# In Situ Characterization during Mechanical Testing at MSN-C

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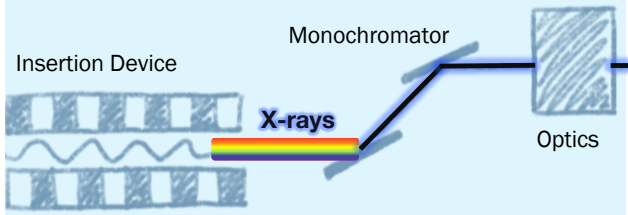
# Anatomy of a Beamline

*Many different customizations required to optimize the signal - dictated by the material characterization needs*

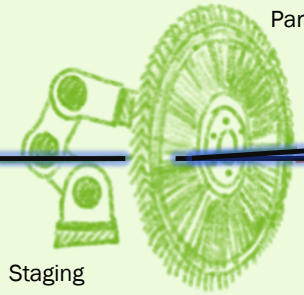
**X-ray Path**

## Beamline Insertion Device and Optics



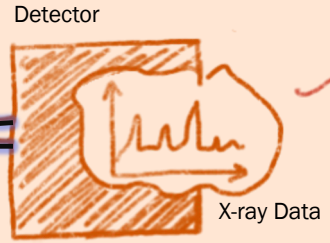

*Options can include:*
No monochromator (1A3)
Wide bandwidth monochromator (3A)
Various Apertures/Slits
Focusing Optics

## Staging and Sample Environment




*Options can include:*
- Multiple Staging Tables and Motor Assemblies
- Part Fixtures
- Specialized Load Frames
- Heating Stages

## Detectors




*Options can include:*
- Multiple Detectors
- Energy Dispersive Detectors
- Large-format Area Detectors
- Scintillator + Camera for Imaging
- High-speed detectors

## Data Reduction Software & Data Curation


*Workflows for each technique. Ongoing efforts to modularize code for efficiency*

**Controls & Data Collection**

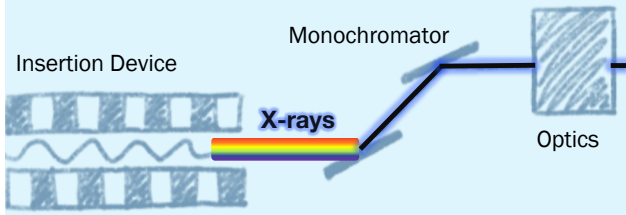
# Beamline Shared Resources

Many different customizations required to optimize the signal - dictated by the material characterization needs

X-ray Path

## Beamline Insertion Device and Optics

**All Dedicated**




## Staging and Sample Environment

**Dedicated:**
Industrial Robot

**Shared:**
Load Frames,
Furnaces
In Situ Processing

Anything that can roll in and out of the station (and fit):

