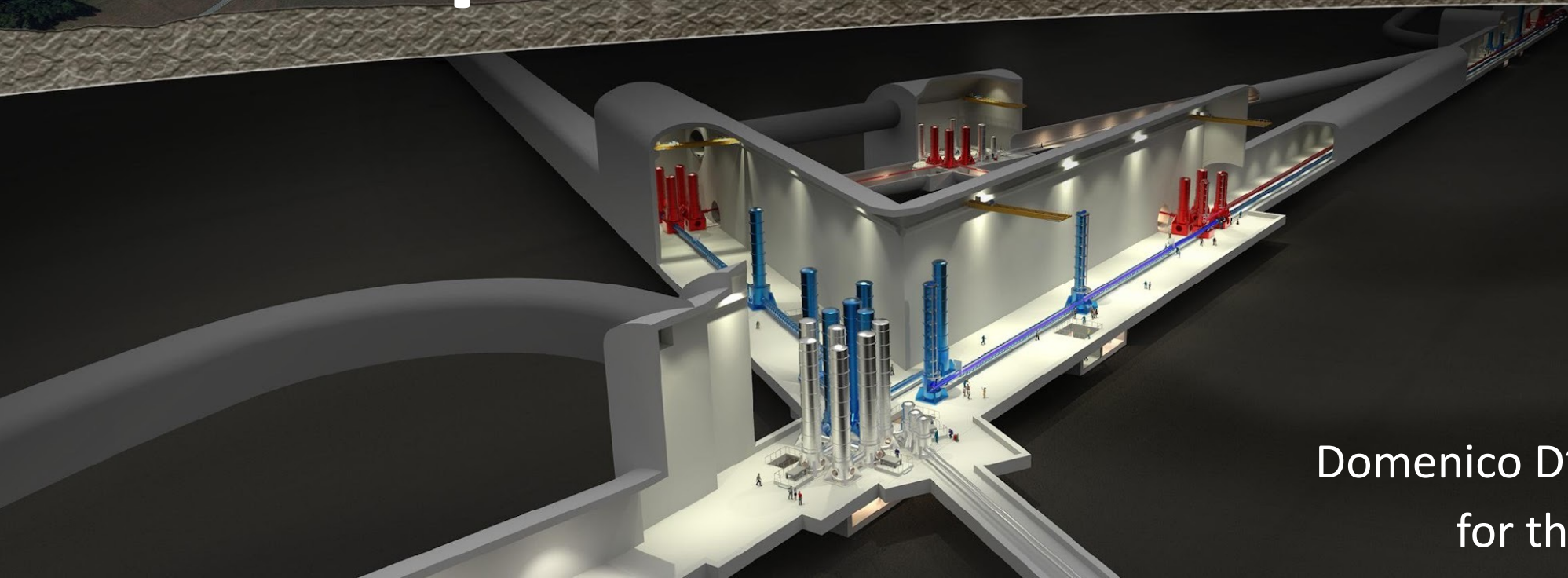




# Site Characterization & Preparation Board Activities



Domenico D'Urso Frank Linde  
for the SCB/SPB



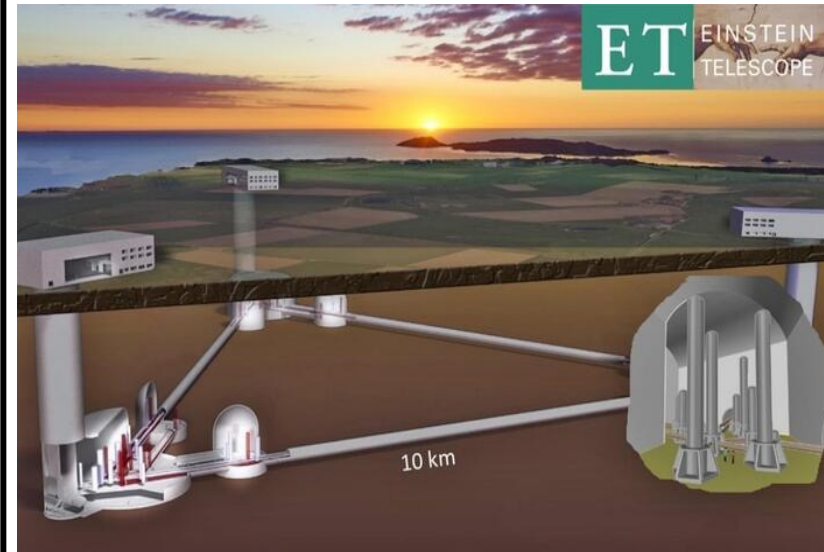
# ET Candidate Site(s)

- Currently there are two sites, in Europe, candidate to host ET:
  - ❑ The Sardinia site, close to the Sos Enattos mine
  - ❑ The EU Regio Rhine-Meuse (EMR) site, close to the NL-B-D border
- A third option in Saxony (Germany) is under discussion



# Fabulous political support for ET

## Sardegna: Italy

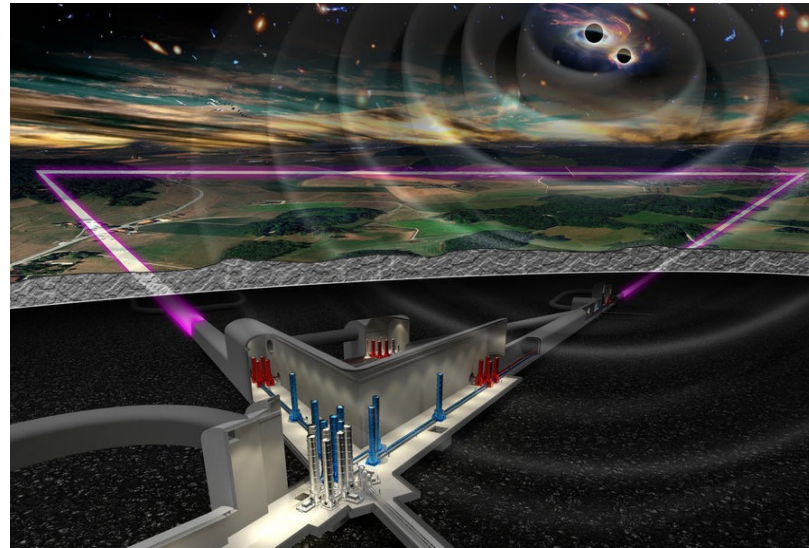


**50 M€ for R&D/preparatory work**

**R&D/preparatory work funding  
Multi 100 M€ funding to host ET if in  
Sardinia**

October 18th, 2022

## Euregio Meuse-Rhine: Netherlands



**42 M€ for R&D/preparatory work**

**R&D/preparatory work funding  
Multi 100 M€ funding to host ET if in  
the Euregio Meuse-Rhine**

ET ISB workshop

## Saxony: Germany



**New research center, ~ 170 M€/yr**



## Pressemitteilung

**Forschung von Weltrang in der Lausitz**

Deutsches Zentrum für Astrophysik – Forschung.  
Technologie. Digitalisierung. (DZA) gewinnt Wettbewerb  
zur Strukturförderung

# SCB/SPB: General Mission

The SCB/SPB must lead the effort on the Einstein Telescope site related activities

- It must coordinate the activities to acquire the required characteristics for each site proposing to host the Einstein Telescope;
- Collect, organize and/or produce all the characterizations and documentation needed for a fair comparison of the sites;
- Propose a common framework and common basis for the evaluation of the candidate sites.



# Site Characterisation/Preparation Board

**ET Collaboration**

**Project Directorate**  
**Fernando Ferroni – Andreas Freise**

**WD1**

*physical variables  
&  
characterisation*

**WP1.1**

*seismic noise*

**WP1.2**

*gravimetry  
geodynamics*

**WP1.3**

*magnetic noise*

**WP1.4**

*other env. noise*

**WD2**

*geology*

**WP2.1**

*structural geology*

**WP2.2**

*hydro-geology*

**WP2.3**

*geophysics*

**WP2.4**

*geotechnics*

**WD3**

*bidbooks*

*needs  
BGR  
guidance*

**WD4**

*costs, schedules  
&  
risk assessment*

*together  
with  
ISB/infra  
OSB*

**WD5**

*legal issues  
&  
site preservation*

**WD6**

*socio-economic  
& environmental  
impact*

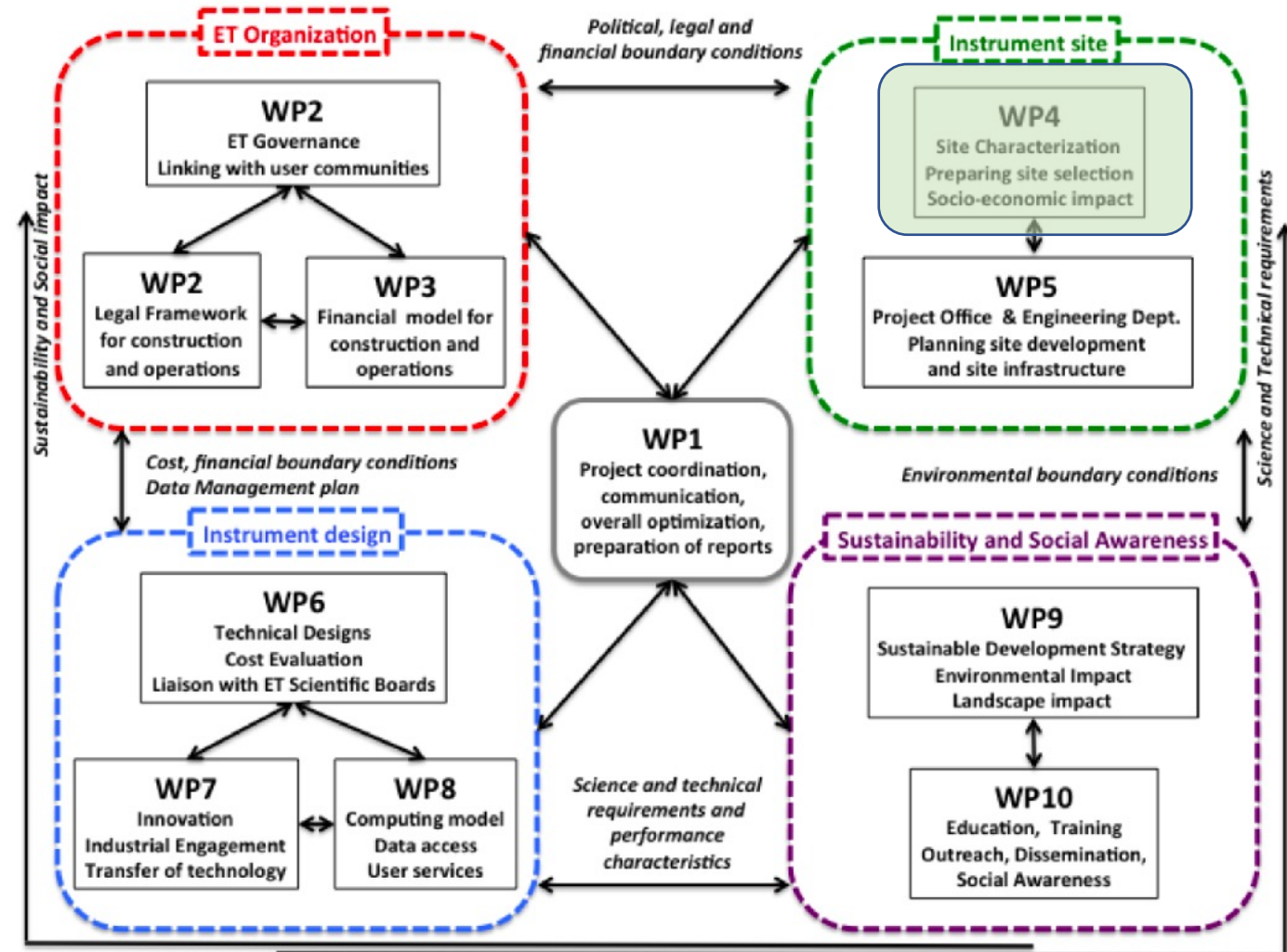
**Want to join? Click:**

[https://lists.infn.it/sympa/subscribe/et-spb?previous\\_action=review](https://lists.infn.it/sympa/subscribe/et-spb?previous_action=review)

