



Presented at the FIG Working Week 2023,
28 May - 1 June 2023 in Orlando, Florida, USA

FIG WORKING WEEK 2023

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Uncertainty assessment of high frequent strain measurements

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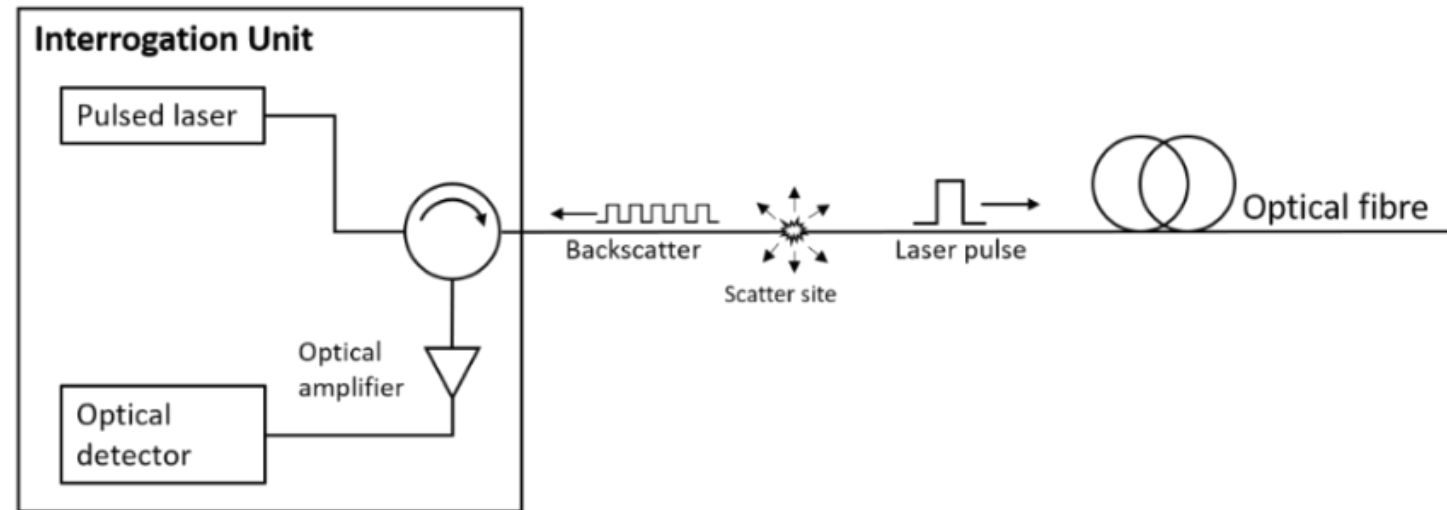


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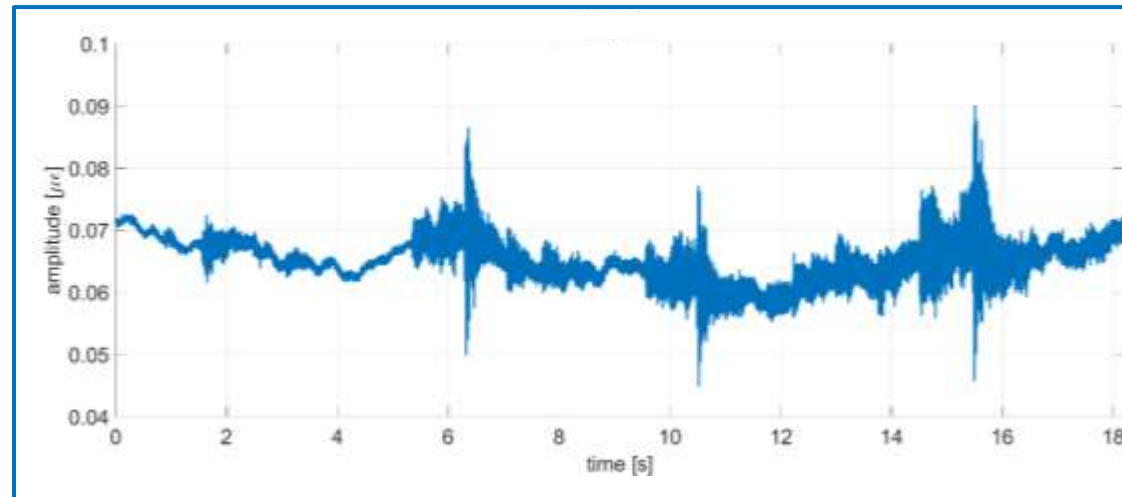
Distributed Acoustic Sensing

- Working principle
 - Light pulses are injected into a fibre with high frequency
 - Light is reflected at every position along the fibre
 - Intensity changes and/or phase changes are determined at every position



