FAMU-FSU College of Engineering

Team 501
Tribometer in Spacelike Conditions

VDR6 240319

Team Introductions

Branham Channell
Materials Engineer

Cobi Johnson
Systems Engineer

Madison Retherford
Mechatronics Engineer

Javier Ibanez
Structural Engineer

Joshua Wesley
Computer Hardware Engineer

FAMU-FSU College of Engineering

Sponsor and Advisor

Dr. Brandon Krick

3M Science. Applied to Life.™

Dr. Shayne McConomy

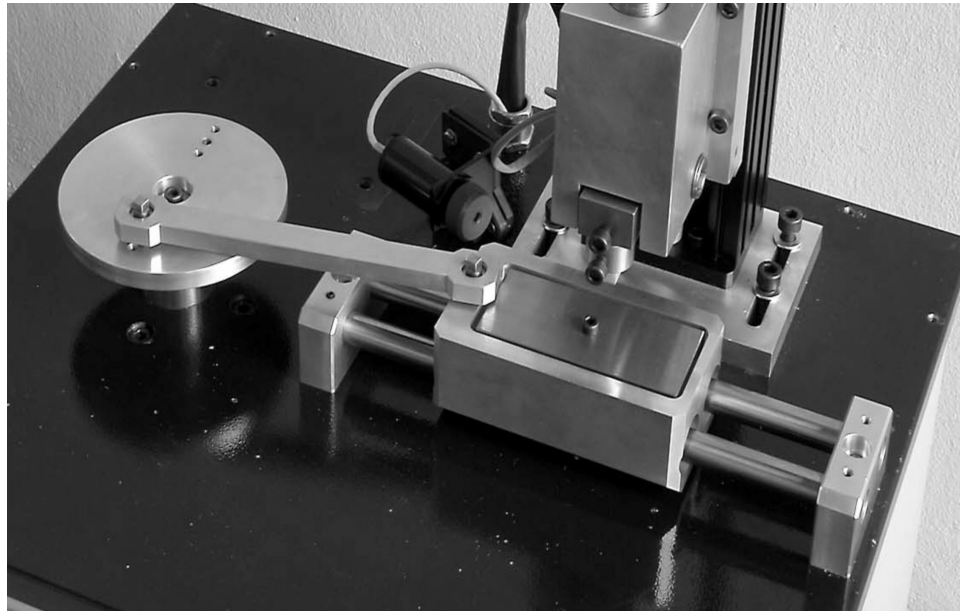
FAMU-FSU College of Engineering

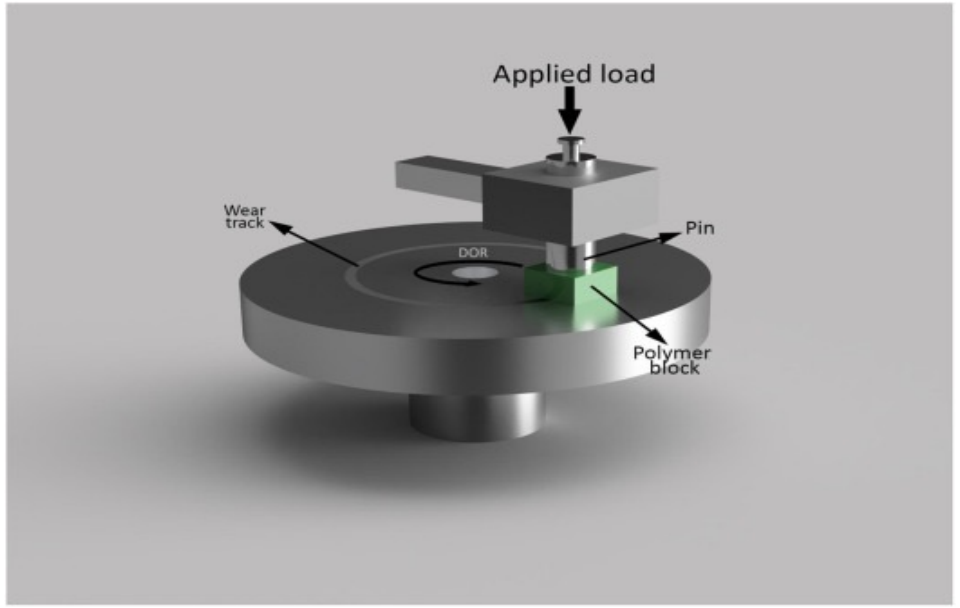
Objective

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?

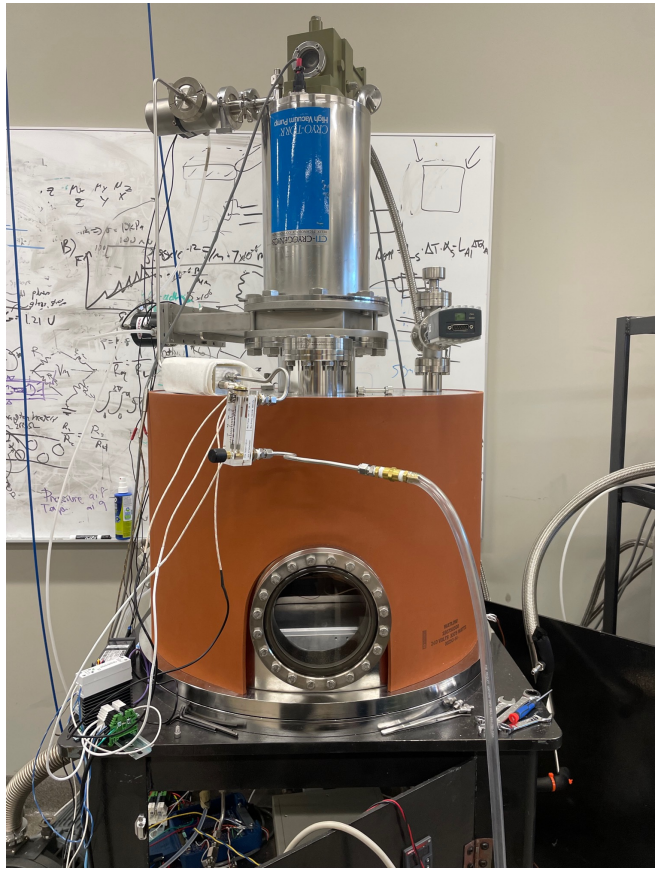
Tribometers measure quantities such as coefficient of friction, friction force, and wear volume on two surfaces in contact by simulating friction in controlled conditions.





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 1.5×10^{-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

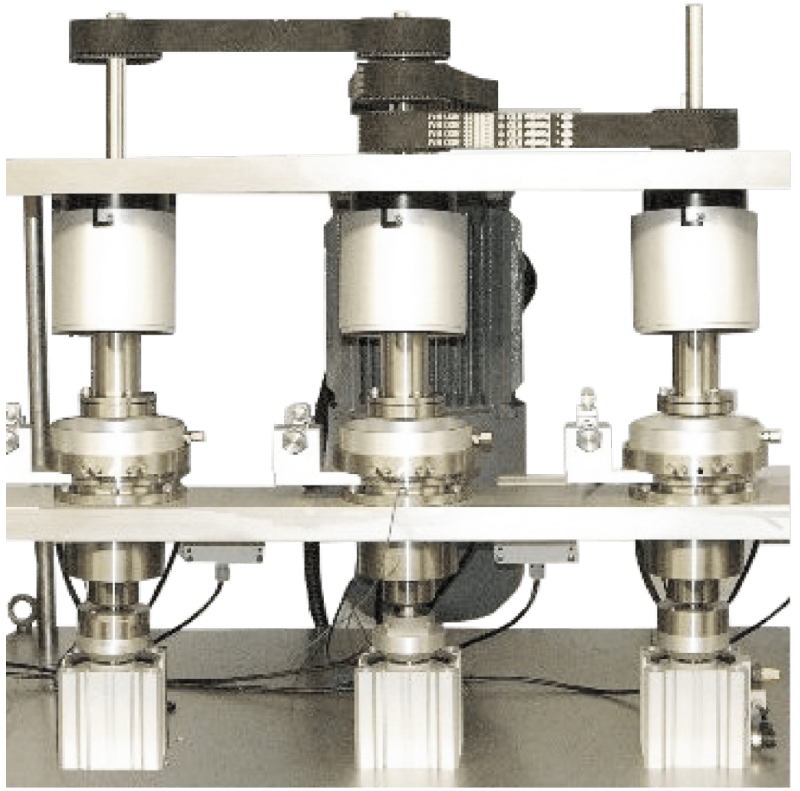
- Switch to the much stronger cryo-pump.
- Takes vacuum down to 10^{-5} mbar quickly.

Step 3

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

Key Goals

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

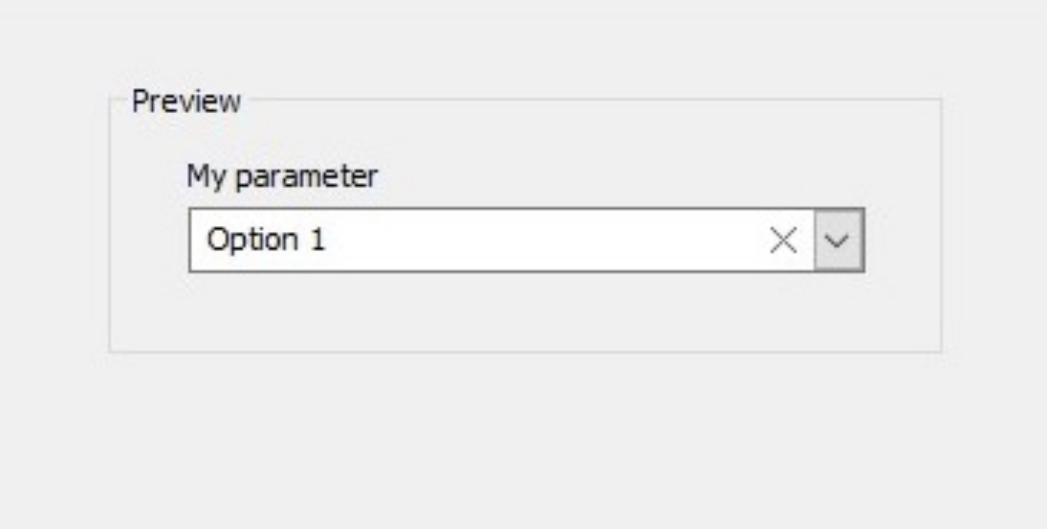


Key Goals

Test multiple samples

Control parameters:
- **-200C to 200C**
- **Max 100 N normal load**
- **Max 60 N friction load**

Operate in spacelike conditions



FAMU-FSU College of Engineering

Key Goals

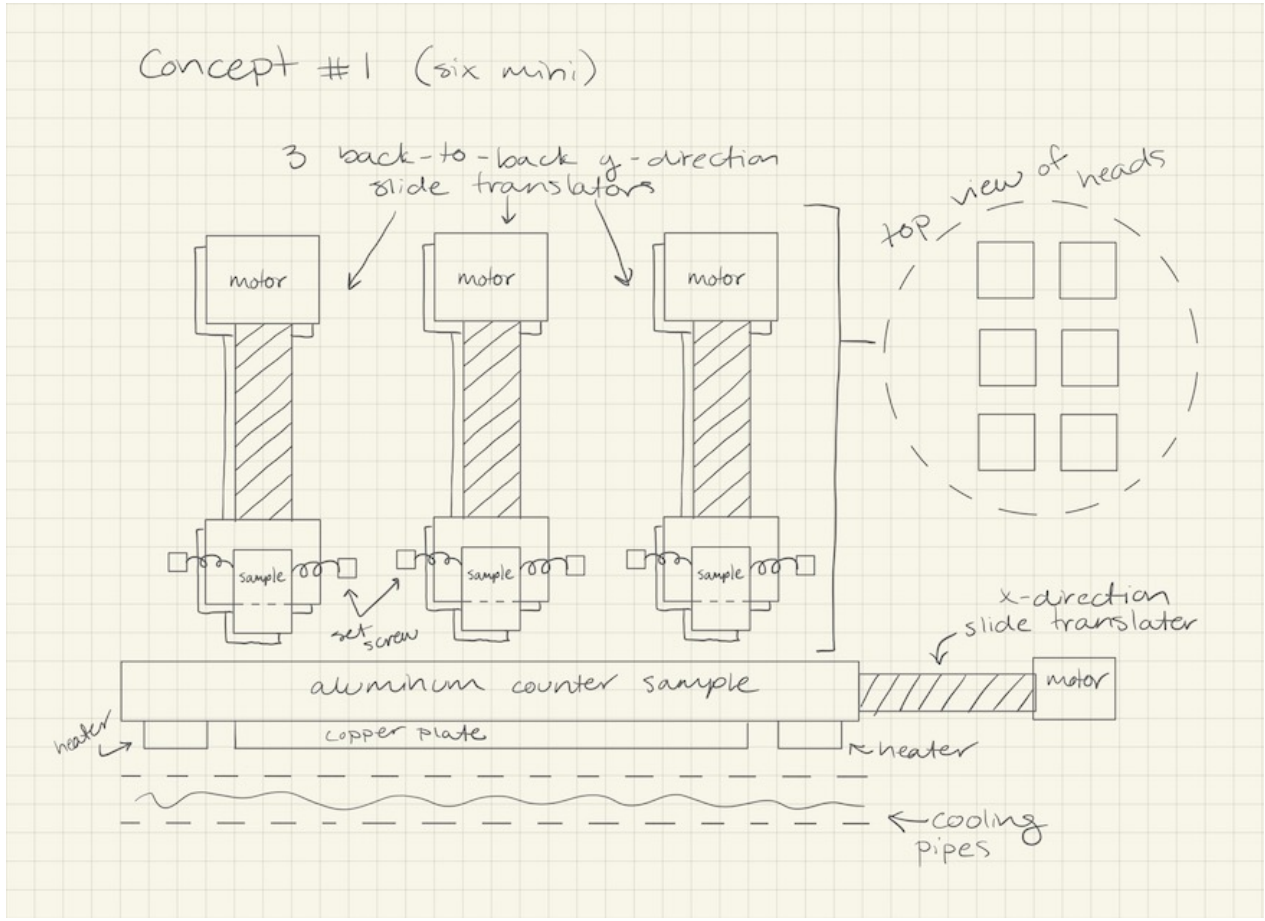
- Test multiple samples
- Control parameters
- **Operate in spacelike conditions**

