# Stabilization of an Electro-Optic Etalon

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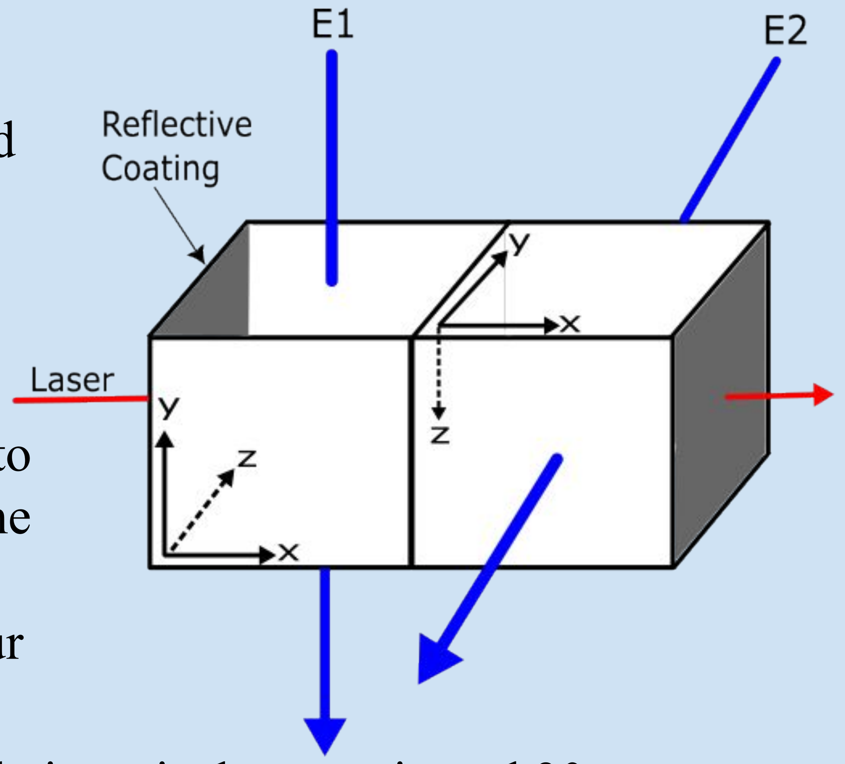
## Introduction:

A Fabry-Perot interferometer, or etalon, is an optical tool with telecommunication, spectroscopy, and astronomy applications for spectral analysis. Formed by the cavity between two highly reflective surfaces, an etalon allows multiple beam interference of an incident beam, theoretically resulting in 100 percent transmission of resonant light. Our research aimed to **characterize the birefringence** and **stabilize the transmission** of a unique etalon by adjusting applied voltage on the device and manipulating the wavelength of incident light. With a robust system, the etalon will be used as a demodulator for phase-shift keyed optical signals.

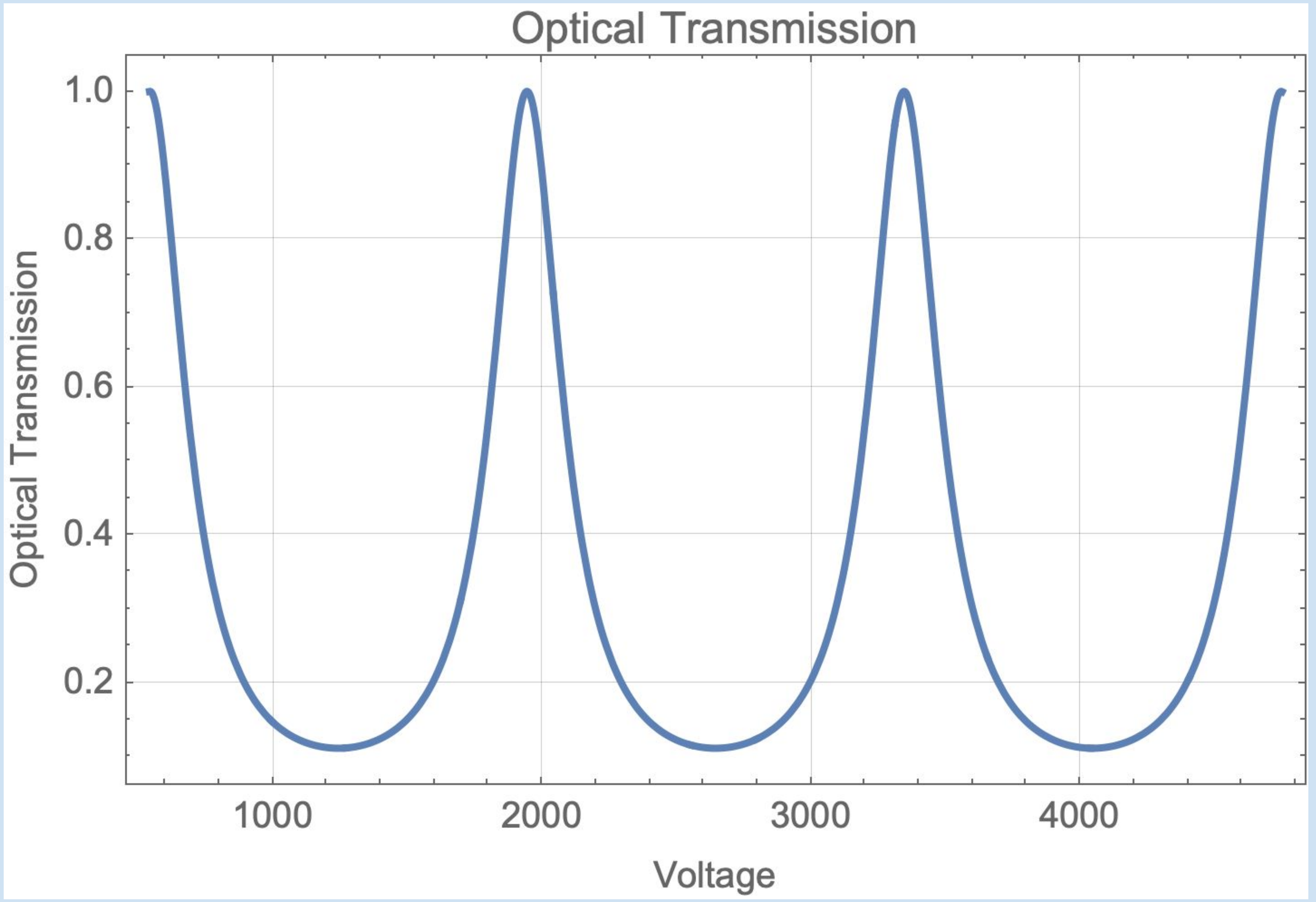
## Electro-Optic Etalon:




