

Free-Space Mode- Locking Fiber Laser

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Introduction

Background

Laser Setup

Properties of the Laser

How to Measure Pulses

Autocorrelator Design

Conclusions

Future Work

Passive Mode-Locking

Spontaneous emission

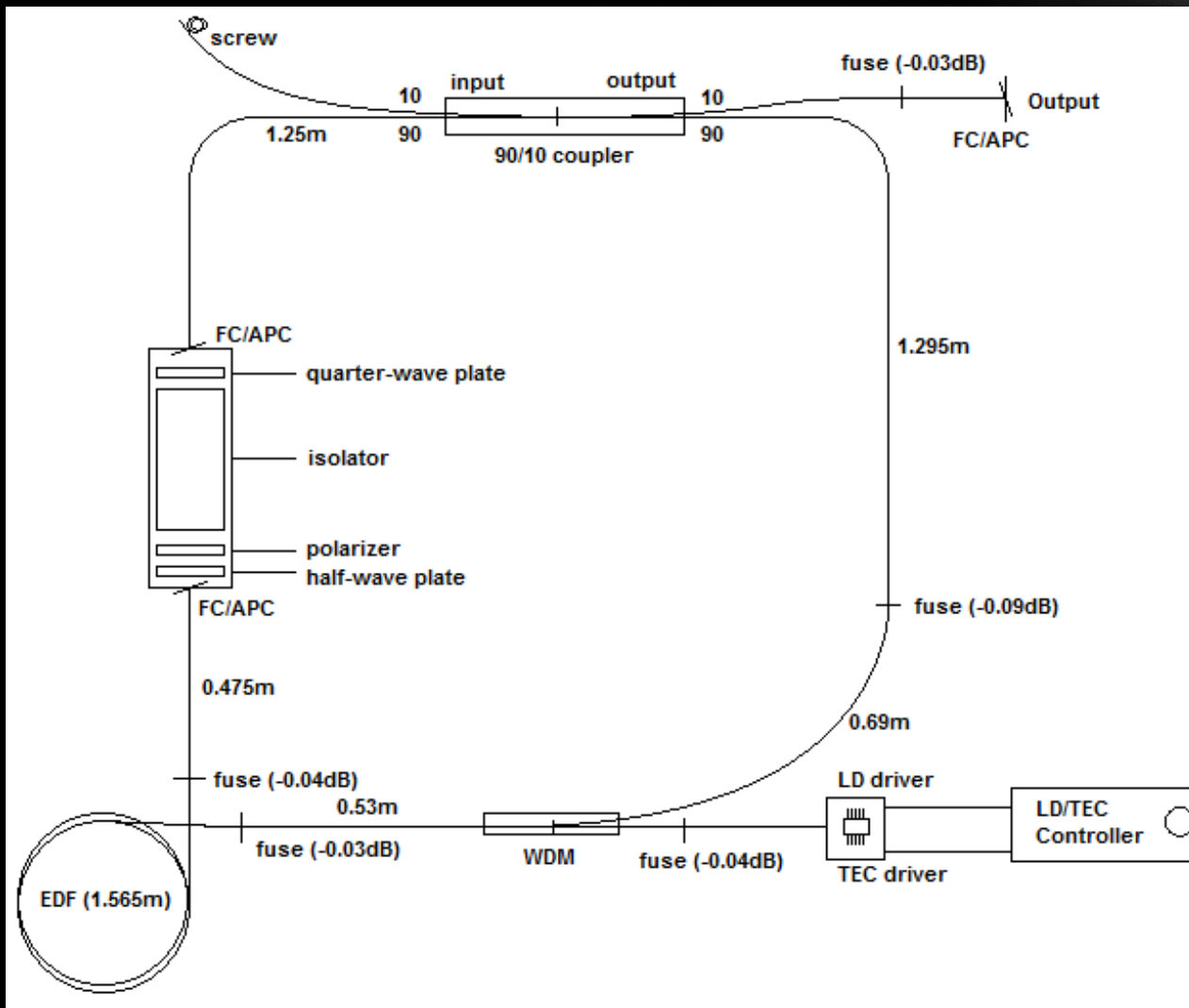
Saturable absorber

Stimulated emission depletes the gain

Absorption depletes population in lower states.

