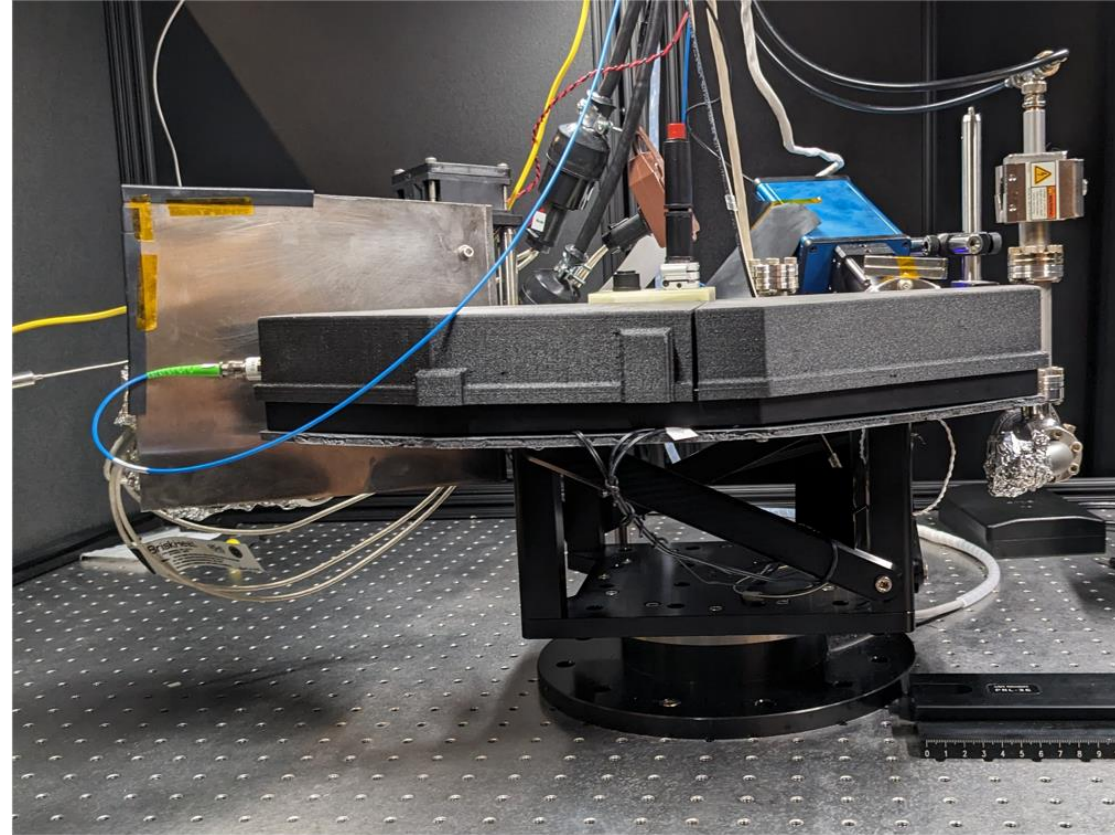


Independent Laser System for Strontium Atom-Interferometer Gyroscope



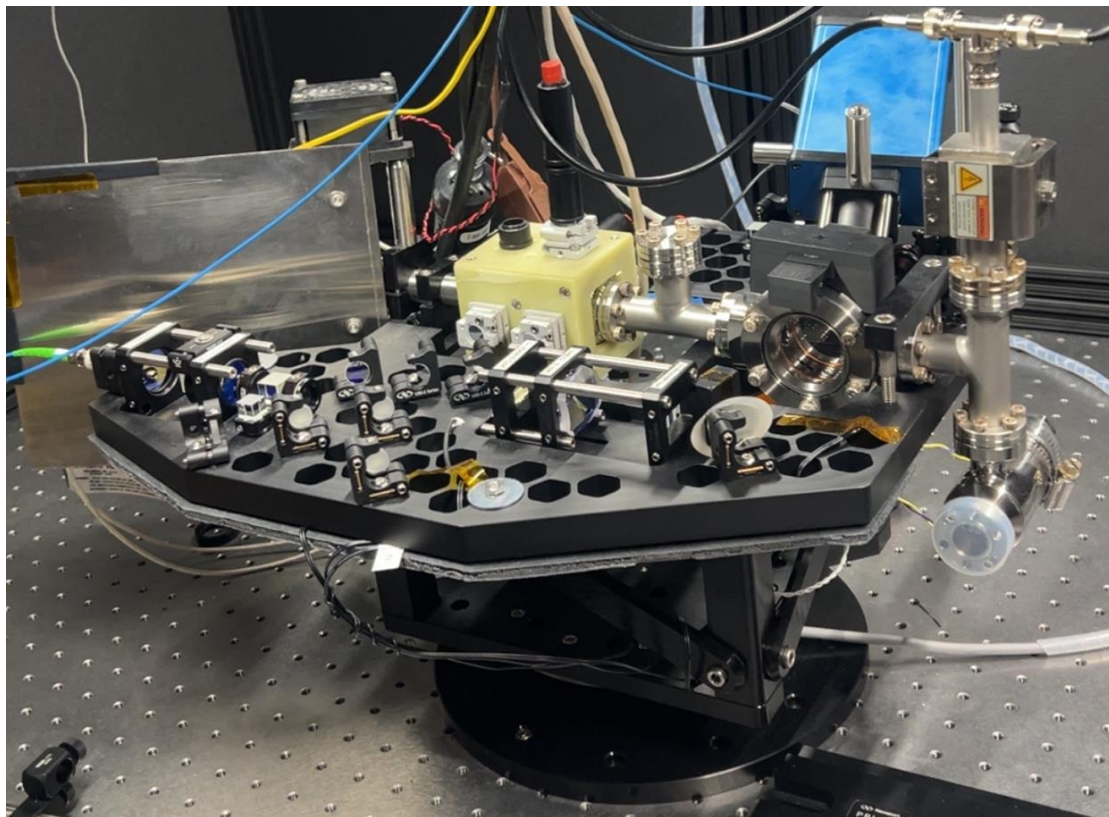
Matterwave interferometer in Lin Hall

Claude Valdez

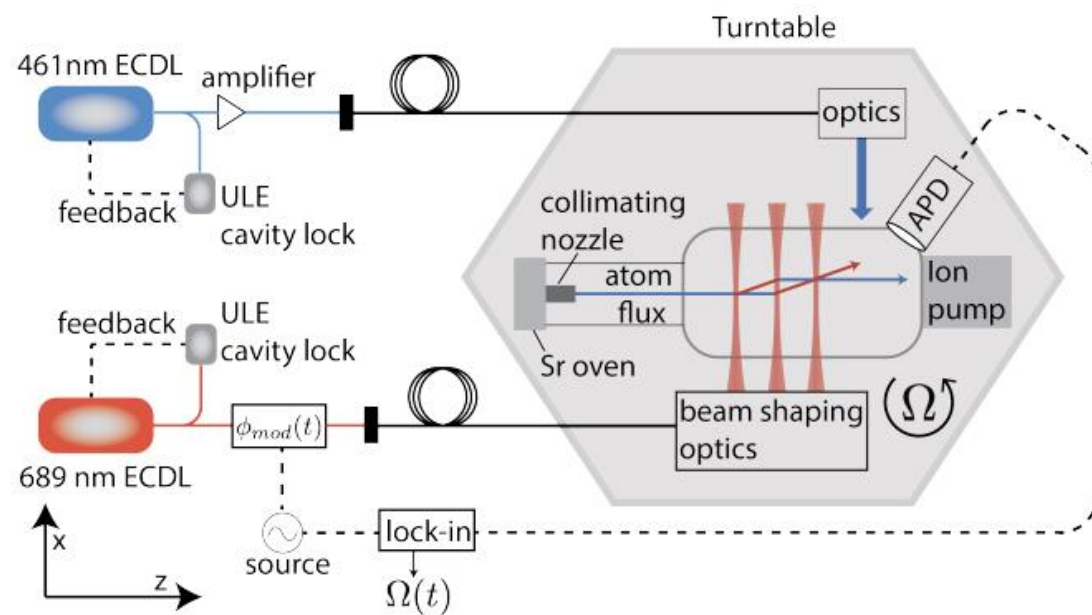
