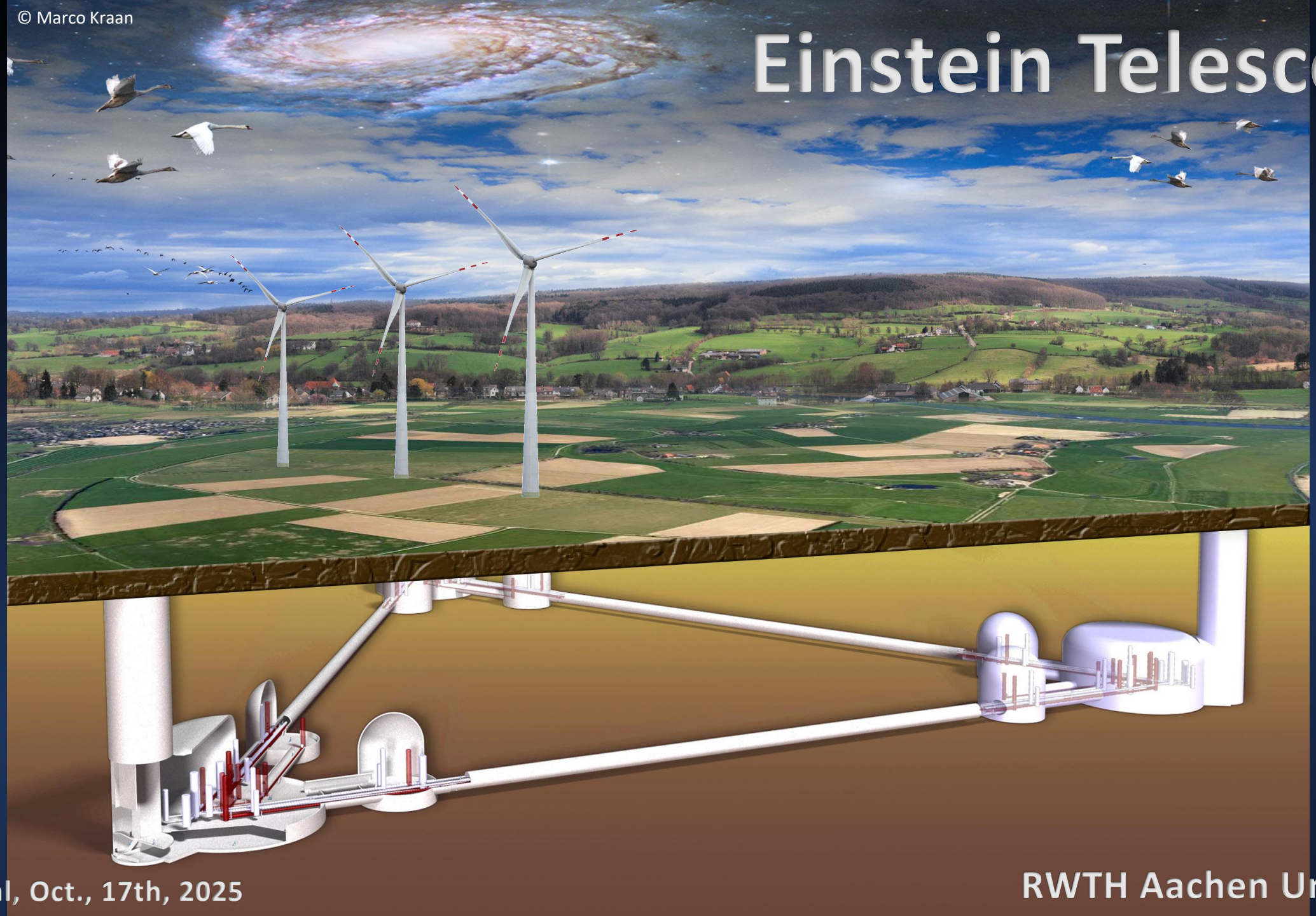


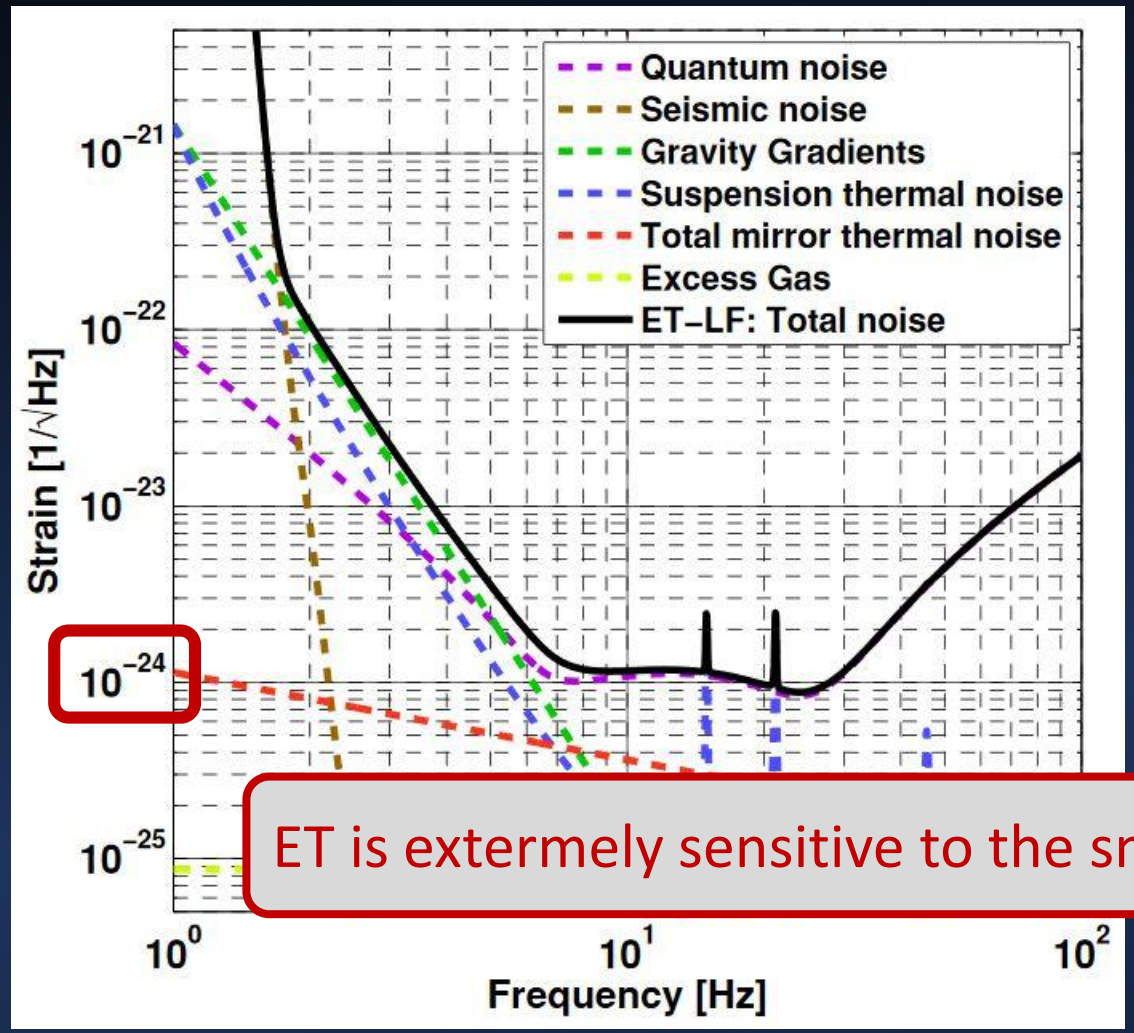
Einstein Telescope

Achim Stahl, Oct., 17th, 2025

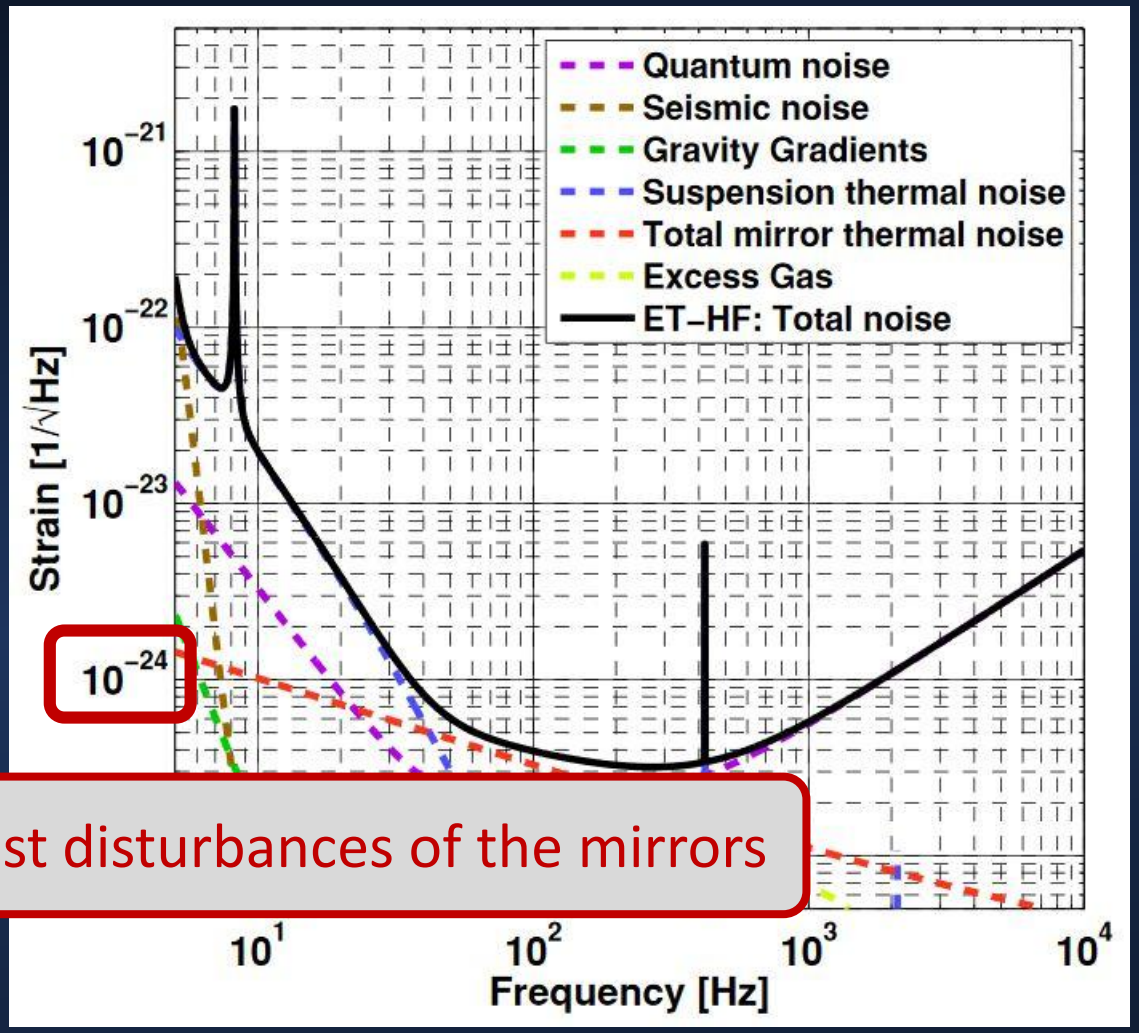
