

Near-IR Extended Cavity Diode Laser for Methane Spectroscopy

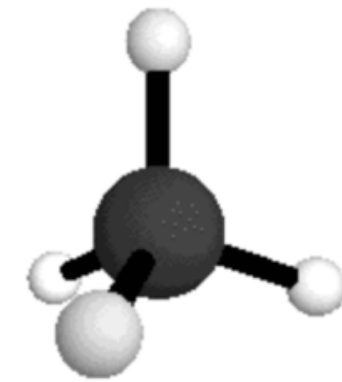
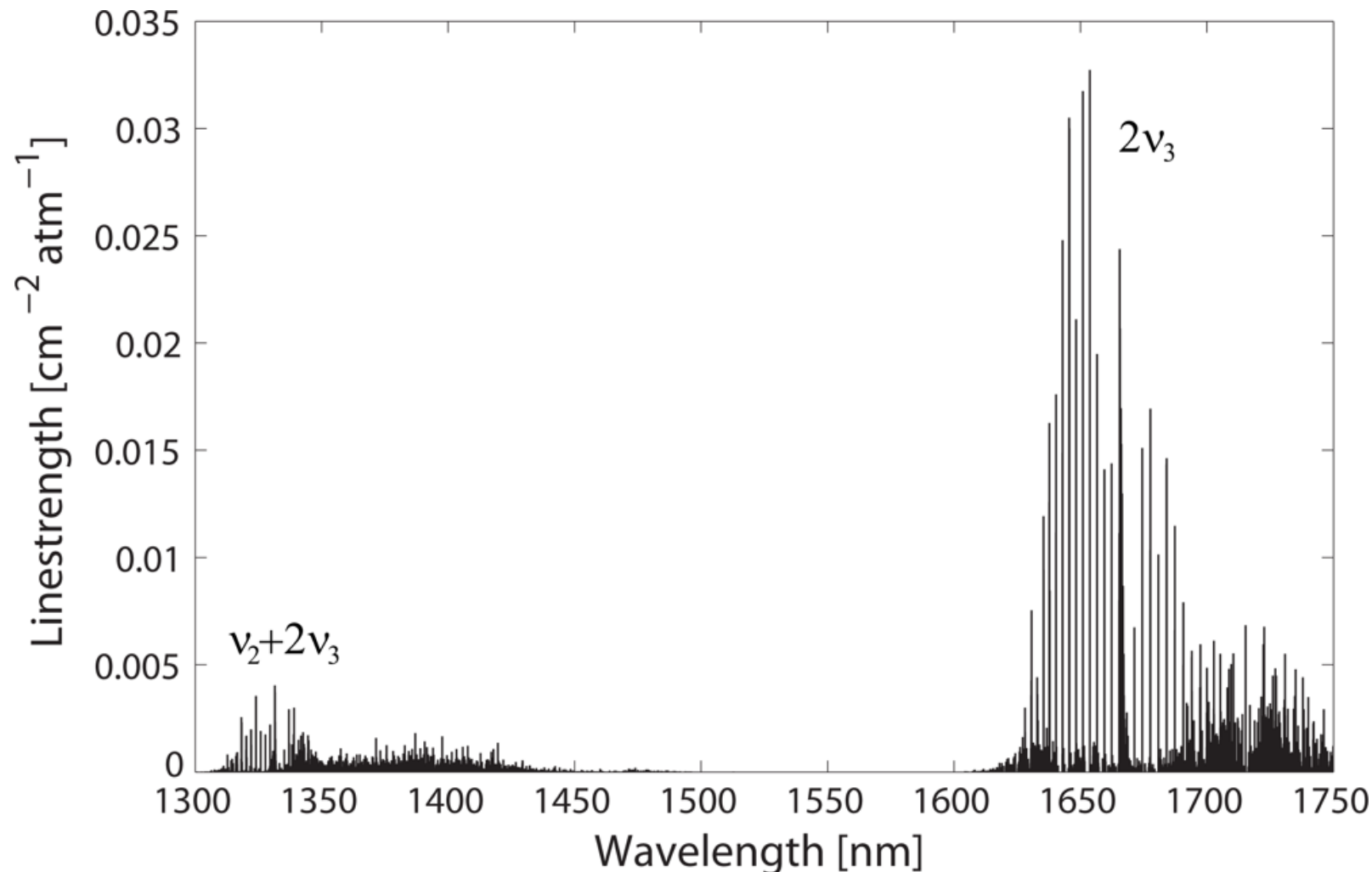
David Mayrhofer, University of Rochester
Dr. Brian Washburn, Kansas State University

Why do we want to look at methane?

- Destructive Greenhouse Gas
- Important Agricultural Gas
- Optical Reference for Telecommunications in the near-infrared (1600 nm)

Methane Spectroscopy

$\nu_3 = 3156.8 \text{ cm}^{-1}$
 F_2 Symmetry



Spherical Top Molecule

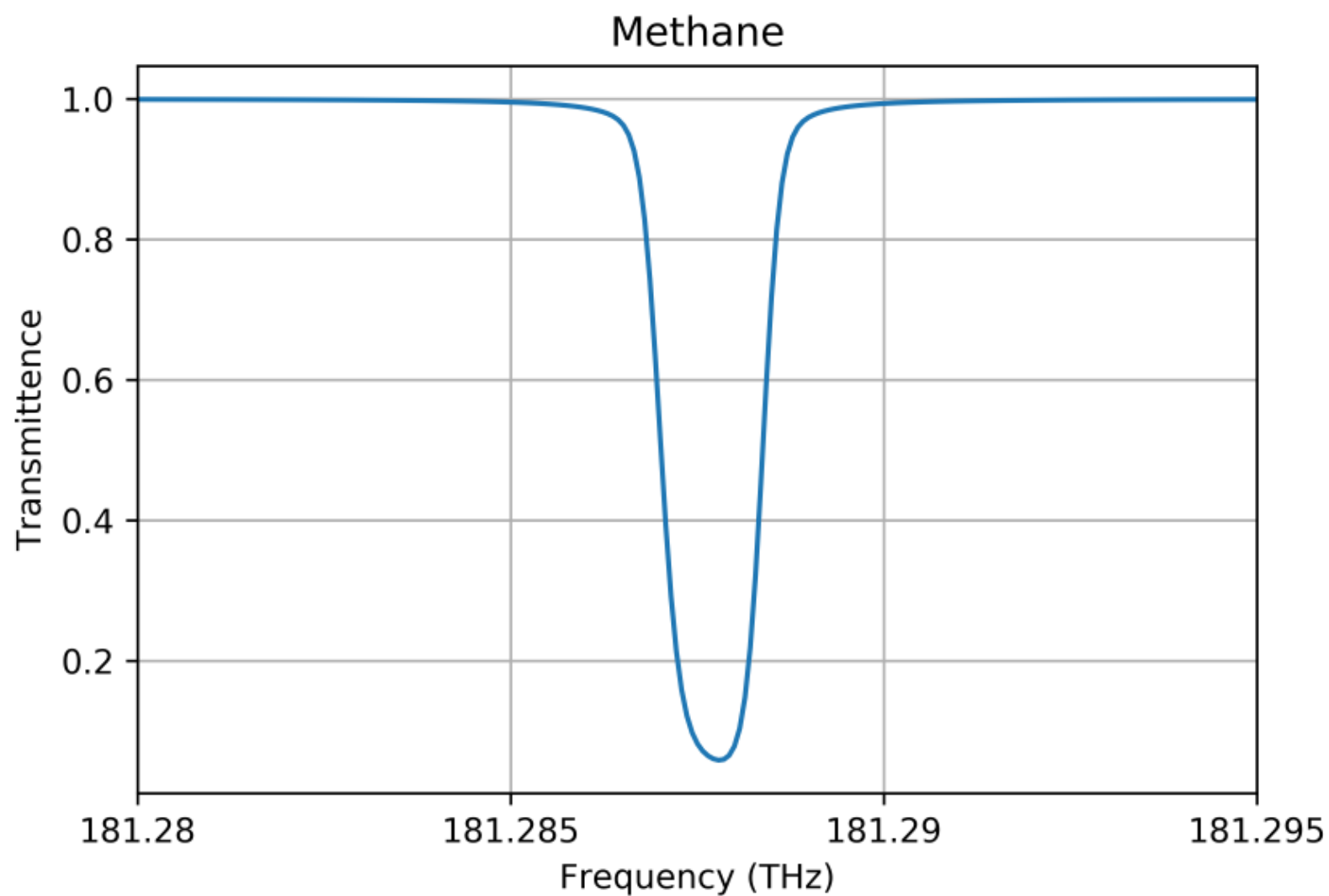
J	Line Position (nm)
R3	1653.7284
R3	1653.7255
R3	1653.7222

Left: From "Gas Sensor Based on Photonic Crystal Fibres in the $2\nu_3$ and $\nu_2 + 2\nu_3$ Vibrational Bands of Methane" by [Ana M. Cubillas](#), [Jose M. Lazaro](#), [Olga M. Conde](#), [Marco N. Petrovich](#), and [Jose M. Lopez-Higuera](#)

Top Right: http://www2.ess.ucla.edu/~schauble/MoleculeHTML/CH4_html/CH4_page.html

Bottom Right: Data from "Methane spectroscopy in the near infrared and its implication on atmospheric retrievals" by C. Frankenberg, T. Warneke, A. Butz, I. Aben, F. Hase, et al.

