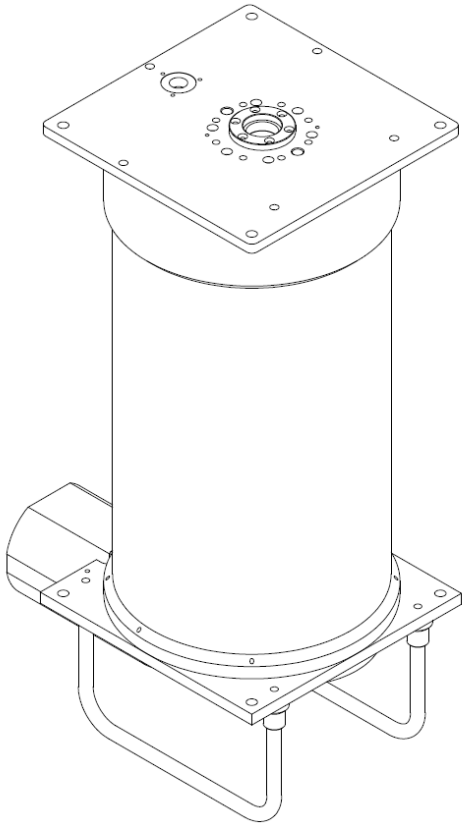
X-Band OMT Evaluation
SOC Design Thermal Analysis

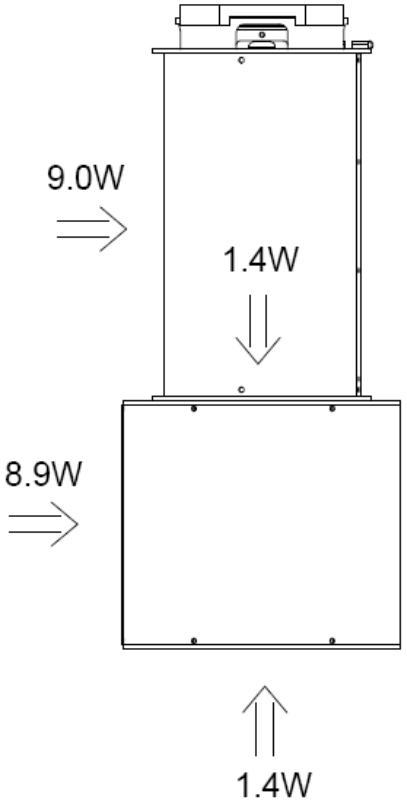
2009/10/01

Approach

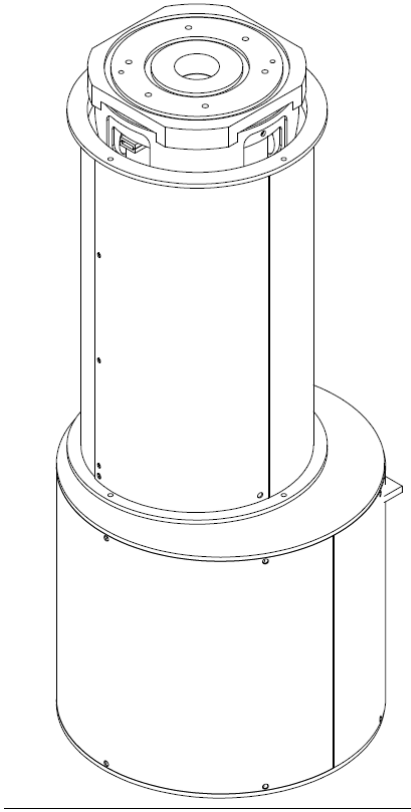
- Finite Element Analysis
  - Have the tools (CFDesign)
  - No verified models
  - Learning curve
  - Limited time
- Simplified Approach
  - Treat the complex surfaces as cylinders and plates
  - Only evaluate critical areas (large surface areas with large temperature differences)
  - Evaluate for the worst case thermal conductivity and emissivity
  - Calculate all of the 300K to 50K and 50K to 15K loads
  - Compare with the cold head capabilities