The etalon is constructed using two cold-welded uniaxial lithium niobate (LiNbO3) crystals arranged in optical series with a 50% reflective coating covering parallel faces. Crystal etalons are beneficial because of their ability to be adjusted using high voltage but are susceptible to birefringence. Because birefringence changes the polarization of incident light, it can impact success in signals communication. Therefore our etalon aims to limit birefringence in two ways:

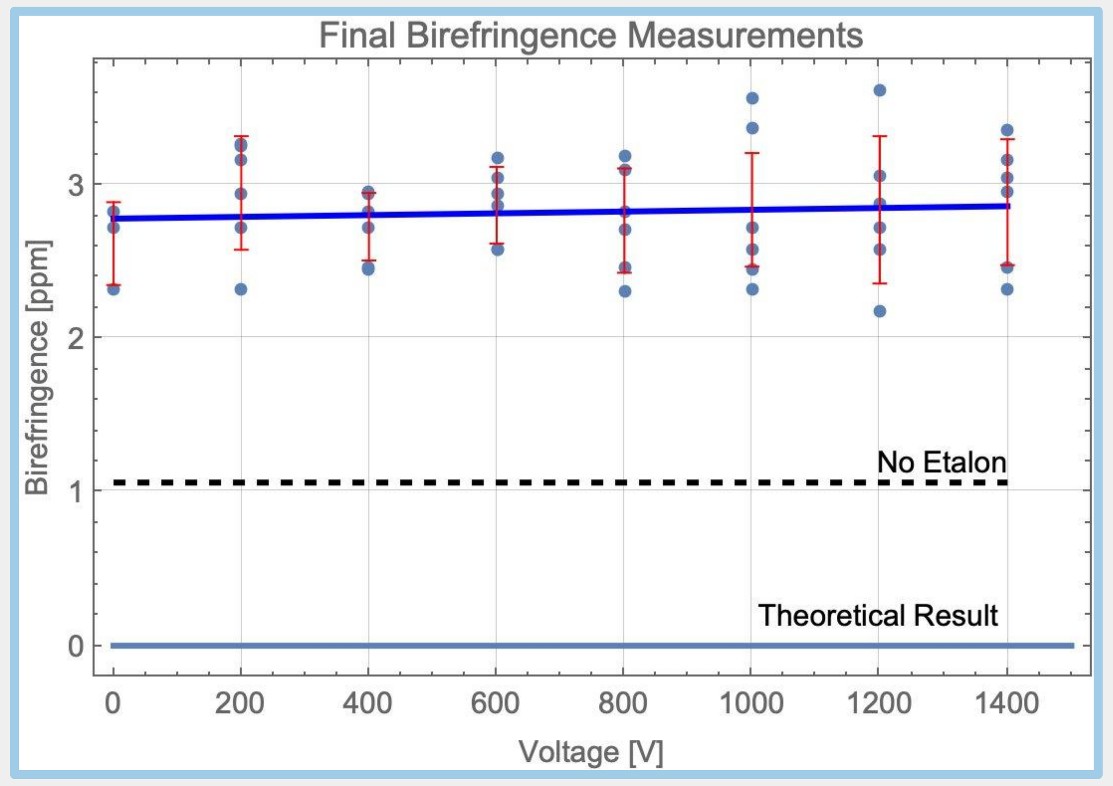
- The crystals in our etalon are arranged with their optical axes oriented 90 degrees relative to each other.
- Identical electric fields E1 and E2 are individually applied across each crystal using high voltage to tune their indices of refraction and resulting transmission.

