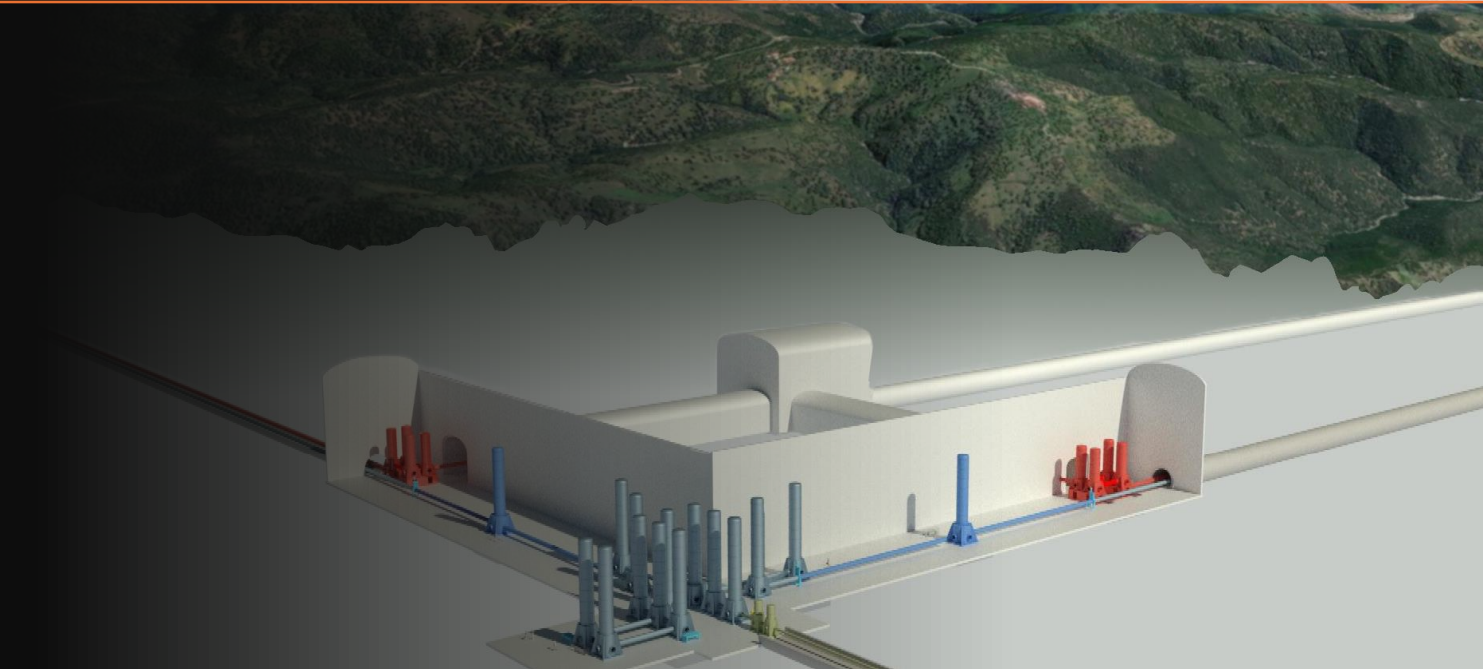
EINSTEIN TELESCOPE

Einstein Telescope: the Italian site in Sardinia

Luca Naticchioni

INFN Roma

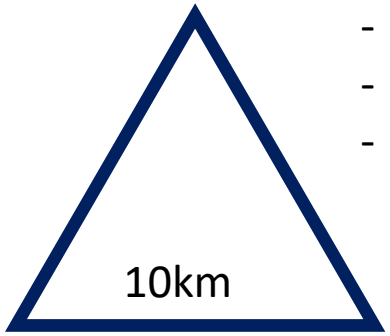


INFN Istituto Nazionale di Fisica Nucleare

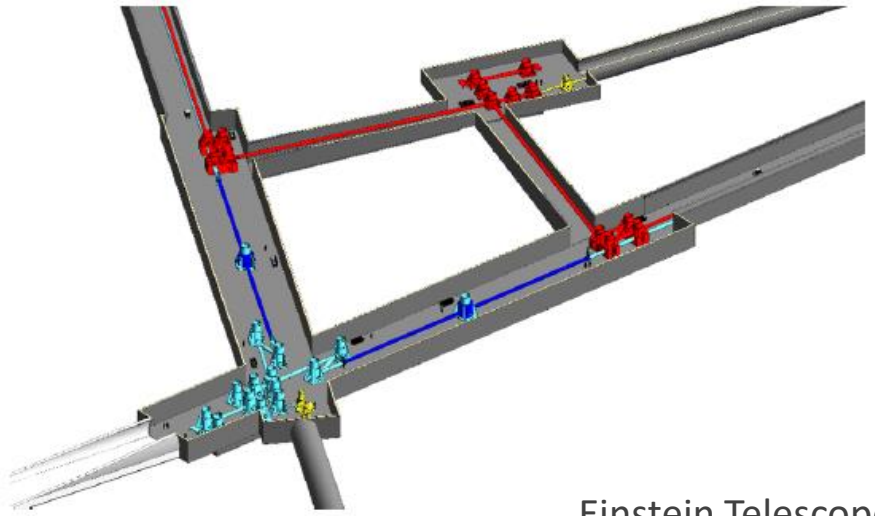
ET ITALY Einstein Telescope