## Detectors

**Dedicated:**
Energy Dispersive Detector

**Shared:**
Direct X-ray Area Detectors

Imaging Detectors

## Data Reduction Software & Data Curation

**Dedicated:**
Technique specific software

**Shared:**
Cyber Infrastructure

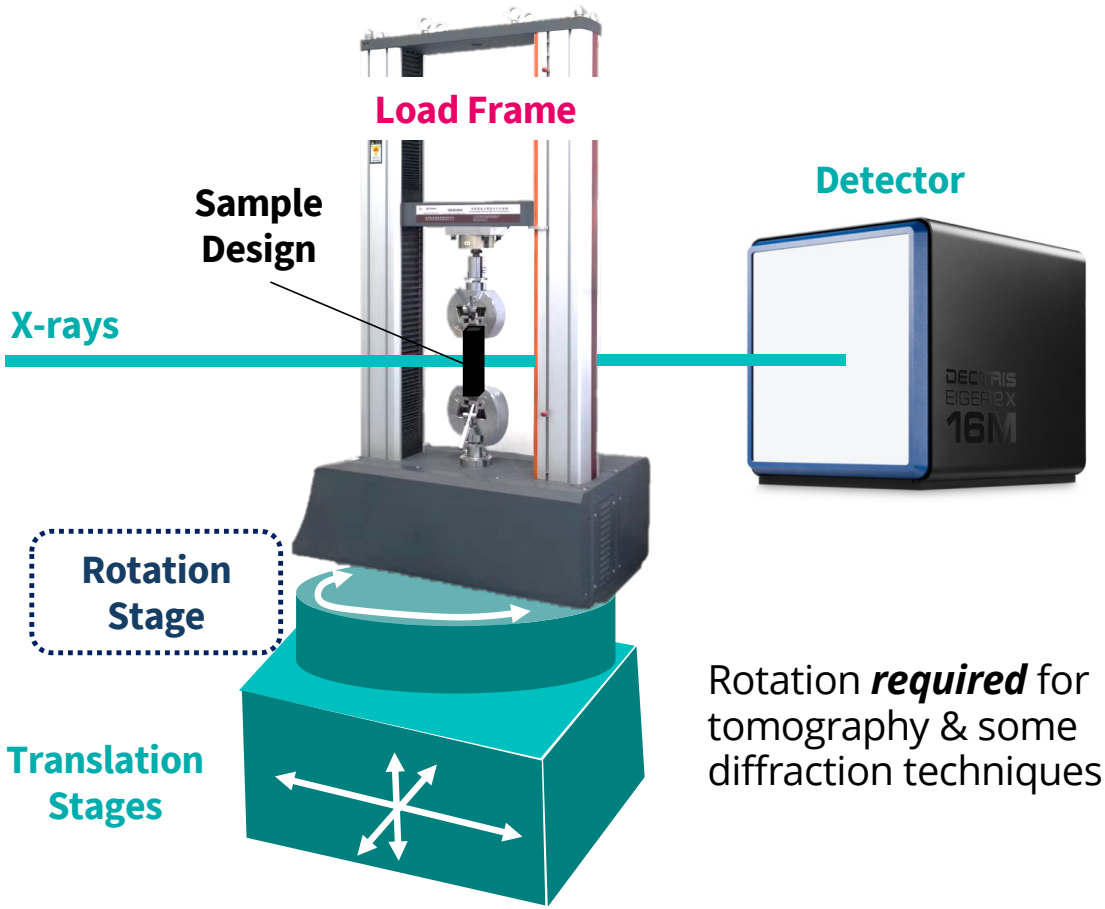
Data and Metadata Handlers

Analysis Pipelines

Controls & Data Collection
**Shared hardware and strategies**

# In Situ Mechanical Testing at a Synchrotron

Integrate **Mechanical Load Frame** with a **Beamline**




Rotation ***required*** for tomography & some diffraction techniques

Important considerations:

## Data Collection Rates

Limited by motor motions & detection requirements

## Targeted Measurement

Collect meaningful data at **right** time

## Test Interpretability

Requires incredibly **detailed and comprehensive state monitoring of instrument** (load frame + beamline)

