

Seismic on Piles project

Monitoring soil properties on offshore wind turbine structures

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Creating future by technological progress

Fraunhofer IWES is dedicated to supporting a sustainable development for society's well-being.

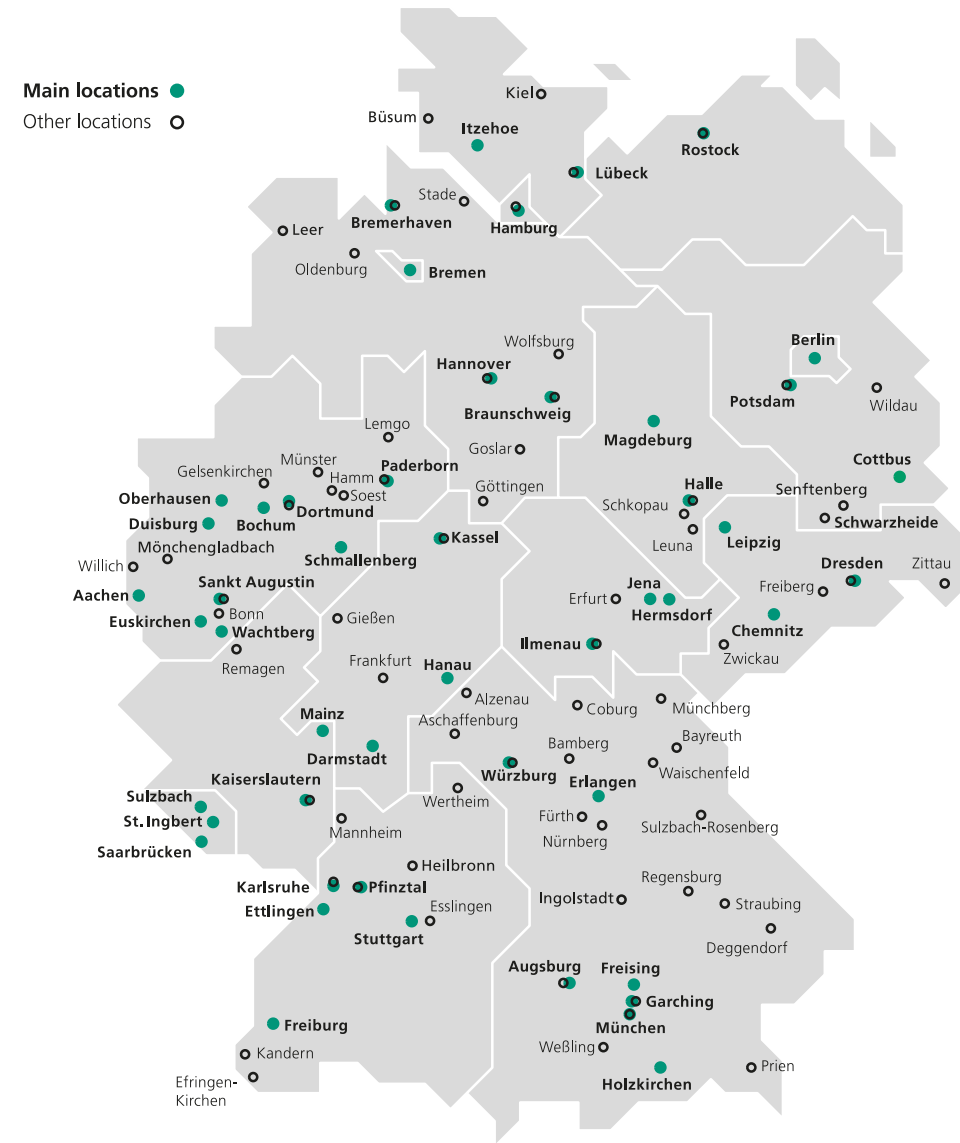
Our solutions are designed to enhance the quality of life – by supporting the further expansion of wind energy and creating far-reaching synergies through systematic research into the interaction between wind energy and hydrogen generation, reverse power generation and grid integration.

We seize the opportunity.

Fraunhofer-Gesellschaft

Locations in Germany

- 76 institutes and research facilities
- 30,800 employees in total
- € 3.0 billion total funding
- € 2.6 billion contract research



Research and Service Spectrum of IWES

Supporting the Wind Energy Sector in all aspects



Site Assessment and CFD



Nacelle Testing and System Reliability



Field Tests



Qualification of Composite Materials and Parts



Testing of Drive Components and Large Bearings



Certification of Electrical Characteristics



Hydrogen System Performance and Reliability



Validation of Support Structures

Fraunhofer IWES - Sub-Surface Investigation

Say Hello! You will find us in the at the **Stand G351**



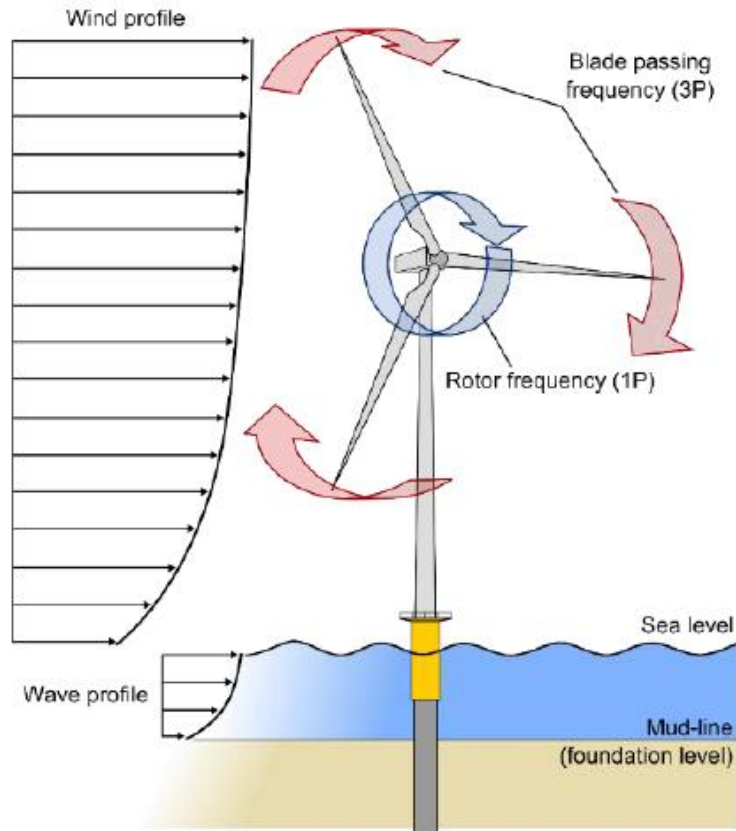
Link: SSI website



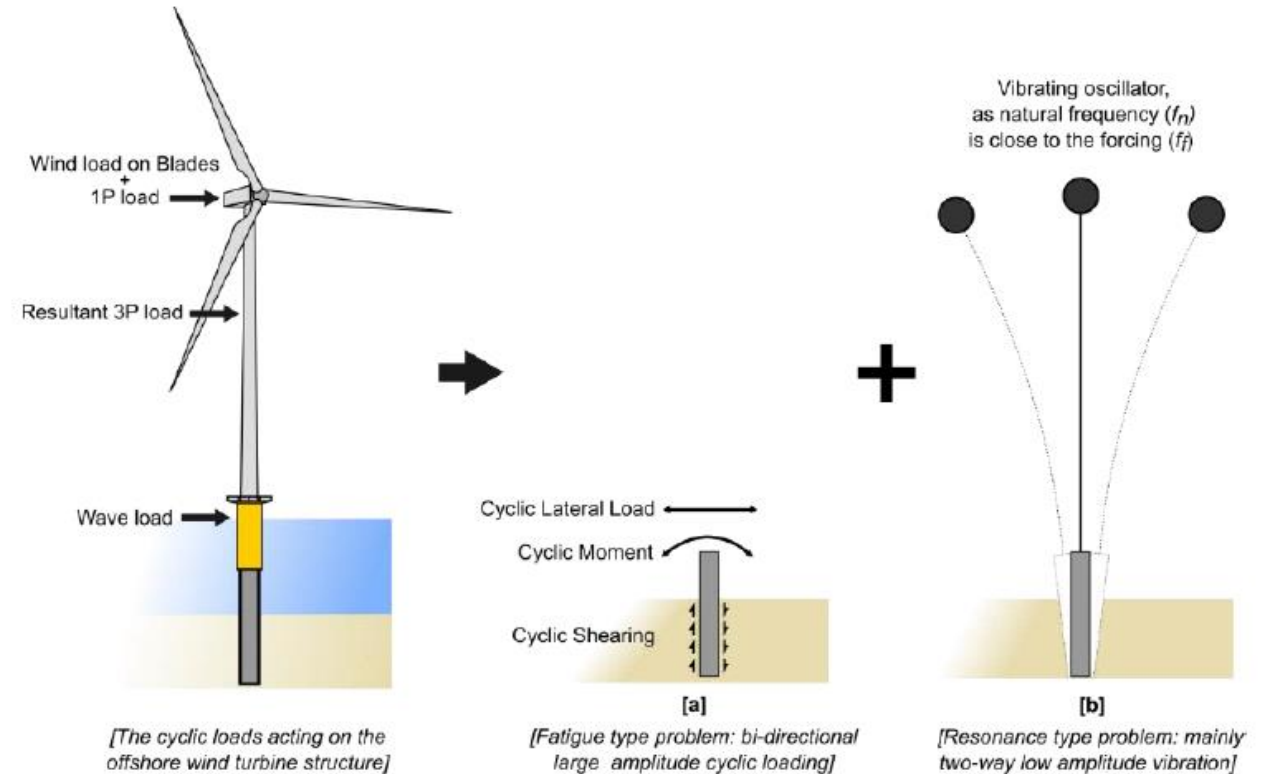
Gino Frielinghaus	Viola Bihler	Anna Galperina	Jude Castelino
Geophysicist	Geophysicist	Geophysicist	Geophysicist
Department manager	Group manager	Scientific associate	Scientific associate
Unconventional geophysical imaging	Unconventional geophysical imaging	Unconventional geophysical imaging	Unconventional geophysical imaging
Research and technology development	Object Detection	Interpreter	Cable Detection