October 18th, 2022

# INFRADEV: ET-PREPARATORY PHASE

- ET governance
- Legal framework
- Financial Model
- **WP4: Site characterization**
- Project Office & engineering
- Technical design
- Innovation
- Computing Model
- Sustainability Strategy and Environmental impact
- Outreach





# WP4 Objectives

- WP4 is responsible for collecting and processing, from each potential site, all the required information necessary for site qualification. This includes **site specific characteristics** that might impact the ET scientific performance, **socio-economic impacts, legal implications, and civil engineering costs**. The information will be treated in a coherent and transparent manner, with the aim of facilitating a site selection process in a timescale consistent with ET anticipated schedule

Participating institutions: INFN, Nikhef, UW (Warsaw), Wigner RCP (Budapest) & Uliège (Liège) *(and anyone else is of course more than welcome!)*

Available funding: 200 k€ for professional consulting expenses related to civil engineering costs and socio-economic impacts.

# Deliverables: WP4 of ET/PP-INFRADEV project

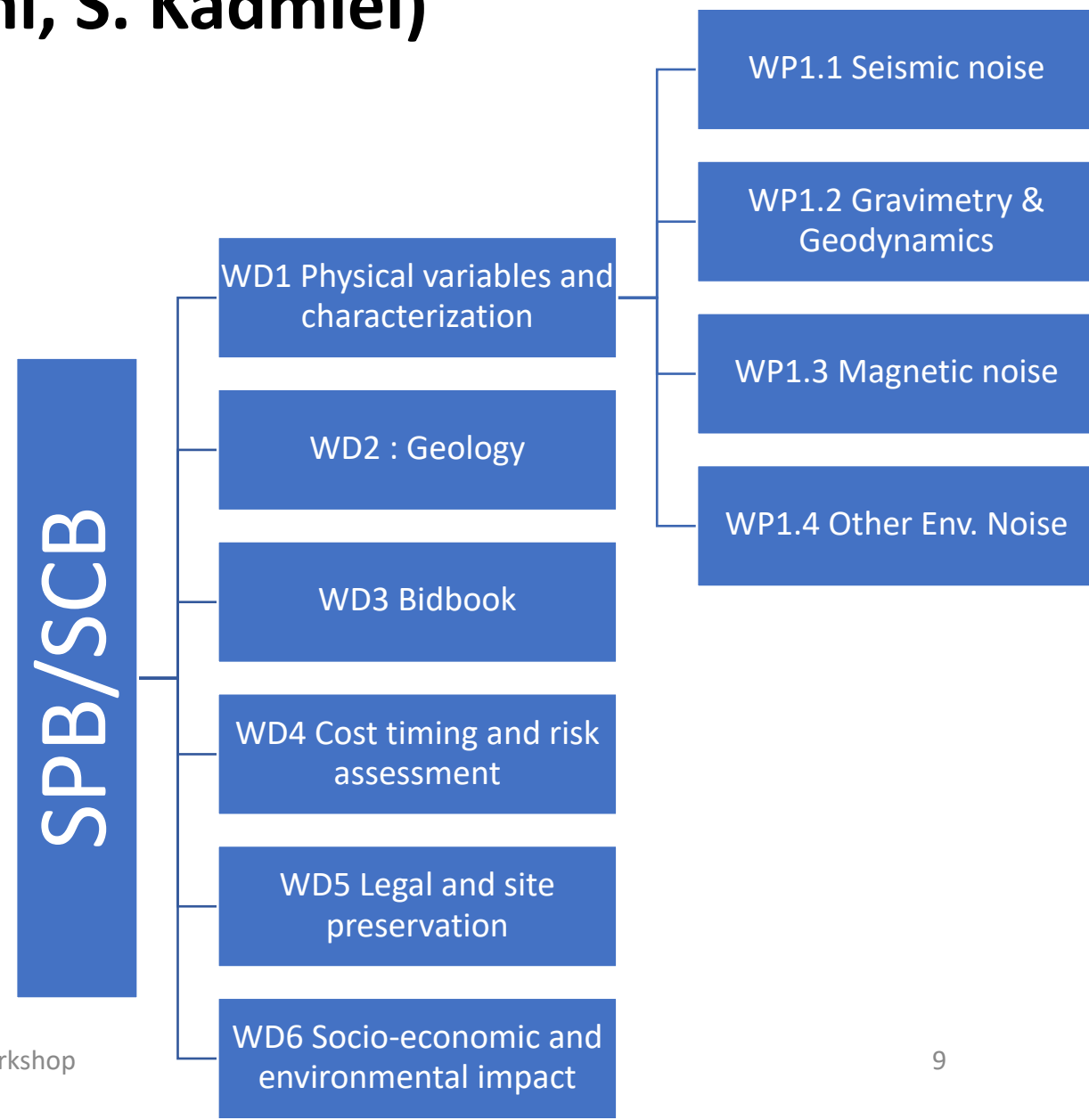


Deliverable	Comments
<b>D4.1 – M10/Nikhef</b> <i>Scan of legal affairs</i>	EMR: legal scan awarded to Tractebel/Amberg by Liège University (due jan/2023)
	Sardegna: work ongoing, part of large Italian funding application
<b>D4.2 – M15/INFN</b> <i>Socio-economic impact</i>	EMR: 4 studies performed of which 2 public (ESFRI annex)
	Sardegna: 1 study performed of which 1 public (ESFRI annex)
<b>D4.3 – M28/UW</b> <i>Impact ET performance</i>	Needs input from ISB/OSB. A paper already exists. Must be formulated as requirements/characterisations which can be directly measured
<b>D4.4 – M30/INFN</b> <i>Geology &amp; ET siting</i>	EMR: substantial work still required. Corner points not yet identified
	Sardegna: far advanced. Corner points identified ( $\Delta$ )
<b>D4.5 – M42/Nikhef</b> <i>Cost update civil engineering</i>	Ideally to be addressed as a collaborative efforts in which site related costs & risks must/can be differentiated. Alternative: separate site-specific efforts. Almost certainly requires close cooperation with civil-engineering industry



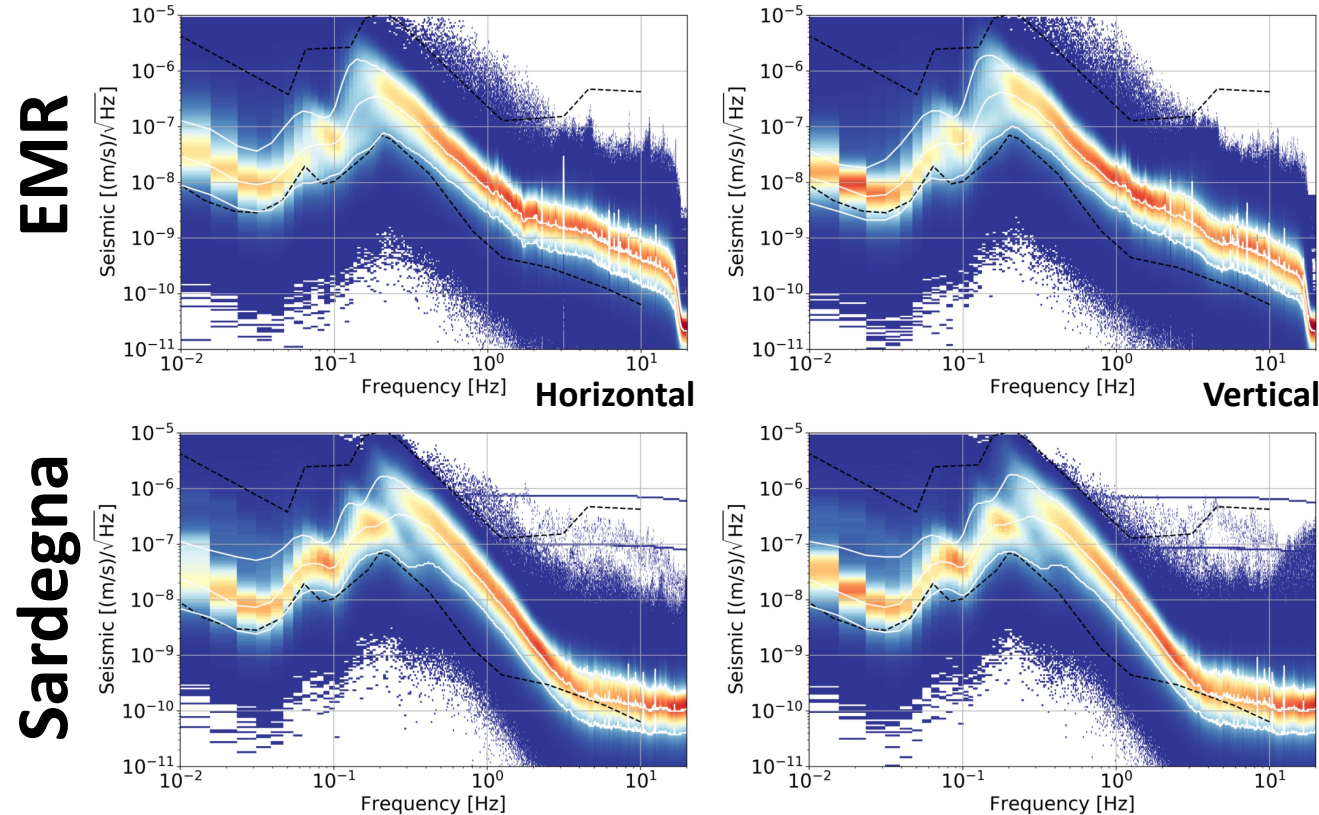
# WD1 : Physical Variables and Characterization (L. Naticchioni, S. Kadmiel)

- Definition of the needed physical variables for the site characterization **and for their possible impact on the detector performances** ( $\leftrightarrow$ ISB);
- Definition of surface and underground (and/or borehole) accurate noise measurements, with procedures and standards;
- Coordination of the measurement campaigns at the candidate sites (ongoing and planned)  $\rightarrow$  interaction with the host teams to have comparable long/short-term, active/passive measurements;
- Definition of standard data formats, repository and (open) analysis tools.



