Advances in laboratory modeling of wave propagation

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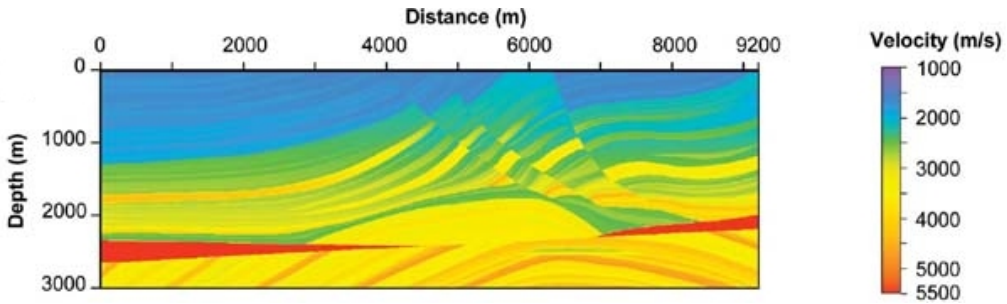
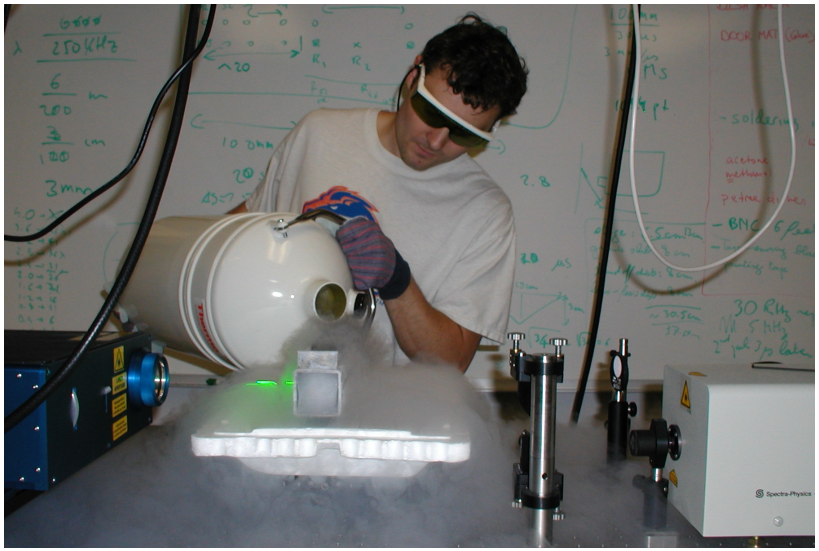
Outline

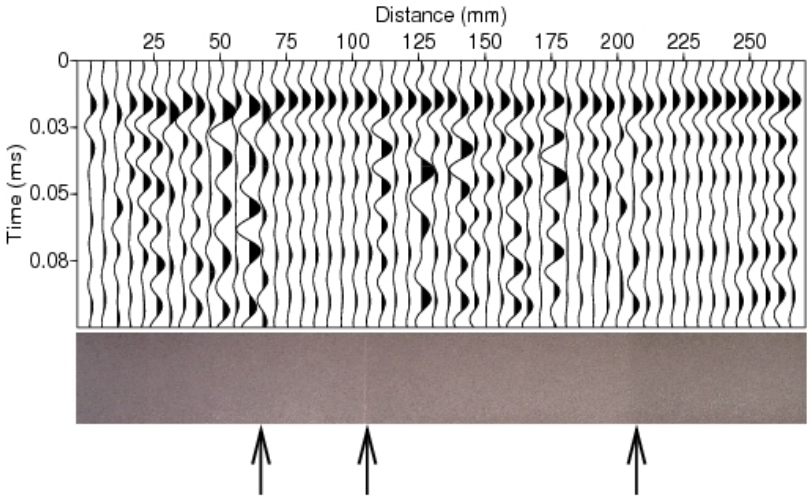
Ultrasonic laboratory modeling

- Bridge between full-size experiments and numerical modeling
- Controlled environment
- Scaled models of challenging seismic exploration settings