Methane Line Width

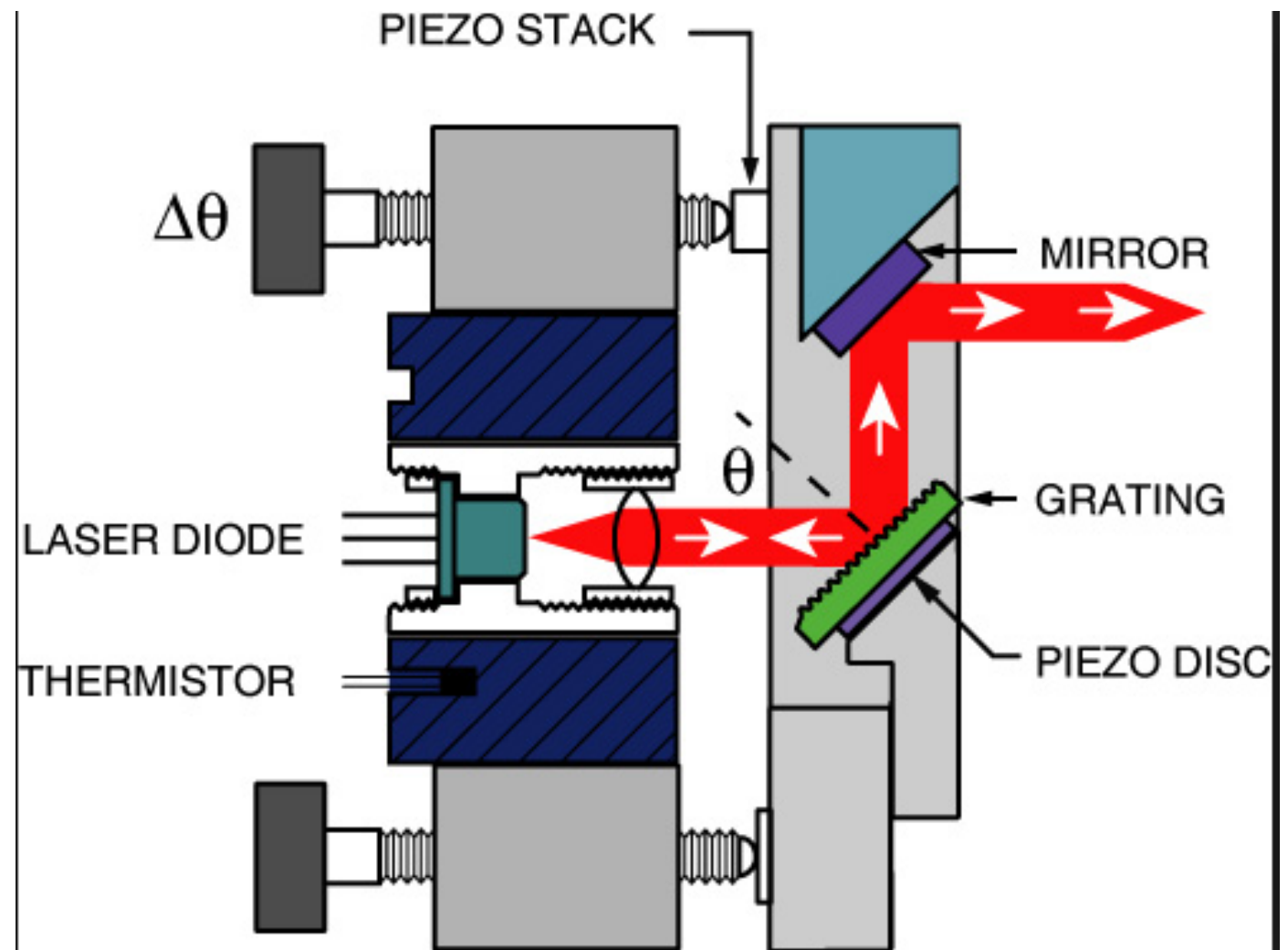


For a 1 meter fiber at 10 torr

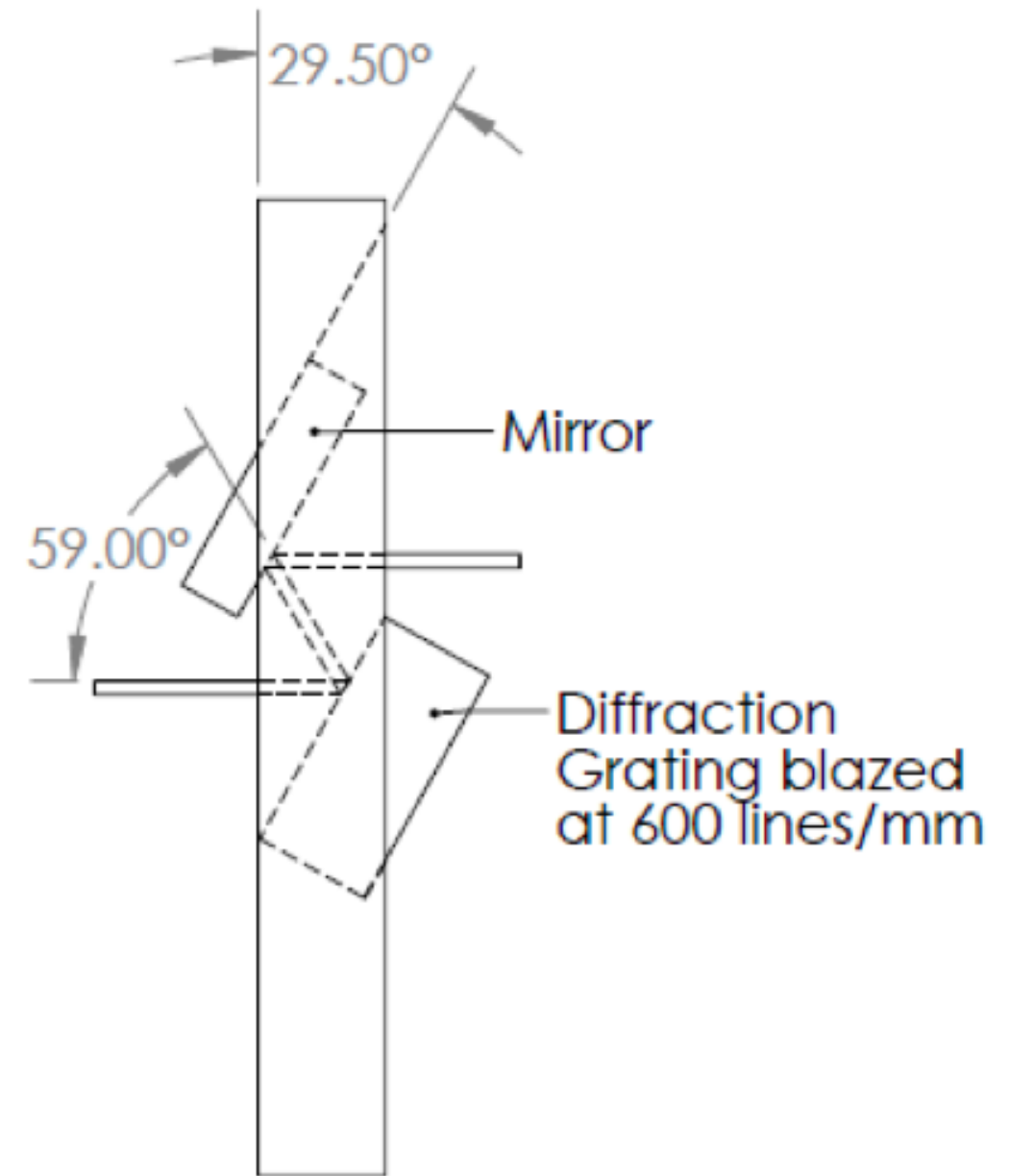
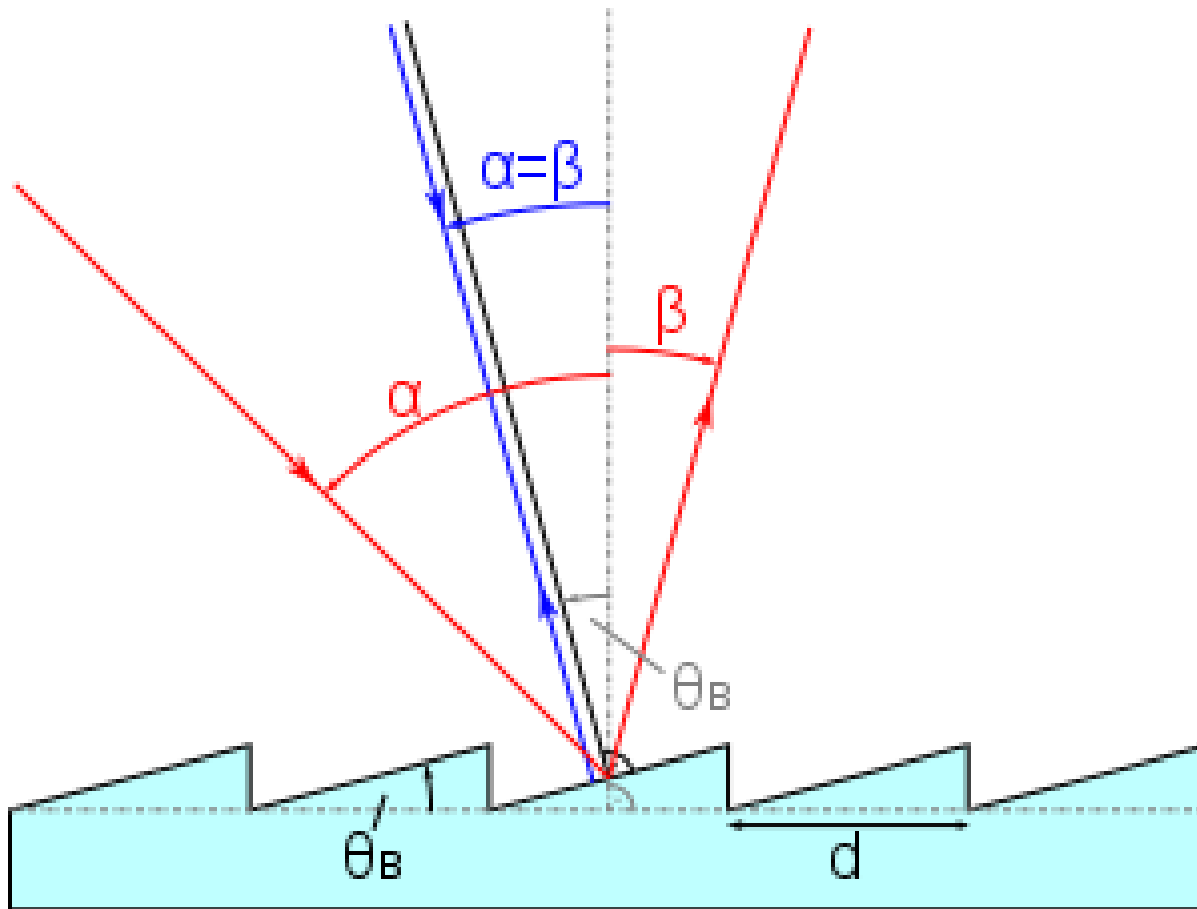
J	Line Position (THz)
R3	181.28732
R3	181.28764
R3	181.28800