ET: which configuration?

One site: “triangle”, 3 detectors (6 interferometers)

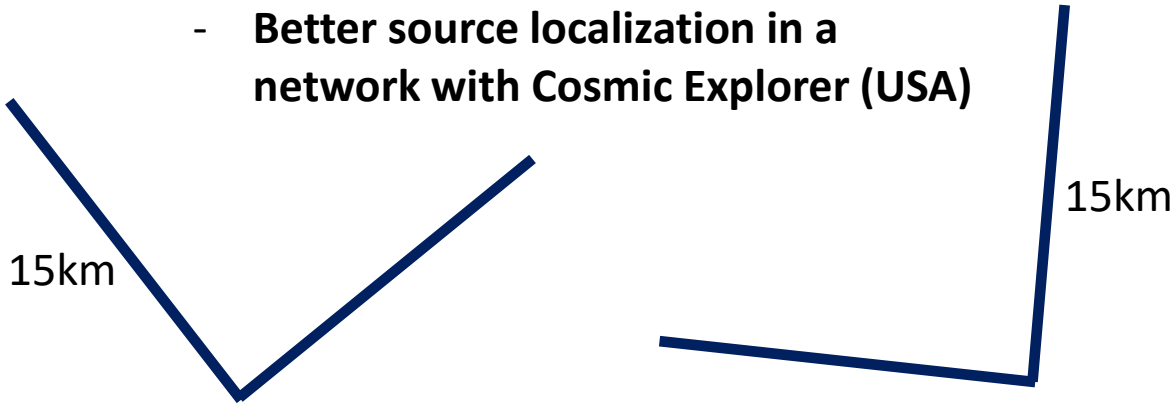


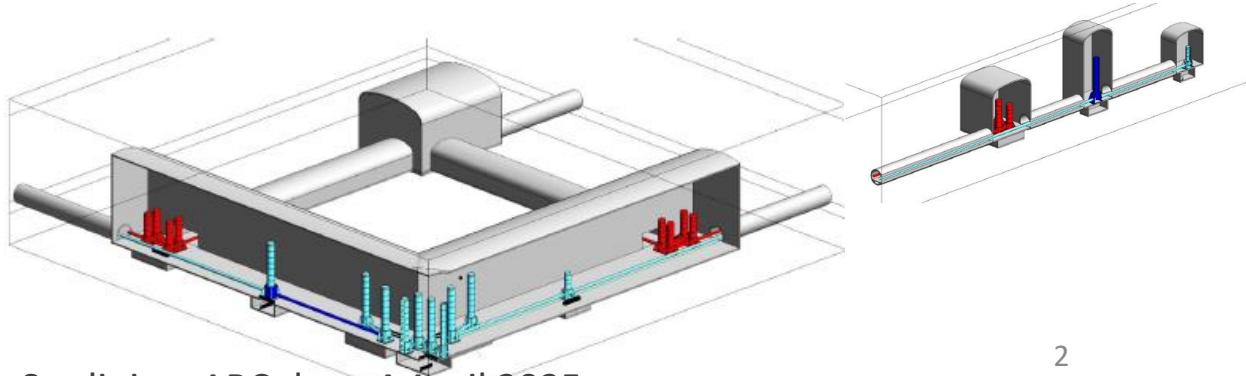
- **Initial baseline.**
- **Stand-alone solution.**
- **Source localization even if operating alone.**