RWTH Aachen University

The noise

Low-frequency (cryogenic)



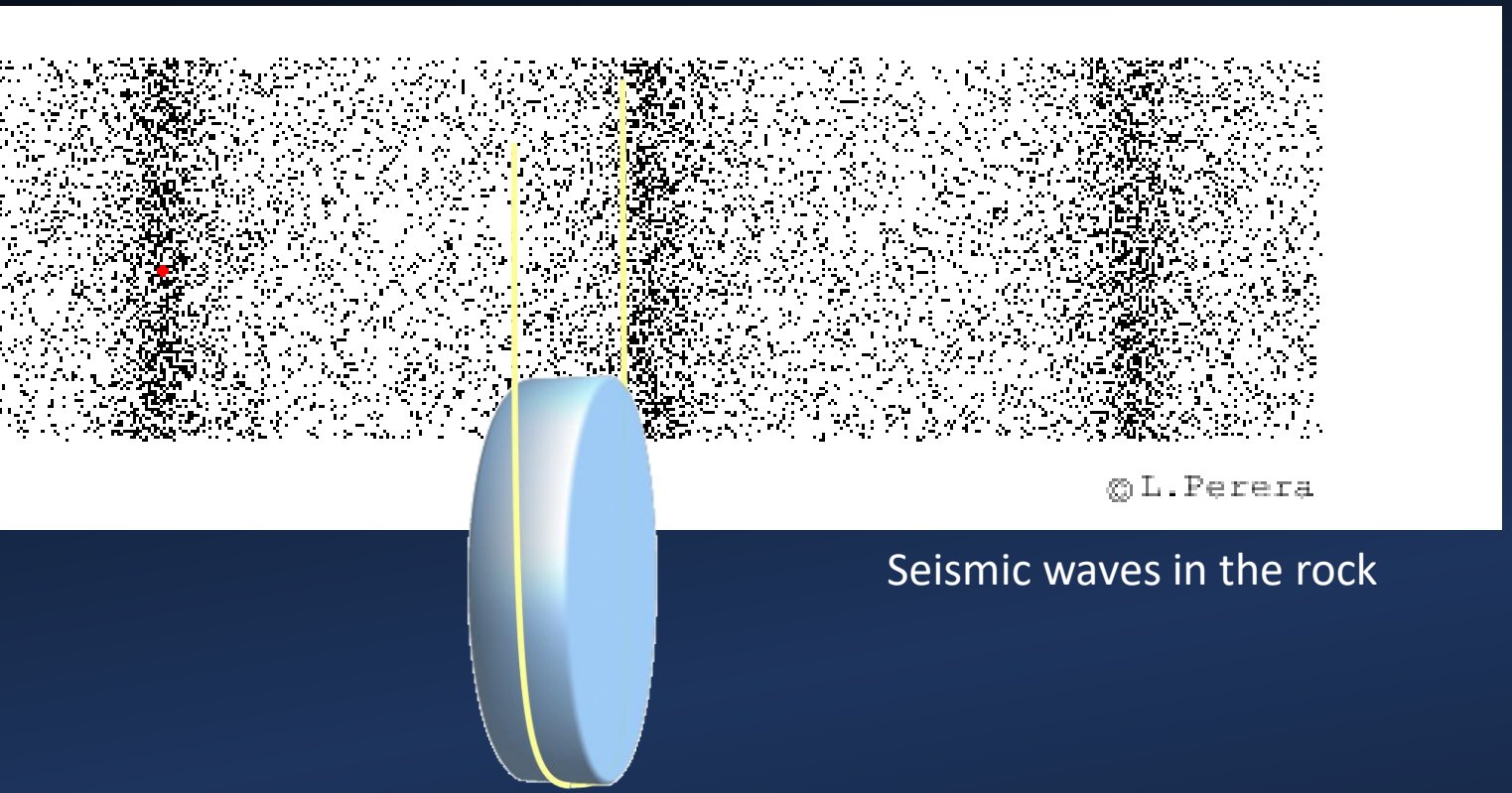
High-frequency (conventional)