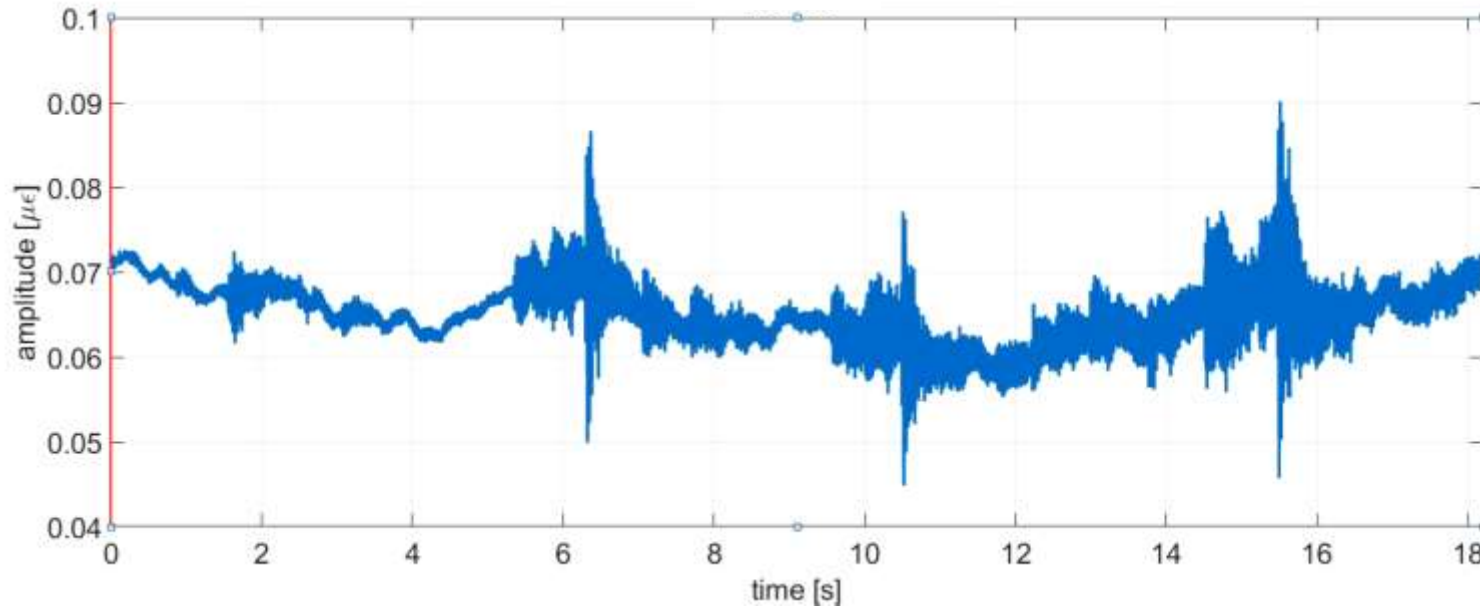
Phase Coherent DAS

- Full acoustic signal



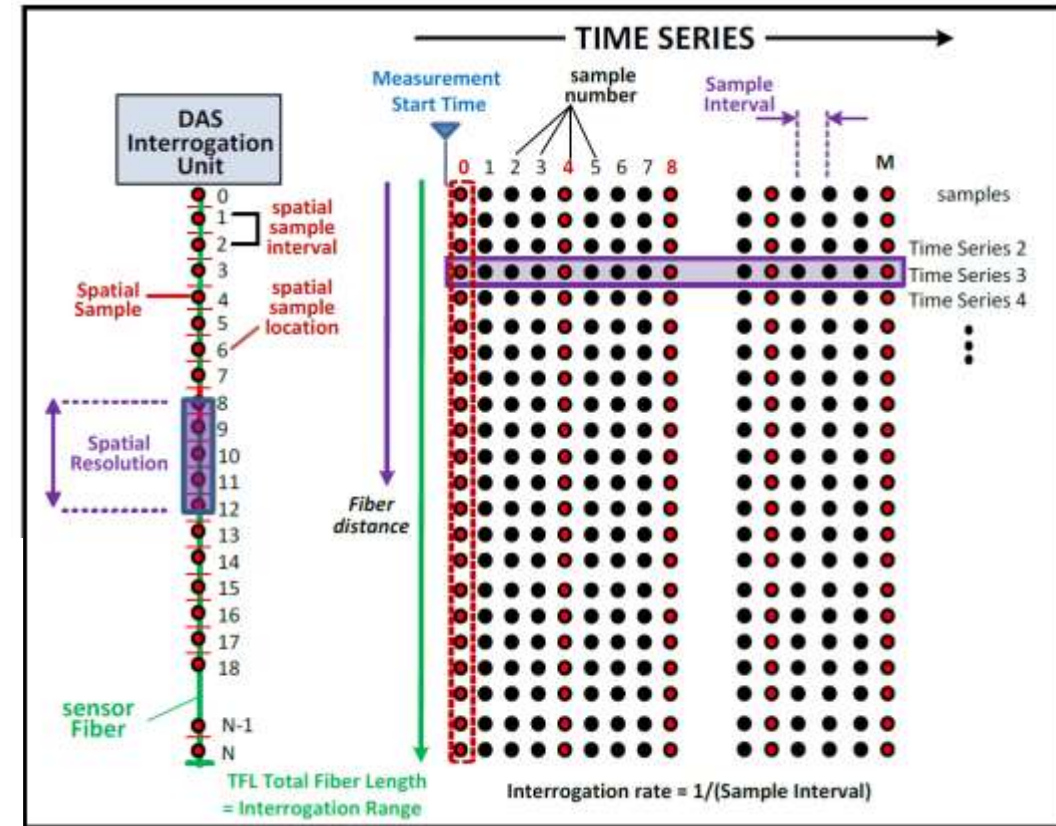
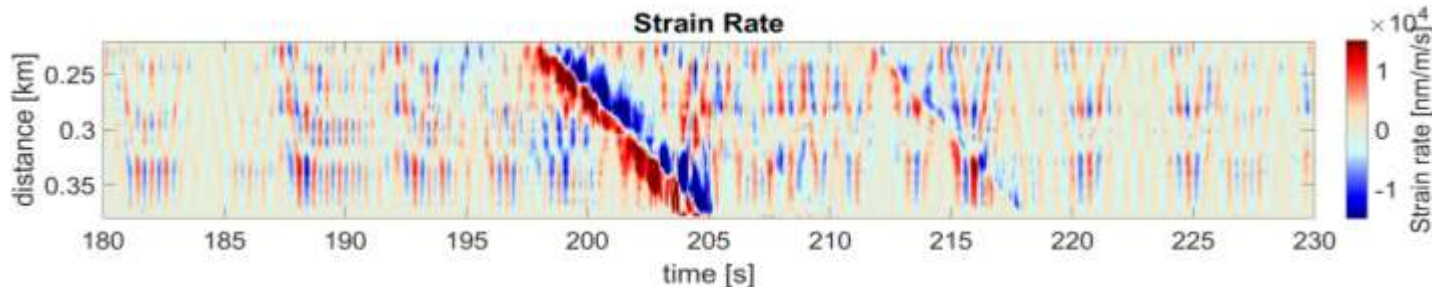
Phase coherent DAS

