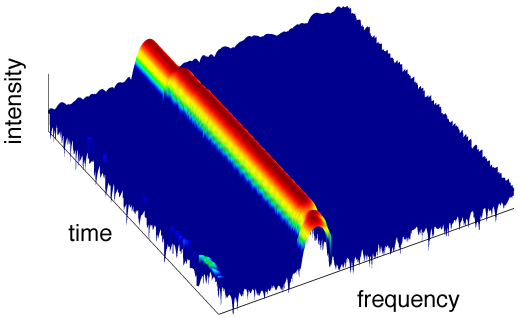

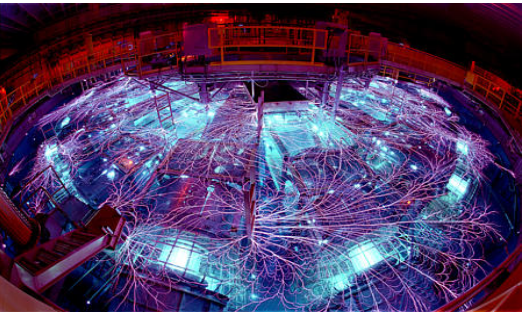

Development of a 1064 nm PDV system

Sandia National Laboratories

Exceptional service in the national interest

T. Ao and D. H. Dolan

Sandia National Laboratories, Albuquerque, NM

Photonic Doppler Velocimetry Workshop 2016
Livermore, CA, June 7-9, 2016

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Outline

- Background and motivation
- Design and implementation
- Dynamic compression test

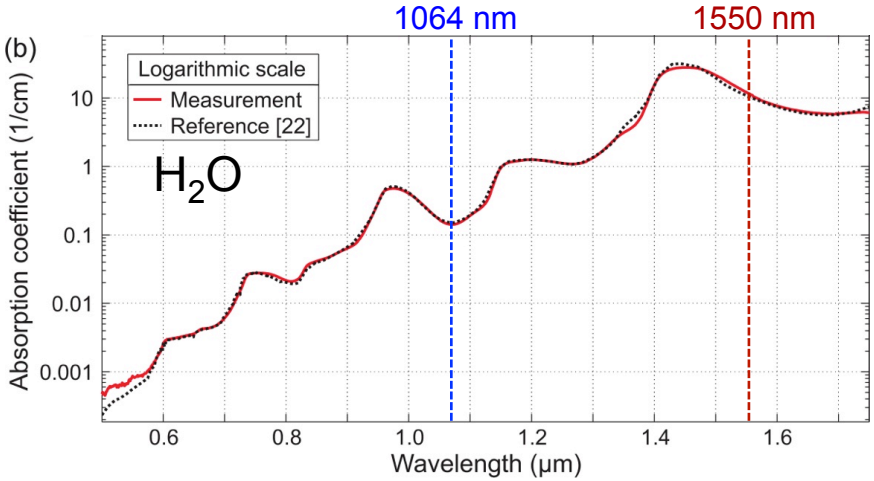
Background

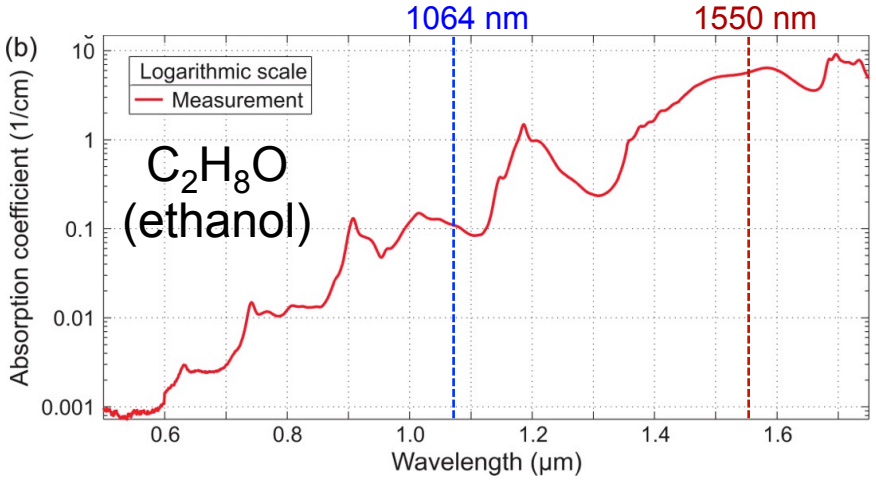
- PDV uses readily available fiber-based components (λ_0 = 1550 nm)
  - Infrared lasers
  - Circulator
  - Fiber coupler
  - Fast infrared detector
  - GHz digitizer

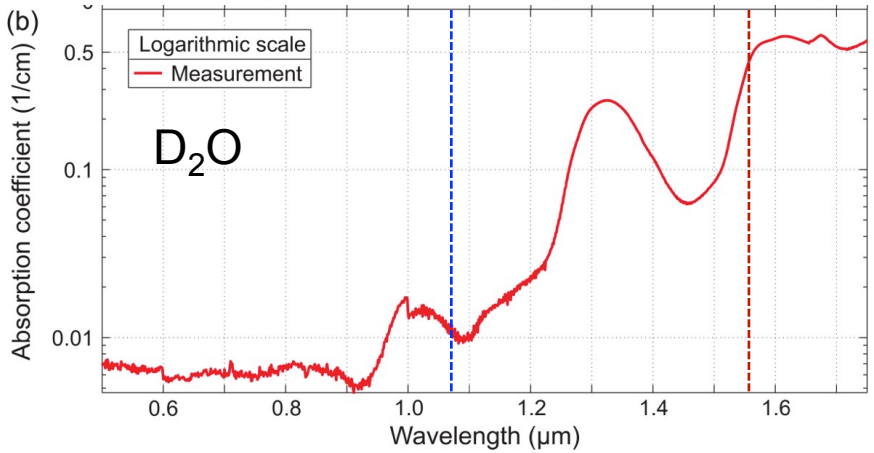
- Beat frequency proportional to velocity: $f = \frac{2v}{\lambda_0}$
  - For 1550 nm:
    - 1 GHz ➔ 0.775 km/s
    - 1 km/s ➔ 1.29 GHz
  - For 1064 nm:
    - 1 GHz ➔ 0.532 km/s
    - 1 km/s ➔ 1.88 GHz

