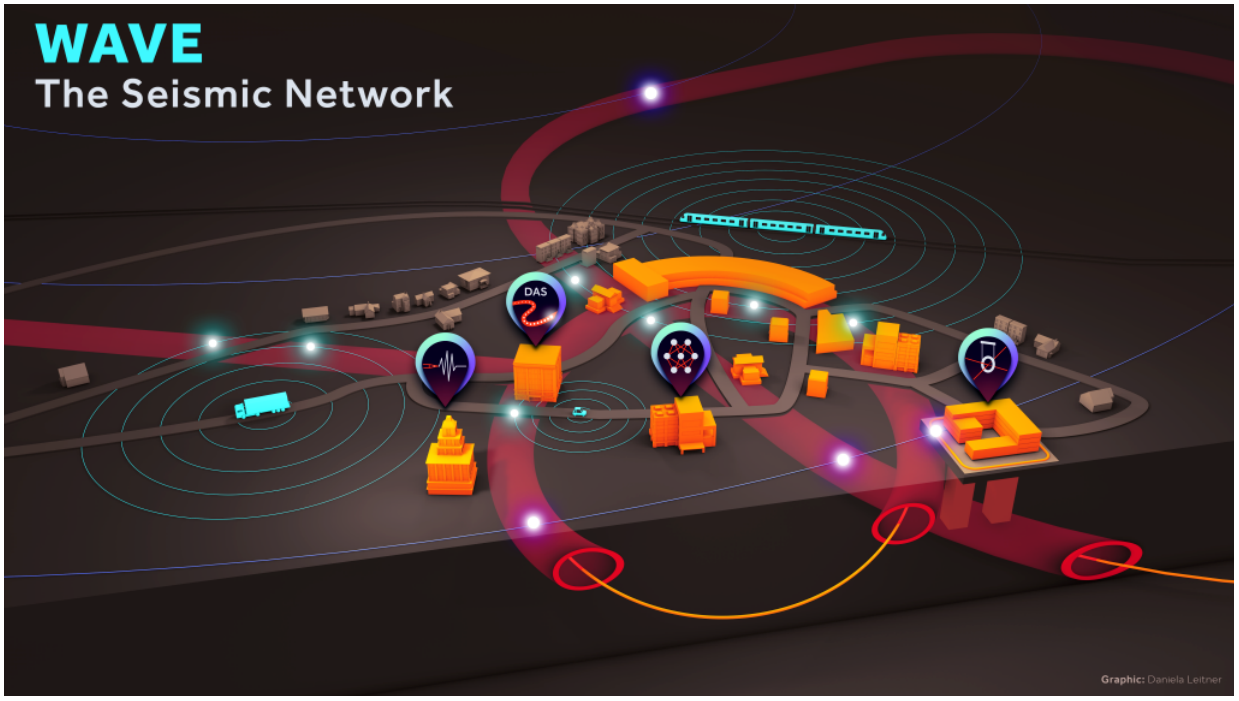


# Master's & PhD Opportunities

Thesis topics in Distributed Acoustic Sensing (DAS) and seismic data analysis

## Why work with WAVE?

The WAVE project provides unique Distributed Acoustic Sensing (DAS) data from large-scale research infrastructures such as DESY and the European XFEL. Students and PhD candidates work with real-world data, modern signal processing techniques, and interdisciplinary applications ranging from seismology to infrastructure monitoring.

## General Information

- **Location:** DESY, Hamburg, Germany
- **Start:** By arrangement
- **Contact:** Dr. Markus Hoffmann

The projects are embedded in an active research environment with established collaborations and contacts to the following universities:

- Helmut Schmidt University Hamburg (HSU)
- Universität Hamburg (UHH)
- RWTH Aachen University
- University of Münster

Depending on scientific progress and mutual interest, Master's thesis topics may be extended into PhD projects. Funding opportunities for follow-up doctoral research and institutional collaborations may be explored.

A Distributed Acoustic Sensing (DAS) interrogator and fiber infrastructure already exist at and around DESY. Further information can be found at wave-hamburg.eu.

## Master's Thesis Topics

- Signal processing and denoising of DAS data
- Detection and classification of seismic events using DAS
- Traffic and vibration analysis from urban fiber networks
- Comparison of DAS measurements with conventional seismometers
- Visualization techniques for large DAS datasets
- Machine learning approaches for event detection in DAS data

Master's projects typically focus on a well-defined scientific or technical question and can be adapted to backgrounds in physics, geophysics, data science, or engineering.