Gain must be greater than losses

Laser Setup



Dispersion

SMF 28 (negative dispersion)

EDF (positive dispersion)

β_2 dispersion factor

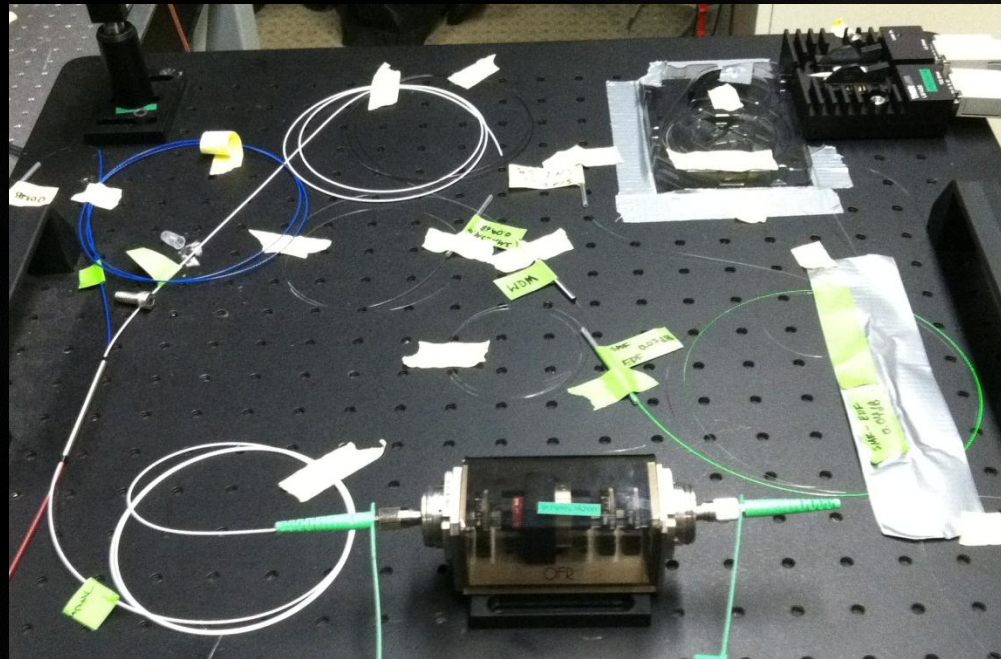
- (-0.023ps²/m) SMF 28
- (+0.061ps²/m) EDF