ET is extermely sensitive to the smallest disturbances of the mirrors

Newtonian noise / Gravity Gradient Noise

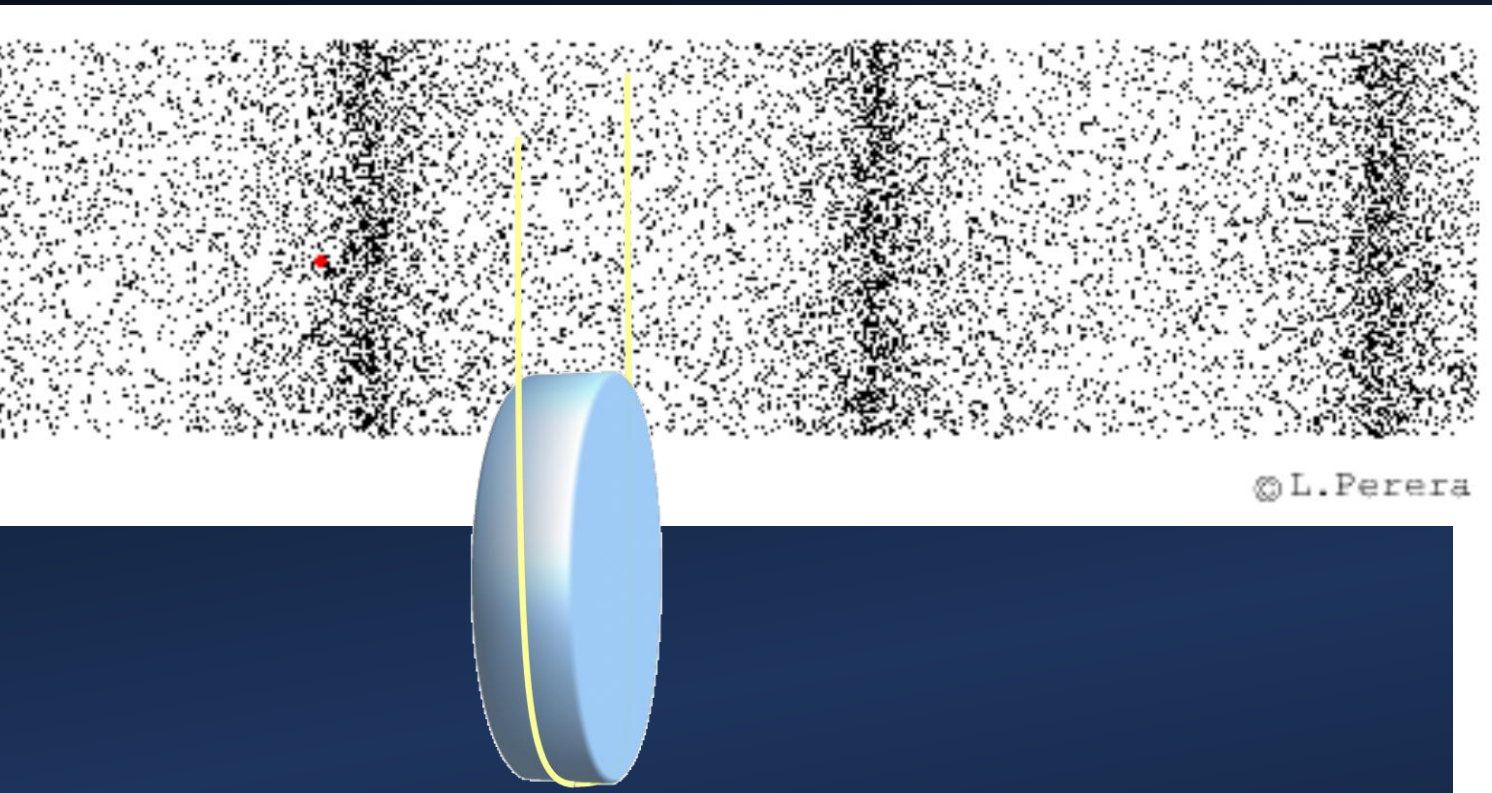
Attraction by moving objects cannot be shielded



Seismic waves in the rock

Newtonian noise

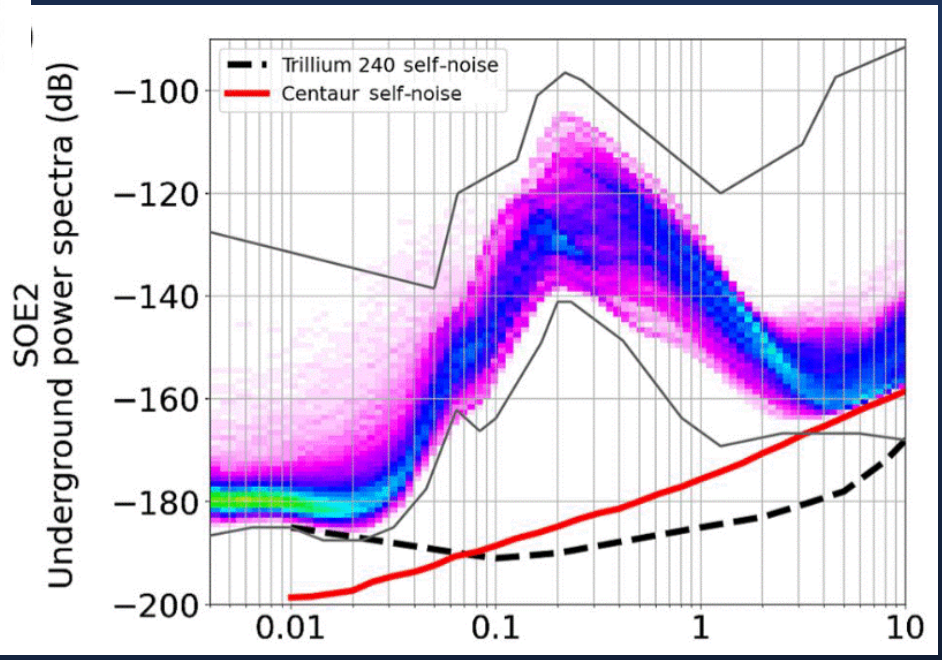
Attraction by moving objects cannot be shielded



