FAMU-FSU College of Engineering

Team 501
Tribometer in Spacelike Conditions

VDR5 240227

Team Introductions

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3M Science. Applied to Life.™

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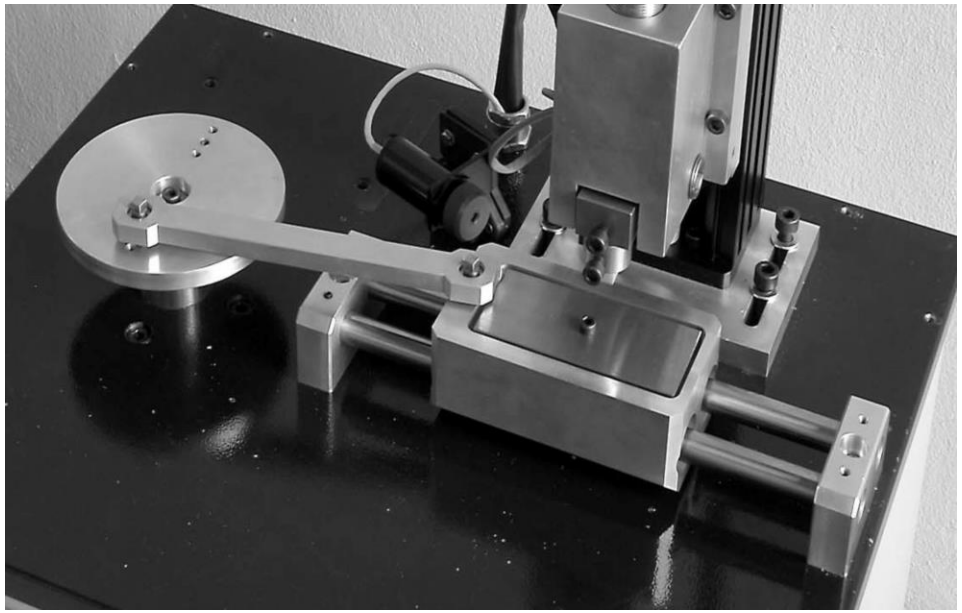
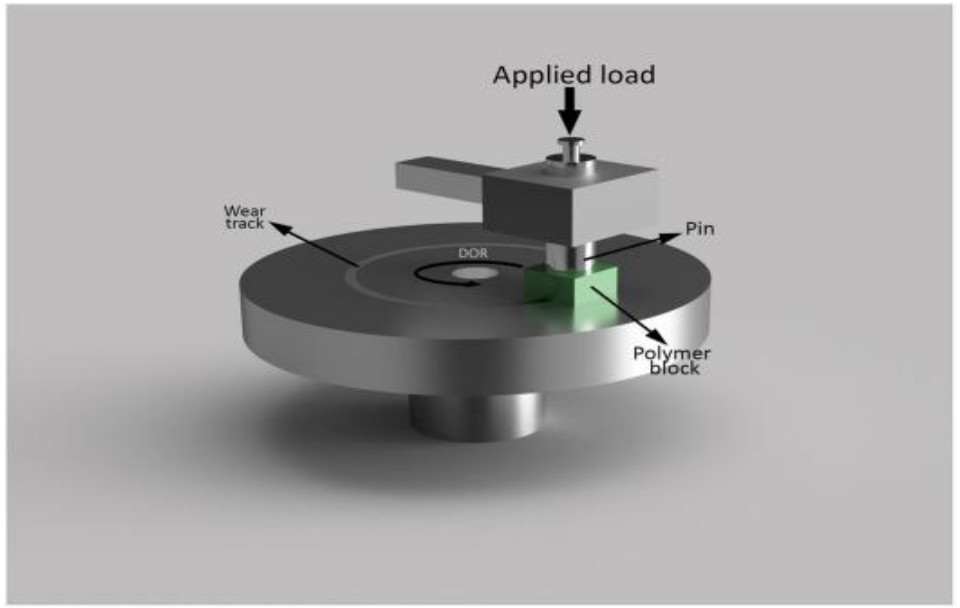
Objective

The objective of this project is to design, develop, and implement a system that enables the simultaneous testing of multiple samples within a vacuum chamber using a tribometer. This system aims to increase testing throughput and enhance overall efficiency while maintaining prior accuracy and control.

What is a Tribometer?

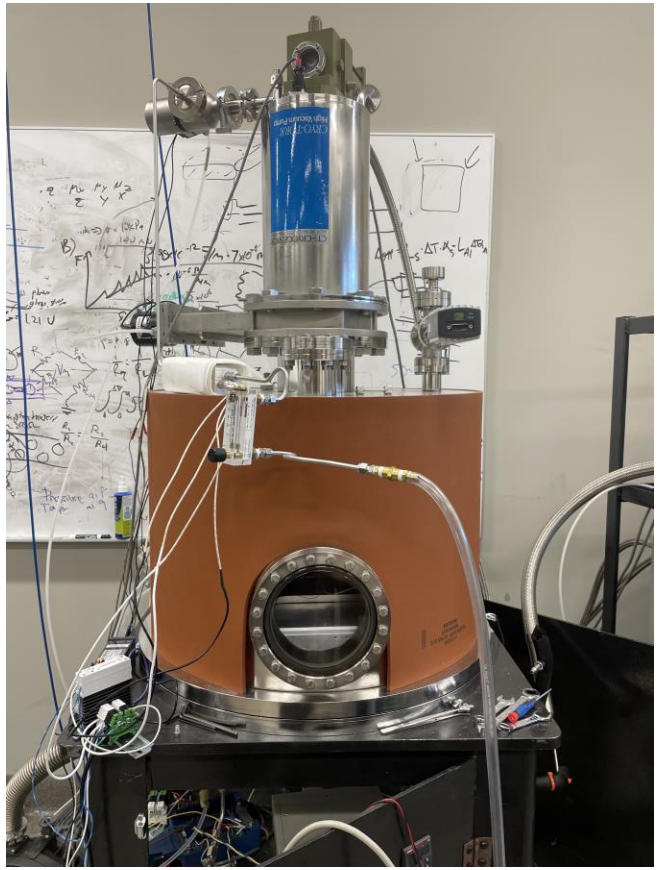
Tribometers measure quantities such as coefficient of friction, friction force, and wear volume on two surfaces in contact by simulating friction in controlled conditions.





AME's Vacuum Chamber

- Vacuum chambers work by removing air and gas from a vessel using a pump.
- The lab's is a bell-style high-vacuum chamber.
- It can reach pressures as low as $1.5x10^{-6}$ mbar.



Steps to High-Vacuum

Step 1

- Roughing pump pulls initial vacuum on system.
- This "rough vacuum" is around 10^{-1} to 10^{-2} mbar.

Step 2

- Switch to the much stronger cryo-pump.
- Takes vacuum down to 10^{-5} mbar quickly.

Step 3

- Let sit overnight (or at least 12 hours).
- Achieves 10^{-6} mbar range.