Laser ultrasonics: experimental setup

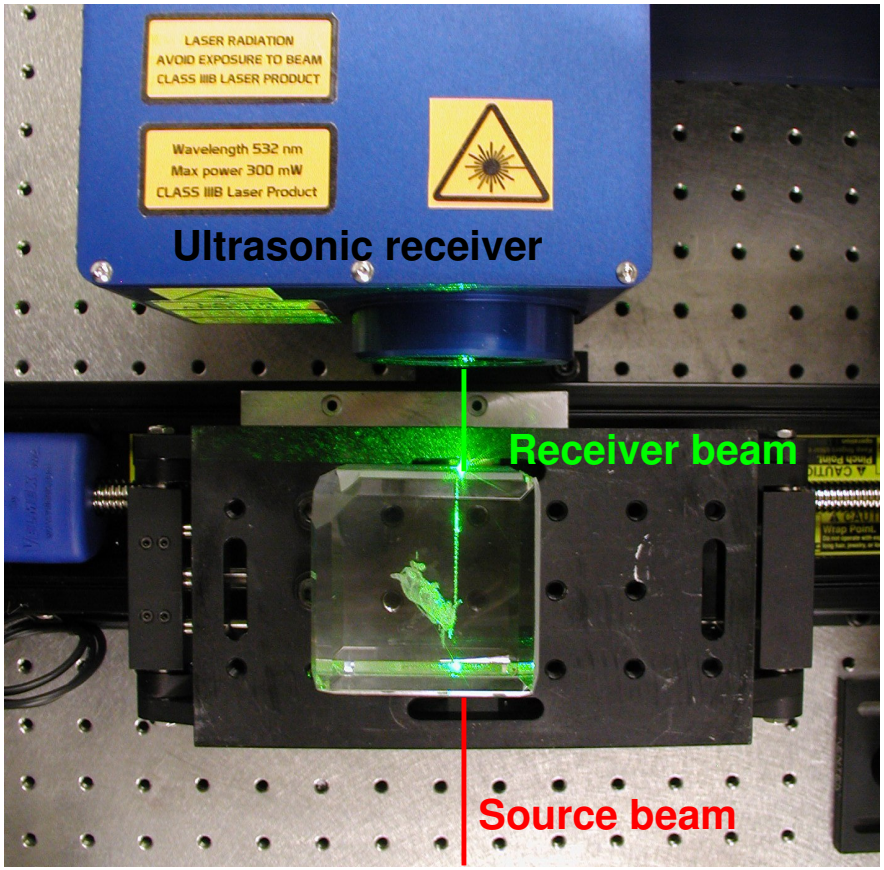




Laser ultrasonics: non-contacting technique

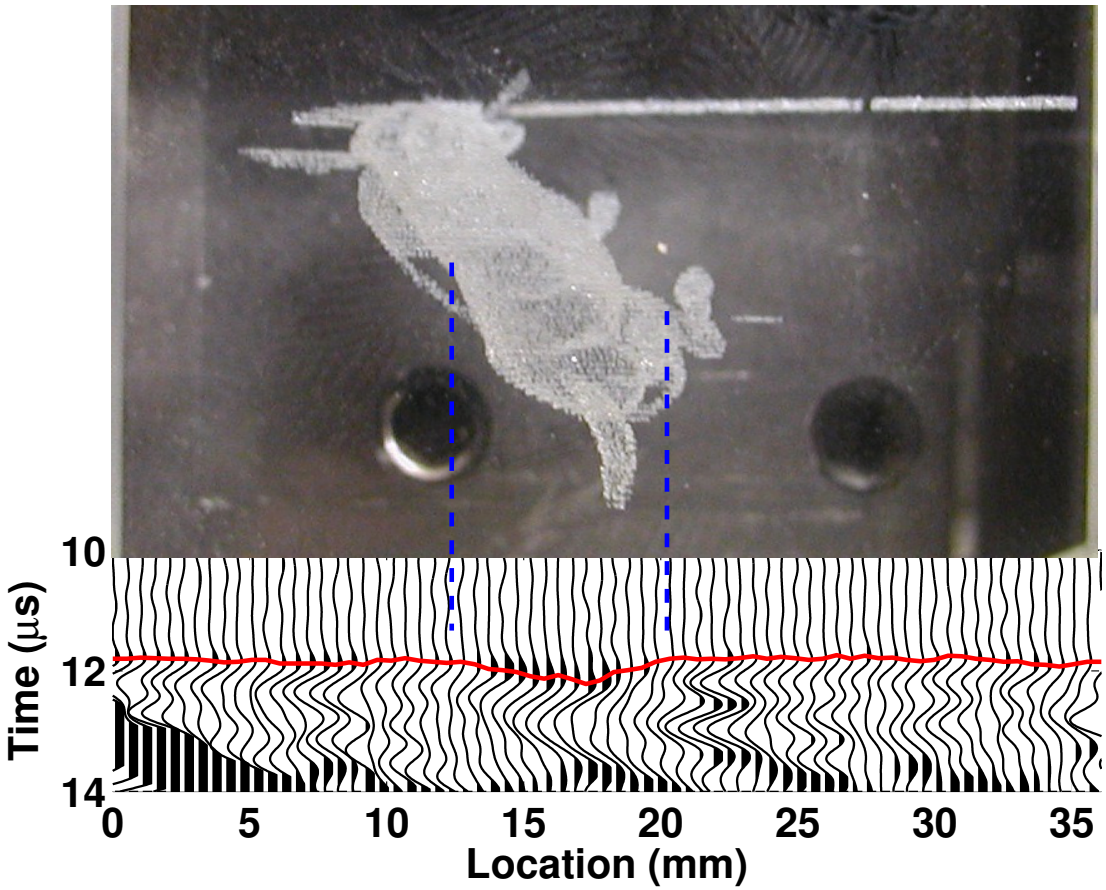
- Fast and automatic 3D acquisition
- No coupling issues
- No interaction with the wave-field and sub-wavelength size: similar to geophones in a seismic survey
- No moving parts in the receiver

Scaled modeling

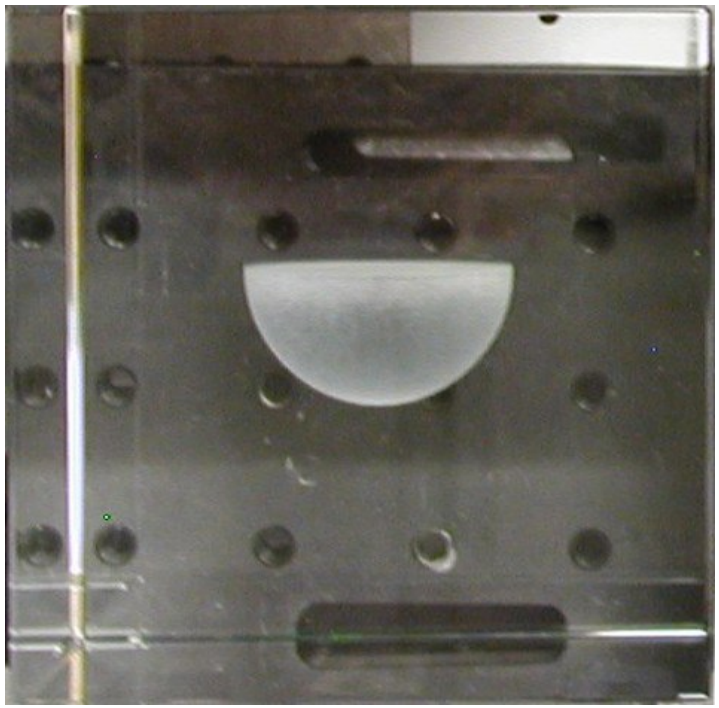


- 62x62x62 mm glass cube
- Engraved bubbles: shape of a mule
- Glass is transparent: reflective tape