Advisor: Grant Biedermann

Graduate Student: Jason Gordon, Hanbo Yang, Luke Kraft

Strontium AIG Apparatus

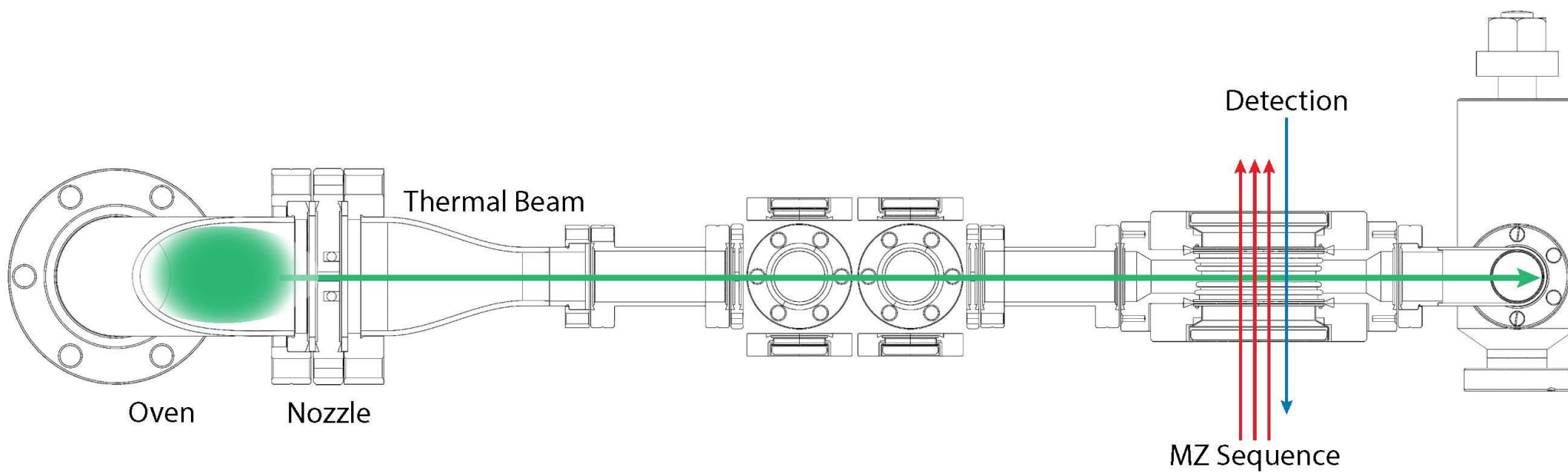


Apparatus

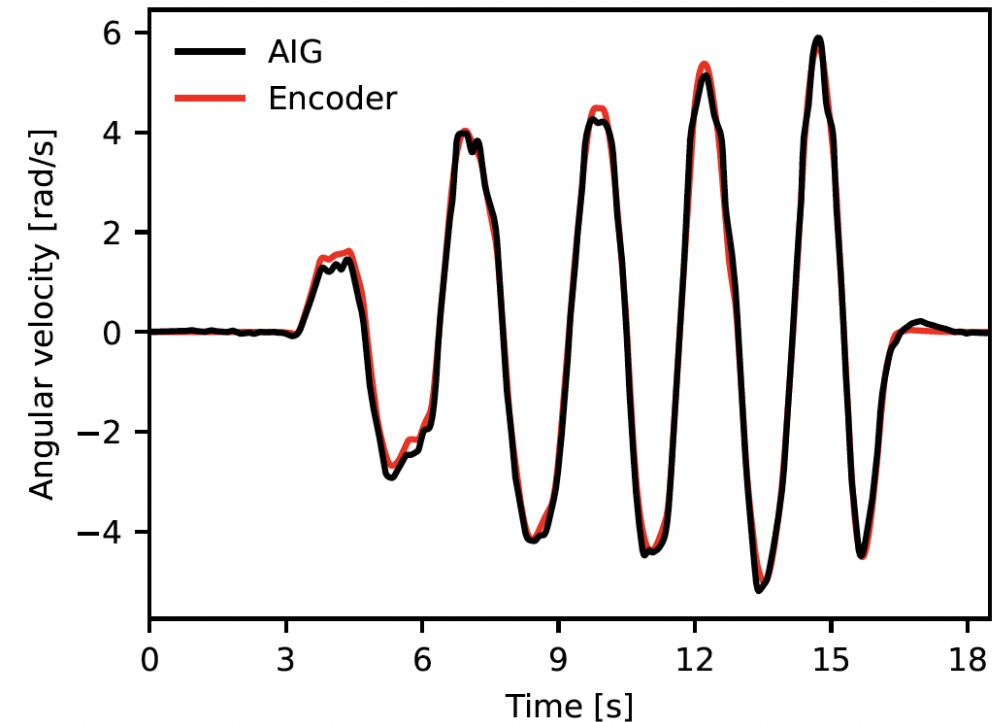
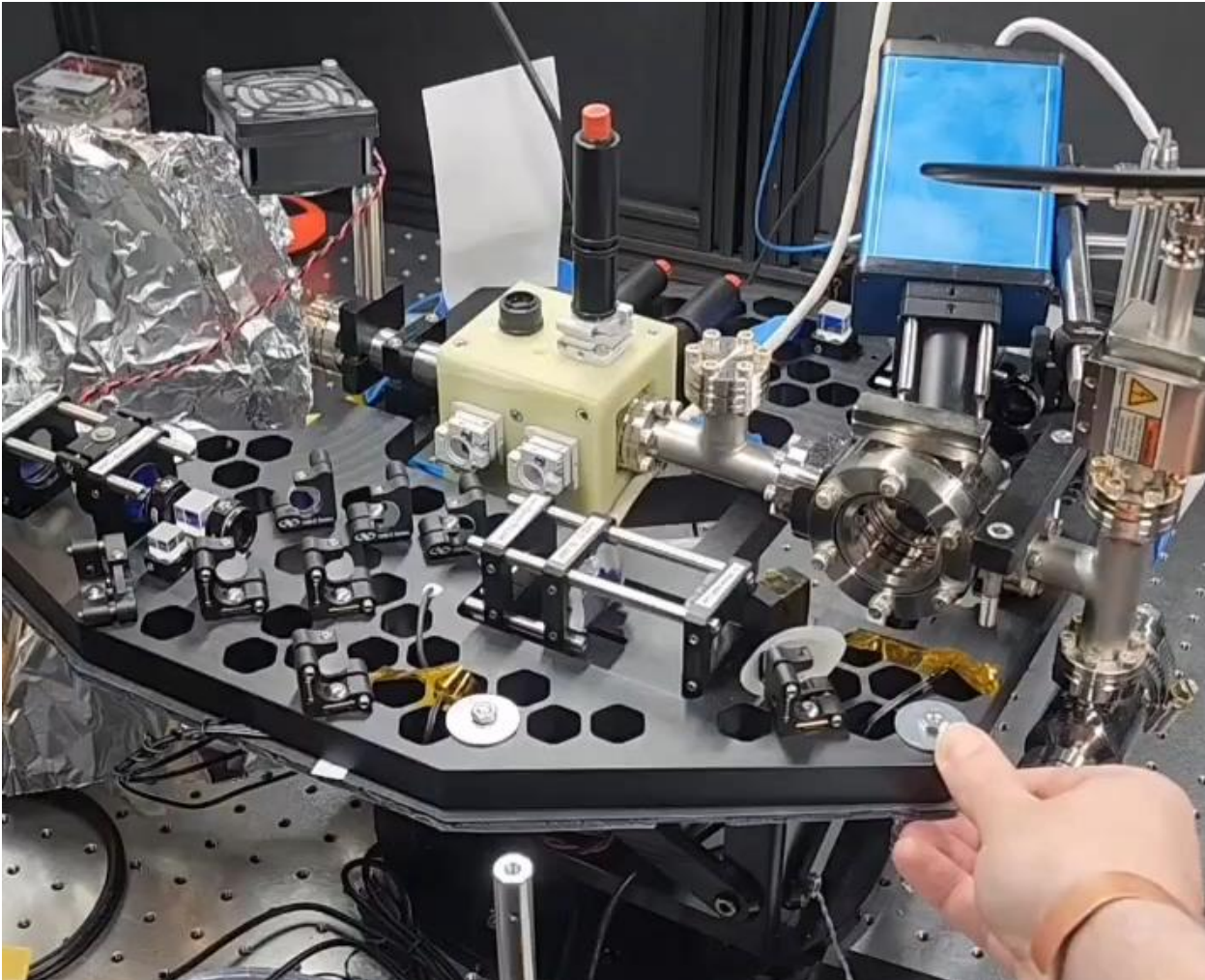