$$\beta_2 = 0.061x - 0.023y$$

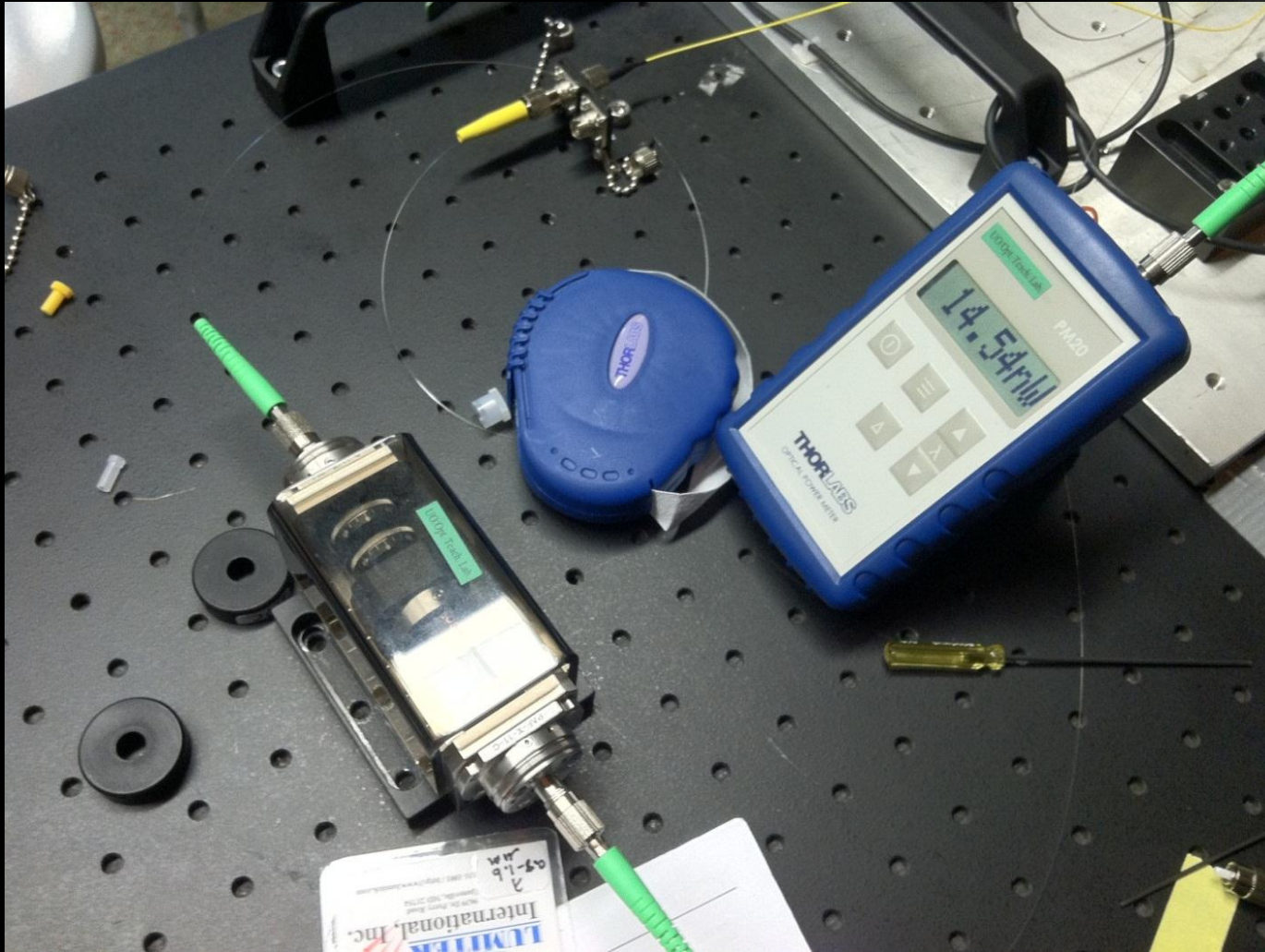
Feedback Loop

Components

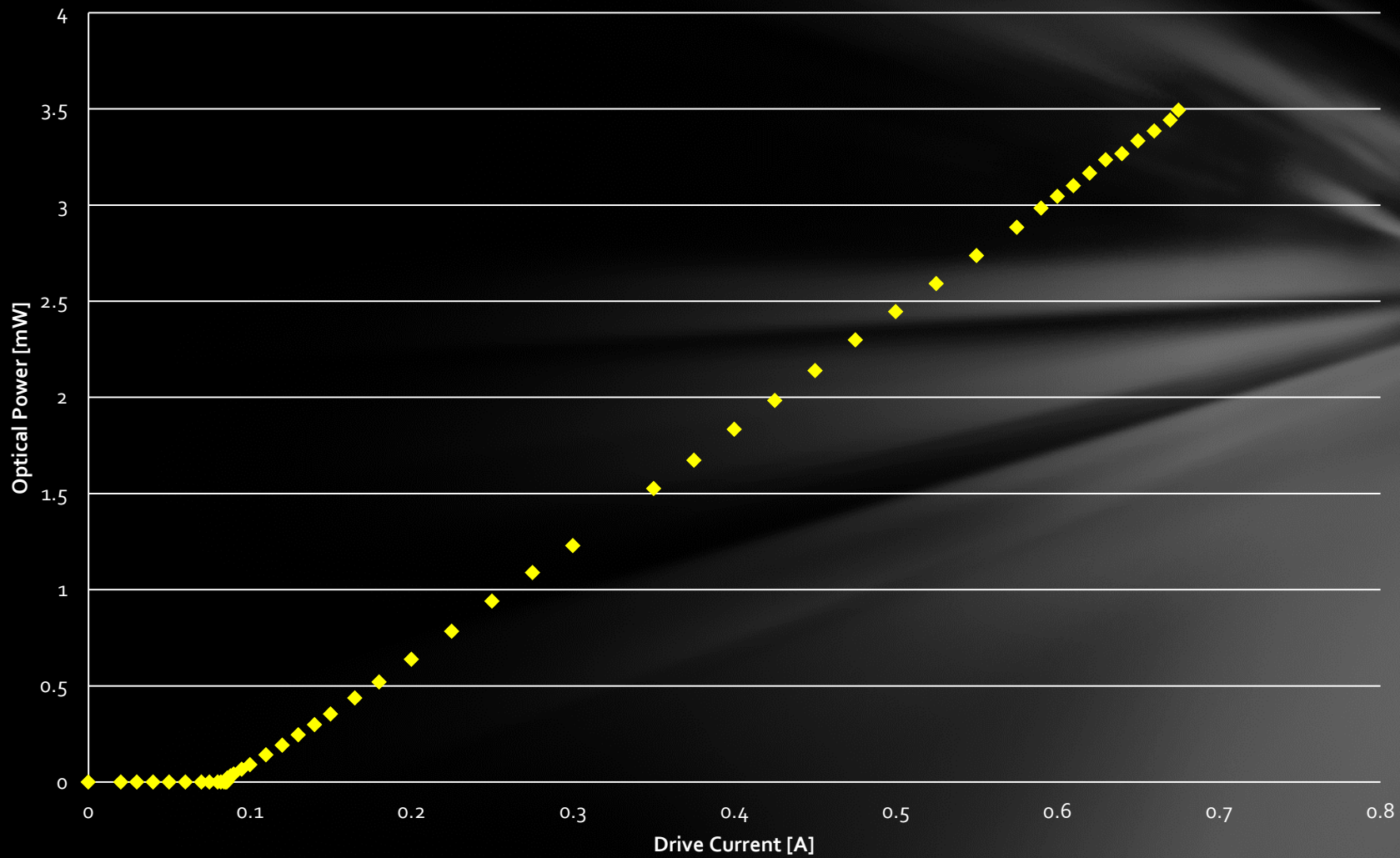
- WDM
- EDF
- Free-Space
 - $\lambda/2$ plate
 - Polarizer
 - Isolator
 - $\lambda/4$ plate
- 90/10 coupler