Transmission results: $\sim 3\%$ delay in travel-time

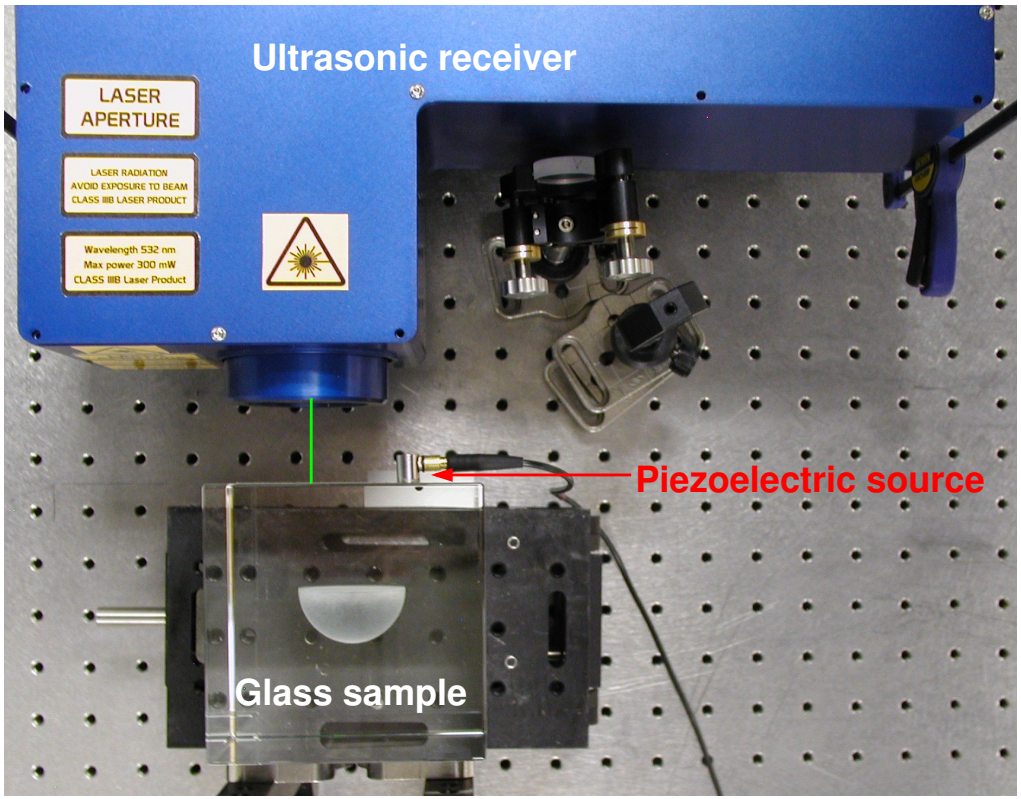


Dome model



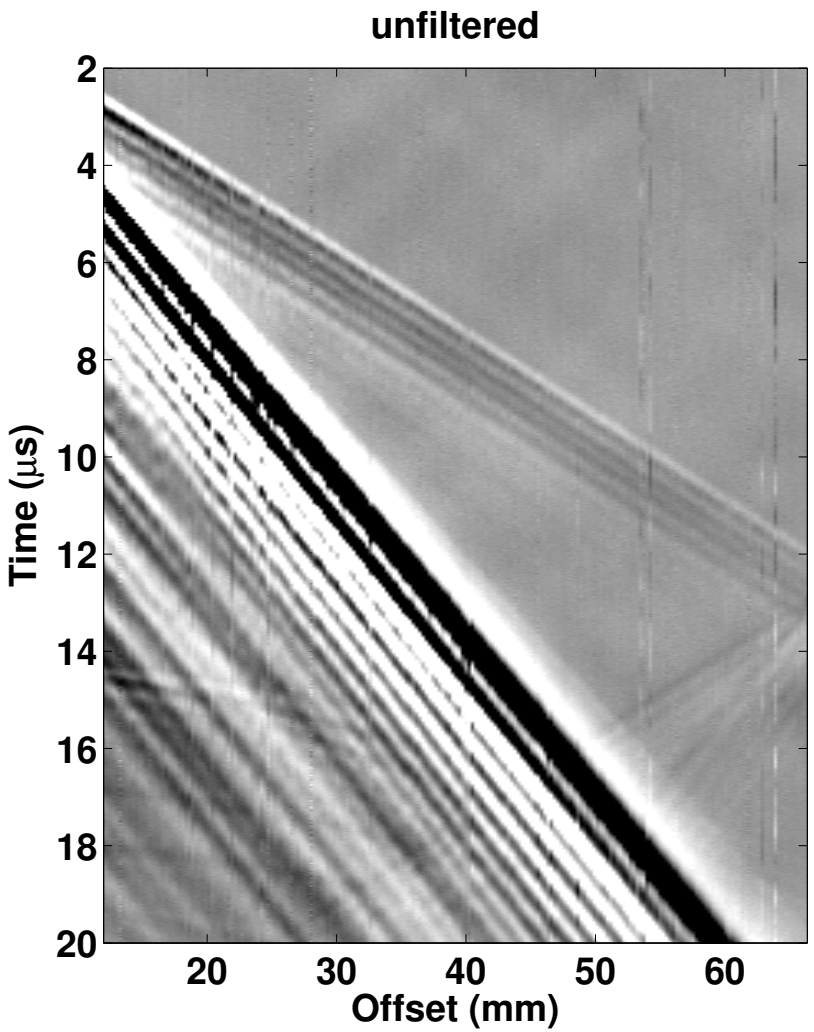
- 100x100x100 mm glass cube
- Half-dome in bubbles (hollow)