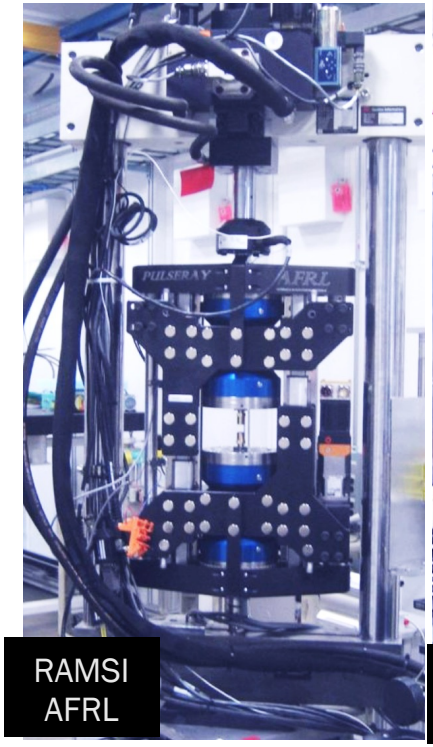
# Rotational and Axial Motion Systems

AFRL
AIR FORCE RESEARCH LABORATORY

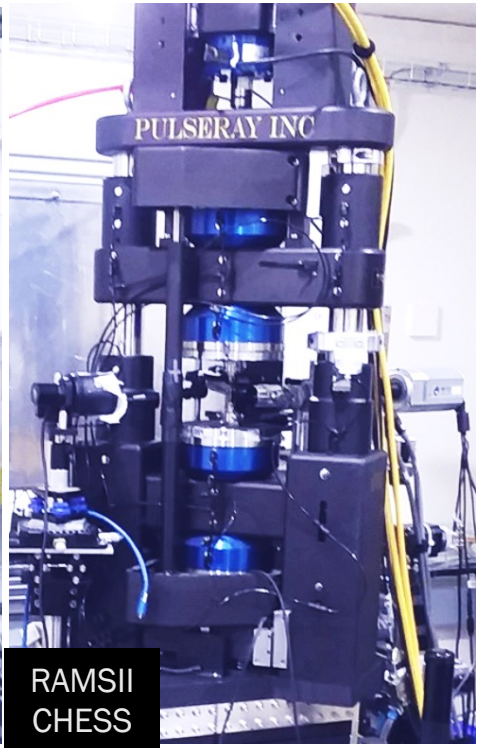
Rotation Axes within load frame for fast, accurate rotation

All mechanical testing controls designed *in house* for

- Accurate mechanical tests
- Interfacing with the X-ray end station controls for synchronized data collection

