CTEC: CubeSat Thermal Environment Chamber

Bryan Klofas, Karl van Dyk, Rick Doe

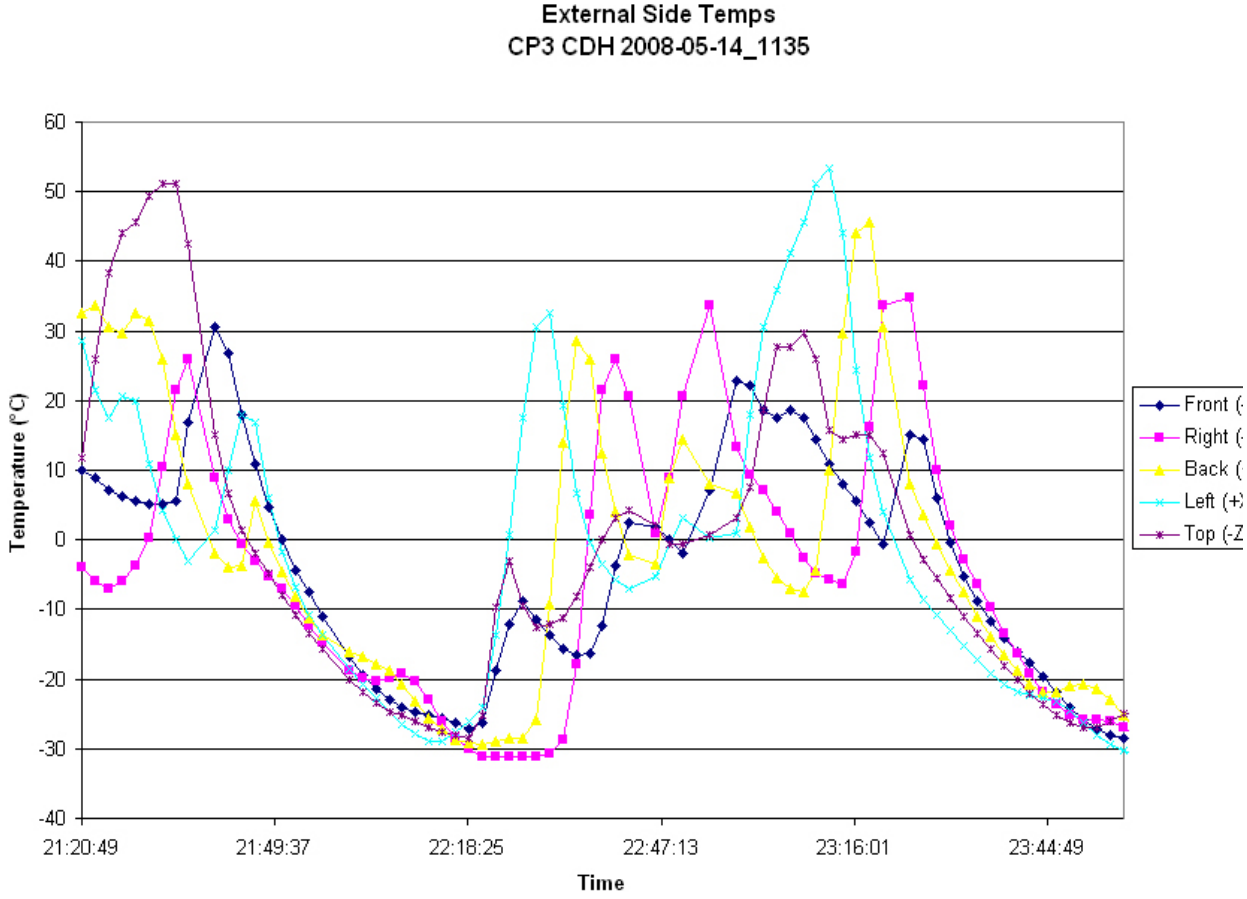
SRI International

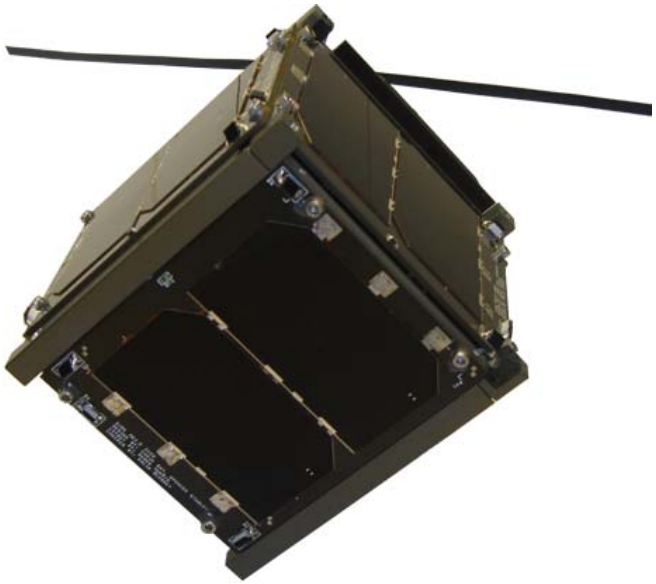
Background

- Traditional CubeSat Thermal Vacuum testing is inefficient for troubleshooting payloads
  - Limited access to internal payload signals
  - Not sure if the problem is on the bus or payload side
- Heat-sensitive and heat-generating payloads need to be evaluated for realistic LEO thermal cycling
- SRI CubeSat payload projects require a rapid, low-cost solution