Experiment Overview

Strontium AIG Apparatus



Demonstration of rotation rate sensitivity



$$\Delta\phi = \frac{4\pi m \Omega A}{h} = 2\vec{k} \cdot (\vec{v} \times \vec{\Omega}) T^2$$

Motivation

1. Minimize Shared Laser Light
 - AIG and Tweezer project need red and blue laser light
2. Boosted AIG Signal
 - More blue power for detection
 - Potential for laser cooling

Phase shift depends on atomic velocity

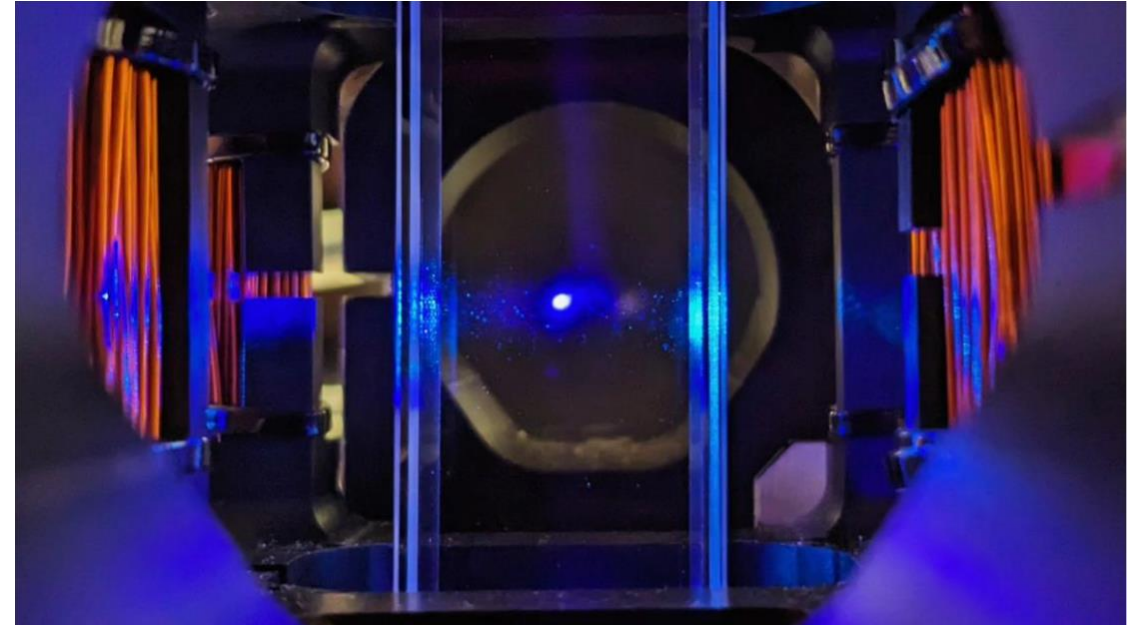
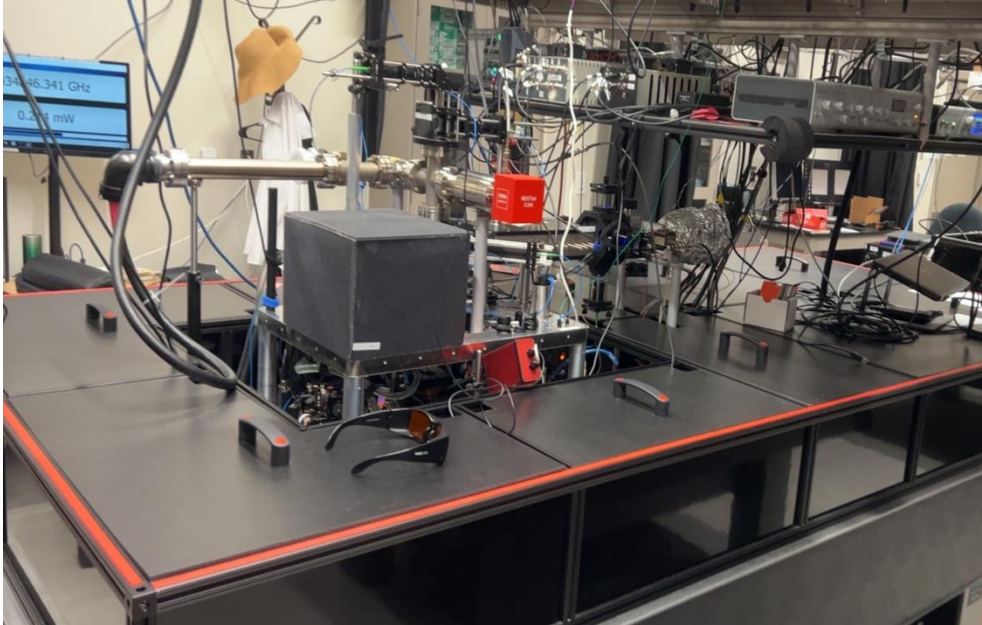
$$\Delta\phi = 2\vec{k} \cdot (\vec{v} \times \vec{\Omega}) T^2$$