Which problems face the OWT?

Dynamic and cyclic loads



■ From Nikitas et al. (2016)



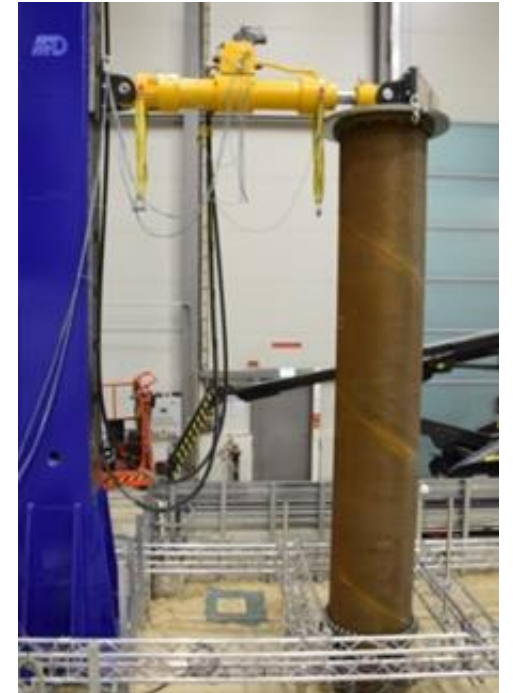
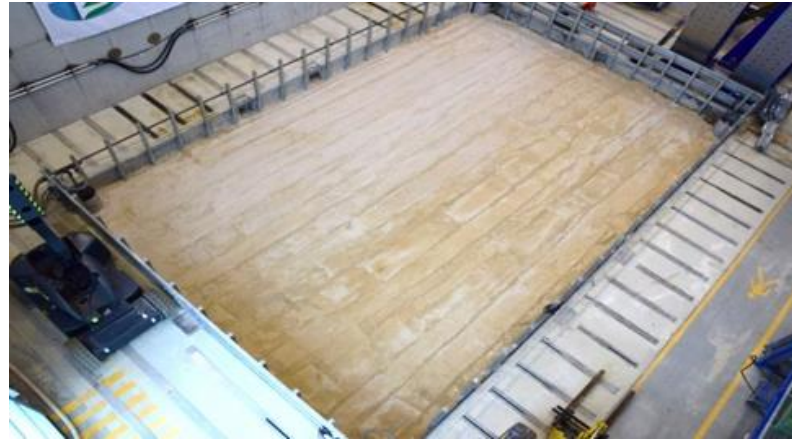
■ From Nikitas et al. (2016)

Test Center for Support Structures

Hannover

Geotechnical pit:

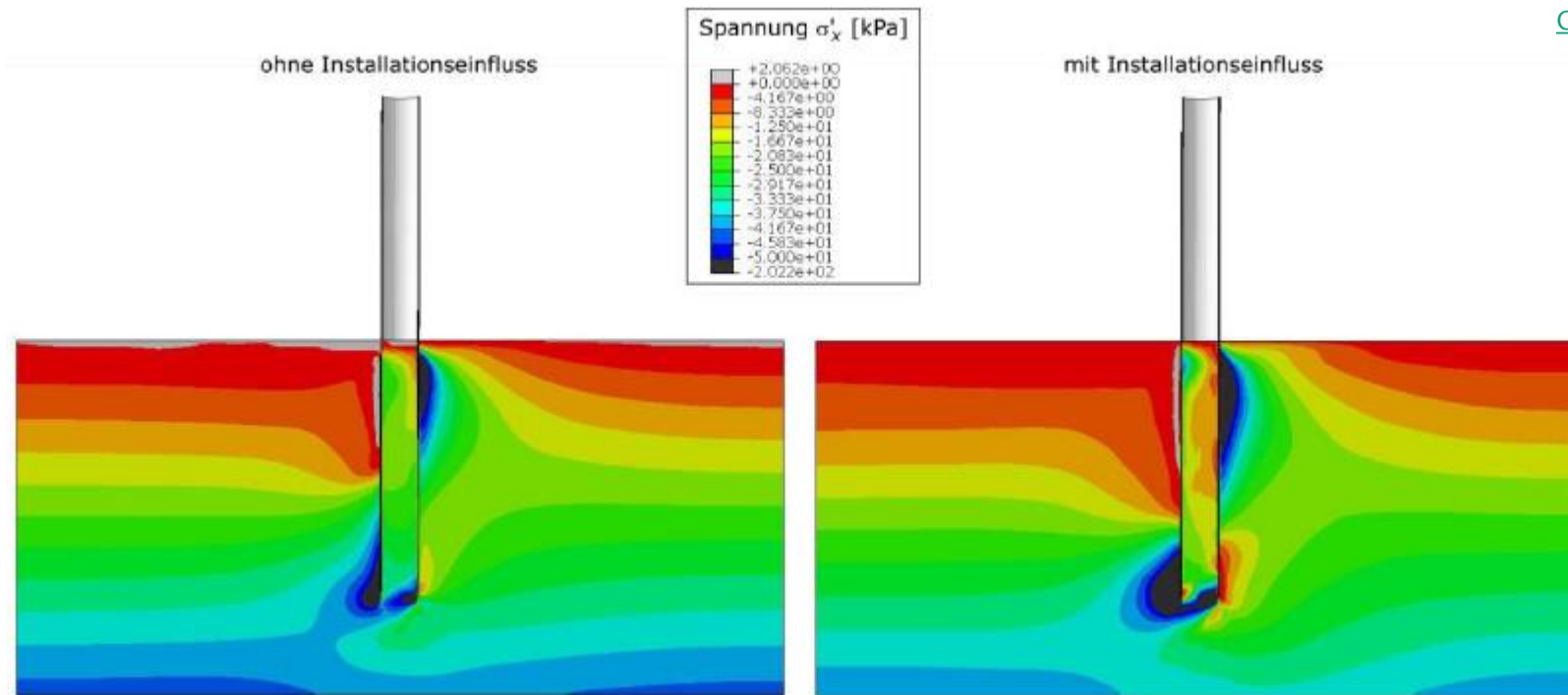
- Length: 14 m, width 9 m, depth 10 m



Test Center for Support Structures

Tandem project

Installation effect:



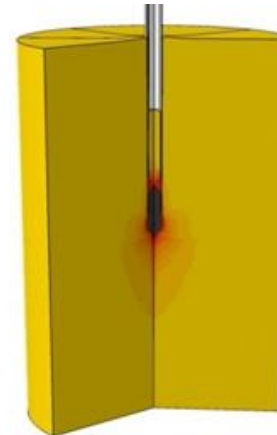
Tandem report, Fraunhofer & Ramboll 2019

- PISA (Pile Soil Analysis): “[...] more accurate methods have the potential to reduce steel requirements for foundation [...]”
- [New design methods for offshore wind monopiles to create cost savings for industry | The Carbon Trust](#)

