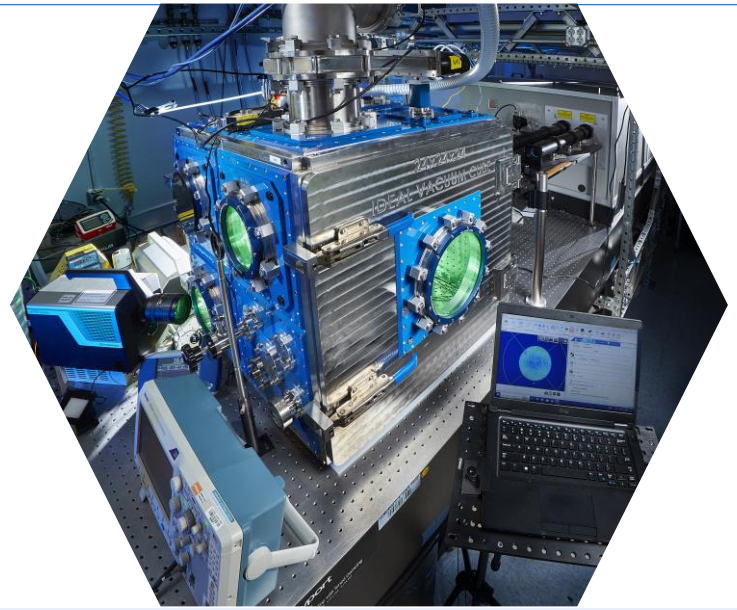
Testing temporal resolution of ultrafast FBG:
Prompt impulse measurements at LIGHT facility

PDV workshop

May 19-20th, 2026



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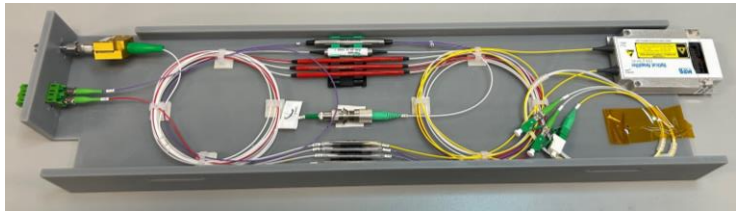
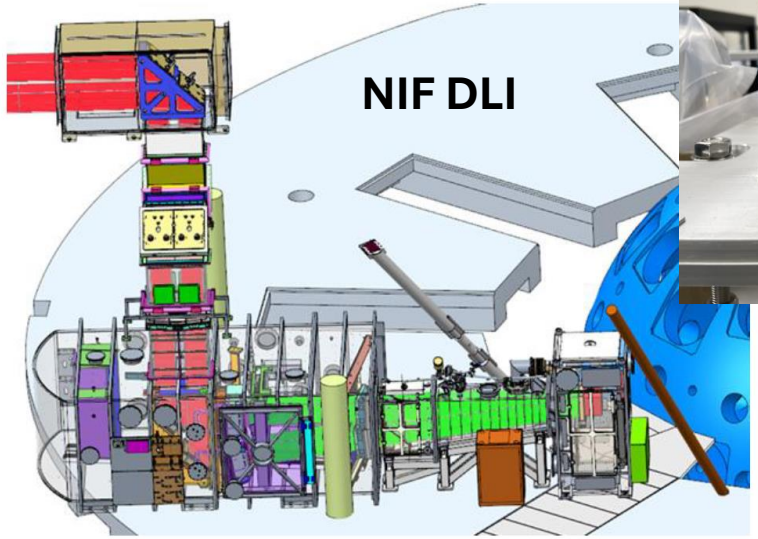
Prepared by LLNL under Contract DE-AC52-07NA27344.