Nozzle limits transverse velocity to $\sim 5\text{m/s}$

Can use blue laser light to cool to $\sim 0.27\text{ m/s}$

Many more atoms contribute

Boosts Contrast

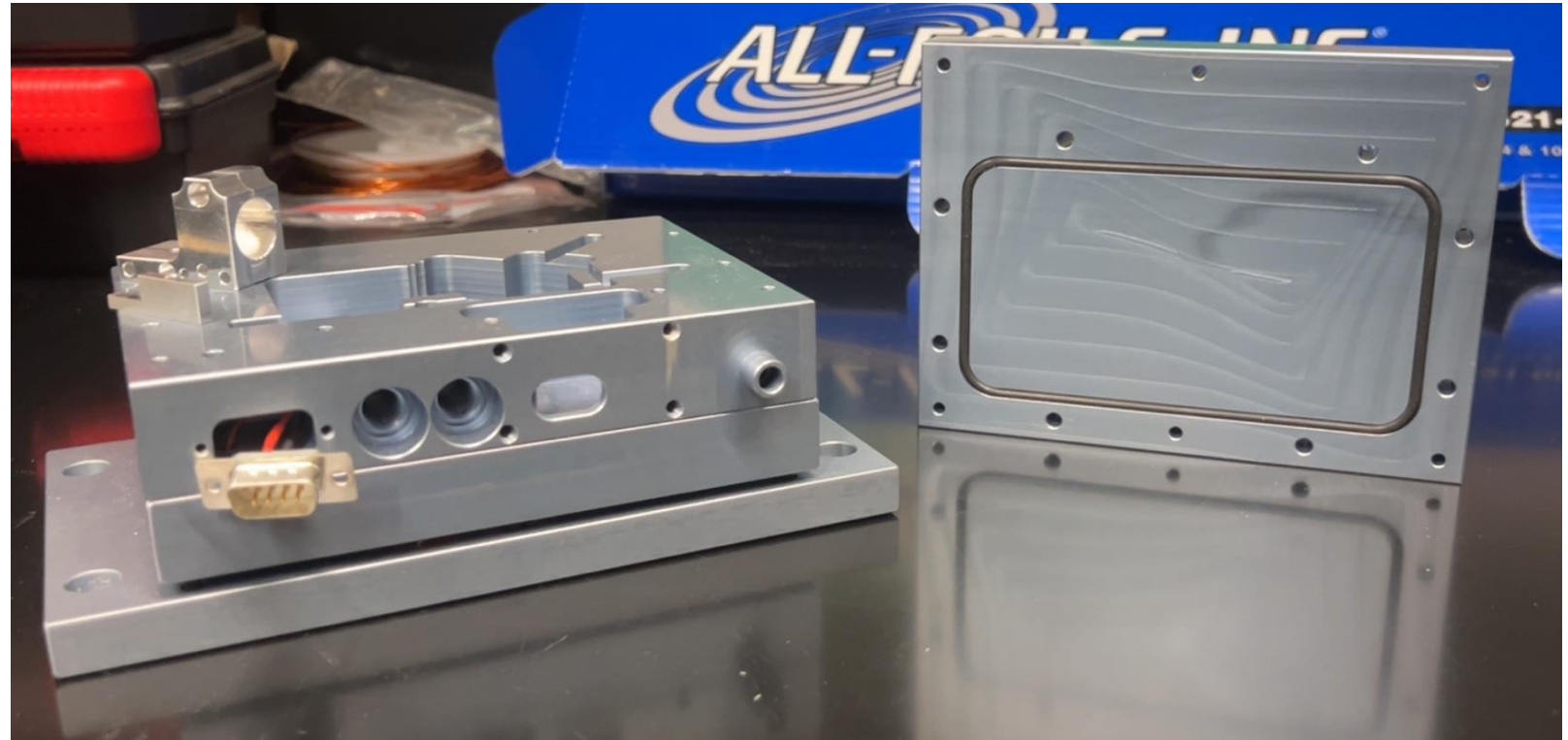


Strontium optical tweezer experiment (left) and magneto optical trap (right)

External Cavity Diode Laser



- Based on Daniel Steck's Design
- Requires
 - Stable Current
 - Stable Temperature
 - Wavelength Selection
 - Precise Cavity Alignment

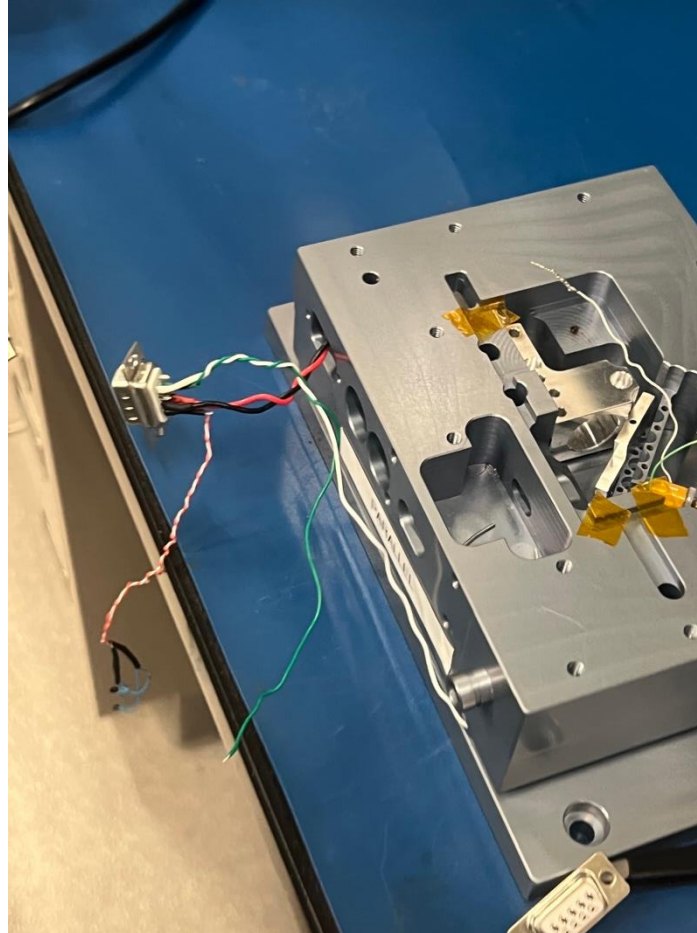


External Cavity Diode Laser (ECDL)

