HALT/ HASS Testing of ATLAS Pixel Detector Modules

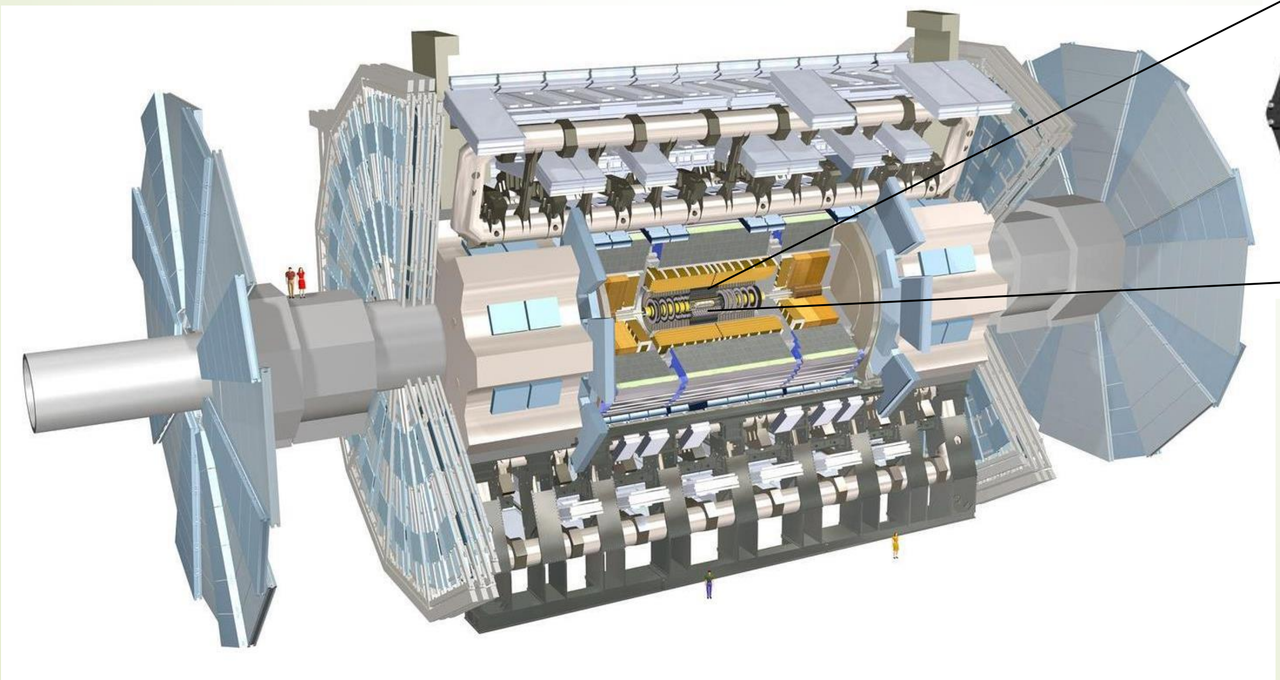
OU REU 2017 - JESSIE JOHNSON

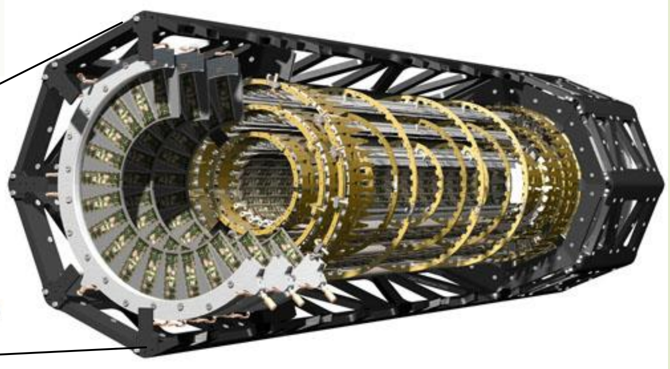
ADVISOR: DR. STUPAK

GRADUATE STUDENTS: JOSEPH LAMBERT & HYOYEON LEE

ATLAS and LHC

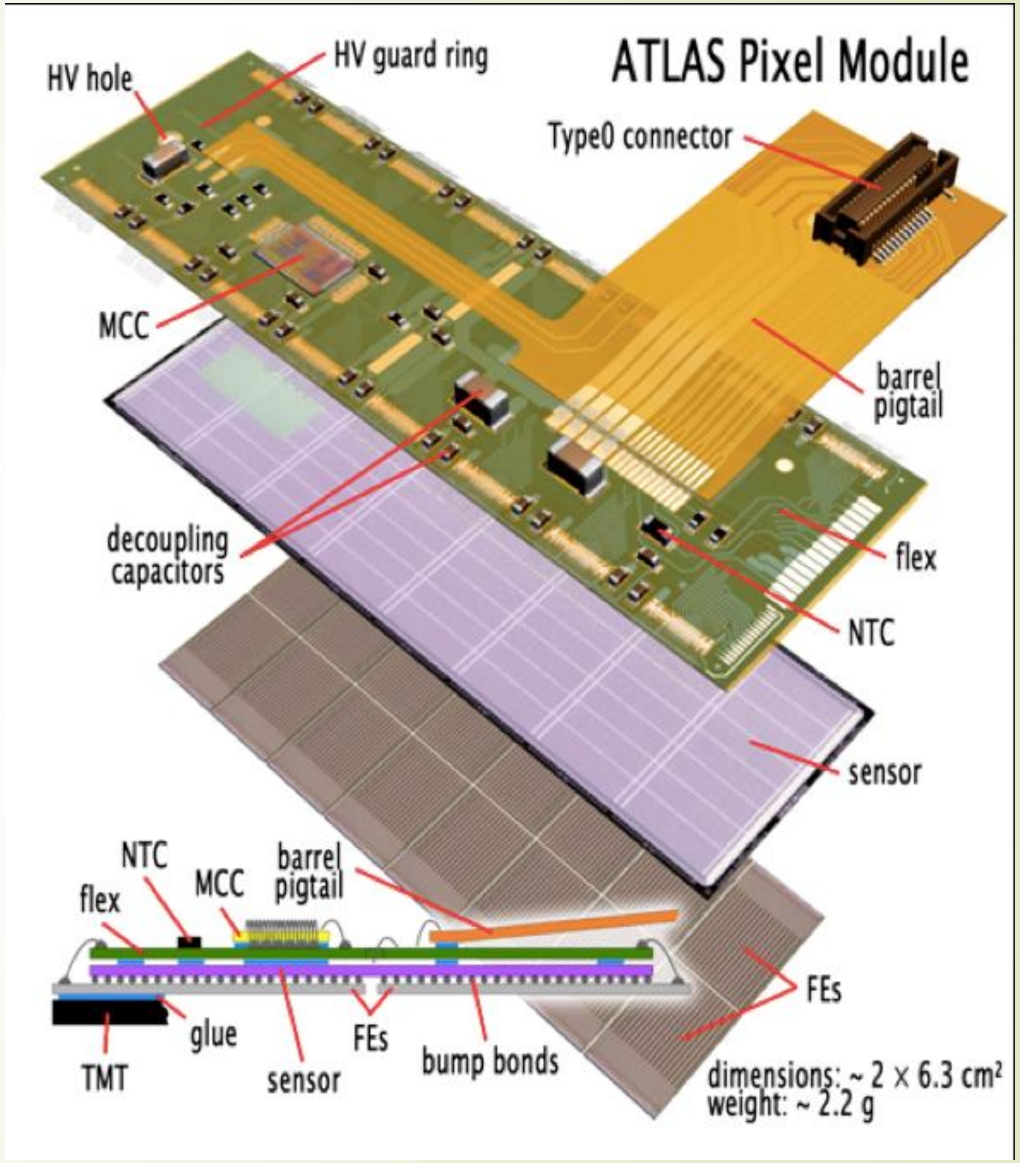
- ATLAS one of two main particle detectors
- Located at the Large Hadron Collider (LHC)
- Largest detector ever built
  - 46 m long and 25 m in diameter
- Has many different layers, each designed to observe different particles
- Inner most part is the pixel detector