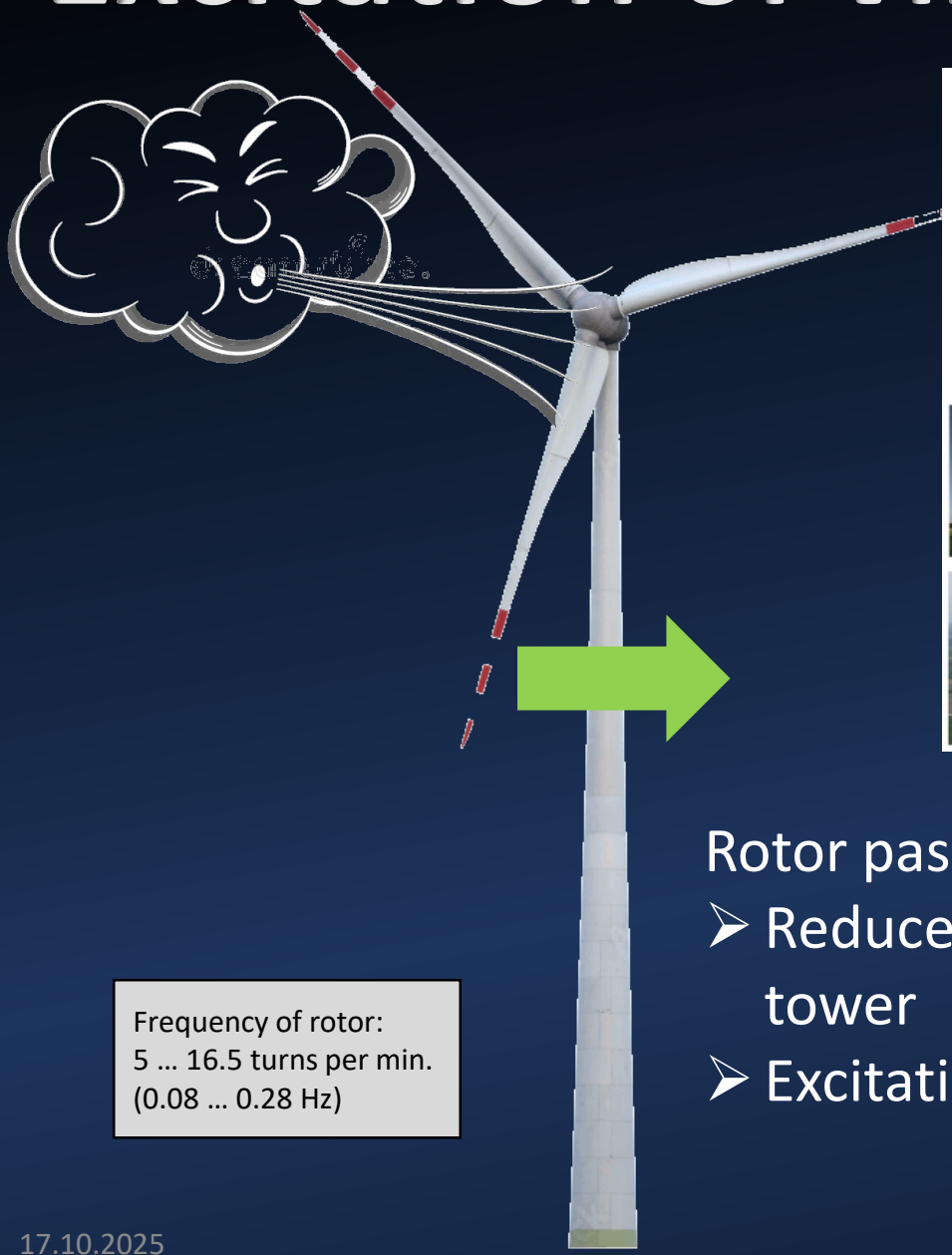
However, WEA add to the noise!

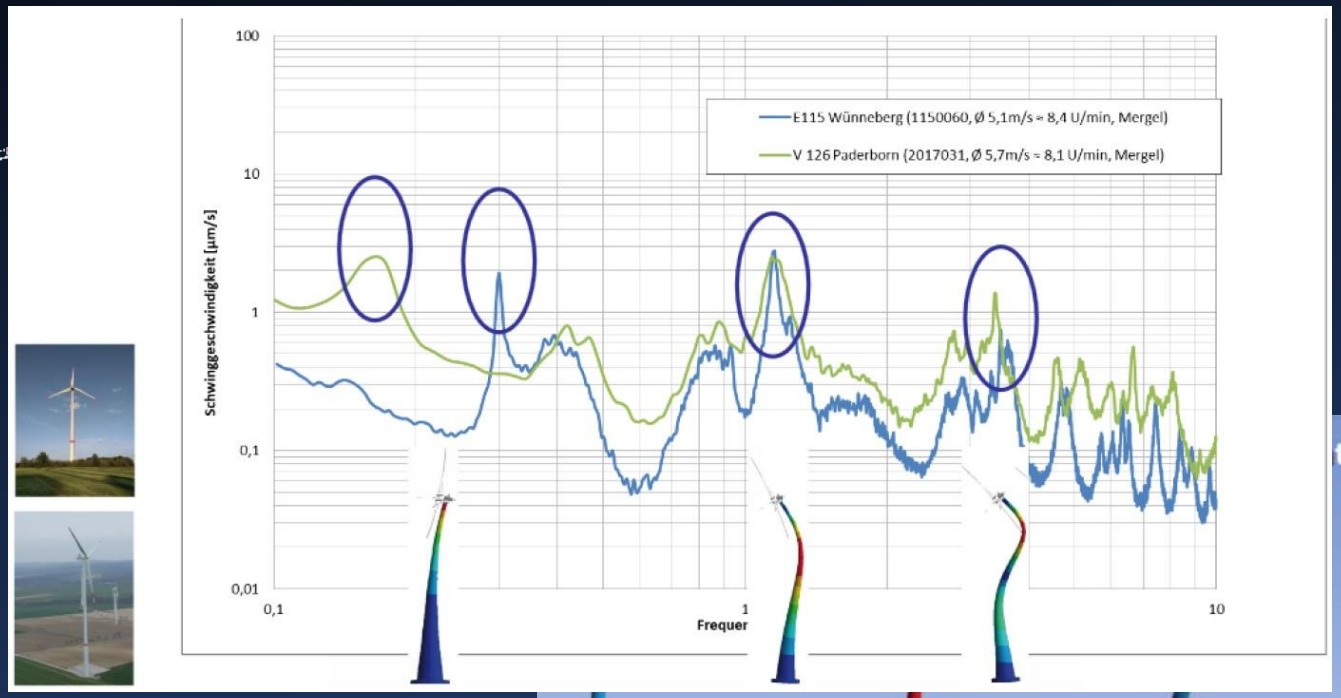
Find a quiet location !