# WD1: physical variables & characterisation

## Seismic noise: borehole measurements

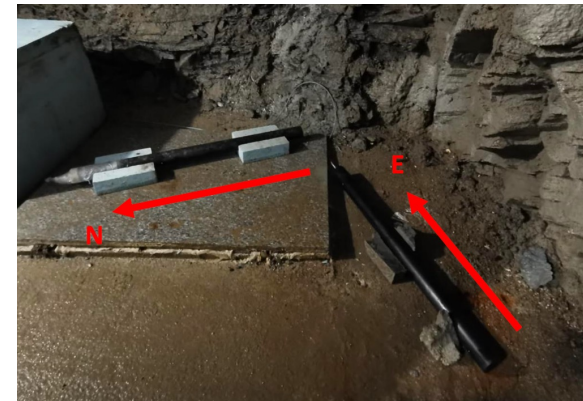


**Newtonian Noise implications: *still a hot topic***

## Magnetic noise

Sardegna: done/ongoing

EMR: should do same



General feeling:

*Probably not very  
different between sites  
unless major EM  
disturbances around*

## Acoustic noise

Sardegna: ongoing in the  
Sos Enattos mine

Preparing  
surface/underground  
Measurement.  
First in Sardegna

Later for the EMR

General feeling:

*Only relevant for  
'shallow' (< 150 m deep)  
implementations of ET*



# WD1: physical variables & characterisation

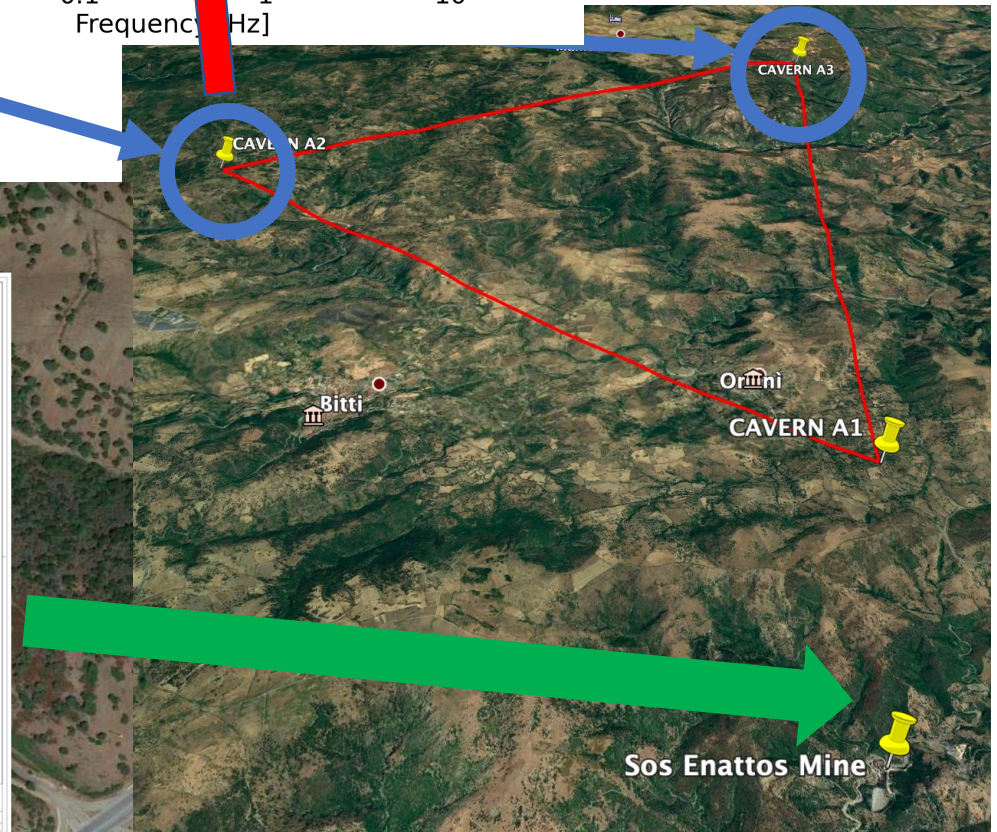
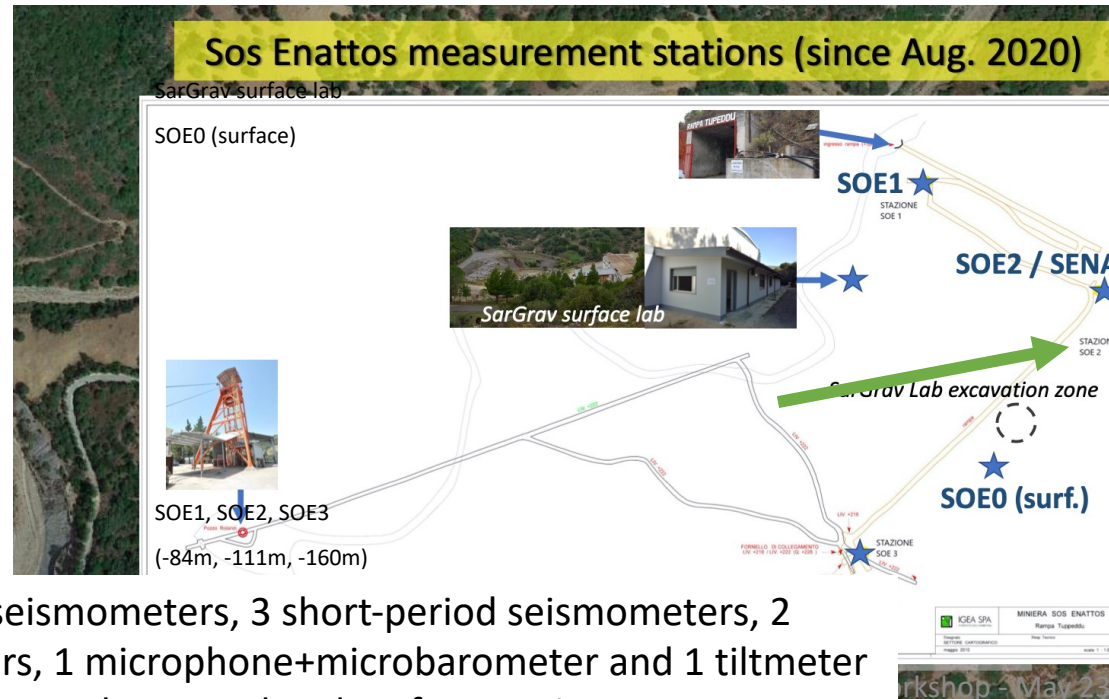
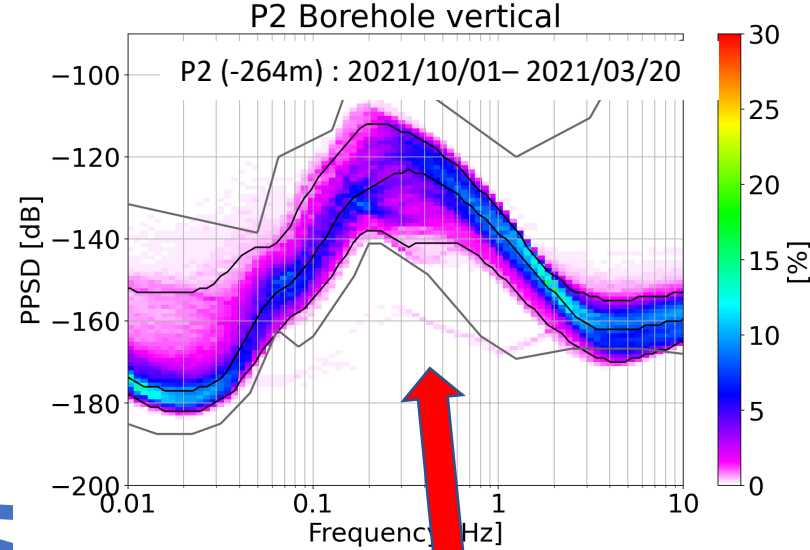
What we are measuring (or we plan to measure) for site characterization:

- **Seismic background:** broadband seismometers (10mHz-10Hz), geophones, gravimeters (<1Hz);
- **Magnetic noise** (MFS-06 type magnetometers, 0.1mHz-10kHz);
- **Acoustic noise** (B&K-GRAS type microphones, 0.1Hz-20kHz);
- **Barometric fluctuations** (Seismowave MB3a infrasound sensors type, 10mHz-28Hz);
- **Radon outgassing** (possible only in the Sos Enattos mine, Sardinia site) and **natural radioactivity**
- **Weather station** (Davis Vantage Pro2): wind, temperature, pressure, rain...

# WD1: Sardinia Site

## Long-term measurements

Characterization of the Bitti and  
Onanì corners:  
Surface and underground seismic  
and environmental measurements