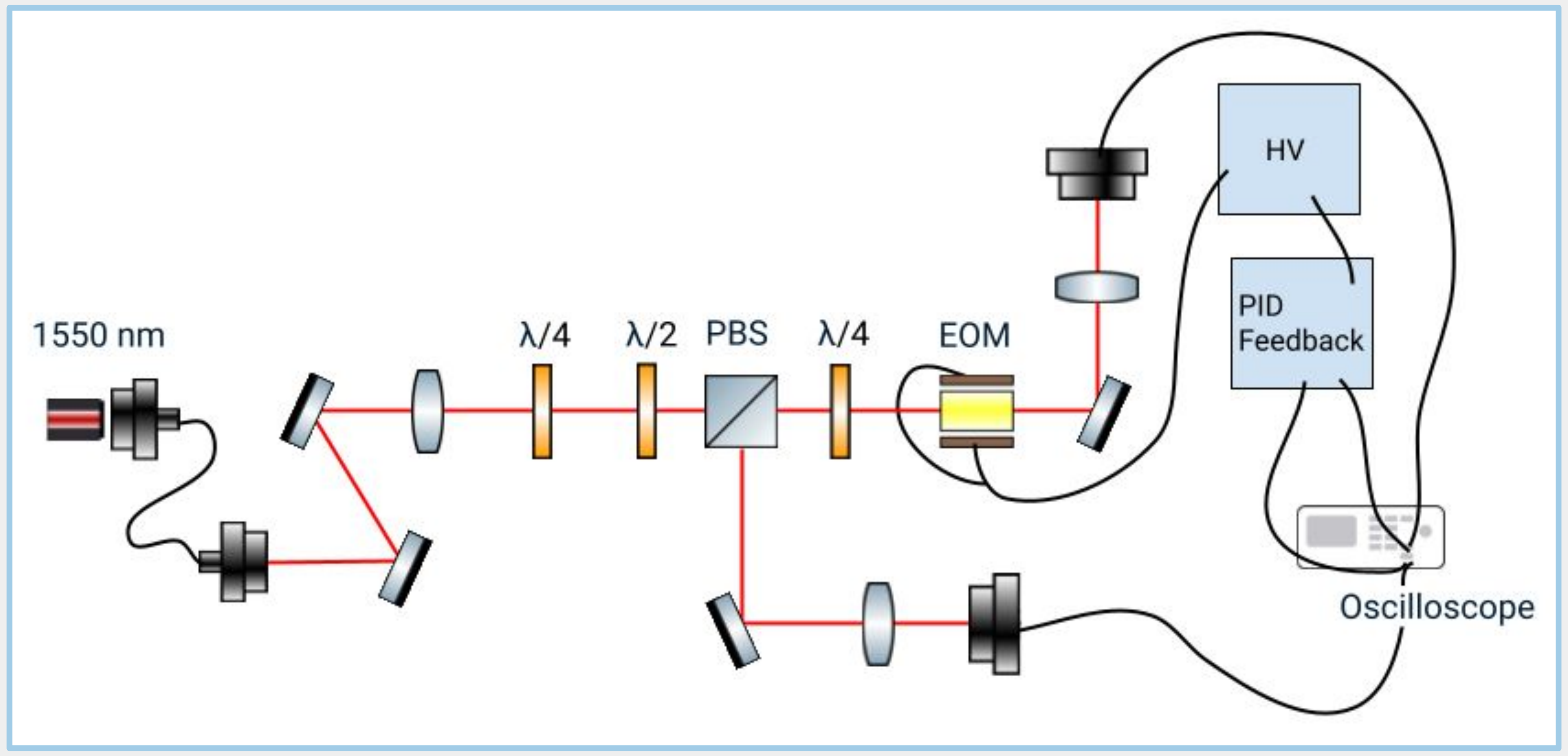
We obtain full transmission by fitting an integer number of half wavelengths in the optical cavity. The transmission fringes through the etalon can be understood in terms of the ratio between the transmitted and reflected light.

