Mitigation of Birefringence in the Kerr E-field Monitor

Andrew Park[1] Alex Sushkov Dima Budker

[1]novakyu@ocf.berkeley.edu

Department of Physics
University of California, Berkeley

nEDM Collaboration Meeting
November 3, 2007

Outline

1. Kerr Effect for Monitoring Electric Field
2. Experimental Setup
3. Results

Outline

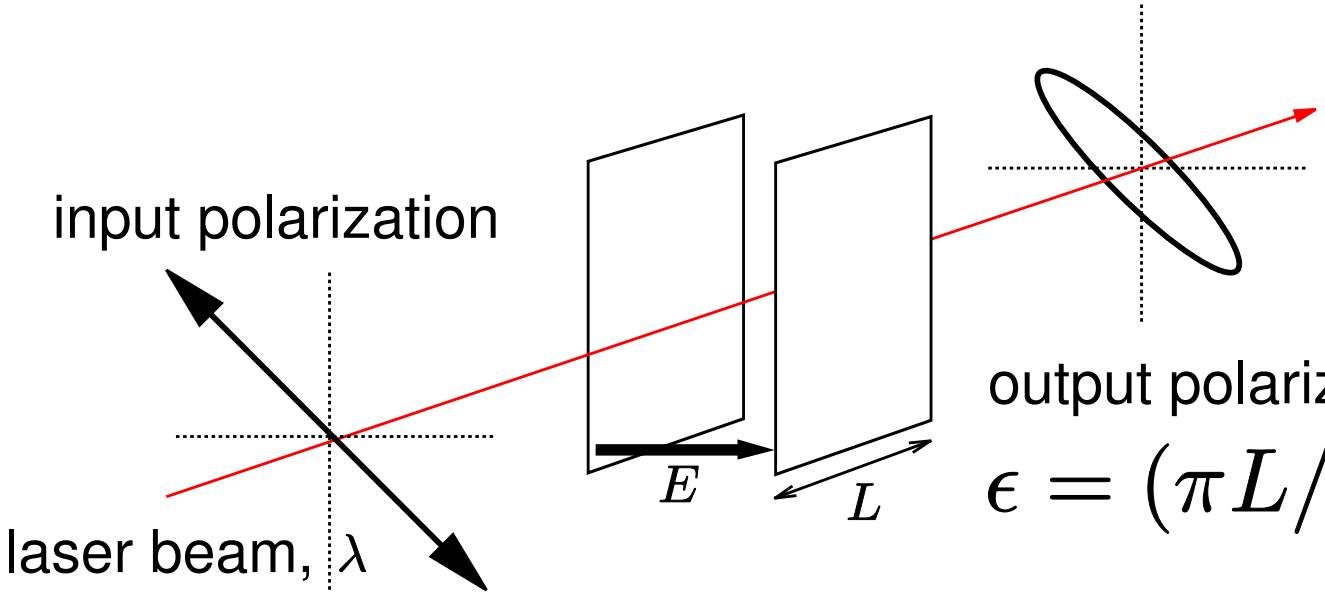
1. Kerr Effect for Monitoring Electric Field
2. Experimental Setup
3. Results

Outline

1. Kerr Effect for Monitoring Electric Field
2. Experimental Setup
3. Results

Kerr Effect in Liquid Helium

- Electric field causes liquid helium to become birefringent
- Kerr constant (K) in liquid helium has been measured[1]
- By measuring output polarization we can monitor the E field in the medium