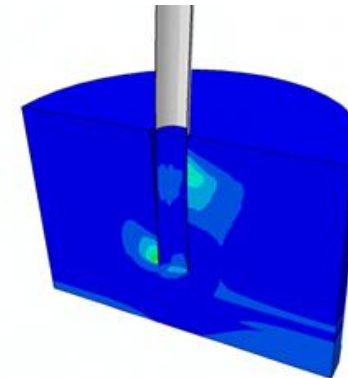
Measuring campaign

~ December 2023

1. Seismic and CPT measurements at the sandpit without piles
2. Installation of the piles:
 1. vibrating and hammering
 2. diameter: 90 cm
3. Seismic and CPT measurements
4. Load program
5. Seismic and CPT measurements



Axially loaded piles



Laterally loaded piles

Seismic on Piles

Project summary

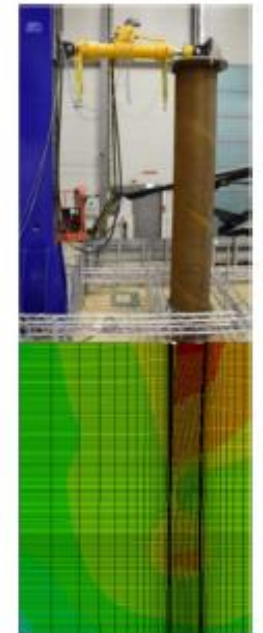
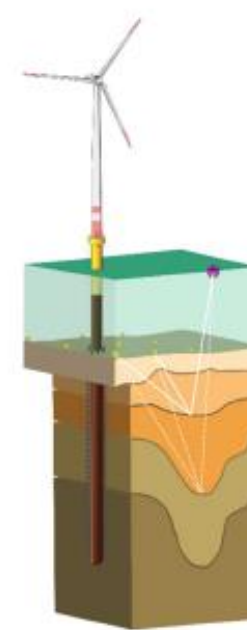
Goal:

→ Monitoring changes of subsoil near to Offshore structures using seismic measurement techniques (4D seismics)

- Assessment of suitability in using seismic methods for detection of parameter changes in the vicinity of mechanical structures
- Development of a monitoring concept for seismic recording of small-scale changes in sediment parameters due to the structure-soil interaction

Cooperation of working group Test center for support structures in Hannover

Seismic measurements → Geotechnical constructions



Measuring campaign

Seismic measurements

Receiver:

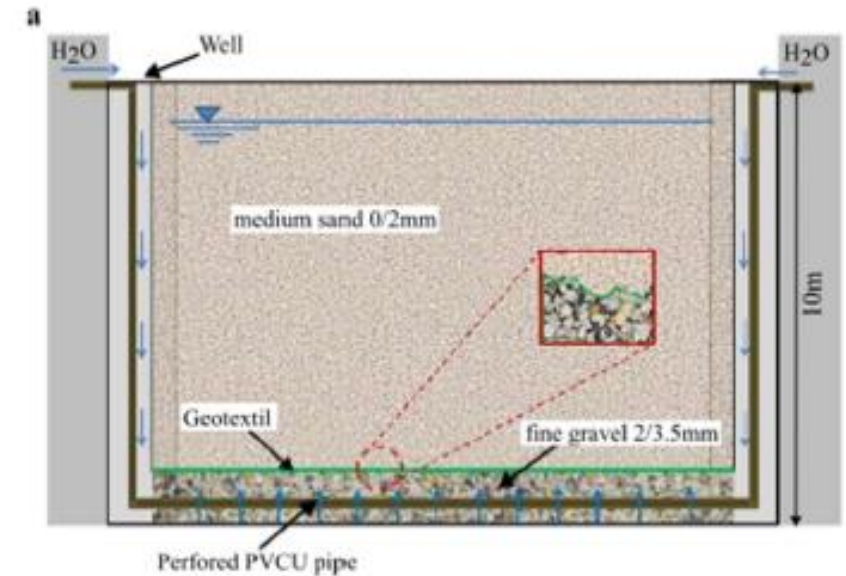
- Ocean Bottom Nodes (OBN)
 - 4 C (3 Geophones, 1 Hydrophone)
 - Sample interval: 0.25, 0.5, 1 and 2 ms
- Geophones
- Broadband hydrophones
- Position: surface



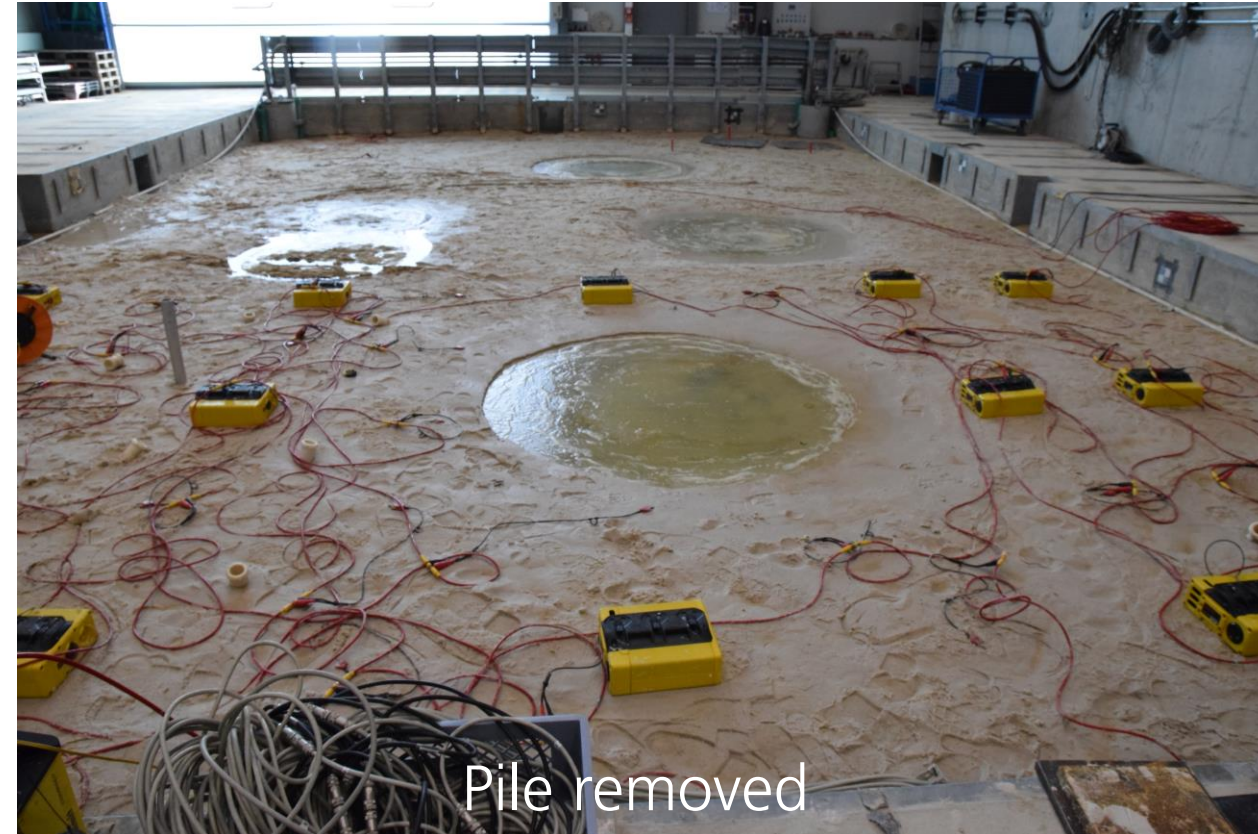
www.inapril.com

Source:

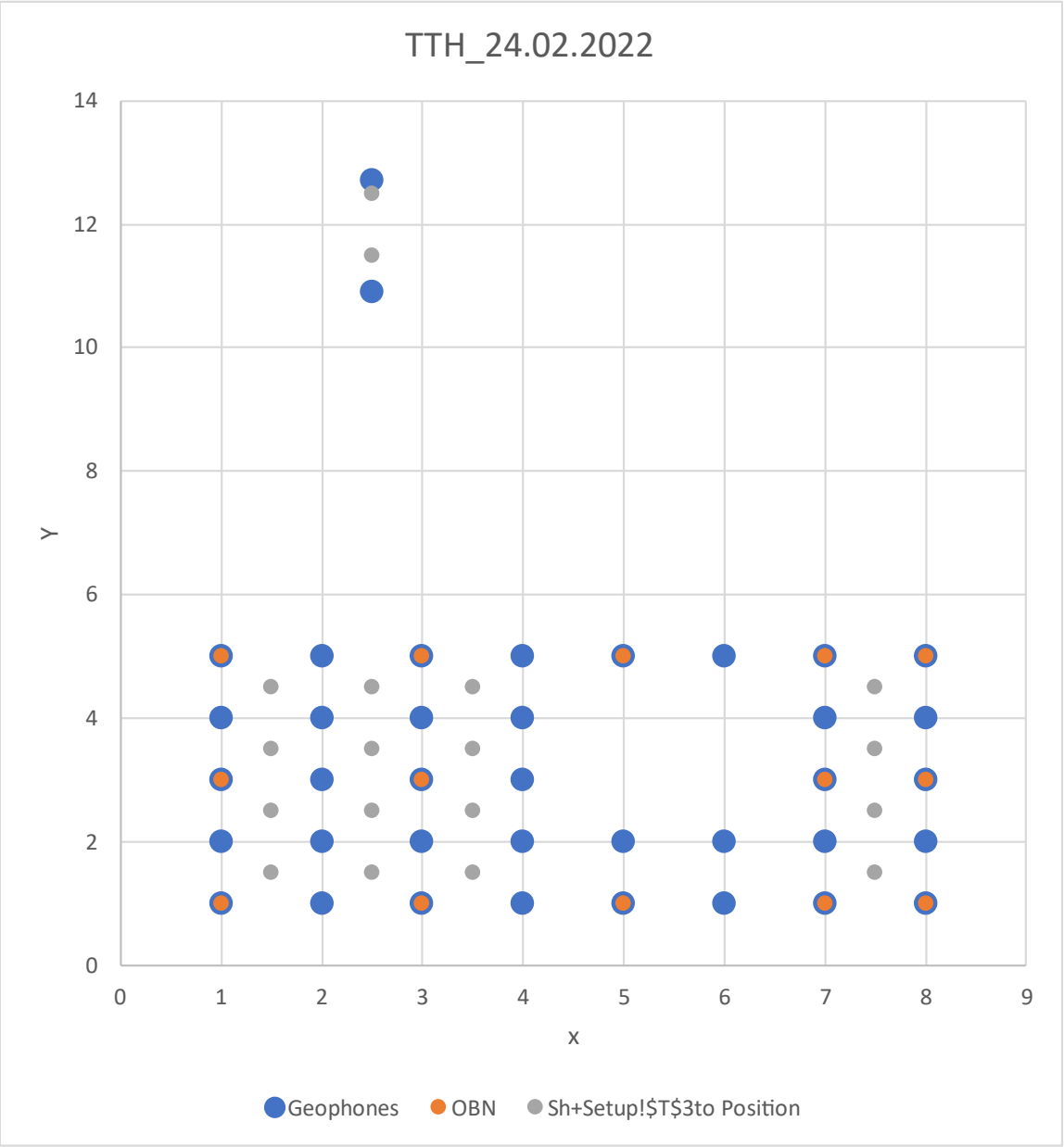
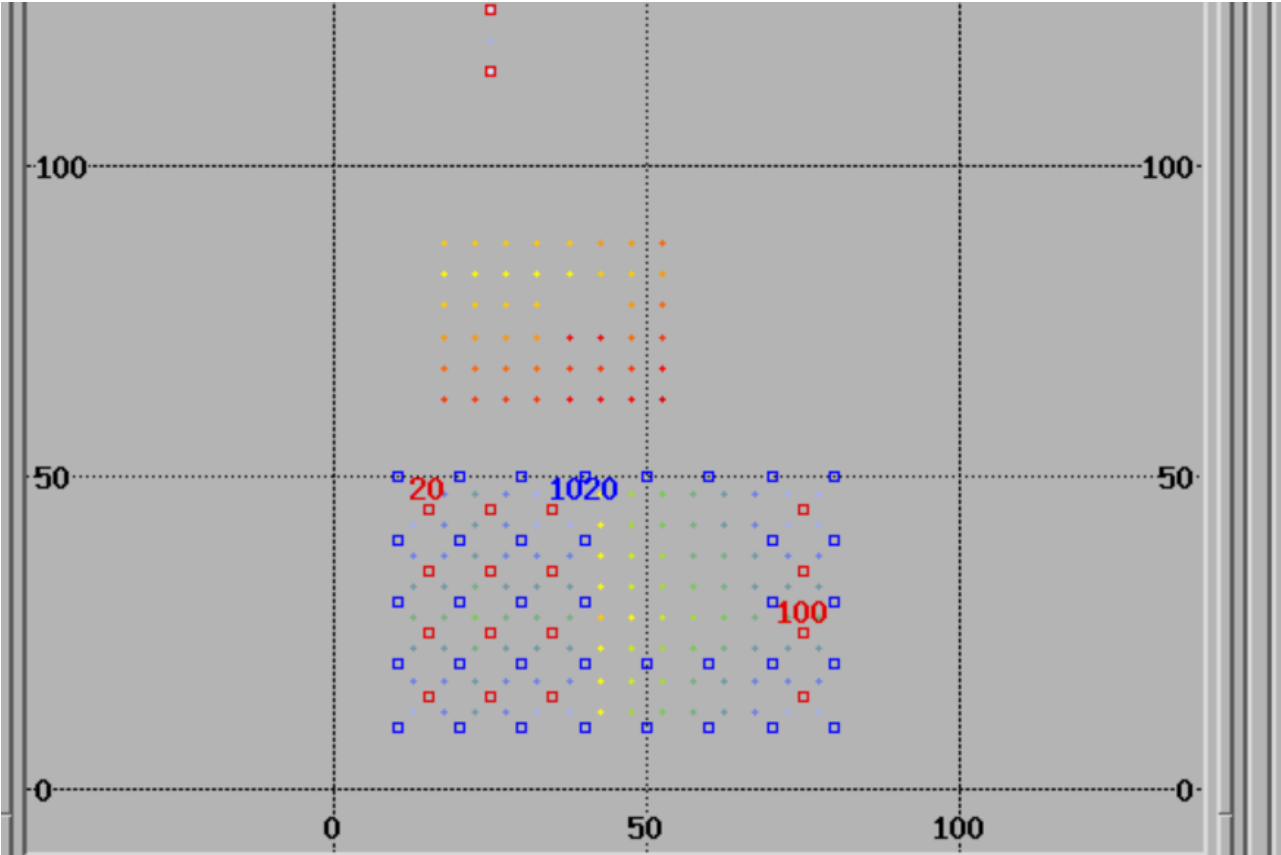
- ~50-Hz
 - Hammer on a plate (P)
 - Pipe (S)



Seismic survey @ the test site



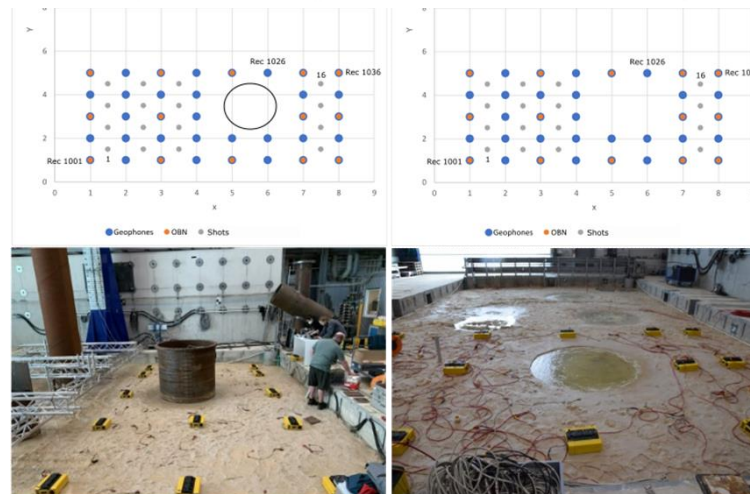
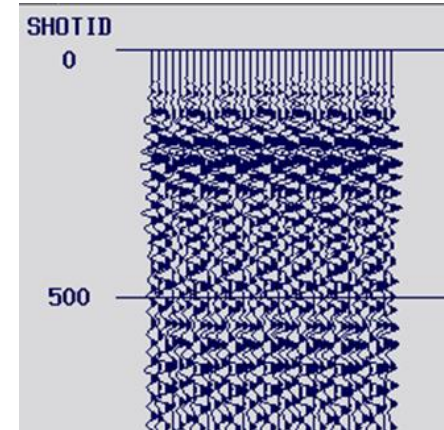
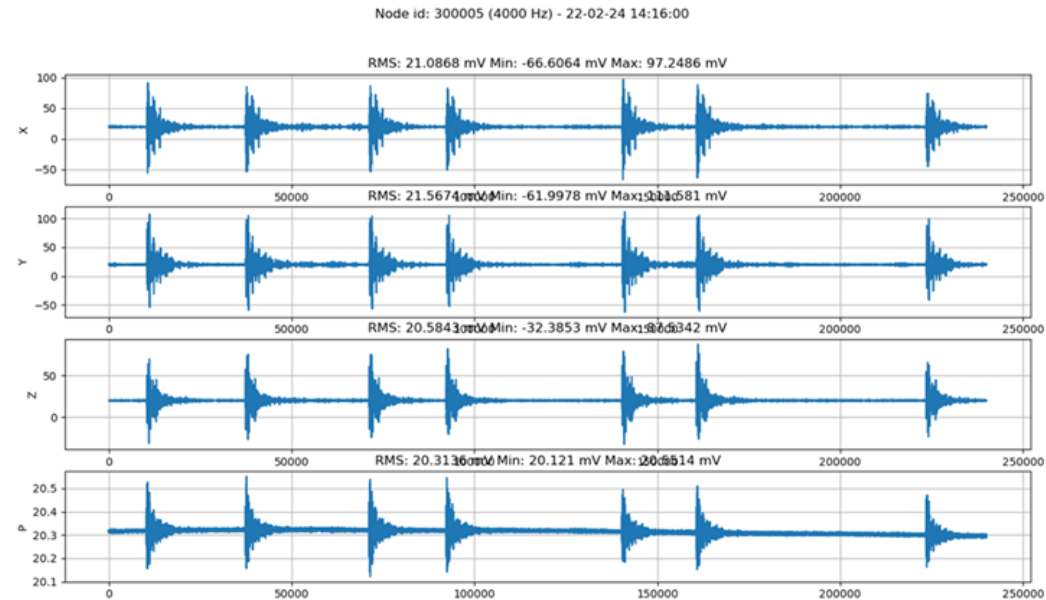
Seismic survey @ the test site