Two sites: 2 “L”, each with 2 interferometers

- **Better scientific capabilities.**
- **Less risks for construction and operation.**
- **Better source localization in a network with Cosmic Explorer (USA)**



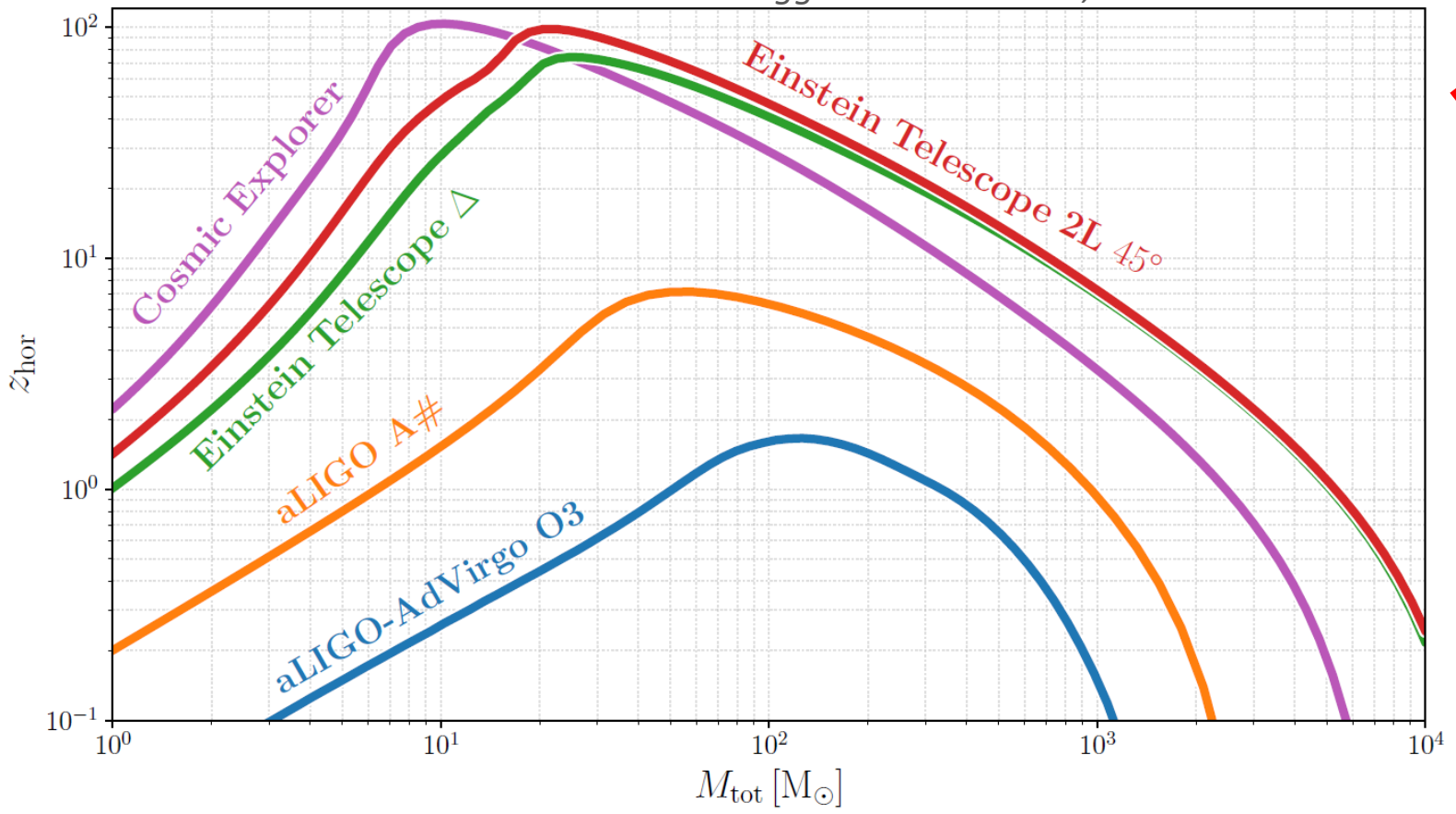


ET: which configuration?

Whatever the chosen configuration, **ET will make a great leap forward** compared to 2G detectors.