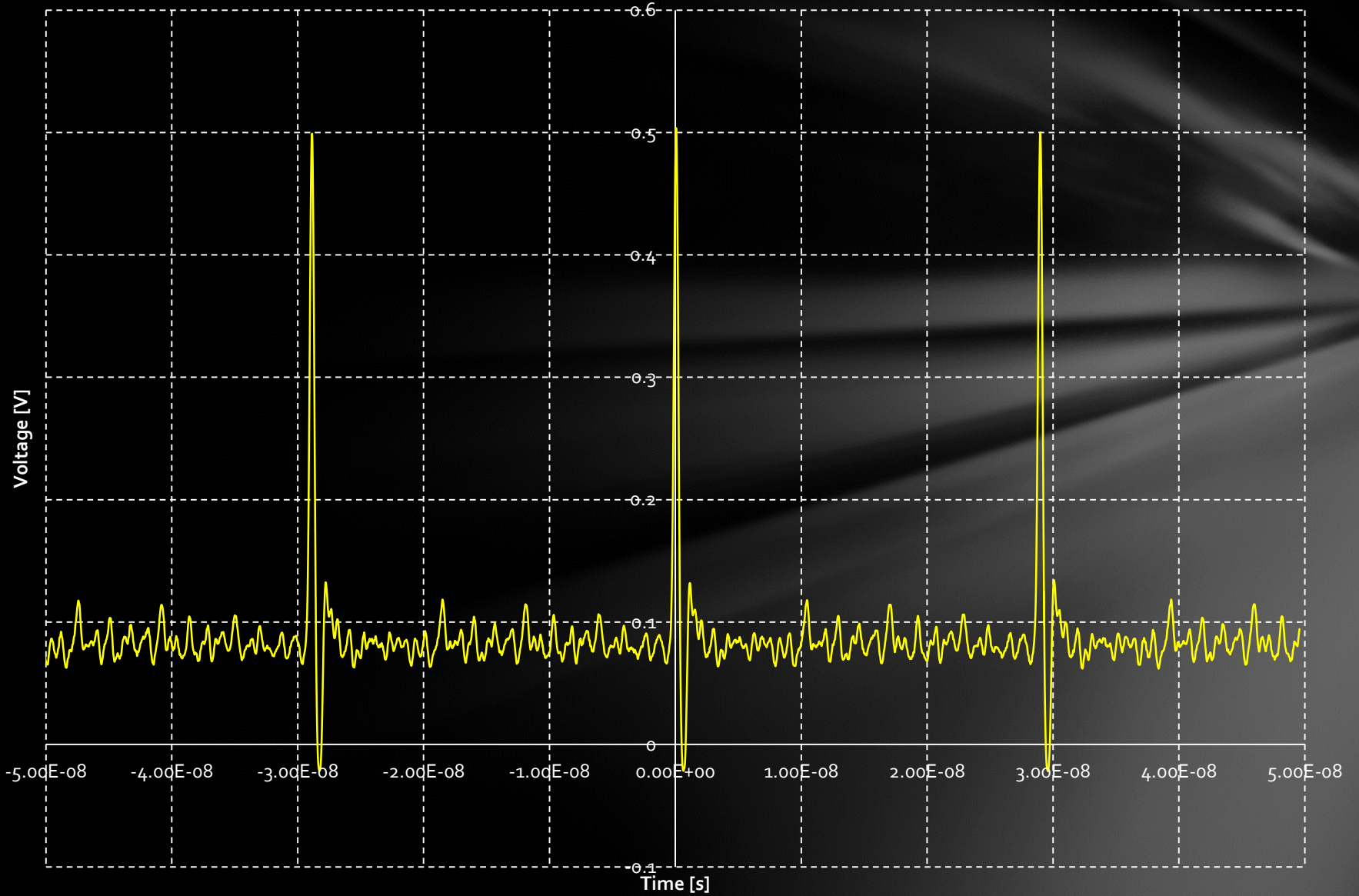
Free-Space Optimization



Laser Characterization



Laser Output



Soliton?

- β_2 approximately -0.001
- Pulse width
- Power
- Long distances
- Measuring pulse width

Optical Autocorrelation

Motivation: Measure ultra-short pulses

- Autocorrelation
- Two photon absorption in silicon
- Our apparatus
- Troubleshooting
- Outlook

AutoCorrelation?

- Cross-correlation: Tells us how similar $f(t)$ and $g(t)$ are for different values of t
- Autocorrelation: If $f(t)=g(t)$, our correlation function tells us how similar a function is with a time delayed copy of itself.