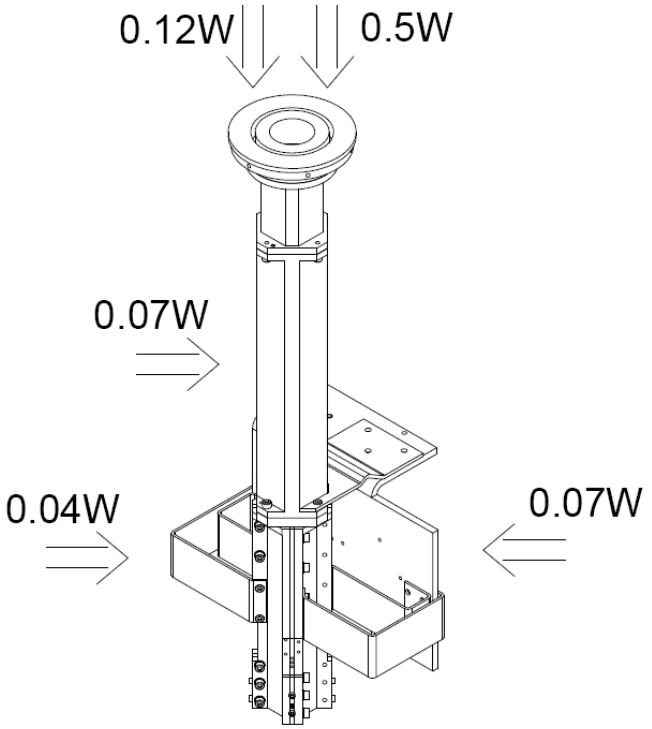
First Stage Loads





Second Stage Loads

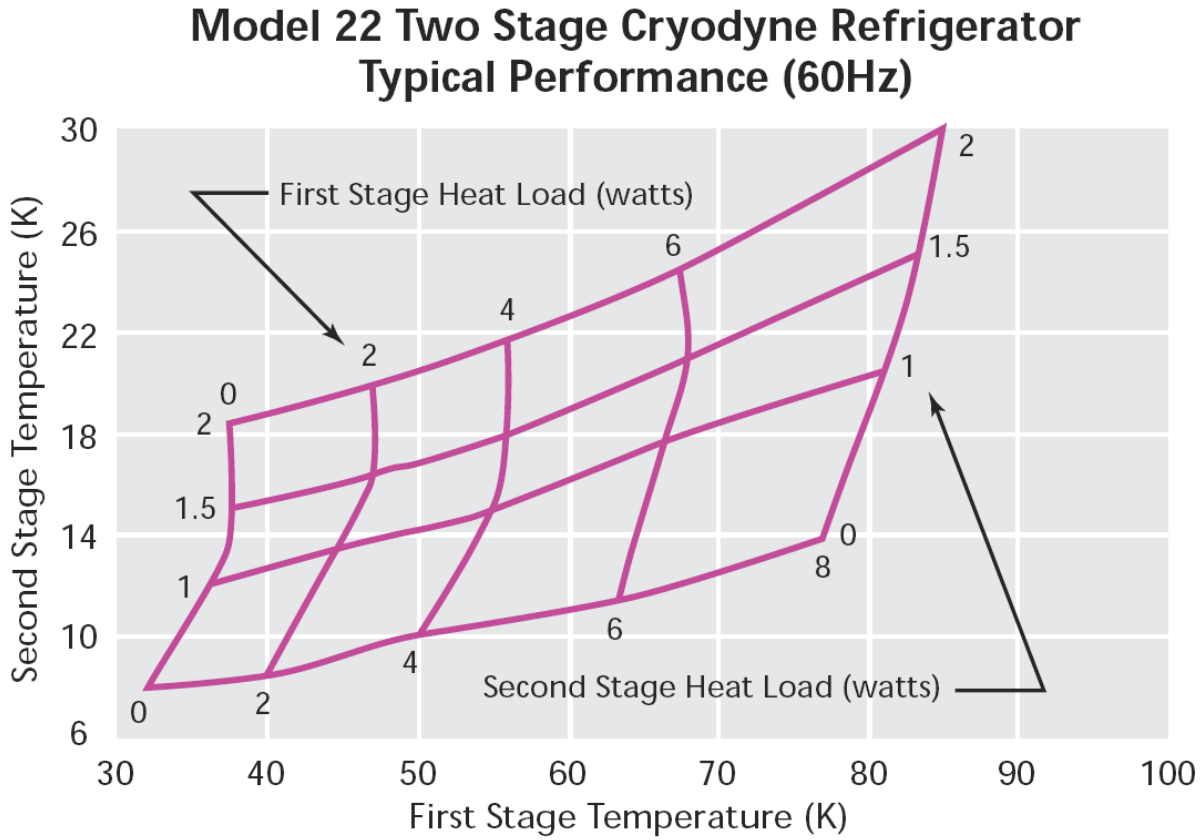




Approximate Total Loading

- First Stage: 21.1W
- Second Stage: 0.75W
  - Assuming 100K Shield
- Compare with CTI Performance Chart

CTI Model 22


Model 22 Two Stage Cryodyne Refrigerator
Typical Performance (60Hz)
Second Stage Temperature (K)
First Stage Temperature (K)
First Stage Heat Load (watts)
Second Stage Heat Load (watts)
30
26
22
18
14
10
6
30
40
50
60
70
80
90
100
0
2
4
6
8
1
1.5
2