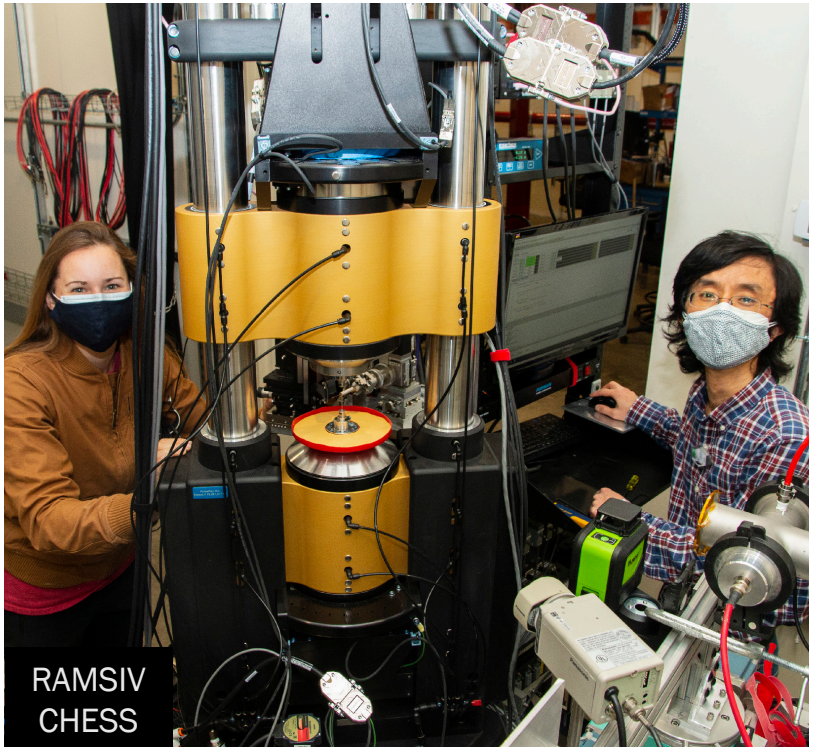


RAMSI
AFRL

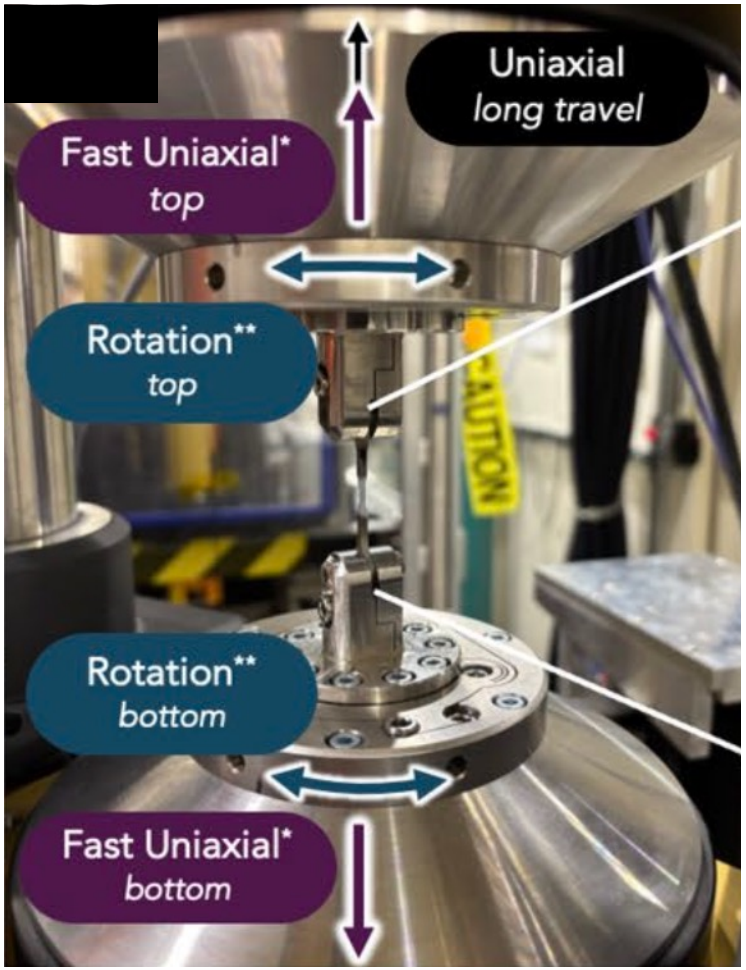


RAMSII
CHESS

RAMSIII
APS


RAMSIV
CHESS

# Rotational and Axial Motion Systems IV

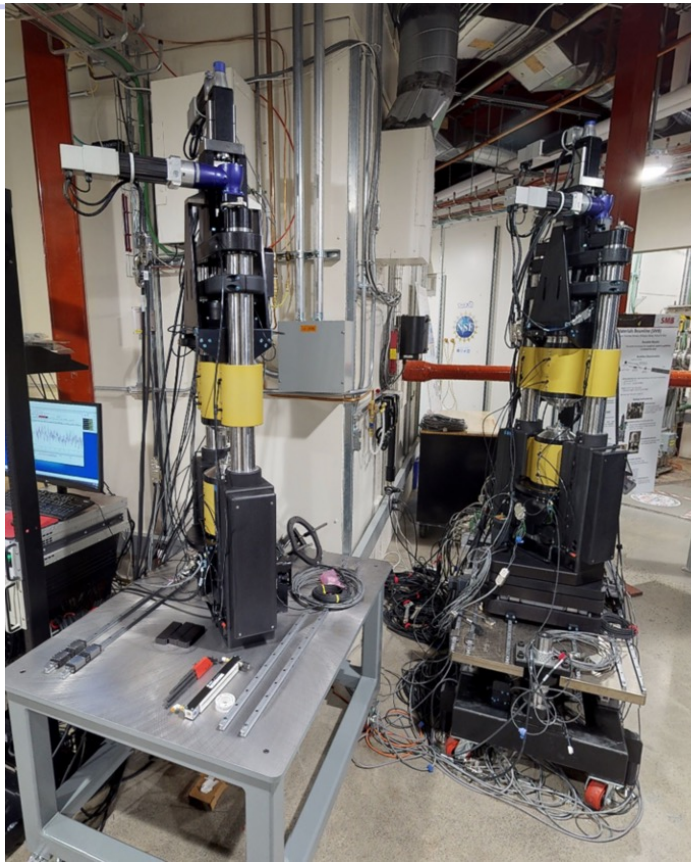



## Uniaxial and Torsional Testing

Fast Uniaxial Motors
- Geared or ungeared motion
- High-Cycle Fatigue 5-10 Hz
- Uniaxial motion up to $10^1$ strain rates