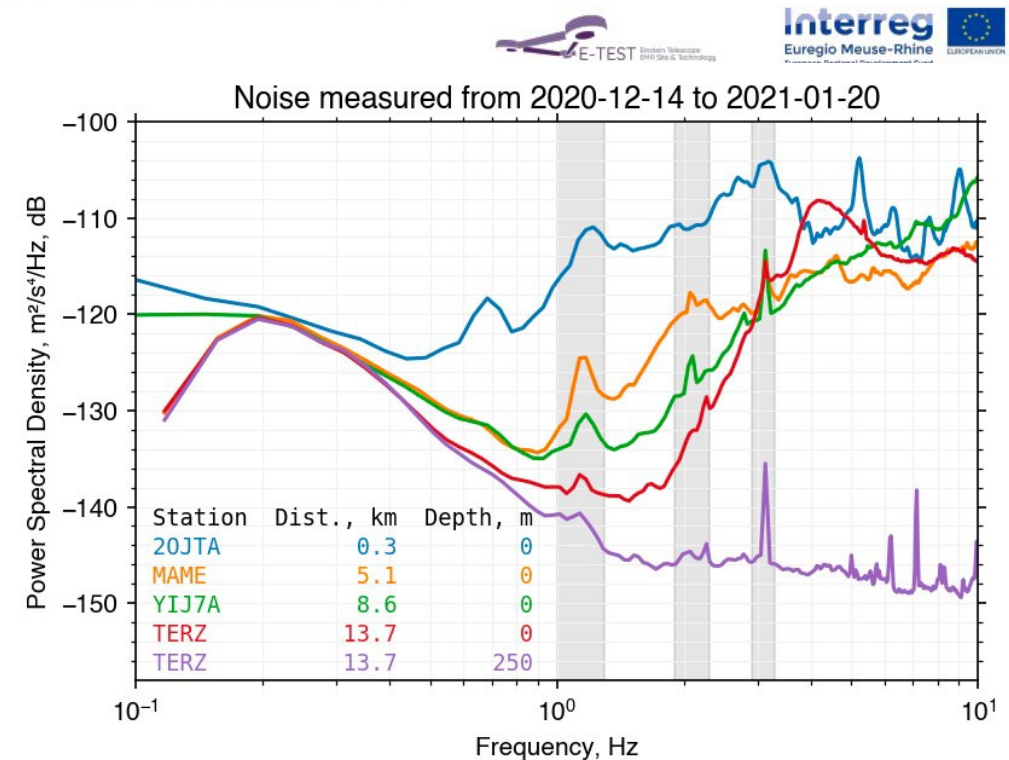
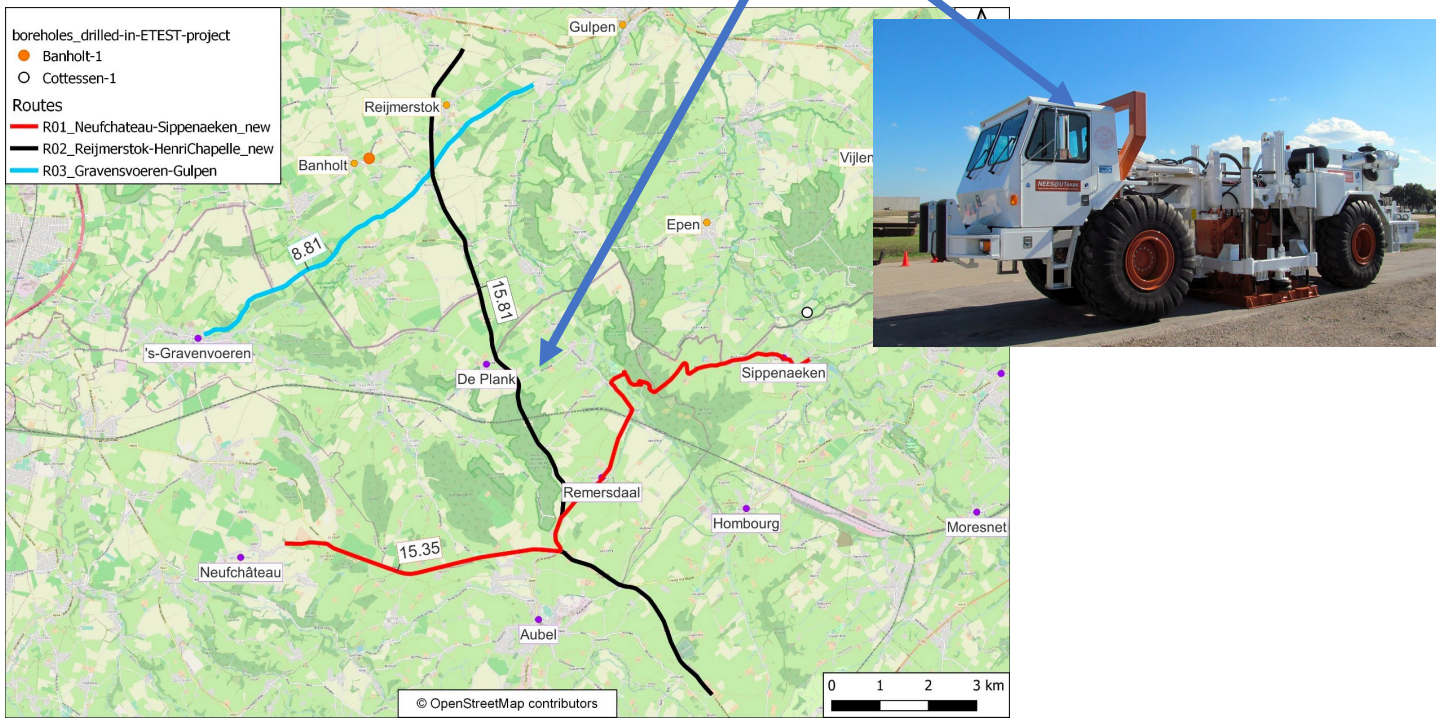
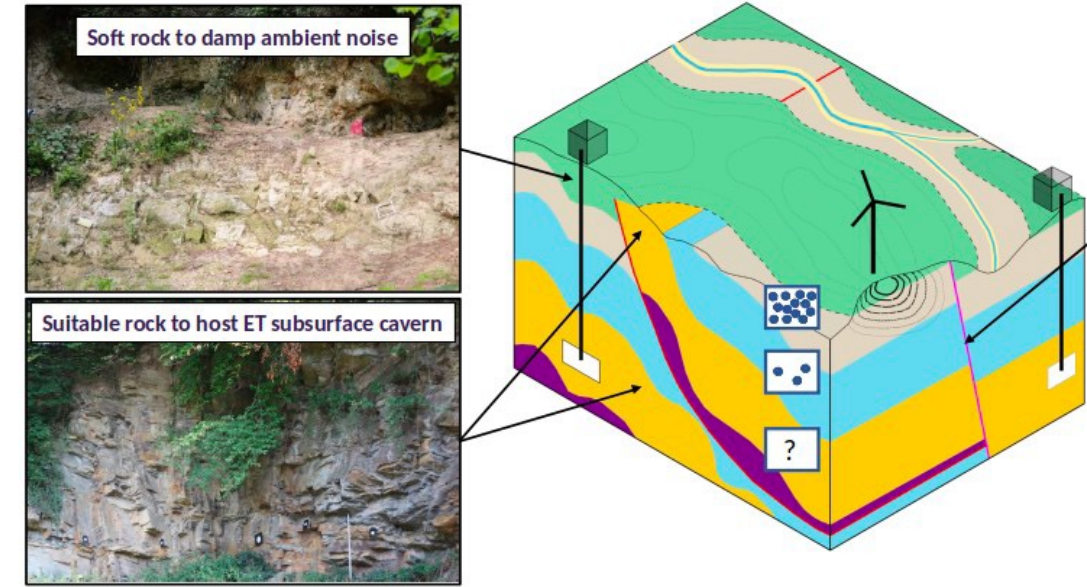


4 broadband seismometers, 3 short-period seismometers, 2  
magnetometers, 1 microphone+microbarometer and 1 tiltmeter  
distributed over underground and surface stations



# WD1: EMR Site Studies

- **7 deep boreholes** (up to 250m) by the end of 2022
- Borehole logging and in-situ testing including hydraulic testing and stress measurement
- Detailed laboratory testing to estimate the strength of the rock
- Seismic studies: boreholes, active and passive campaign







# **Ambient noise variations in Sos Enattos**

**M. Di Giovanni, S. Koley, J. X. Ensing, J. Harms**

**ET Sardinia Site Characterization**

**19/04/2022**

ET Sardinia

(see first ET monthly meeting)



# Shallow subsurface characterization using high frequency ambient noise at Terziet, Limburg

Soumen Koley, Xander Campman,  
Shahar Shani Kadmiel,  
Bjorn Vink, Frank Linde  
GSSI, Nikhef

[soumen.koley@gssi.it](mailto:soumen.koley@gssi.it)

[skoley@nikhef.nl](mailto:skoley@nikhef.nl)

October 18th, 2022



# Future Plan

## ➤ Other Env. Measurements

- ☐ Acoustic, barometric , weather measurements
- ☐ Weather station (use of public data if available)
- ☐ Surface and underground (Sardinia) acoustic campaign
- ☐ First in Sardinia then in the EMR

General feeling:

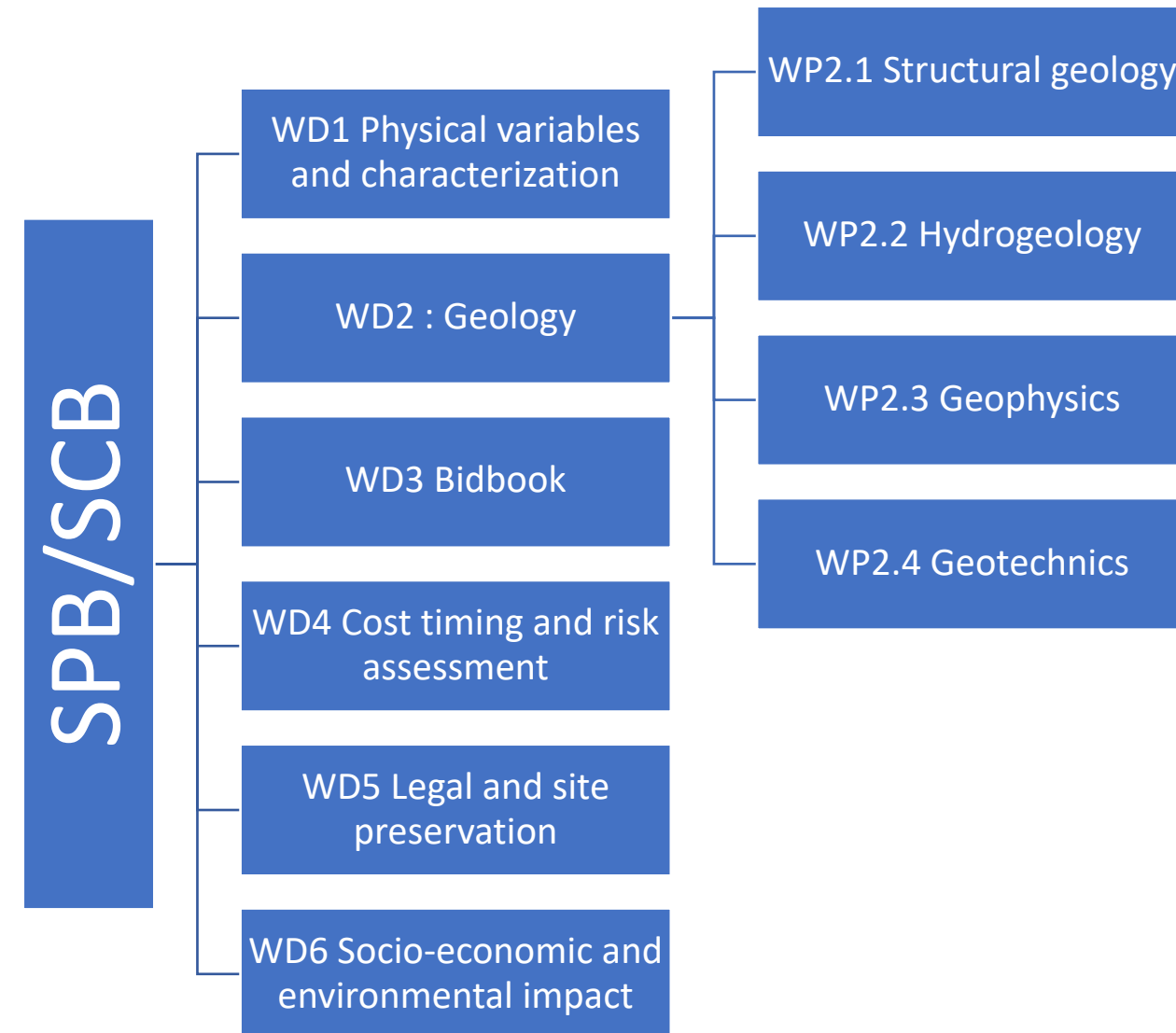
*Only relevant for  
'shallow' (< 150 m deep)  
implementations of ET*

## ➤ Gravimetry measurement campaign under consideration

- ☐ preliminary measurements already performed @EMR
- ☐ Long-term measurement planned @Sos Enattos mine (INGV)