Selection Process

- **Generated concepts for:**
  - Holding the sample
  - Style of the tribometer
  - Regulating temperatures
  - Calculations
  - Emergency protocol

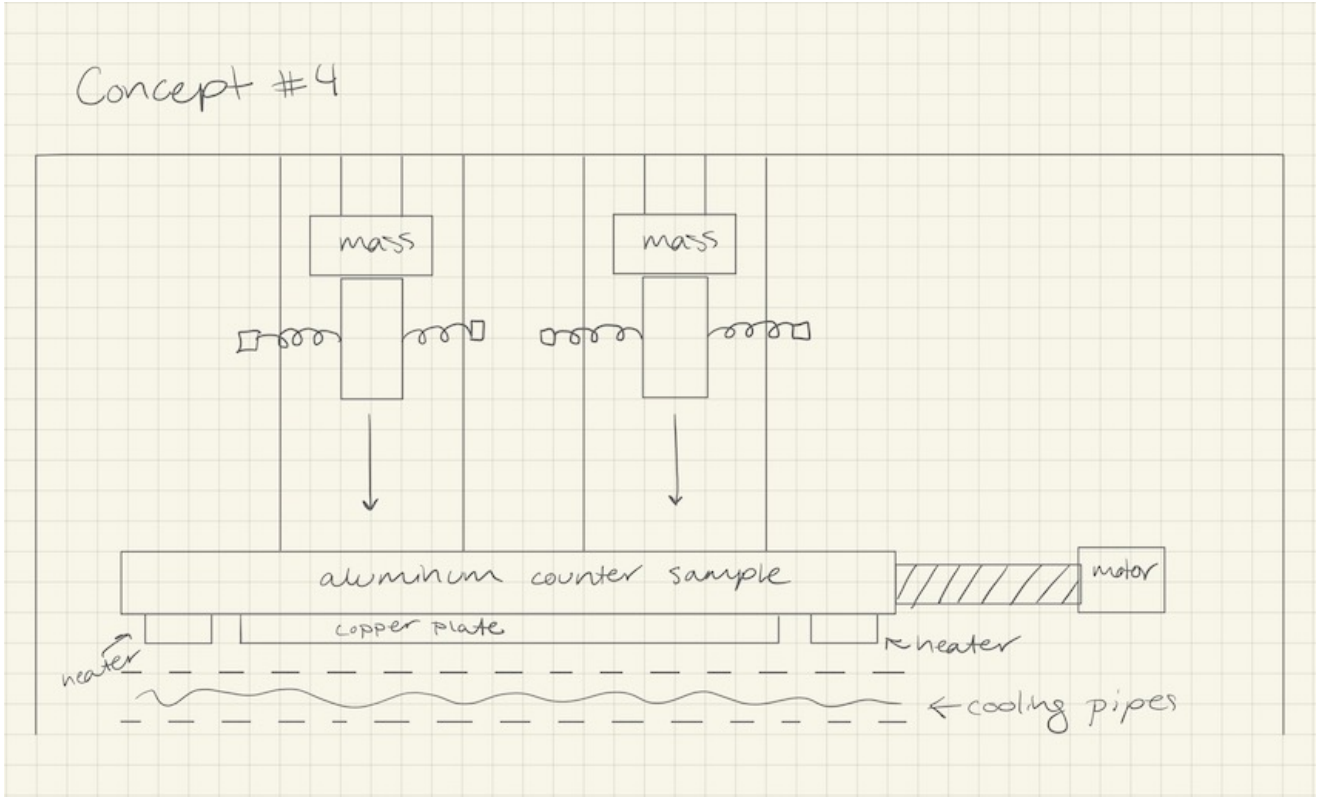
- **Evaluated concepts**
  - Narrowed it down to three high fidelity concepts and five medium fidelity concepts

High Fidelity Concept 1



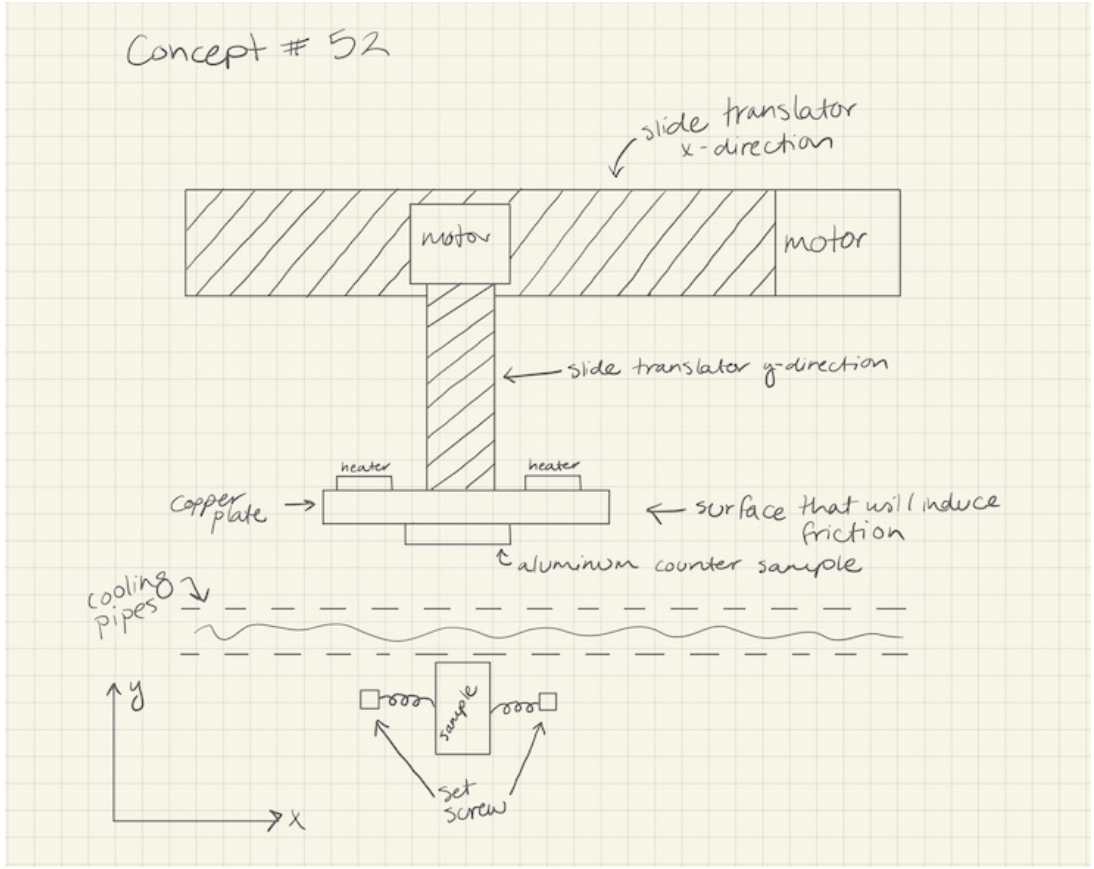
6 mini-identical tribometers.

High Fidelity Concept 2



Loading weights on samples to produce normal load.

Medium Fidelity Concept 1

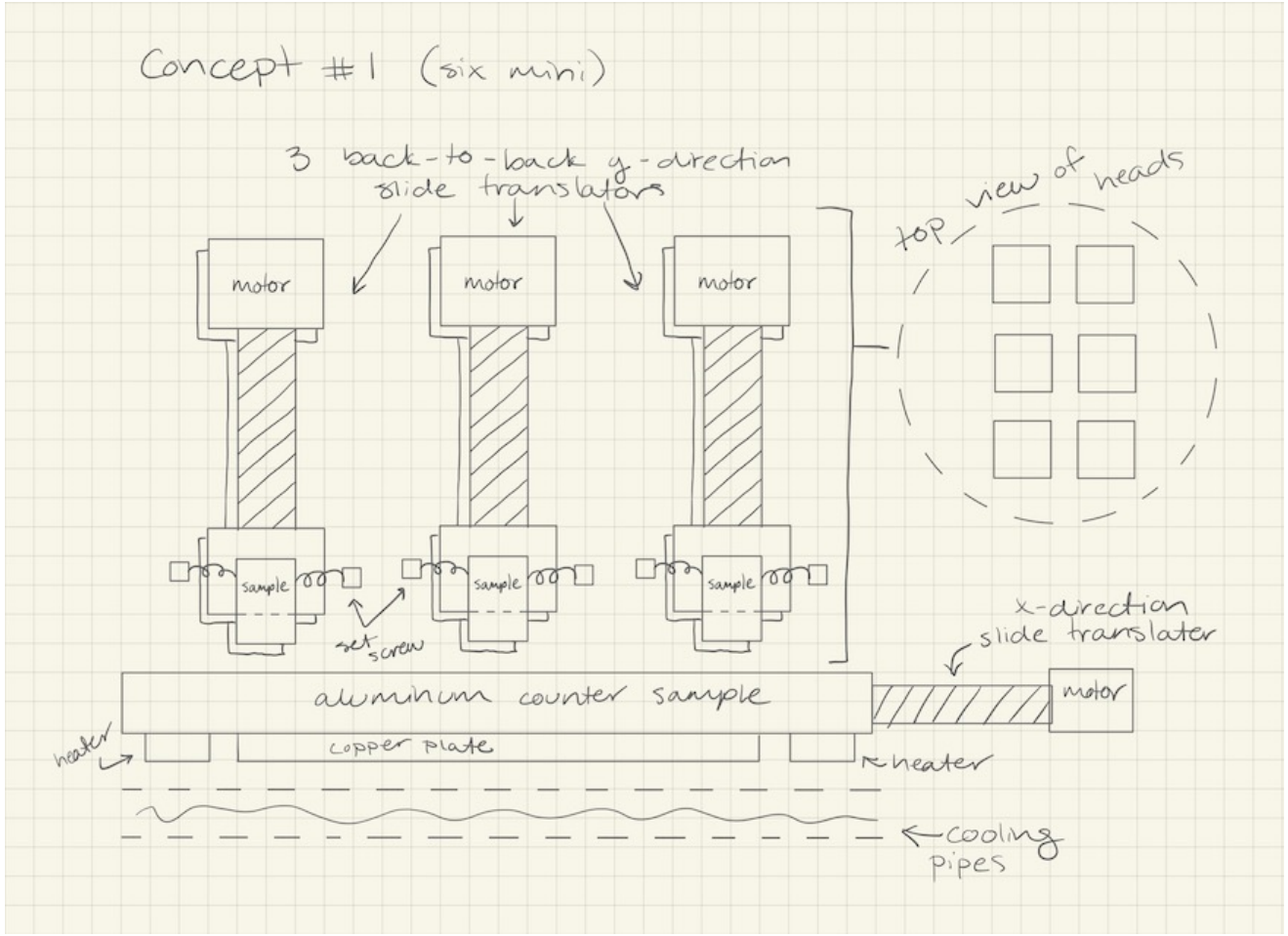


Inverted existing tribometer.