Rotation Motors
- Air bearing stages
- Geared or ungeared motion
- 400 degrees / second

Control Modes:
- Load control
- Displacement control
- Strain control



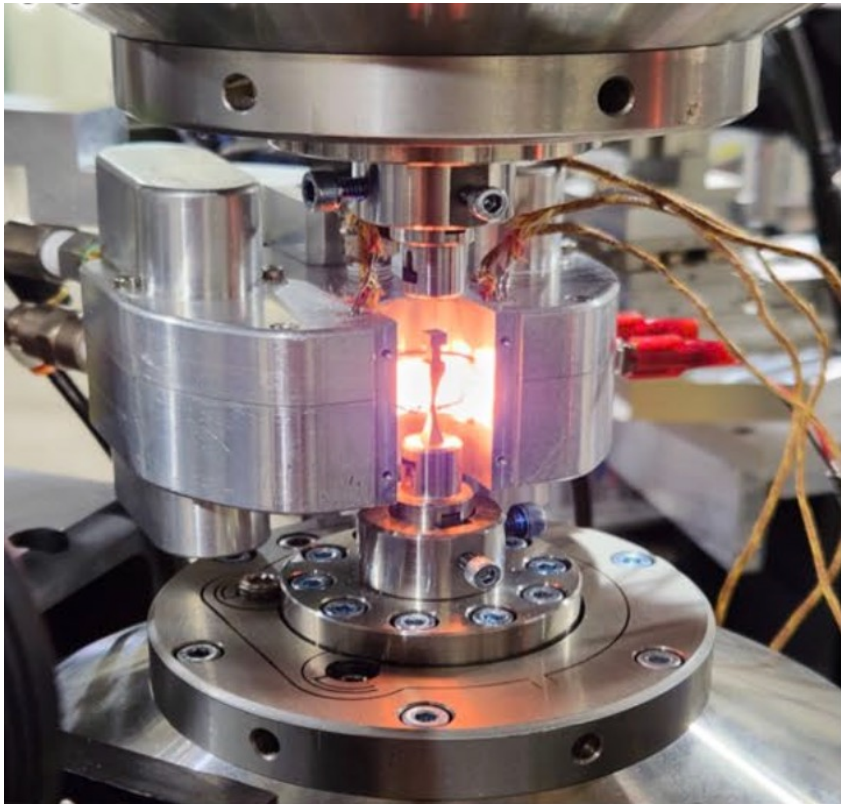
**Sister system lives at AFRL**

Controls development, design, and bench testing

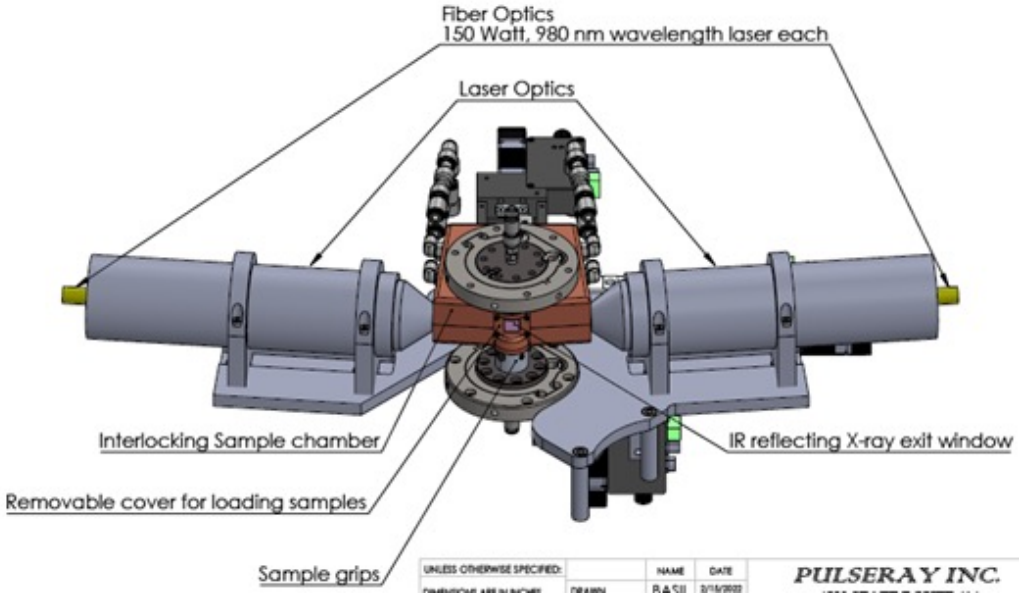
# RAMSIV Accessories (Furnaces)