Extended Cavity Diode Laser

- Narrow Bandwidth (< 1 MHz)
- Stable and Tunable Frequency (Over 7.5 GHz)
- Cost Effective

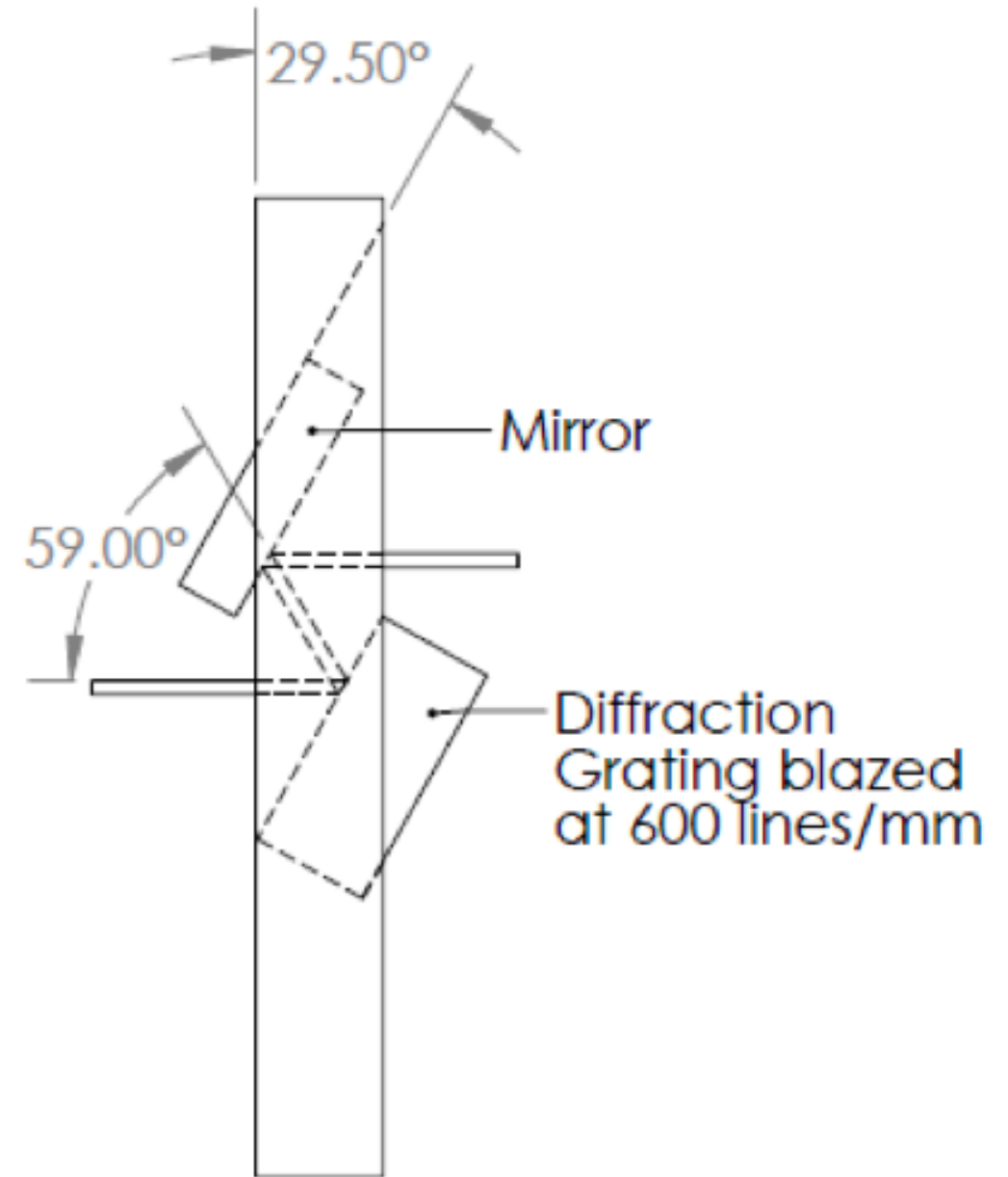
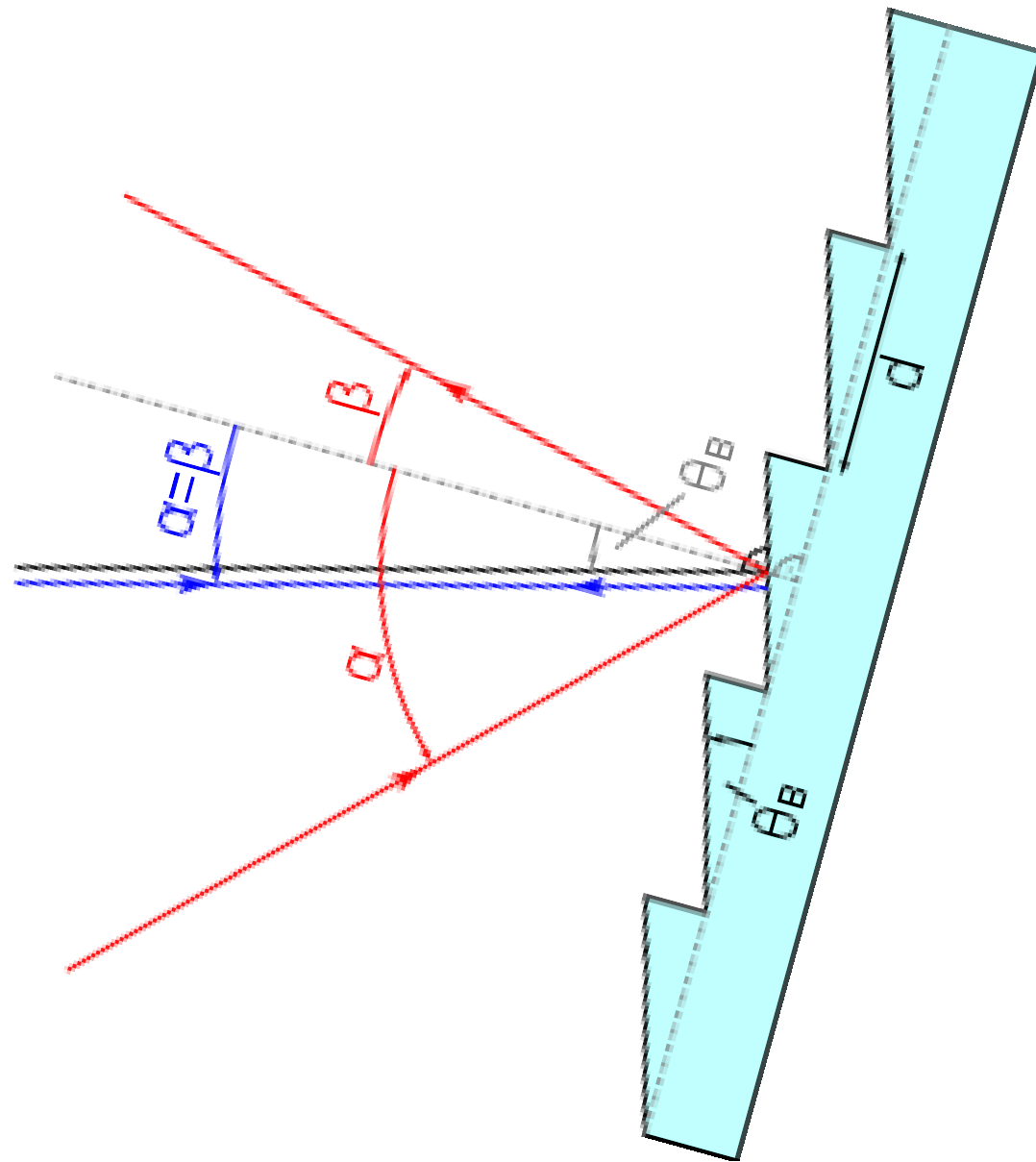


