurements
2. $\Delta T \sim 0.5K - 1.5K$
3. Measure Parasitic Conductance
4. Manual Data Processing

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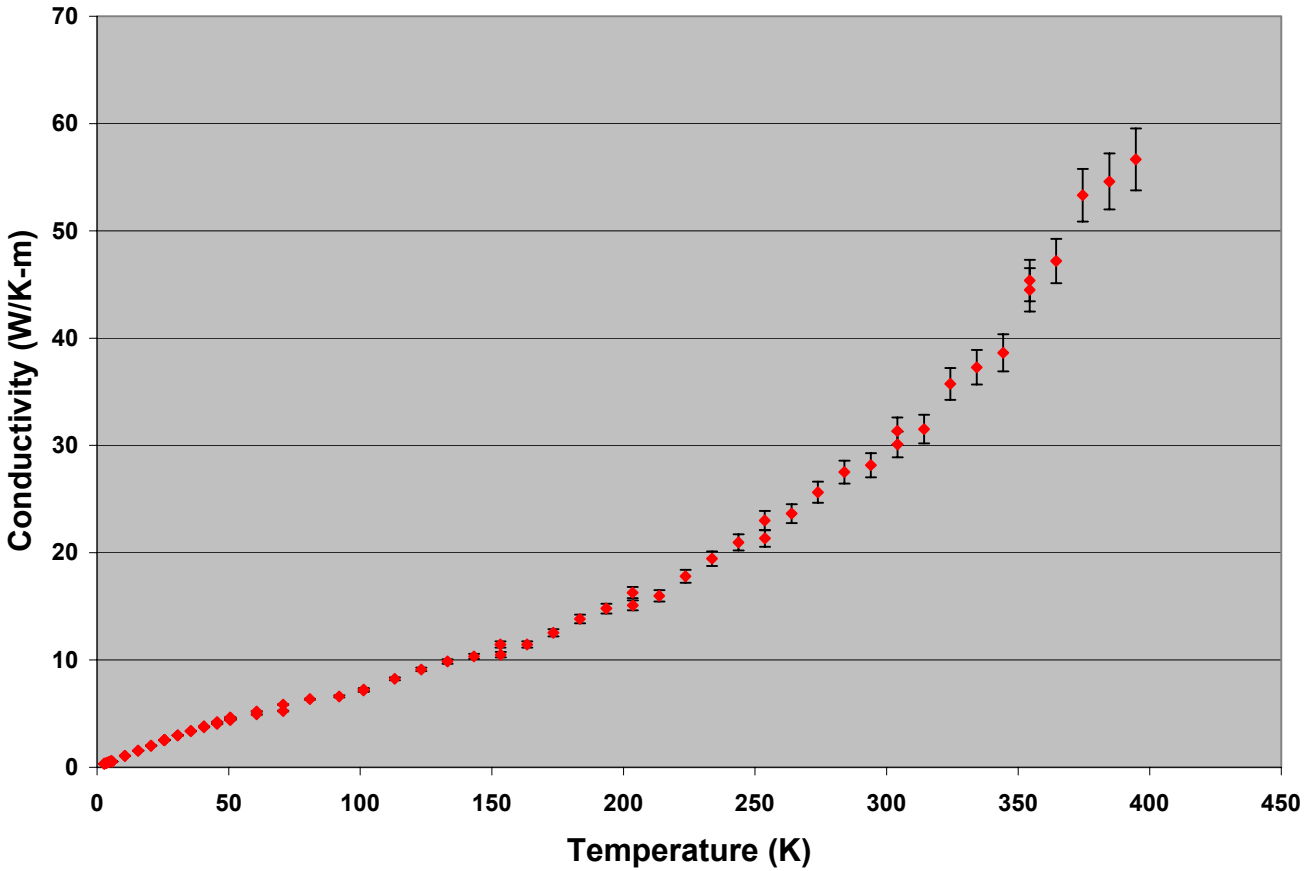
Thermal Conductivity



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Heat Capacity - Theory

1. Generate Heat Pulse
2. Measure RC
3. Estimate Corrections
4. Calculate Heat Capacity!

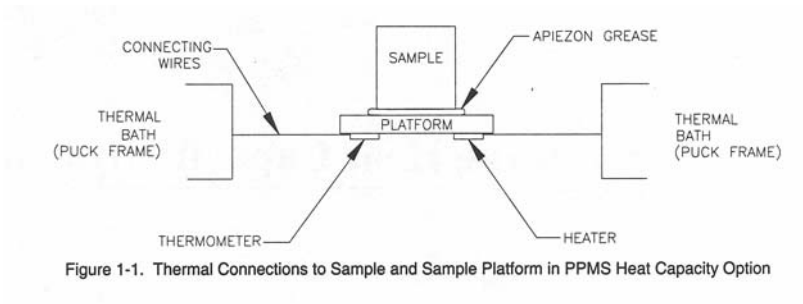

Figure 1-1. Thermal Connections to Sample and Sample Platform in PPMS Heat Capacity Option