Preliminary test measurement (OBN)

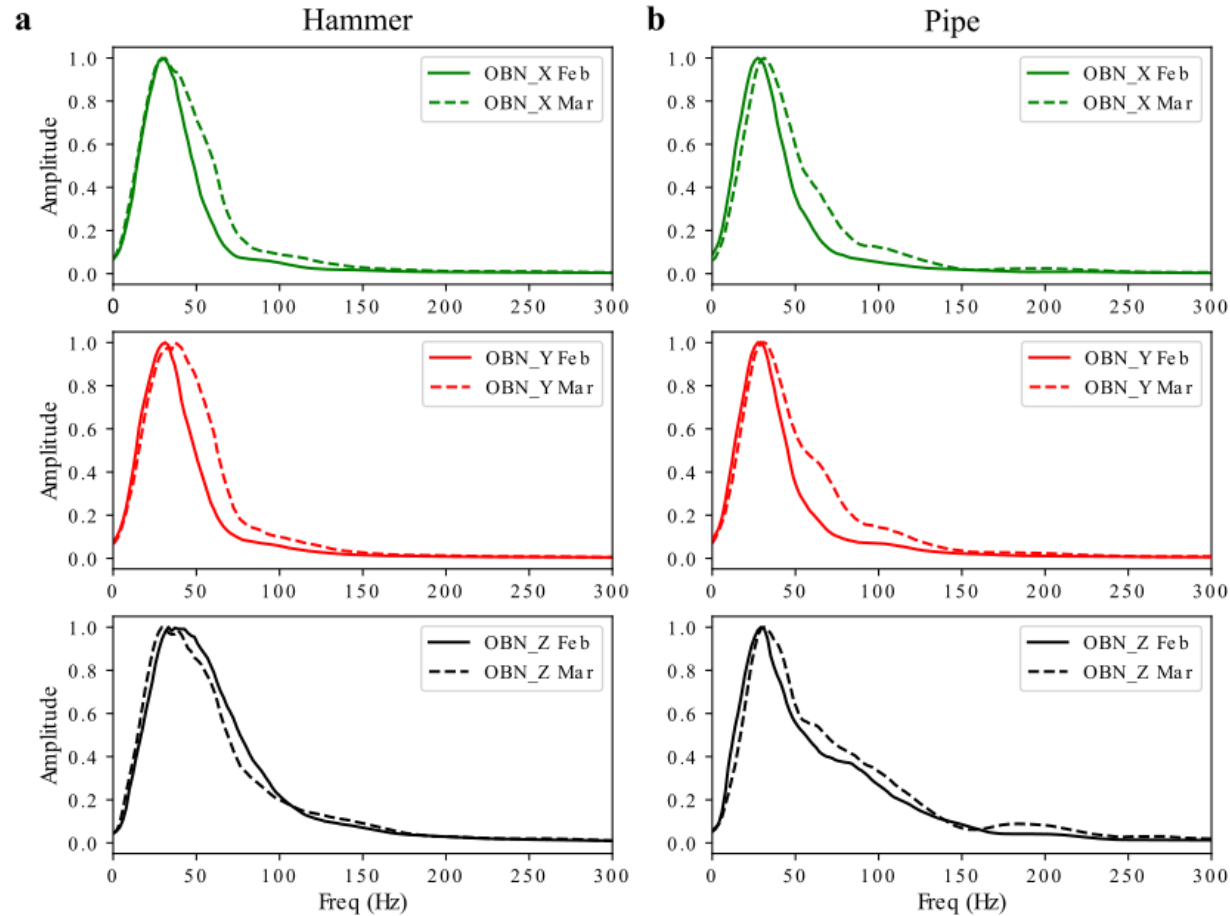
Test setup

- Source: Hammer and pipe
 - Low frequencies ~ 50 Hz
 - 1 m spacing
- Receiver
 - DMT geophones, OBN
 - 1 m spacing
- 4D approach:
 - Same geometry before and after deinstallation
 - Repeatability of source signal