Expected Temps on Orbit

- CP3 showed us -30 to +50 degrees Celsius
- Not attitude controlled in any way

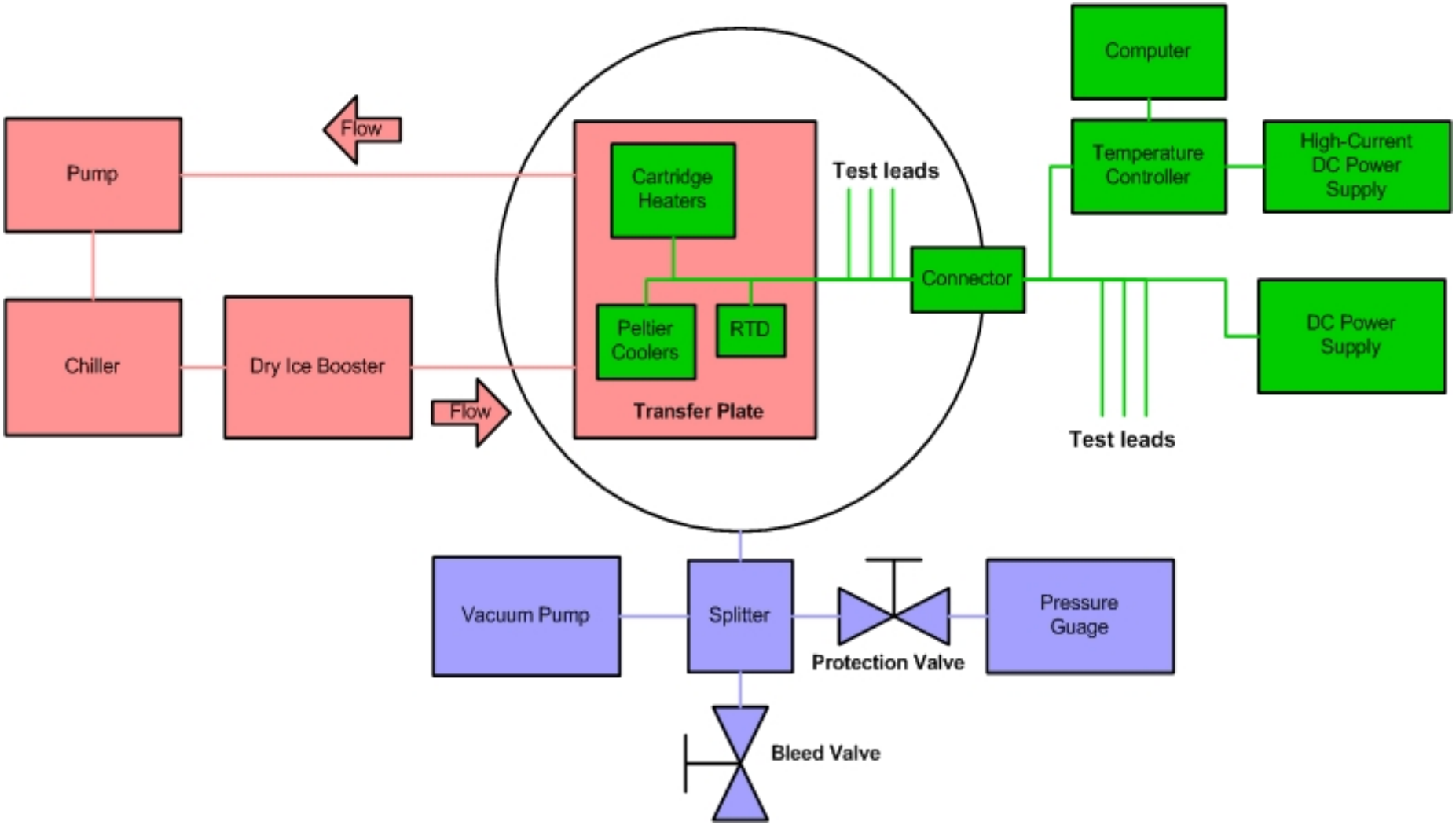




Approach

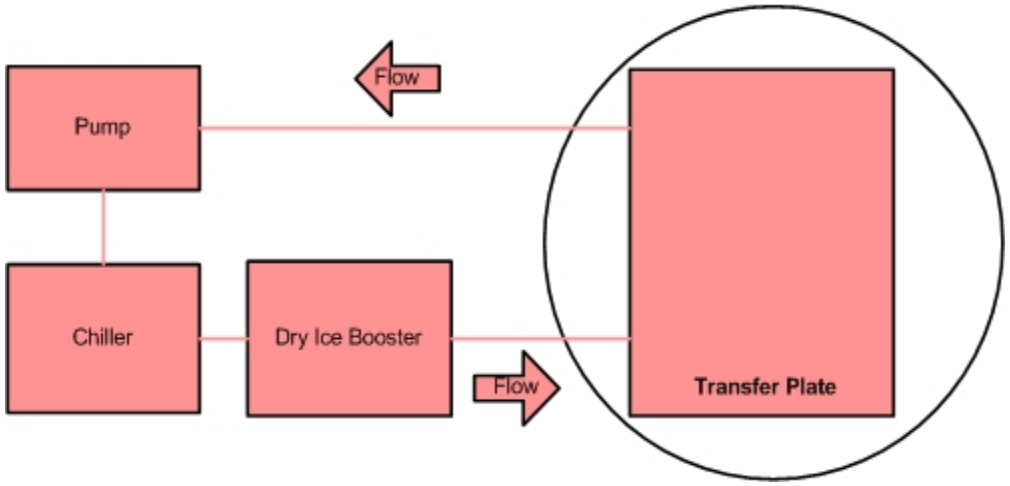
- Build a vacuum chamber sufficient to suppress convection.
- Design a simulated CubeSat external skin capable of user-specified thermal forcing.
- Limit volume of chamber for rapid evacuation and purging to ease payload access.
- Provide multiple twisted pair and RF signal paths.
- Keep material costs cheap.
- No consumables.