P-wave reflection setup

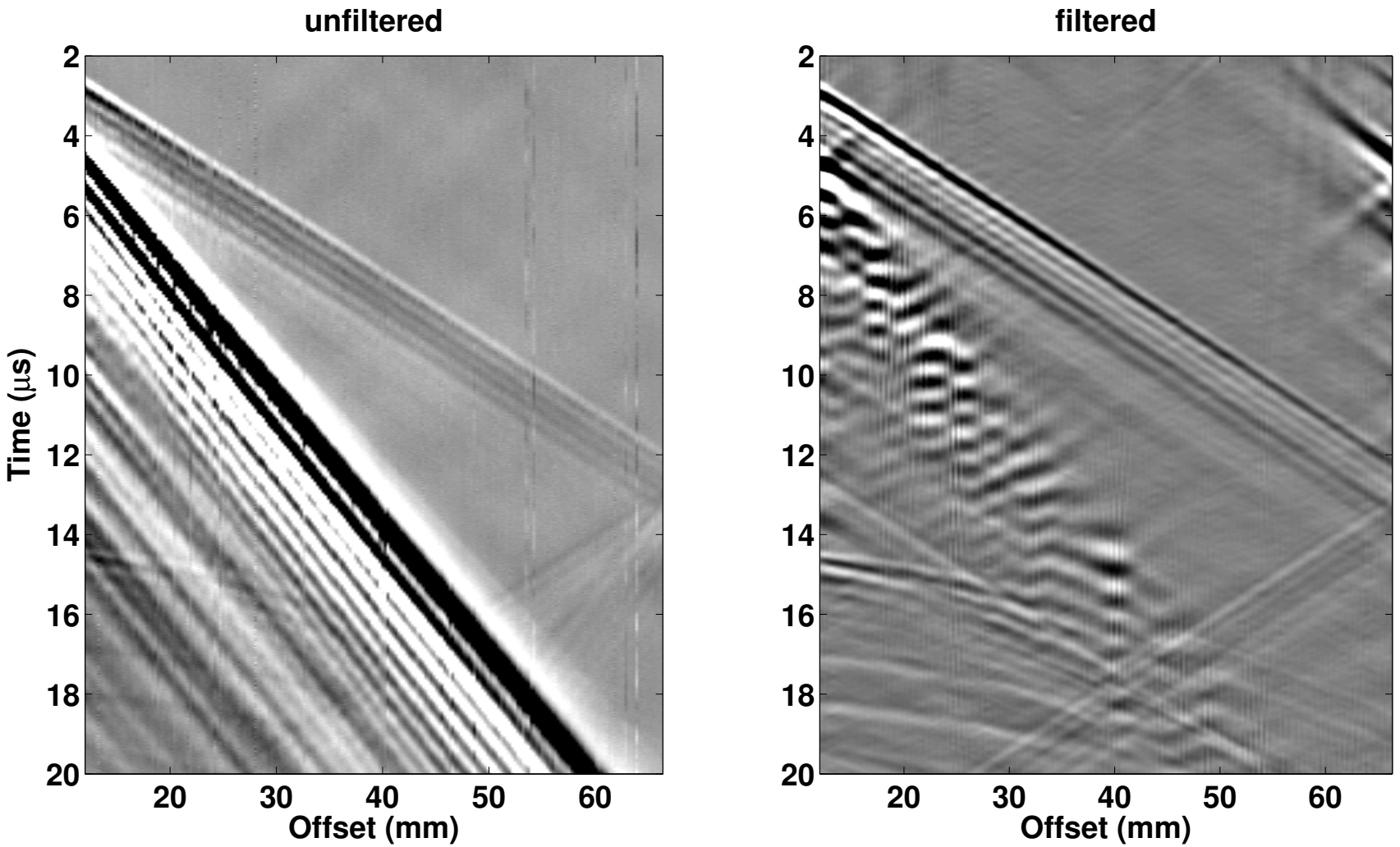


- 5 MHz piezoelectric source
- 215 traces
- 11 traces/λ

Reflection results: 215 traces, 60 mm



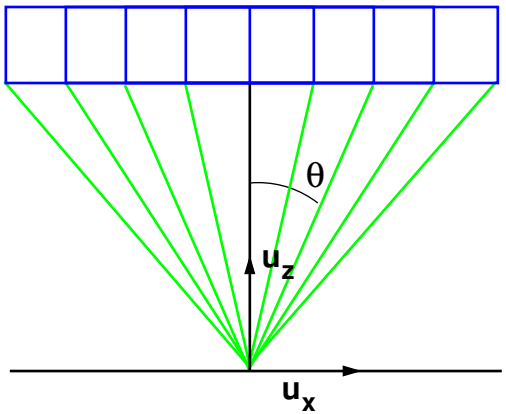
Reflection results: 215 traces, 60 mm

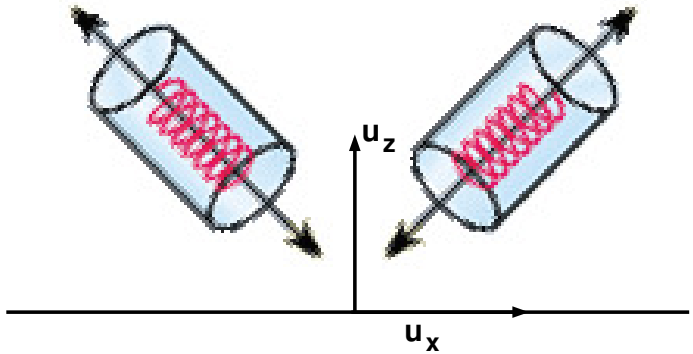


Multicomponent detection