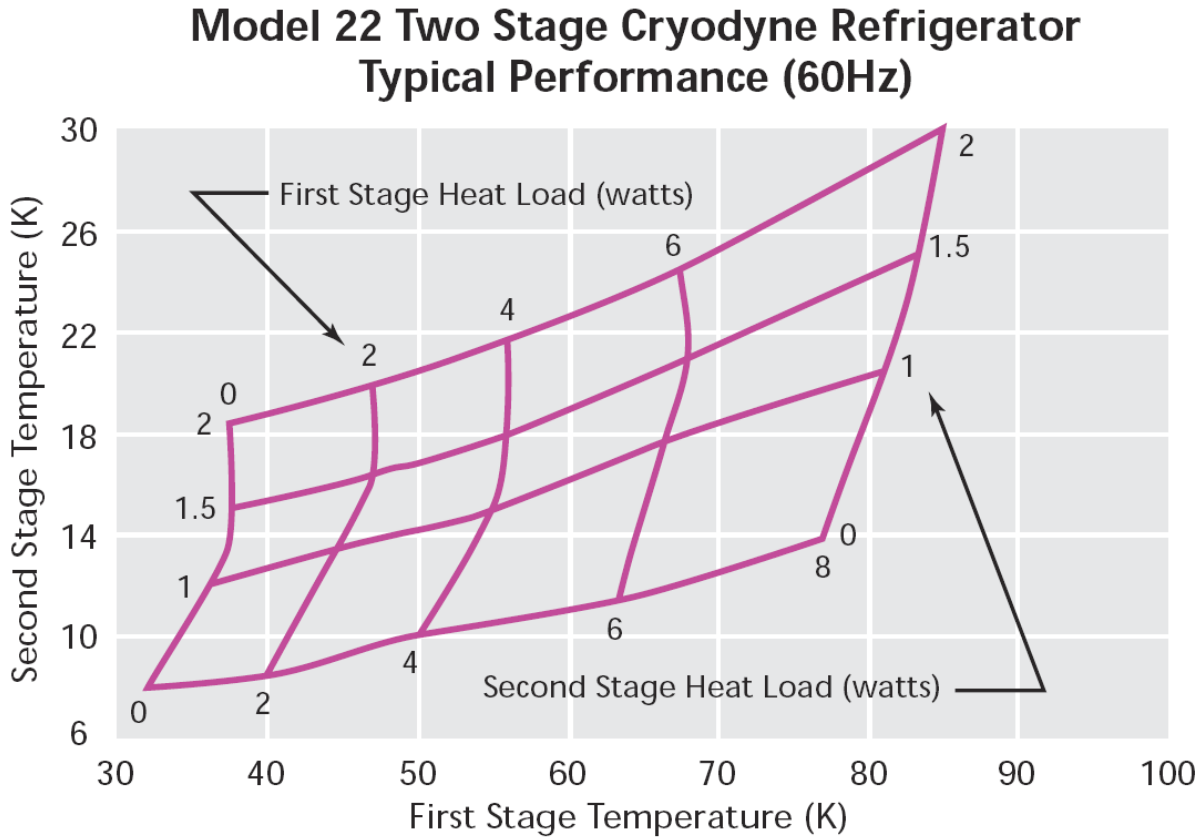
Evaluations

- The loads are within the range of the second stage
- To get the OMT below 20K the first stage needs to be around 100K
  - Previous second stage load was calculated from a 100K second stage
- At least 10W off the chart on the first stage
  - Add radiation blankets (floating shields) to provide protection from the 300K environment

Floating Shields

- The use of independently floating, cascading shields should provide a reduction of transferred power by a factor of N+1
- Use of a 4 layer radiation blanket should gives an 80% reduction in transferred power
- Reduces the load on the first stage to 5.4W