Final Concept Selection

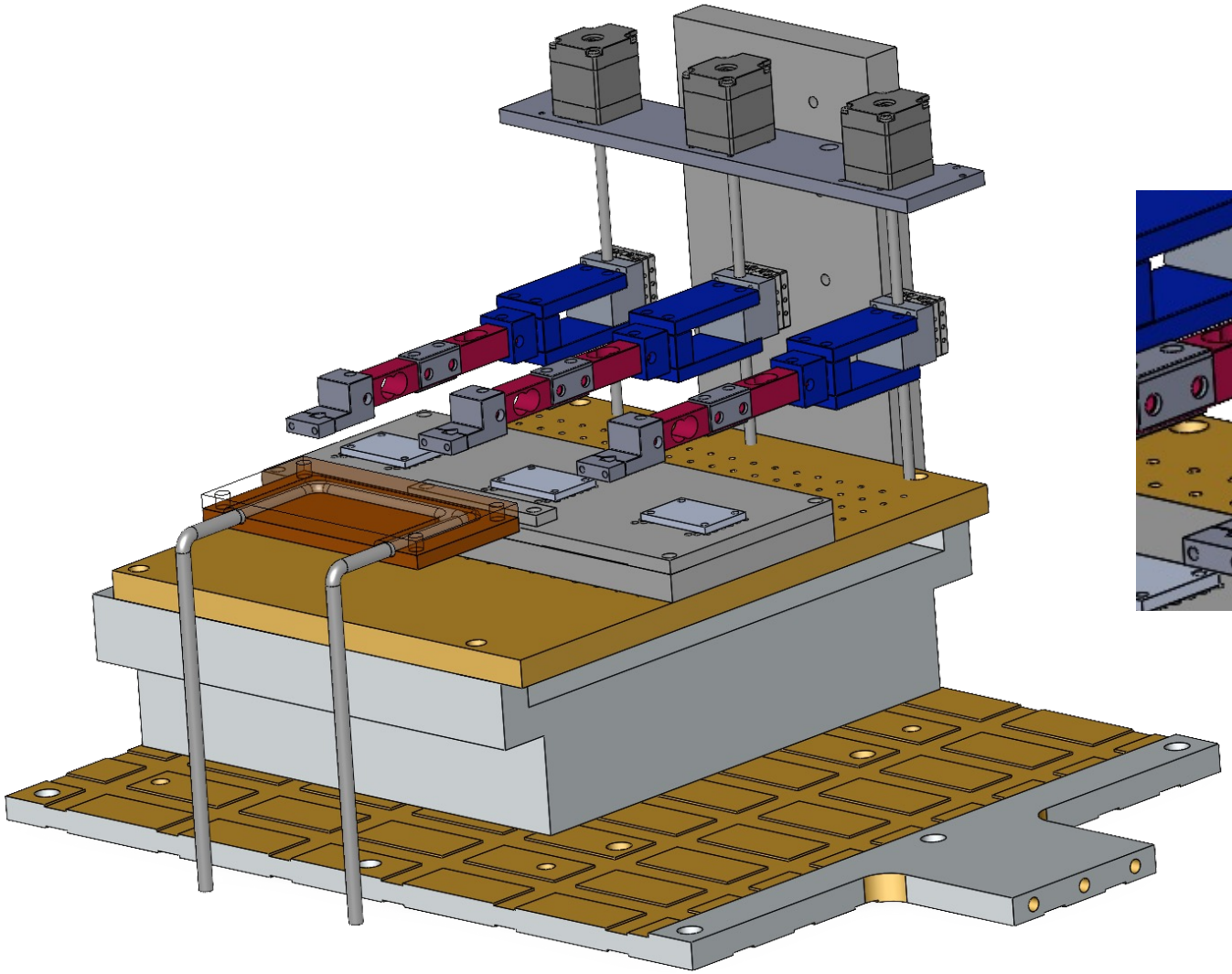
Concepts	Alternative Value	RANK
Six Mini-Identical Tribometers Side by Side	0.344	2
Weights Loaded on Samples to Produce Normal Load	0.418	1
Inverted Existing Tribometer	0.237	3

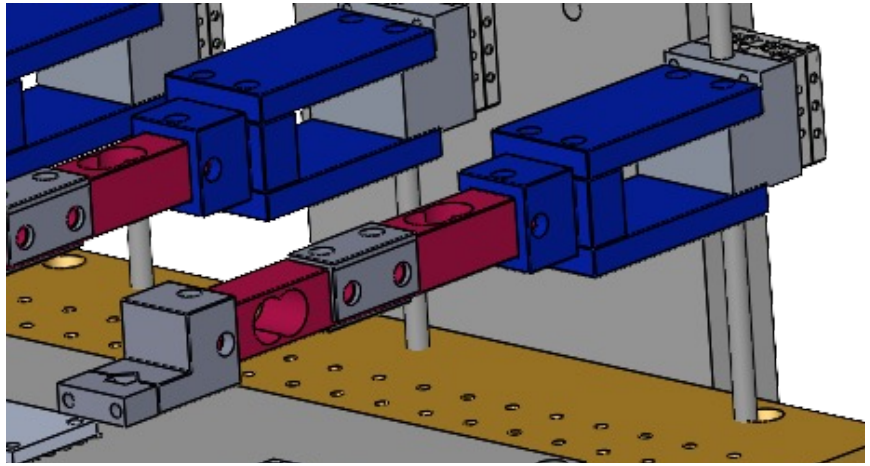
Final Concept Selection



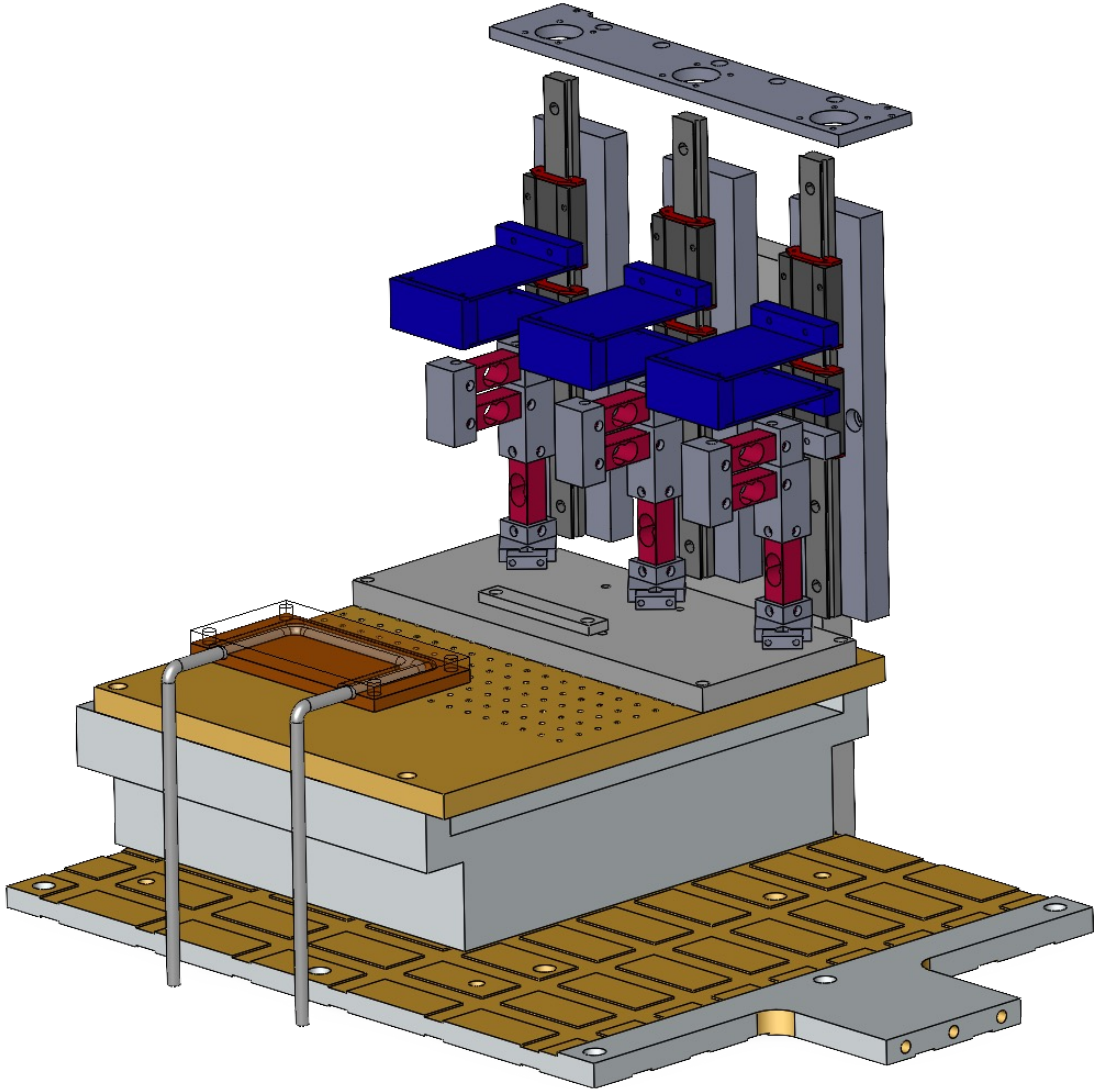
6 mini-identical tribometers.

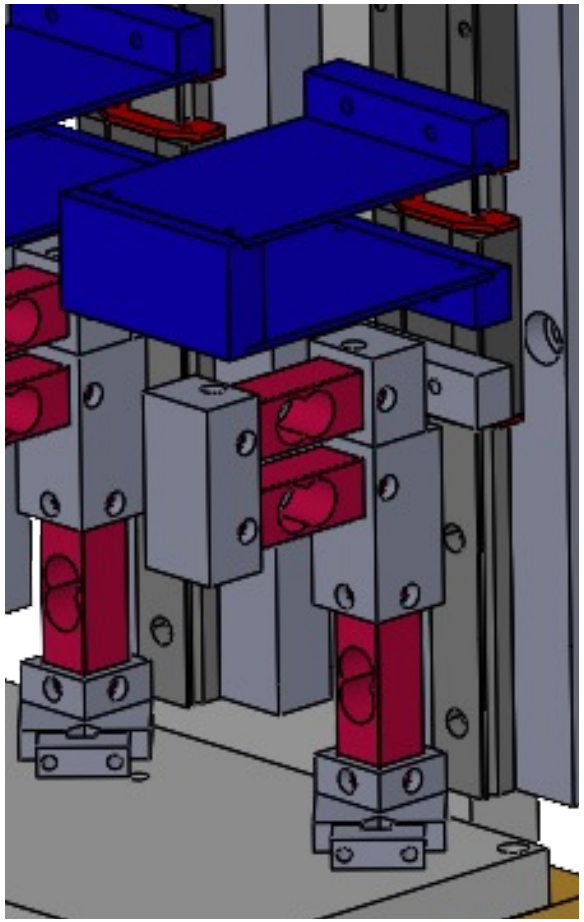
CAD Design: Mach 1 (Rejected)