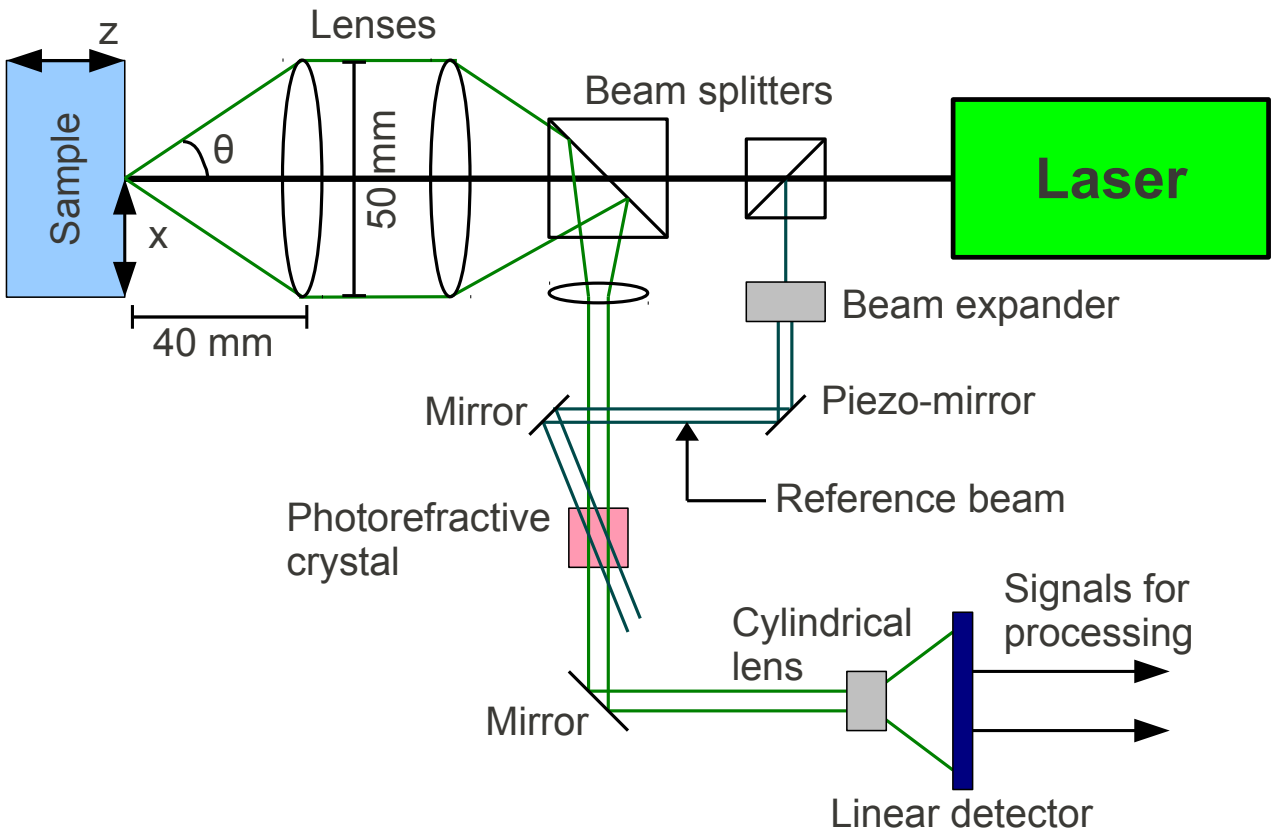
Description

- Prototype of a multi-component laser interferometer, based on an existing vertical displacement receiver
- Uses the roughness of the material surface to collect light scattered away from the angle of incidence: carries horizontal information
- 10 kHz – 10 MHz bandwidth