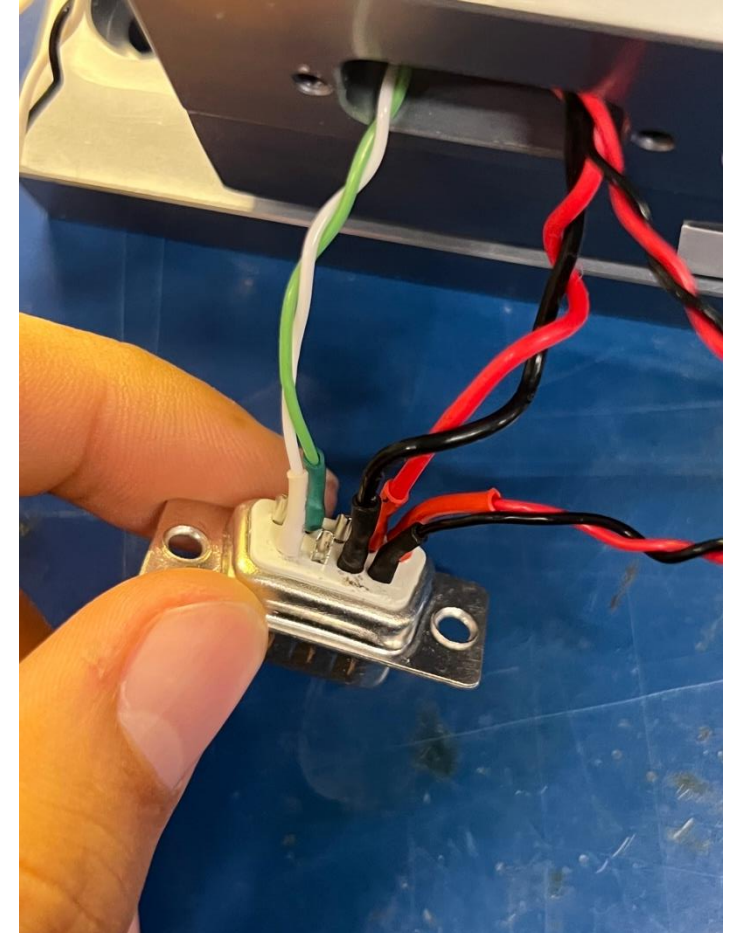
Electronics



- Stable current prevents wavelength drift
- Stable temperature prevents wavelength drift
- Built twisted pair cables
 - Reduces electromagnetic interference
 - Replaced damaged cables



Cable damage during assembly

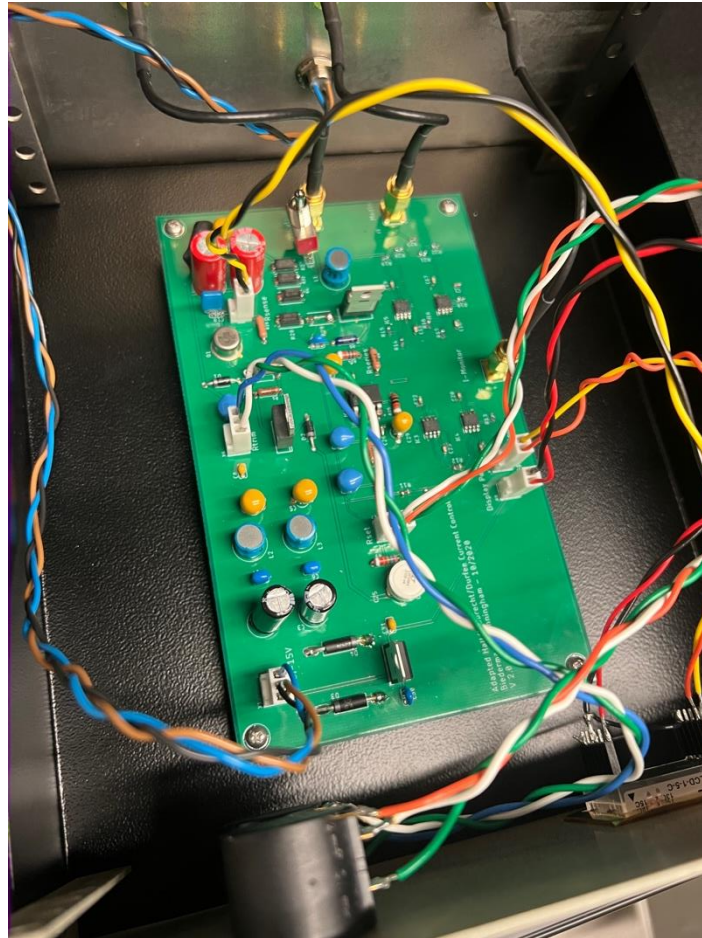


Twisted pair cable assembly

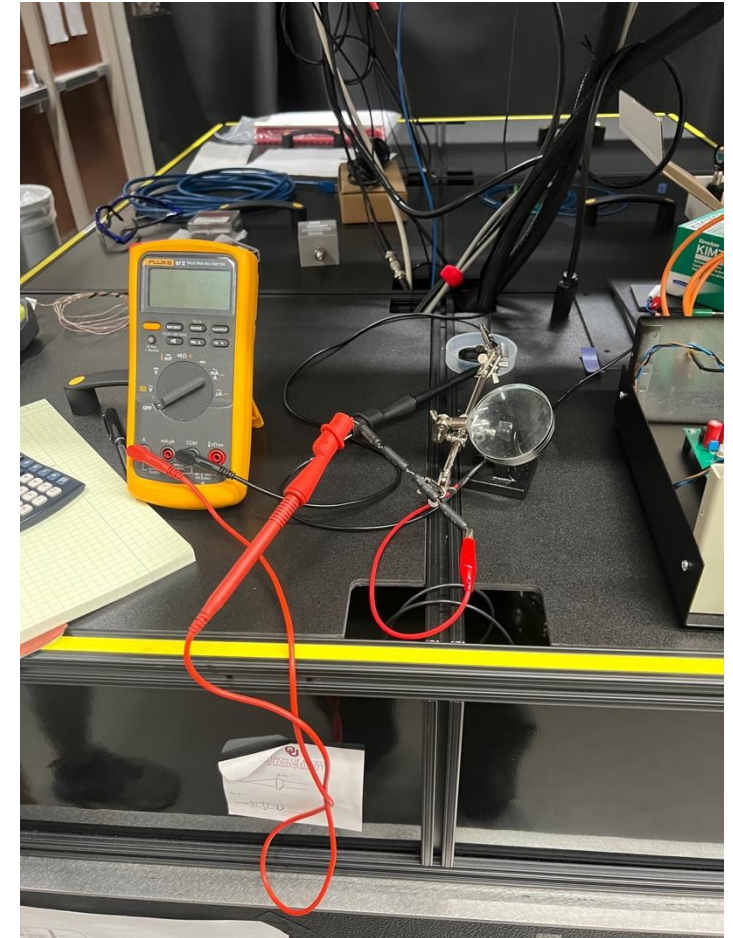
Current driver



- Supplies stable current
 - 0-400 mA
- Tested before connecting diode
 - 16 Ω test load
- Protected laser diode
 - Current driver shorting switch