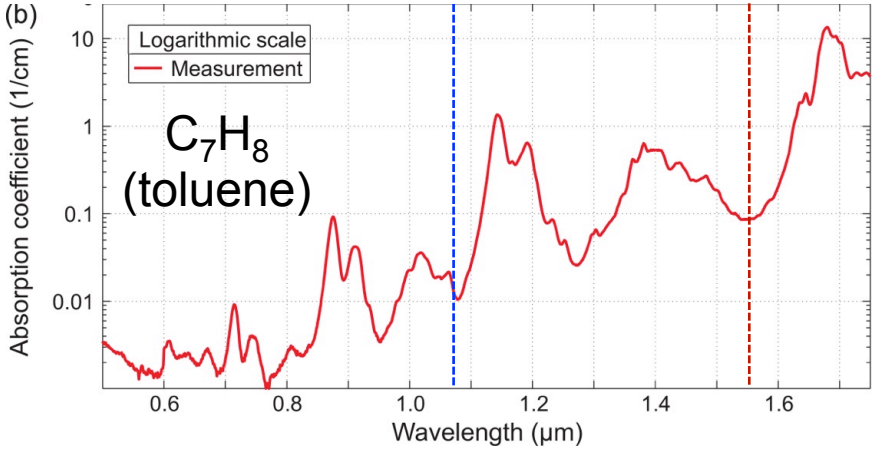
Motivation

- Absorption of near infrared light in liquids due to vibrational overtones



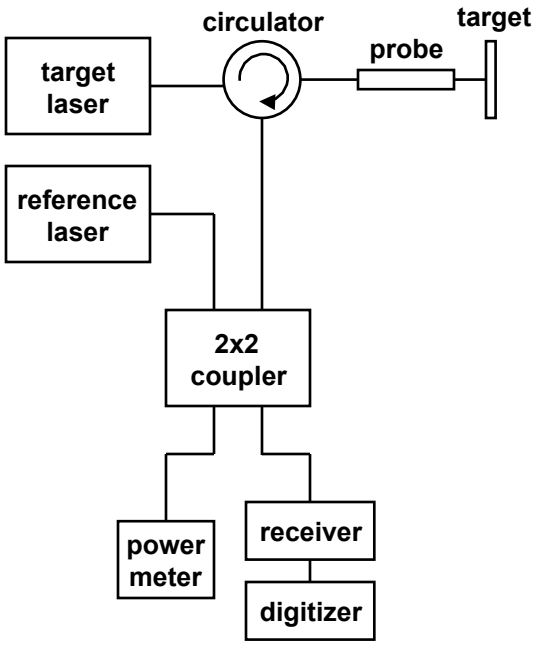




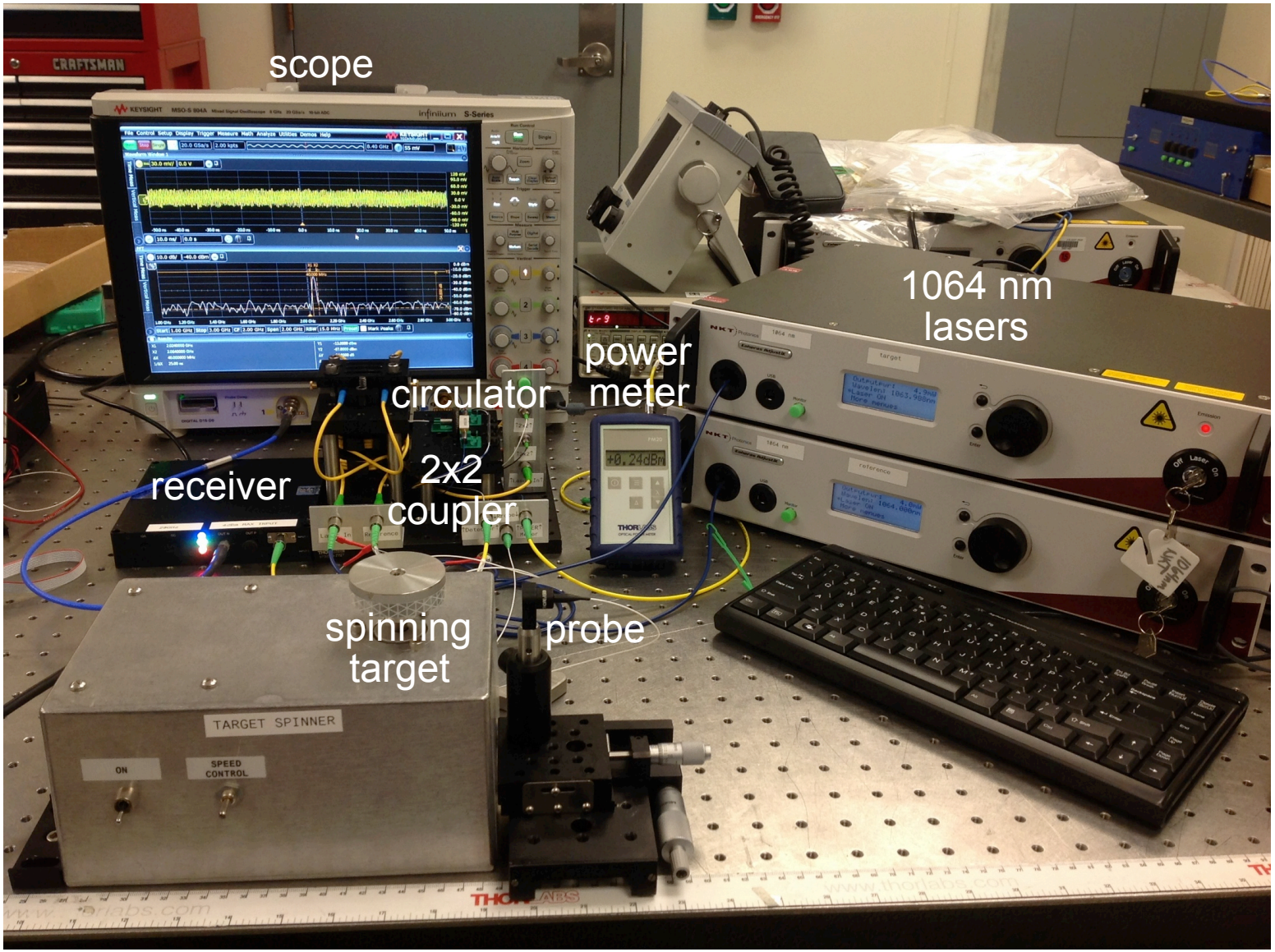


Design of 1064 nm PDV system

- Lasers
  - Reference: NKT Photonics Koheras Adjustik Y10 Standard (10 mW)
  - Target: NKT Photonics Koheras Adjustik Y10 Power (100 mW)
- Fiber components
  - Circulator
  - 2x2 coupler
  - Probe: GRIN collimator and lens
  - SM980 fiber/patch cables
- Detectors
  - Optilab high-speed receiver, 20 GHz
  - Thorlabs power meter
- Digitizer
  - Keysight scope, 8 GHz, 20 GSa/s
  - Tektronix scope, 6 GHz, 25 GSa/s