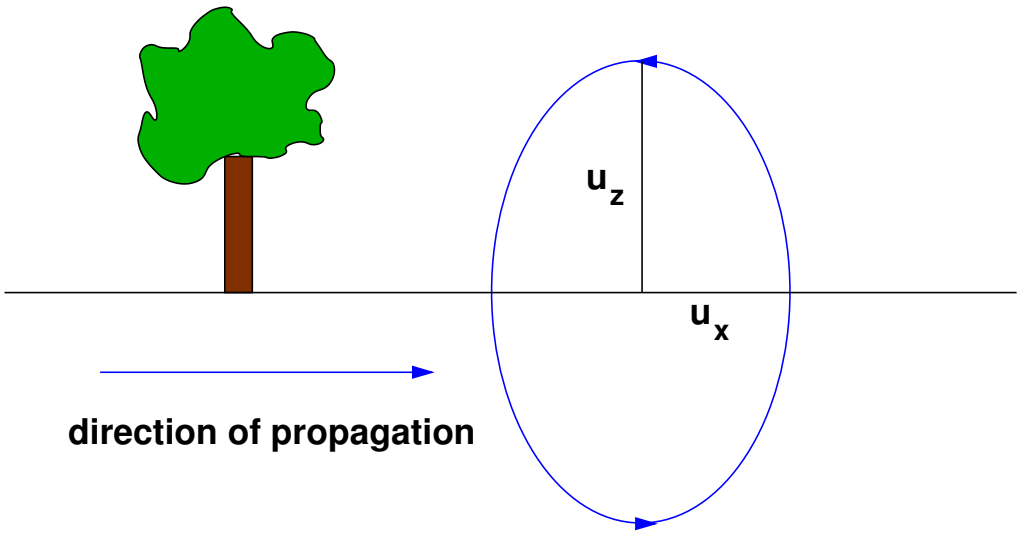


Optical setup

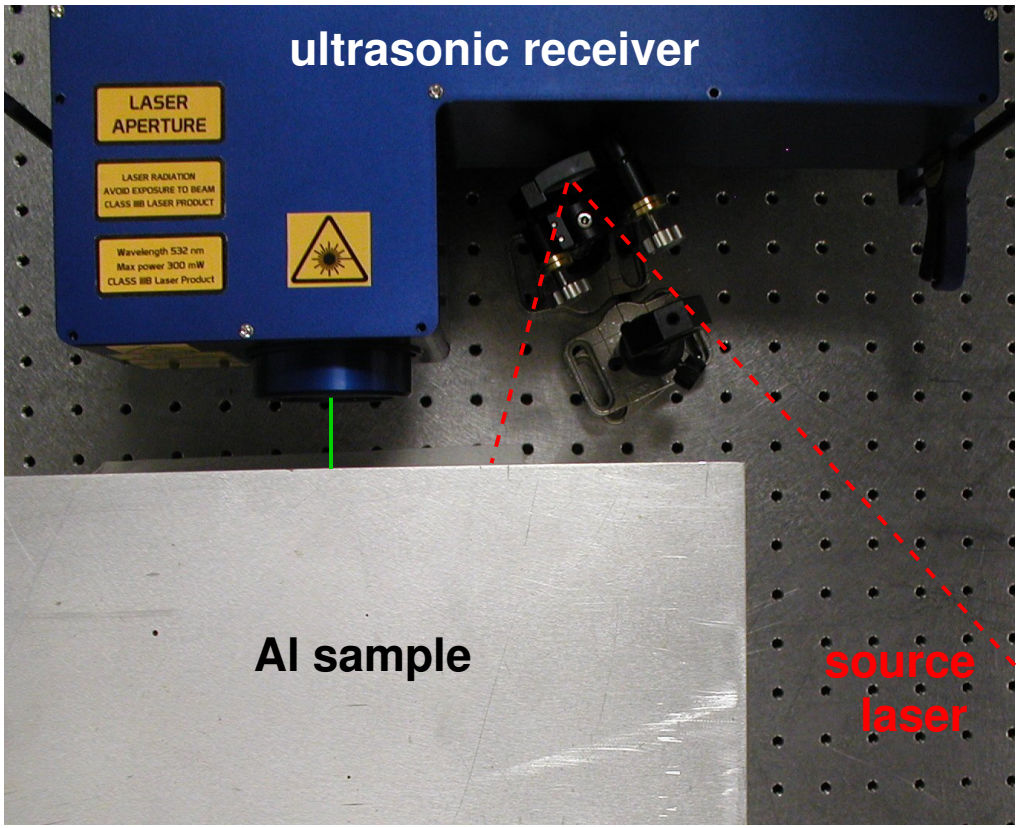


Calibration: point measurement

Rayleigh wave: phase shift $\Phi = 90°$, ellipticity $H/V = 0.64$