Pixel Detector Modules

- 1,744 modules in total
- Different layers and materials can cause problems
- Top PCB, middle silicon sensor, bottom readout chips
- Layers can expand or contract at different rates depending on temperature
- Once installed cannot be removed
- Test them before installing them

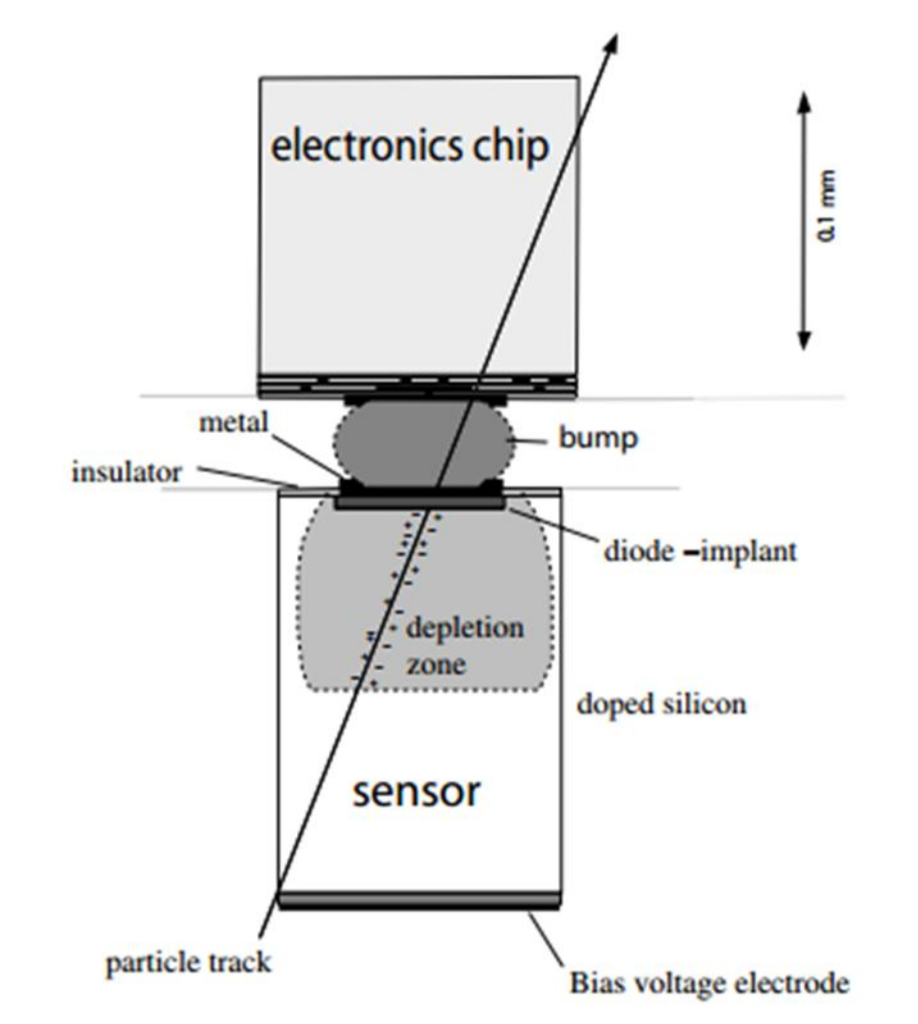


HALT/ HASS Testing

- Stress testing method for enhancing product reliability
- HALT- highly accelerated life test
  - High stress used to find weak spots in product design
  - Identify fundamental limits
- HASS- highly accelerated stress screening
  - Make sure they preform reliably for their intended service, not defective
  - Uses high stress beyond the operating level, but below destruct limits
- Goal of HALT/HASS testing is to quickly uncover problems associated with product design and production