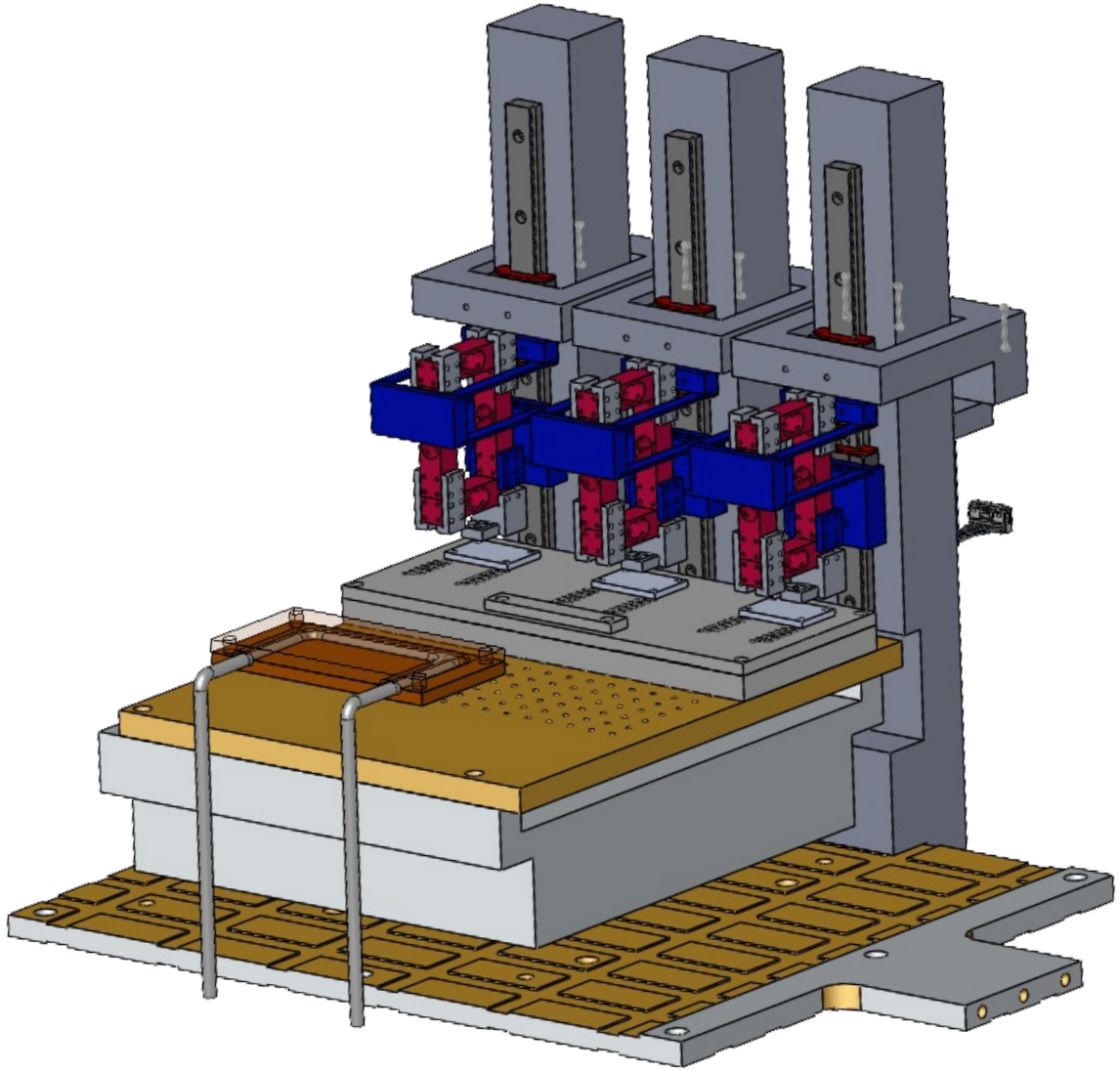


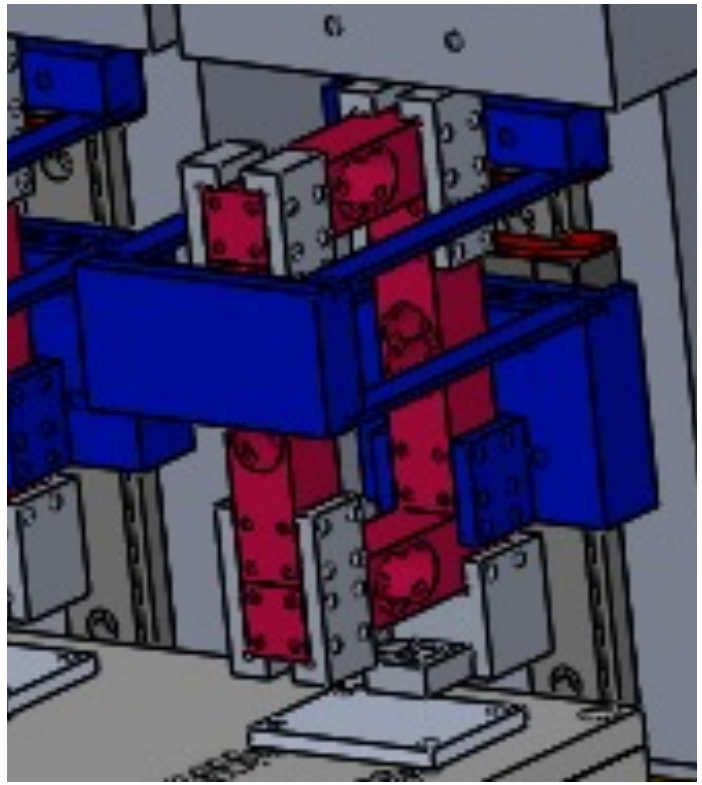
CAD Design: Mach 2 (Rejected)



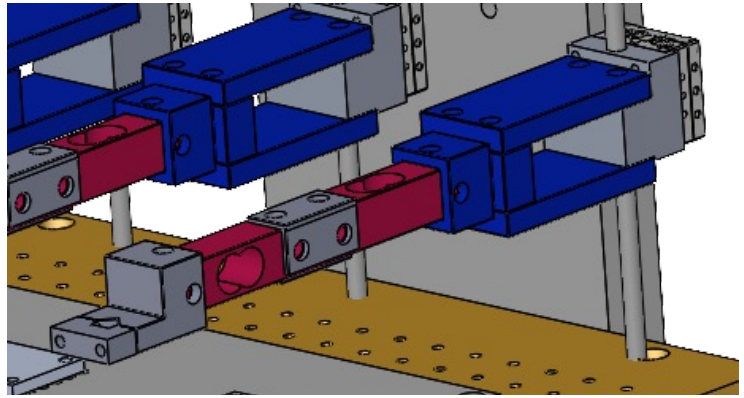


CAD Design: Mach 3 (Approved)