- Full acoustic signal



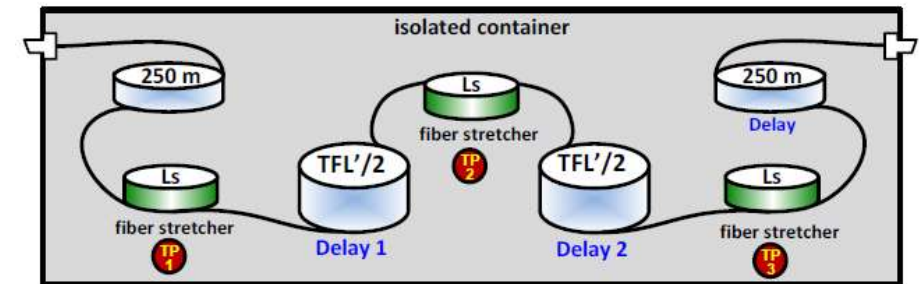
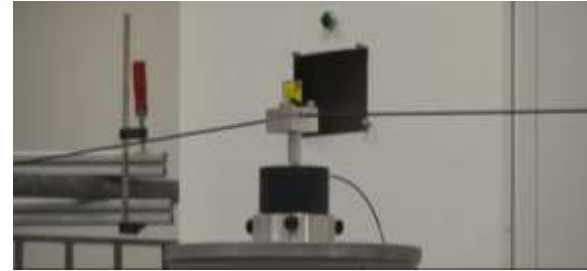
DAS Data Processing

- Phase measurements
- Converted to strain rates
- Can be integrated to strain



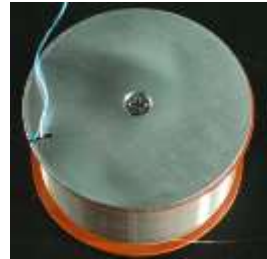
Dynamic Strain Evaluation

- Local mechanical excitation
 - Mechanical shakers
 - Piezo stretchers
- Acoustic excitation
 - 8 stretched segments with 10 m each
 - Speakers for constant frequencies or sweeps
- SEAFOM MSP-02 setup
 - 40 km with 3 stretchers



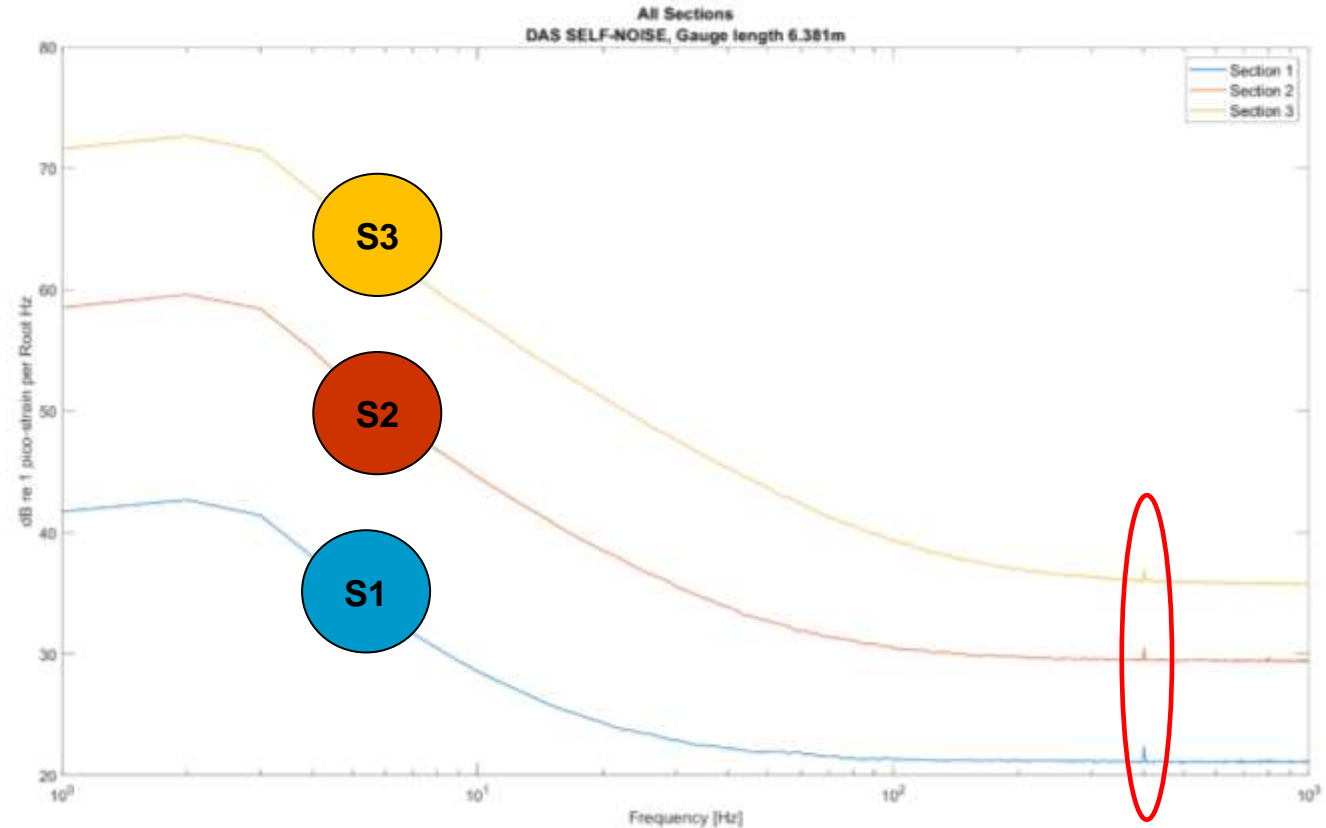
SEAFOM – MSP02 Standard

- IGMS setup
 - TFL: 40 km
 - 40 m on each stretcher
- Test scenarios
 - No vibration
 - Constant vibration
 - Frequency sweeps
 - Amplitude sweeps