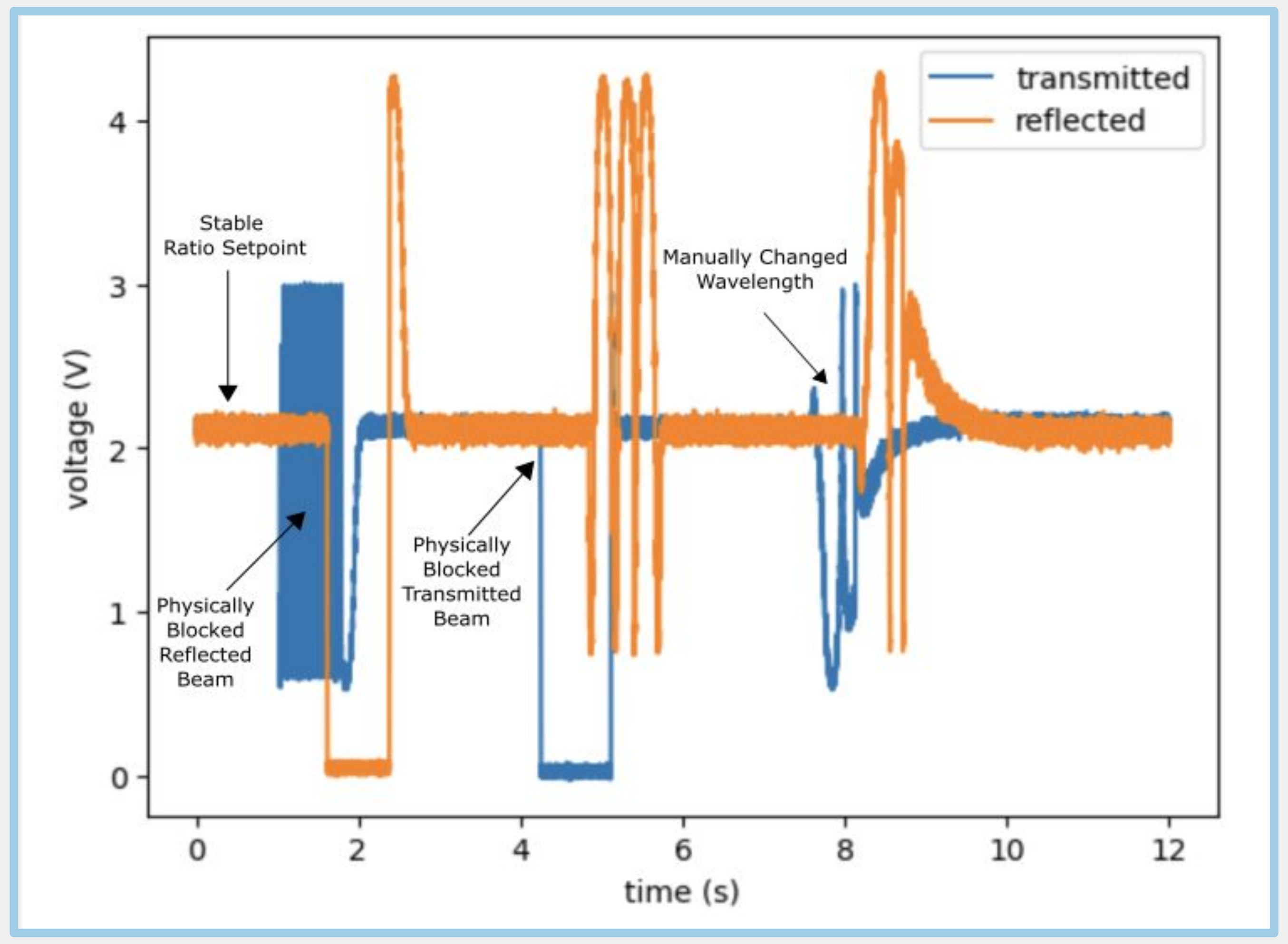



## Characterizing Birefringence:

In order to operate properly regardless of the input light's polarization, the etalon must be polarization-independent, also known as birefringence-free. Birefringence is defined as the difference between the ordinary and extraordinary indices of refraction. A singular lithium niobate crystal has a birefringence of 0.08. Our etalon consisted of two lithium niobate crystals, designed to be polarization-independent with the rotation of the crystals 90 degrees with respect to each other. By placing the etalon between two crossed polarizing beam splitters we calculated the birefringence. The birefringence was measured to have an average value of 2.862 ppm, showing the success of the design at limiting birefringence.




## Feedback and Stabilization:

A circuit including a Teensy 4.0 Microcontroller, a digital-analog converter, and multiple operational amplifiers monitored the light reflected from and transmitted through the etalon, controlling the ratio between the two signals. This feedback loop allowed for the automation of an applied high voltage. When one signal was physically blocked, the feedback loop would correct the ratio. Python, connected through an oscilloscope, recorded and printed the resulting data.