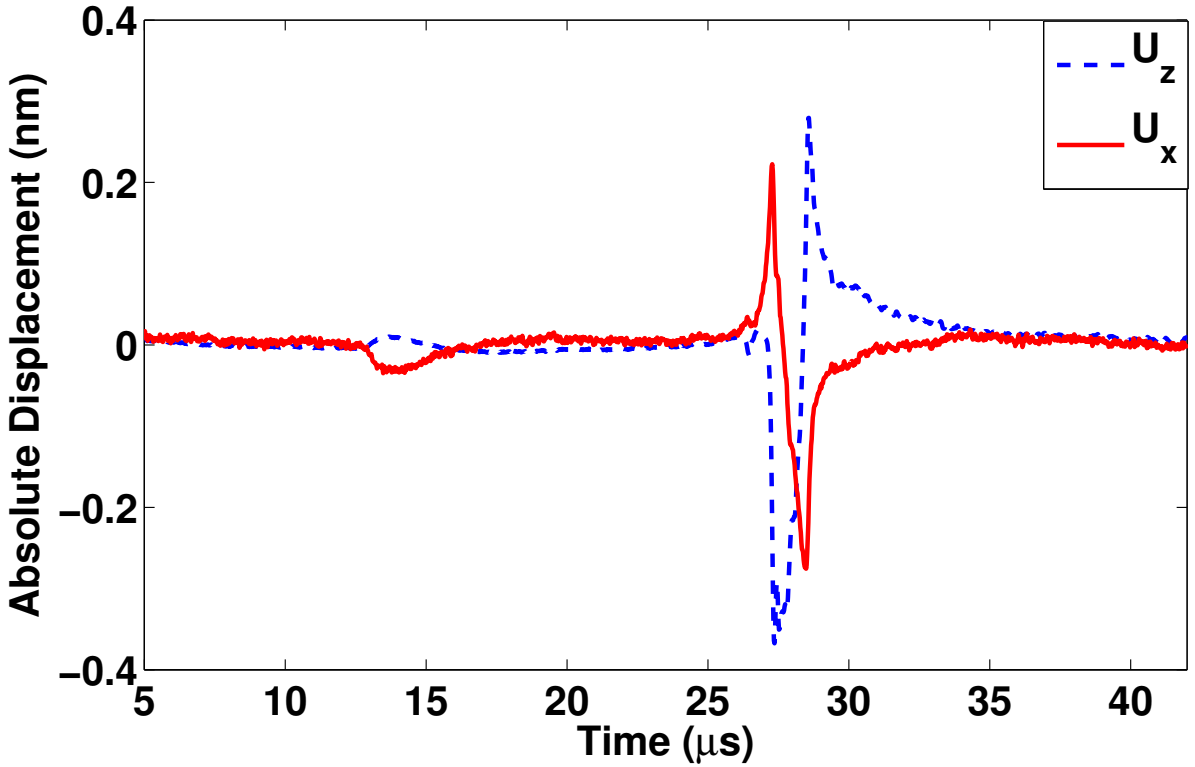


Point measurement: setup



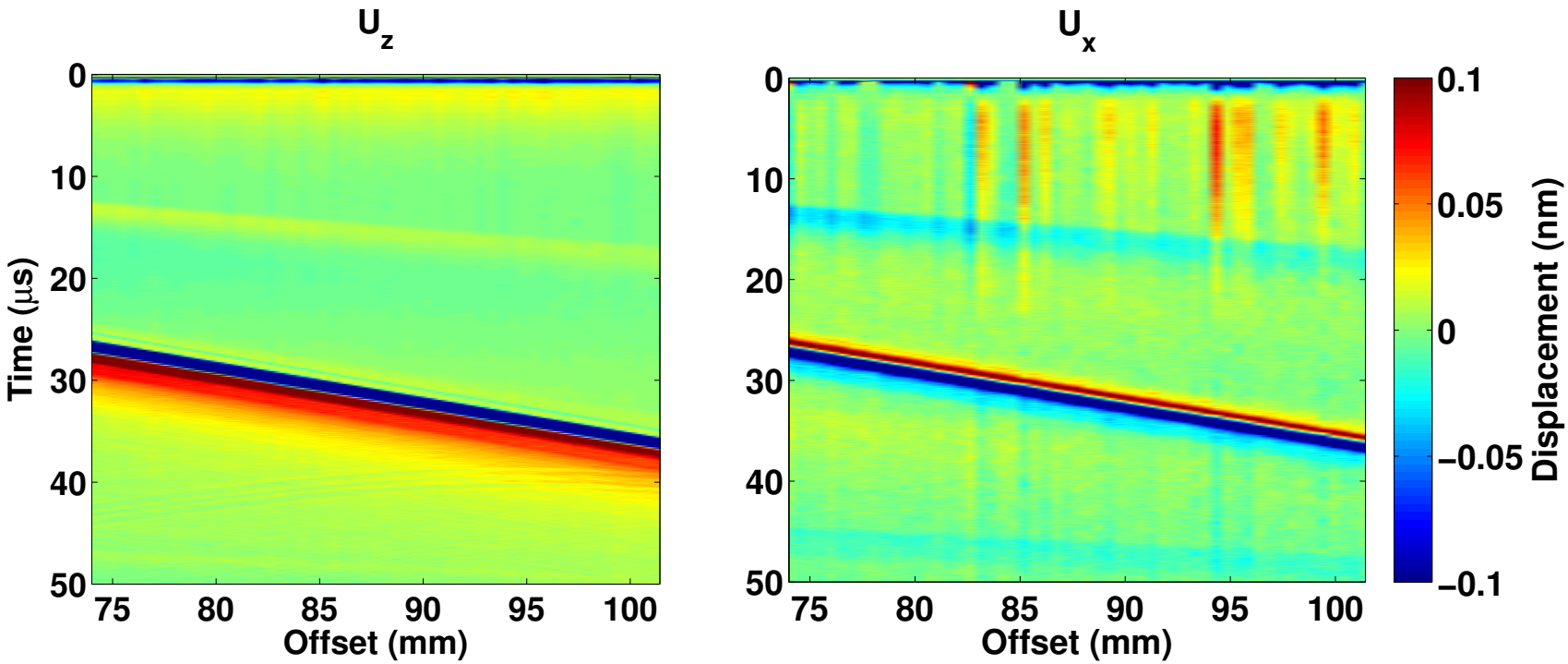
- Aluminum block (214x232x277 mm)
- Laser source
- 500 averages per trace