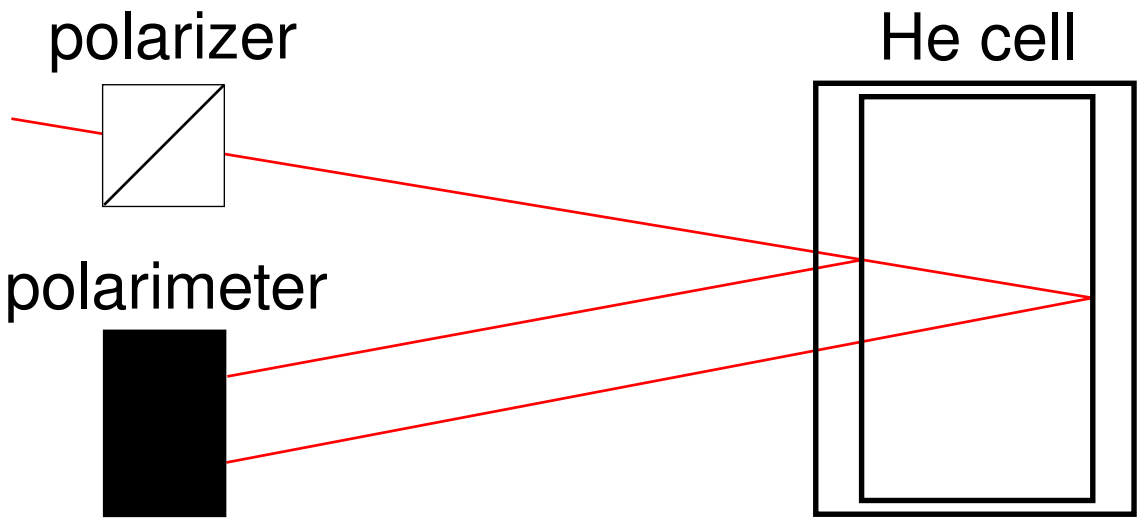
$$\epsilon = (\pi L/\lambda) K E^2$$

[1] Sushkov, et al. *PRL* 93, 153003 (2004)

Optical Access for Kerr Effect Measurement

- Small LHe Kerr constant: $K_{\mathrm{He}} = 1.4 \times 10^{-20}\ (\mathrm{cm/V})^2$
  - compare: $K_{\mathrm{N_2}} = 4.3 \times 10^{-18}\ (\mathrm{cm/V})^2$
- Expected Kerr effect signal $\approx 10\ \mu\mathrm{rad}$
- Cell window becomes birefringent due to temperature gradient and stress
  - In our cryostat (fused-silica, epoxy-mounted windows), offset of 0.02 rad and **drift of 100 μrad over hundreds of seconds**