Block Diagram



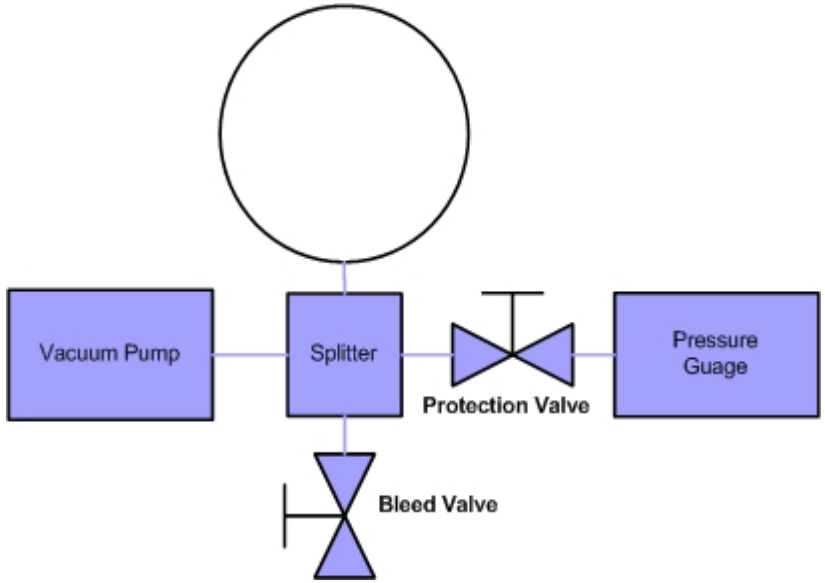
Thermal System

- Off-the-shelf chiller
- Pump (preferably self priming)
- Custom transfer plate (CPU cooler?)
- Swagelok connectors



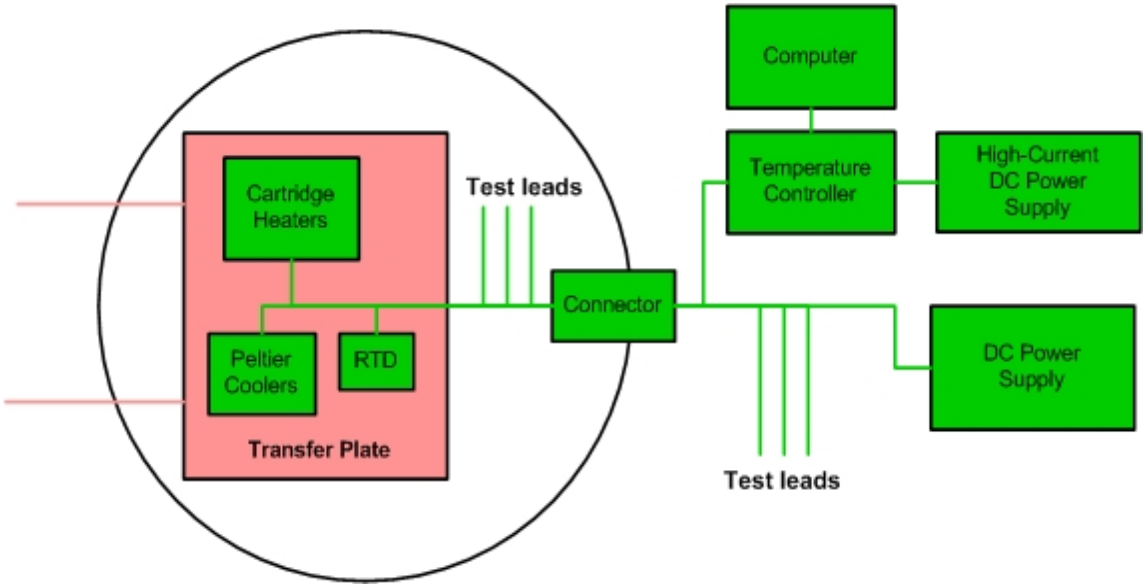
Vacuum System

- Uses a Ultra High Molecular Weight Polyethylene ring (McMaster-Carr)
- Plexiglas bottom plate cracked, replaced with aluminum plate (conductive)
- 14 liter Bell jar