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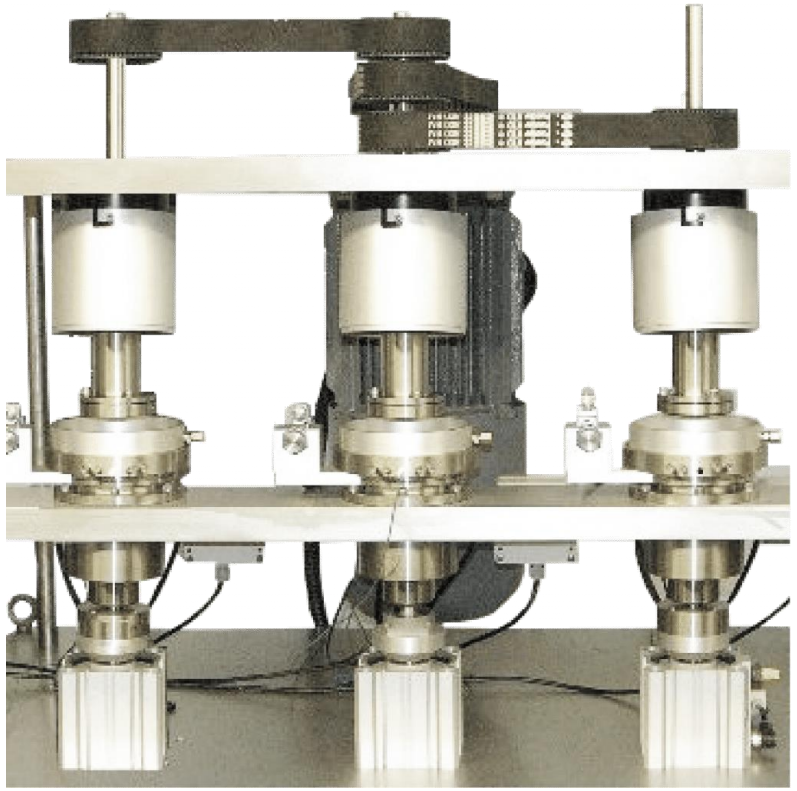
Key Goals

- **Test multiple samples**
- **Control parameters**
- **Operate in specific conditions**



Key Goals

Test multiple samples

Control parameters

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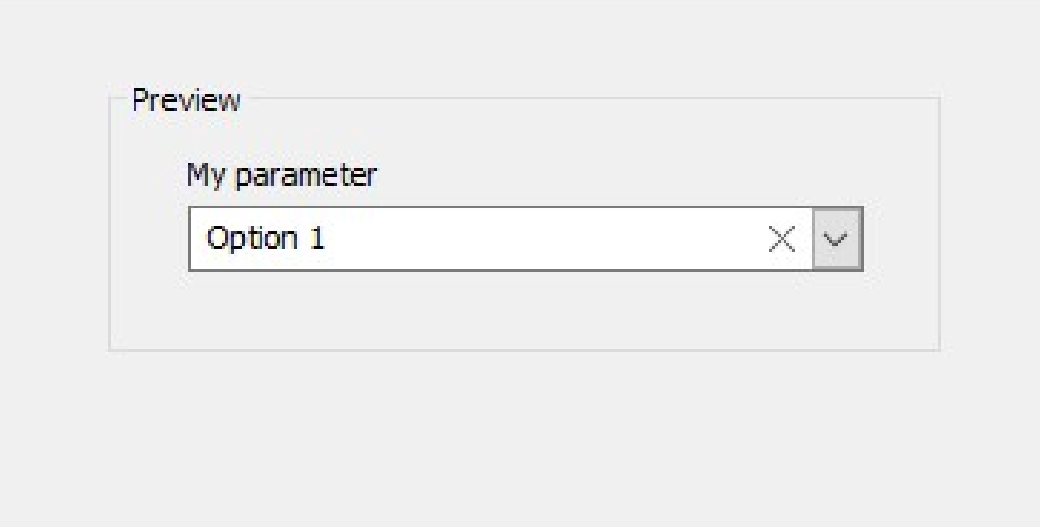

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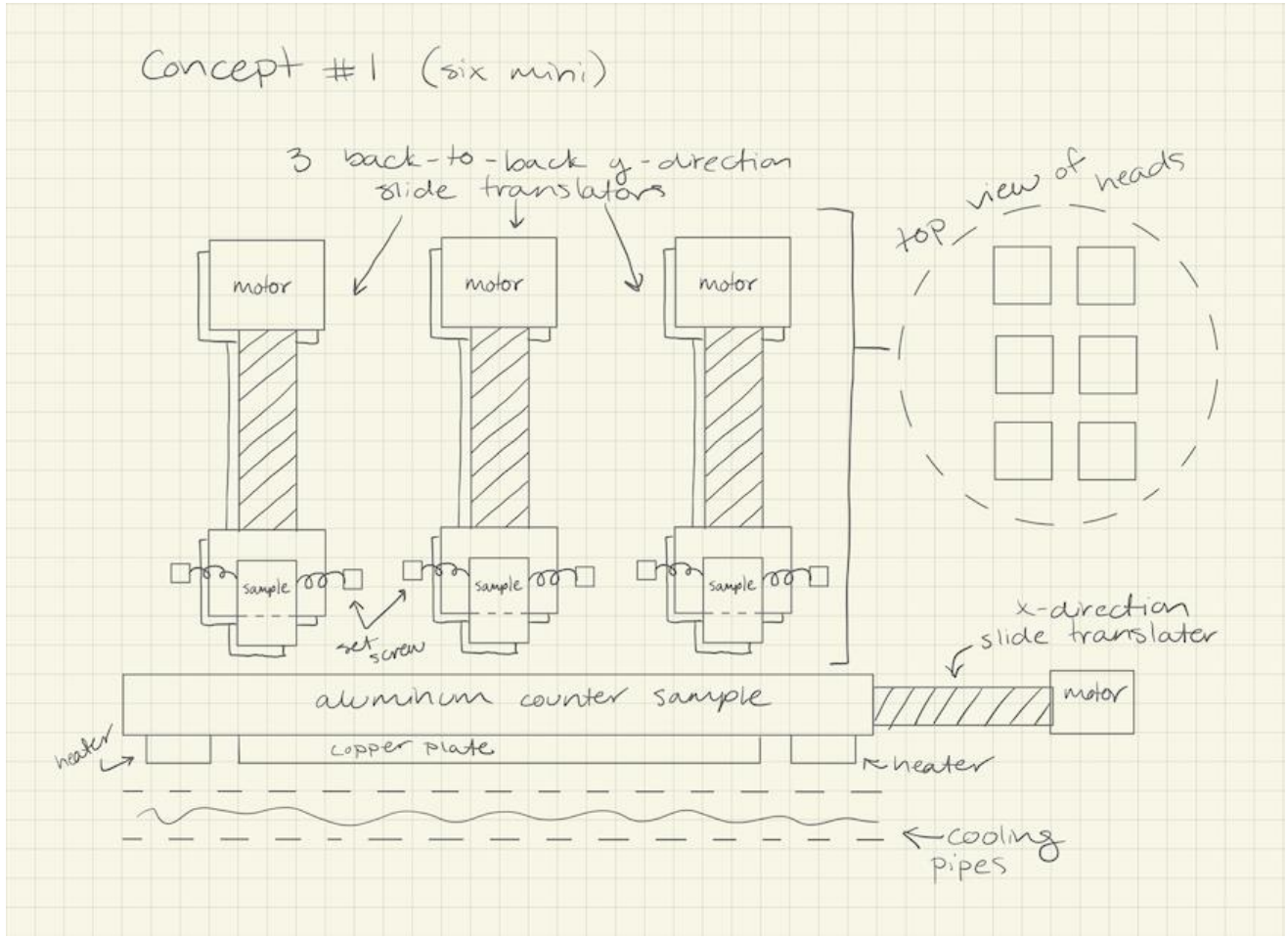
Final Concept Selection