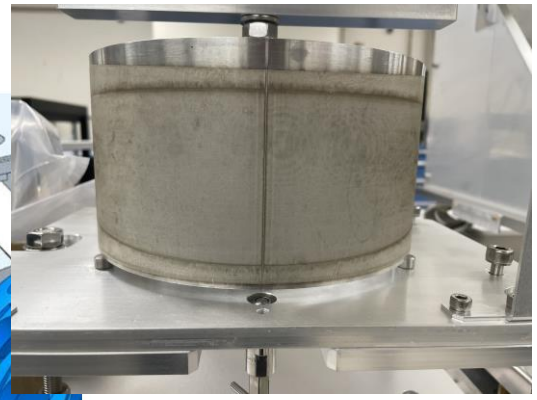
LLNL survivability system



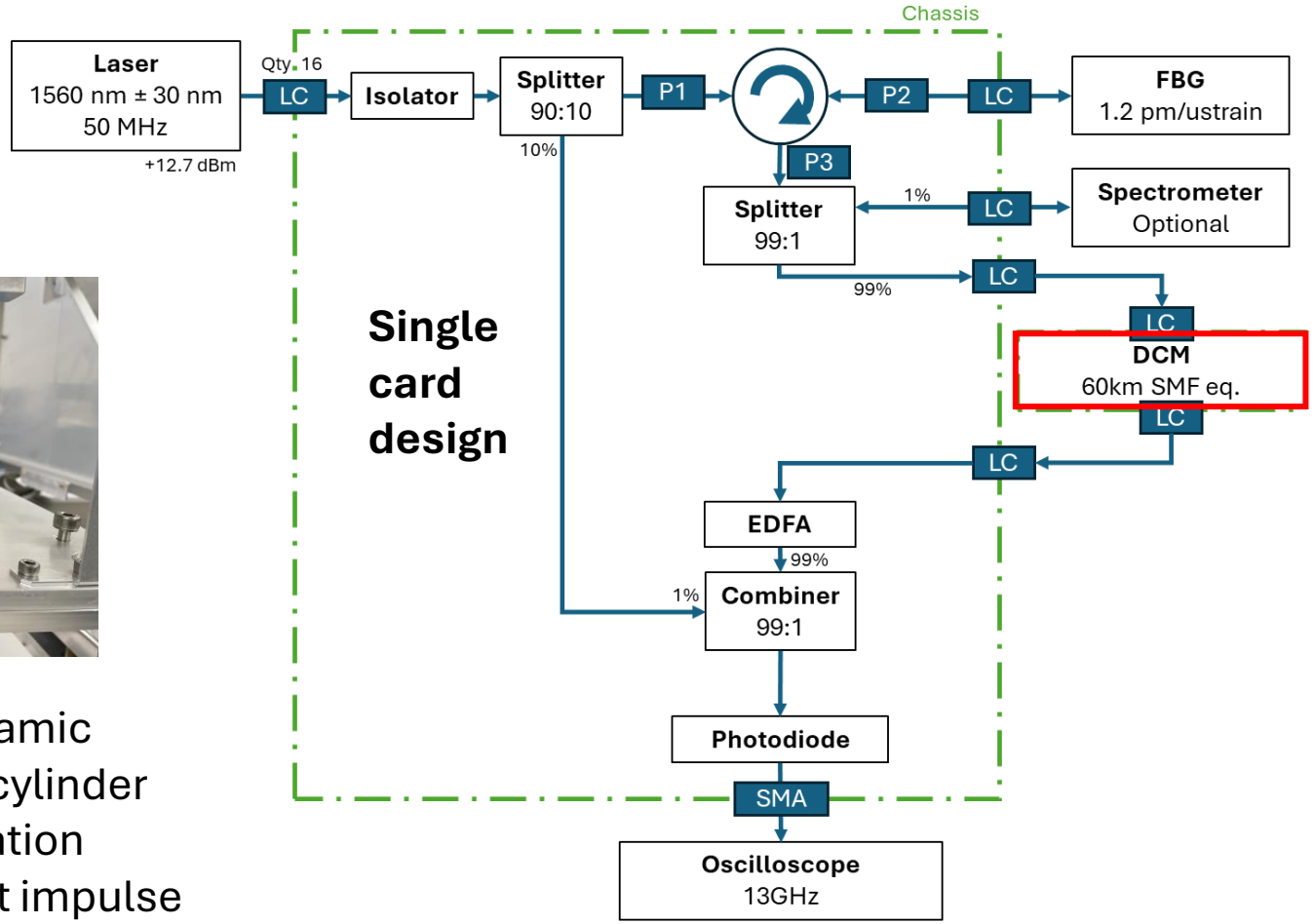
Needs

- Structural response of large objects
- 16 channels, 3 FBGs per channel
- Reaching up to 10,000 u-strains
- Readouts of up to 10ms





Example: Dynamic response of a cylinder after laser ablation launched short impulse



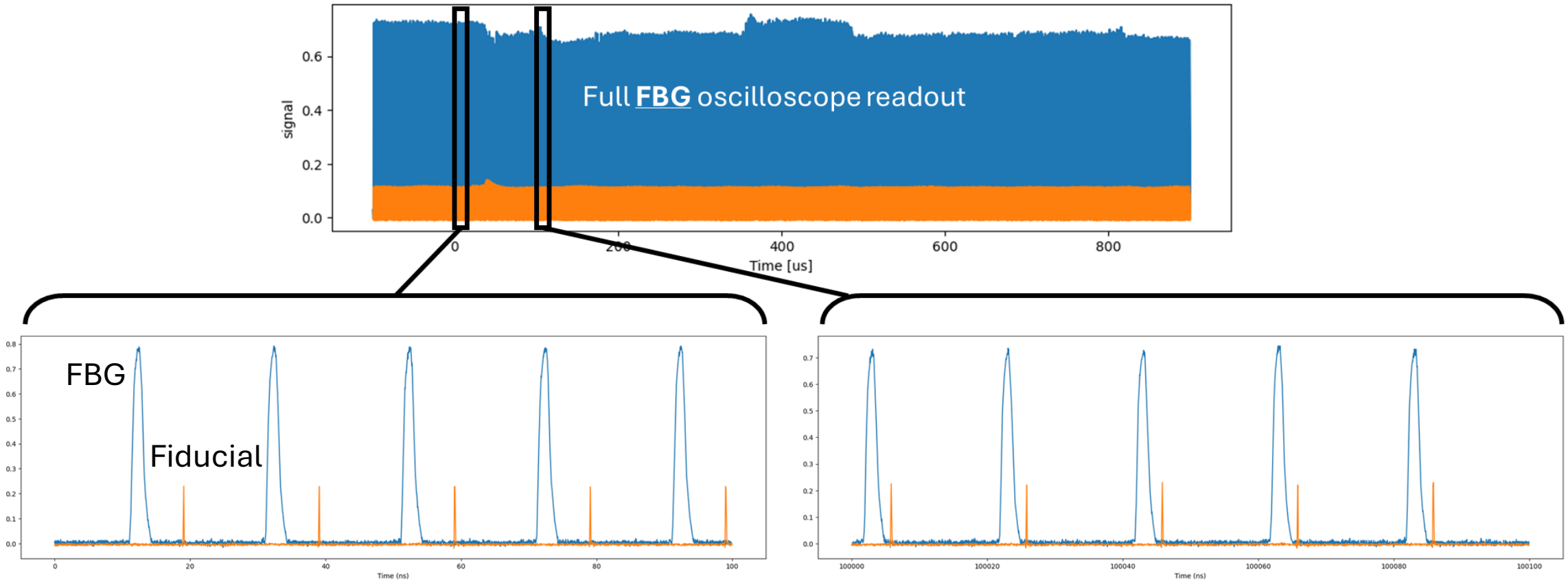
Principle

$$\text{Time shift} * \left(\frac{\text{nm}}{1024\ \text{ps}}\right)\left(\frac{\mu\text{strain}}{1.2\ \text{pm}}\right) = \text{Strain}$$