- $\Delta T = T_{\infty}\exp[-t/R_8(C_P+C_G+C_S)]$

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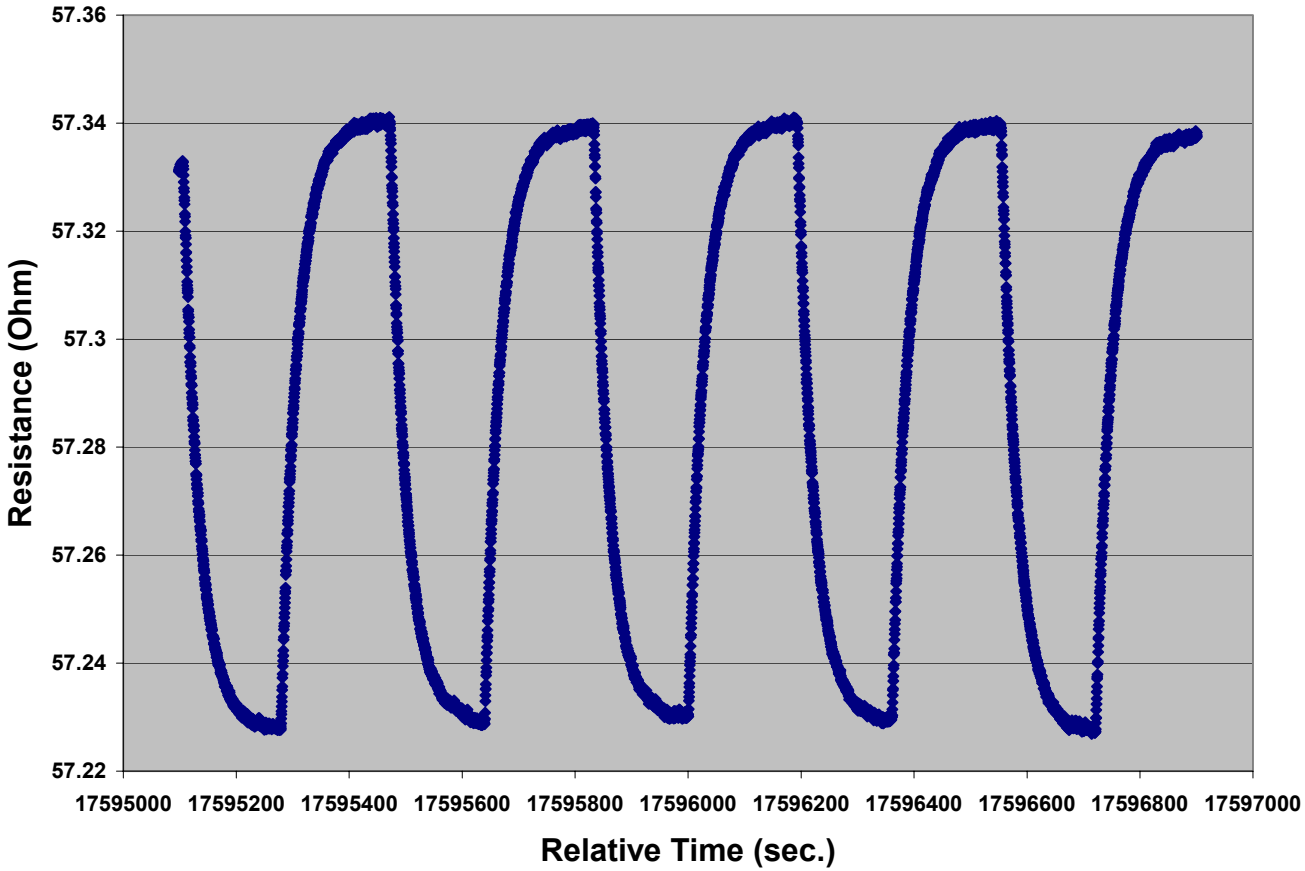
Heat Capacity – Sample Data



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Q Factor Measurement