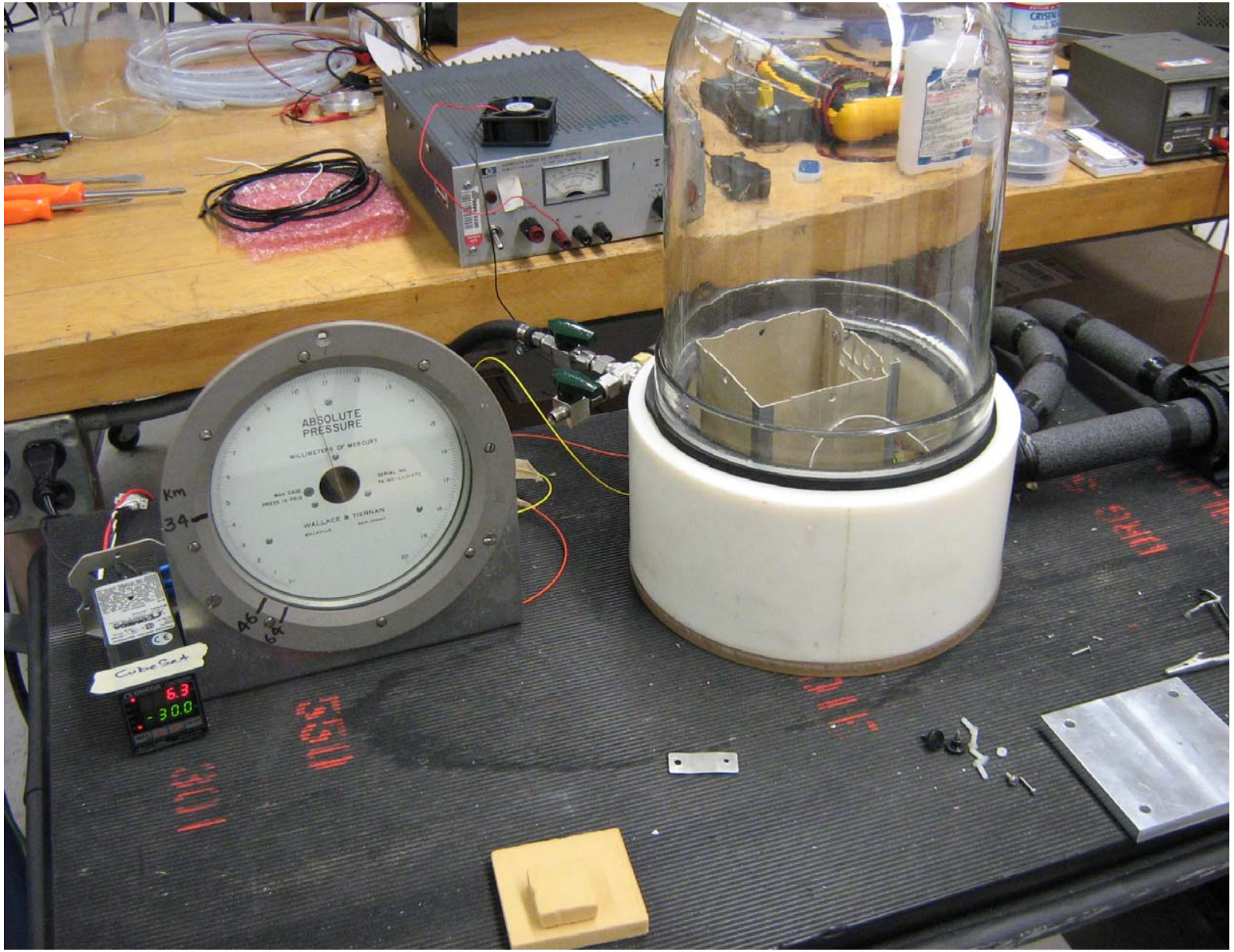


Electrical System

- Temperature controller for Peltier coolers
- Potted non-pressure-rated connector (DigiKey)
- Lots of extra pass-through test leads for power, signal measurement