# WD2 : Geology (L. Casini, F. Ngueyen, W. Walk)

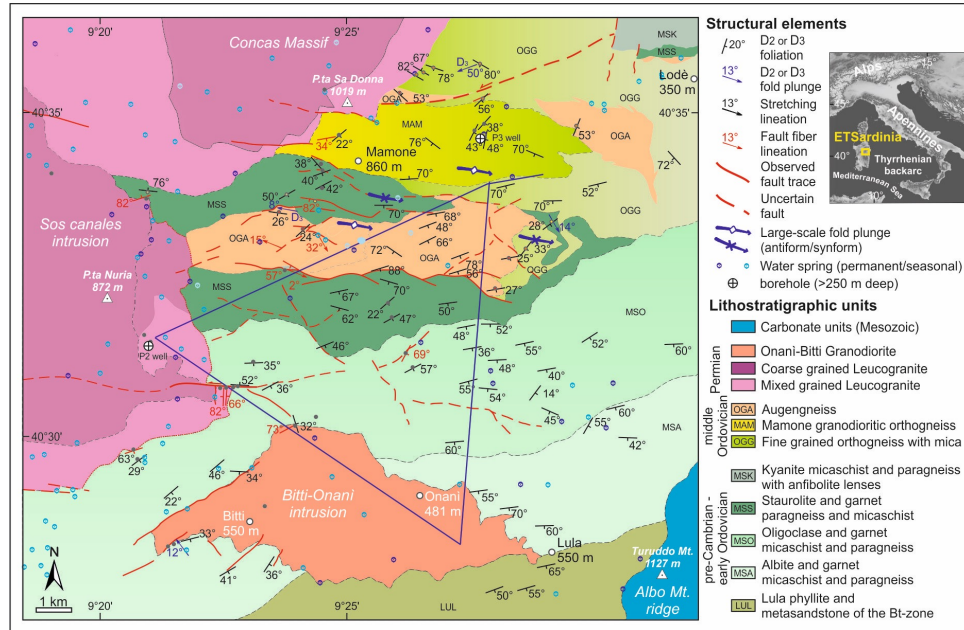
- Target **common objectives and timing** in terms of the subsurface parameters that will impact the **ET sitting, costs and/or operation**
- **Coordinate** team effort and promote **data/methods exchanges**
- Provides **imaging** at regional (tunneling) and local scales (caverns)
- Derive **structural model** and **rock quality model** (design TBM)
- Define **groundwater conditions** in terms of pressure and flow (prevent issues)
- **Link** with WD1 (e.g. impact in terms of vibration propagation) and with WD4 (costs impact as a function of rock quality or water ingress) + others as well



# WD2 : Geology

## Sardegna: advanced – (active&passive) Seismic, ERT, Borehole studies

### A NEW STRUCTURAL MAP



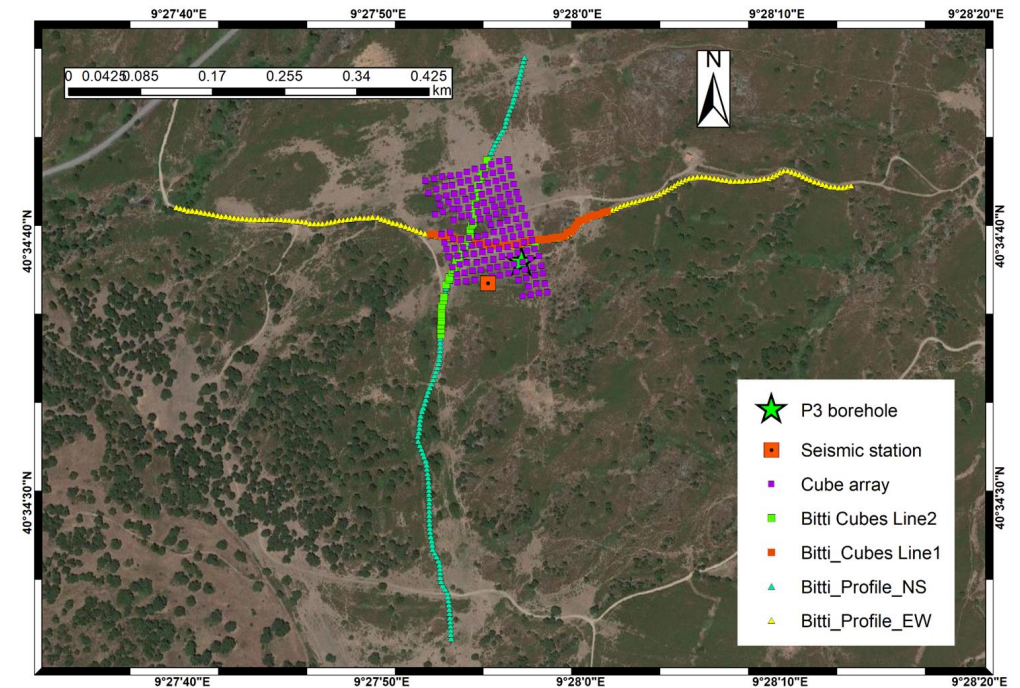
We have merged the lithologic information from published maps (also by comparing satellite images) and added new data collected in the field.

#### Site P3: surveys 1 vertical seismic profile

#### 2 high-resolution seismic profiles with multi-fold wide-aperture geometry

Deployment by other  
teams:

nodal array of 153 3-D  
component cubes (K.I.T.)  
2 linear arrays of 3-D  
component cubes (K.I.T.)  
DAS vertical array (K.I.T.)  
1 broadband seismic  
station (INGV-Pisa)

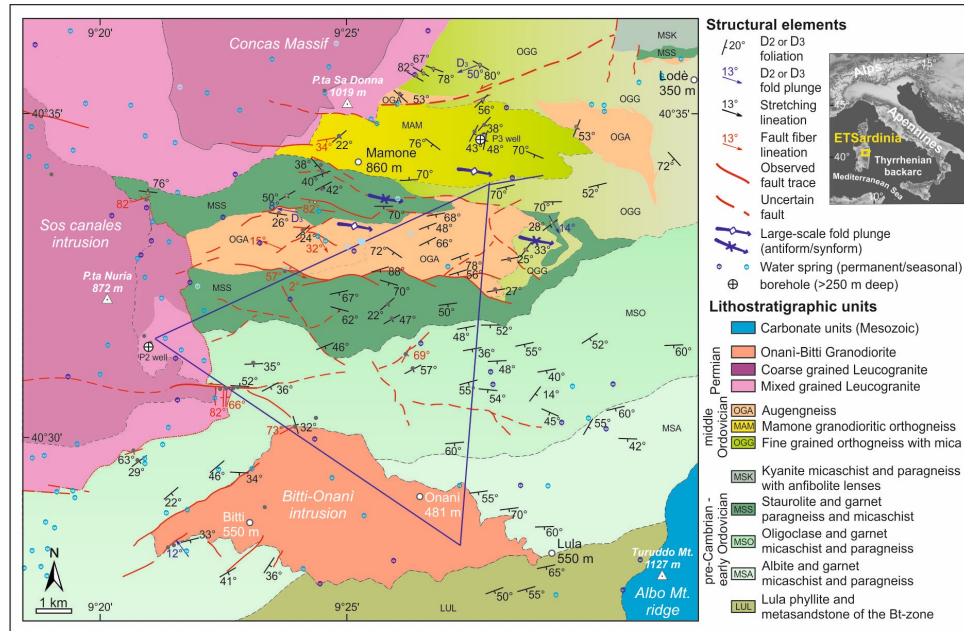




# WD2 : Geology

## Sardegna: advanced – (active&passive) Seismic, ERT, Borehole studies

### A NEW STRUCTURAL MAP



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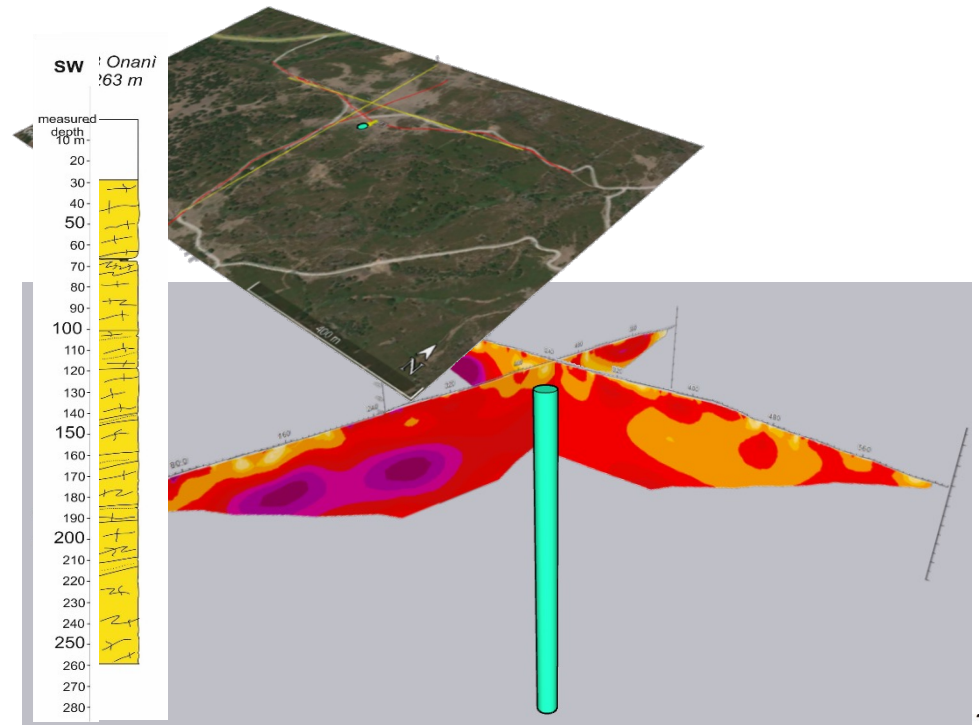
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Deployment by other teams:

nodal array of 153 3-D component cubes (K.I.T.)  
2 linear arrays of 3-D component cubes (K.I.T.)  
DAS vertical array (K.I.T.)  
1 broadband seismic station (INGV-Pisa)



# WD2 : Geology

**EMR: poor prior knowledge – Seismic, ERT, Borehole studies, hydrology**

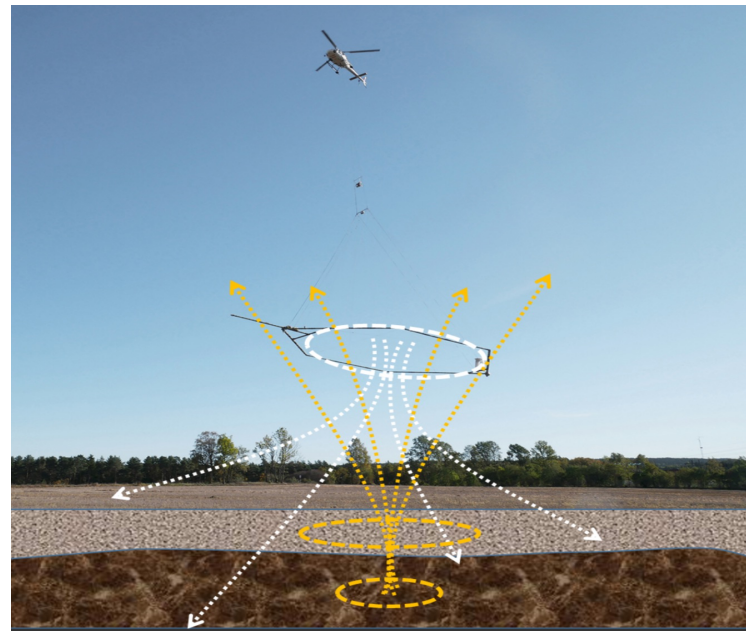
2D & possibly 3D active seismic

Electro-magnetic (resistivity)