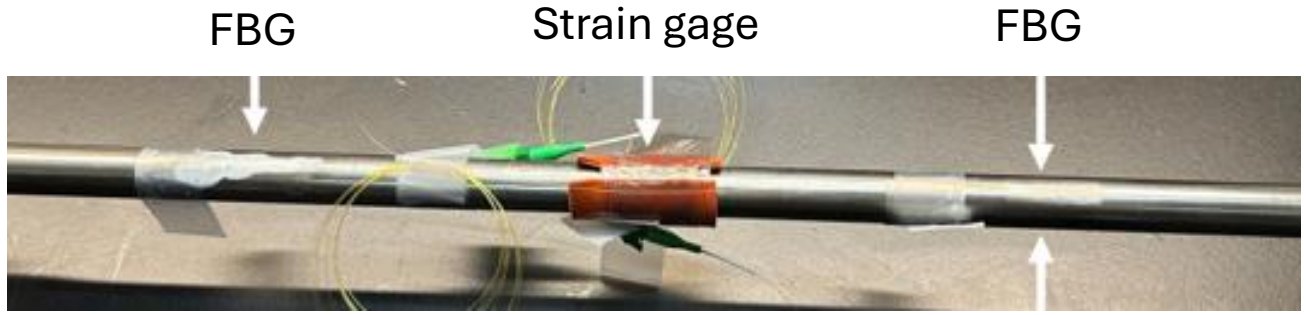
Dispersion fiber spec

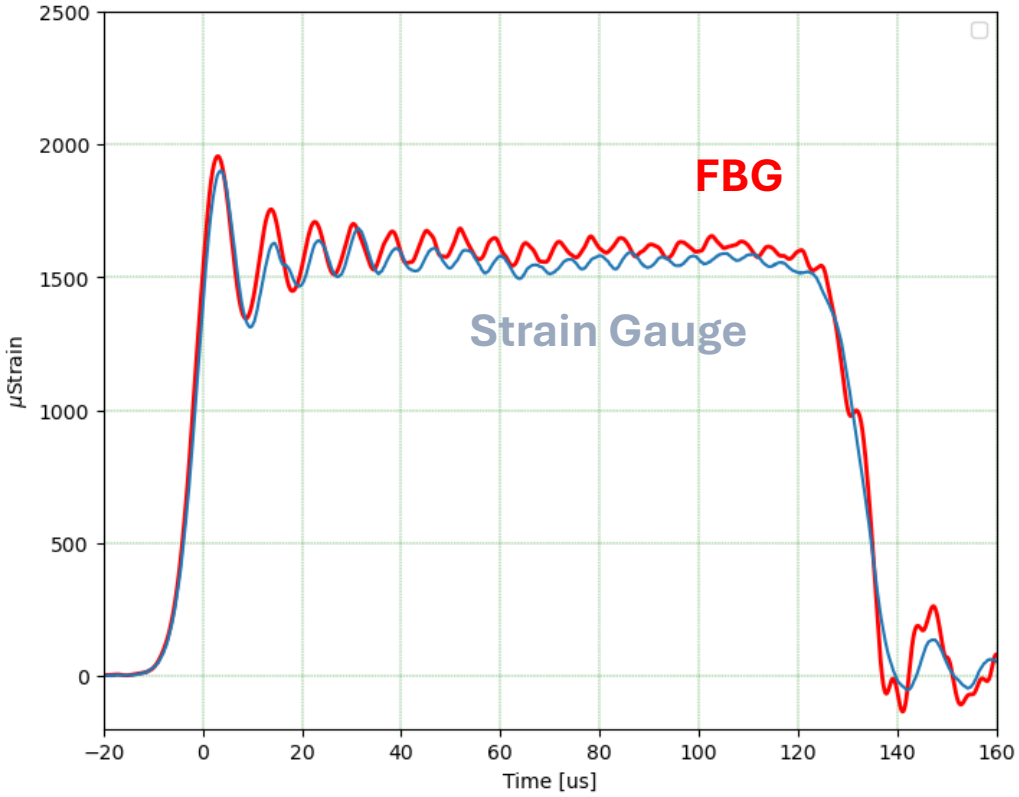
FBG spec

Before After



Commissioning using Kolsky bar

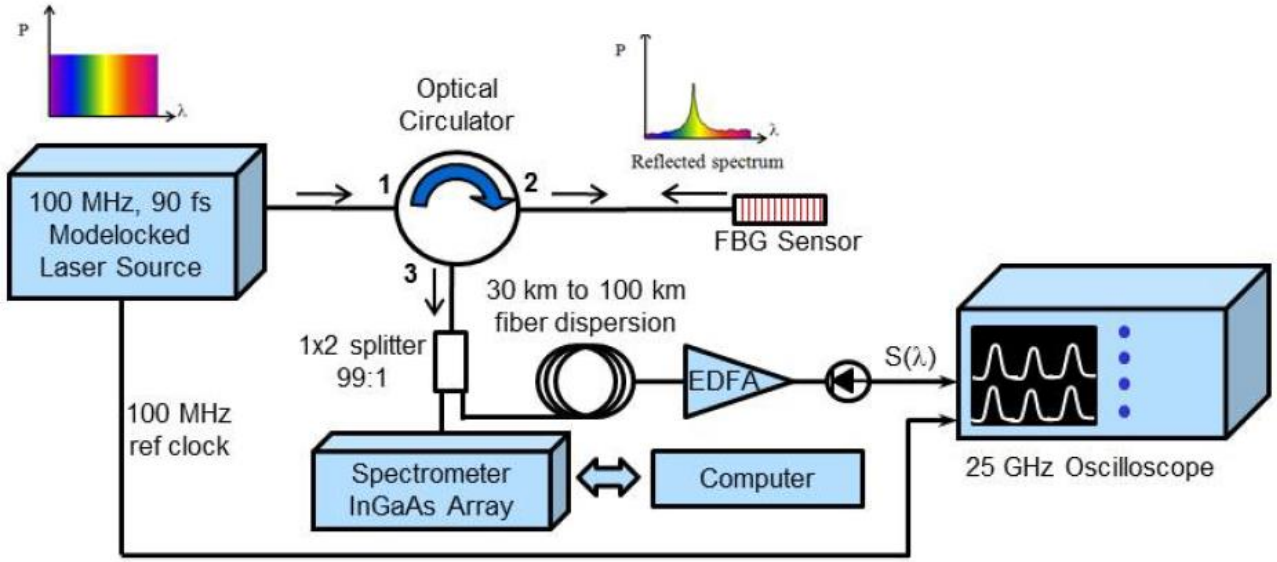




- Good agreement between FBG and SG
  - Peak rise time 10-90%: t_r ~ 10 us
  - Bandwidth: 0.35/t_r **~ 35 kHz**
  - Ringing feature: **~ 100-200 kHz**
- System intrinsic limitations
  - Laser pulses every 20ns: **50 MHz**
  - Wave propagation along FBG: 2mm/5mm/us = 0.4us: **2.5 MHz**
  - FBG mounting details