6 mini-identical tribometers.

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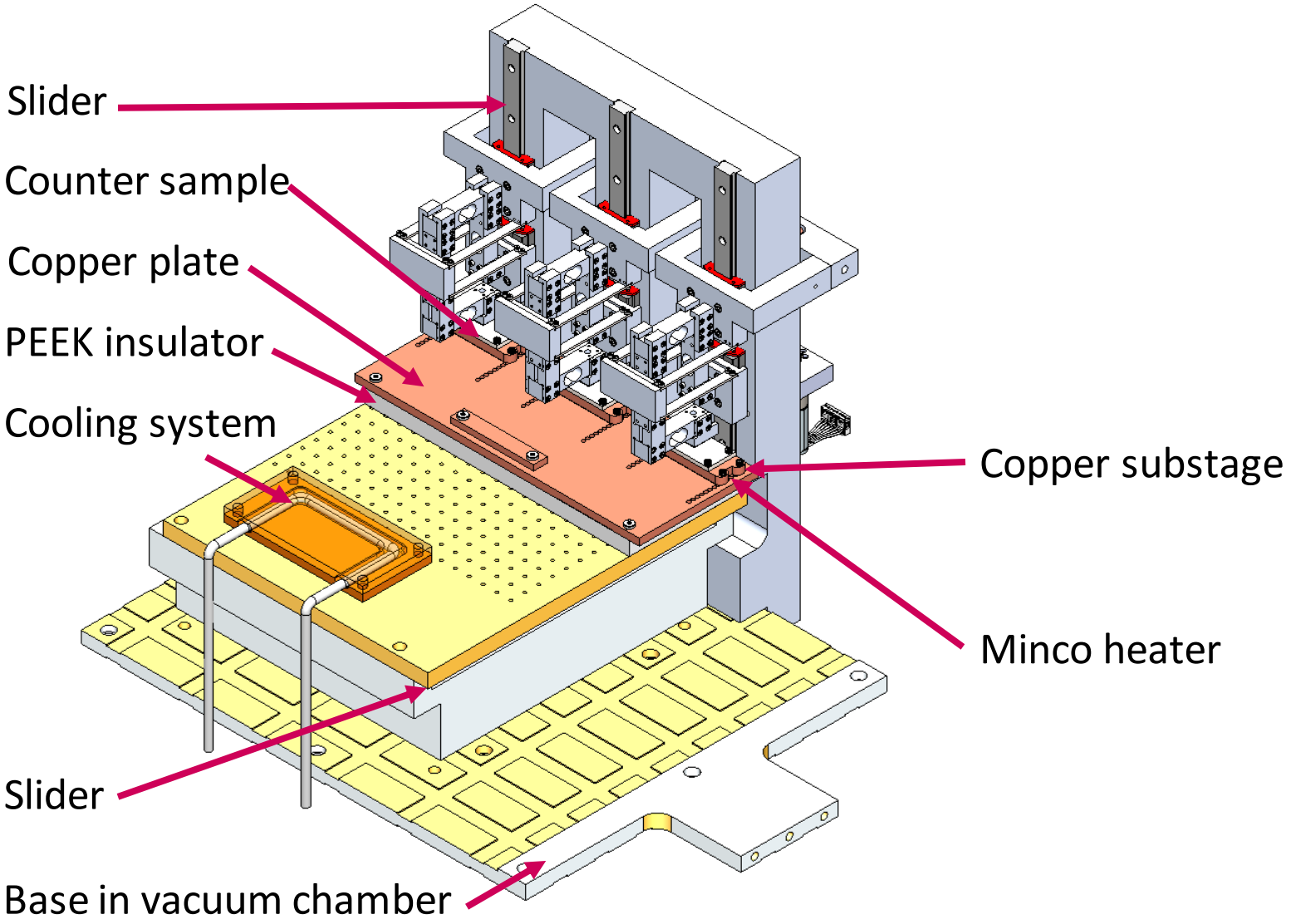
CAD Design: Mach 3 (Front)