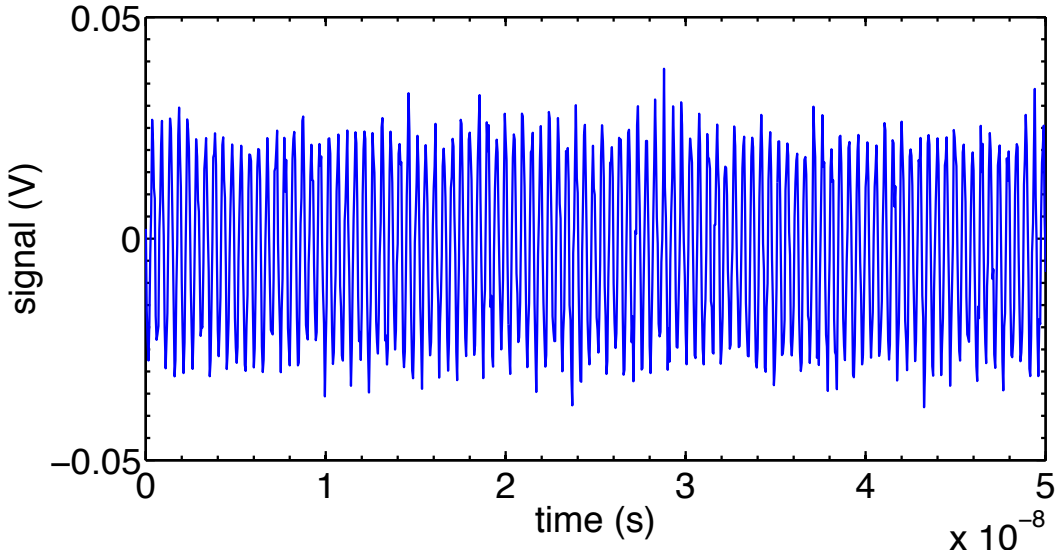


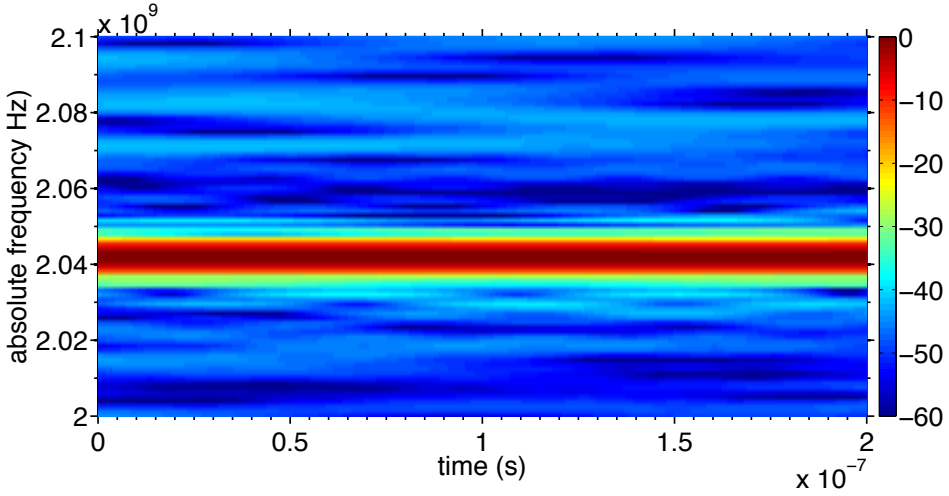
Spinner target test setup

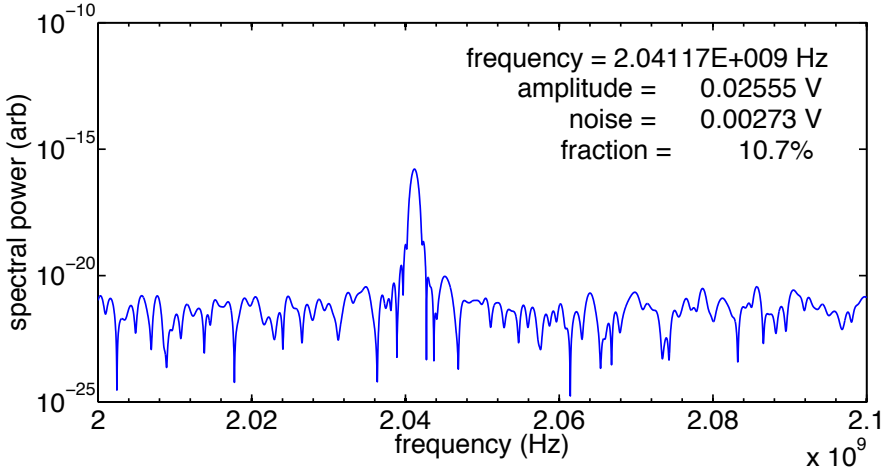


Static spinner target

- Diffuse reflector: Reference = 0 dBm; Target = -16 dBm

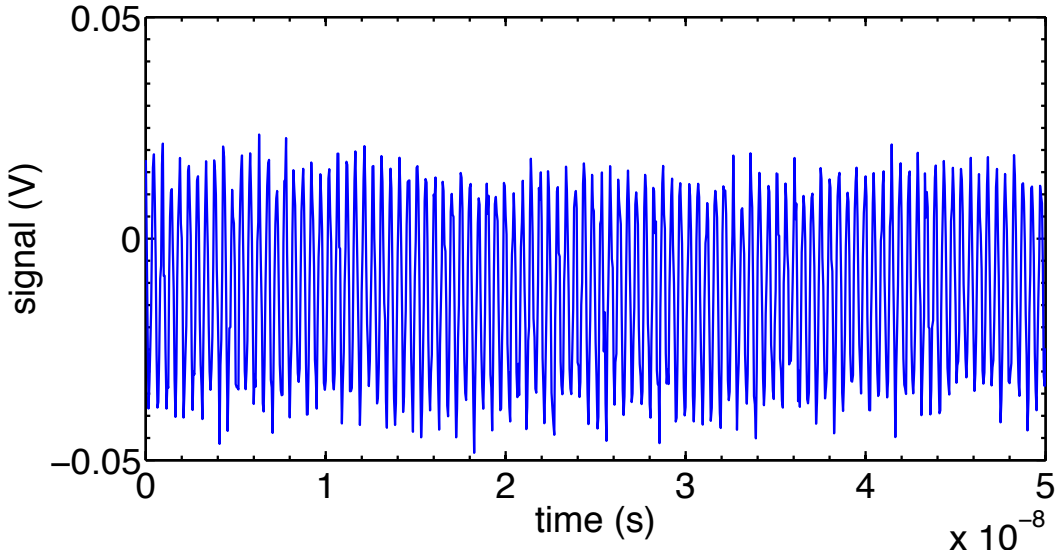


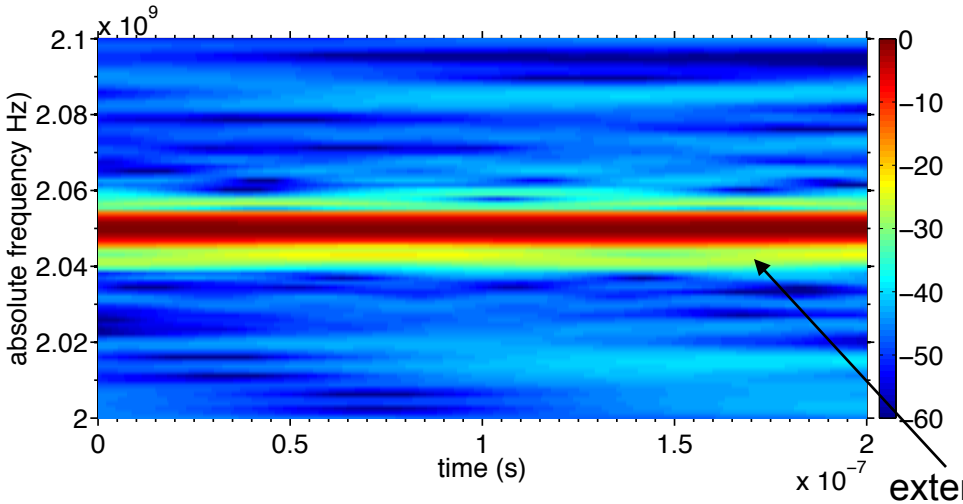


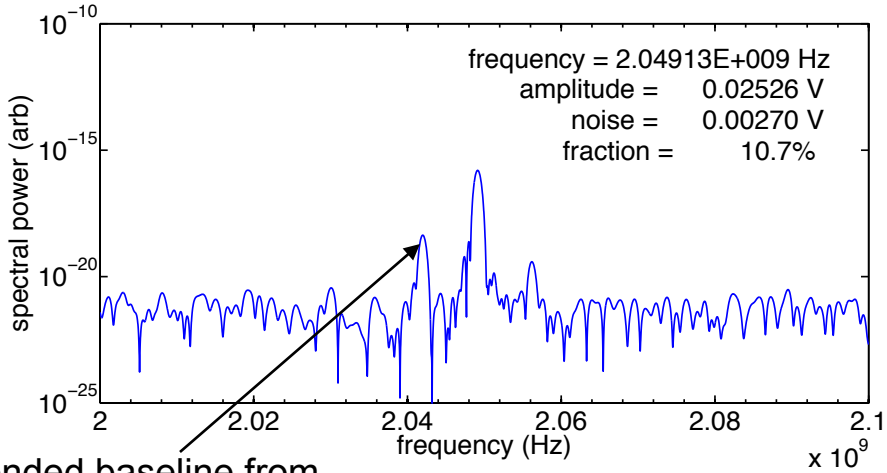


Spinning target

- Measured 8.0 MHz shift in beat frequency; 4.2 m/s velocity