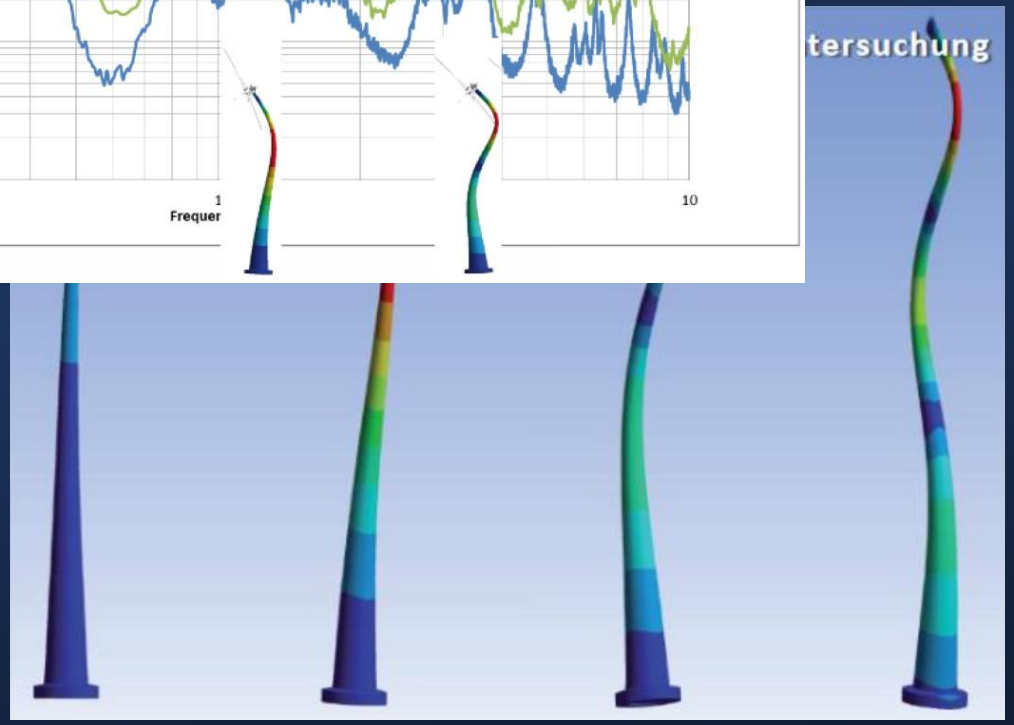
Los Enatos Sardenia



Excitation of vibrations



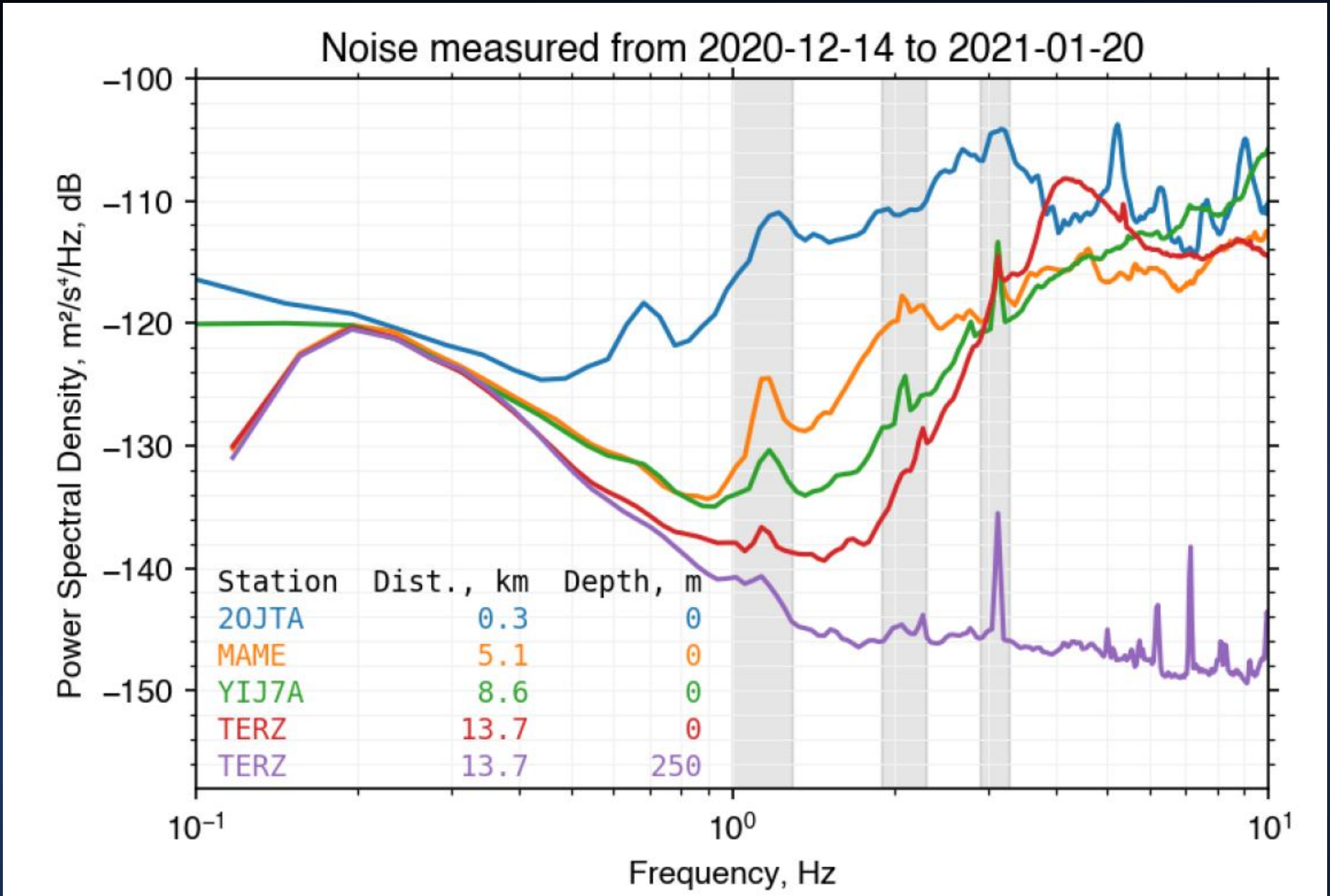




Rotor passes tower:

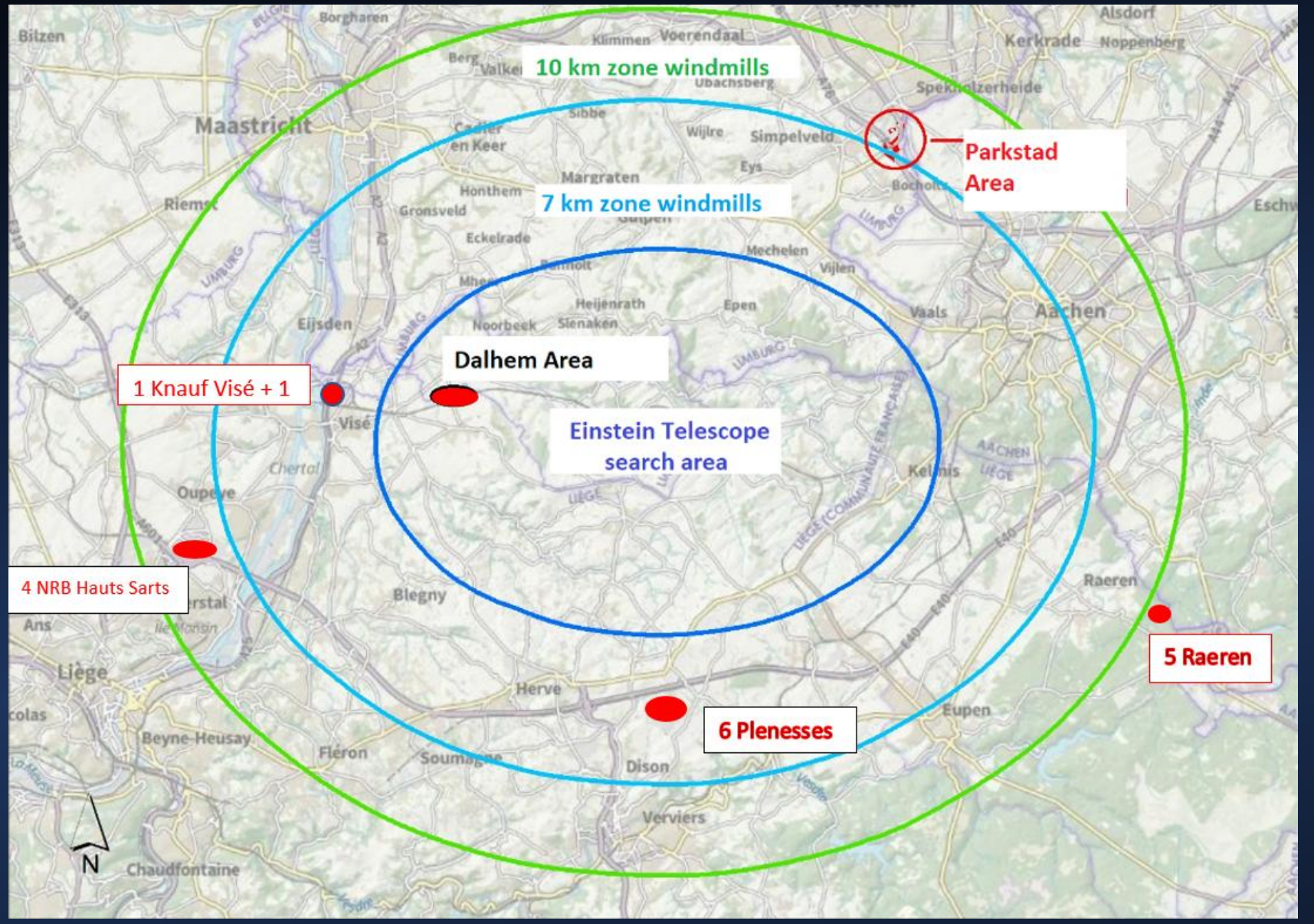
- Reduced pressure on the tower
- Excitation of oscillation