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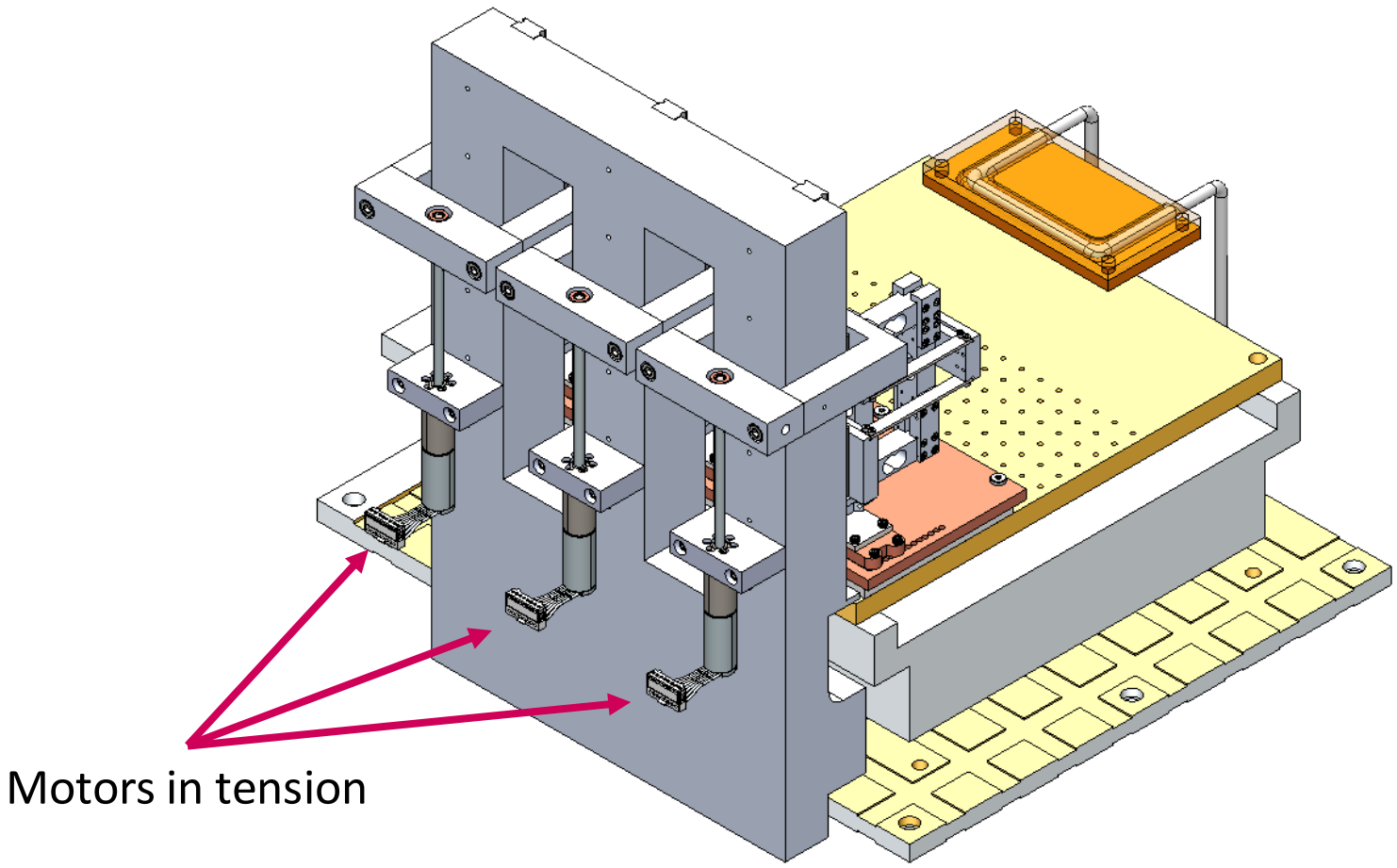
CAD Design: Mach 3 (Back)



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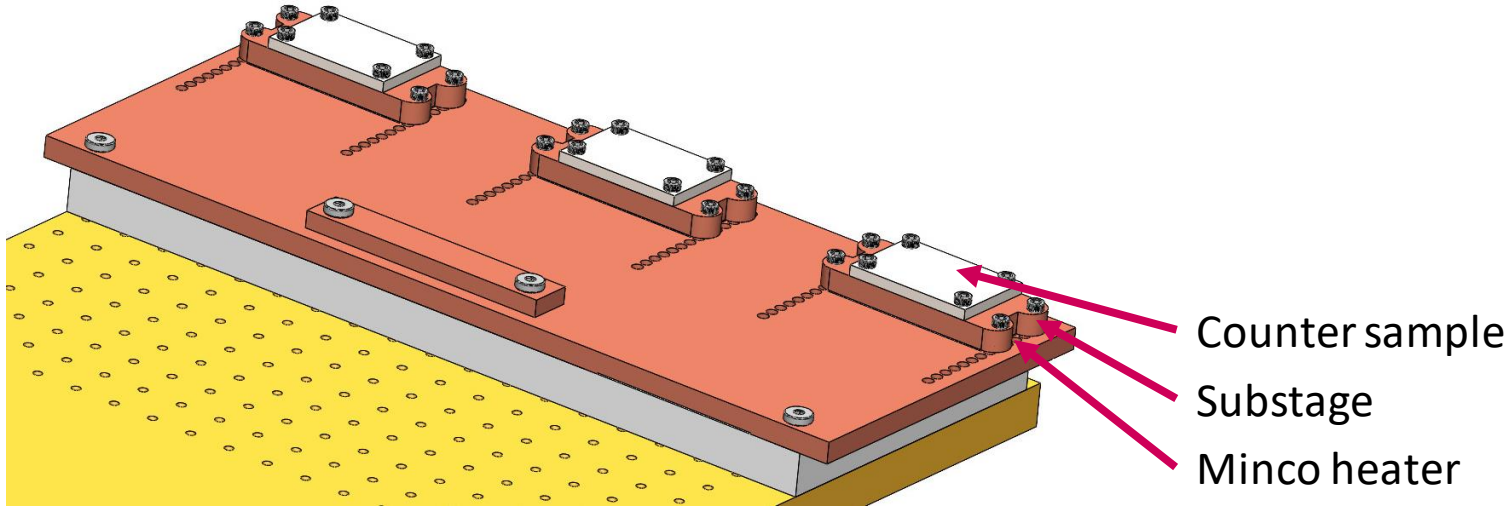
Thermal Assembly

Heat to take material from -196C to 200C in 30 minutes:

- Copper substage = 6.28 Watts
- Aluminum counter sample = 1.95 Watts

Maximum heater output is 88 Watts so,

$$Q_{heater} > Q_{copper} + Q_{aluminum}$$



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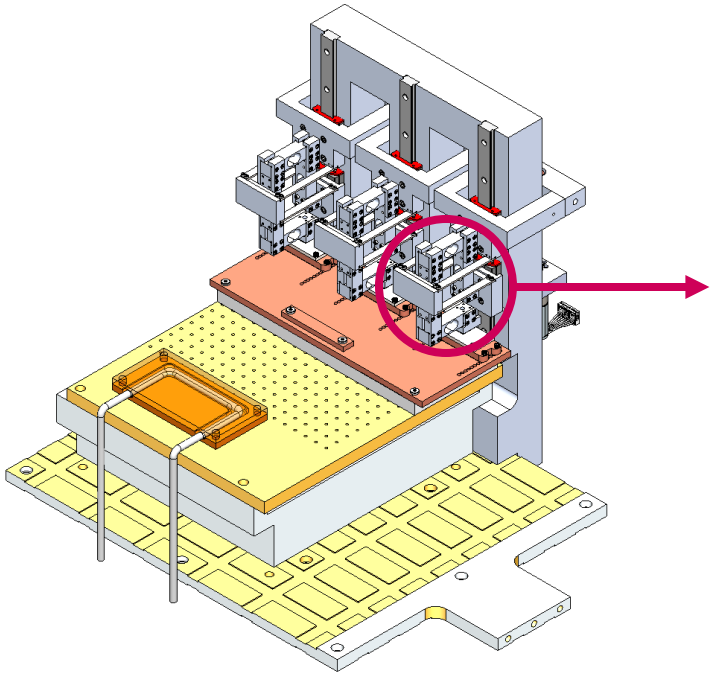
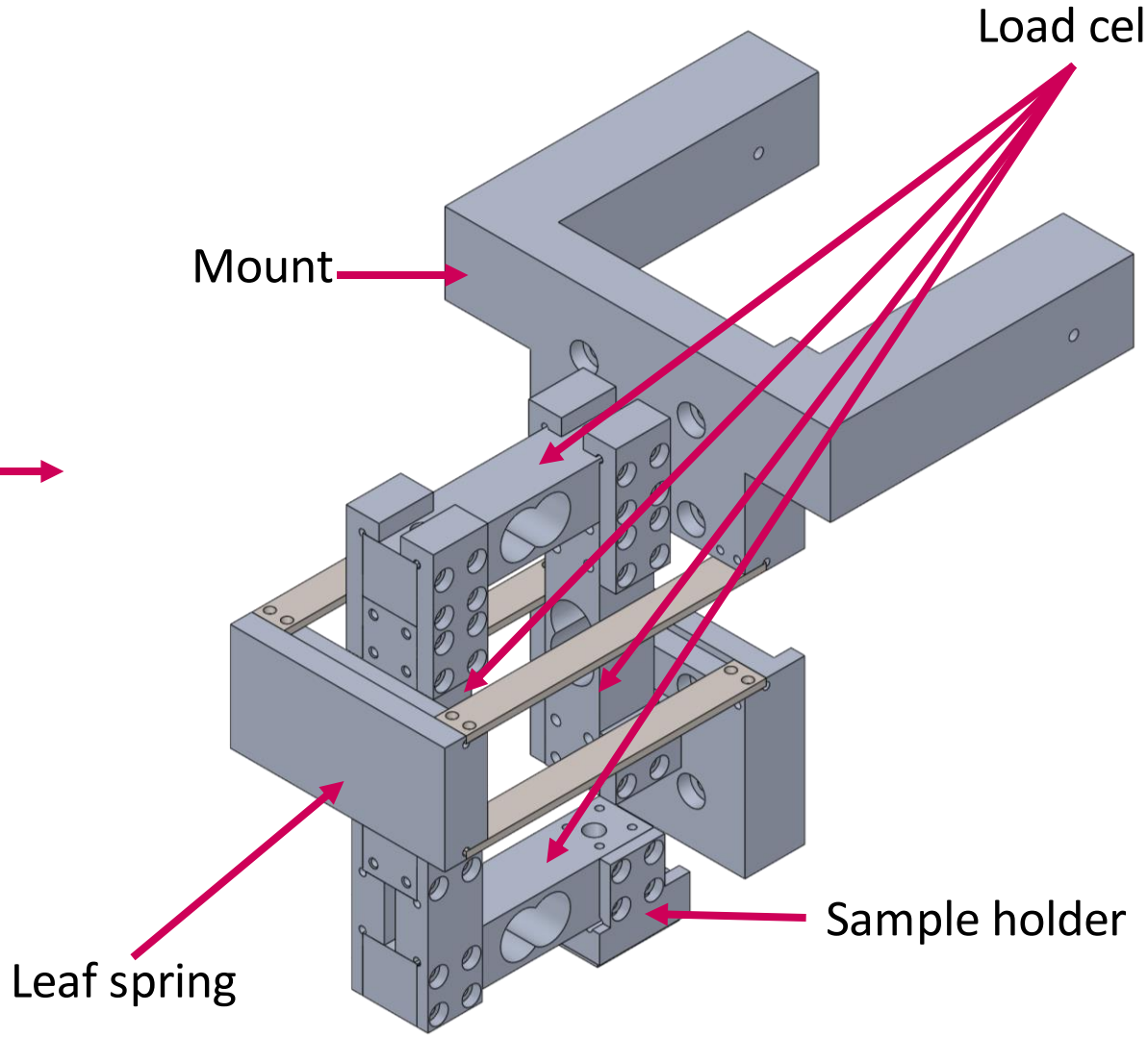
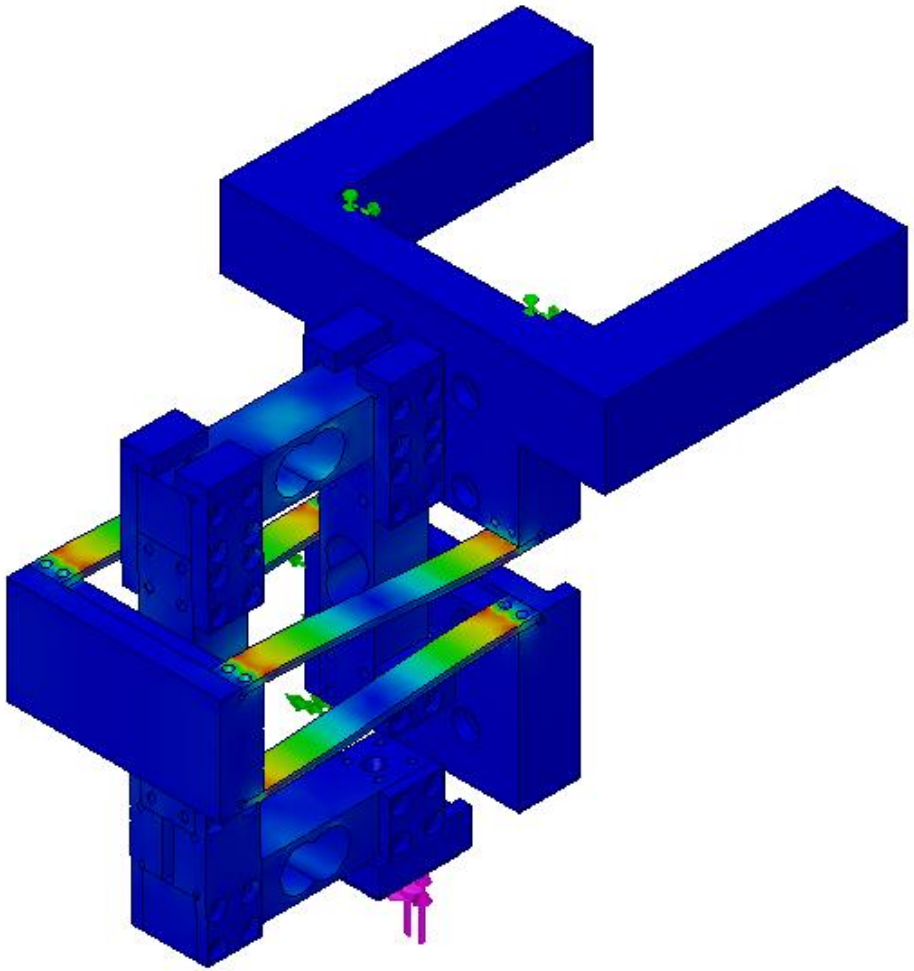
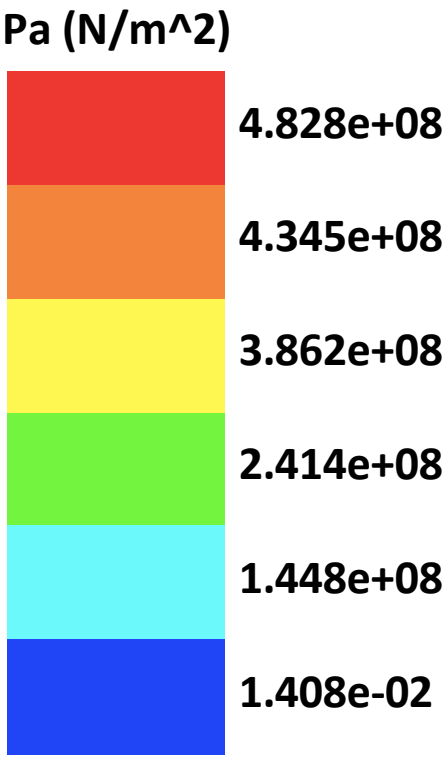
CAD Design: Load Head