Historic context

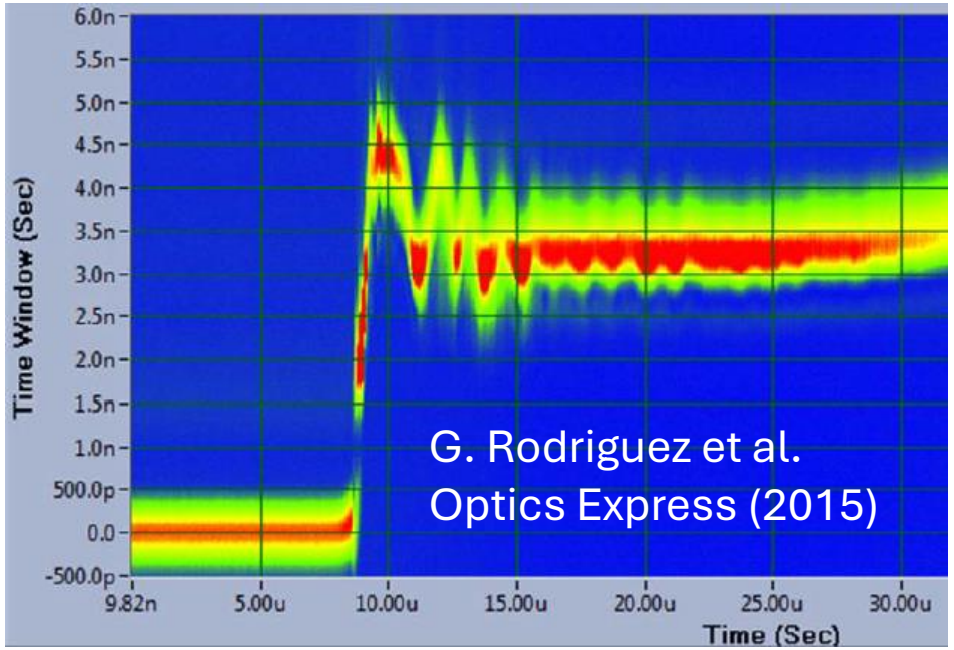
Ultrafast photonic systems for FBG sensing developed at LLNL more than a decade ago



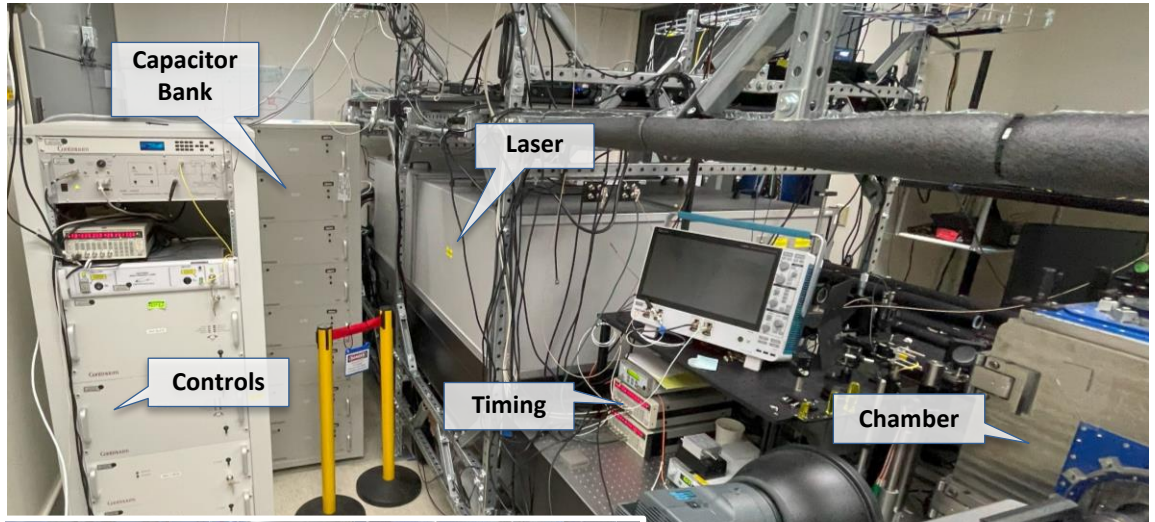
"Capable to interrogate dynamic events occurring at a microsecond time scale with nanosecond level time resolution"

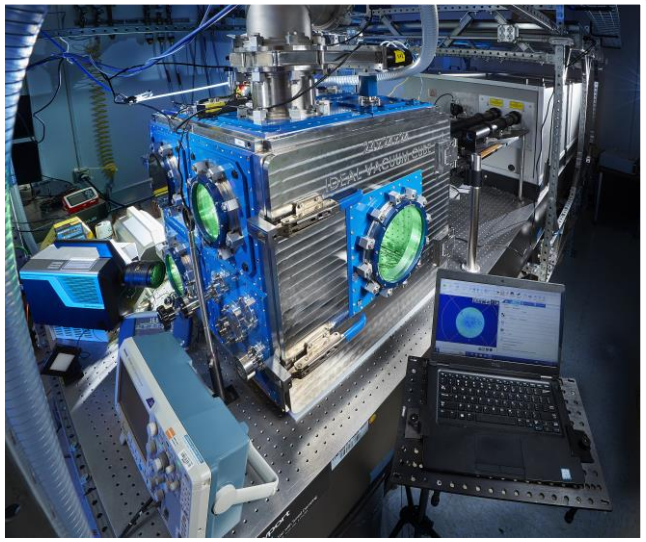
Examples

- Pressure measurements in thermal ignition of high explosives detonation
- Pressure wave tracking in weak inert shocks
- Strain measurements during magnetic field driven magnetostriction effects