Frequency of rotor:
5 … 16.5 turns per min.
(0.08 … 0.28 Hz)

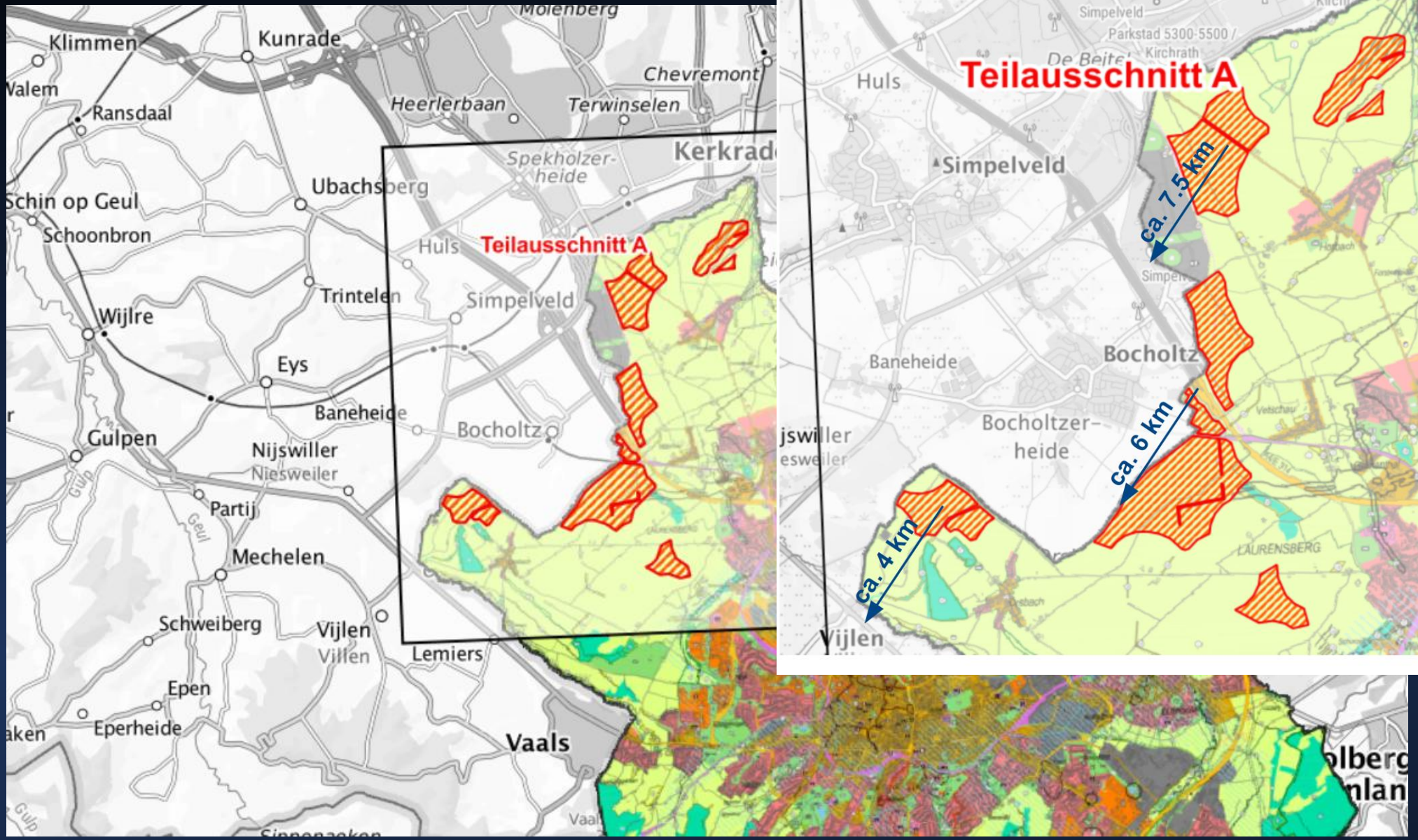


noise from Aachen windpark; measurement by Sahar Shani-Kadmiel

Exclusion Regions



Aachen Windparks



dbMiss: WP8 – Einstein Telescope

Our task: Achieve technical compatability between ET and WEAs
→ Develop technical solutions to reduce the seismic waves emitted from WEAs.
→ Technical solutions should be

- Efficient in reducing the emission
- Affordable (less than about 10% of the cost of the WEA)
- (Almost) ready to be used
- Campatible with the TÜV approval of the WEA

Technical approach:

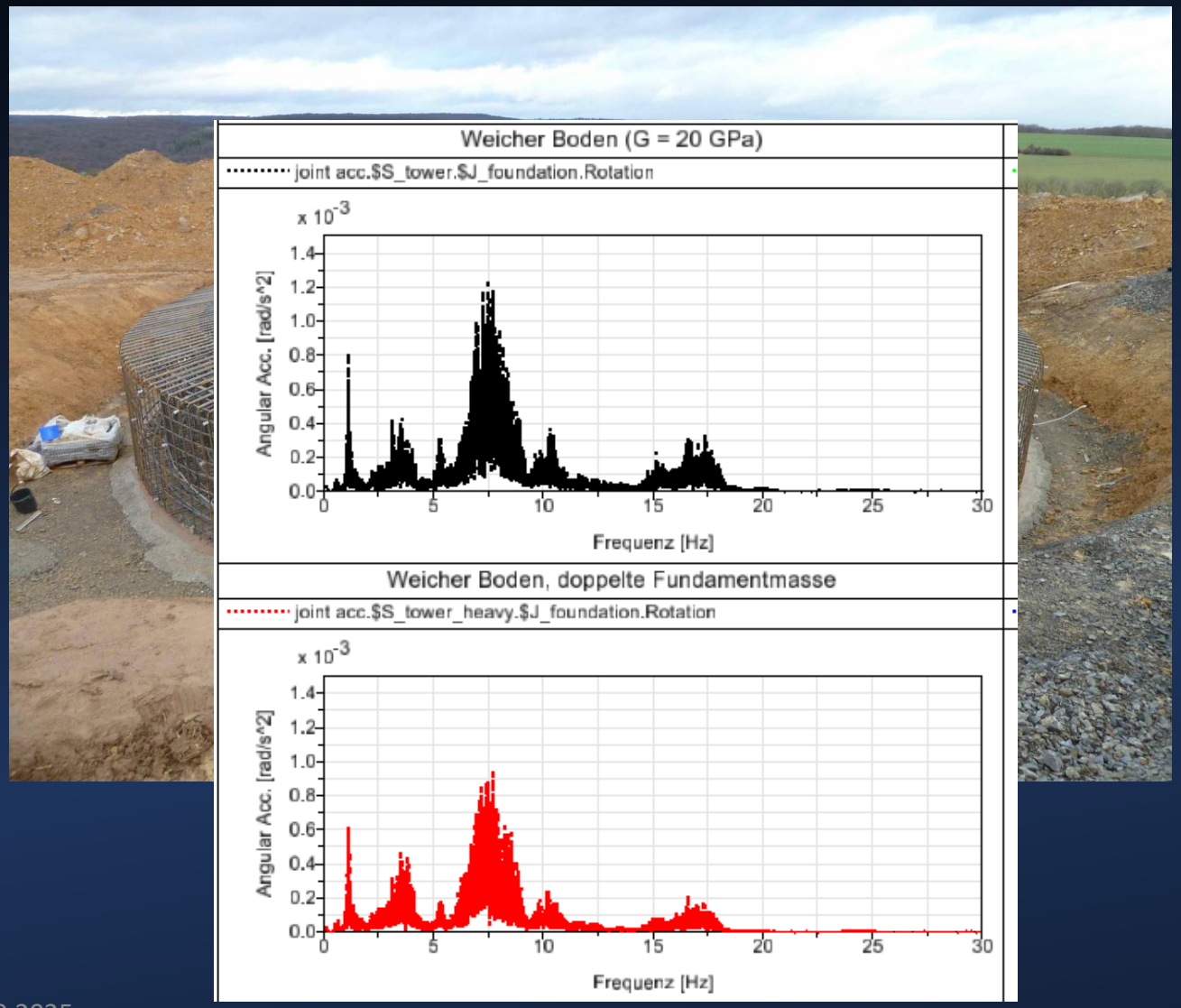
- reduce excitation
- dampen oscillation
- decrease coupling to underground

Technical Approach

Workshop: Feb. 15th, 2024, Aachen:
Identified five promising approaches

- Larger / more massive foundation
- Tuned mass dampers (pendulum)
- Pitch control
- Girder masts
- Active damping

Foundation



- Shallow foundations preferred over deep foundations: Aachen ✔
- Double the mass:
  30 – 50% Reduction; cost < 10%
- Wider Fundations:
  Reduction ?; no cost

Status

- Partner: RWTH Centre for Windpower Drives
- Simulations of a realistic WEA ongoing
- Good progress
- Report expected by the end of 2025

Tuned Mass Dampers

Very efficient

- better than x 1/10
- single frequency only

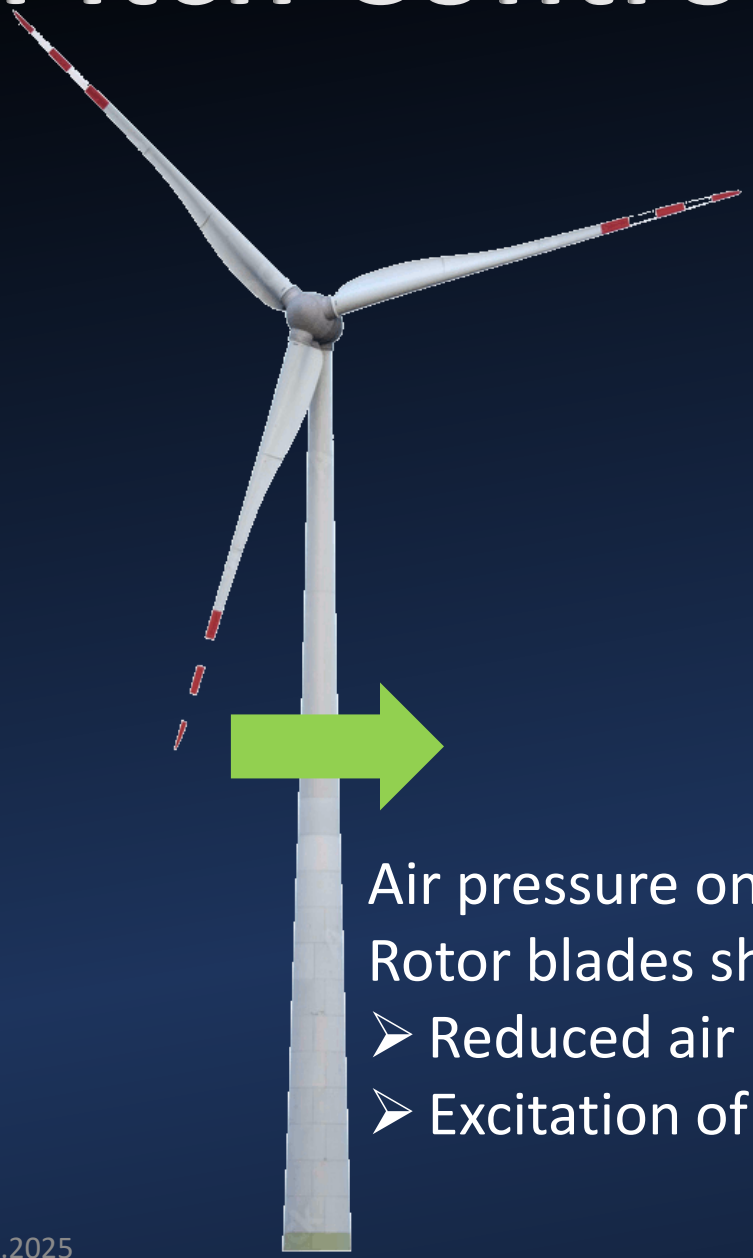
Cost:

- design ~ 50 k€
- hardware + installation

Status

- ESM was interested to provide the design
- Call for bids opened, but ESM did not reply (too busy with other coustomers)
- We are making contact with other vendors
- New call in preparation.

Pitch Control



Increase pressure on the rotor upon passage in front of the tower

But:

- ➢ Different impact point of force
- ➢ Pitch control is used for other purposes (optimization of efficiency)

Reduction ?