Position of Grating



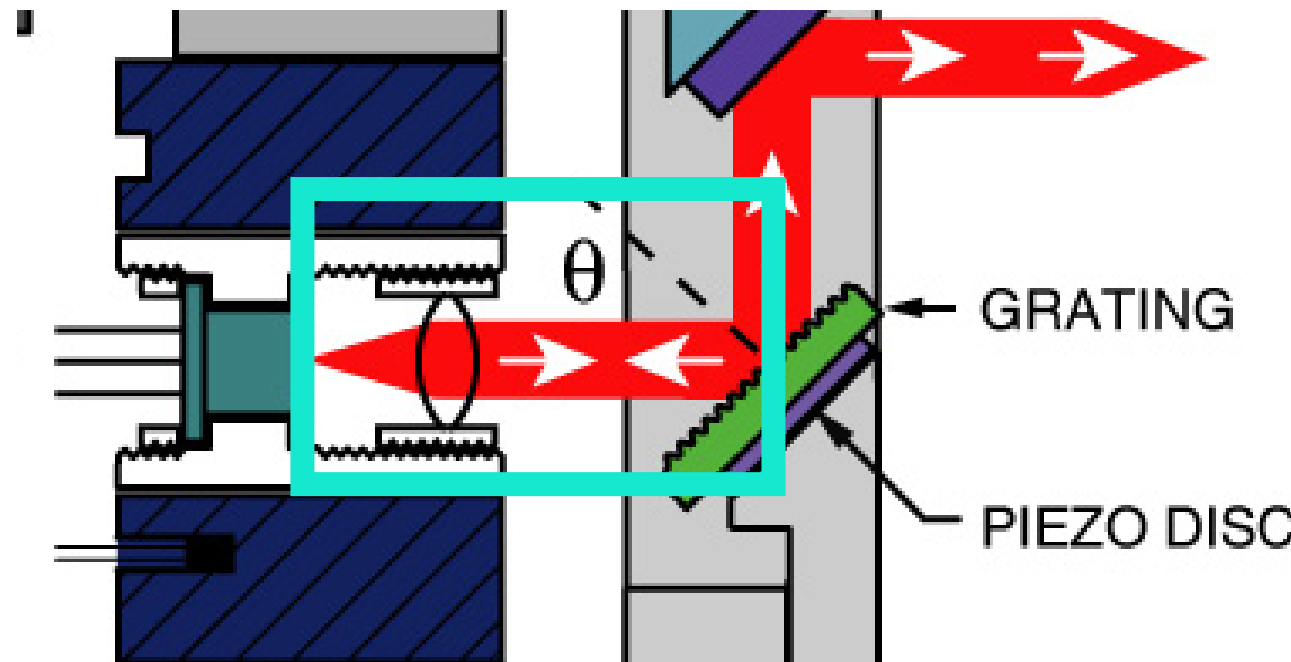
Left: <https://commons.wikimedia.org/w/index.php?curid=21807350>
Right: Design by Otilia Ni

Position of Grating



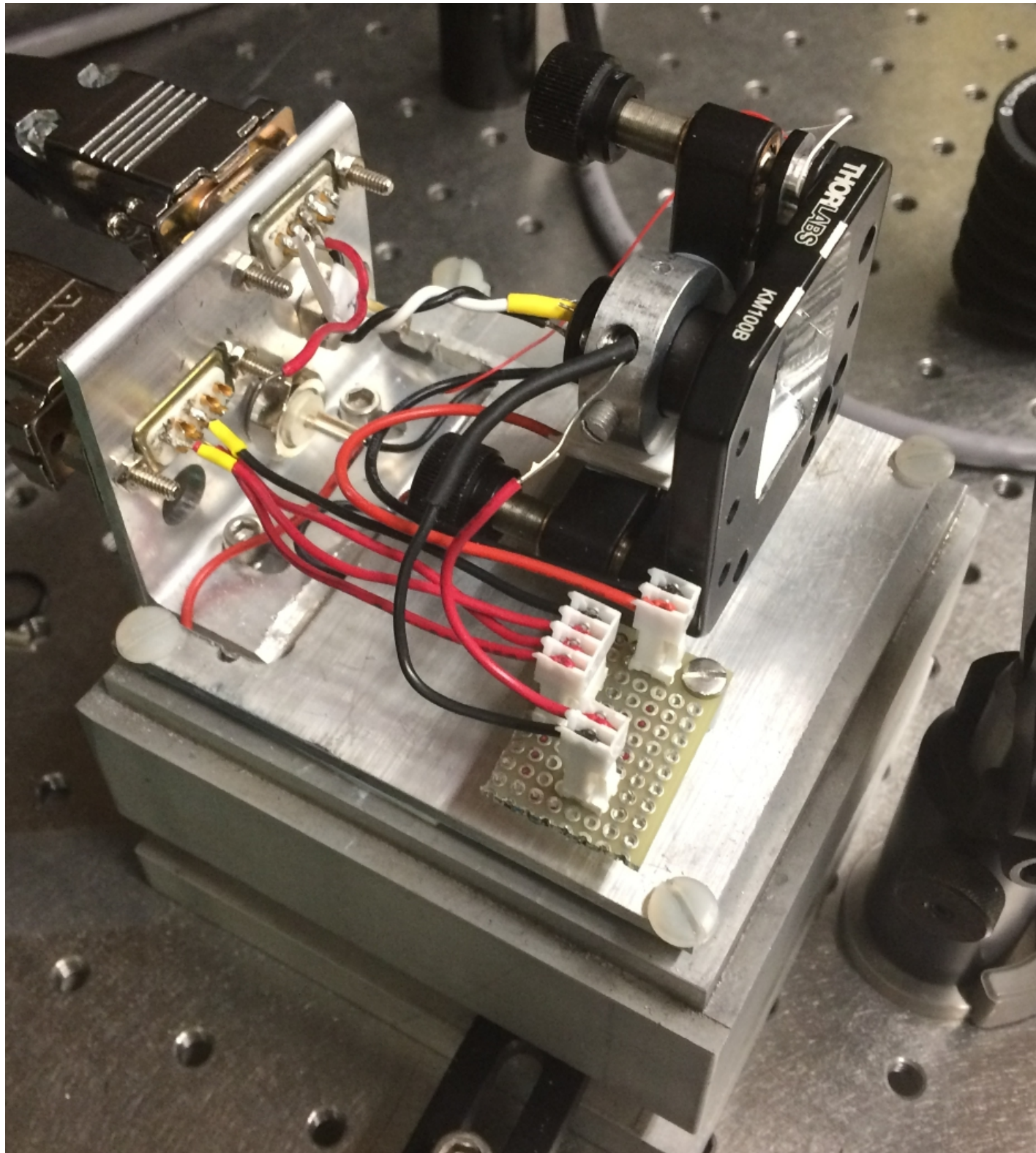
Left: <https://commons.wikimedia.org/w/index.php?curid=21807350>
Right: Design by Otilia Ni