Testing Conditions

- Two stresses: Thermal and Vibrational
- Operating stresses present
  - -20°C to 20°C
  - General vibrations present
- HALT test range: break the modules
- HASS test range: less than destruct limits
  - Temperatures: -40°C to 40°C
  - Vibrations: 4 grms to 40 grms

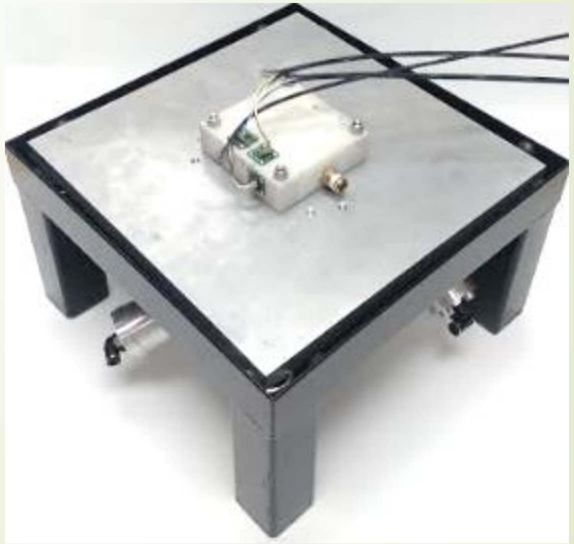


Testing Equipment

- HALT: vibration table in environmental chamber
- HASS: vibration table with cooling plates
  - Cooling using peltier and water as coolant
  - Cooling using liquid nitrogen and peltier as a heater

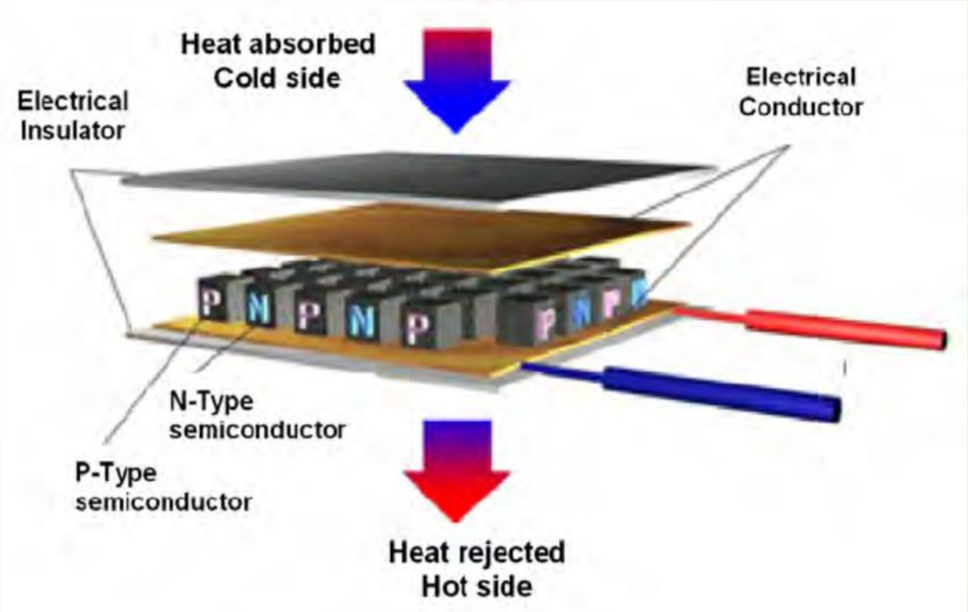
Vibration Table

- Graduate students doing most of the work on this
- 3 cylinders on the bottom of the table with pistons inside
- Design changes to combat problems of control and max grms
  - No plastic caps = high grms but bad control
  - Larger diameter caps = better control, wide range of grms