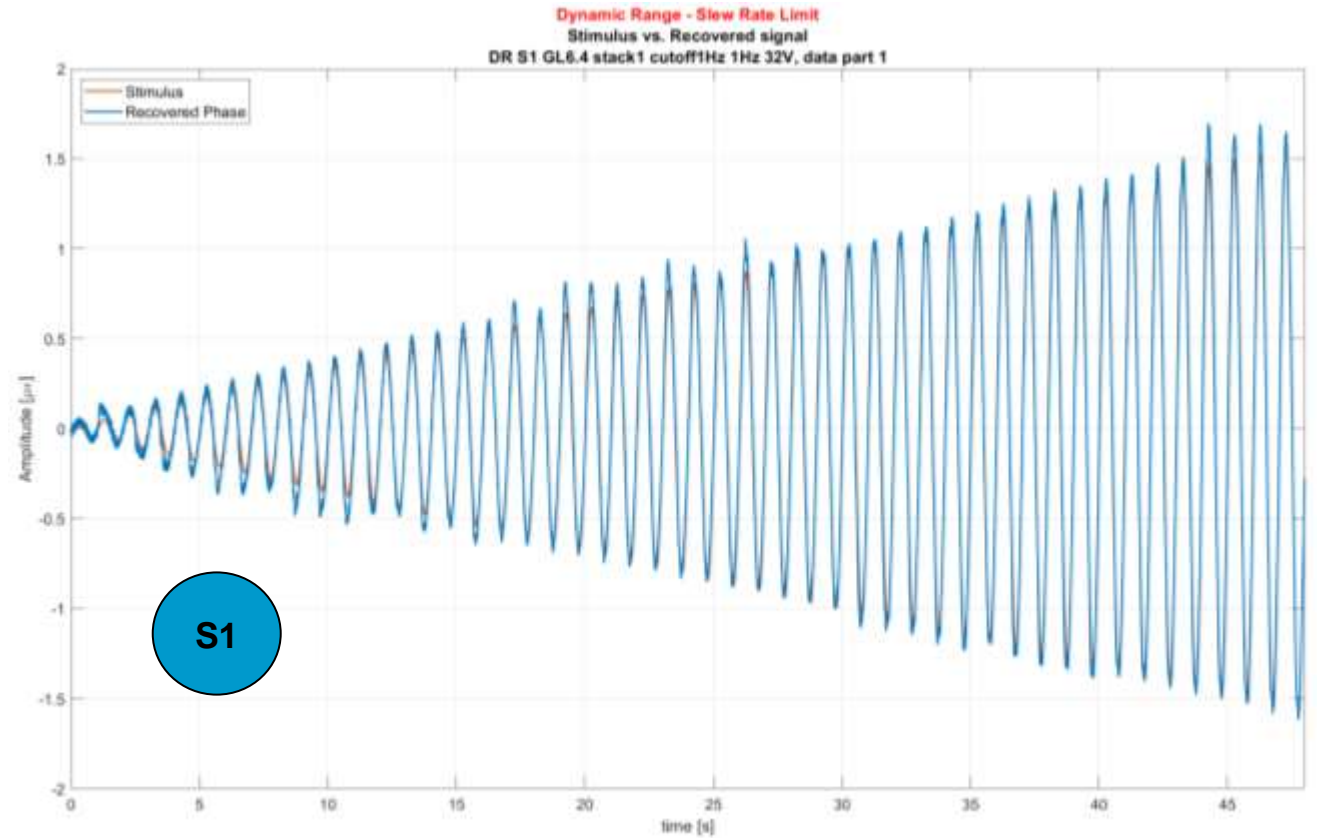
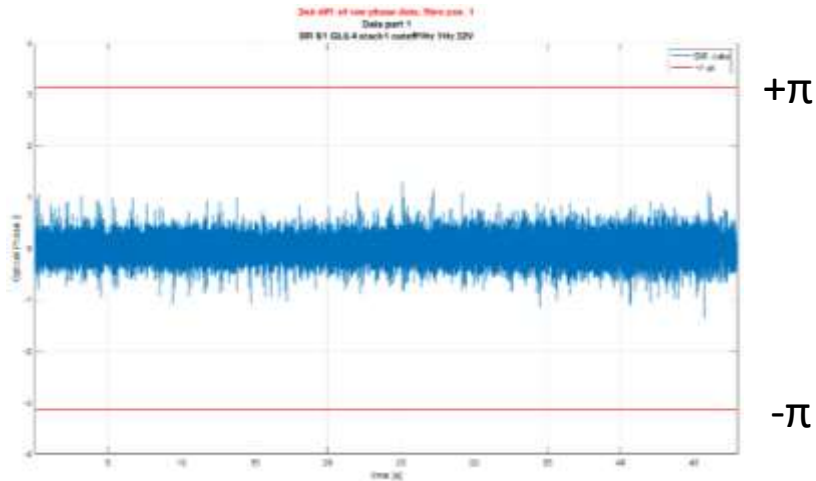
SEAFOM – MSP02 Standard

- Self noise test
 - Noise is increasing with distance
 - High noise at 400 Hz for this specific instrument