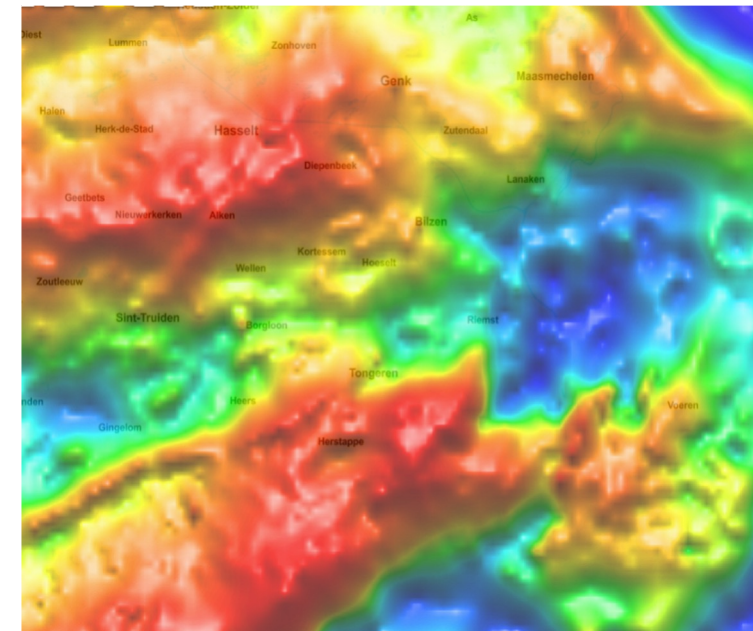
Gravimetric



*Small area: 2019 in Terziet*  
*Large area: Sep/2022 ~ 40 km (E-TEST project)*  
*Anticipated: 2023 ~ 500 km (NGF project)*



*Discussed since 2021 with Emerald  
Geomodelling (Sardegna & EMR)*  
*First tests Aug/2022*  
*Large air-borne campaign in future?*



*Considered*



# WD2 : Geology

EMR: *poor prior knowledge – Seismic, ERT, Borehole studies, hydrology*

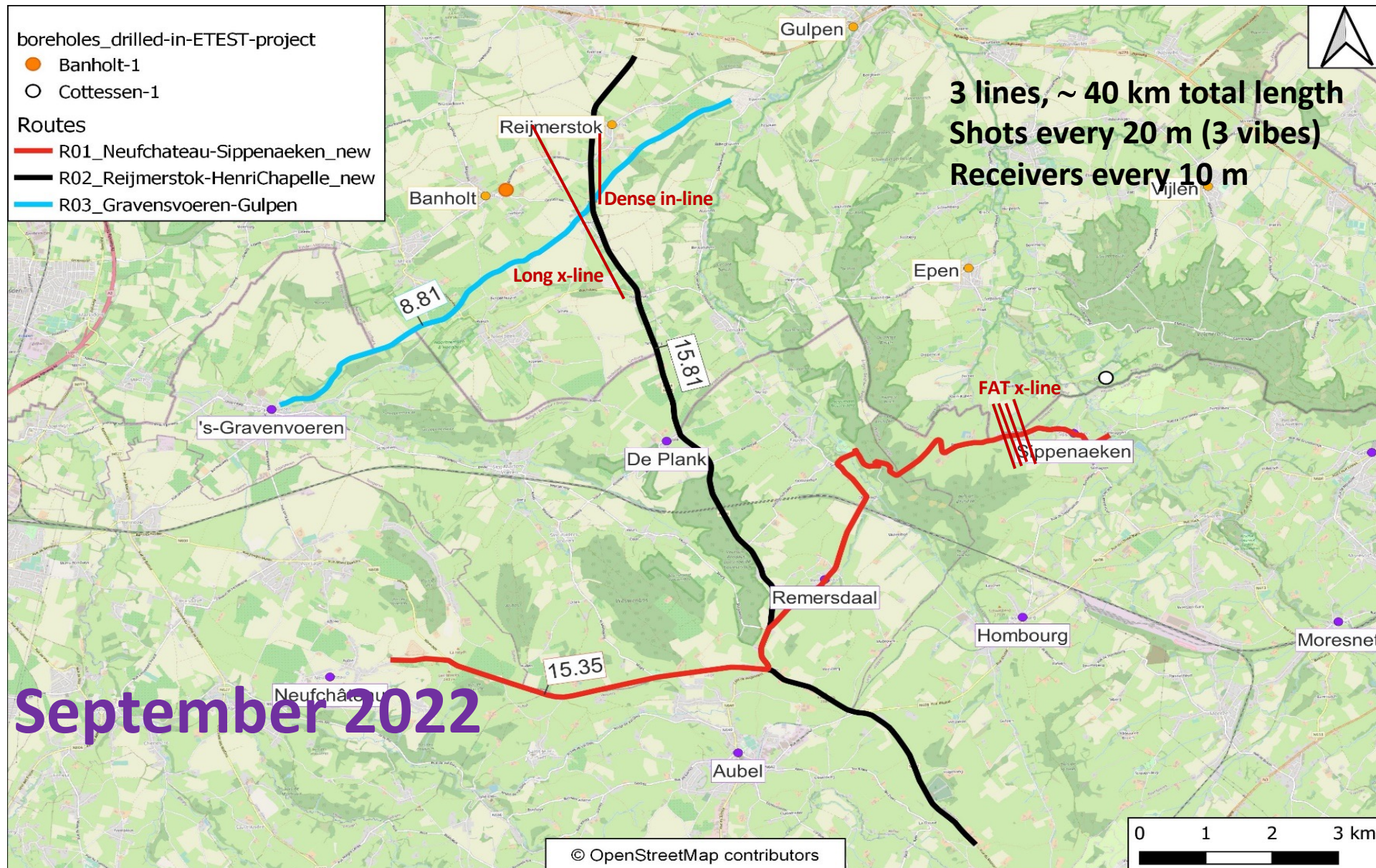


Measurements at two locations each about few 100 × few 100 meters and at one smaller area location:

- *Moving setup (EM pulses every few meter) as shown in photo*
- *Stationary setup with a very large (about 40×40 m<sup>2</sup>) source coil ‘WalkTEM’*
- *Report (Emerald Geomodelling) expected soon. Hope to reach few 100 m depth*



# WD2 : Geology – Active seismic campaign

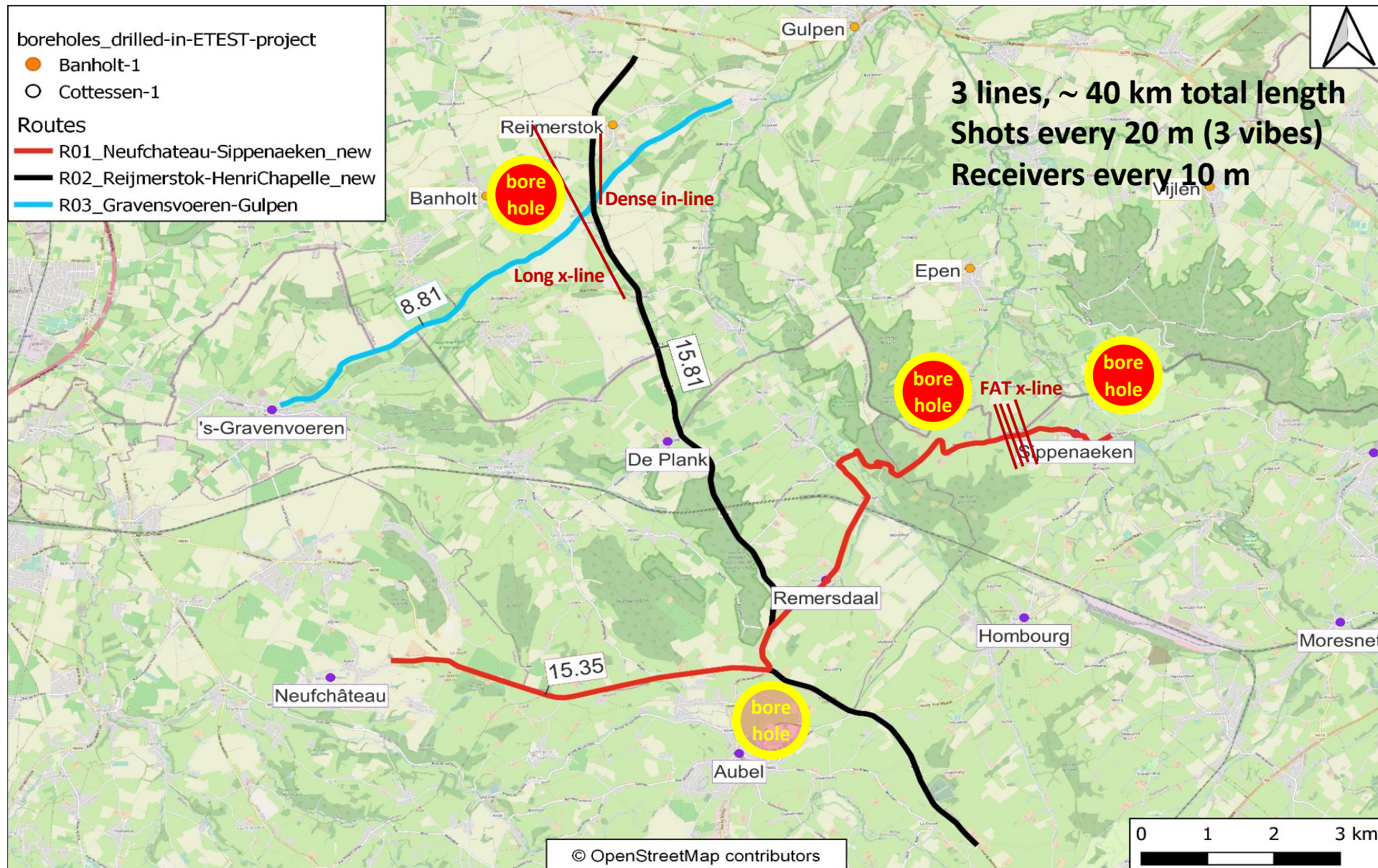


## Extra tests:

- *Study 3D potential: by adding 'cross' lines*
- *Best receiver separation: 400 m line – 1 m spacing*