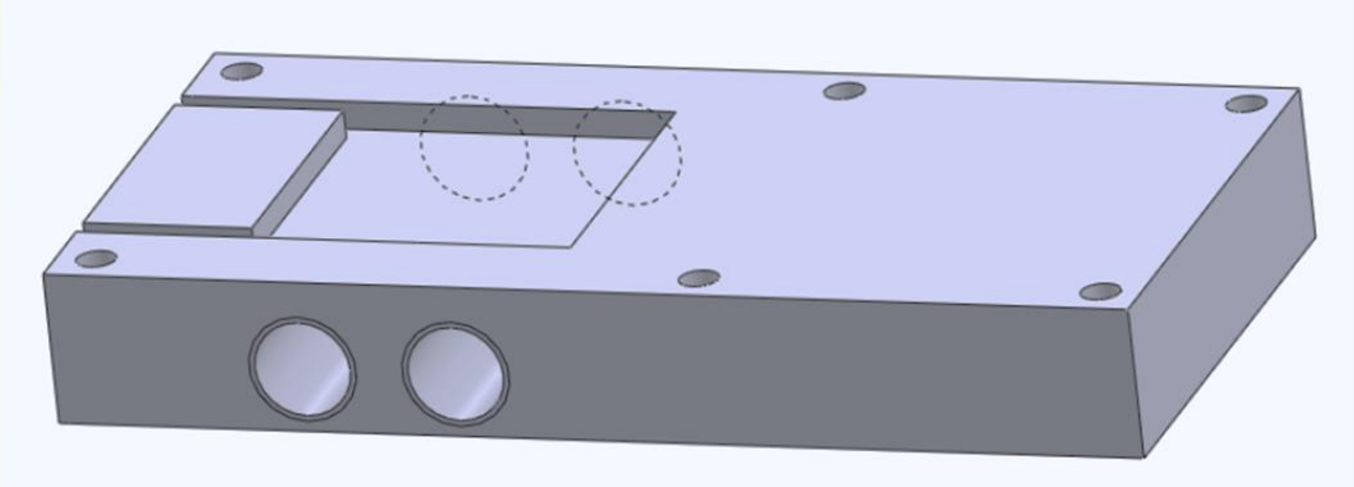
Cooling Method: Peltiers

- Utilize peltiers
  - Act as a heat pump
- Maximize cooling capabilities means keeping hot side cool
  - Need a heatsink to dissipate heat = cooling plate
- Versatile
  - Heat or cool
  - Can use liquid nitrogen if needed/ wanted
- Controllable