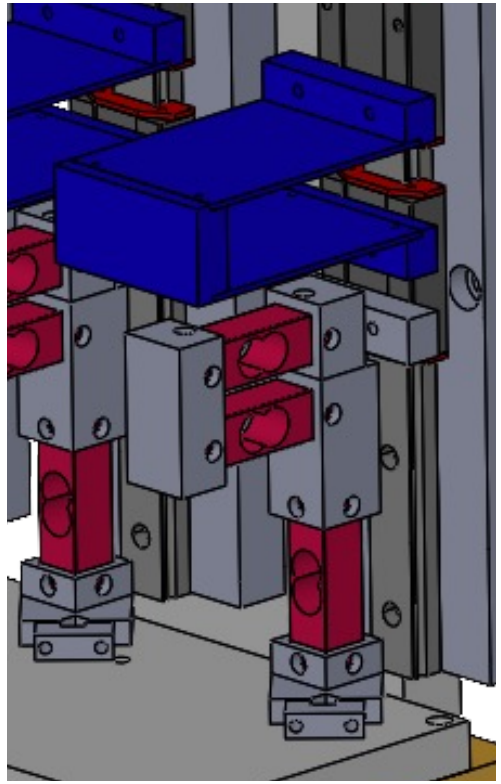




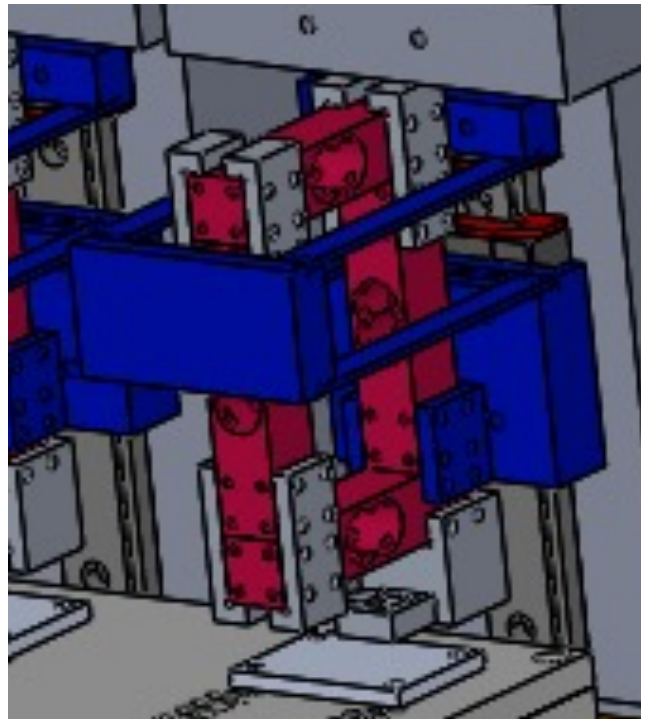
Comparison of Load Heads



Mach 1

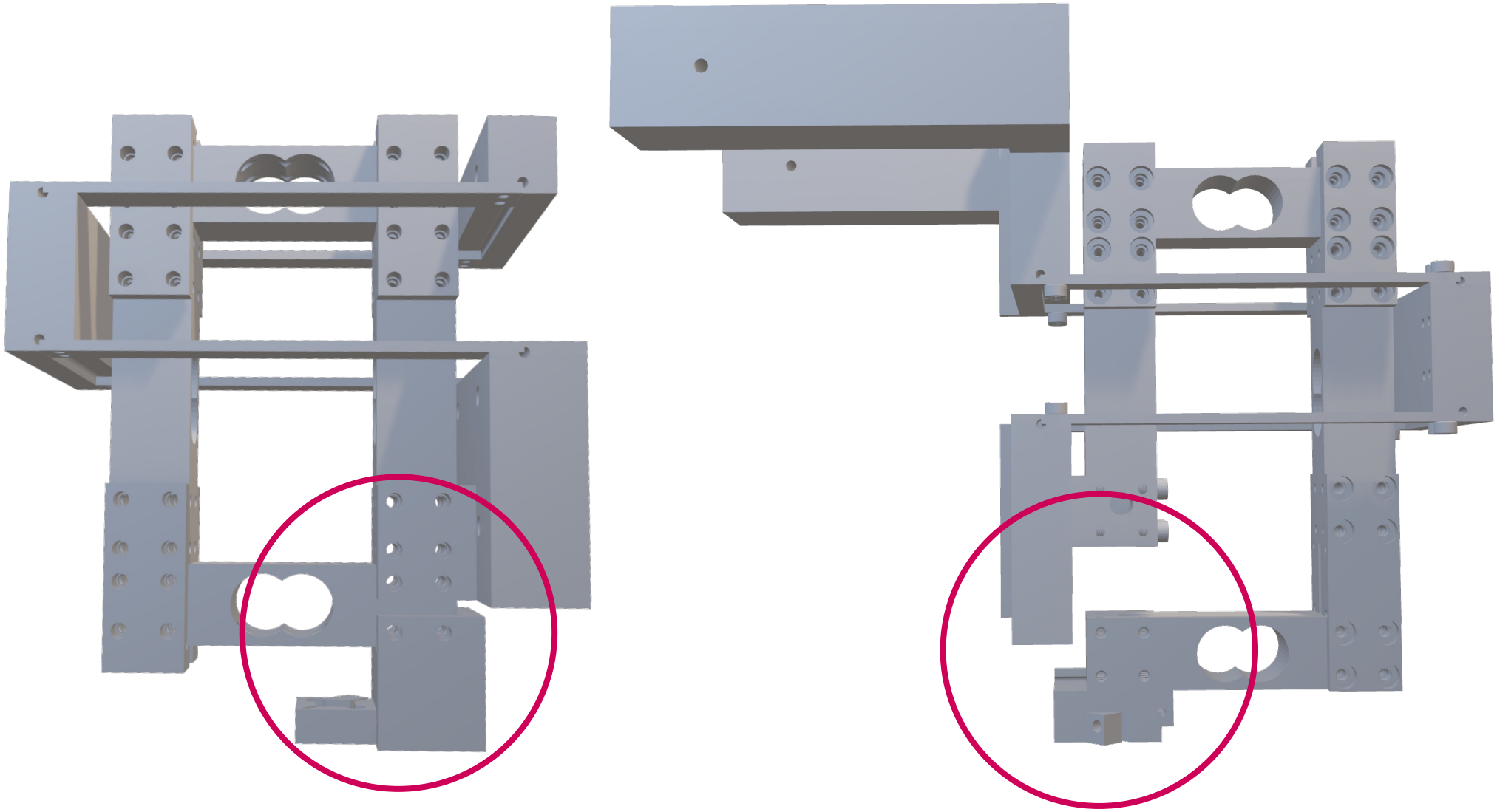


Mach 2

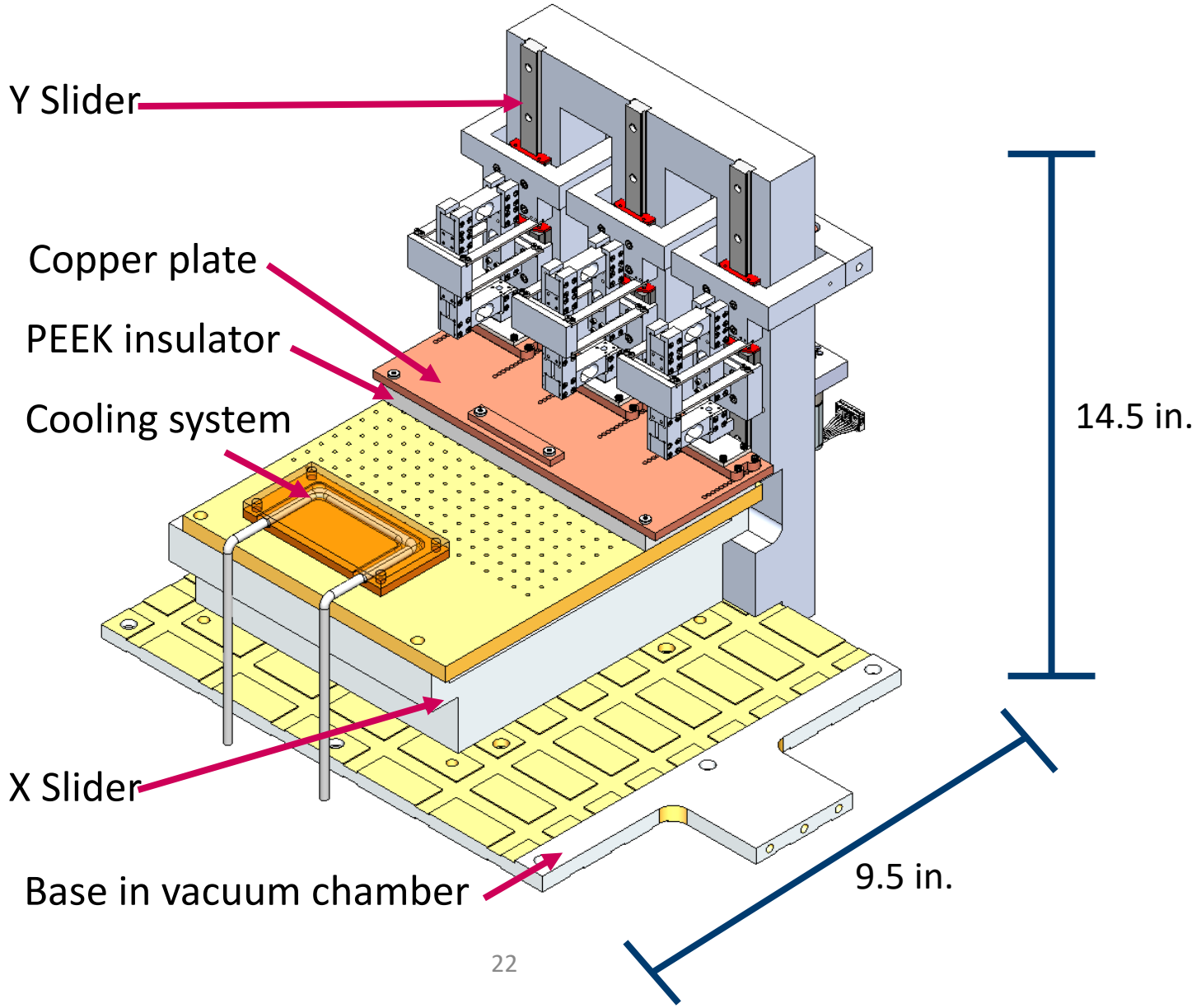


Mach 3

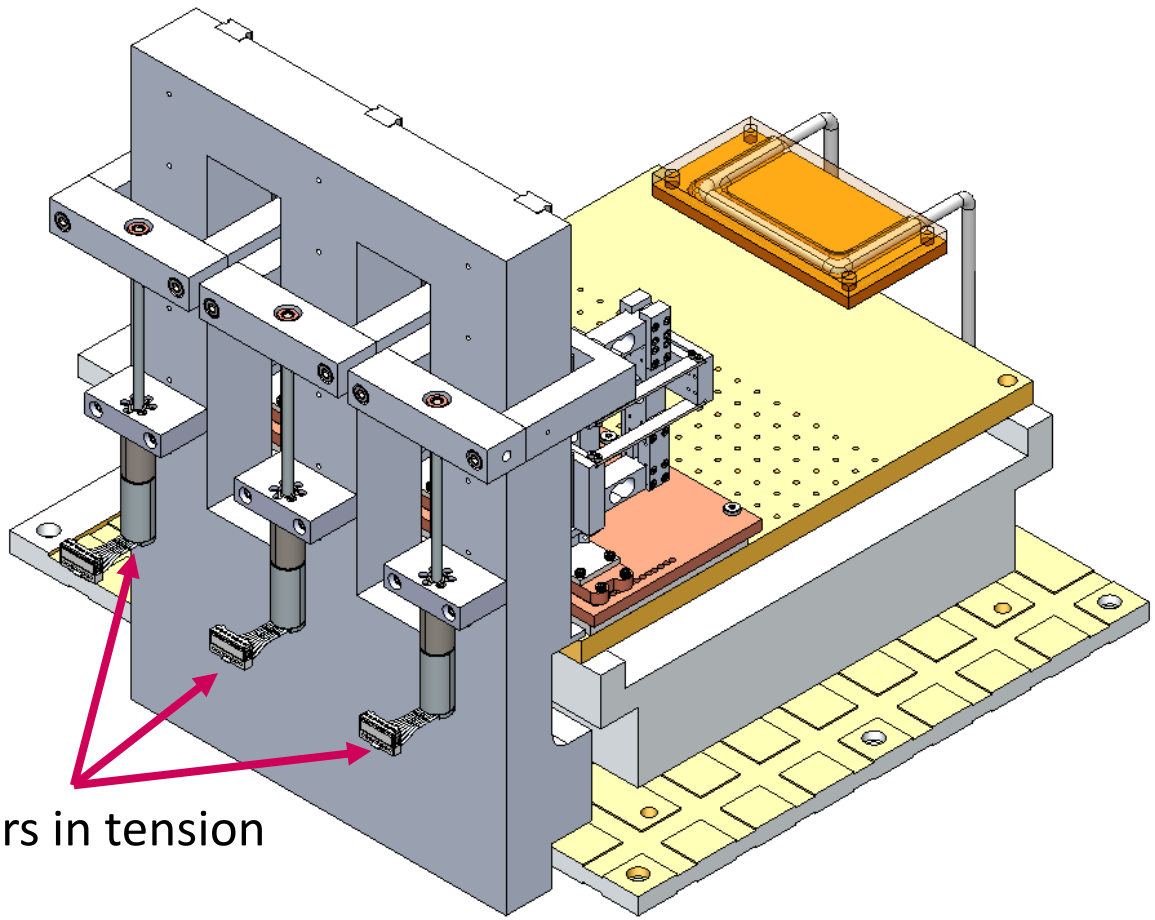
CAD Re-Design: Mach 4 Load Head

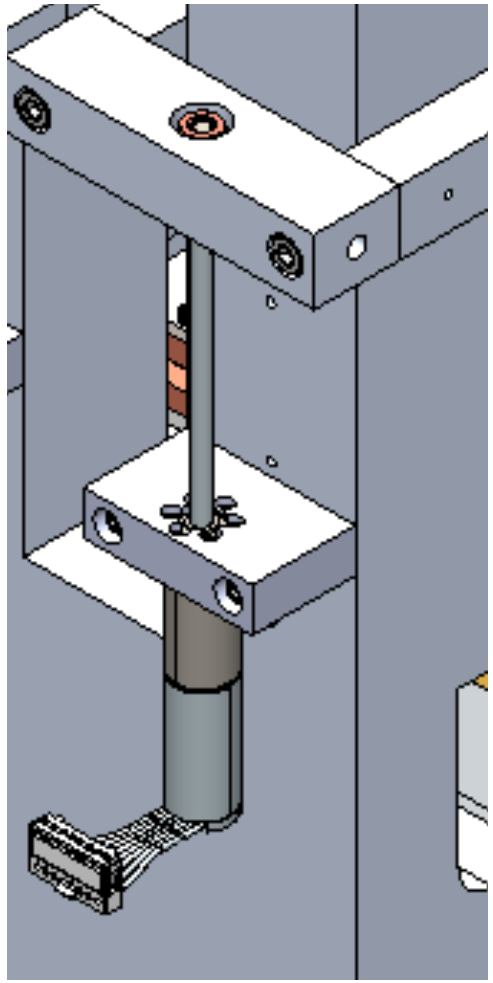


Final Design: Mach 4

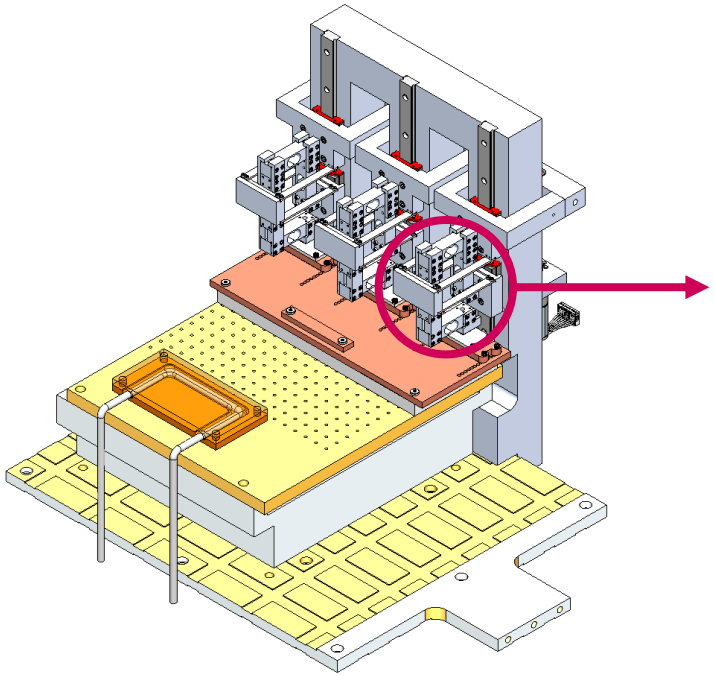


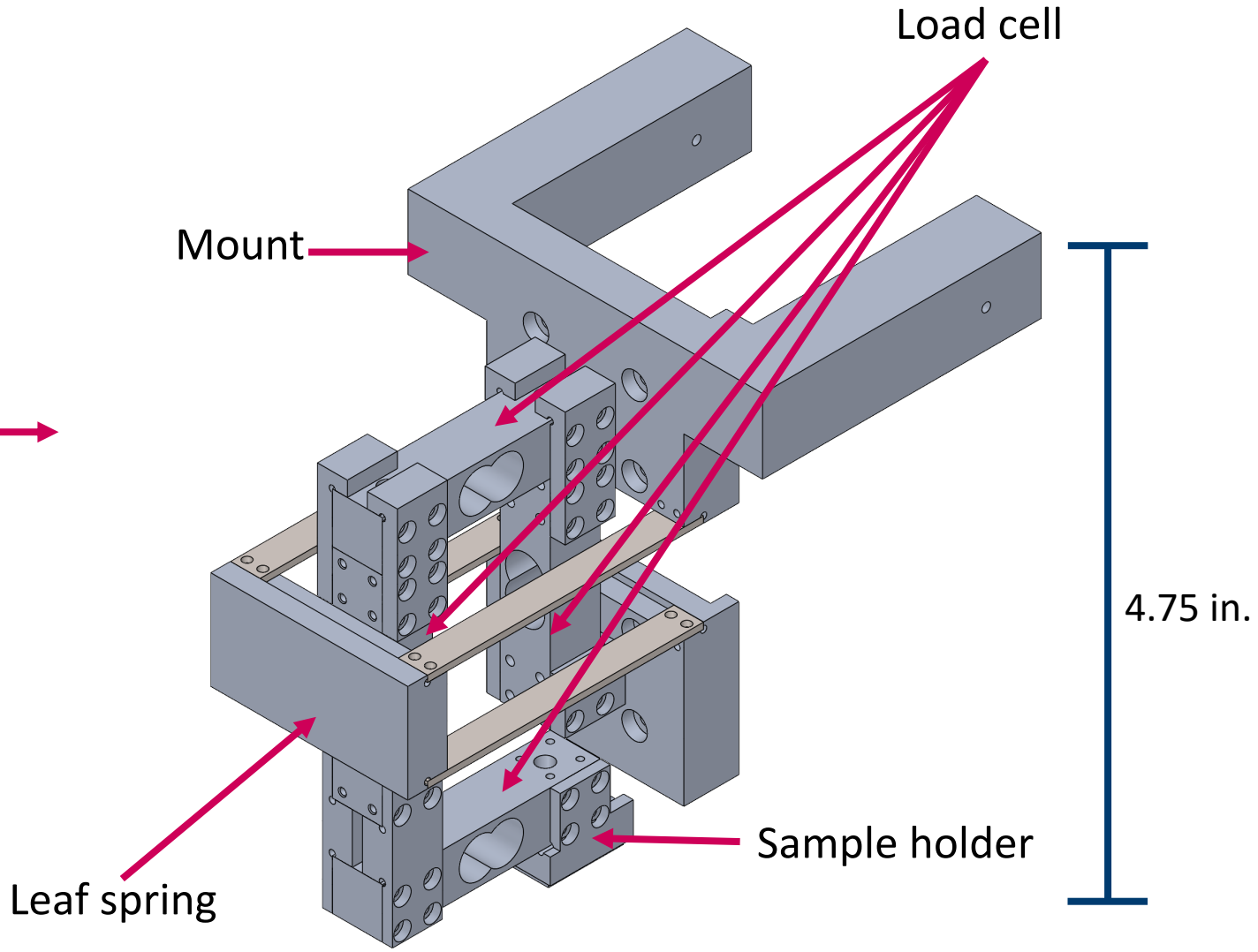
Final Design: Mach 4



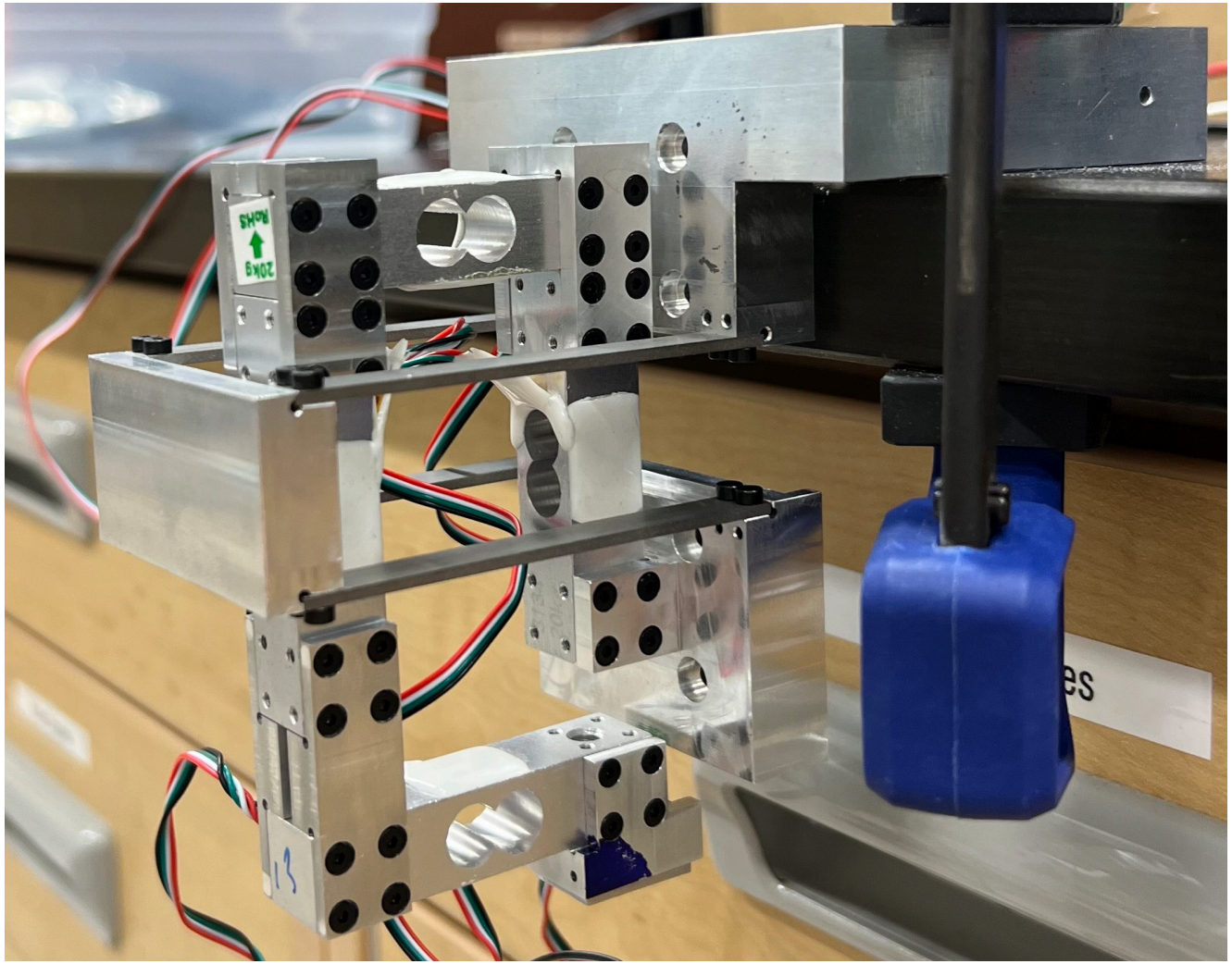


Final Design: Load Head