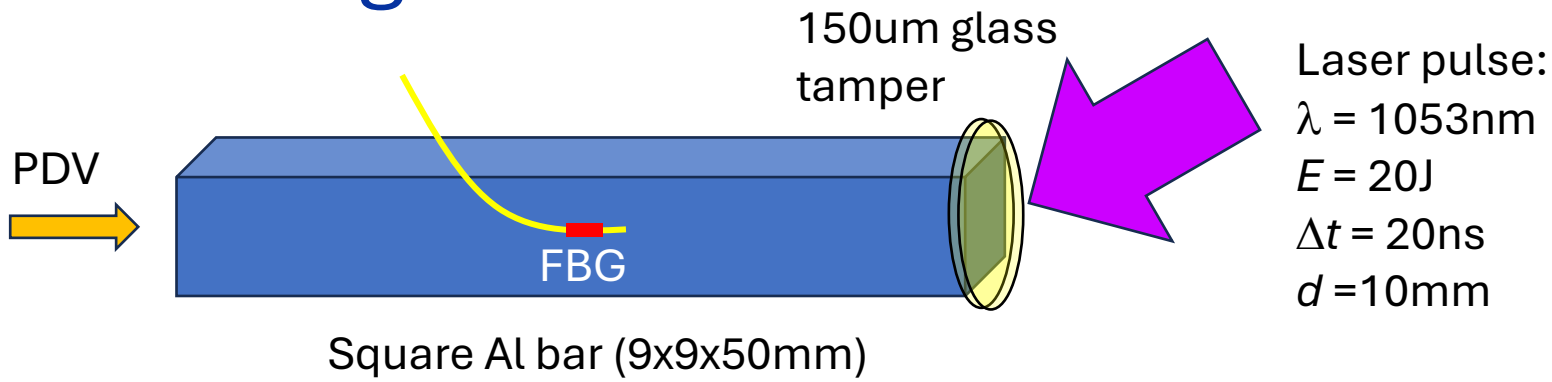


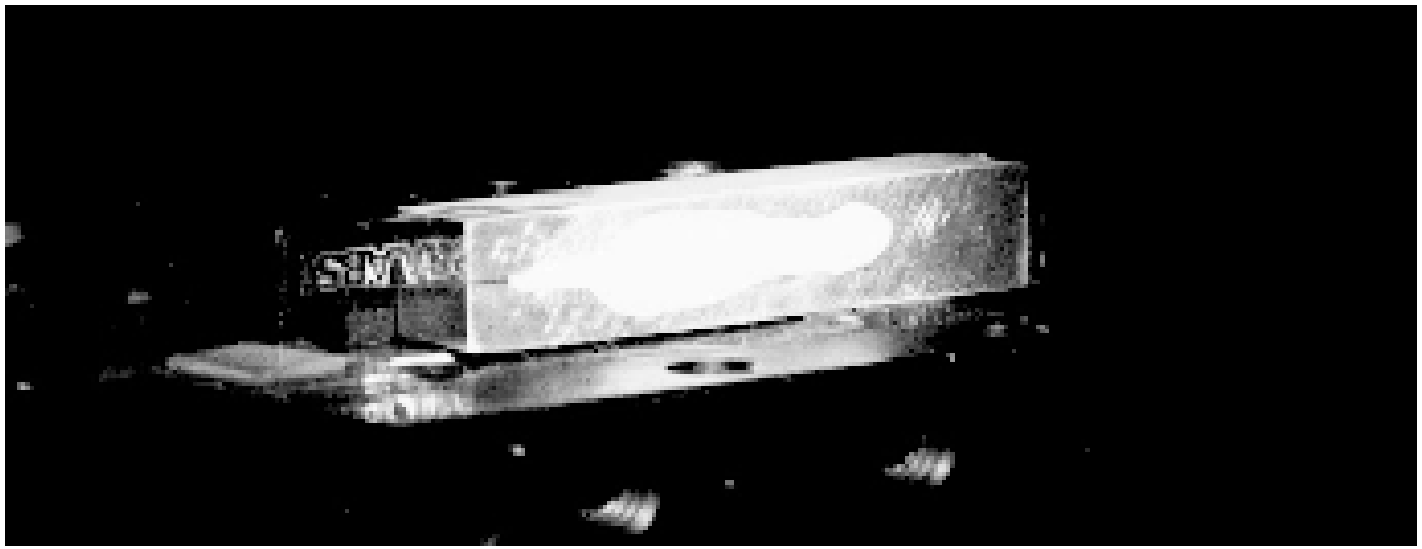
Testing at LIGHT facility





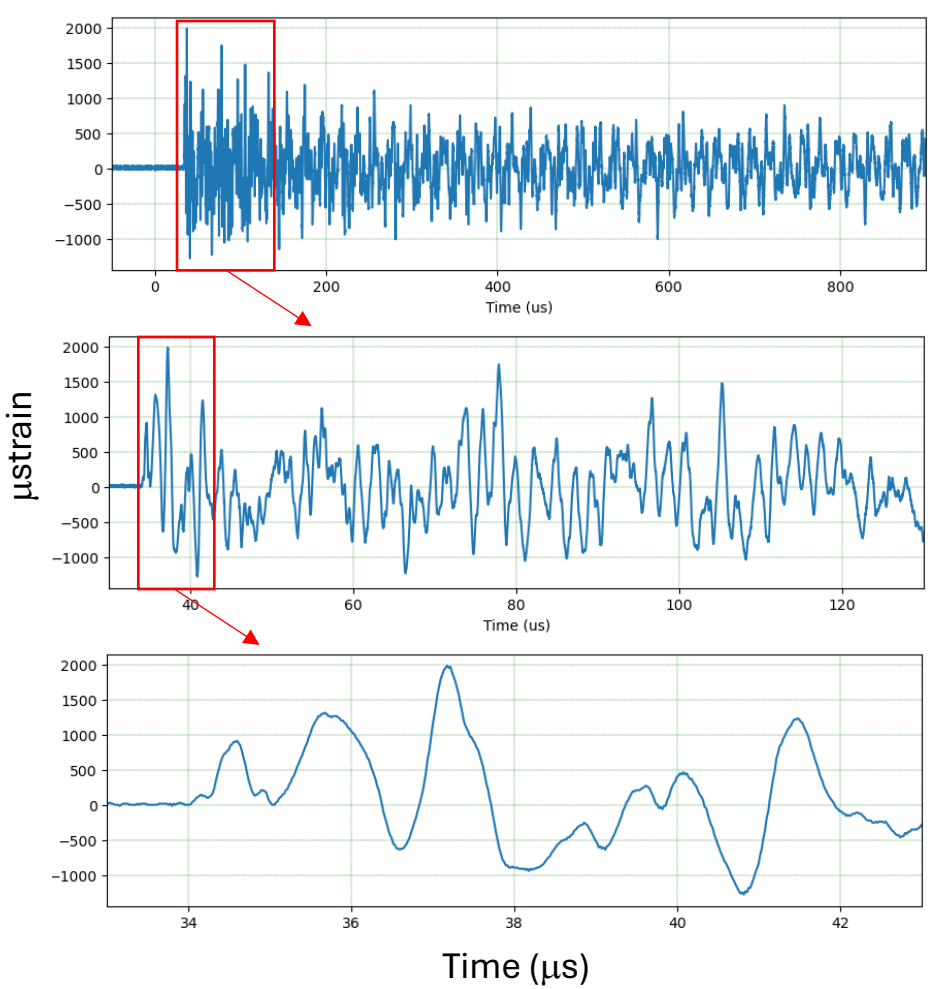
Experiment design



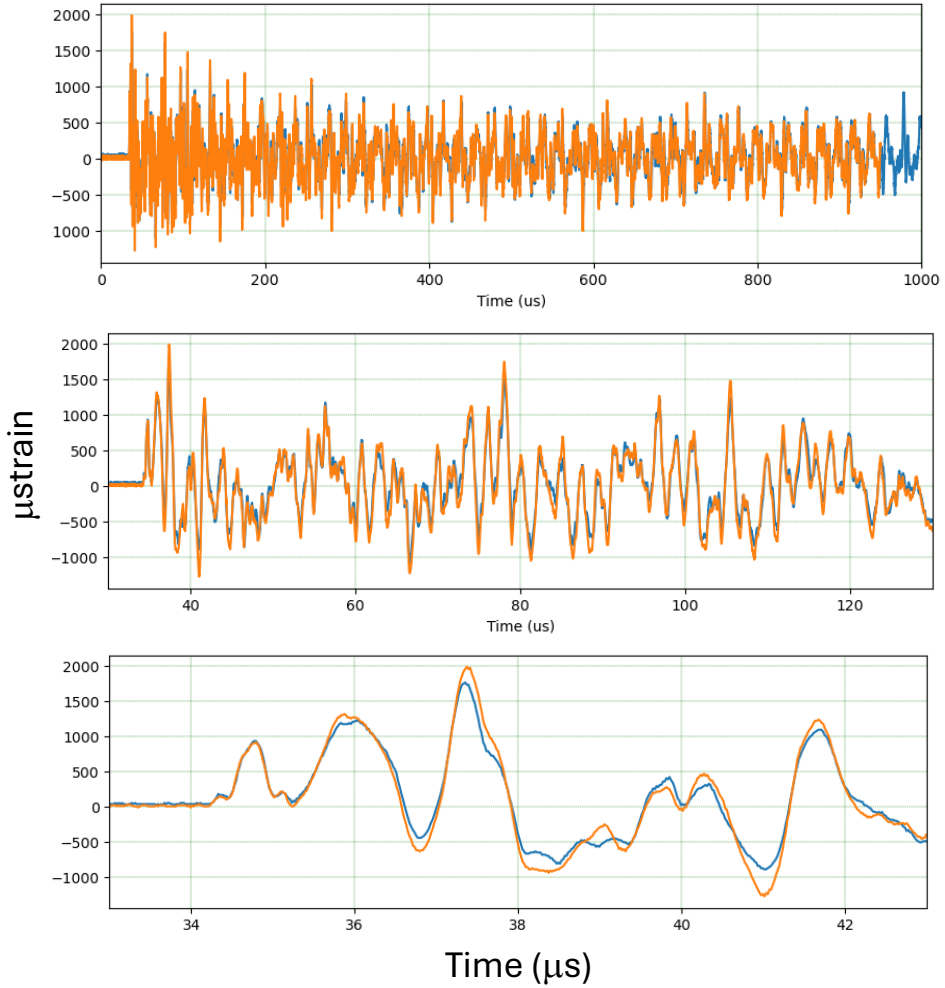


FBG results and reproducibility

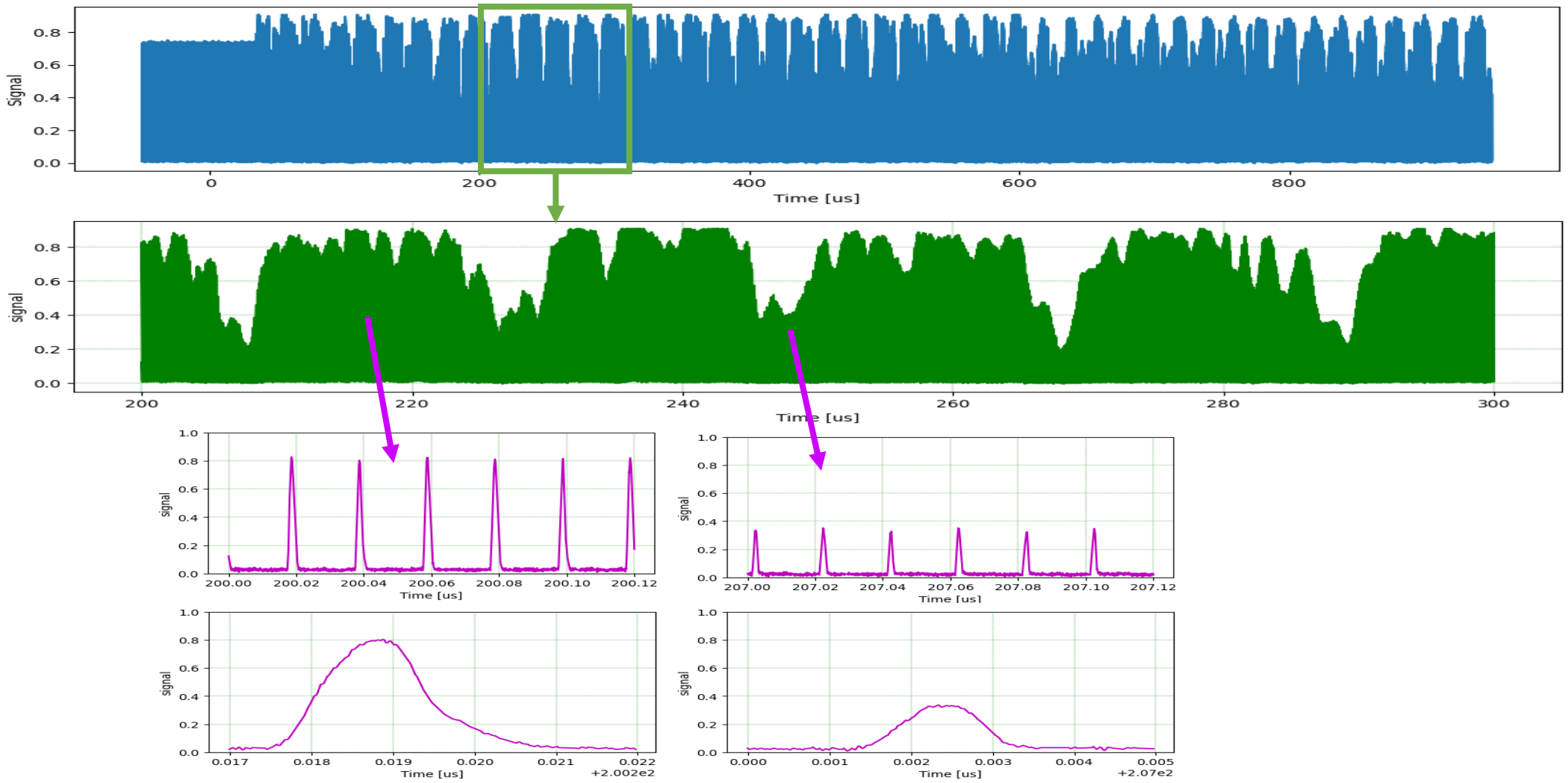
Shot 1