FEA: Stress





- Force is **evenly distributed** across the leaf spring to **ensure constant and even contact of sample to counter sample**.
- Max stress: ~480 MPa (red)
- Titanium Leaves Yield Strength: ~1100 MPa

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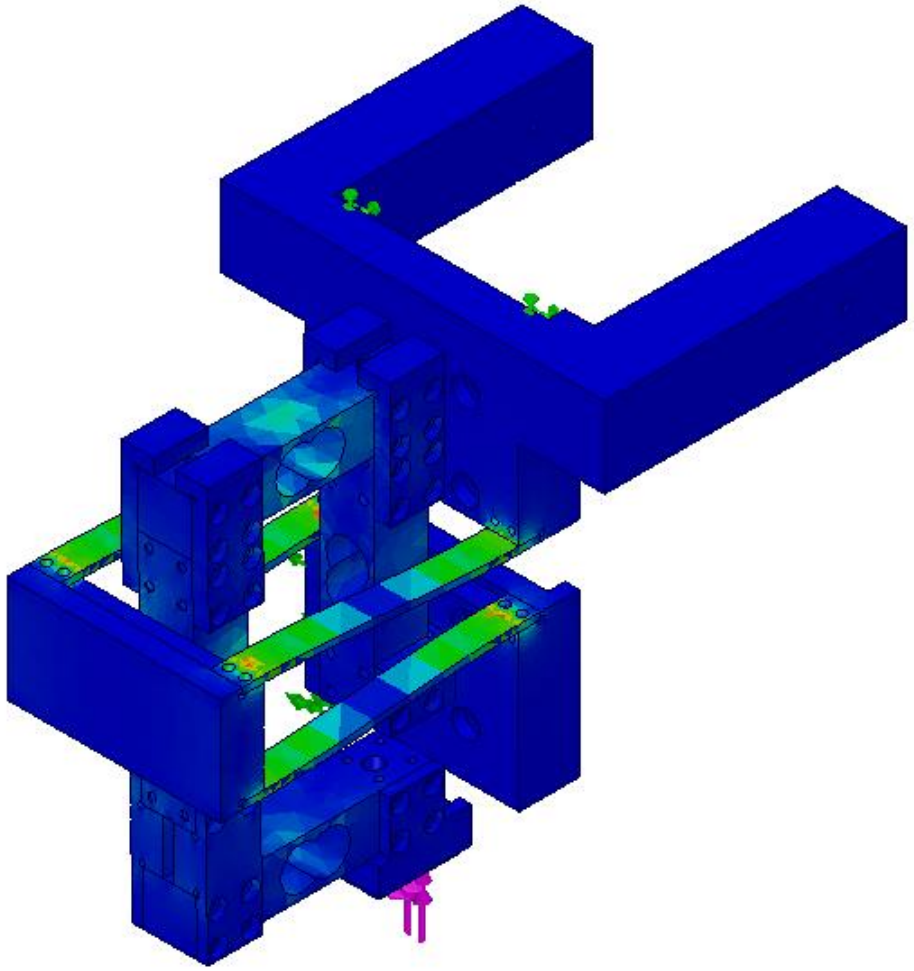
FEA: Strain



Strain is all in the leaf spring and load cells.

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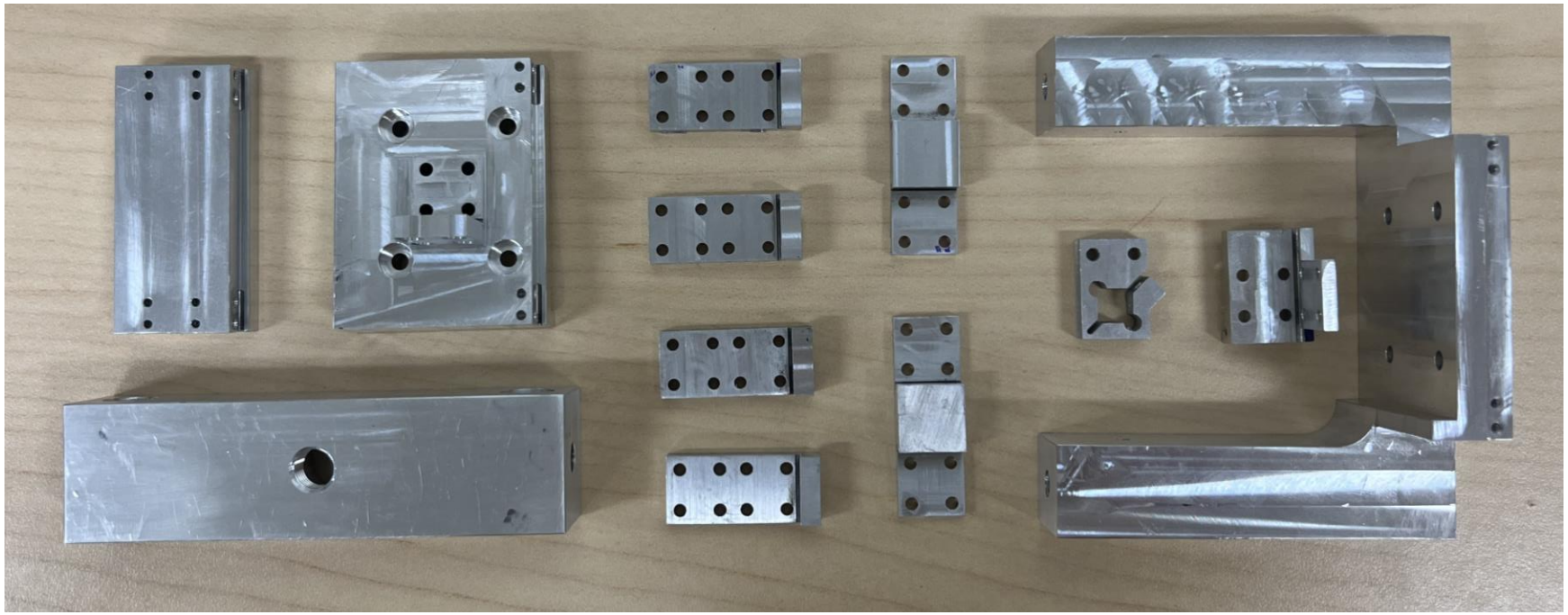
Machined Parts: Load Head