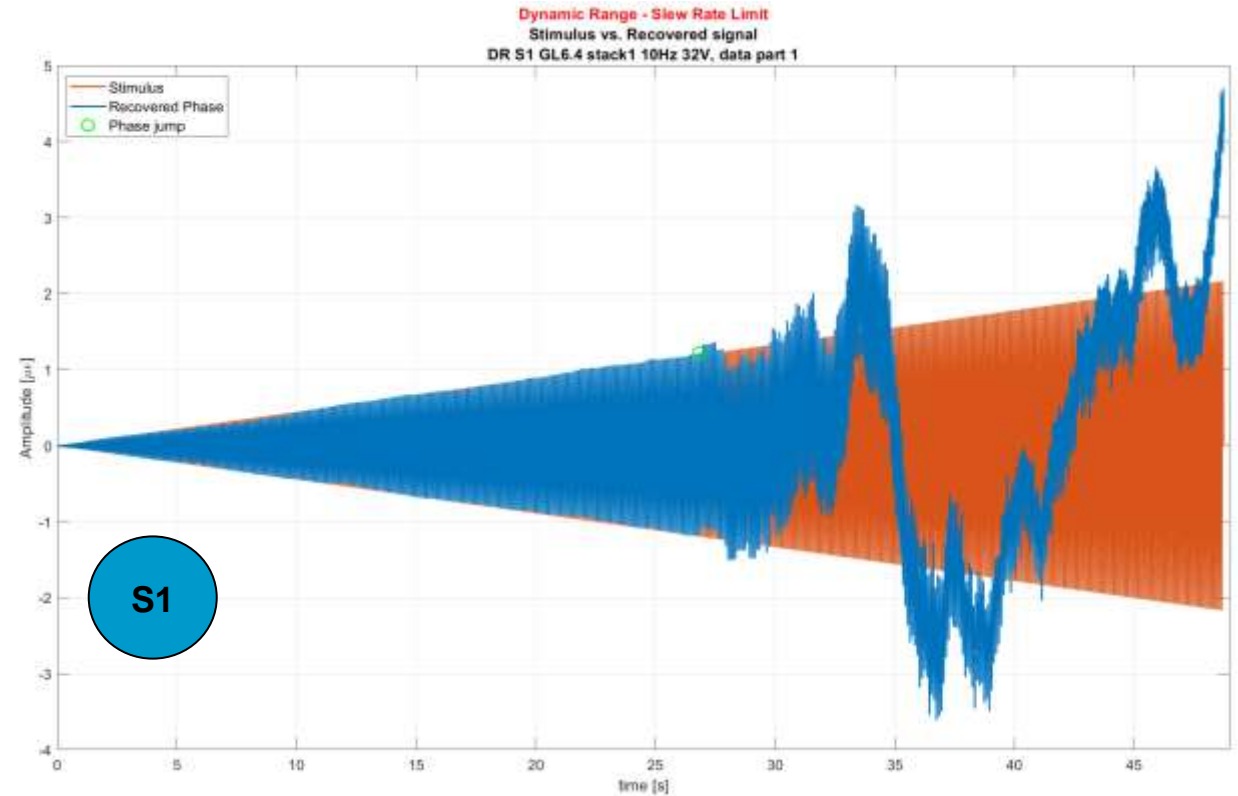
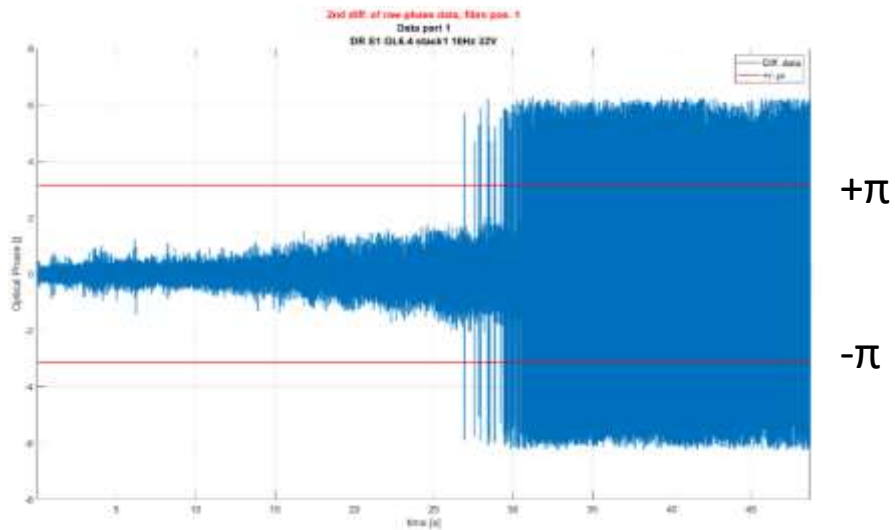
Amplitude Sweep at 1 Hz