Free Spectral Range

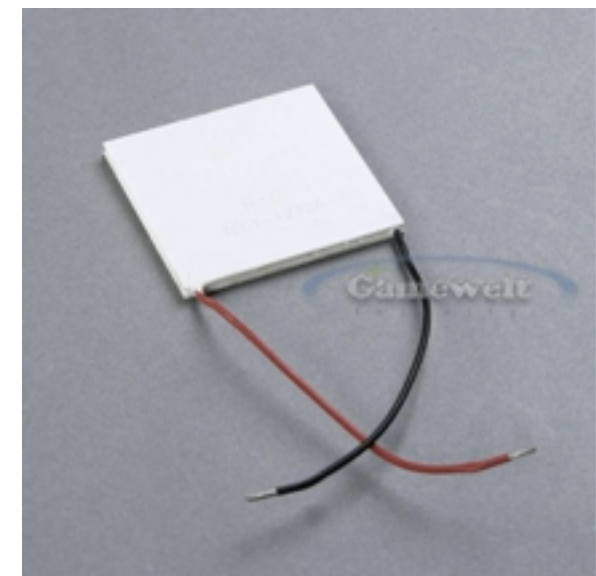


$$\text{FSR} = \frac{c}{2Ln} = \frac{2.998 \times 10^8 \text{ m/s}}{40 \text{ mm}} \approx 7.5 \text{ GHz}$$