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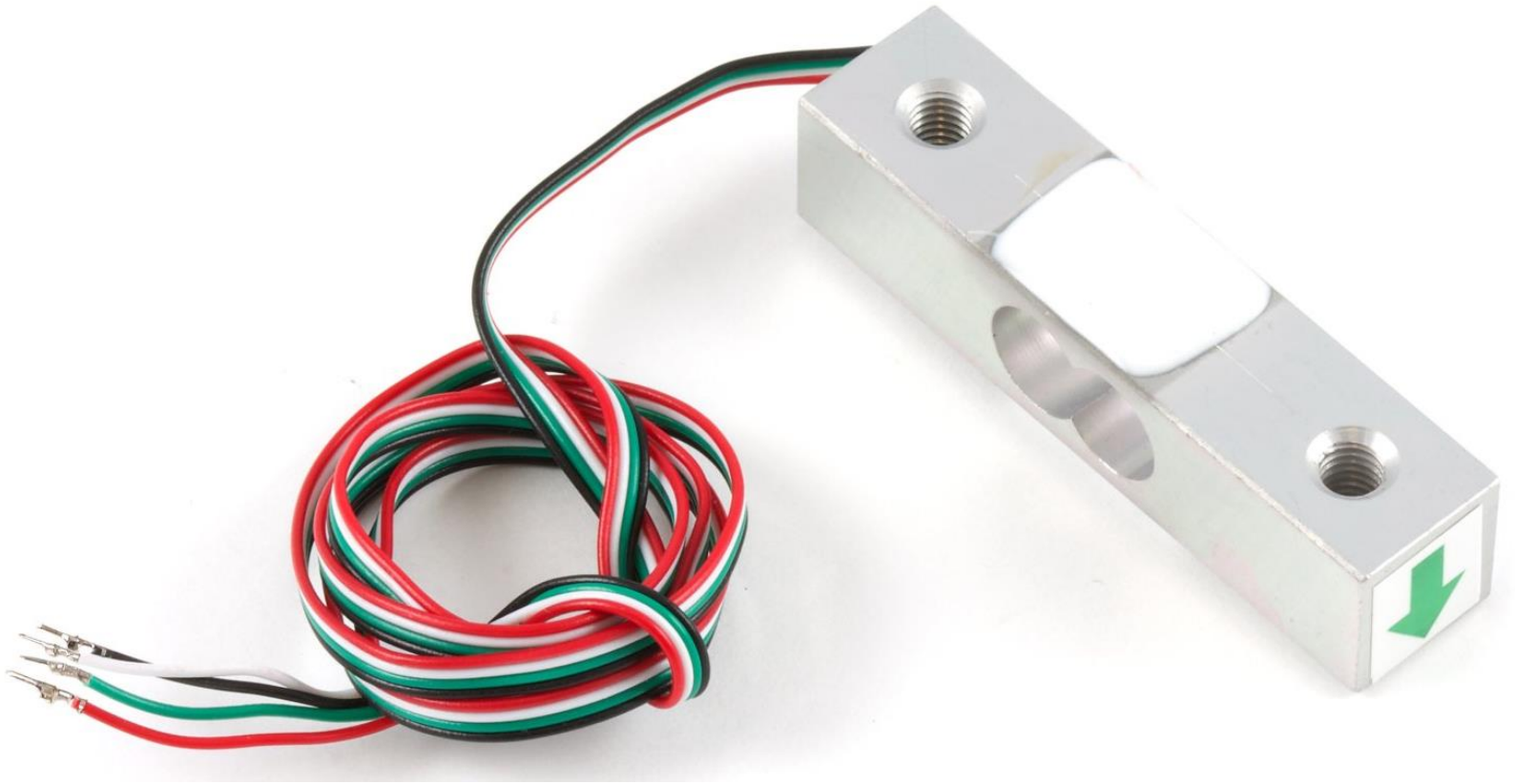
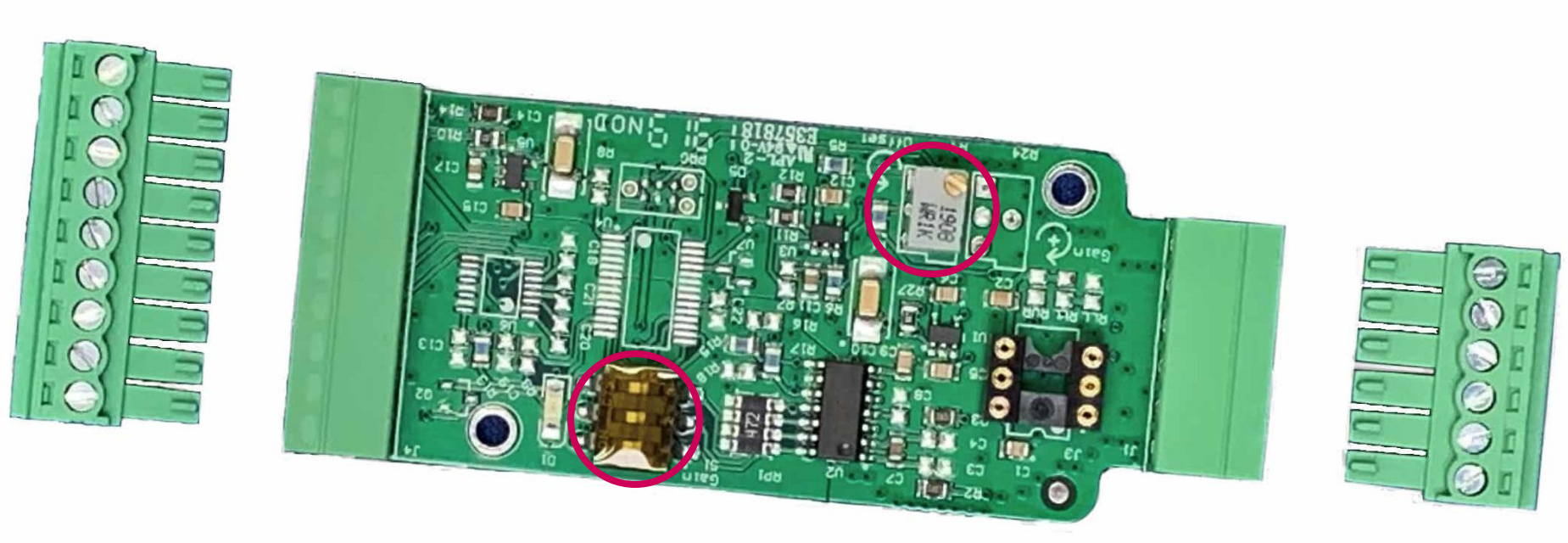
Load Cell



- Measures force by converting mechanical strain into electrical signals.
- Output, mV/V, is converted to other units of measurement through calibration.

Amplifier



- Output of the load cell is a small signal, needs to be amplified for better measurements.
- Adjusting the gain decreases signal noise.

Summing Junction

Takes 2 to 4 load cell inputs and combines them into a single output.