- Phase correctly unwrapped



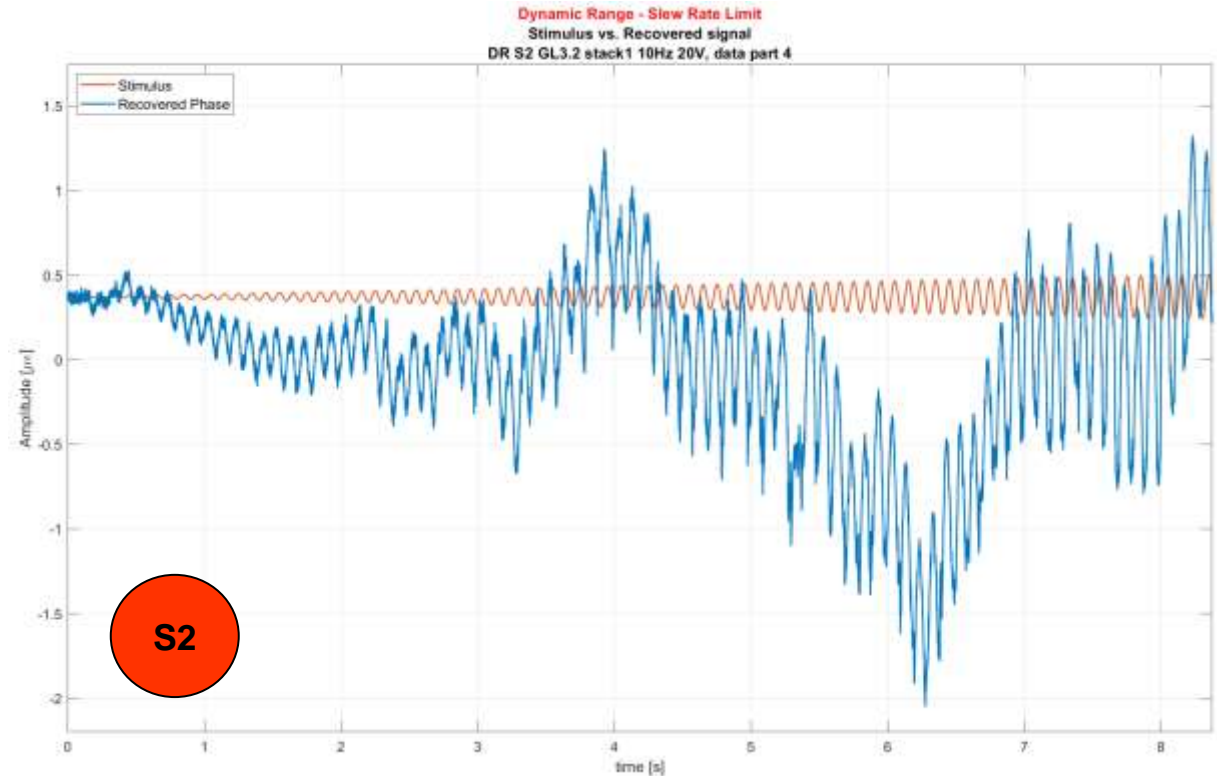
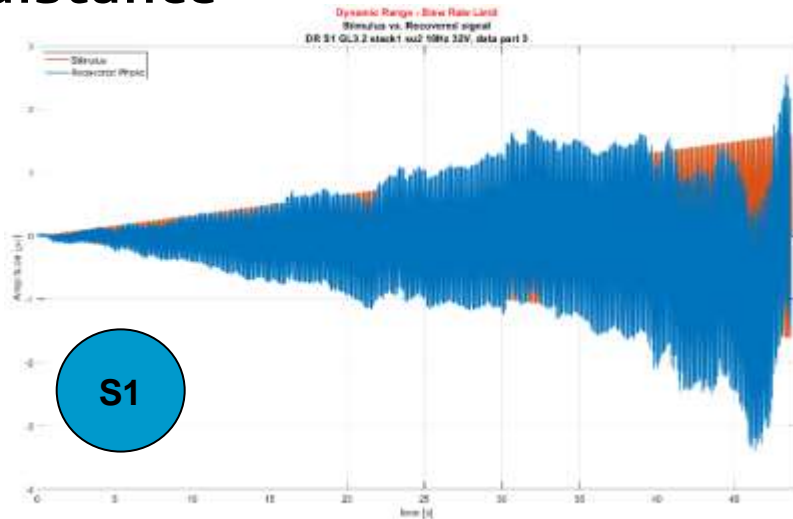
Amplitude Sweep at 10 Hz

- With increasing amplitude phase is not correctly unwrapped



Amplitude Sweep at 10 Hz

- Dependent on gauge length & distance



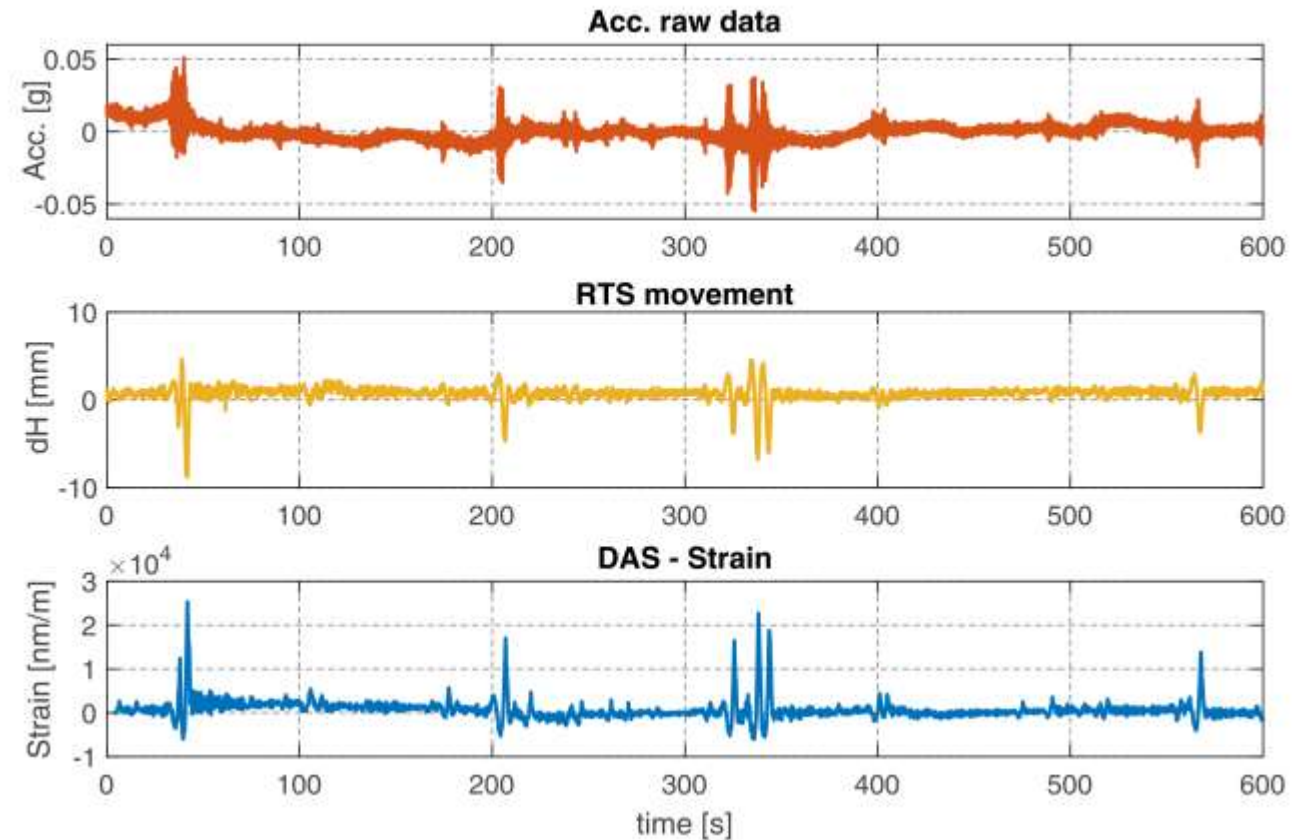
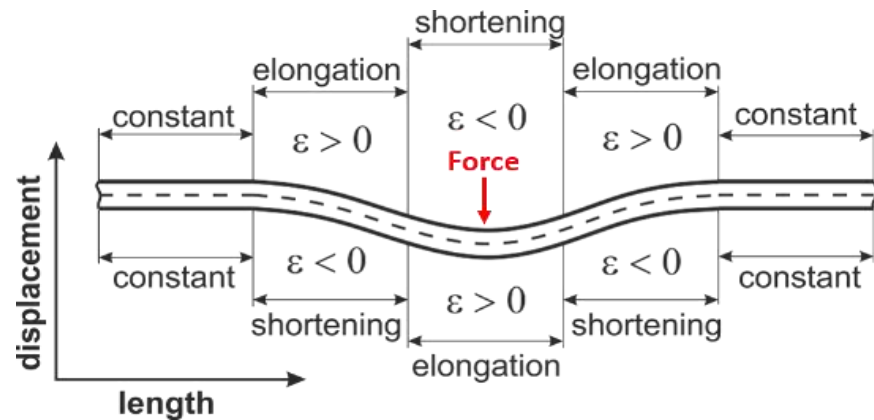
Monitoring Application