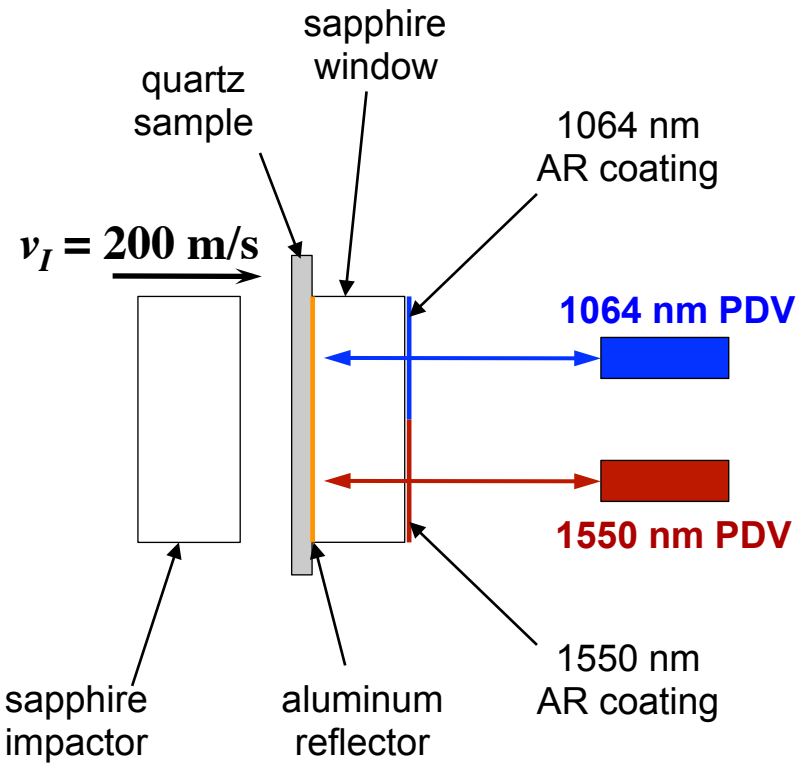


extended baseline from static leakage light

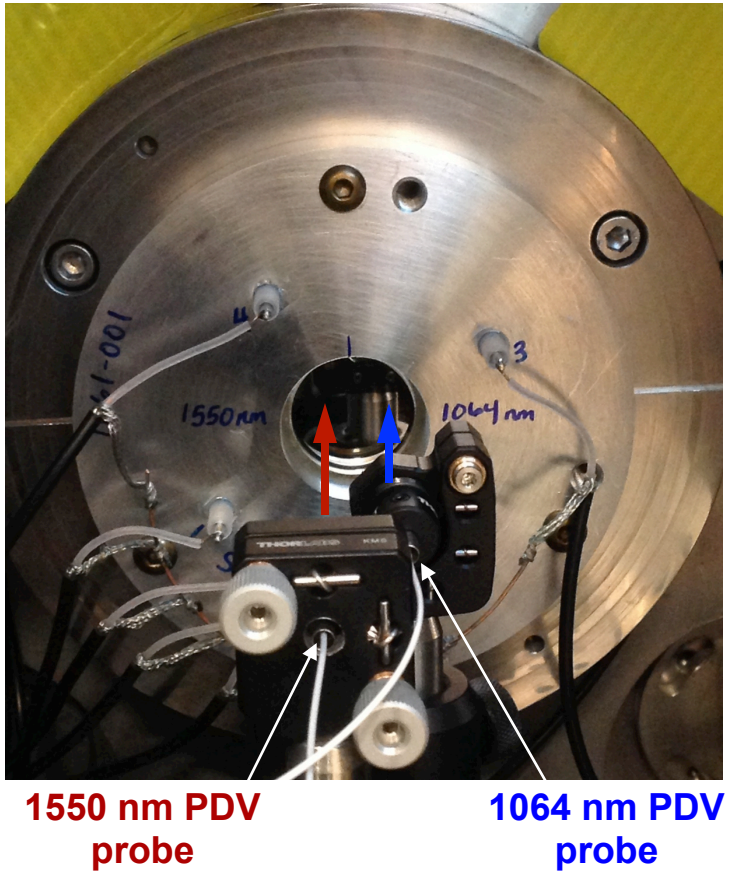
D. H. Dolan, T. Ao, and O. Hernandez, Rev. Sci. Instrum. **83**, 026109 (2012)

Dynamic compression test setup on DICE gas gun

- Quartz sample sandwiched between sapphire impactor and sapphire window
- Direct comparison between 1550 nm and 1064 nm PDV systems