## PhD Research Topics

- Advanced seismic imaging using large-scale DAS arrays
- Urban seismology and infrastructure monitoring with fiber optics
- Wave propagation studies in complex underground environments
- Long-term monitoring of anthropogenic and natural seismic sources
- Scalable data processing pipelines for DAS at research facilities
- Integration of DAS data into multi-sensor monitoring systems

PhD projects are embedded in ongoing research collaborations and may involve close interaction with DESY, European XFEL, and external academic partners.

## Supervision & Environment

Students are supervised by researchers from the WAVE consortium and benefit from access to high-quality experimental data, computing resources, and an international research environment.

Topics can often be tailored to individual interests and academic backgrounds.

## How to apply

If you are interested in a Master's thesis or PhD position, please contact us with a short description of your background, interests, and preferred topic area.

Applications and informal inquiries are welcome year-round.

## Available Topics

- Master's Thesis: Vibration Coupling into Building Foundations
- Master's Thesis: Seismic Wave Dispersion on the DESY Campus
- Master's Thesis: Plant Monitoring using DAS
- PhD Topic: ML-based Seismic Source Localization

## Master's Thesis Topic: Characterization of Vibration Coupling from Subsurface to Building Foundations using Distributed Acoustic Sensing (DAS)

**Location:** DESY, Hamburg, Germany

### Topic

Experimental and data-driven determination of coupling factors and transfer functions between subsurface vibrations and the vibrational response of a building foundation using Distributed Acoustic Sensing (DAS).

### Project description

The aim of this Master's thesis is to investigate how seismic or machine-induced vibrations originating in the subsurface are coupled into a building foundation. For this purpose, an innovative measurement setup based on Distributed Acoustic Sensing is available.

One fiber-optic loop is deployed in the subsurface around the building, while a second fiber is attached directly to the concrete foundation (either glued onto or embedded within the structure).

By comparing the spatially resolved DAS signals from both fiber loops, coupling factors and transfer functions between ground motion and foundation response will be determined and characterized. The project offers significant freedom for developing and testing own ideas in data analysis, signal processing, and modeling.

### Tasks (examples)

- Planning and execution of DAS measurement campaigns
- Signal processing and analysis of time- and space-resolved vibration data
- Development of methods to estimate transfer functions between subsurface and foundation
- Optional application of data-driven or model-based system identification approaches
- Interpretation of results in a physical and engineering context

### Required background

- Students from physics, geophysics, building physics, or electrical engineering
- Alternatively: data science, computer science, mechanical engineering, or related engineering disciplines
- Interest in vibration analysis and structural dynamics
- Interest in sensor technology and data processing
- Programming experience (e.g. Python or MATLAB) is an advantage

## Master's Thesis Topic: Seismic Wave Dispersion on the DESY Campus

### Project background

Seismic wave propagation in the near-surface environment is governed by different wave types. Two of these are body waves: compressional (P) waves and shear (S) waves. In addition, two types of surface waves exist: Rayleigh waves and Love waves.

The propagation velocity of surface waves depends on wavelength and on the vertical structure of the subsurface. By analyzing this frequency-dependent dispersion, valuable information about soil properties and layering can be obtained.

Using Distributed Acoustic Sensing (DAS) data recorded on the DESY campus, this Master's thesis aims to determine the frequency-dependent propagation velocities of seismic surface waves.

### Research objectives

Large volumes of DAS data have already been collected, enabling the use of statistical analysis methods. One possible approach is to extract many individual measurements of propagation velocities for each frequency bin and apply clustering techniques to separate the different seismic wave types. Alternative data-driven or physics-informed approaches are also possible and can be explored within the project.