# Boreholes: 3 done, 1 planned (E=TEST)



## Extra tests:

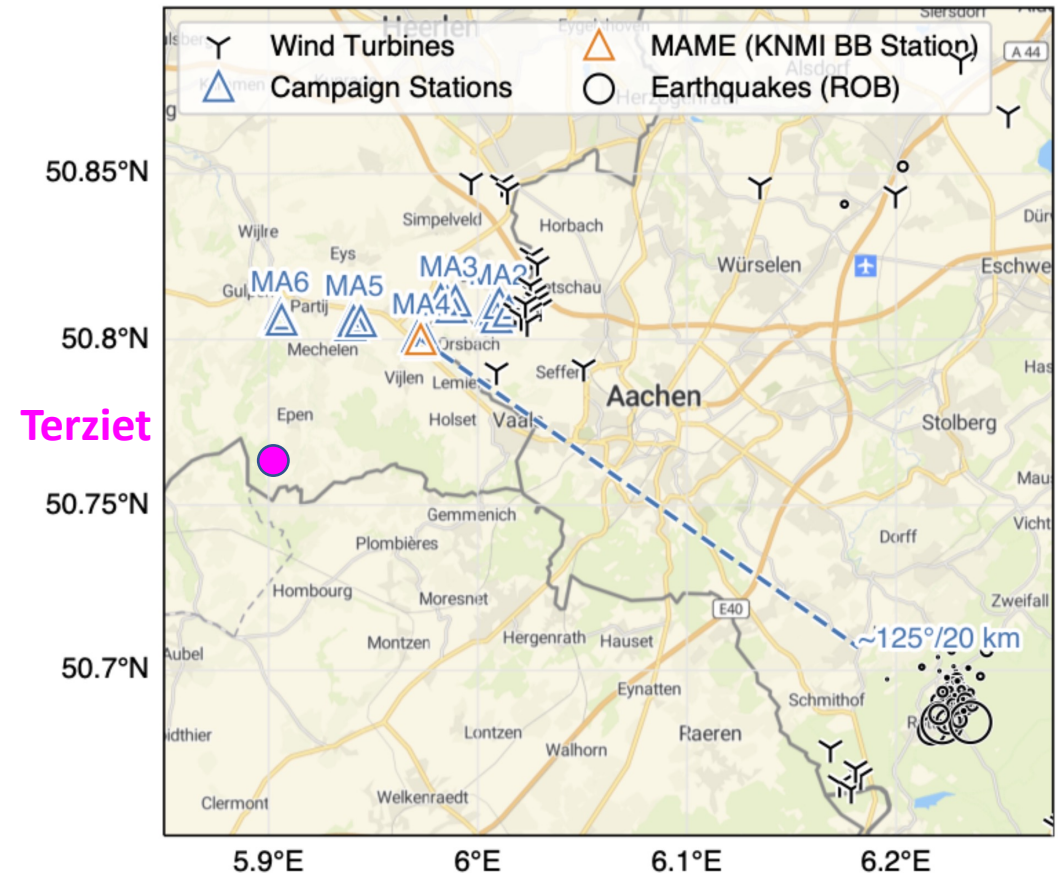
- *Study 3D potential: by adding 'cross' lines*
- *Best receiver separation: 400 m line – 1 m spacing*



# WD5: *legal issues & site preservation*

## Windturbines

Very popular, even more so with present electricity prices





# WD5: *legal issues & site preservation*

## Windturbines

Very popular, even more so with present electricity prices

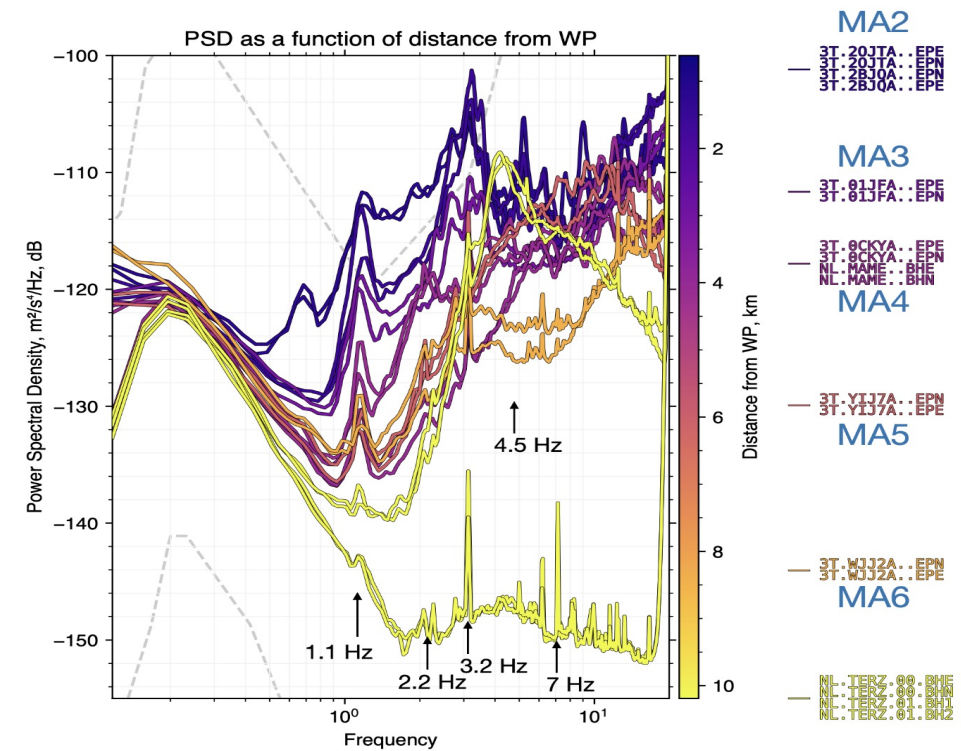


Figure 2: PSD as a function of distance from the wind park. The 1.1, 2.2, & 3.2 Hz peaks are consistently decreasing as a function of distance from the wind park. The yellow curves at just over 10 km distance from the wind park, were computed for station NL.TERZ, which hosts broadband seismometers at the surface and at 250 m deep in a steel cased borehole. The 4.5 Hz peak remains unexplained at this time and the 7 Hz peak, is most likely related to resonance in the steel casing.

# WD5: *legal issues & site preservation*

## Windturbines

Very popular, even more so with present electricity prices



### EMR

Netherlands:- ban on new windturbines

- discussions on future human activities that may affect ET performance adversely ongoing

Belgium:

- discussions ongoing with notably Engie (large windturbine supplier) regarding new initiatives.
- 2-3 existing initiatives challenged in court

Germany: - ?

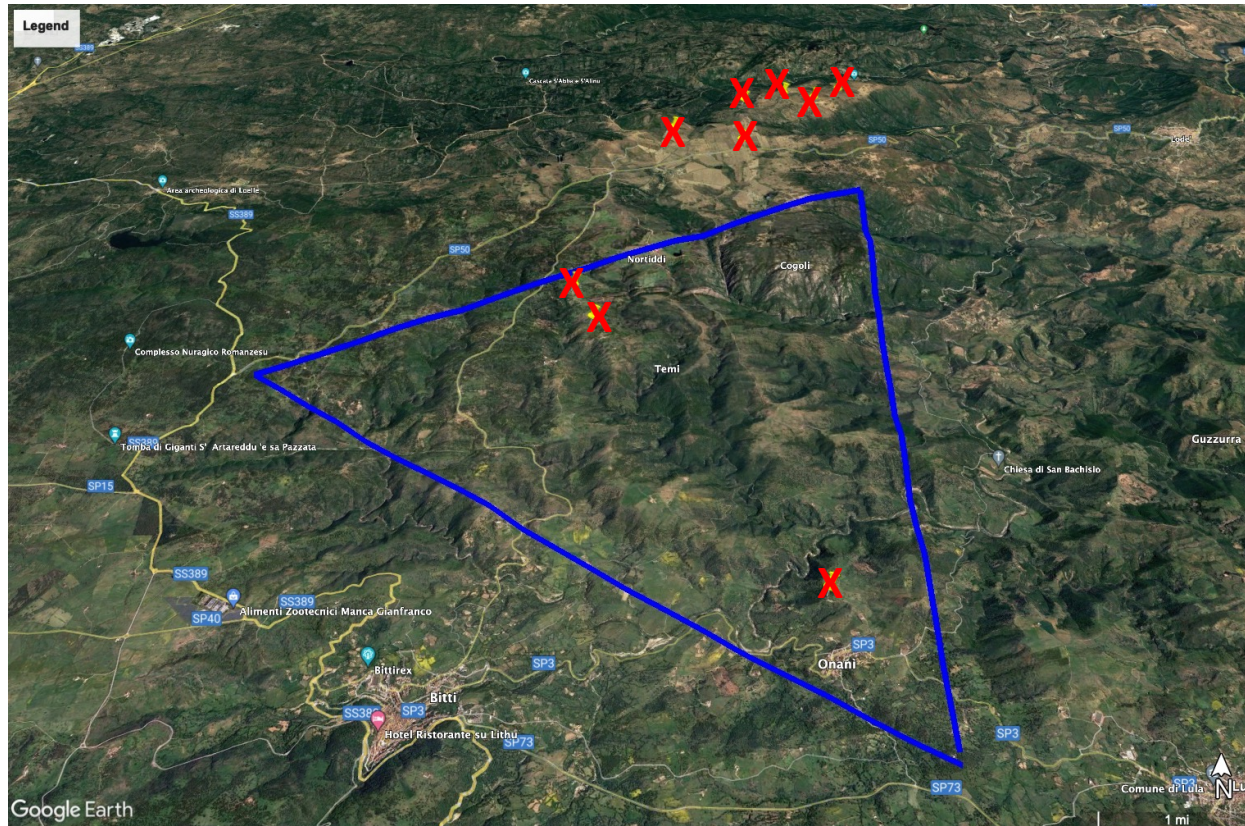
*More measurement campaigns in preparation (with Engie)*



# WD5: *legal issues & site preservation*

## Windturbines

Very popular, even more so with present electricity prices



## Sardinia

- several windturbine projects stopped
- discussions on future human activities that may affect ET performance adversely ongoing
- Recently a windturbine project got authorization (strong discussions on going among the national government/local communities and scientific community)
- Measurement campaigns in preparation with **existing windmills**