Top View

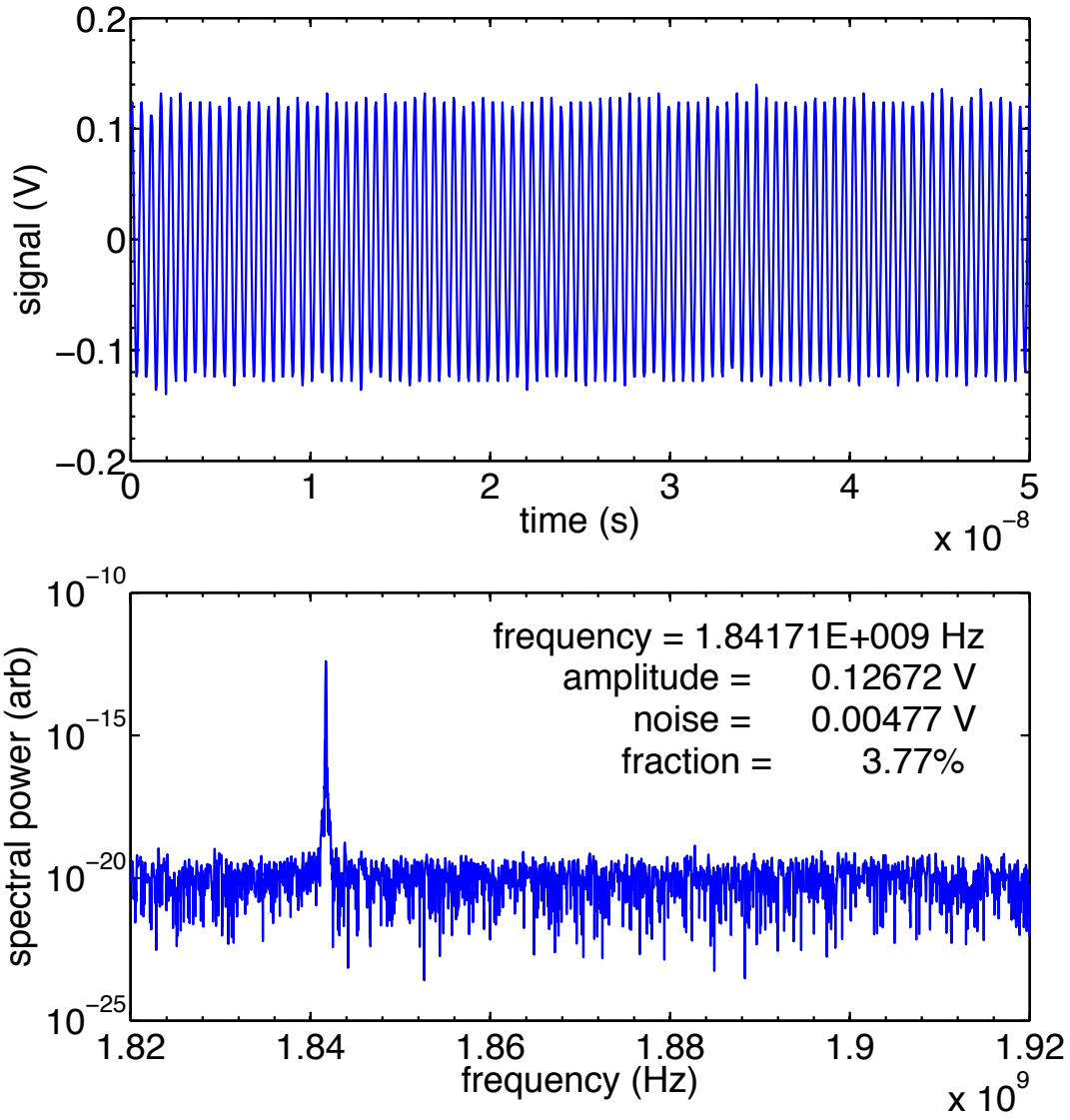


Rear View

T. Ao and D. H. Dolan, Rev. Sci. Instrum. **82**, 023907 (2011)

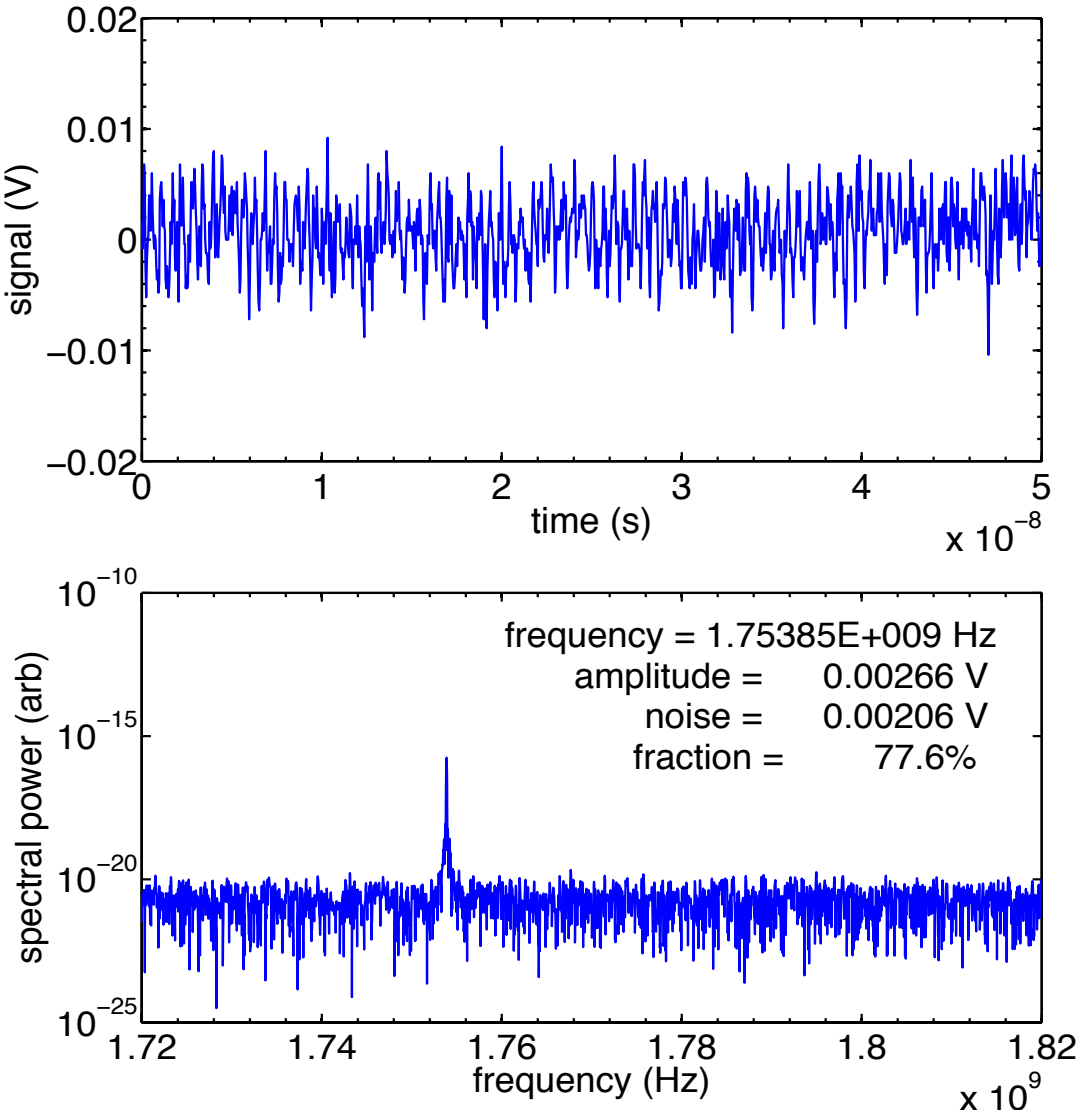