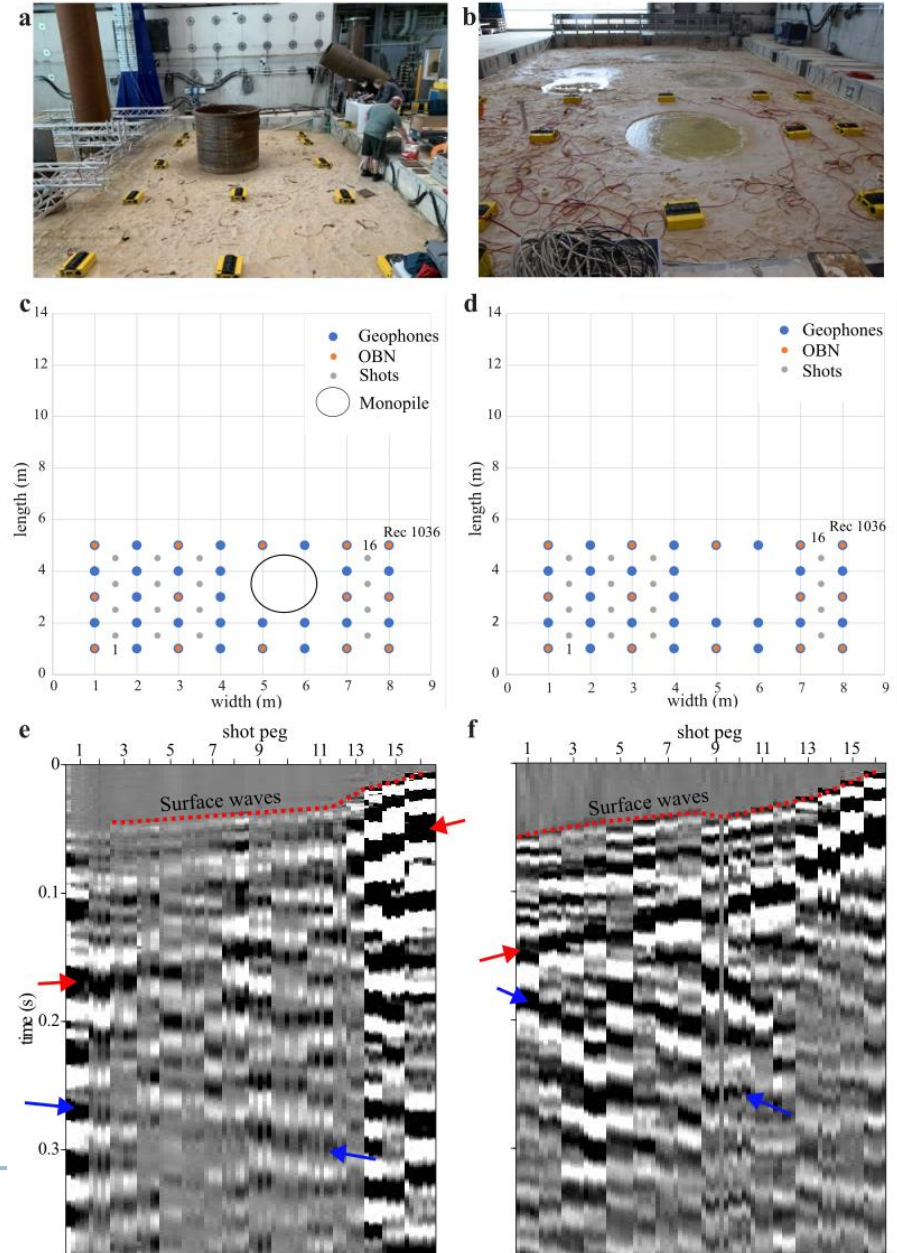


Preliminary test measurement Results

- OBN analysis

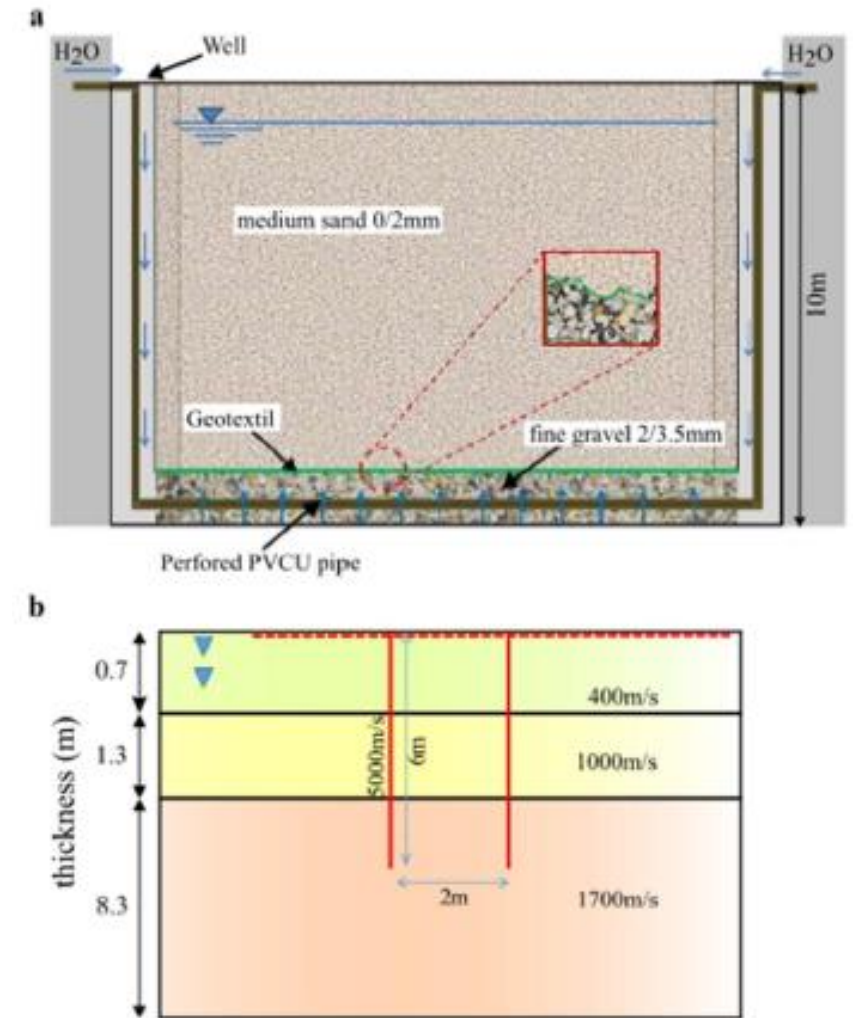
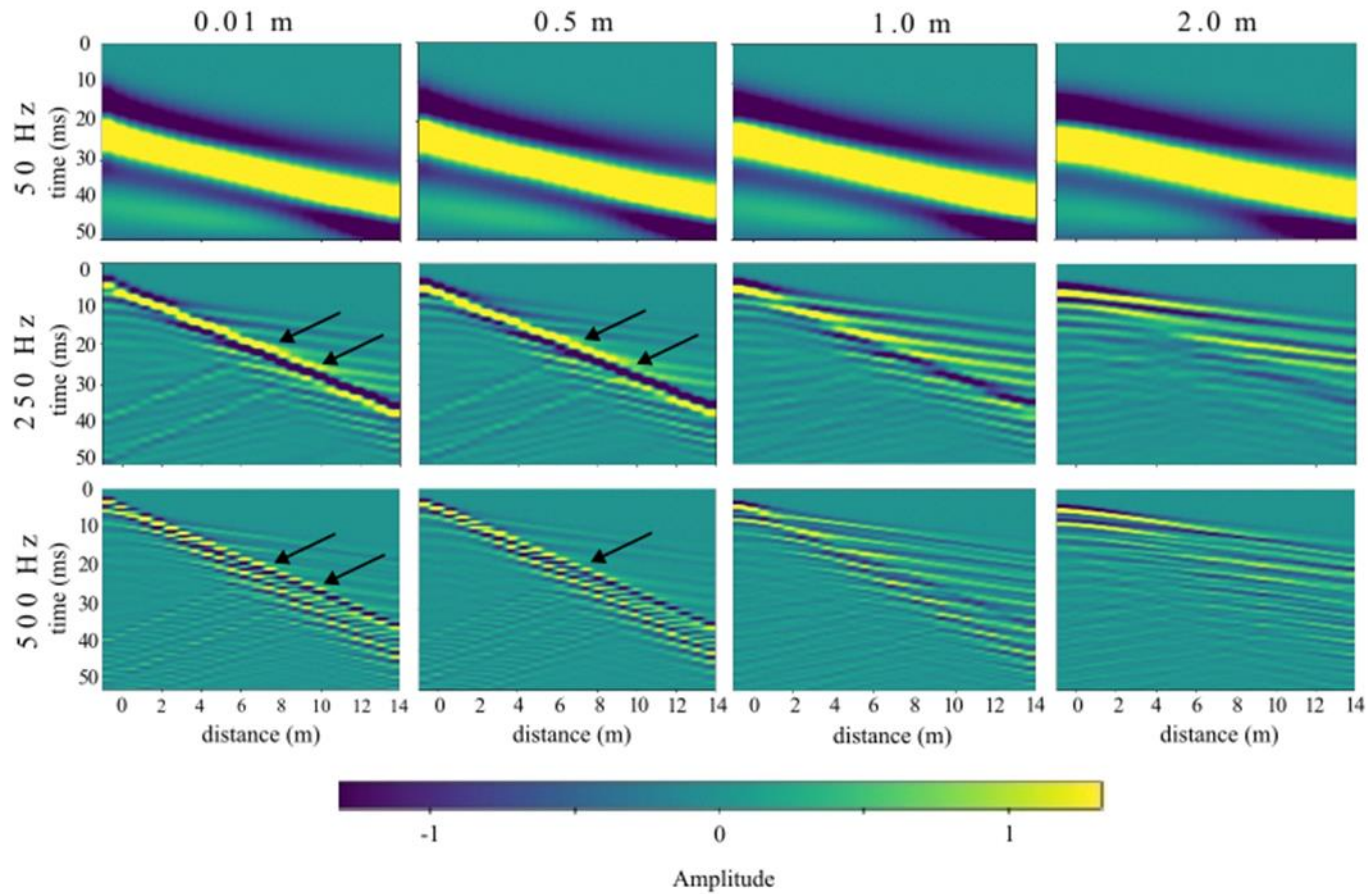