Picture


ABSOLUTE
PRESSURE
MILLIMETERS OF MERCURY
WALLACE & TIERNAN
Km
34
46
54
CubeSat
6.3
- 30.0

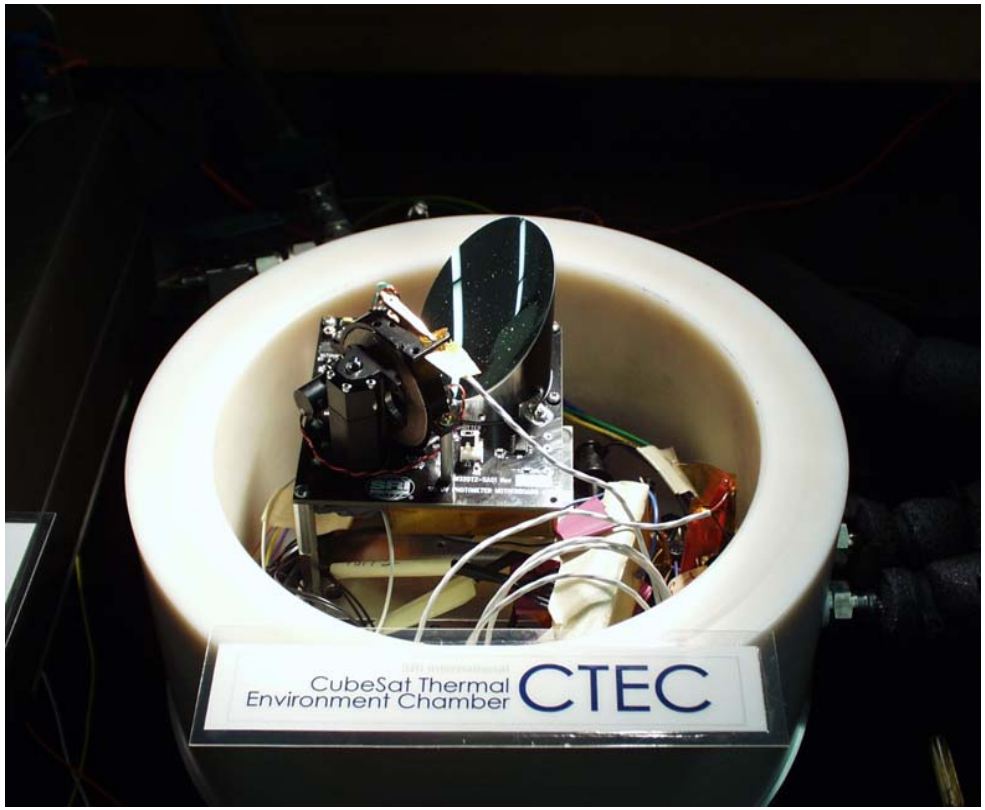
Parts list

- On Hand:
  - 14-liter bell jar, roughing pump, polyurethane ring connectors, plumbing, and Tygon tubing
  - 15V 12A power supply
  - Pumpkin Inc. 1U solid frame CubeSat skin
- Purchased
  - RTDs, Peltier coolers, cartridge heaters, fish tank cooler (180 W), pond pump
- Manufactured
  - Heat transfer plate