Initial Design

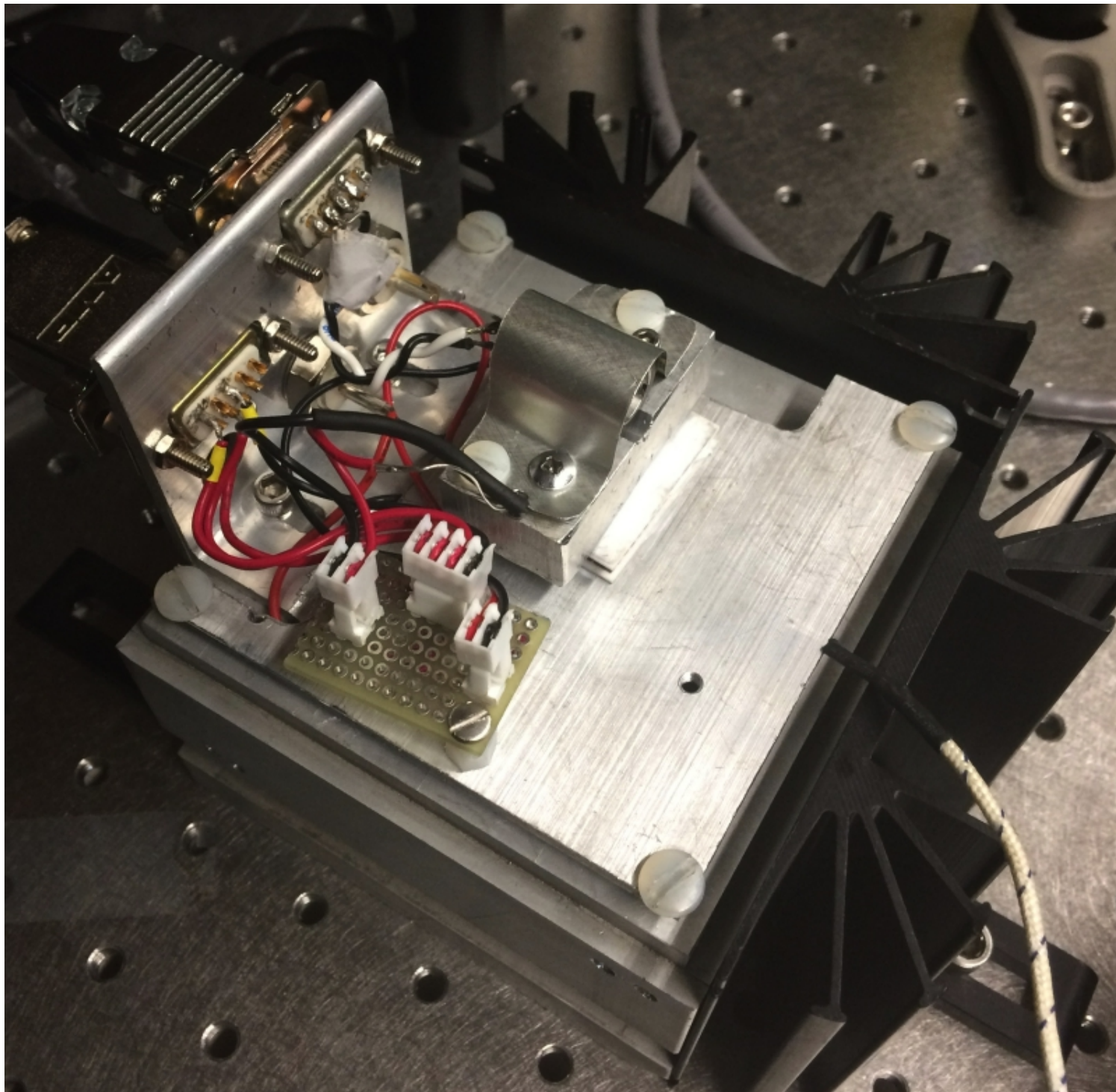


- **Cooling system ails at currents above 500 mA**



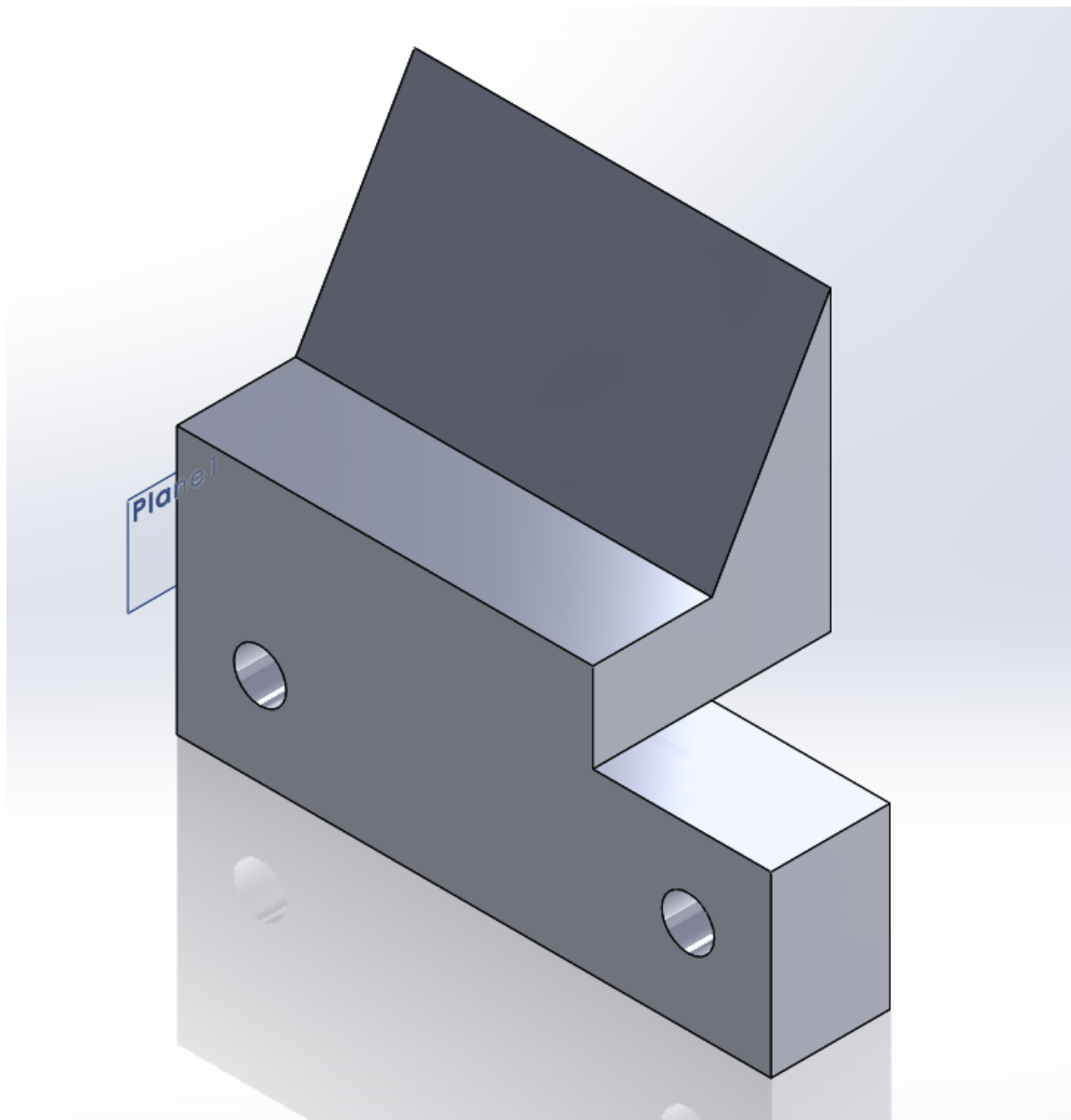
Peltier Cooler

Cooling System Changes

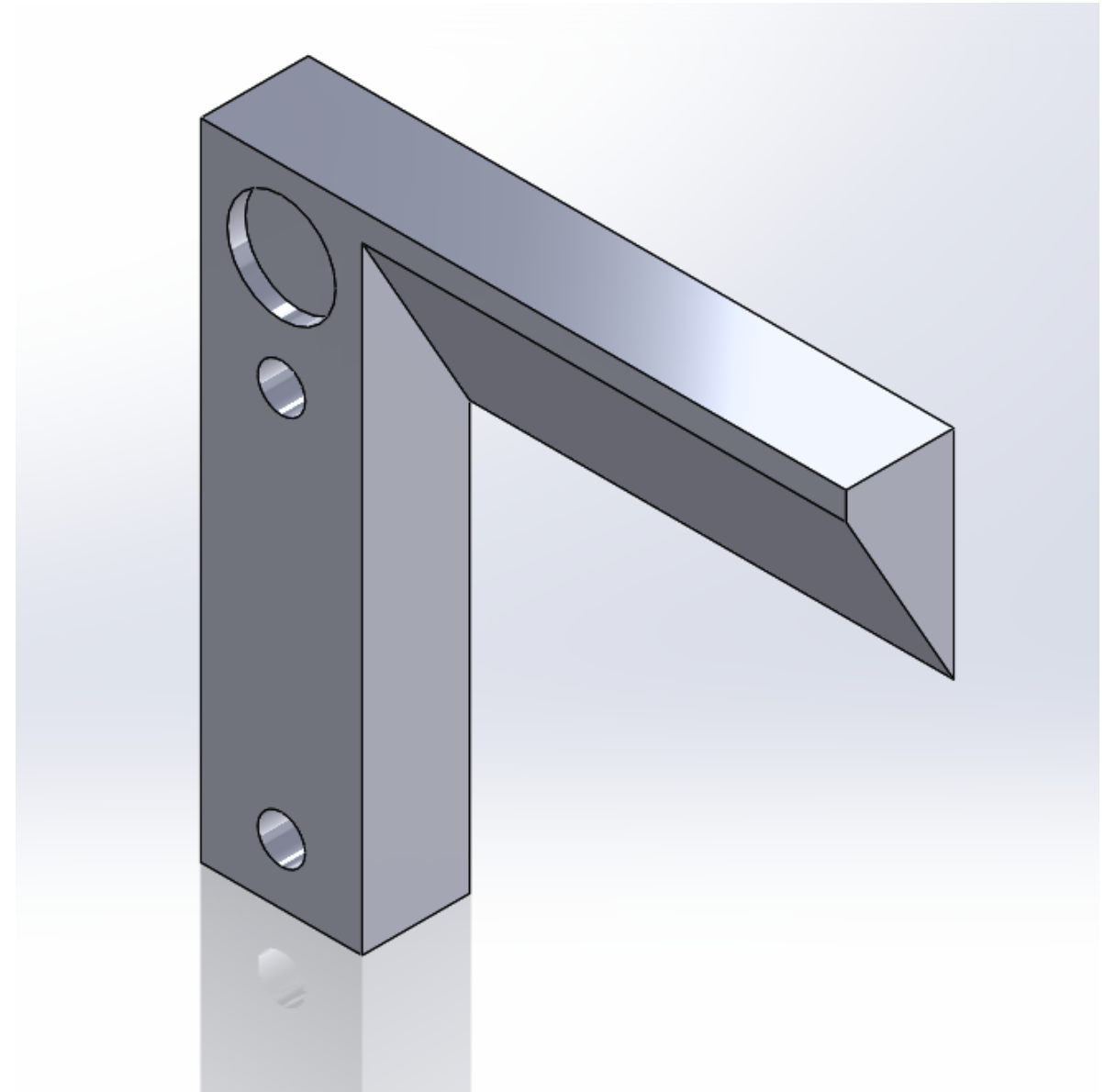