# SPB-ISB Interactions

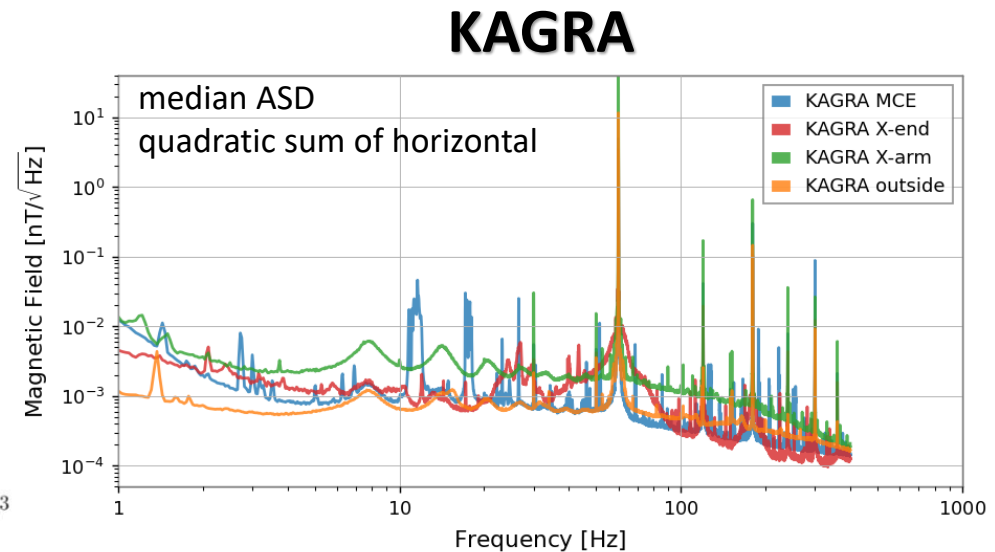
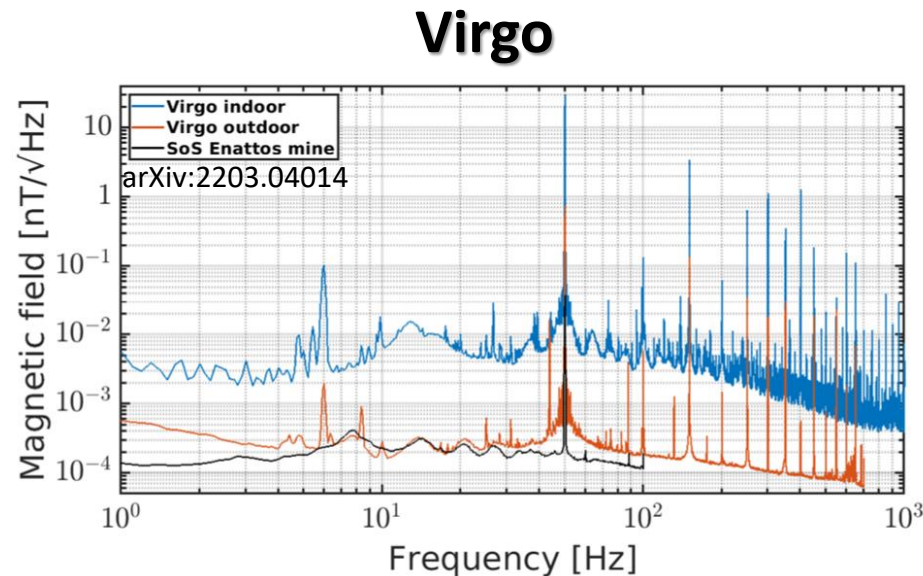
- July 11<sup>th</sup>: Meeting on July 11: Infrastructure and noise
  - ❑ [Lesson learned from Virgo](#)
  - ❑ [KAGRA experience with infrastructure noise](#)
- Sept. 19<sup>th</sup> : preliminary call SPB-ISB (organized by L. Naticchioni)
  - ❑ WD1 Div. Chairs, ISB Div. Chairs (Active Noise Mit., Interferometer, Suspensions)
  - ❑ Update of physical variables to be measured
  - ❑ Common methodology to estimate impact of site characteristics on ET sensitivity
- Talk and meeting on Site characterization @ ISB workshop  
17-21 Oct. GSSI L'Aquila <https://indico.ego-gw.it/event/465/>

# Lesson from KAGRA

3/12

## Ground surface vs. Underground (Magnetic noise)

- At Virgo, indoor magnetic noise is larger than the outdoor ( $\sim$ order 2)
- At KAGRA experimental site, some peaks are seen but the floor level is not so dirty.
- The Schumann resonance is observed to be larger in the KAGRA tunnel.





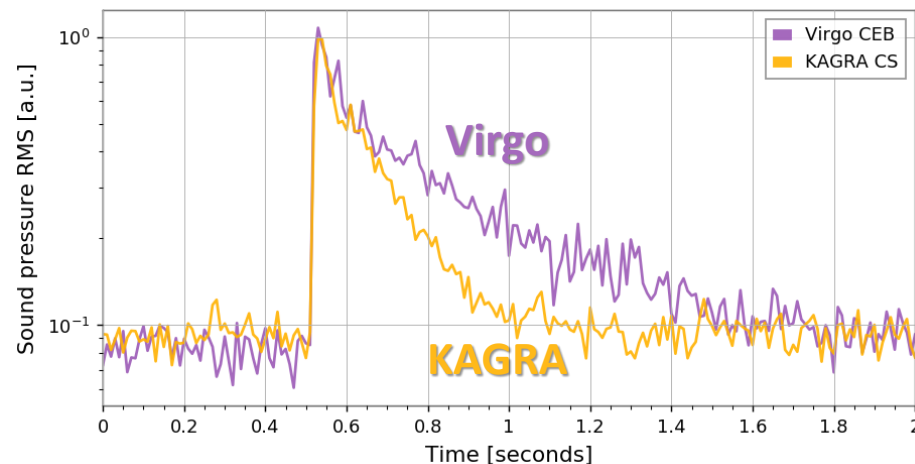
# Lesson from KAGRA

8/12

## Acoustic reverberation time

Reverberation time (decaying time of impulse sound) in the KAGRA site is much shorter than that of LIGO and Virgo.

- This is because of the difference in the inner surface of the walls, rather than the location.
- The original aim of this KAGRA's wall design was just to save cost and time.

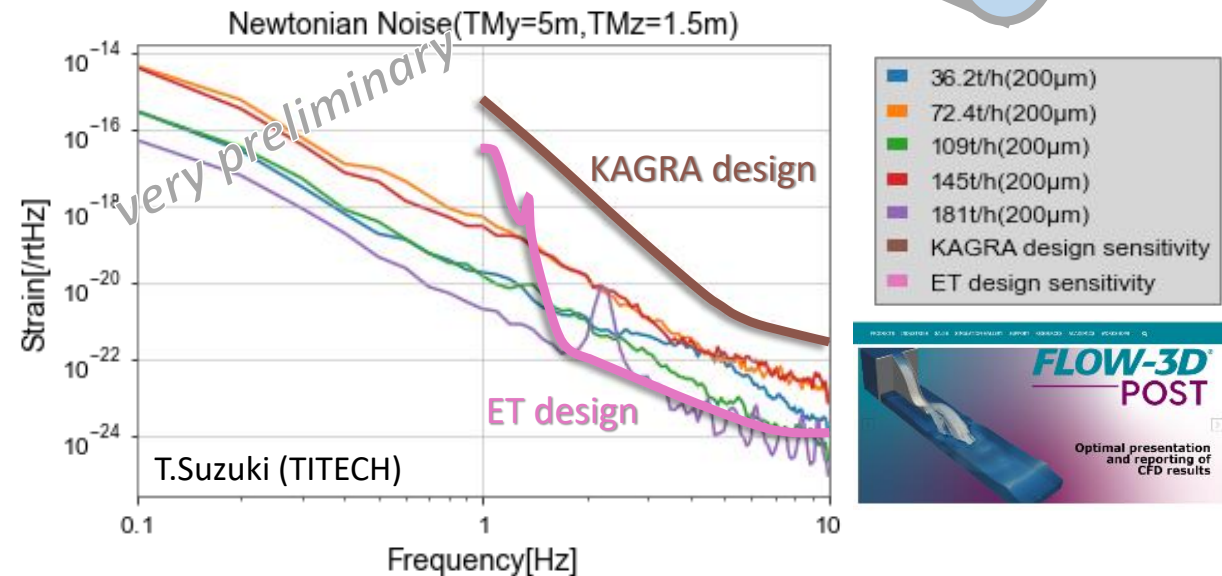
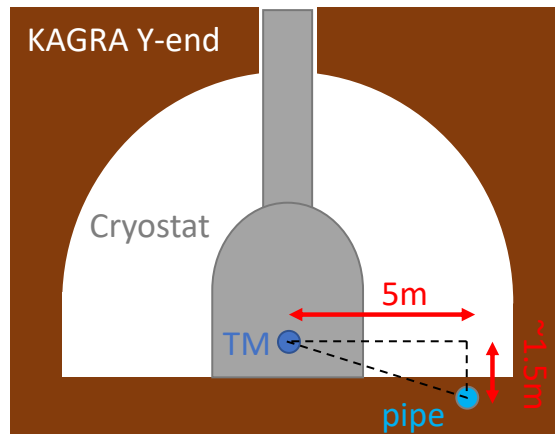
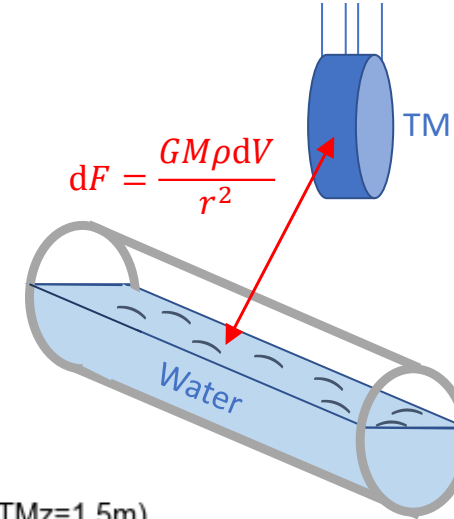


# Lesson from KAGRA

11/12

## Newtonian noise by Water fluid

- Water fluid in the drain pipe (dynamics of the surface) causes the Newtonian noise.
- We are working on a simulation study to estimate it.
- For KAGRA's configuration (geometry, flow rate, ...) the NN is smaller than the design sensitivity, but larger than the ET design.





- Acoustic and magnetic noises at KAGRA are caused by many instruments
  - ❑ Some of them can be turned off or reduced during observation.
- Design of the inside wall is important to reduce the acoustic noise.
- Global magnetic noise are amplified by the long beam ducts.
  - ❑ Cross-checking it at LIGO/Virgo/LNGS might be worth understanding the effect of the underground.
- Water fluid NN might be a serious problem in ET.
- Other important topics for underground
  - ❑ Working efficiency, QOL, Safety, ...

# Lesson from Virgo: good practices

- ★ DC power distribution (Virgo, LIGO, Kagra)
- ★ Accurate grounding
- ★ Accurate cable routing, segregation, shielding
- ★ Adopt dedicated power supply for sensitive components (i.e. LIGO electrostatic drivers)
- ★ Pay special attention to electronics/sensors/wires close to ITF sensitive parts (e.g. vacuum stuff, in-vacuum electronics);
- ★ Implement remote switch off capability
- ★ Enforce standardization on: cables, connectors, power supply voltage levels, communication standards ...

## EM compatibility of devices?

*devices should possess a “large” degree of immunity against external disturbances and have “low” level of emission of possible disturbing noise...*

Not easy!

EMC standards (electro-medical, military,...) are likely not suited for us.

Risk is to get caught up in long, dispendious, and not conclusive tests.

One way could be to accept the risk, set no limits but apply good practices from literature.



# Next SPB workshop: *Maastricht,* *January 23th-26<sup>th</sup> 2023*



3 days with optional excursion to experience the Euregio Meuse-Rhine and to visit ETpathfinder

**Do we miss something important that could affect the detector performances (sensitivity, locking, duty cycle...)?**

e.g.:

Seismic measurements → ISB-SUSP

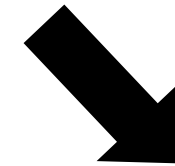
Seismic measurements → NN modelling → ISB-ANM-NN

Seismic measurements → glitchness → ISB-ITF

Magnetic noise measurements → ISB-ANM-MN

Environmental measurements → ISB-ANM-ES

...



ISB-ITF: sensitivity, duty cycle...