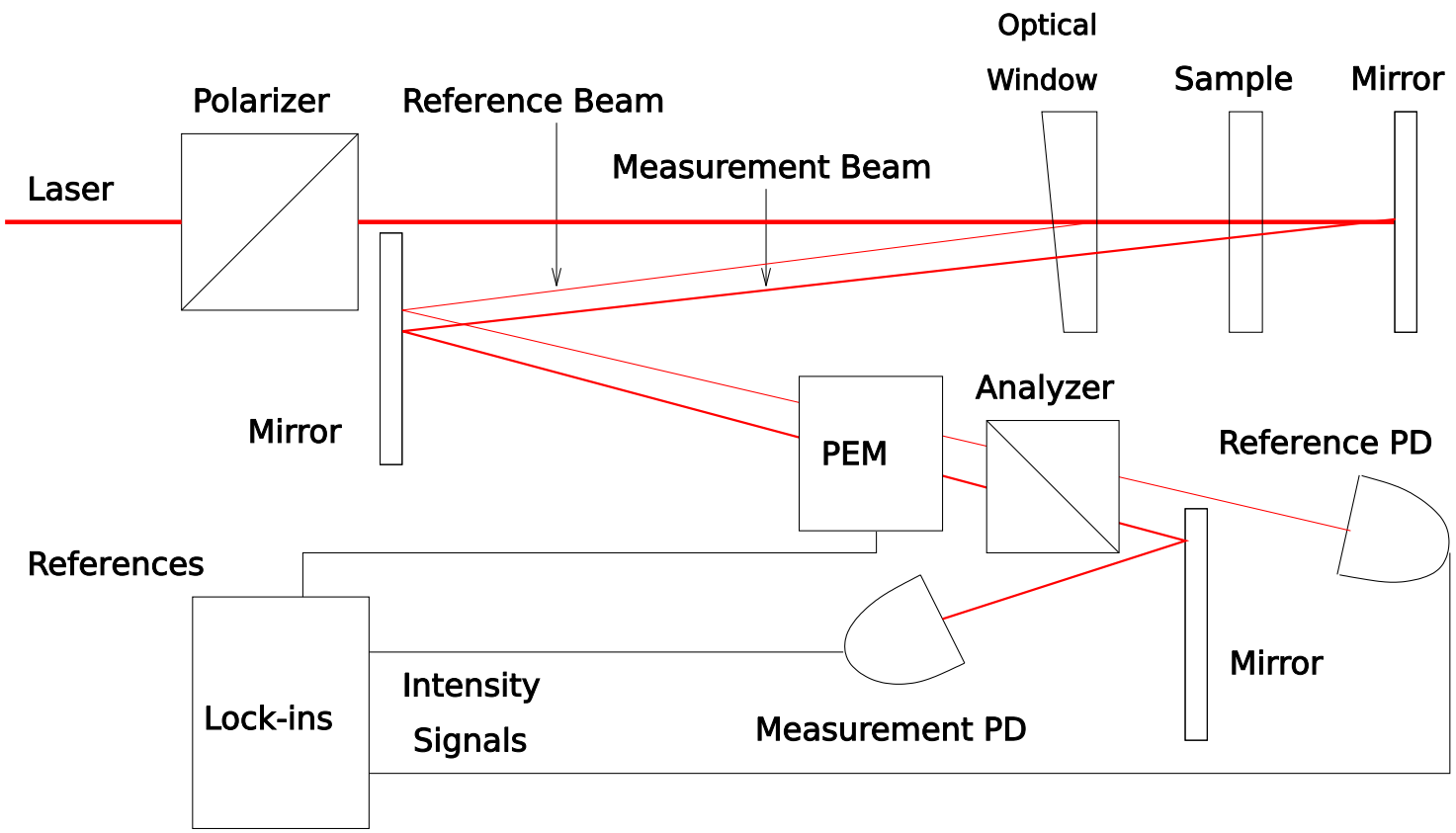
Schematic Setup for Cancellation



- For small ($\ll$ 1 rad) birefringences, window birefringence can be subtracted off
- Also doubles Kerr effect signal
- Limited by spatial variation of window birefringence