Two furnace systems at different temperature ranges

Halogen Lamp Furnace (up to 1000 ˚C)
Environment control: flowing Ar gas



Laser Furnace (up to 2000 ˚C)
Environment control: flowing Ar gas ($O_2$ ~5 ppm)



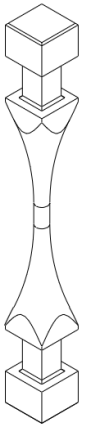
# RAMSIV Data Collection

## Data Collection Rates

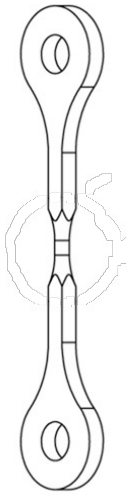
| | Historically | Now | Currently Rate Limiting? |
|---|---|---|---|
| **Rotation speed** | 20 deg/s max | 400 deg/s | No |
| **Detector frame rate (large format)** | 10 Hz max | 200 Hz max | Problem Dependent (typically no) |
| **Write out speed** | minutes | N/A (now asynchronous) | No |
| **Communication Overhead** | 10's seconds | seconds | Problem Dependent (typically no) |
| **Signal Strength** | Longer Dwells | Shorter Dwells | **Yes** |

**Future improvements through increased X-ray flux (New insertion device)**

# RAMSIV Grip Designs



"Keeper Grip" Design