Cooling Plate

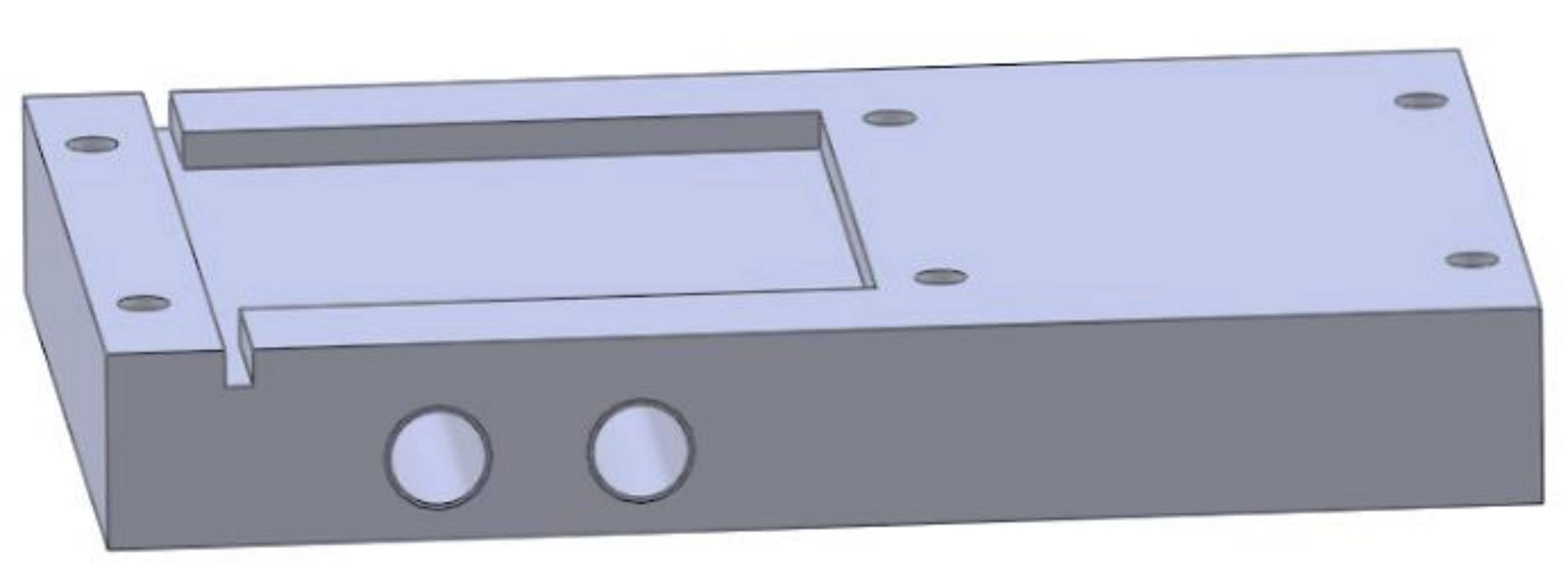
- Initial design



- Problems:
  - Holes too large
  - National Pipe Thread (NPT) sizes

Cooling Plate

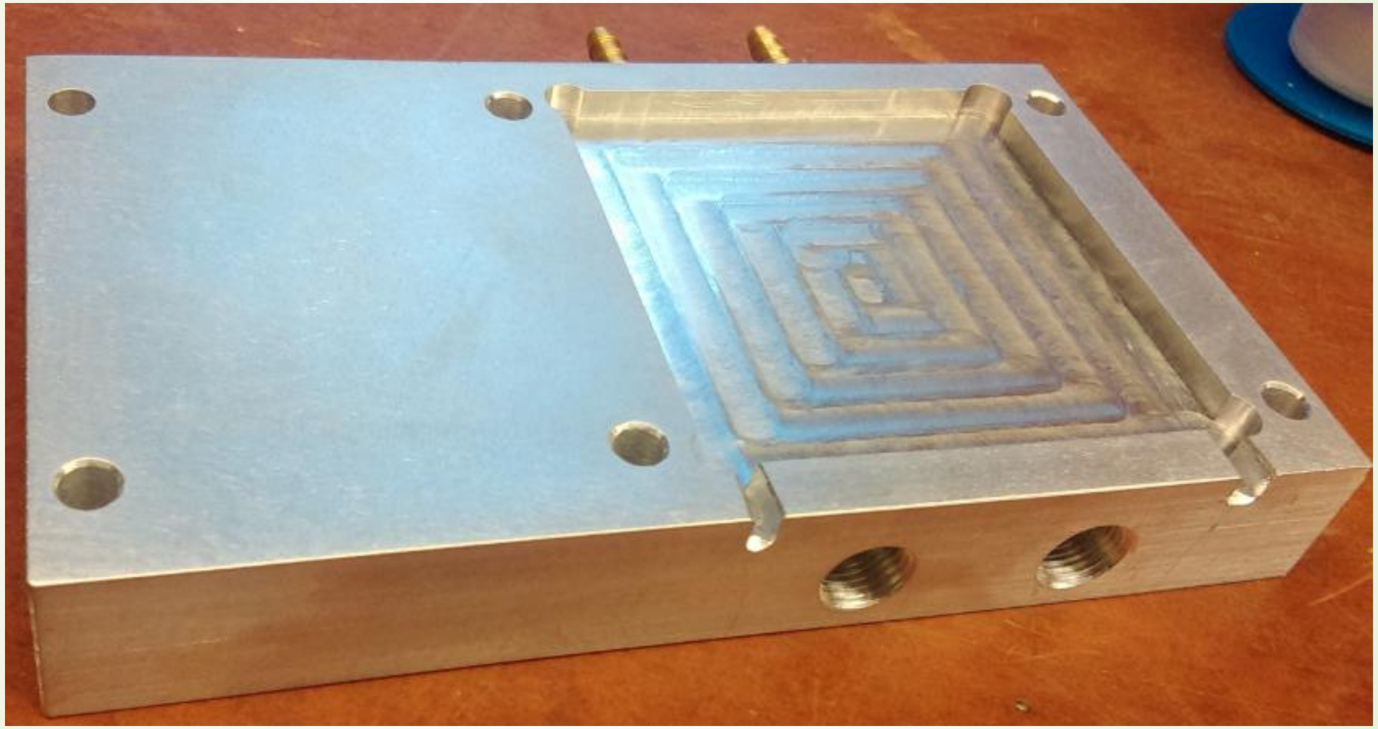
- Redesigned to fit larger peltier



- Sent drawings to the shop like this
- Changes were still made

Cooling Plate

- As built

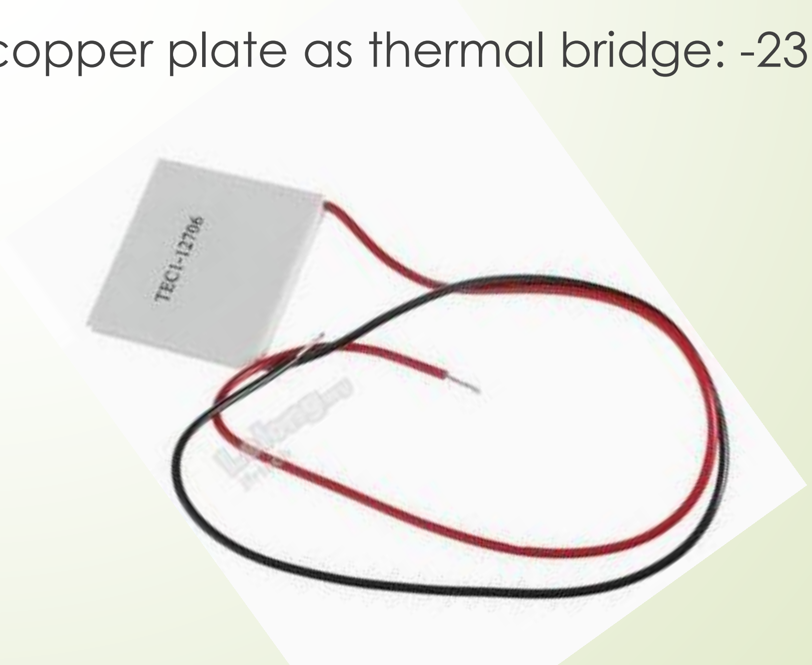


- Still flaws in the design
- Thermal contact of module carrier on top of peltier and cooling plate will create a thermal bridge

Results: Small Peltier

- Ran a variety of tests trying to get lowest temperature possible

- Only peltier on cooling plate: -29°C
- Peltier on cooling plate w/ copper plate on top of peltier: -30 °C
- Peltier on cooling plate with copper plate as thermal bridge: -23 °C
- Stacked small peltiers: -34 °C