Polarimeter Setup with Photoelastic Modulator

for simultaneous monitoring of both beams



- PEM + analyzer forms the polarimeter setup

Real-time Cancellation of Birefringence

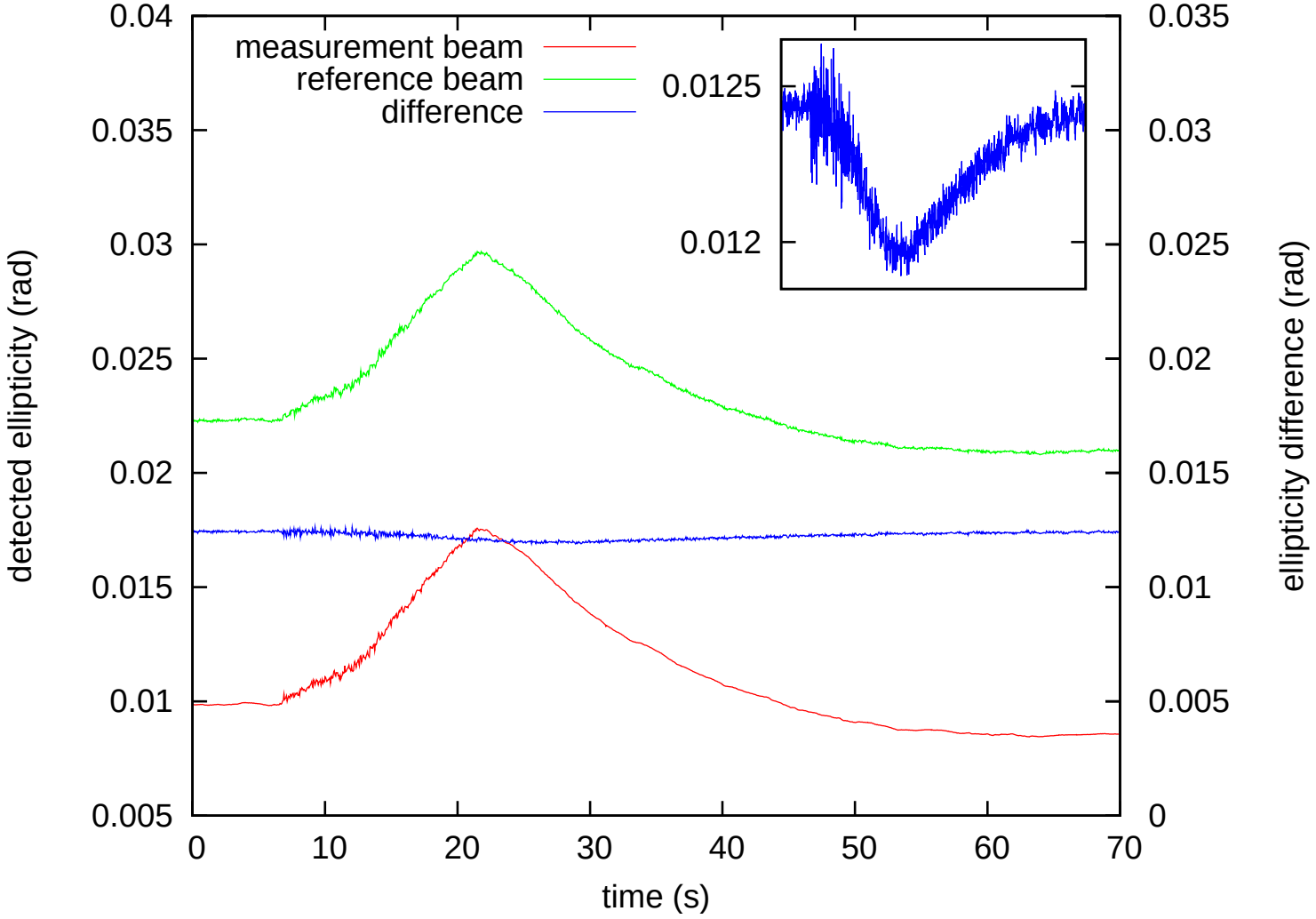
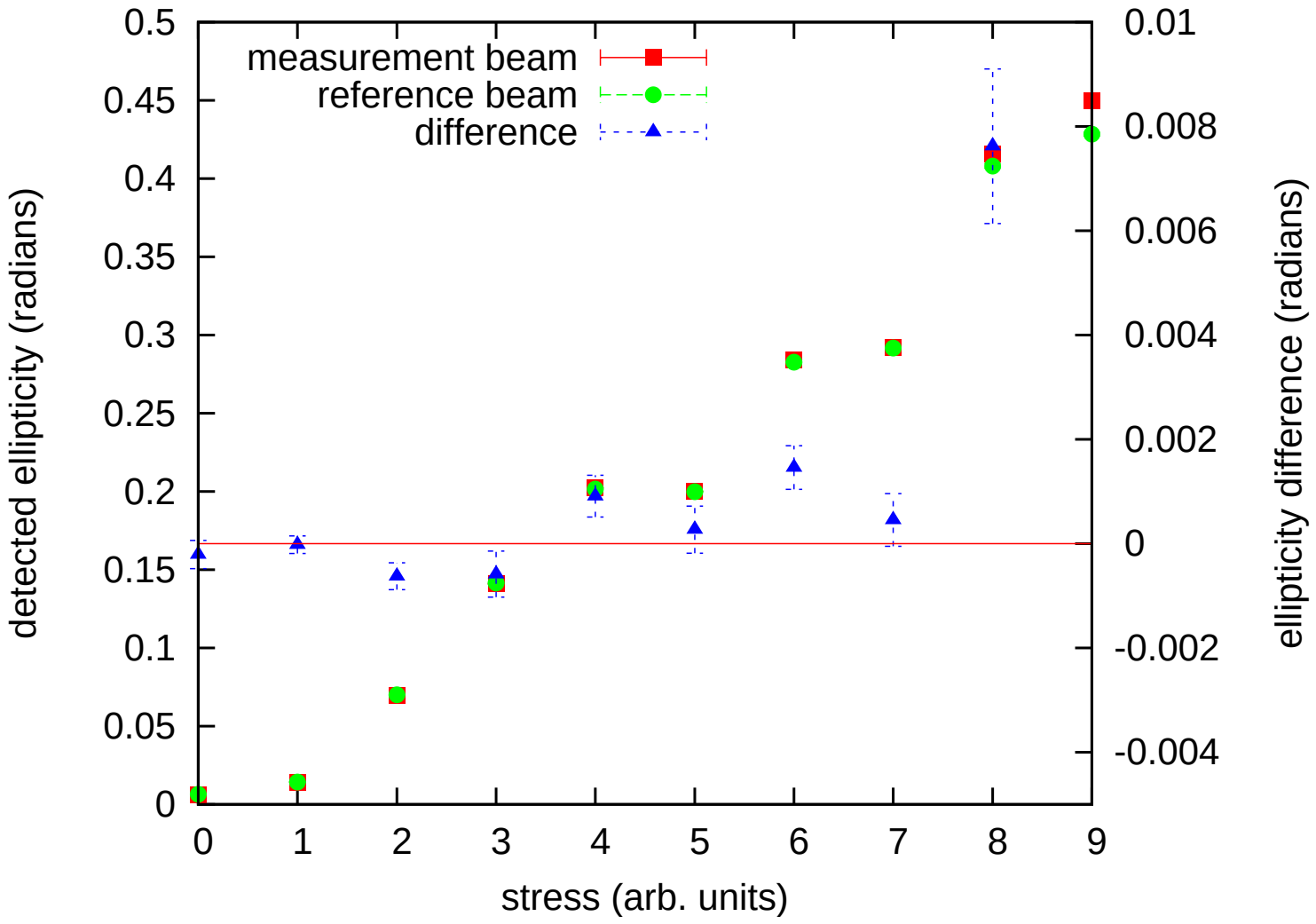