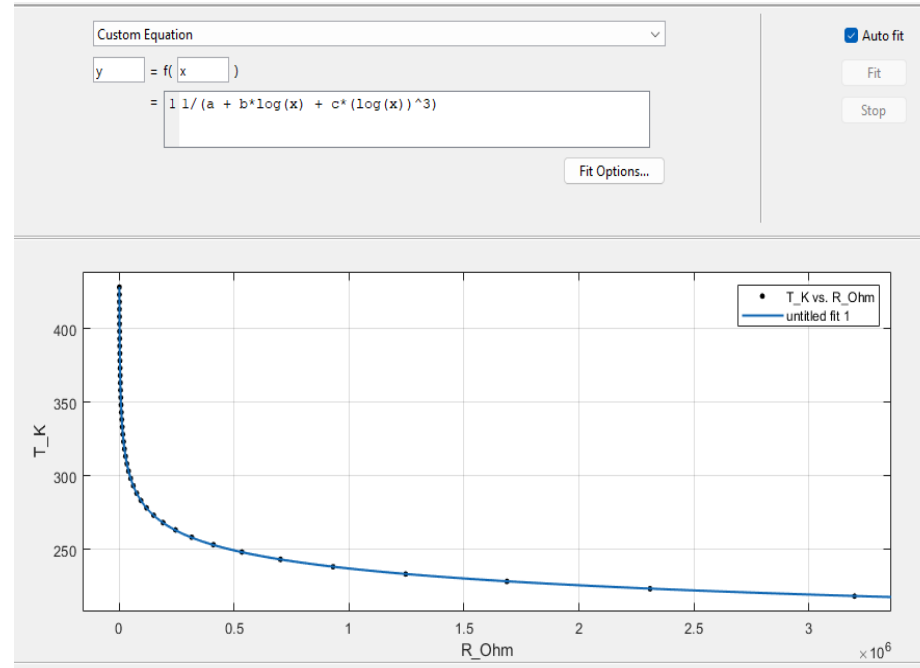
Modified current driver



16 Ω load testing

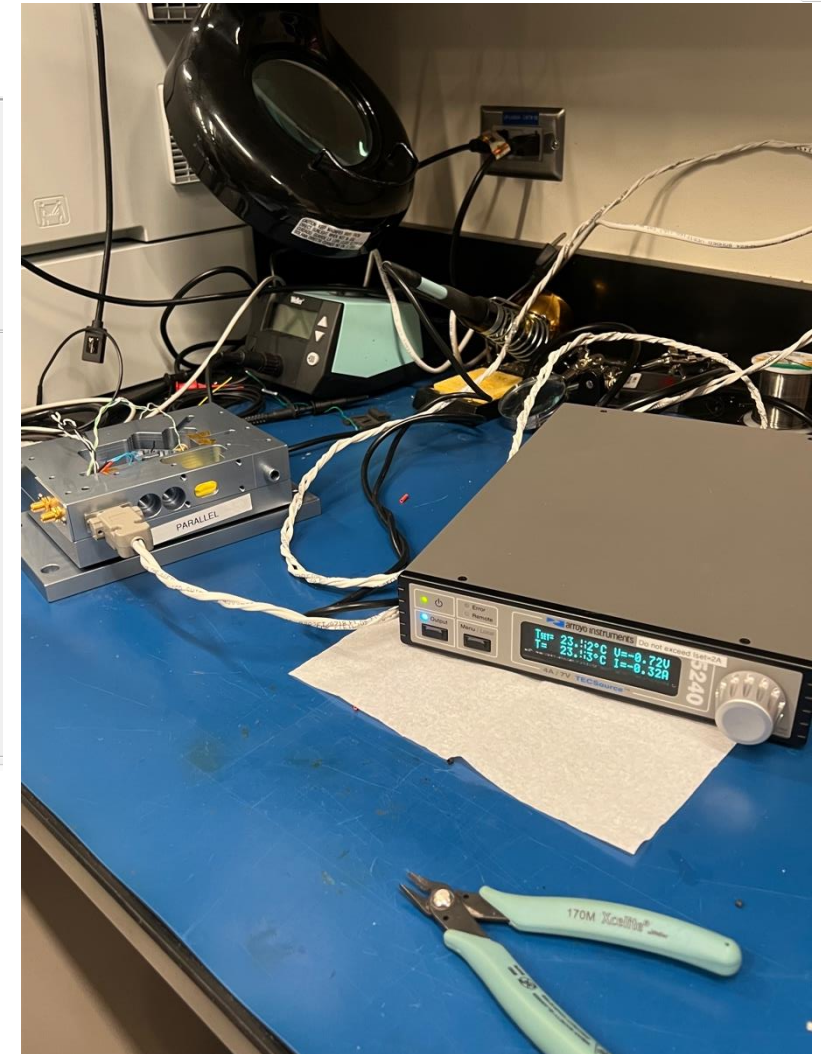
Thermo-Electric Cooler (TEC)

- Temperature changes laser wavelength
- Thermistor measures temperature
- TEC heats or cools diode
- PID maintains constant temperature
- Calculated thermistor coefficients



$$\frac{1}{T} = A + B * \ln(R) + C * \ln^3(R)$$

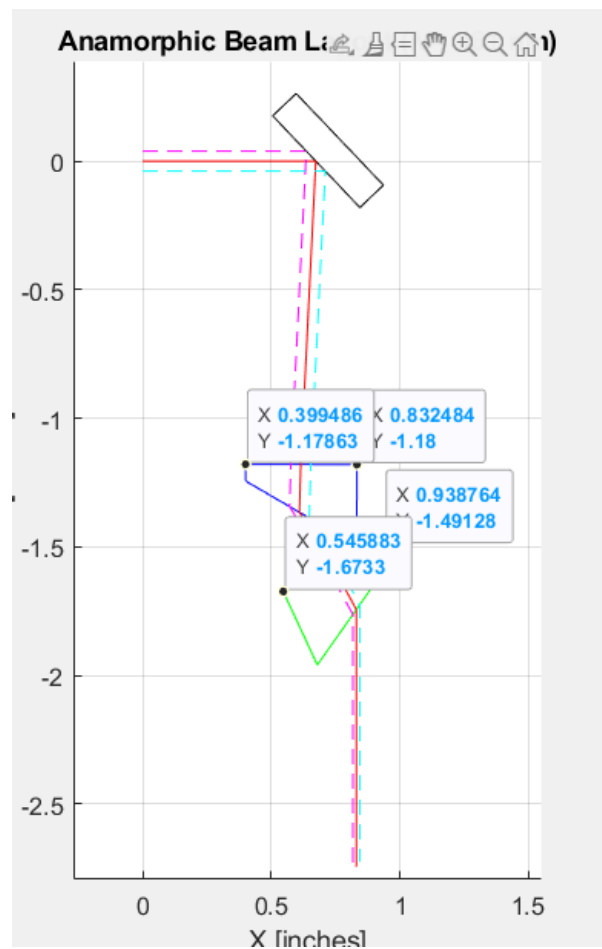
Temperature coefficient measurement



TEC performance testing

Prism mount

- Beam leaves diode elliptical
- Prism pair compresses beam
- MATLAB calculated prism angles
- Modified SolidWorks design
- Printed custom prism mount