CTI Model 22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60
70
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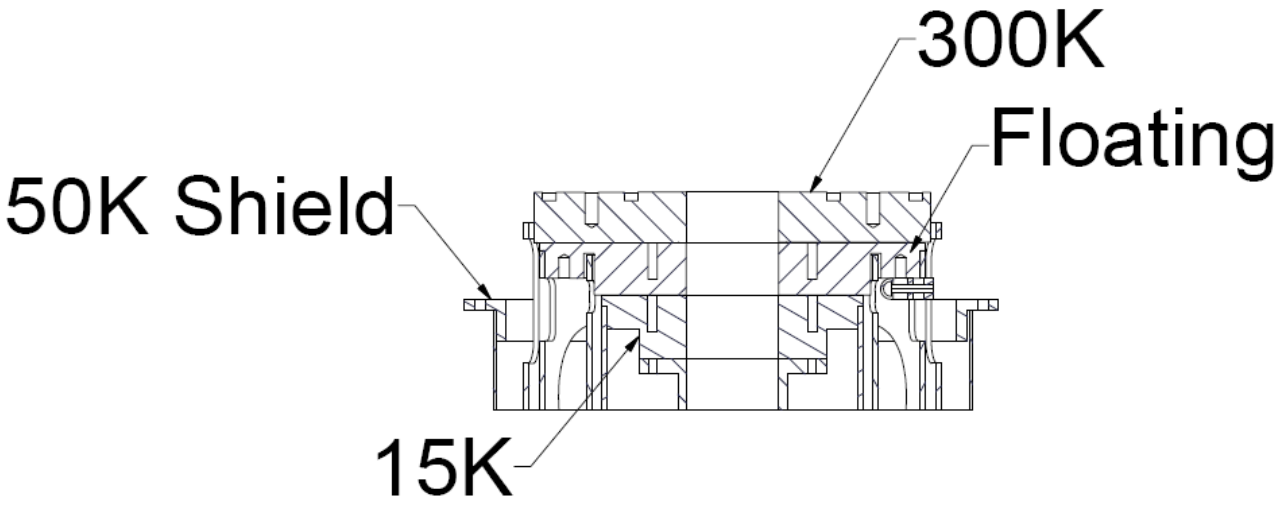
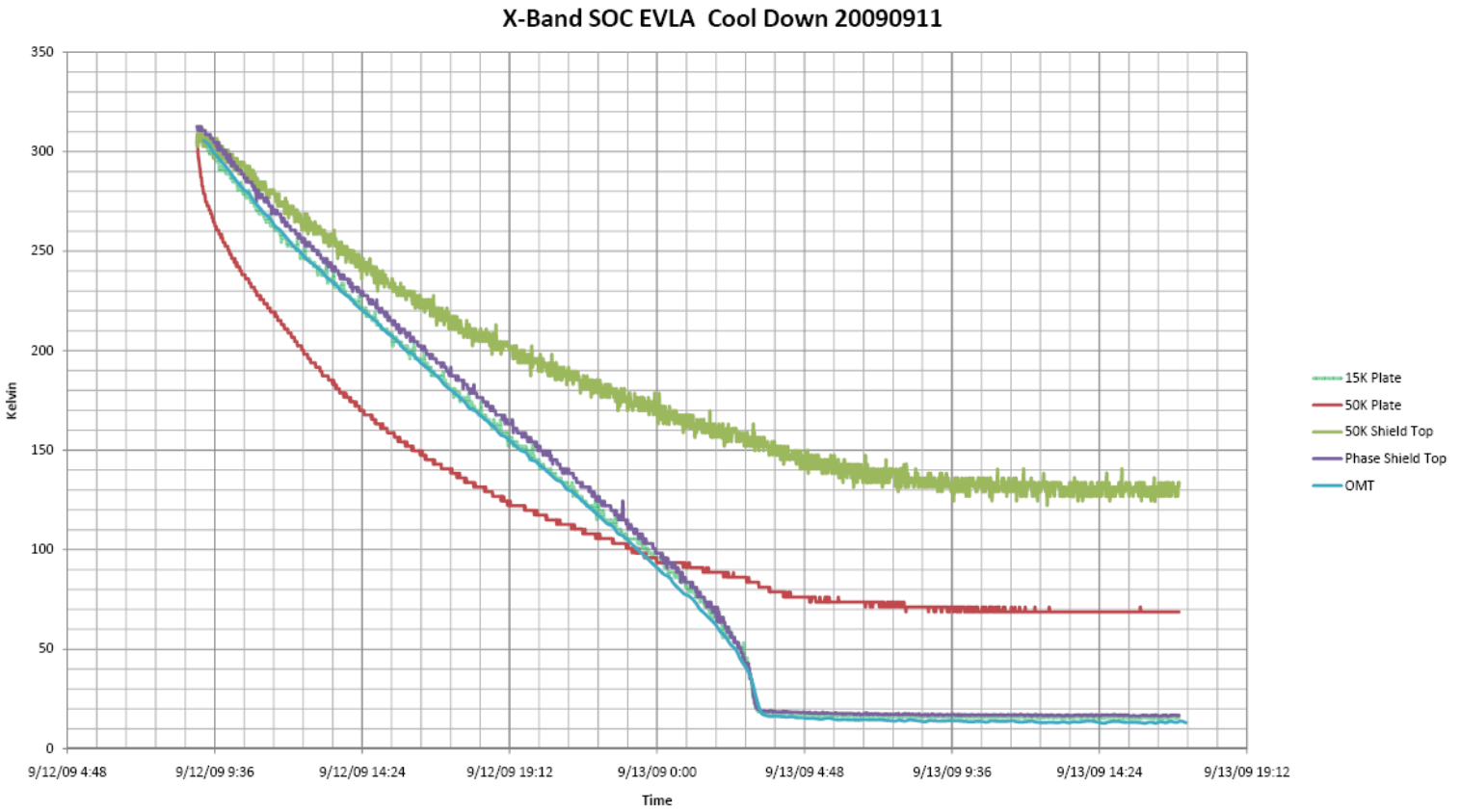
100
0
2
4
6
8
1
1.5
2

Further Reductions



- Note that top of the thermal gap (15K) is exposed to the 300K
- Adding some shielding here could also help the load on the second stage
- Use of a quasi floating gap (tied to the first stage) transfers 99% of the load (0.11W) off of the second stage and onto the first.