Point measurement: results

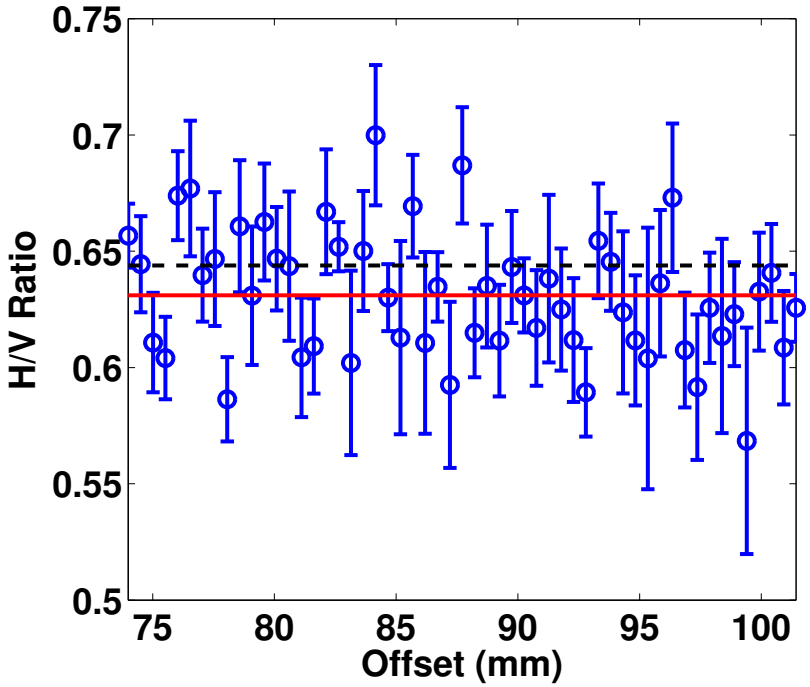


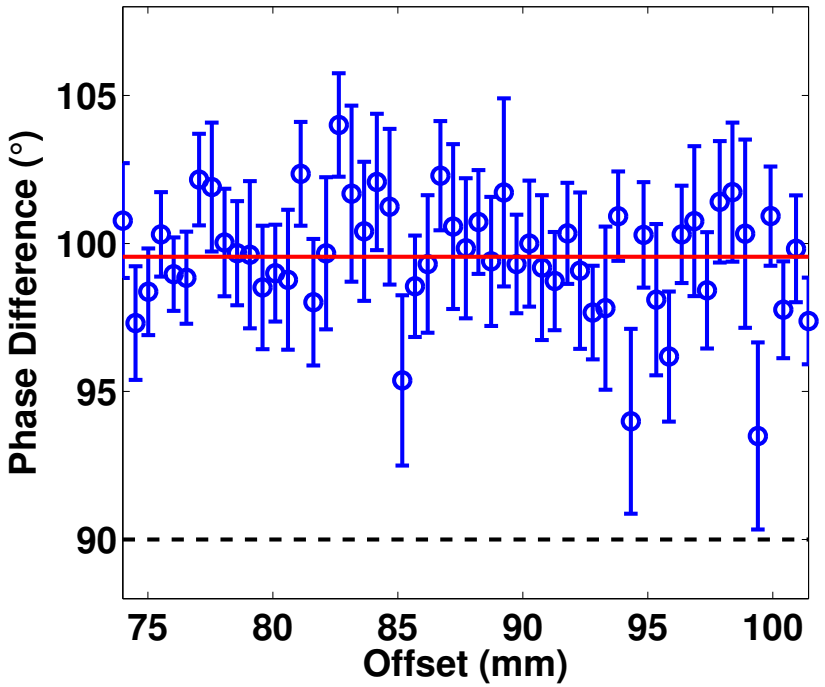
- Amplitude and phase spectrum between 300 and 900 kHz
- $H/V = 0.64 \pm 0.02$, and $\Phi = 97 \pm 1°$: bias of 7°

Line scan: 27 mm line, 55 receivers



Line scan: results

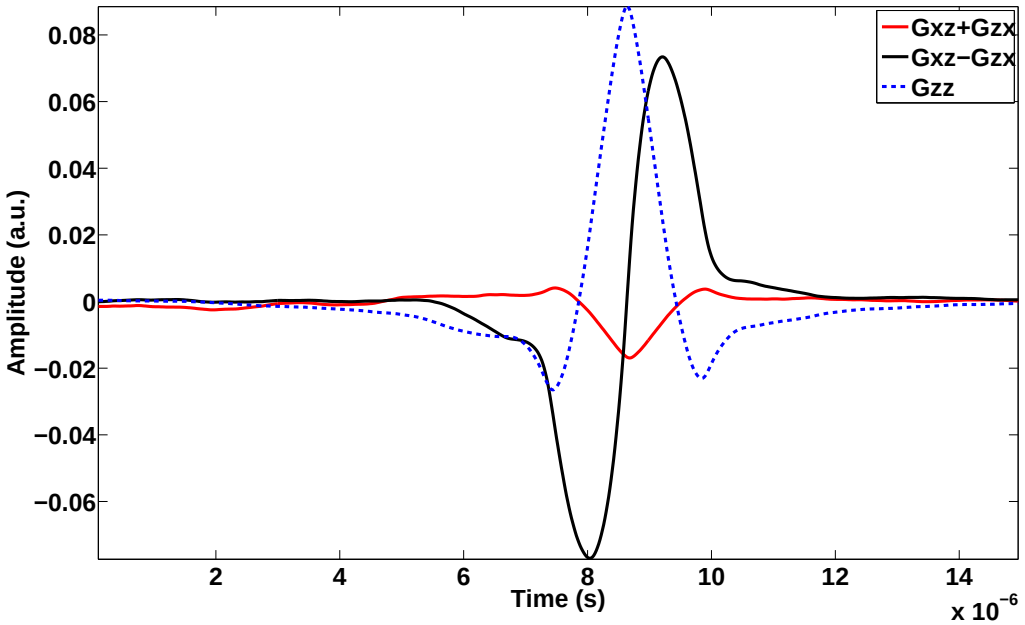




- $H/V = 0.63 \pm 0.05$
- $\Phi = 99 \pm 4°$ averaged over scan
- Horizontal measurement very sensitive to focus

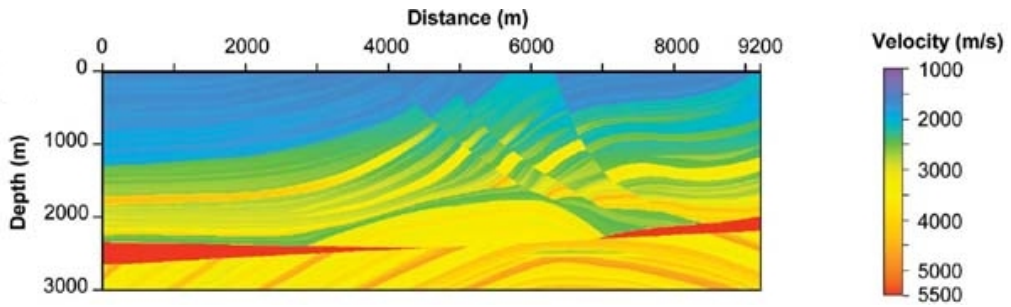
Conclusion

- Accurate and fast technique to measure up to two components of the wavefield: 75 receiver locations, 500 averages in 1h
- Application to ultrasonic surveys on small-scale models
- Testing of new processing algorithms



Future work

- 3C: flip receiver and measure transverse component
- Ultrasonic imaging of customizable shapes in glass



Aknowledgements

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