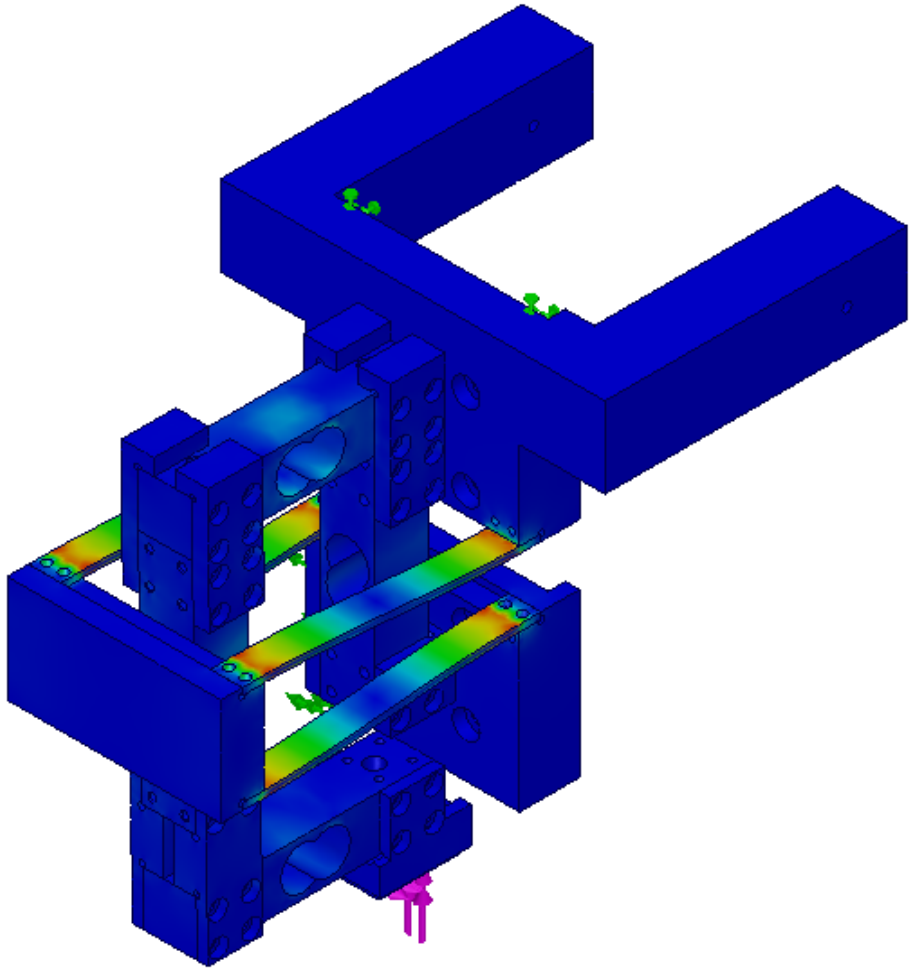


Load Head Assembly



FEA: Stress

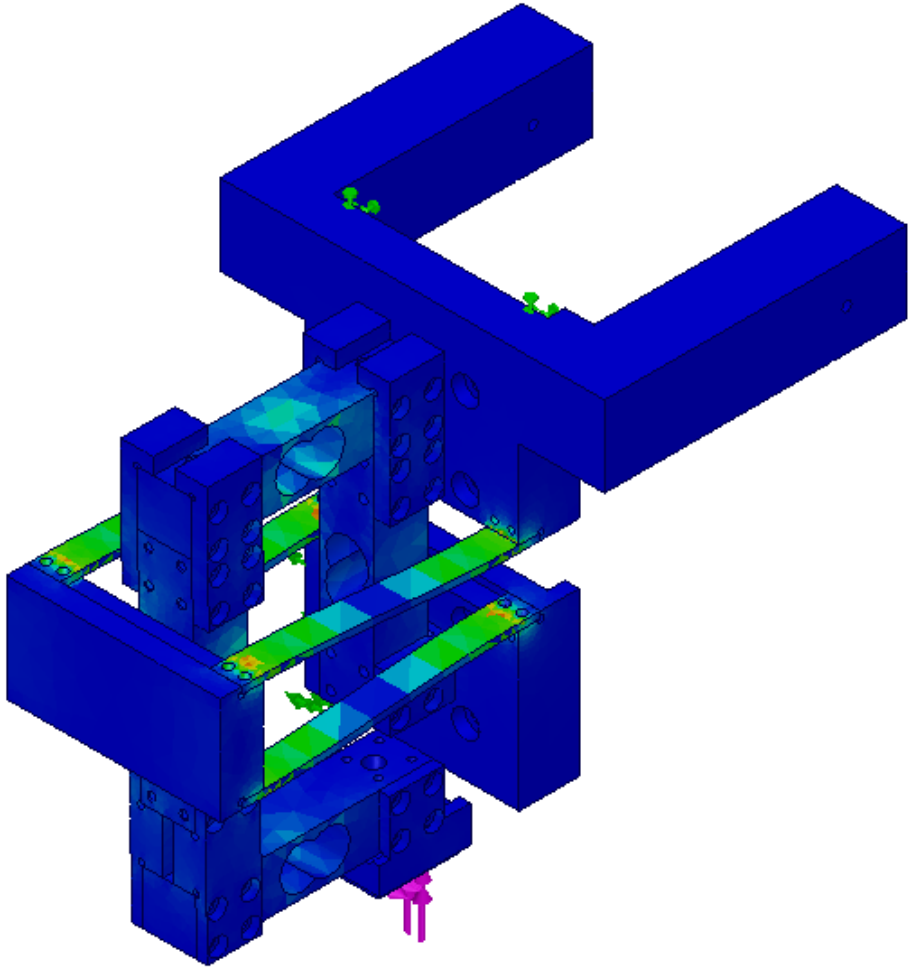
Leaf spring is ensuring constant and even contact of sample to counter sample.

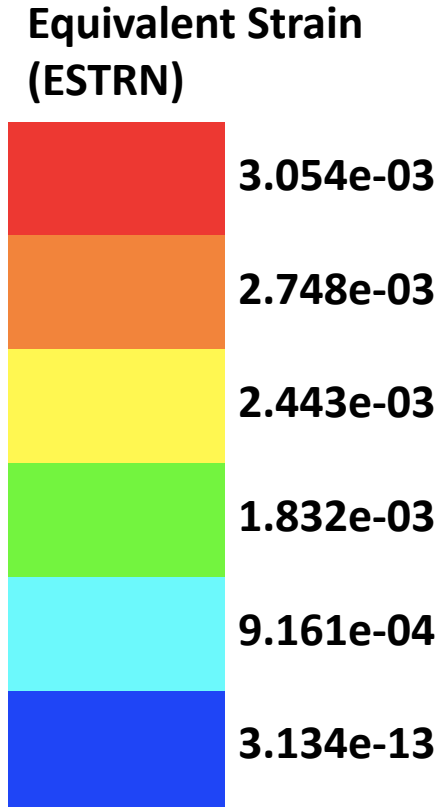


- Max stress: ~4.80e+08 Pa (red)
- Titanium Leaves Yield Strength: ~11e+08 Pa

FEA: Strain

Strain is all in the leaf spring and load cells.





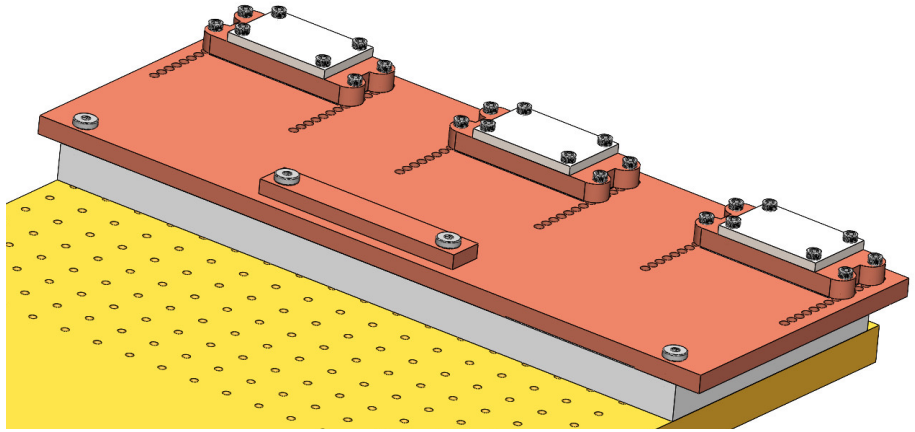
Thermal Assembly

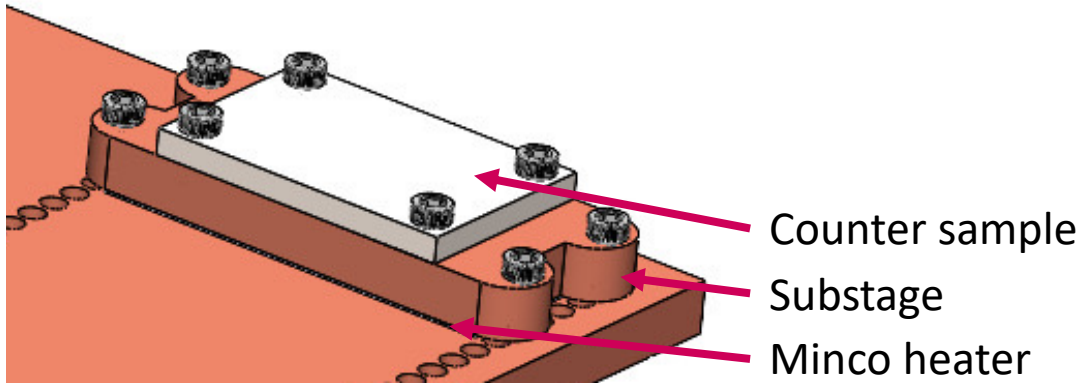
Heat to take material from -196C to 200C in 30 minutes:

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

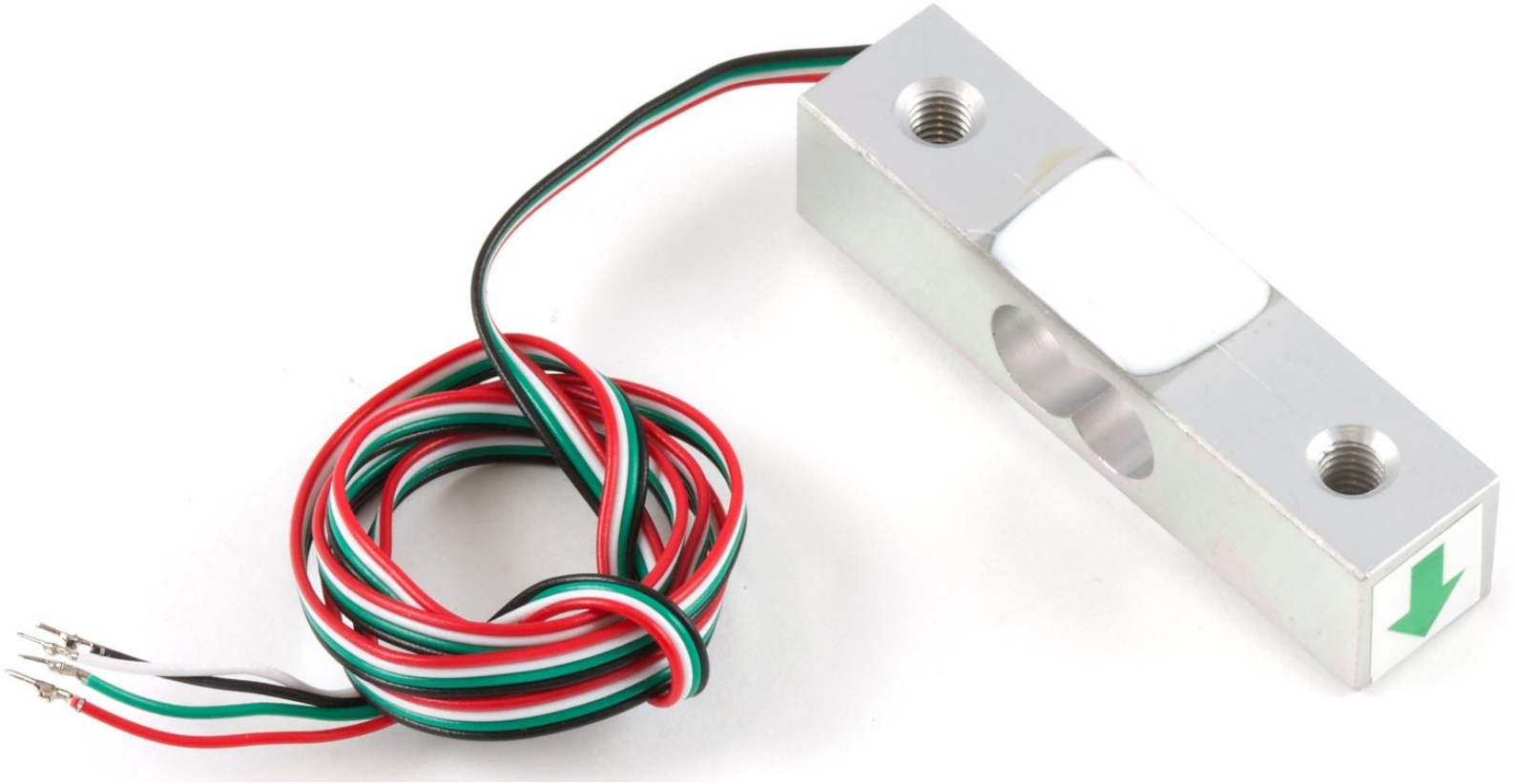
Maximum heater output is 88 Watts so,

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



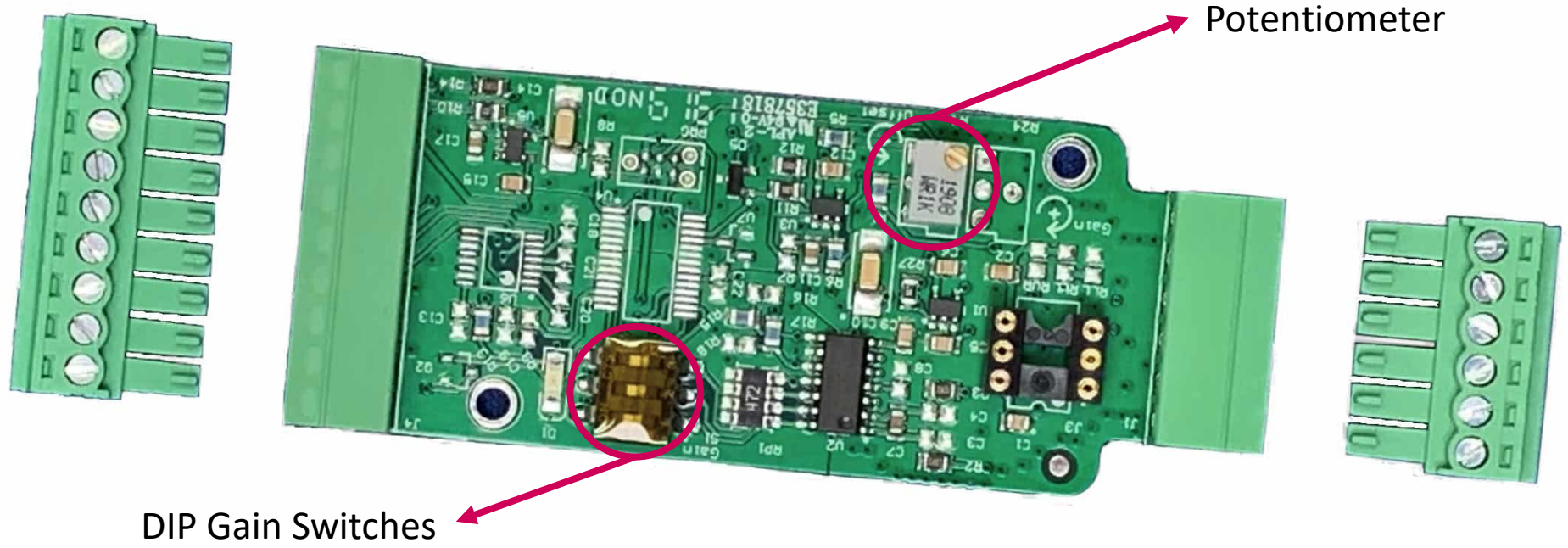


Load Cell



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

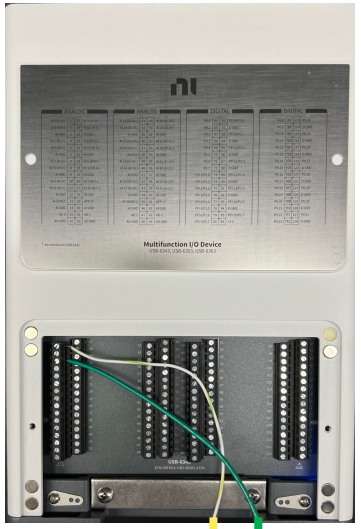
Amplifier/Signal Conditioner



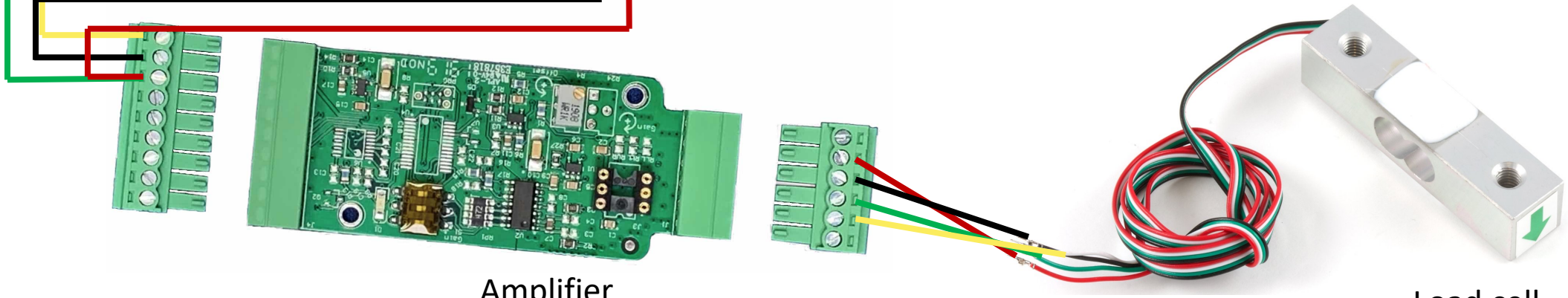
- Output of the load cell is a small signal, needs to be amplified for better measurements.
- Adjusting the gain decreases signal noise.