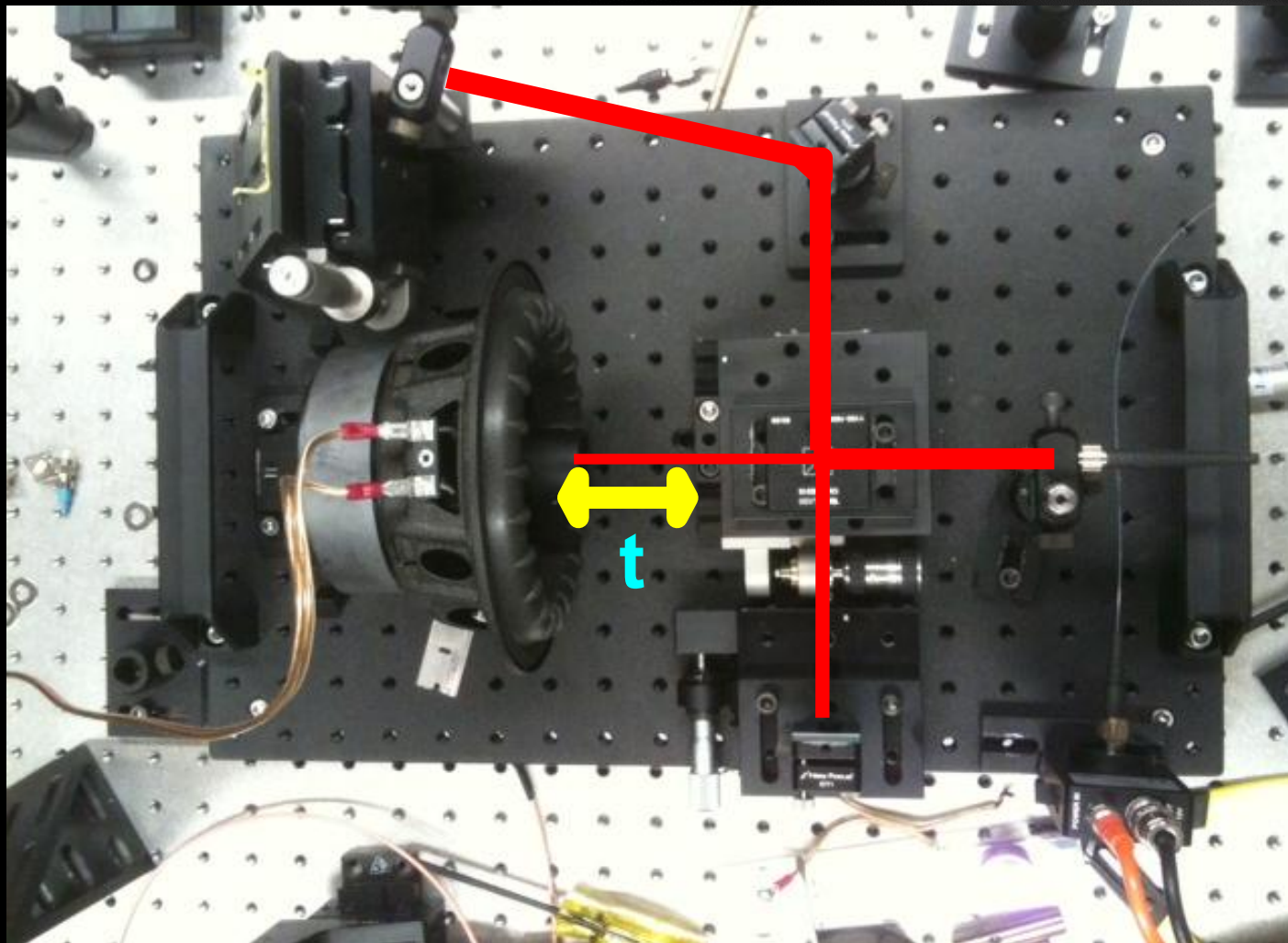
Optical Autocorrelation

- Consider $f(t)$ as an electric field and $A^{(n)}(t)$ as the n th order autocorrelation.
 - First Order: The field autocorrelation
 - Second Order: The intensity autocorrelation

Two Photon Absorption in Si

- Third order non-linear process: $\text{TPA} \sim I^2$
- Silicon bandgap ~ 1.12 eV
 - Perfect for 1.55 μm