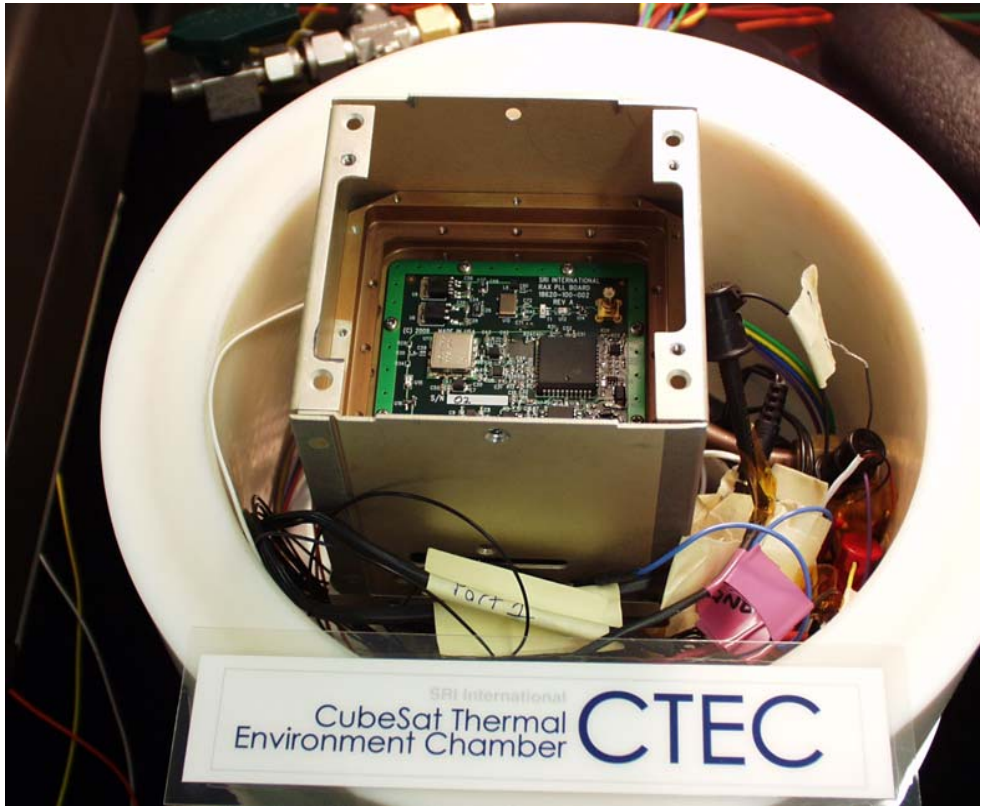
Specs

- Heat transfer capacity: 100W
- Minimum cold soak temperature: -40 deg C
- Cycle characteristics: min to max in 40 minutes
- Internal volume: 14 L + 2 inches
- Evacuation time: 5 minutes
- Repressurization time: 20 seconds
- Pressure: 0.2 Torr

Payloads Under Test



CTIP Payload



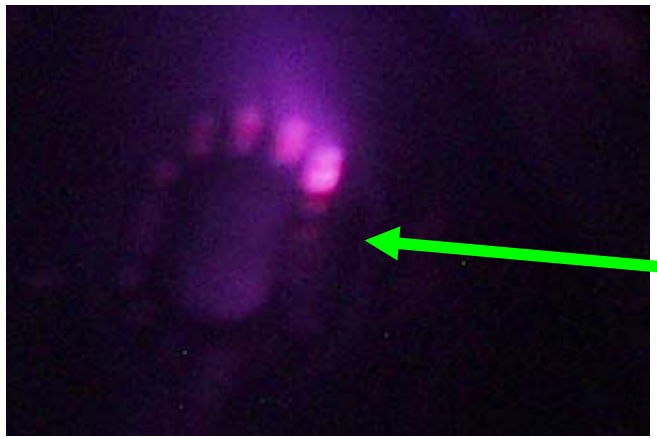
RAX Payload

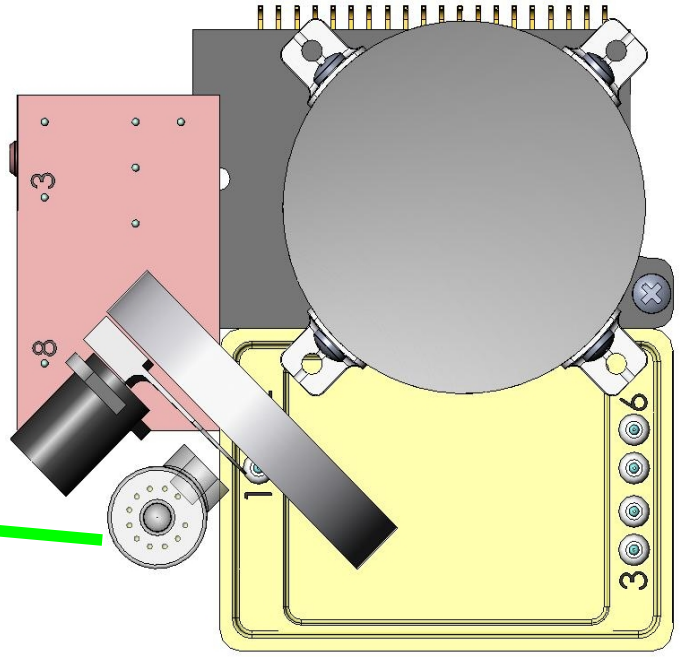
Interesting Things We Have Learned

- Pure ethanol is a great coolant
- Self priming pumps eliminate the need for suction pump priming
- Use of high voltage power supplies at milliTorr pressures creates plasma arcing

Paschen's Law

- Breakdown characteristics of a gap are a function of pressure, electric field, and gap length.
- As pressure goes down, breakdown voltage distance decreases.





Benefits over Regular T/VAC

- Faster to pump down
- Less expensive
- Free RF propagation (no metal sides)
- Much quicker to modify payloads during test

Lessons Learned

- Use a bigger chiller
- Use a self priming pump with less tubing
- Change only one thing at a time
- Have more pass-throughs than you ever think you would need – Cat5, RF, USB

Questions?

- Parts list available
- Thanks for your time

- bryan.klofas@sri.com