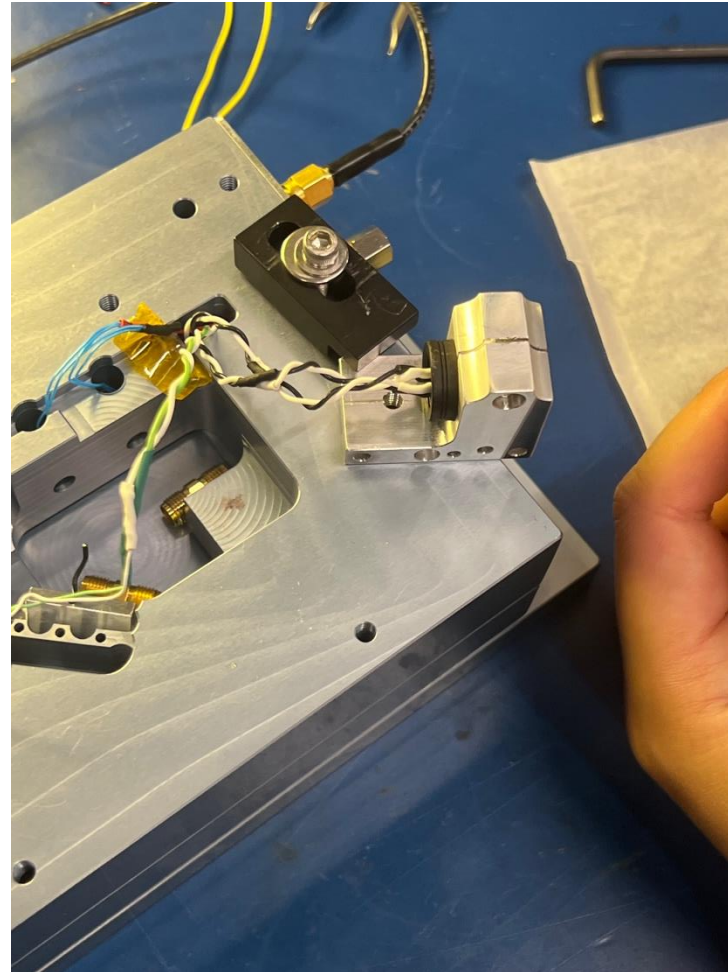
MATLAB prism angle calculation



3D printed prism mount

Installing the Diode

- Nichia diode
- Extremely sensitive to electrostatic discharge (ESD)
- Machined custom adapters
- Successfully mounted diode
- Installed collimation lens



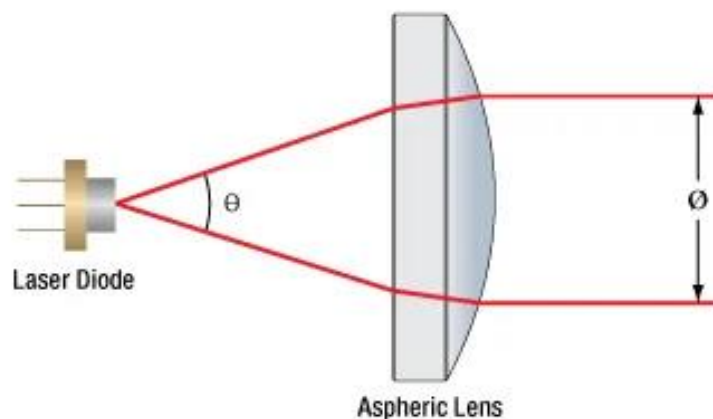
Lens mounted in ECDL



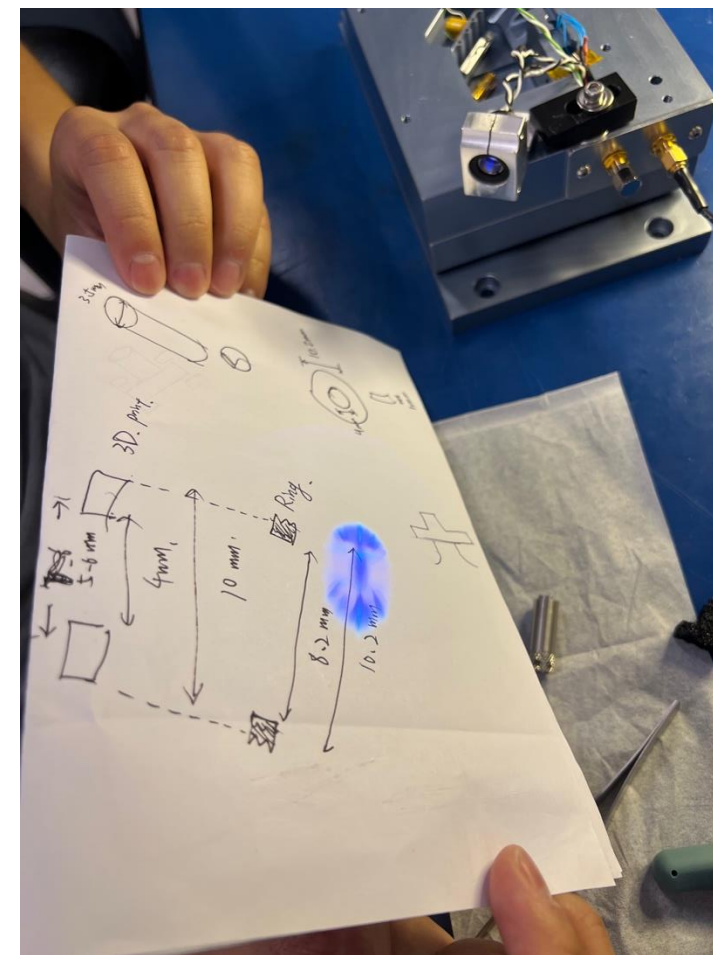
Laser diode installed

Collimation

- Laser beam initially diverges
- Lens produces parallel rays
- Improves beam quality
- Prepares beam for grating