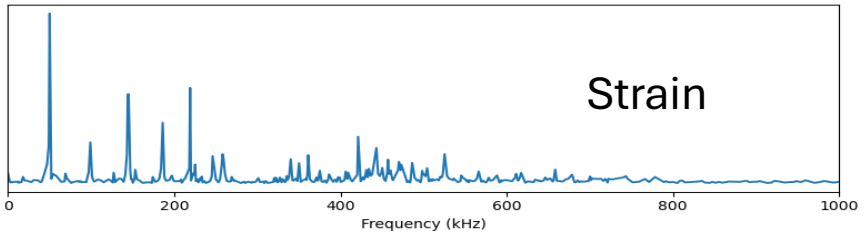
Shot 2

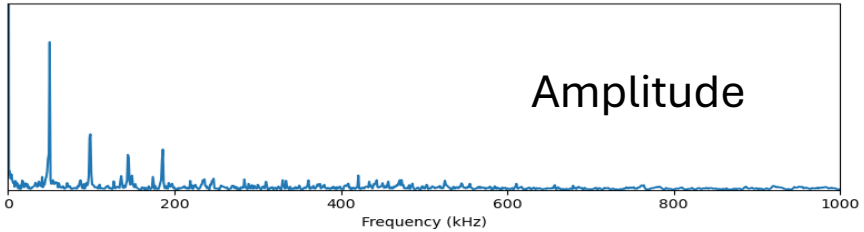


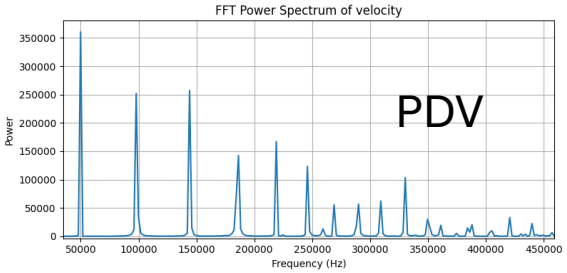
Signal amplitude variations

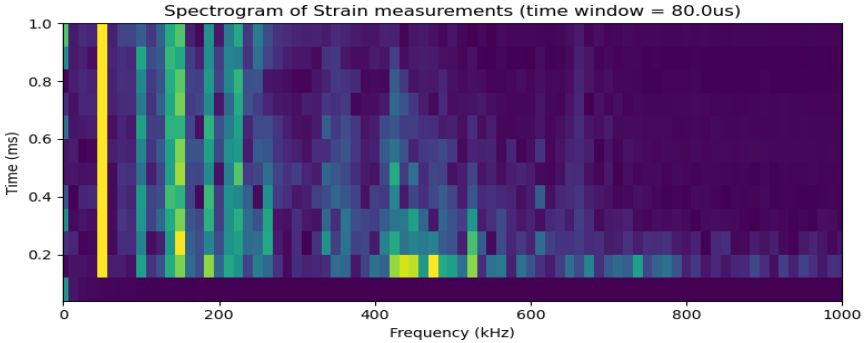


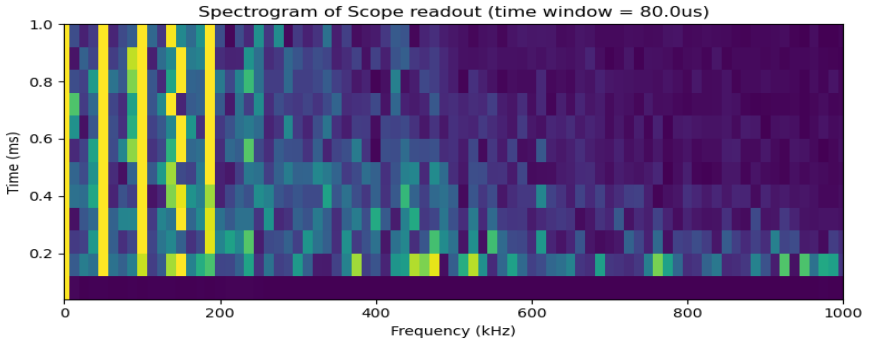
FFT and spectrograms

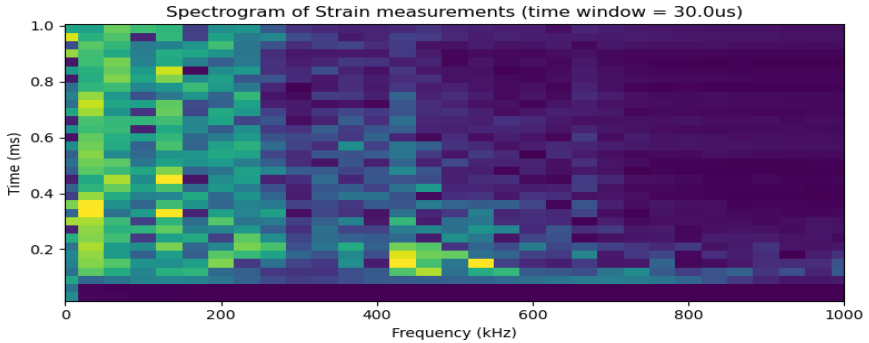