- **Replaced Ring With Block**
- **Unable to fit the original grating/mirror mount in setup**

Grating/Mirror Mount

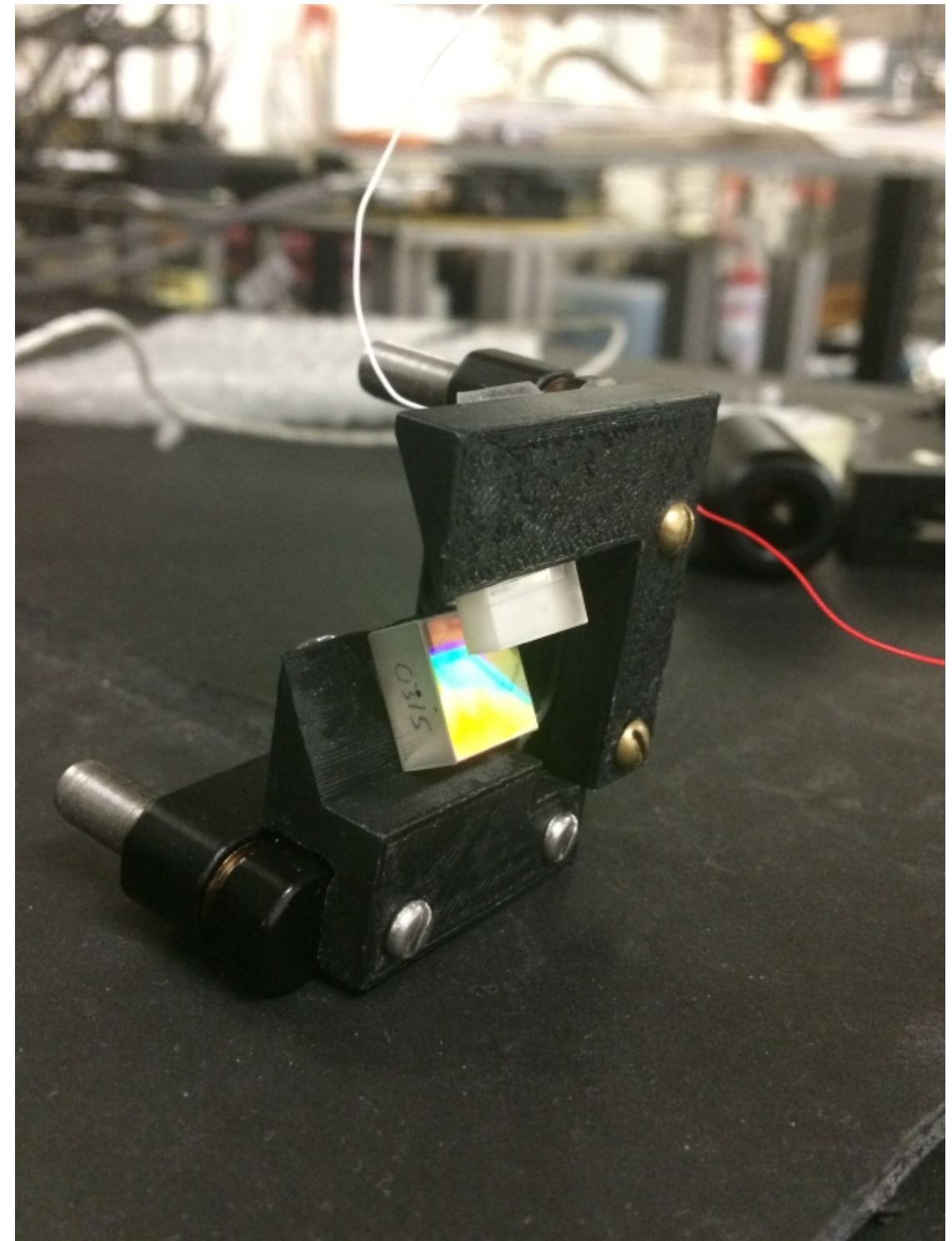
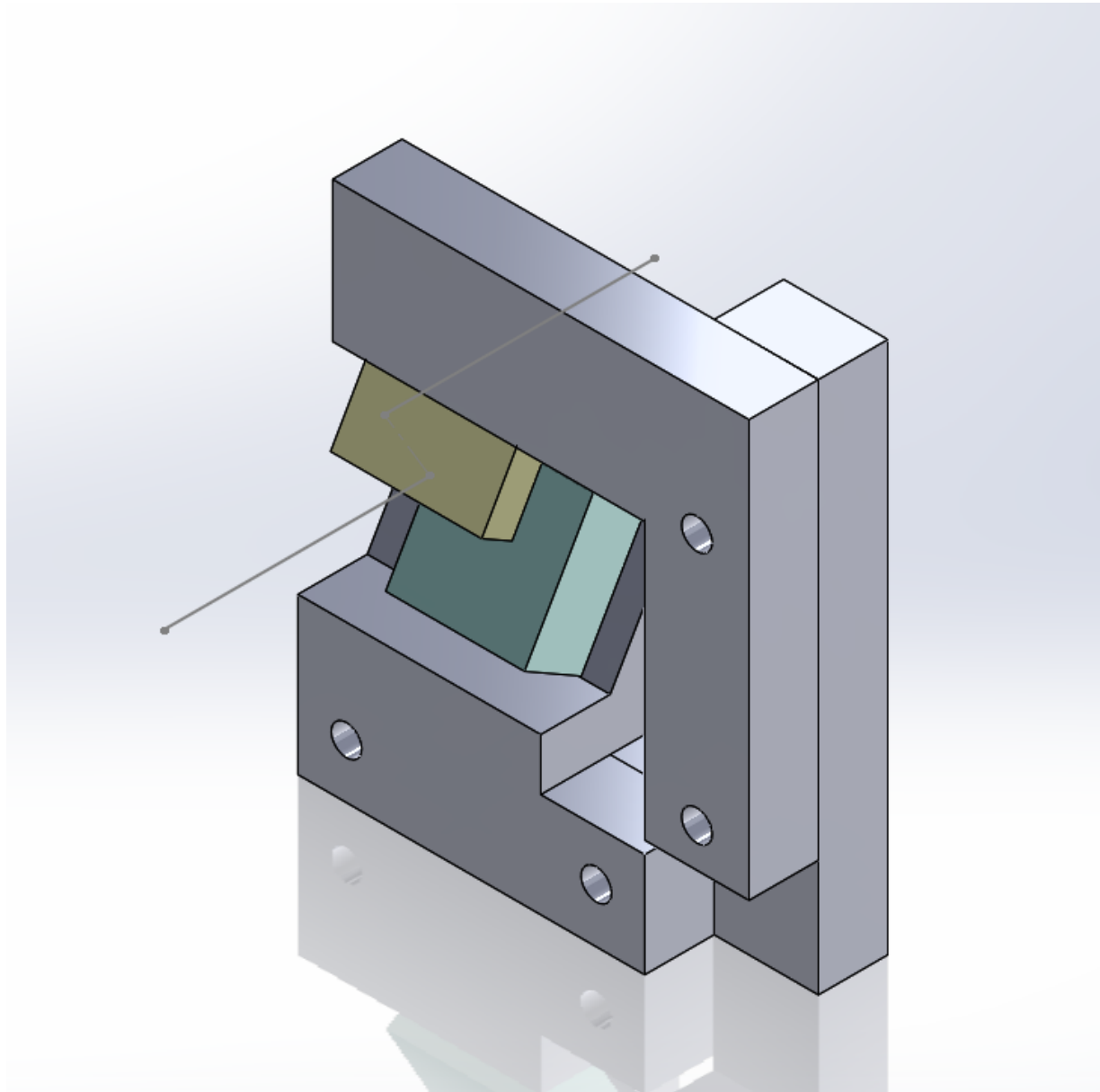