1550 nm PDV static

- Reference = 0 dBm; Target = -10 dBm

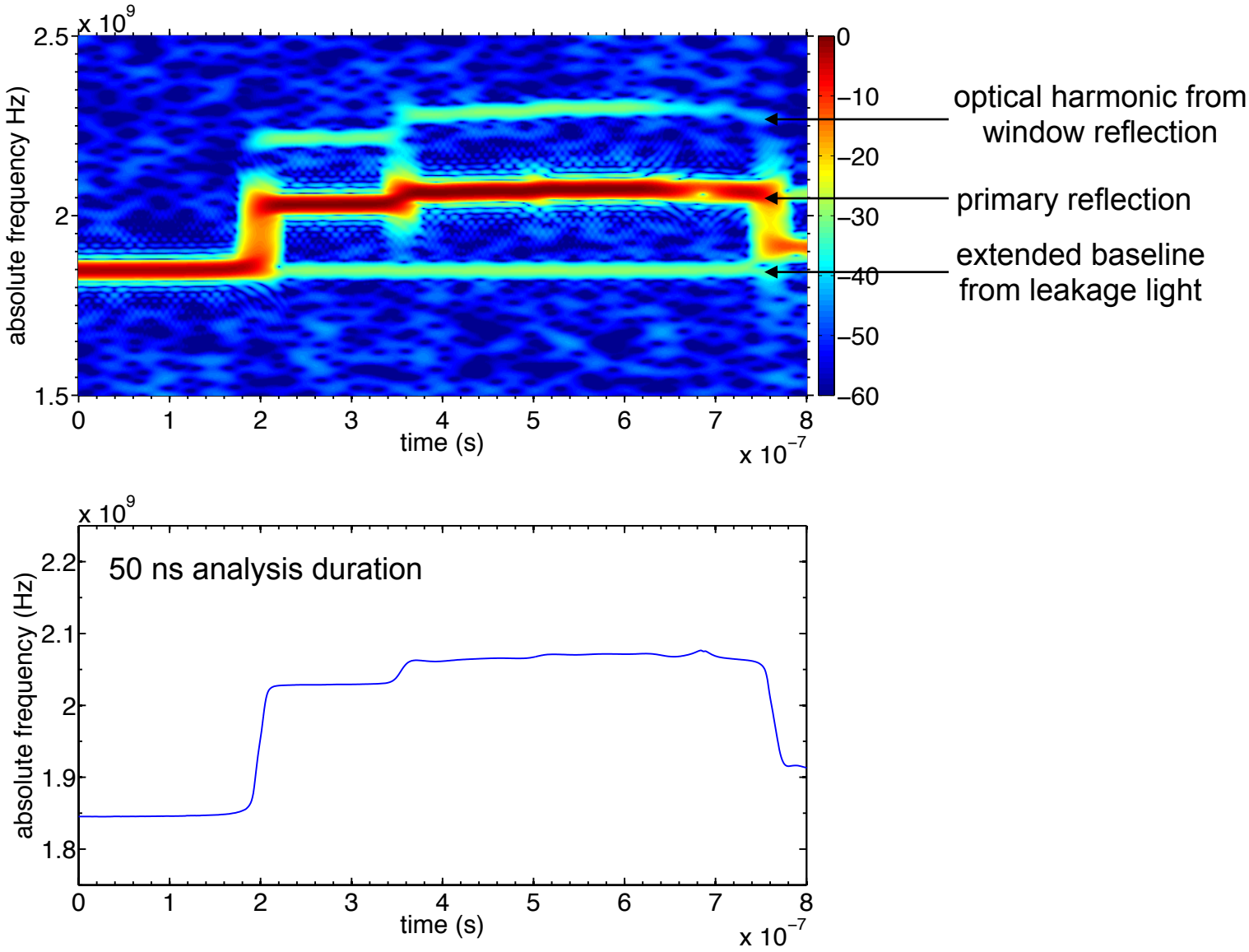


1064 nm PDV static (weak laser issues)