- Highway bridge
- DFOS
 - Sensing fibre on span 6+7
- Accelerometer
 - 3 axis accelerometer
- RTS
 - Dynamic tracking of prism



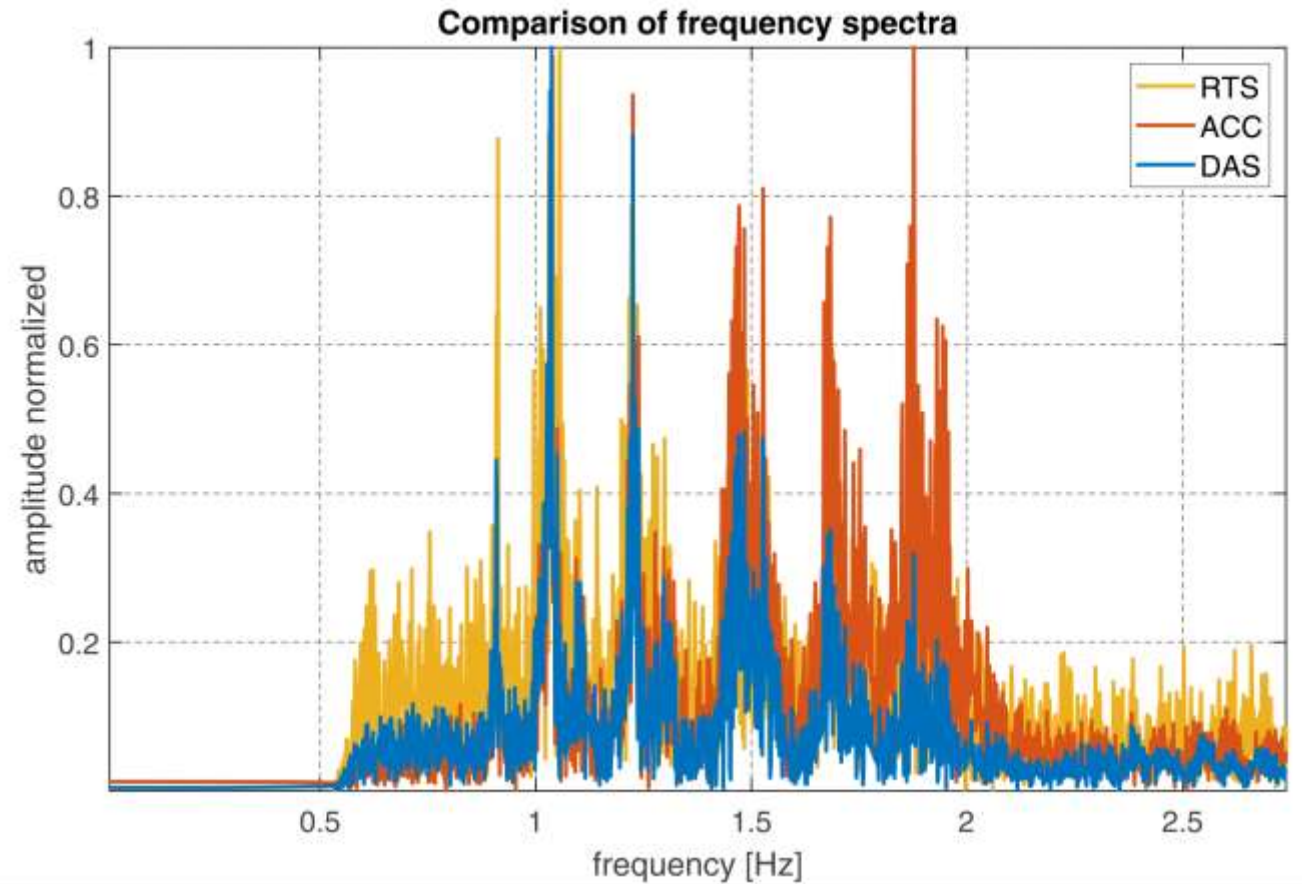
Comparison of Data

- Individual vehicles can be identified in all time series



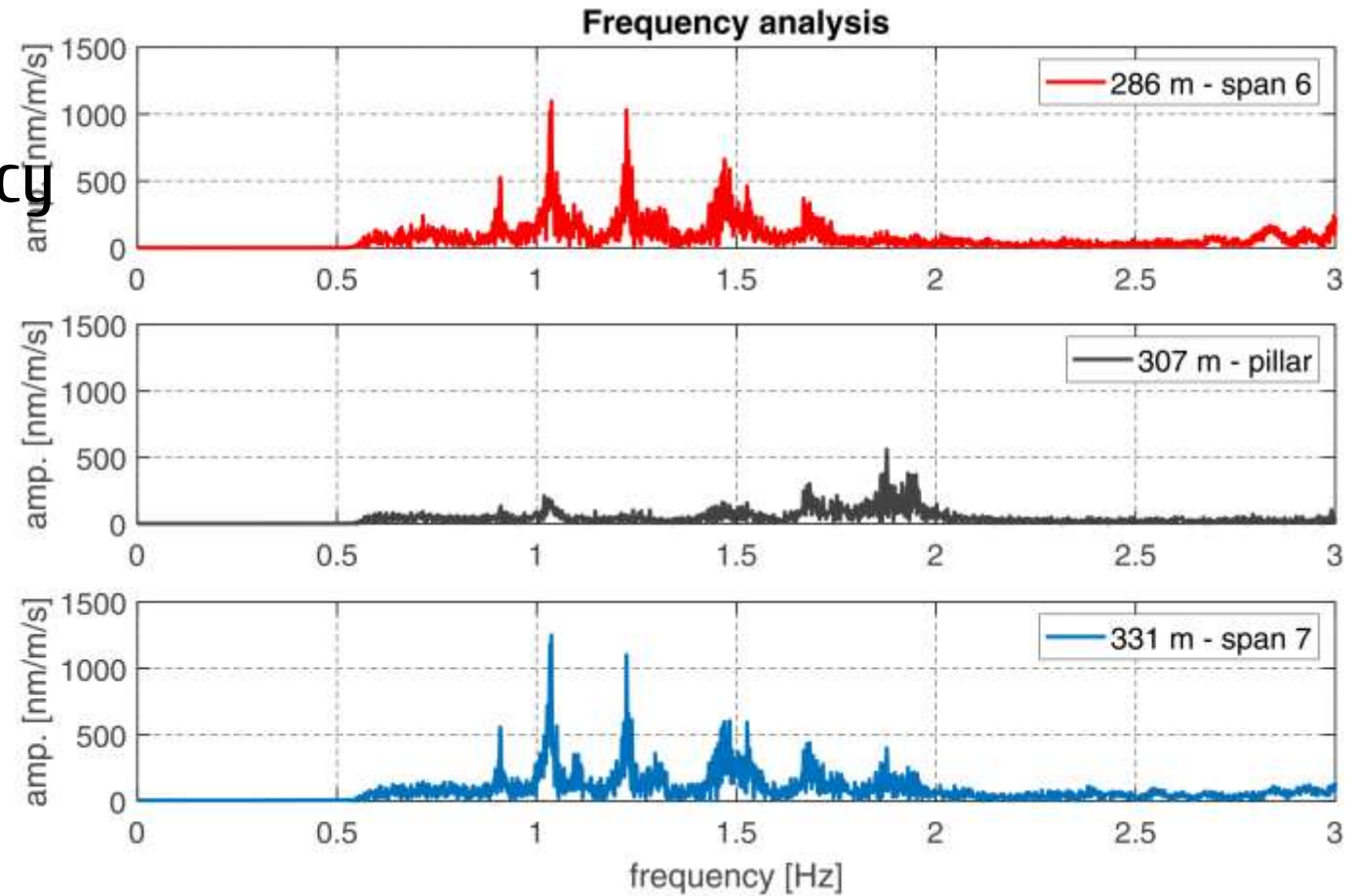
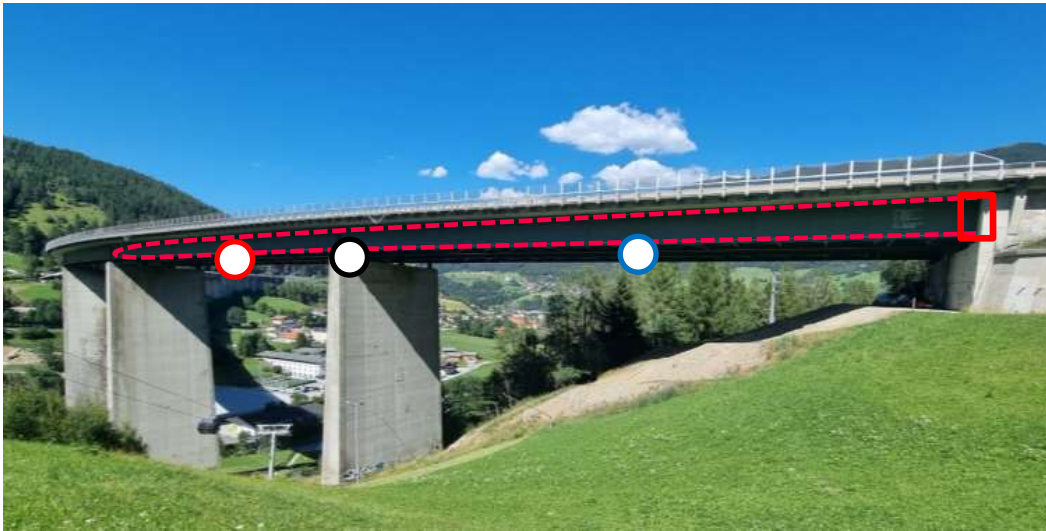
Frequency analysis

- High pass filter with cut off frequency of 0.5 Hz
- Main frequencies can be identified by all measurement techniques
- Highest noise in RTS data



Advantage of DAS

- Distributed nature enables frequency analysis at all positions



Summary and Outlook

- DAS offers new opportunities in the assessment of the frequency response of structures (mode shapes etc.)
- Challenges
 - Dynamic range of instruments
 - Integration (strain rate \rightarrow strain \rightarrow displacement)
- Next steps
 - Correlation analysis of individual DAS channels
 - Further investigations on real structures





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Thank you very much for your attention!

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