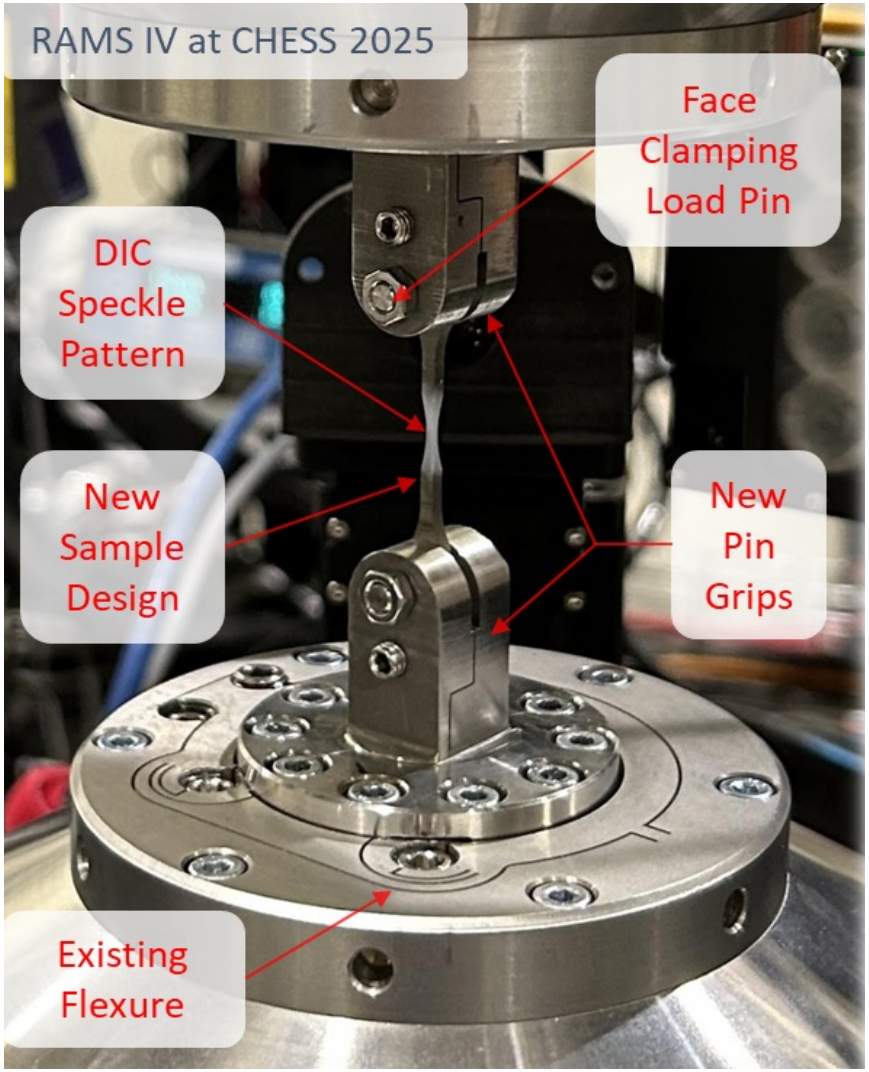


"Pin Grip" Design

Sample Geometry Considerations:

2500N – 4000N load cell

Space between grip fixtures



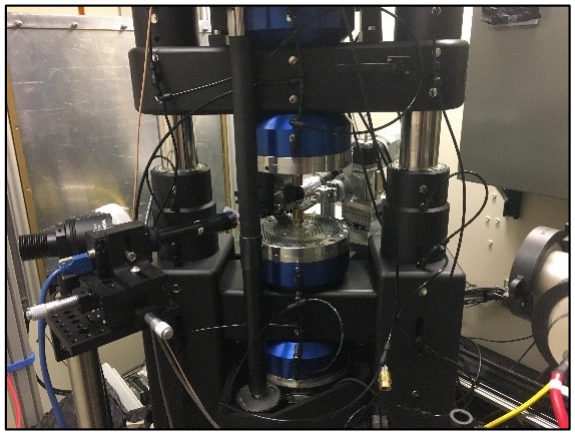

**Open to custom grip designs**

# More Mechanical Testing Frames

## Electro Magnetic Load Frame

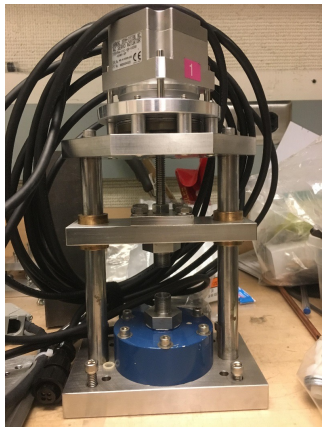
- Full reversed cyclic loading (2500N)
- High Frequency (100 Hz Max)

## RAMS2 (w/AFRL)



- Full reversed cyclic loading (1000-2000N)
- Furnace Available (1000C Max)

## Cornell Compact Load Frame

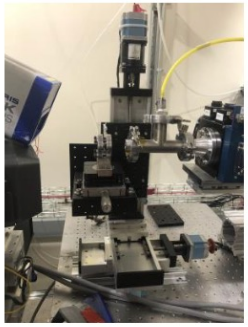


- Full reversed cyclic loading (~5000N)
- Flexible specimen design

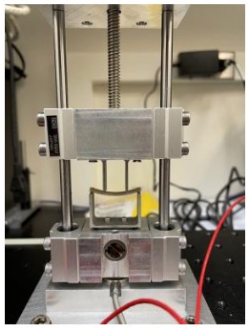
**History of building bespoke loadframes and integrating commercial ones**

**Sample environments can be developed (only heating atm)**

## Diamond anvil cell (CHESS)



## Four-point bender (CHESS)



## Linkam tensile / heat stages