Figure: Result at room temperature, as one side of window is cooled by a burst of cool air

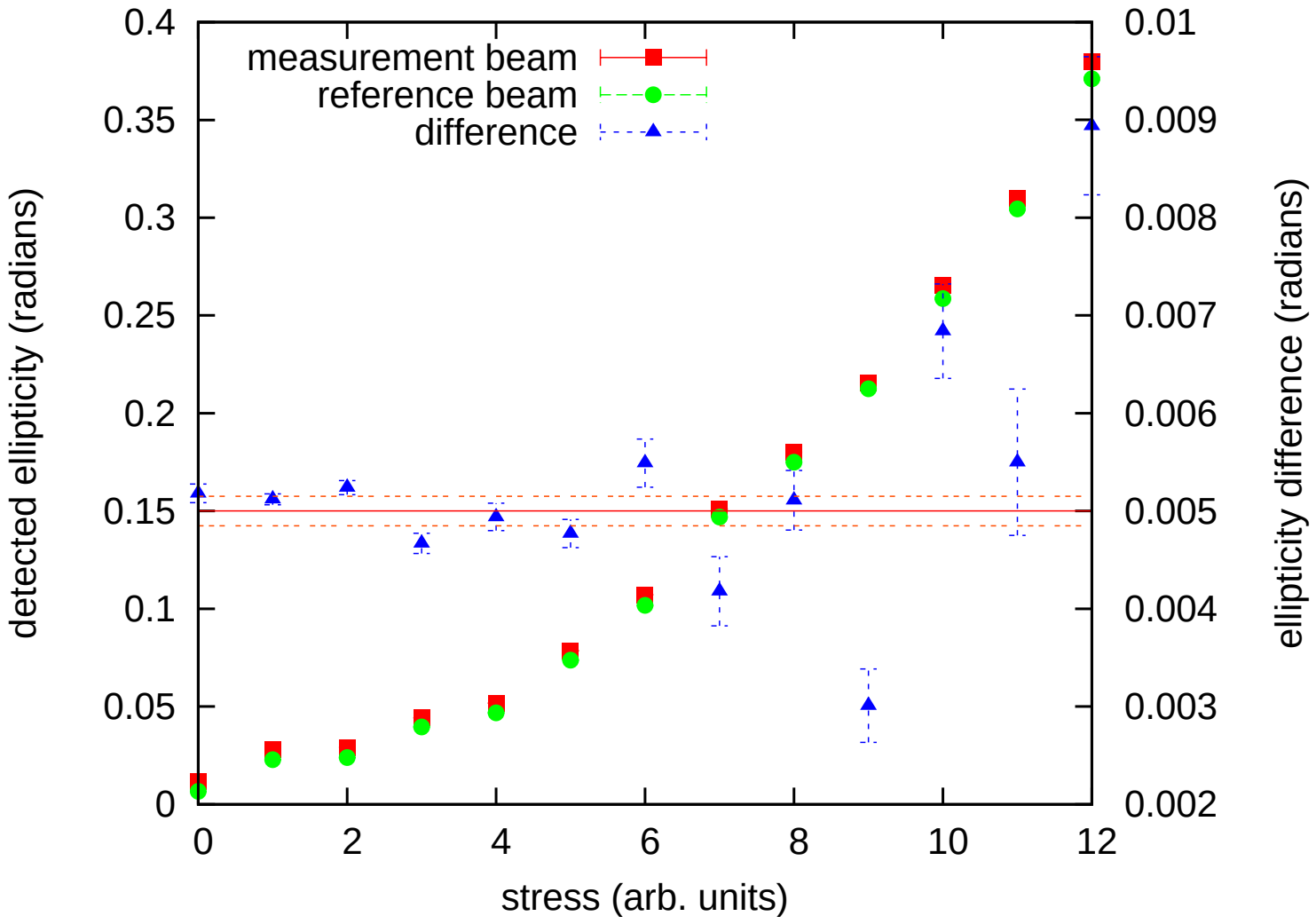
Birefringence Cancellation

over a range of window birefringences with no sample



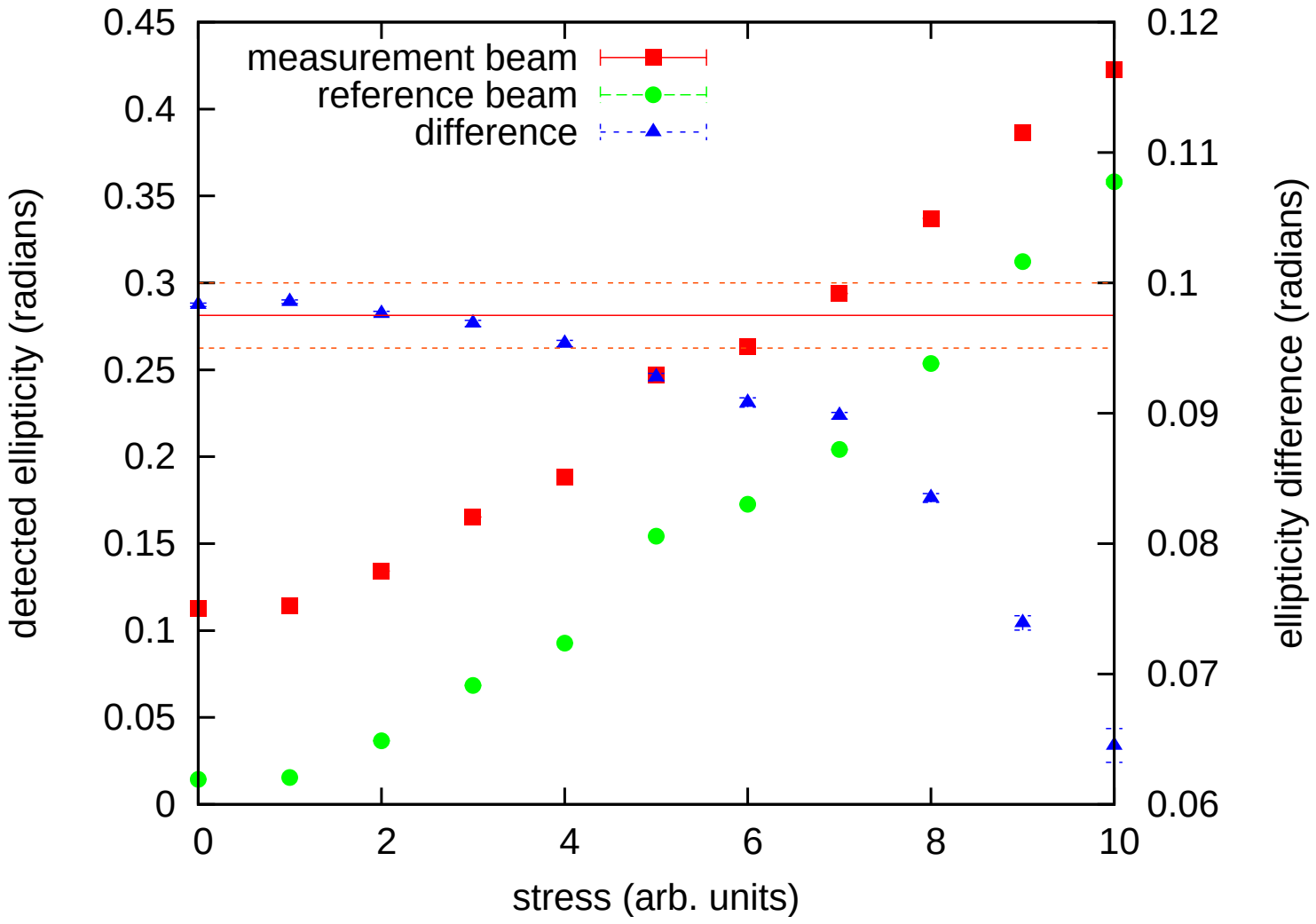
Birefringence Cancellation

over a range of window birefringences with a small-birefringence sample



Birefringence Cancellation

over a range of window birefringences with a large-birefringence sample



Summary

- Cancellation of window birefringence to 1% of its value demonstrated at room temperature
- Method limited by spatial nonuniformity of window birefringence

- Open questions:
  - A realistic estimate of sensitivity
  - Performance at cryogenic temperature
  - Location of all the components of the system: laser, optics (mirrors), polarimeter (PEM, analyzer, photodetector)