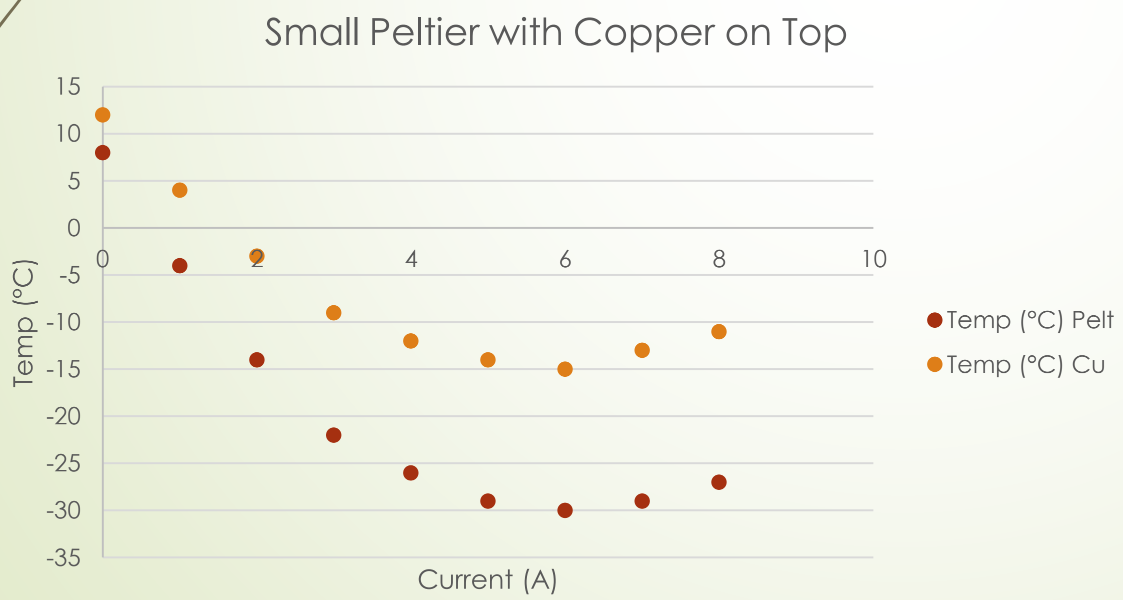
Results: Large Peltier

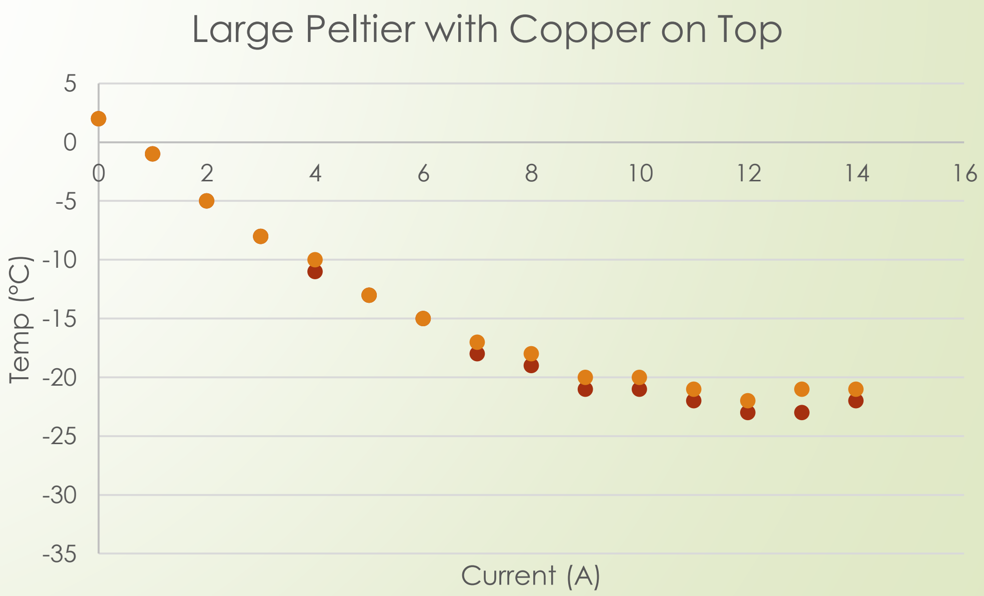
- Ran a the similar tests with the large peltier as with the small

- Only peltier on cooling plate: -18°C
- Peltier on cooling plate w/ copper plate on top of peltier: -23 °C
- The large peltier doesn’t seem to cool as well as the small

Conclusions

- Lowest Temp by Small Peltier: -34°C
- Lowest Temp by large Peltier: -23°C
- Large peltier should be able to get to similar temperatures, but may not be able to dissipate the heat produced from the large peltier
  - Larger surface area of heat from large peltier
- Large Peltier was better at cooling copper plate to temp of the peltier





Next Steps

- Run more tests
  - Run test with plastic insulator
  - Experiment with liquid nitrogen
  - Find more effective ways of cooling
- Write a program to control a power supply to change the temperature
- Obtain a power supply that is programmable and large enough to power the peltiers

Questions?