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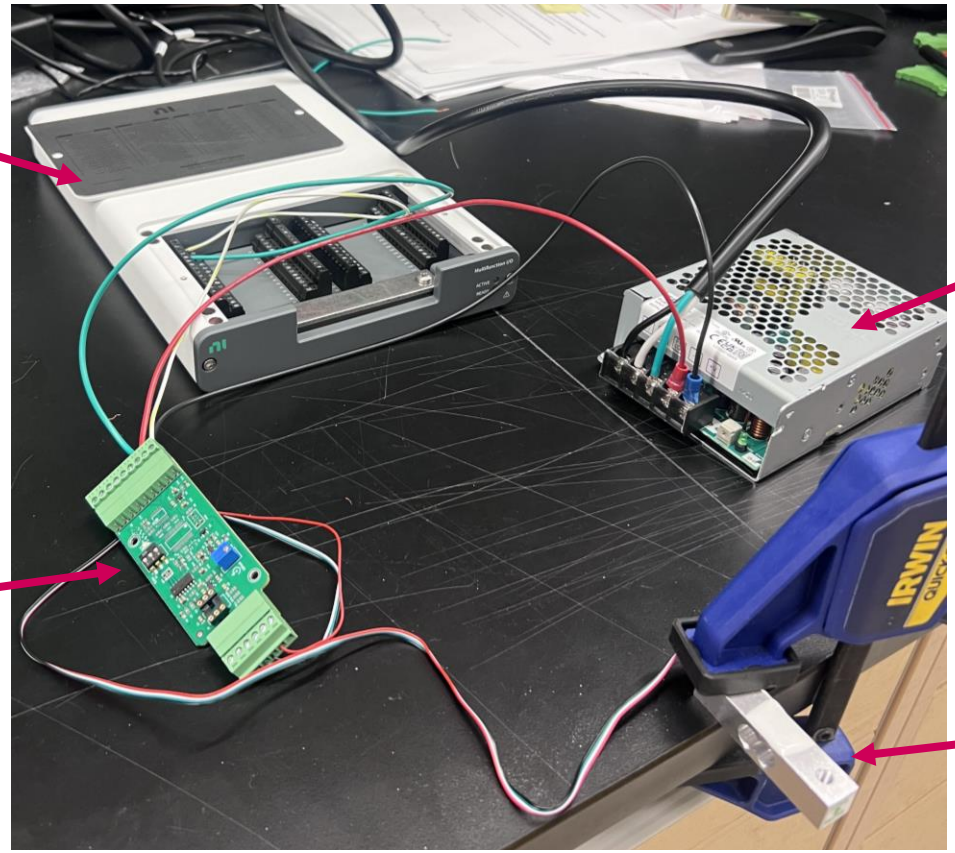
Looking at Force on a Load Cell



Future Work

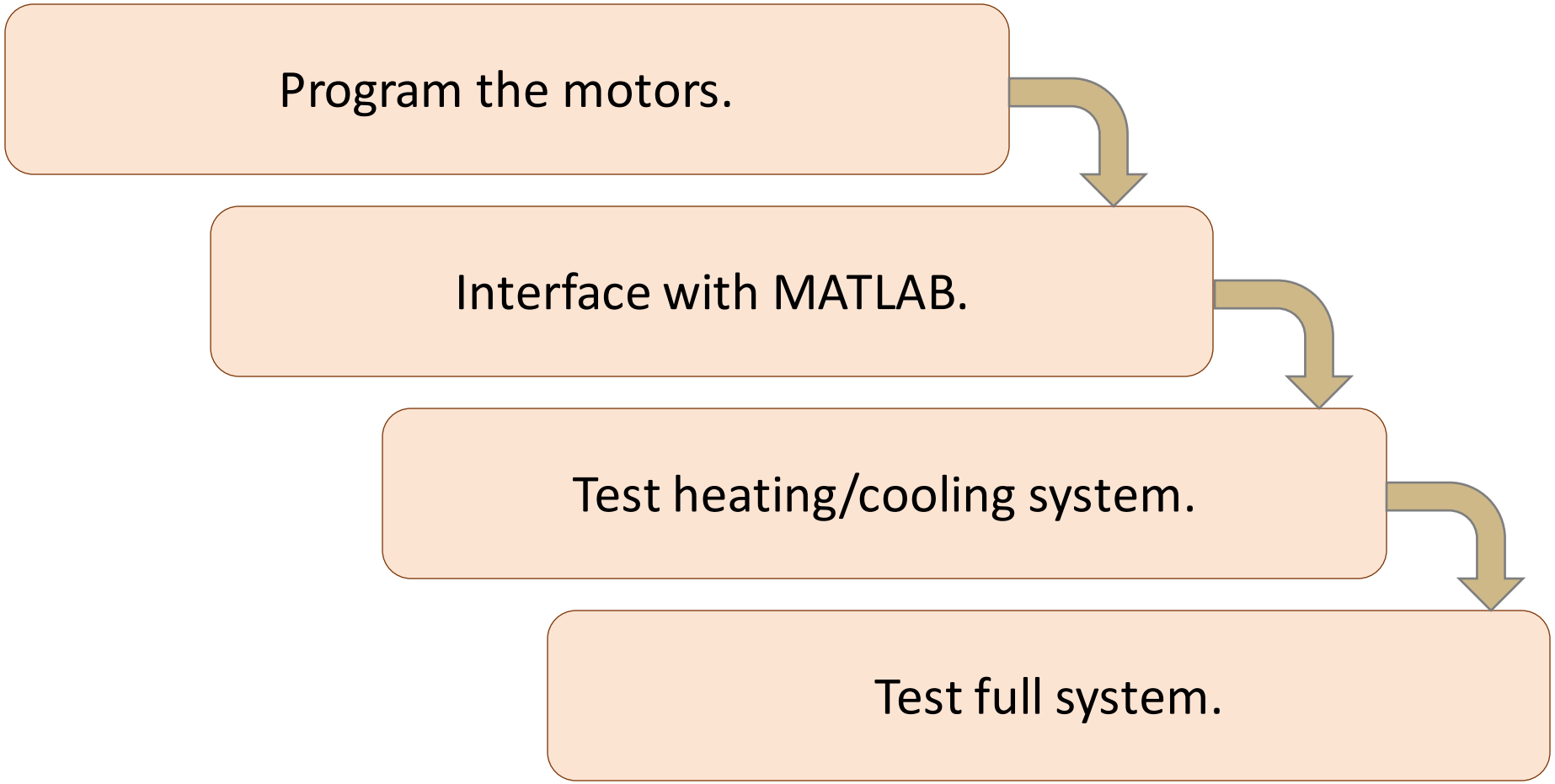
Give large materials to machine shop.

Get large support equipment machined.

Clean all parts to IAW ISO 14644-6.

Assemble parts and run calibration tests.

Future Work


Program the motors.
Interface with MATLAB.
Test heating/cooling system.
Test full system.