- Analysis of S-wave source (Pipe) on DMT sensors



Synthetic data modelling

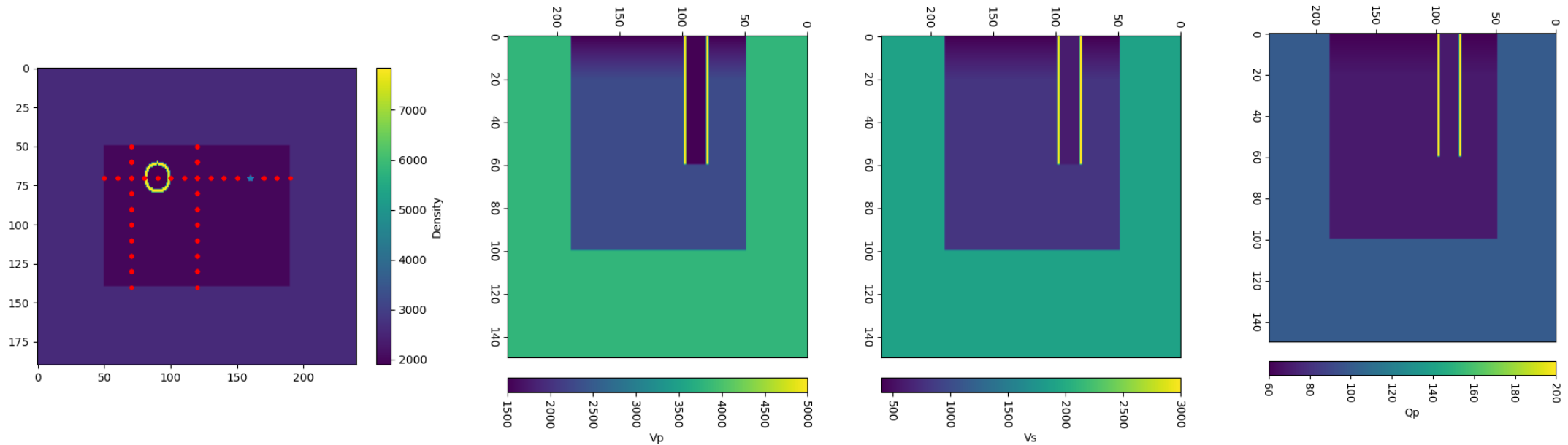
Frequency analysis - Acoustic waves



Synthetic data modelling

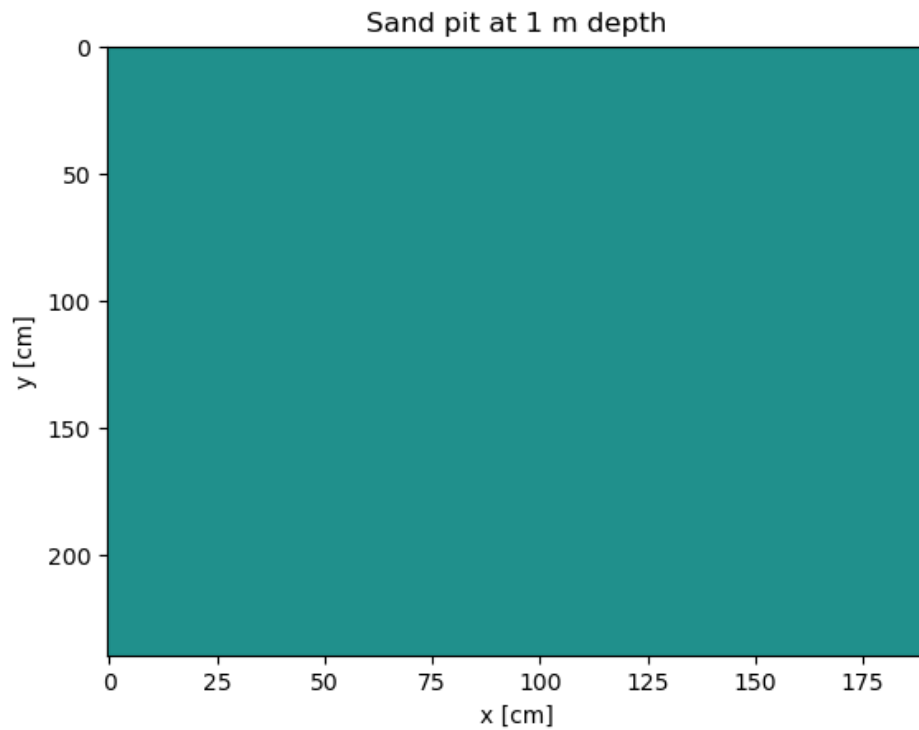
sofi3D

- Evaluation and improvement of test setup
- Evaluation of influence of different objects
- Definition of test parameters
- Preparation and testing of data processing