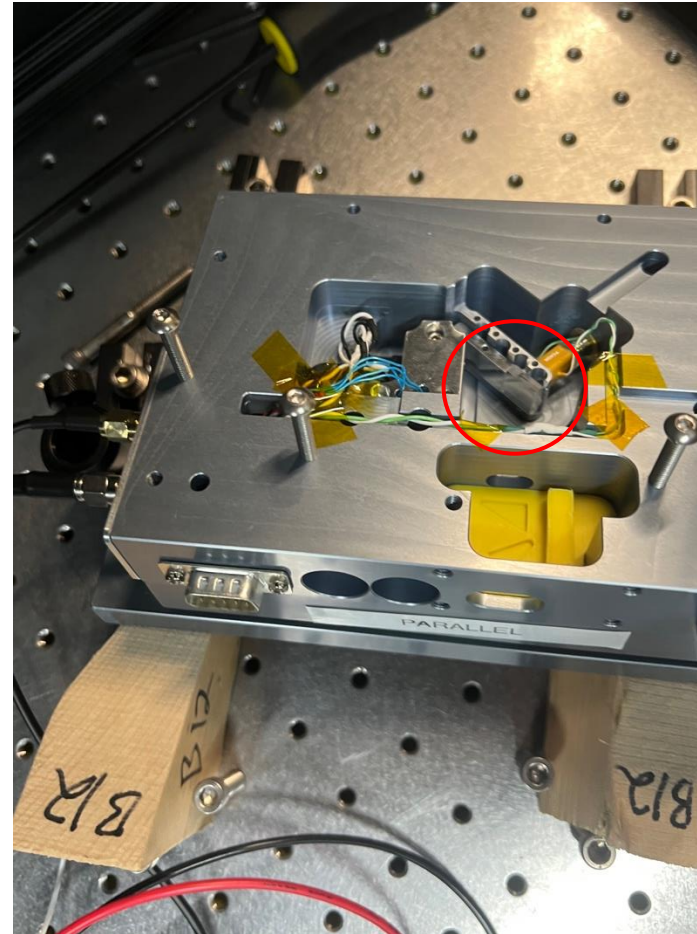
Collimated laser beam



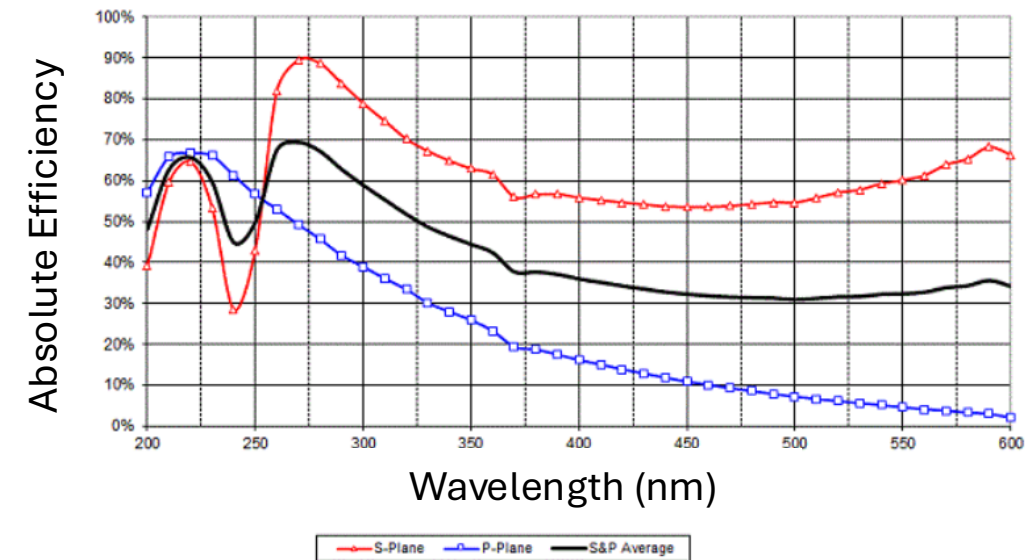
Collimating the laser diode

Installing the grating

- Provides optical feedback
- Selects laser wavelength
- Needed s-polarized light
 - Rotated diode
- Positioned and epoxied



ECDL positioned for grating installation

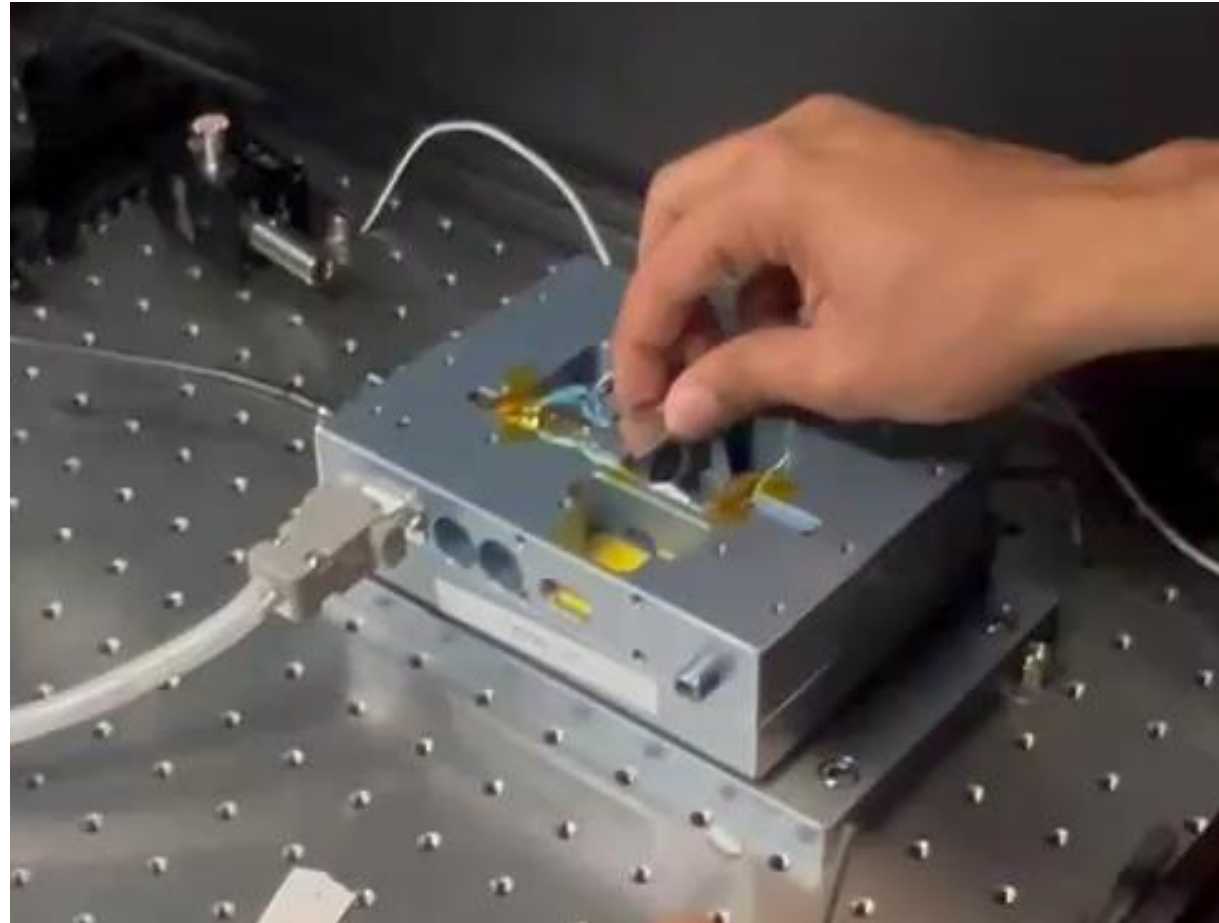


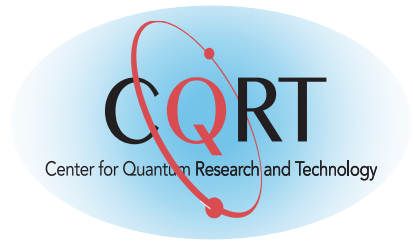
Diffraction grating specification sheet.

Lasing!



- Final optical alignment
- Maximize optical feedback
- Reflected light enters diode
- Higher power at same current
- Achieve stable laser operation





Questions?