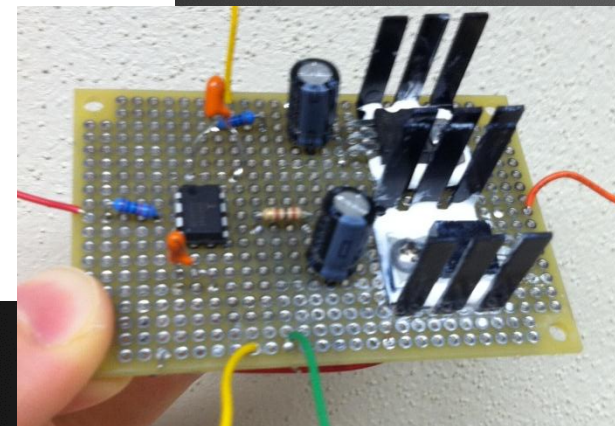
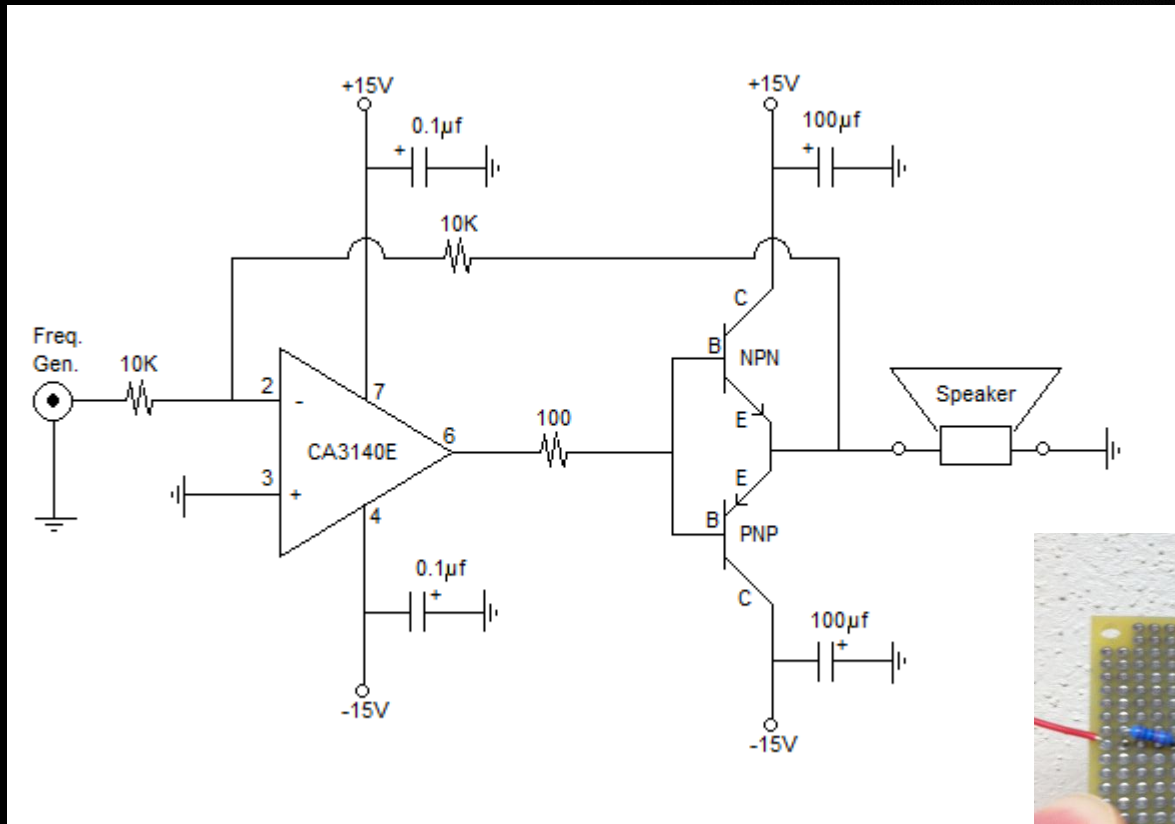
Our Autocorrelator



Troubleshooting

- Getting up to speed...
- Driving the speaker
- Circuitry

Amplifier Circuit



Autocorrelation Outlook

- Play with circuit
- Improve power output
- Carefully adjust armlengths to find interference

Conclusions

Our laser has successfully mode locked and stays mode-locked untouched

Progressed autocorrelation technique for measuring ultra-short pulses

Future Work

Troubleshooting autocorrelator

Once pulse duration can be measured, test soliton stability using long fiber cable

Summary

Background

Mode-Locking

Laser Setup

Autocorrelator

Problems

Future Work

Questions?