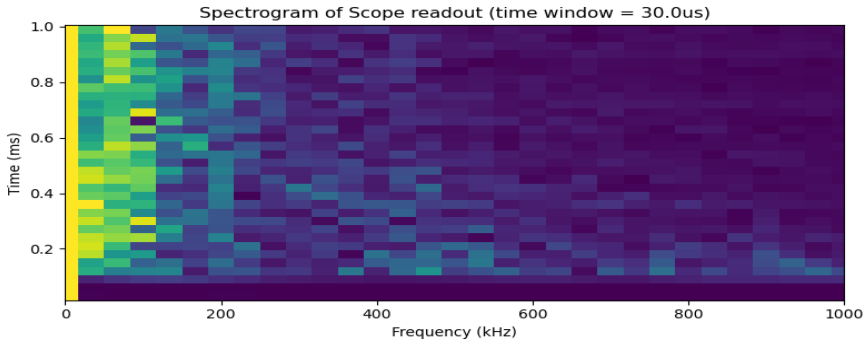










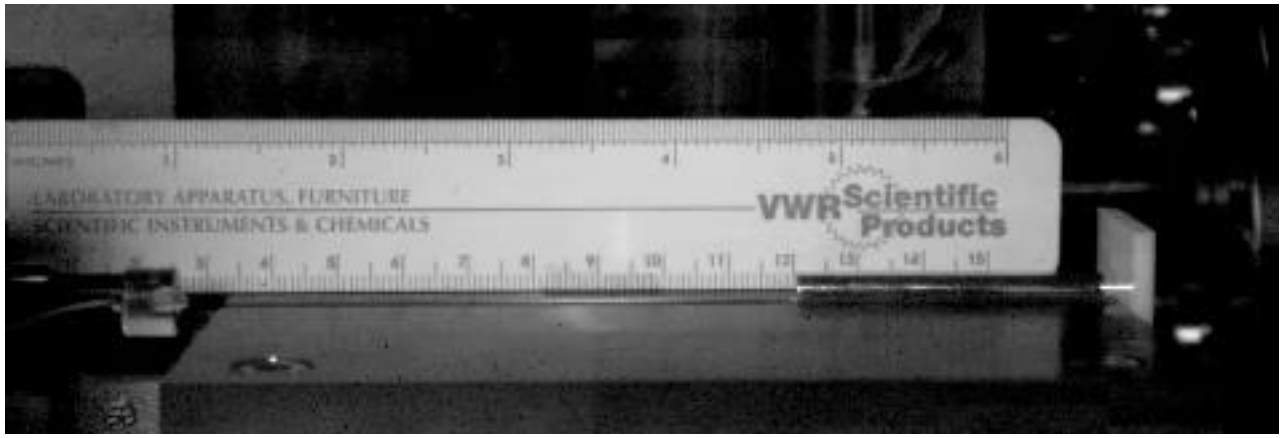


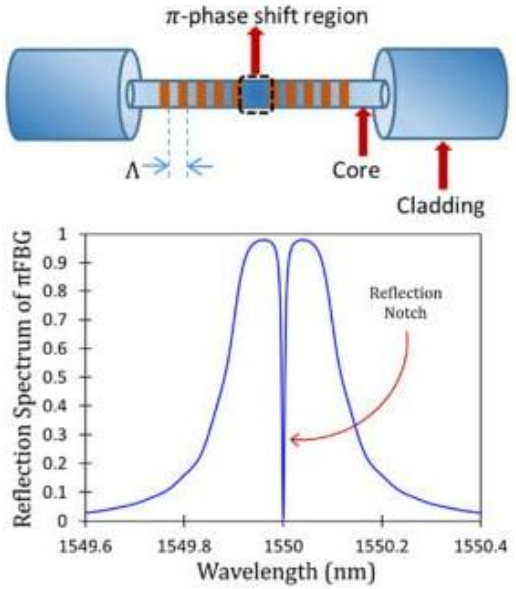
Future developments

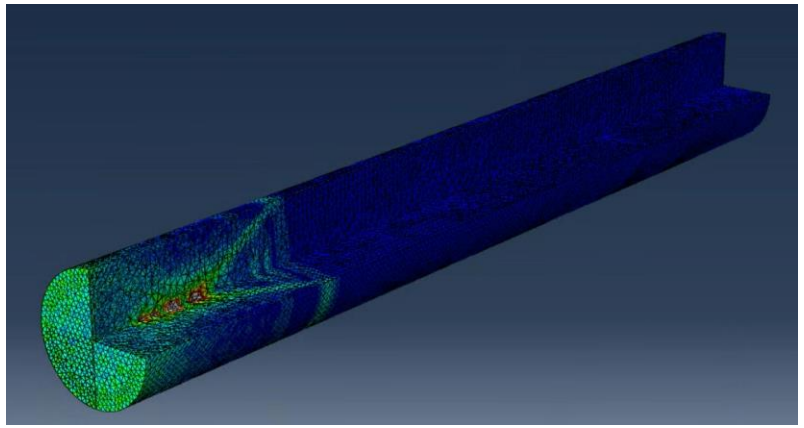
Testing improvements
- Frictionless motion
- Cylindrical bar shape
- Teflon tampers
- Lateral PDV measurements

FBG design
- Different length
- Glue thickness
- Imbedded probes
- Plastic body

Simulations
- Rad-Hydro codes
- Thermo-Structural codes







Summary

- FBG were commissioned using Kolsky-bar
- Fast (~100ns, 10MHz) changes detected LIGHT impulse experiments
- FBG amplitude had frequency content similar to strains