Air pressure on the tower

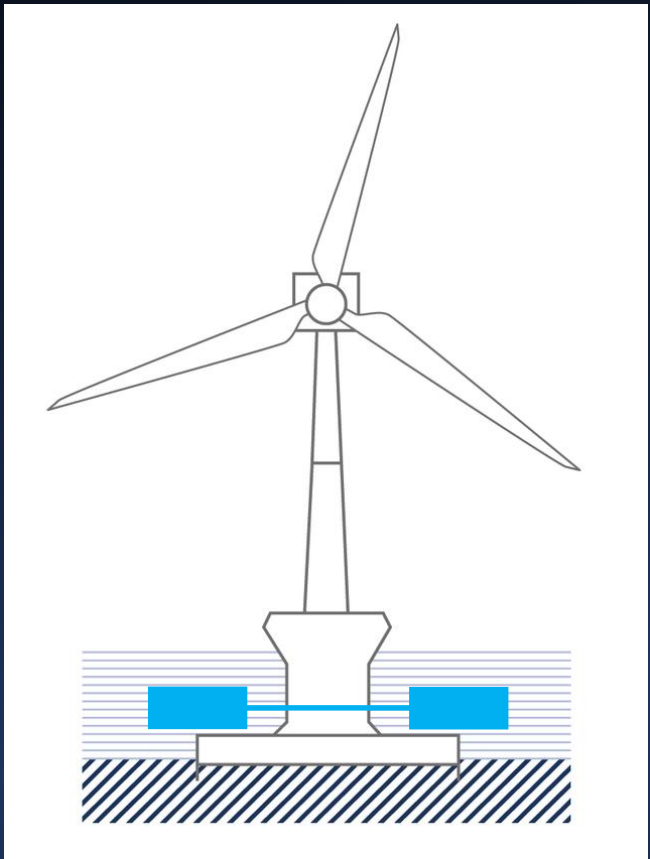
Rotor blades shield the tower:

- ➢ Reduced air pressure
- ➢ Excitation of tower modes

Status

- Found a partner: Wind2Energy.
- Call for bids in preparation.
- Report expected early of next year.

Active Damping



Active counter motion of masses
i.e. pumping water between tanks

- Optimal location: gondola, but space?
- Alternatively on the foundation

Probably a good measure; but substantial effort.

Status

- Discussed many different approaches.
- Now preferred solution, yet.
- Will probably need a substantial amount of R&D.
- Drop this measure for now?

Girder Masts

© ArcelorMittal
Laasow, Brandenburg
180 m Nabenhöhe

Largely permeable to wind
→ Less excistation

Potential vendors in Germany?

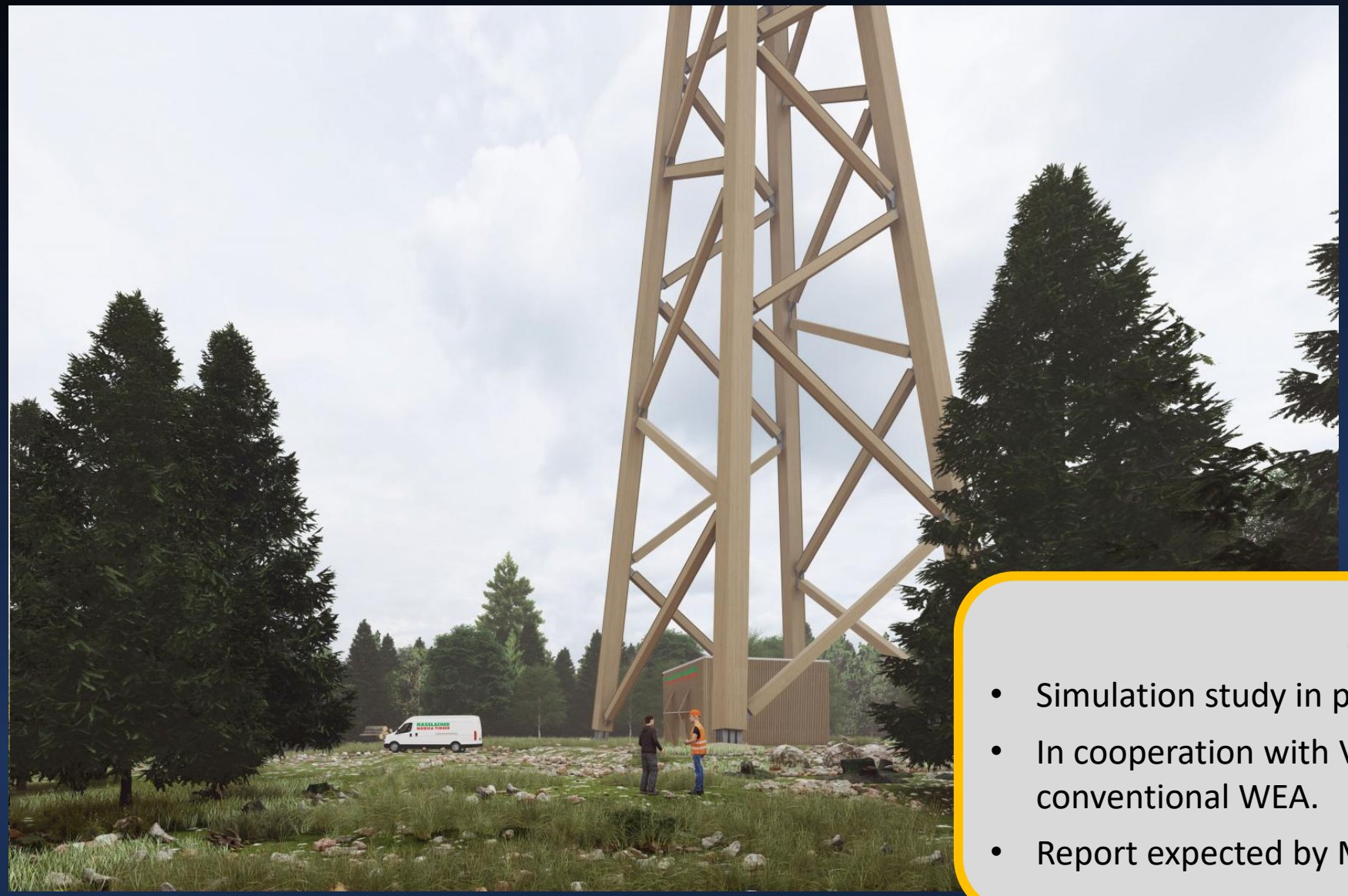
Girder Masts

Largely permeable to wind
→ Less excistation

Potential vendors in Germany?

Gicon
- Specialised in offshore WEA
- Now offering tall WEA
  300 m grider mast tower
- Construction has started in Schipkau

Wooden towers



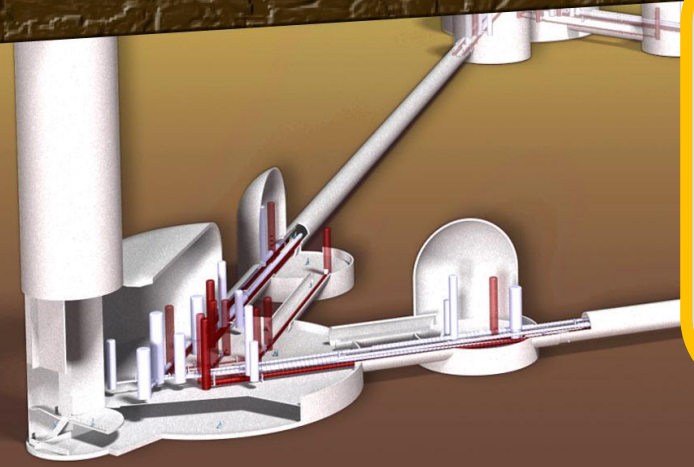
- Girder mast transparent to wind → low excitation
- Wooden structurs high damping → low amplitudes low elasticity → low frequencies

Status

- Simulation study in perparation with Hasslacher.
- In cooperation with Vensys for comparison to a conventional WEA.
- Report expected by March 2026.

© Hasslacher Green Tower

ET & wind turbines



Summary

- Technical solutions look okay.
- Good progress, but some delay with lengthy tendering processes.
- Final report by mid of 2026.

Achim Stahl, Oct. 17th, 2025

RWTH Aachen University