Cool Down


X-Band SOC EVLA Cool Down 20090911
Kelvin
350
300
250
200
150
100
50
0
9/12/09 4:48
9/12/09 9:36
9/12/09 14:24
9/12/09 19:12
9/13/09 0:00
9/13/09 4:48
9/13/09 9:36
9/13/09 14:24
9/13/09 19:12
Time
15K Plate
50K Plate
50K Shield Top
Phase Shield Top
OMT

Cool Down Numbers

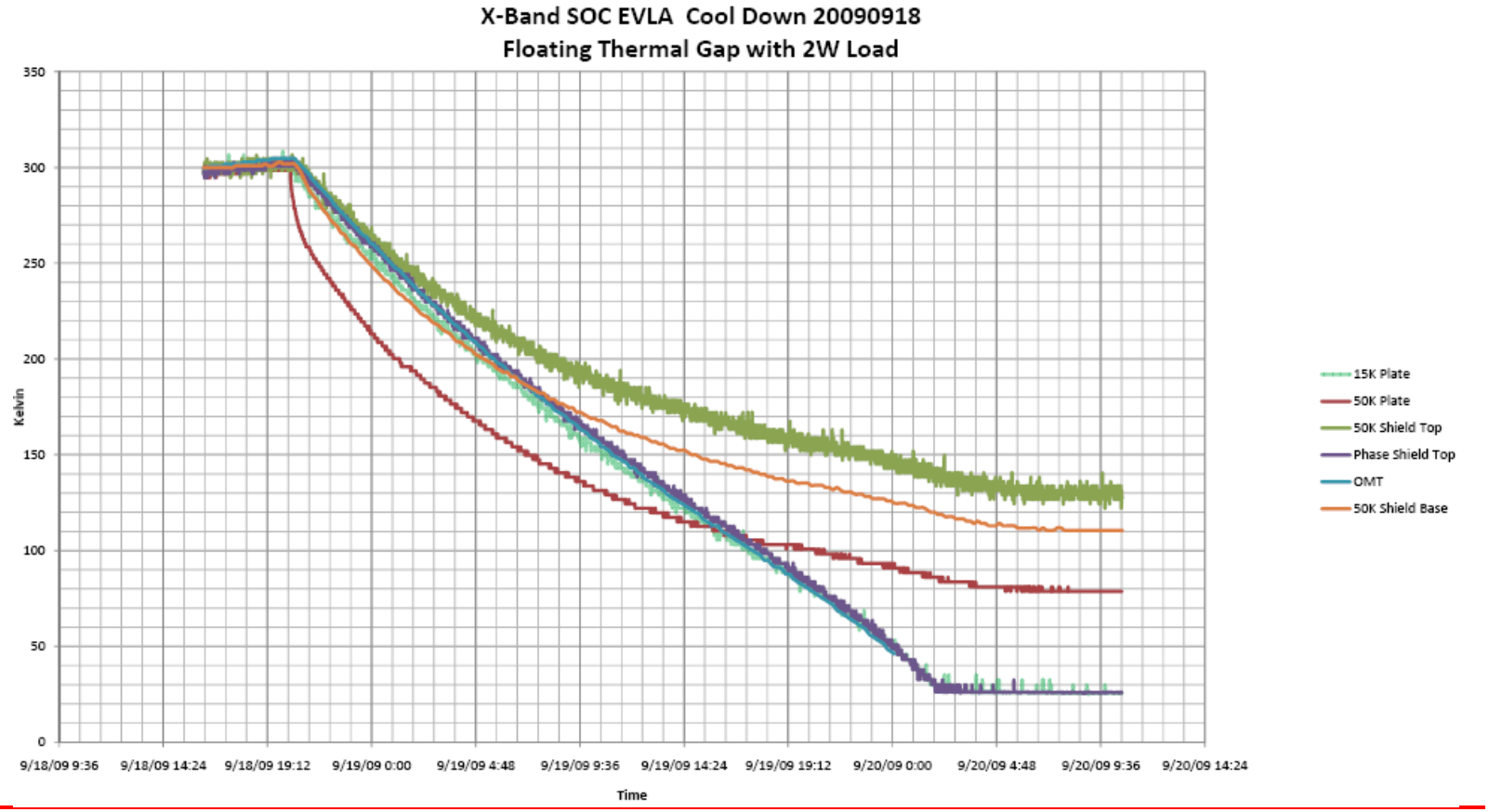
Data Analysis					
	Start Time	Below 20K Time	Total Cool Down Time (hrs)		
	9/12/2009 9:13	9/13/2009 3:23	18.1675		
		Supply Pressure	300psi		
Start Temperatures 9/12/2009 9:13:46 AM			Below 20K Temperatures 9/13/2009 3:23:49 AM		
Location	Value (K)	Recording Device	Location	Value (K)	Recording Device
15K Plate	312	DAQ	15K Plate	18	DAQ
50K Plate	304	DAQ	50K Plate	81	DAQ
50K Shield Base	-	Broke Sensor	50K Shield Base	-	Broke Sensor
50K Shield Top	303	DAQ	50K Shield Top	151	DAQ
OMT	306	Card Cage	OMT	18	Card Cage
Phase Shifter Top	312	DAQ	Phase Shifter Top	19	DAQ
Phase Shifter Bottom	-	Open	Phase Shifter Bottom	-	Open