- Reference = -14 dBm; Target = -30 dBm

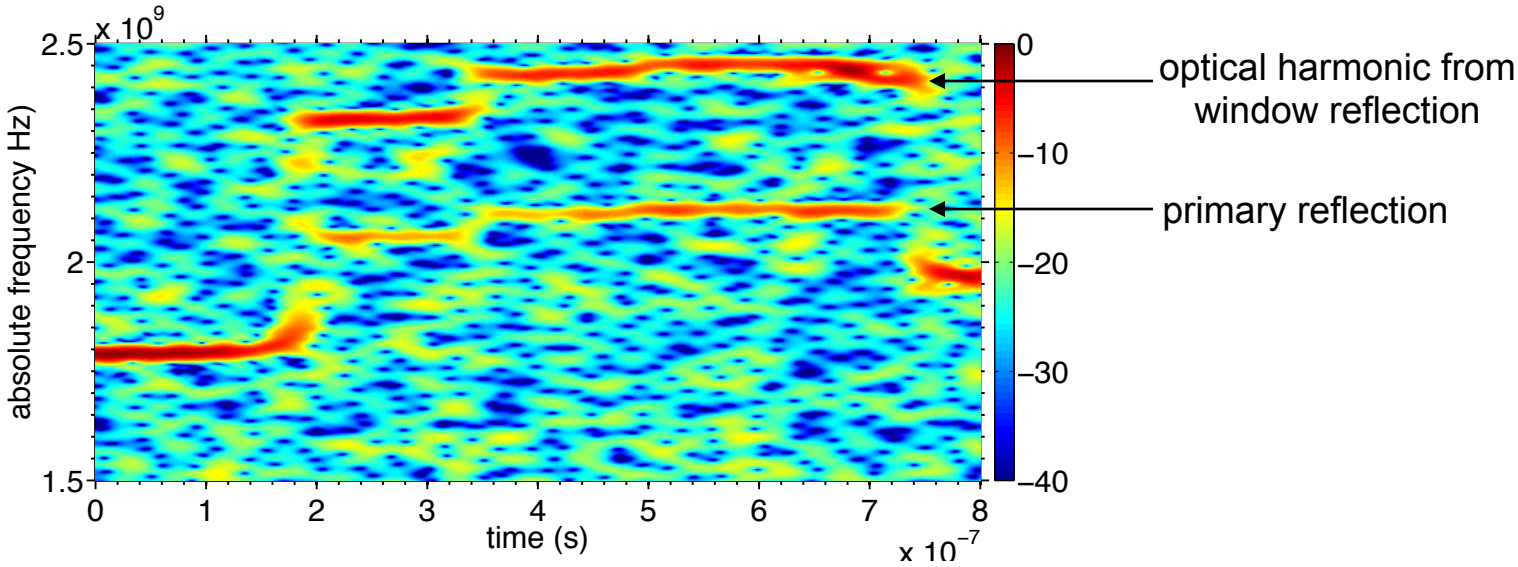


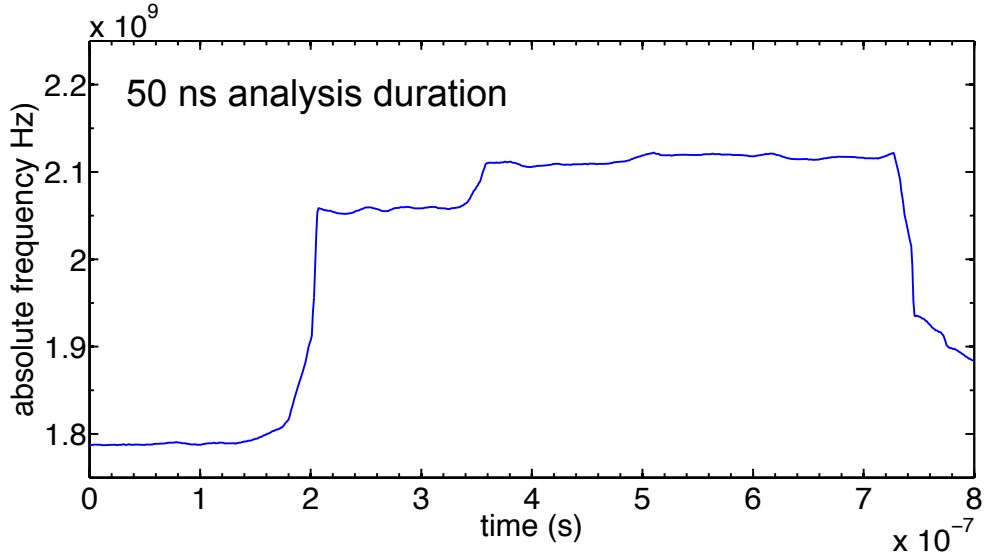
1550 nm PDV absolute frequency



T. Ao and D. H. Dolan, Rev. Sci. Instrum. **82**, 023907 (2011)

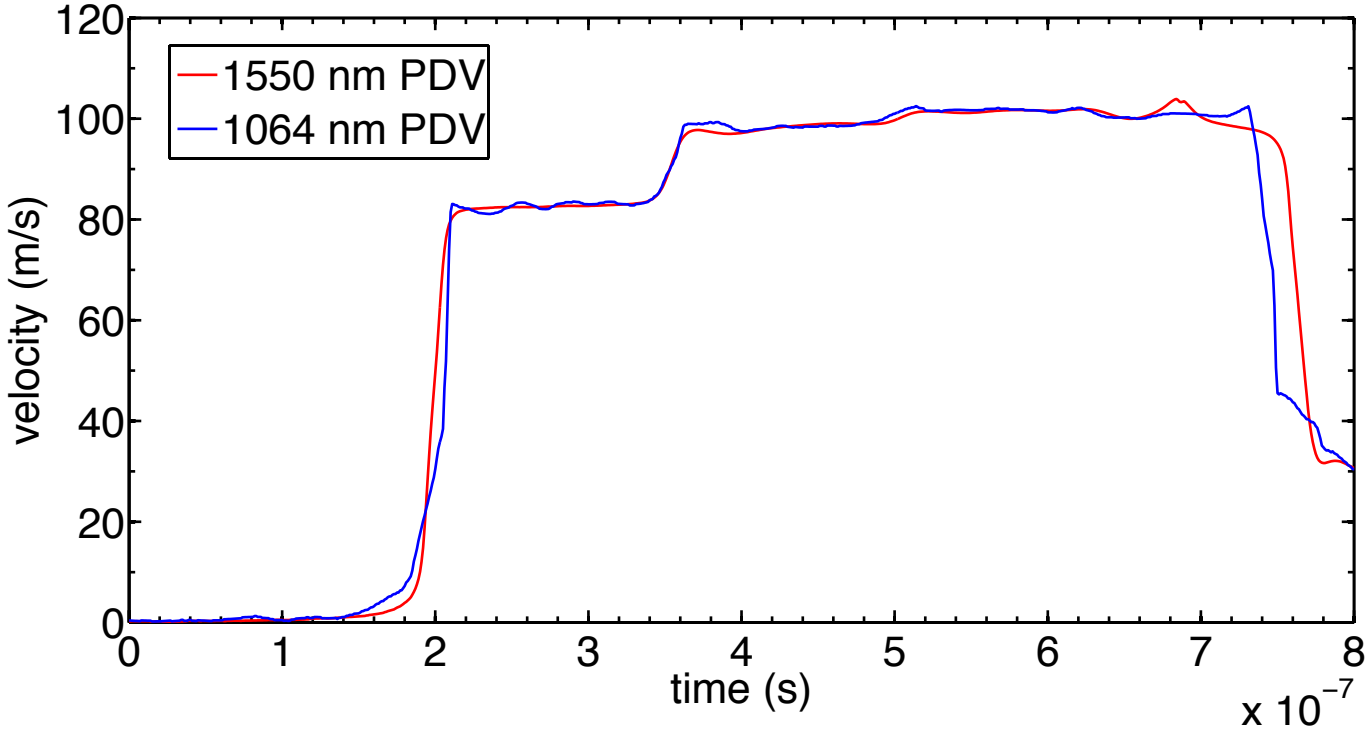
1064 nm PDV absolute frequency





Comparison of velocity histories

- C-cut sapphire index of refraction and window correction
  - 532 nm: $n_0 = 1.772$, $a = 1.785$; D. B. Hayes, *et al.*, J. Appl. Phys, **94**, 2331 (2003)
  - 1064 nm: $n_0 = 1.755$, $a = 1.738$
  - 1550 nm: $n_0 = 1.746$, $a = 1.728$; B. J. Jensen, *et al.*, J. Appl. Phys. **101**, 013523 (2007)



Summary

- A 1064 nm PDV system was designed, implemented and tested on a dynamic compression experiment
  - Extracted velocity history agreed with 1550 nm PDV results
  - Obtained a 1064 nm window correction for sapphire

- Compared to 1550 nm hardware, 1064 nm hardware:
  - Lasers slightly less stable
  - Fiber components slightly more lossy
  - Parts are less available and/or more expensive

- Need to fix 1064 nm laser
  - Repeat experiment to get better 1064/1550 PDV comparison