Looking at Force on a Load Cell

DAQ system



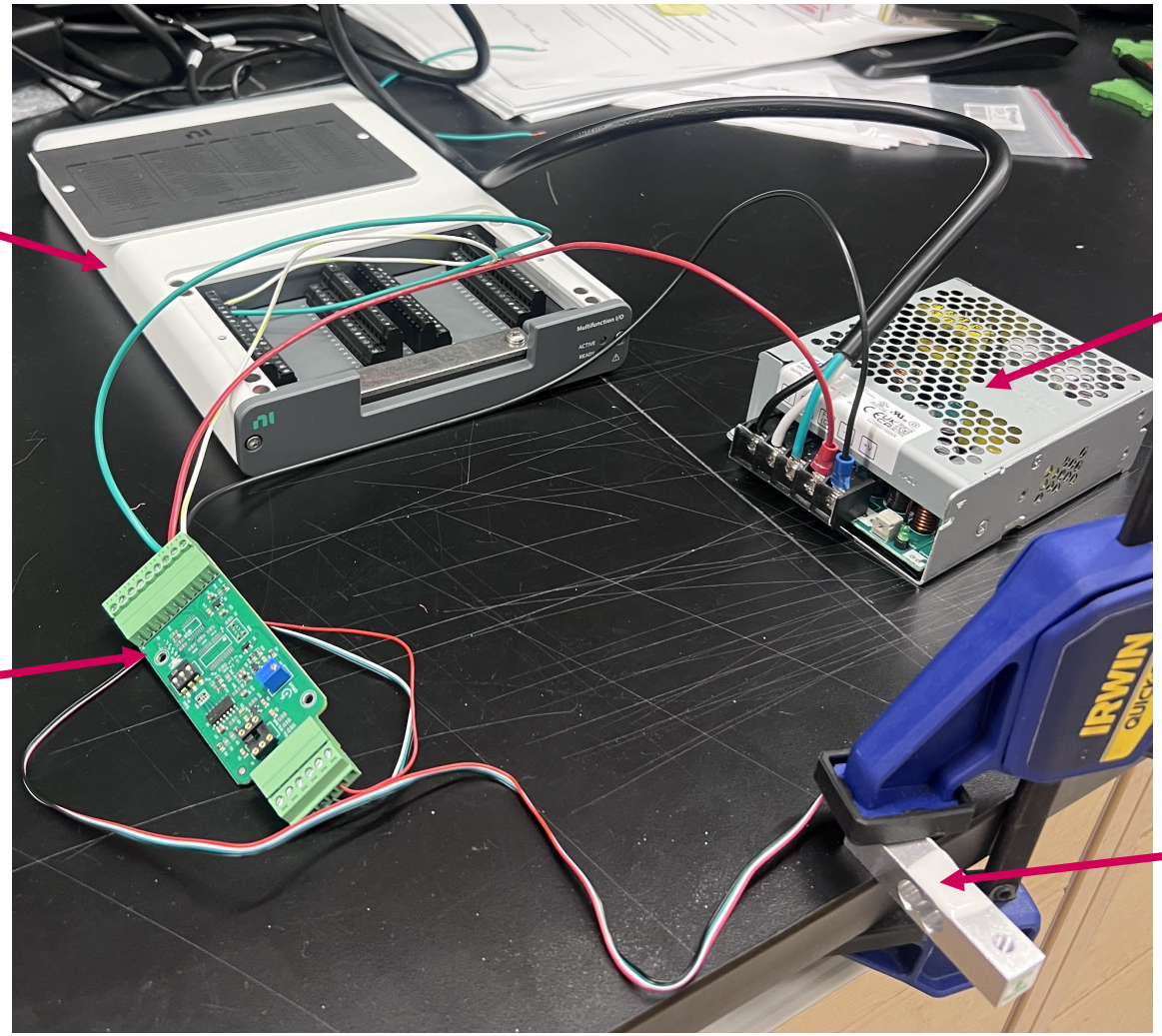
Power supply



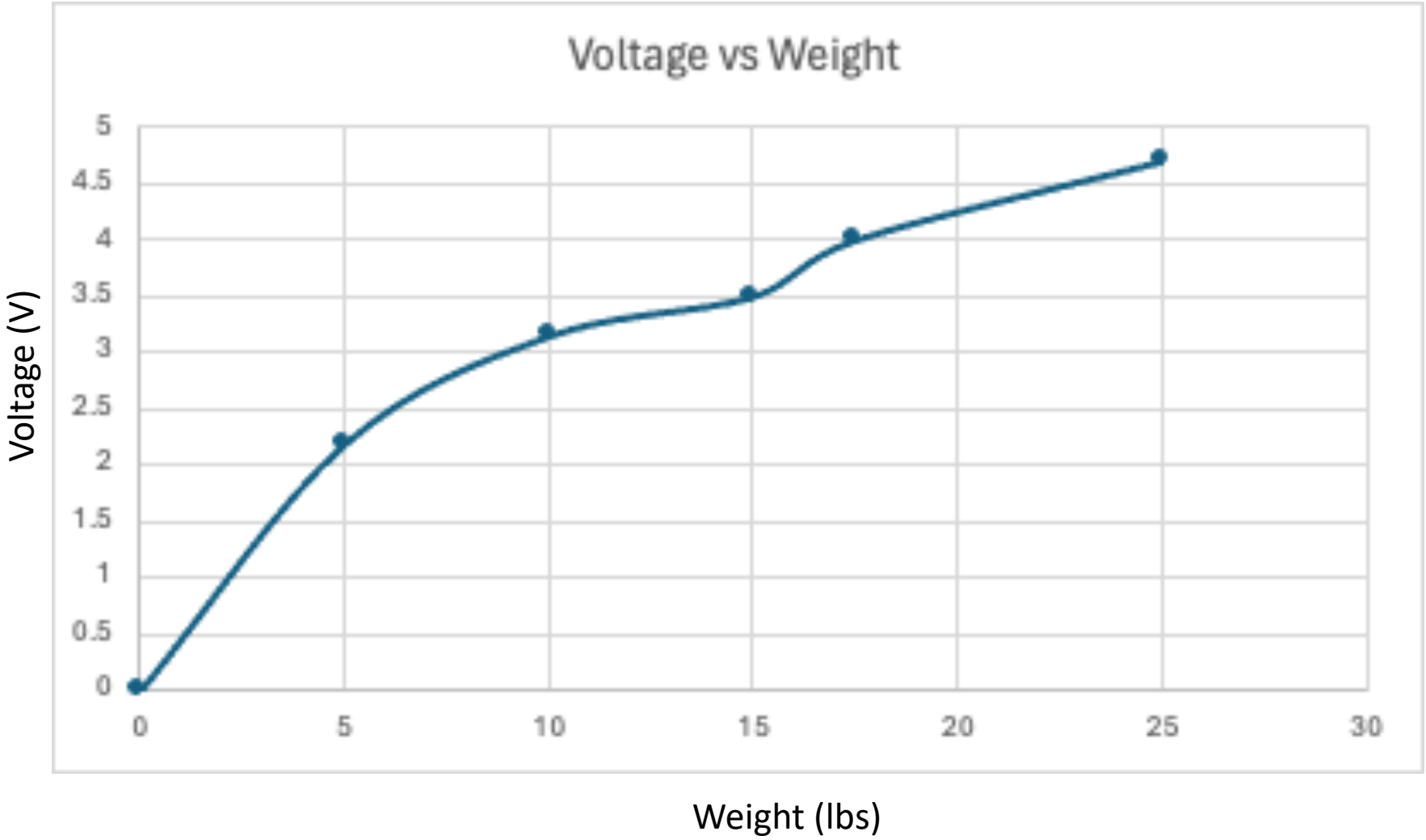
Amplifier

Load cell

Looking at Force on a Load Cell

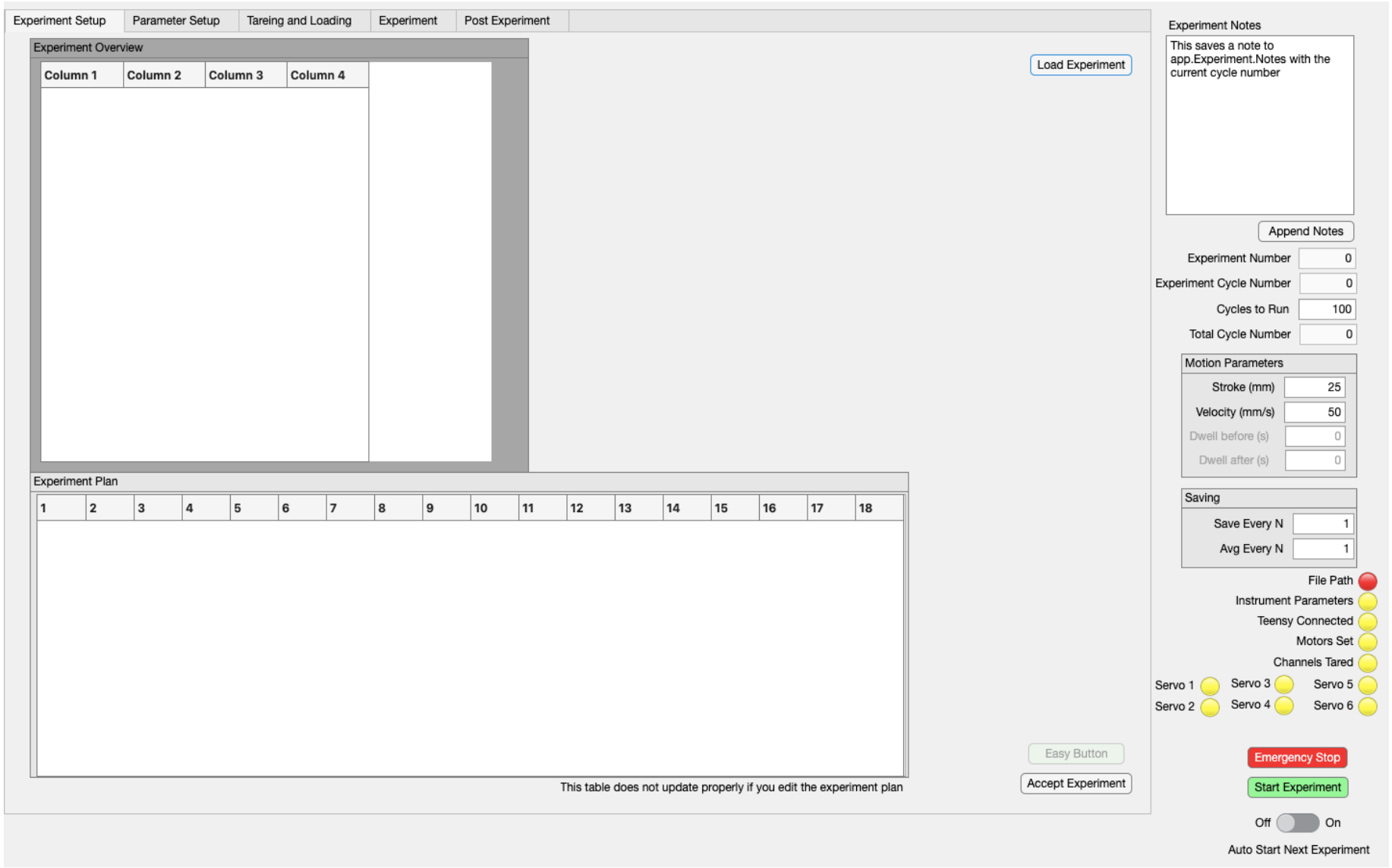


0 lbs to 25 lbs on the Load Cell



Madison Retherford

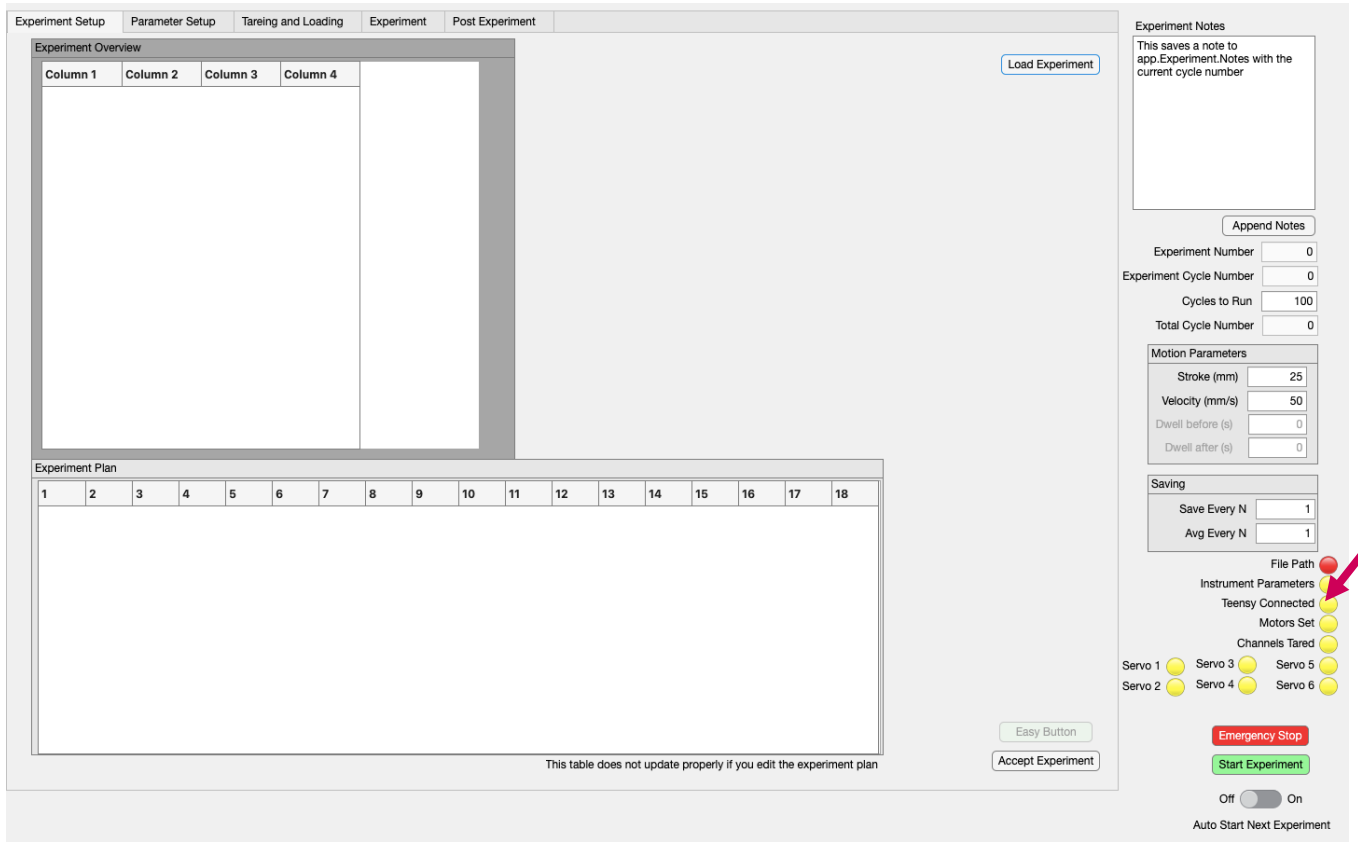
MATLAB GUI

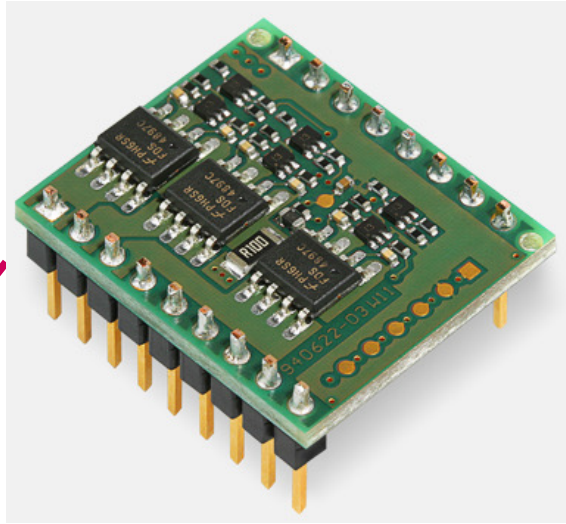


FAMU-FSU College of Engineering

Madison Retherford

MAXON Motor Controller





MATLAB GUI: Parameters

Tribometer Number	EnableLog	Sample	Sample ID	Project	Countersample	Load	Date	Stroke	Velocity	User	Environment
1	1	PTFE	A1	EnterProject	304L Stainless Steel	250		25	50	Krick	Air
2	1	PTFE	B3	EnterProject	304L Stainless Steel	250		25	50	Krick	Air
3	1	PTFE	D2	EnterProject	304L Stainless Steel	250		25	50	Krick	Air
4	1	PTFE	E1	EnterProject	304L Stainless Steel	250		25	50	Krick	Air
5	1	PTFE	E2	EnterProject	304L Stainless Steel	250		25	50	Krick	Air
6	1	PTFE	E3	EnterProject	304L Stainless Steel	250		25	50	Krick	Air

OtherDetails	L	W	H	initialmass	initialmassWithHolder	initialReferenceMass	density	Major1	Percent1
Template	12.5	6.3	6.3	1.2	3.1	0	0.002418745	PTFE	100
Template	12.5	6.3	6.3	1.2	3.1	0	0.002418745	PTFE	100
Template	12.5	6.3	6.3	1.2	3.1	0	0.002418745	PTFE	100
Template	12.5	6.3	6.3	1.2	3.1	0	0.002418745	PTFE	100
Template	12.5	6.3	6.3	1.2	3.1	0	0.002418745	PTFE	101
Template	12.5	6.3	6.3	1.2	3.1	0	0.002418745	PTFE	102

Future Work

Get PEEK and copper re-machined.

Calibrate four load cell assembly.

Assemble the tribometer.

Integrate motor control functionality with MATLAB.

Test critical loads with motors working.