Success?

- Within the target range of 20K on the second stage
- But no heat load from the stainless coaxial cables and amplifiers

- Next Step
  - Apply a 50mW load thru the heating resisters to simulate the electronic heat load
  - Miscommunication and applied a 2W heat load

2W Load Chart



2W Load Numbers

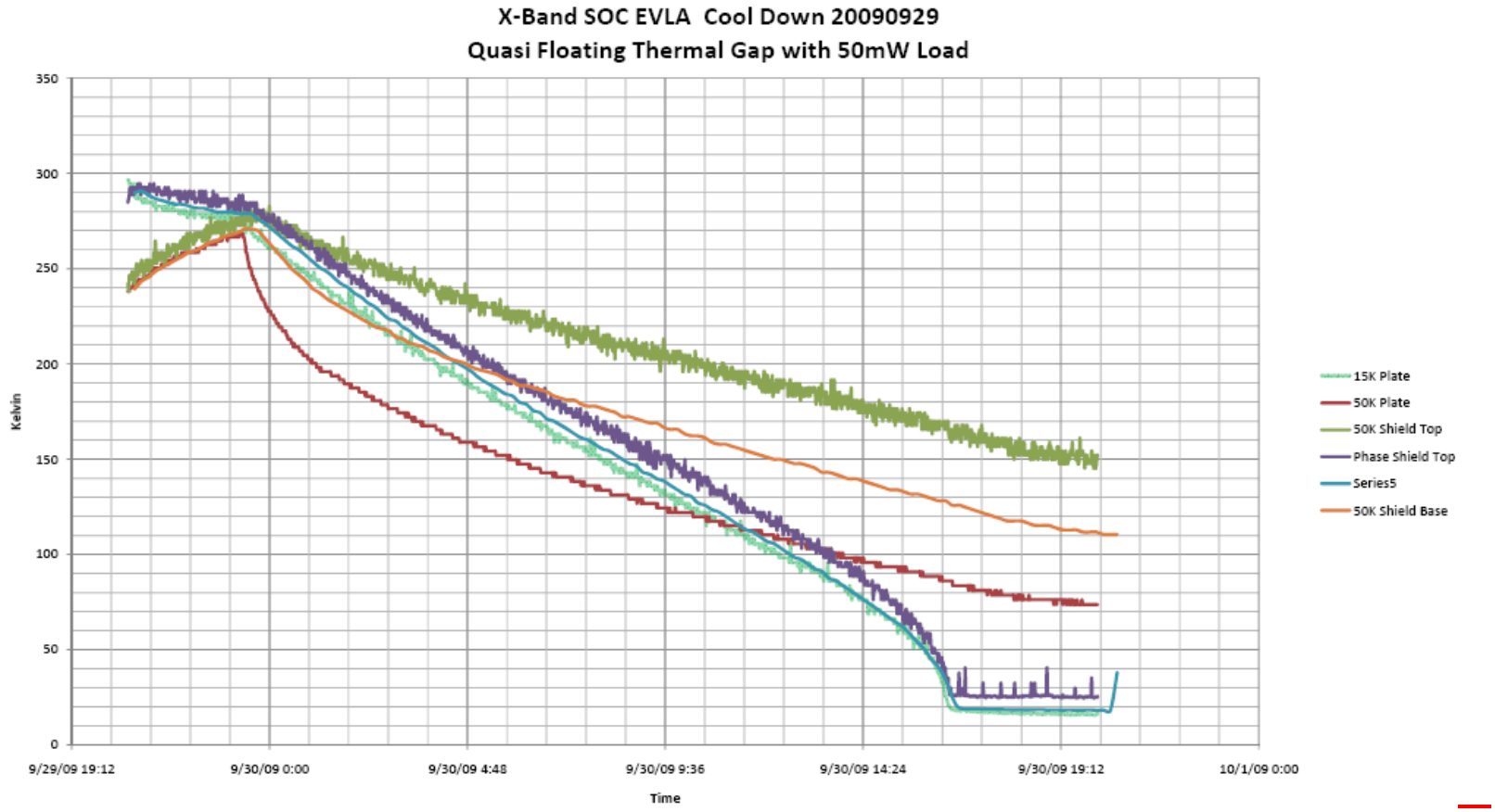
Data Analysis					
	Start Time	Below 20K Time	Total Cool Down Time (hrs)		
	9/18/09 16:16	9/20/2009 2:02	33.8		
	2W 15K Load	Supply Pressure	285psi		
Start Temperatures 9/18/2009 4:16:16 PM			Temperatures (K) 9/20/2009 10:30:49 AM		
Location	Value (K)	Recording Device	Location	Value (K)	Recording Device
15K Plate	298	DAQ	15K Plate	26	DAQ
50K Plate	297	DAQ	50K Plate	78	DAQ
50K Shield Base	300	Card Cage	50K Shield Base	111	Card Cage
50K Shield Top	297	DAQ	50K Shield Top	127	DAQ
OMT	300	Card Cage	OMT	25	Card Cage
Phase Shifter Top	297	DAQ	Phase Shifter Top	26	DAQ
Phase Shifter Bottom	-	Open	Phase Shifter Bottom	26	DAQ

No Such Thing As Bad Data

- Extremely long cool down time: 33hrs
- Failed to reach the 20K target range: 25K
- Floating gap settled at 220K
- Second Stage over loaded by 400 times

- Next Step
  - Apply a 50mW load thru the heating resisters to simulate the electronic heat load

50 mW Load Chart



50 mW Load Notes

- Cool down time*: 17hrs
- Within the 20K target range
- Not an official cool down, unstable starting points
- The CTI Model 22 can handle the electronics heat load

Future Work

- Reduce the resistance between the first stage shields be adding thermal strapping
- Reduce the 300K effects through the waveguide by adding a foam plug into the floating gap
- Reduce the size of the dewar and radiation shields

Conclusion

- The proposed X-Band Quad-Ridge OMT is capable of being cooled with a CTI Model 22 in the 20K range.
- Cool down time in the current configuration are approximately18hrs.
- Appears to be room for improvement

Questions