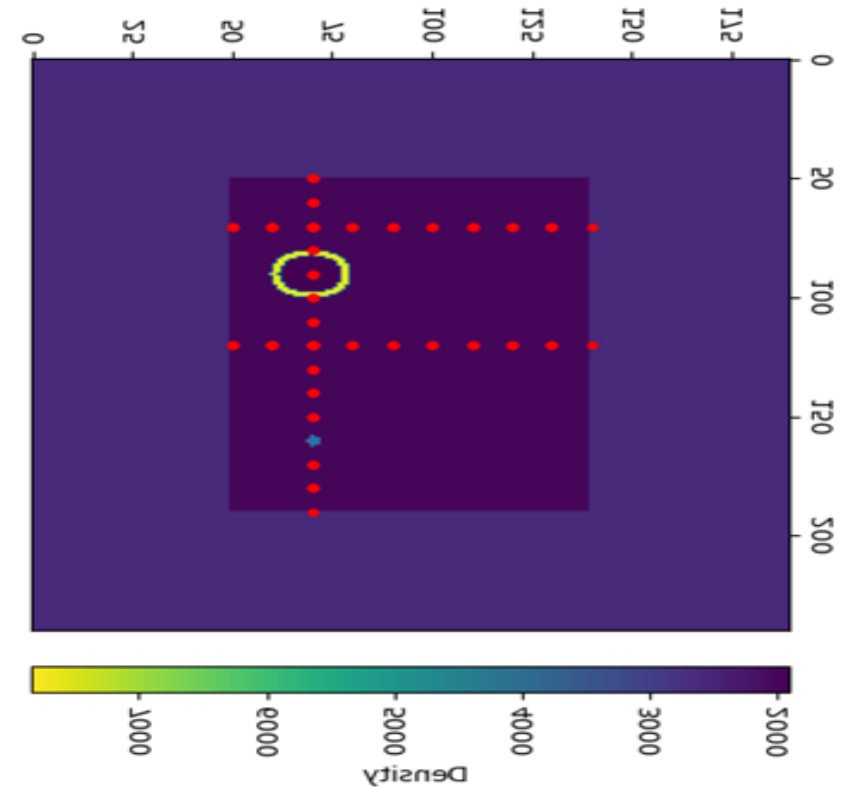


Synthetic data modelling

sofi3D



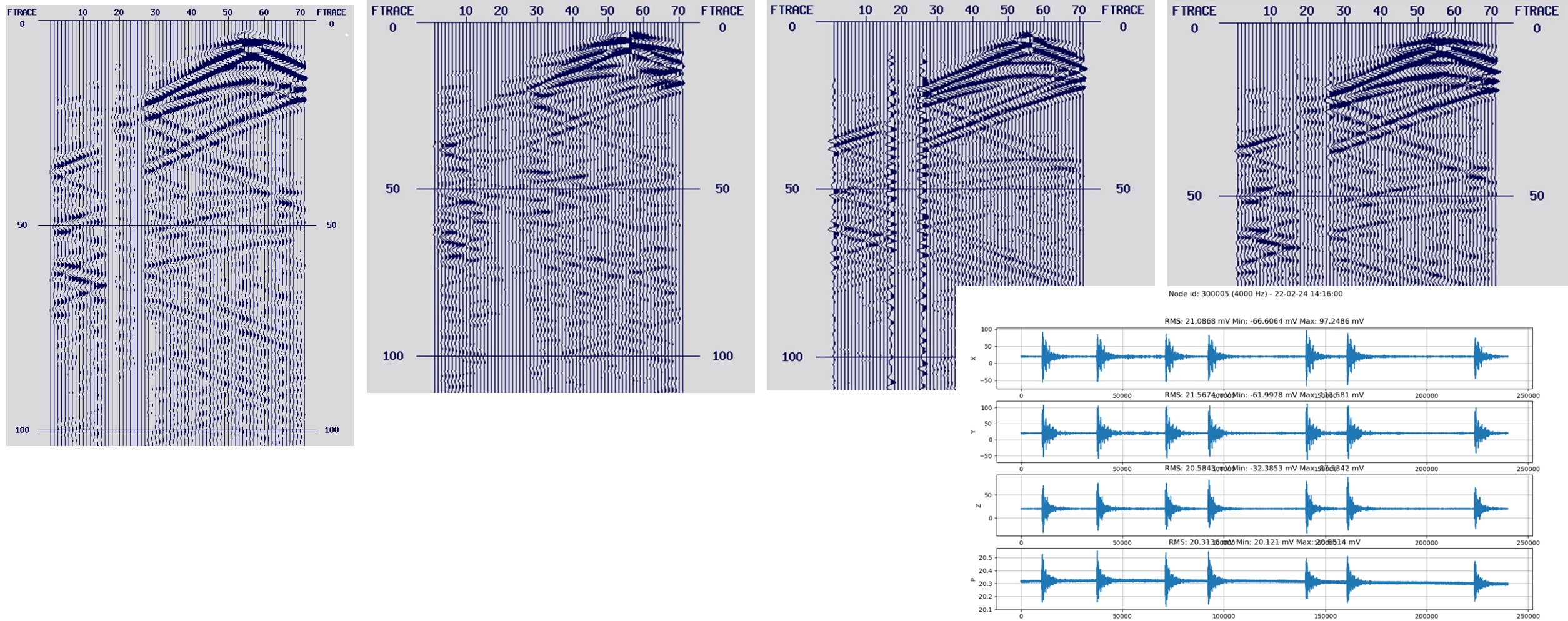
■ div



Synthetic data modelling

sofi3D

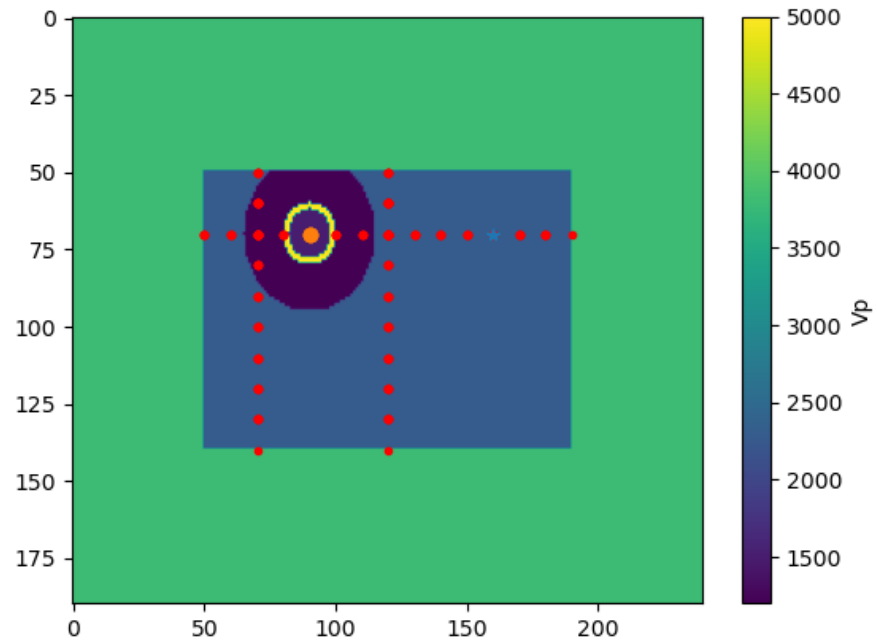
- V_y , v_x , curl, div



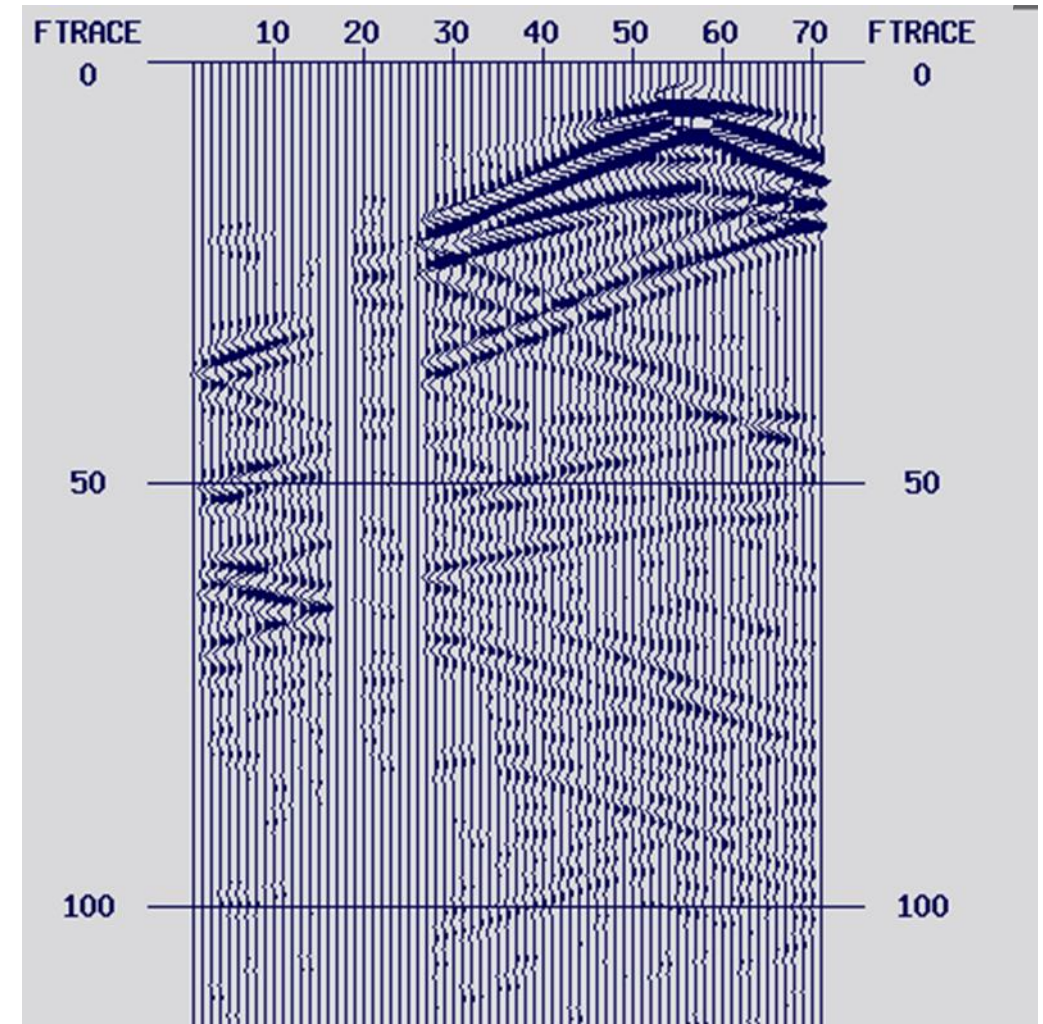
Synthetic data modelling

sofi3D

- Influence zone: 20 % decrease in density



- 250 Hz
- V_y component



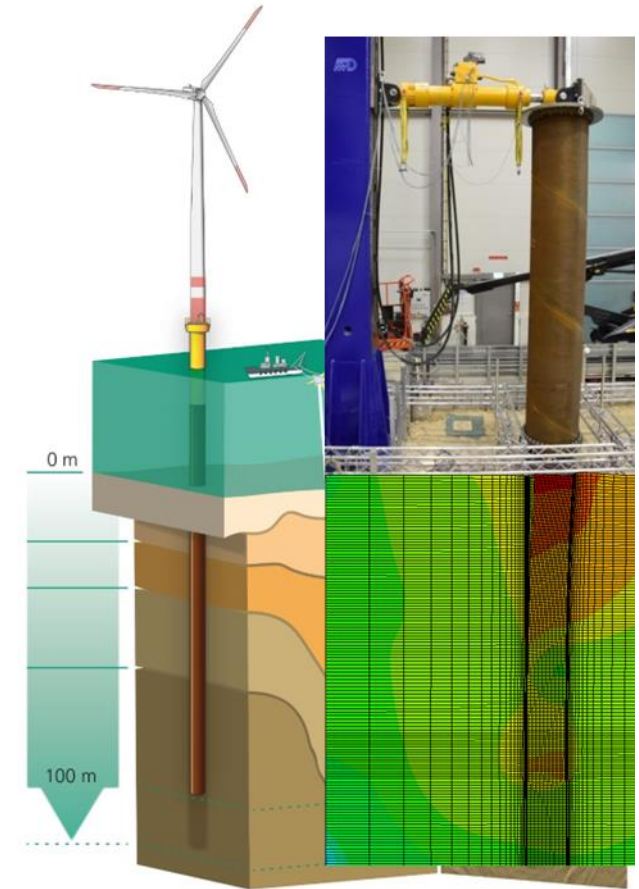
Analysis and Interpretation

Concept

- Evaluation of installation effects
- Analysis using different techniques (tomography, inversion)
- Passive vs active
- Correlation of seismic data to geotechnical data (CPT)
- Assessment of applicability in offshore conditions

Spring – Summer 2024

- 2nd Stage Experiment
 - Higher frequency source
 - Different setup during (hammer / vibration):
 - Pre-installation
 - Installation
 - Post-installation





Thanks a lot for
your attention!

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