### Tasks

- Analysis of DAS data recorded on the DESY campus
- Extraction of frequency-dependent propagation velocities of seismic waves
- Statistical analysis and clustering of velocity estimates to distinguish wave types

- Evaluation and interpretation of dispersion curves in a geophysical context
- Visualization of dispersion relations and analysis results
- Handling and processing of large datasets on a Linux-based computing cluster

### Required background

- Enrollment in or completion of a Master's program in physics, geophysics, or a related field
- Basic understanding of wave physics and signal processing
- Interest in data analysis and statistical methods
- Programming skills, preferably in Python
- Willingness to work with large datasets in a Linux computing environment

## Master's Thesis Topic: Plant Monitoring using Distributed Acoustic Sensing (DAS)

**Location:** DESY, Hamburg, Germany

### Topic

Development of a neural monitoring system for early detection of anomalies in large-scale technical facilities using Distributed Acoustic Sensing (DAS).

### Project description

In this Master's thesis, an innovative approach for condition monitoring of technical infrastructure is to be developed and evaluated. Optical fibers are installed on a large technical system, such as a cryogenic plant for helium liquefaction.

A DAS interrogator records spatially resolved acoustic signals and vibrations along the fiber. Based on these data, the goal of the thesis is to develop a machine-learning -- based monitoring system, using neural networks, that is able to detect anomalies and indicate maintenance needs at an early stage -- before failures occur.

### Tasks (examples)

- Setup and characterization of the DAS measurement system
- Data acquisition and preprocessing (signal processing, feature engineering)
- Development and training of a neural network for anomaly detection
- Validation and testing using real operational data
- Evaluation of detection performance and robustness under realistic conditions

### Required background

- Students from data science, computer science, physics, or geophysics
- Alternatively: control engineering, electrical engineering, aerospace engineering, or related fields
- Interest in measurement and sensor technology
- Interest in machine learning and data-driven methods
- Programming experience (preferably Python) is an advantage

## PhD Topic: Machine Learning for Seismic Source Localization using Distributed Acoustic Sensing (DAS)

**Location:** DESY, Hamburg, Germany

### Project background

Deutsches Elektronen-Synchrotron (DESY) in Hamburg is one of the world's leading research centers for

accelerator physics and synchrotron radiation. In the research group of Dr. Hoffmann, an innovative project focuses on the processing and analysis of seismic data from a large-scale Distributed Acoustic Sensing (DAS) network.

The DAS network is deployed across the DESY campus as well as inside the accelerator tunnels of PETRA III and the European XFEL. The goal of the project is to precisely localize seismic disturbance sources, to better understand their coupling to buildings and tunnel structures, and thereby contribute to long-term improvements of beam stability and femtosecond-level timing synchronization.

The project is carried out in close collaboration with Helmut Schmidt University Hamburg (HSU), Universit&#65533;t Hamburg (UHH), and accelerator physics groups at DESY.

### PhD research focus

The PhD project focuses on the development and application of machine-learning-- based methods for the spatial localization of seismic noise sources using DAS measurement data. The objective is to robustly and efficiently identify disturbance sources in complex environments such as campuses, tunnels, and buildings.

The PhD project is embedded in a larger interdisciplinary team:

- One postdoctoral researcher develops realistic synthetic training data and subsurface models, which are used, among other purposes, for training neural networks.
- A second postdoctoral researcher works on the classification of seismic events using DAS data. A later extension of the PhD project in this direction is optional and can be pursued in close collaboration.

### Tasks and research topics

- Development of machine-learning algorithms for seismic source localization (e.g. on 2D/3D spatial grids)
- Analysis and preprocessing of large DAS datasets
- Use of synthetic training data from seismic simulations (in collaboration with a postdoc)
- Evaluation of localization results with respect to physical plausibility and accelerator operation
- Visualization of extracted parameters and integration into existing analysis and control systems
- Close collaboration with interdisciplinary teams at DESY and external partners
- Participation in the ErUM-SESAM initiative and related collaborative projects
- Contribution to outreach activities and supervision of Bachelor's and Master's theses

### Your profile

- Completed university degree (Master's or equivalent) in physics, computer science, geosciences, mechanical engineering, or a related field
- Strong background in data analysis and/or machine learning
- Programming experience, preferably in Python (knowledge of C/C++, MATLAB is an advantage)
- Experience with Linux-based systems and computing clusters is desirable
- Interest in interdisciplinary research at the interface of physics, data science, and engineering
- Very good command of written and spoken English

### We offer

- A challenging PhD project in an internationally visible research environment
- Access to unique measurement data and state-of-the-art research infrastructure
- Intensive scientific supervision within an active interdisciplinary team
- National and international collaboration opportunities
- Participation in conferences, workshops, and summer schools