Grating

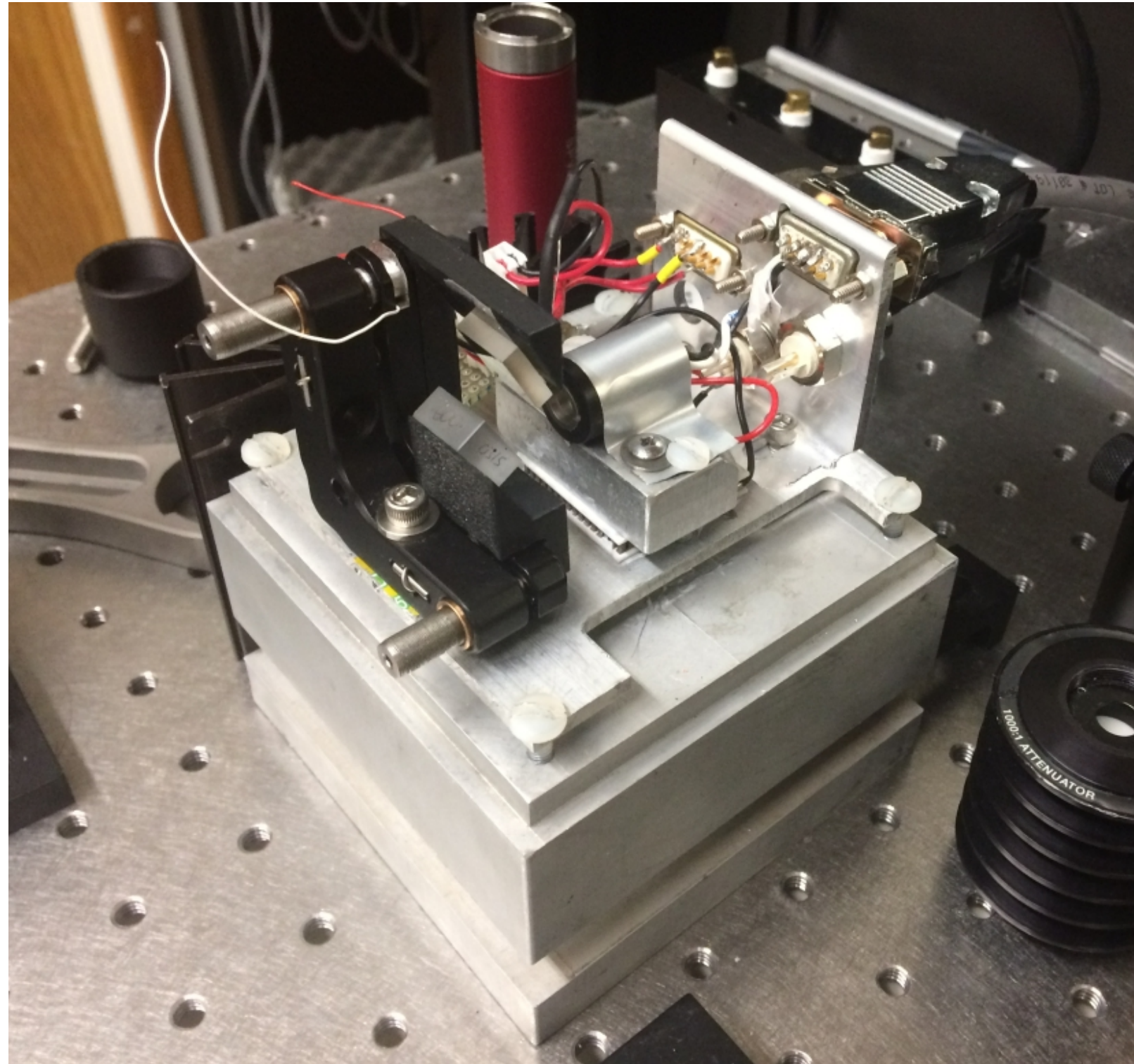


Mirror

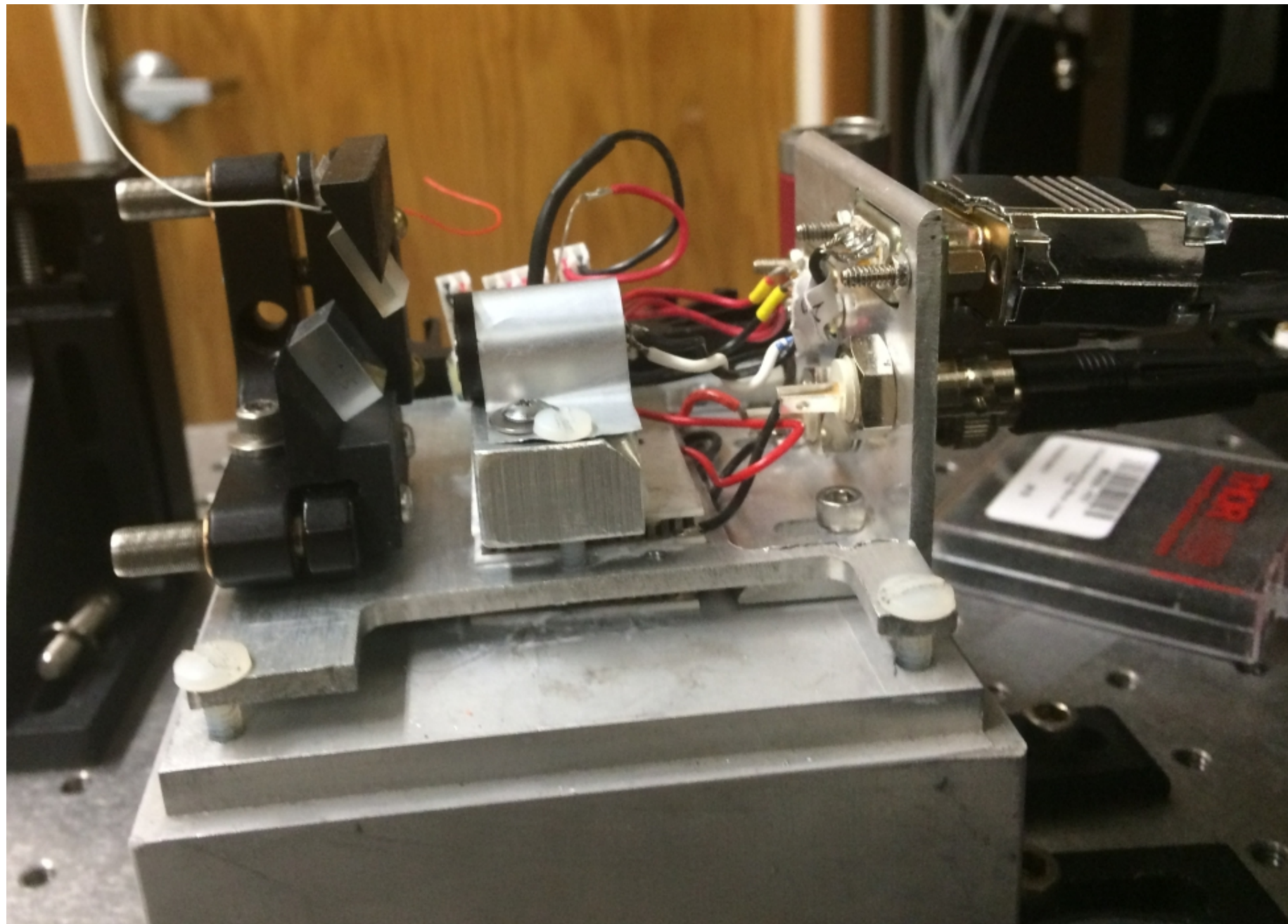
Fully Assembled Mount



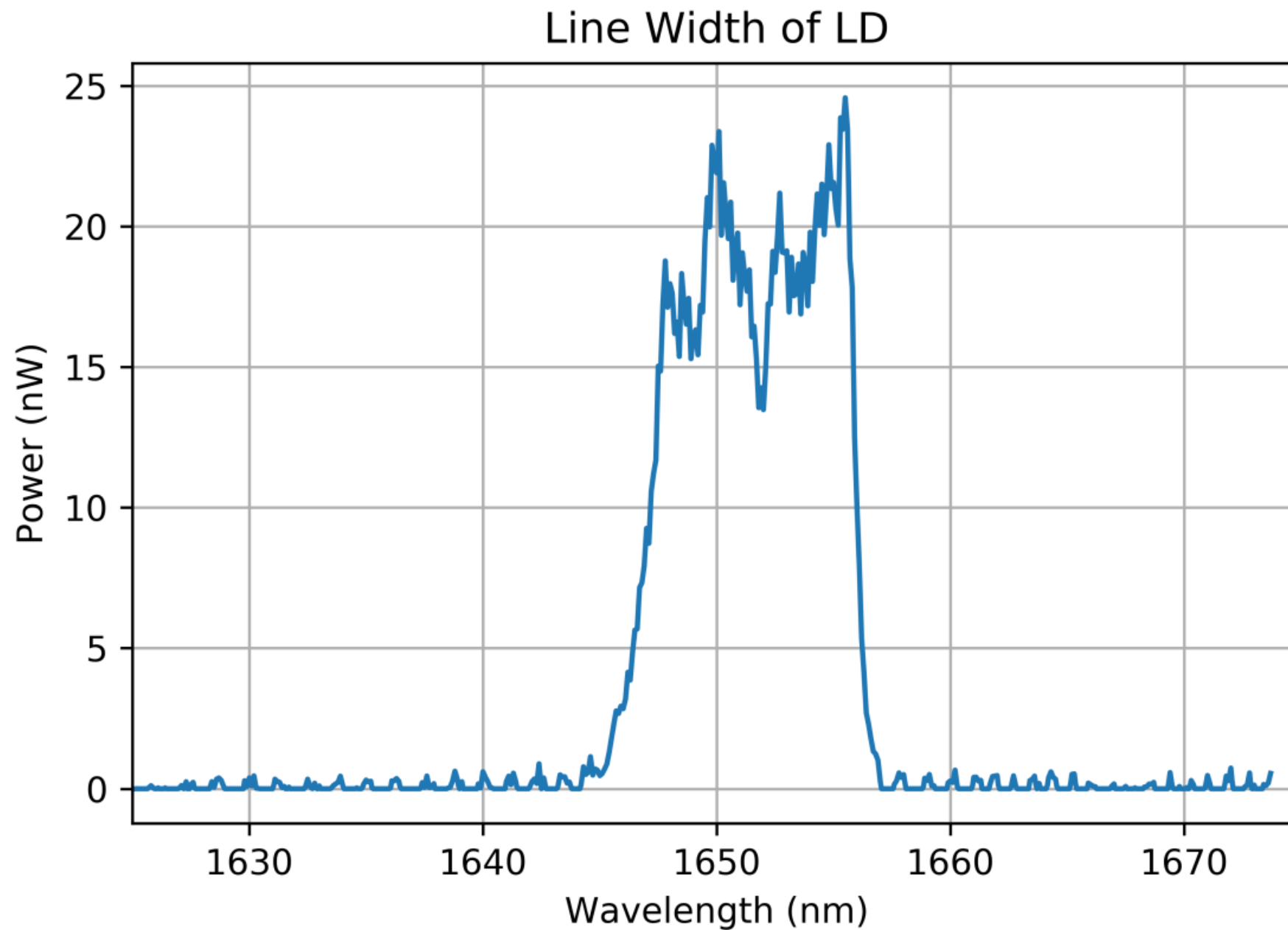
Current Design



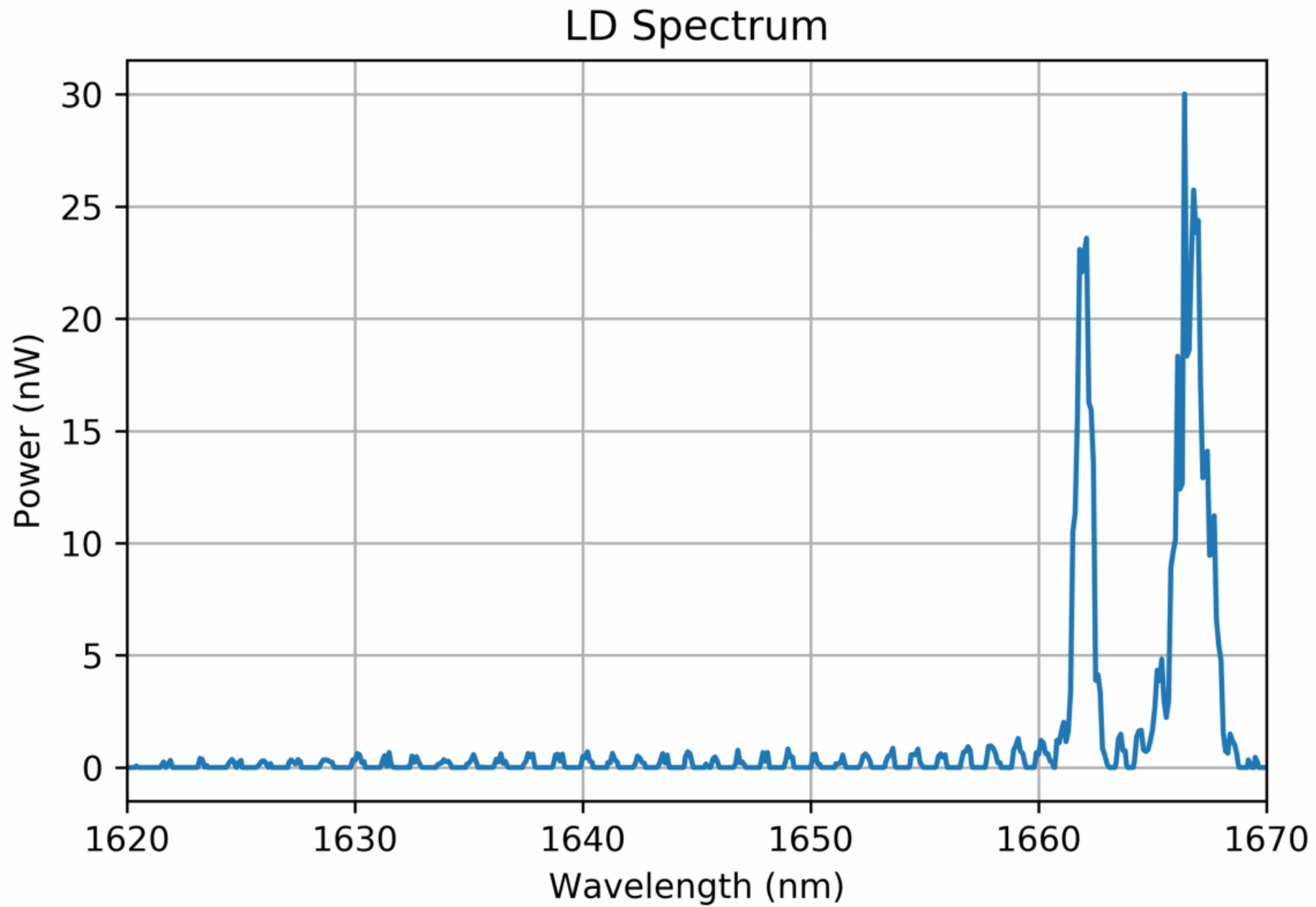
Current Design



Line Width With No Feedback



Line Width With Feedback



1A

Future work and Summary

- Successfully created stable cooling design and mount for the grating to narrow line width
- Continue to work with line width
- Measure tunability of laser
- Measure absorption of methane