Example: Observation horizons for equal-mass spin-less binaries, ET configurations and CE vs 2G.

Credit to: M. Maggiore & F. Iacovelli, arXiv:2407.21442v1



ET: Where?

...a “quiet” site (low noise!)

...configuration: Δ o 2 L

Three official candidate sites:

ET: Where?

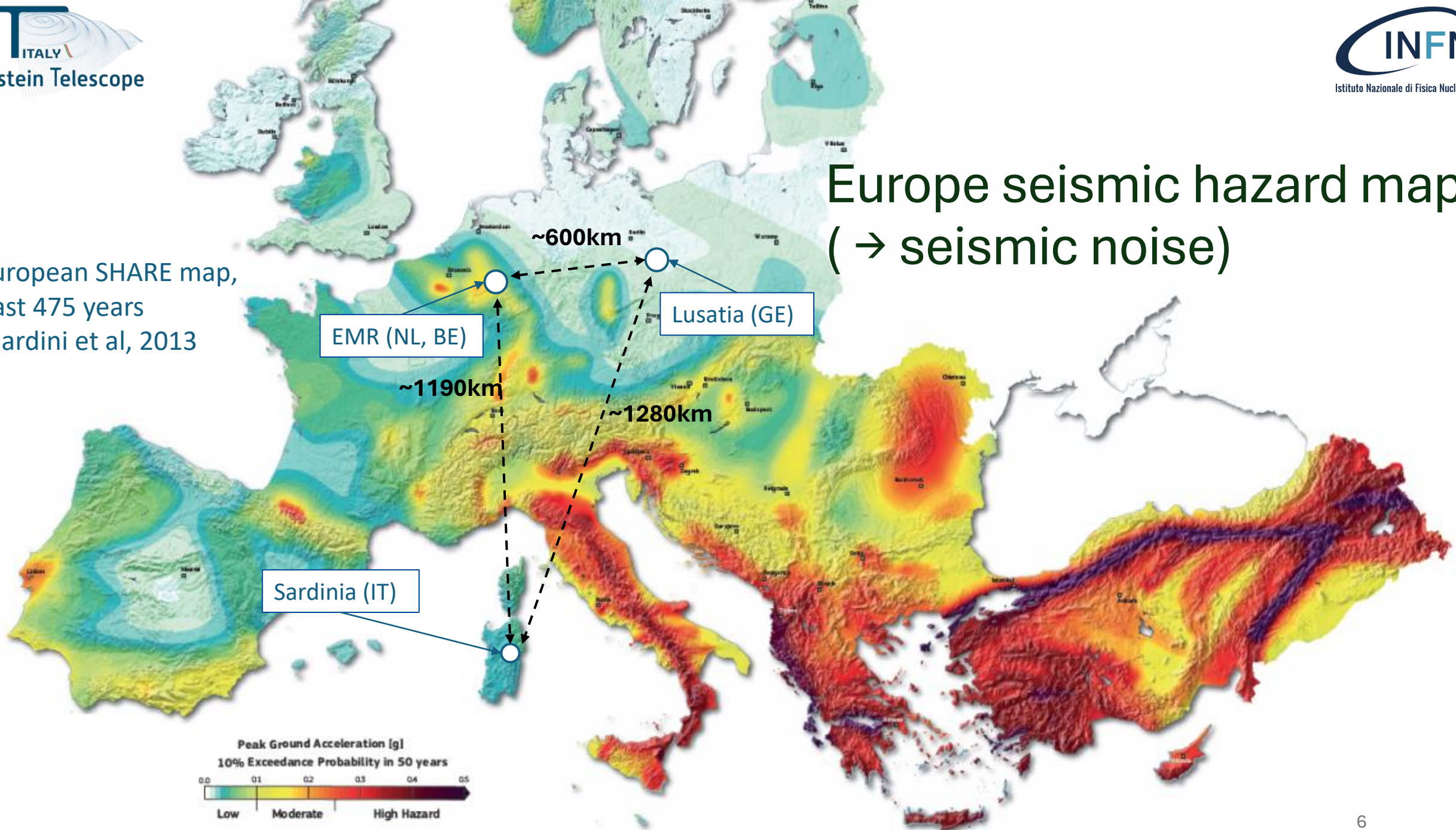
...a “quiet” site (low noise!)

...configuration: Δ o 2 L

Three official candidate sites:

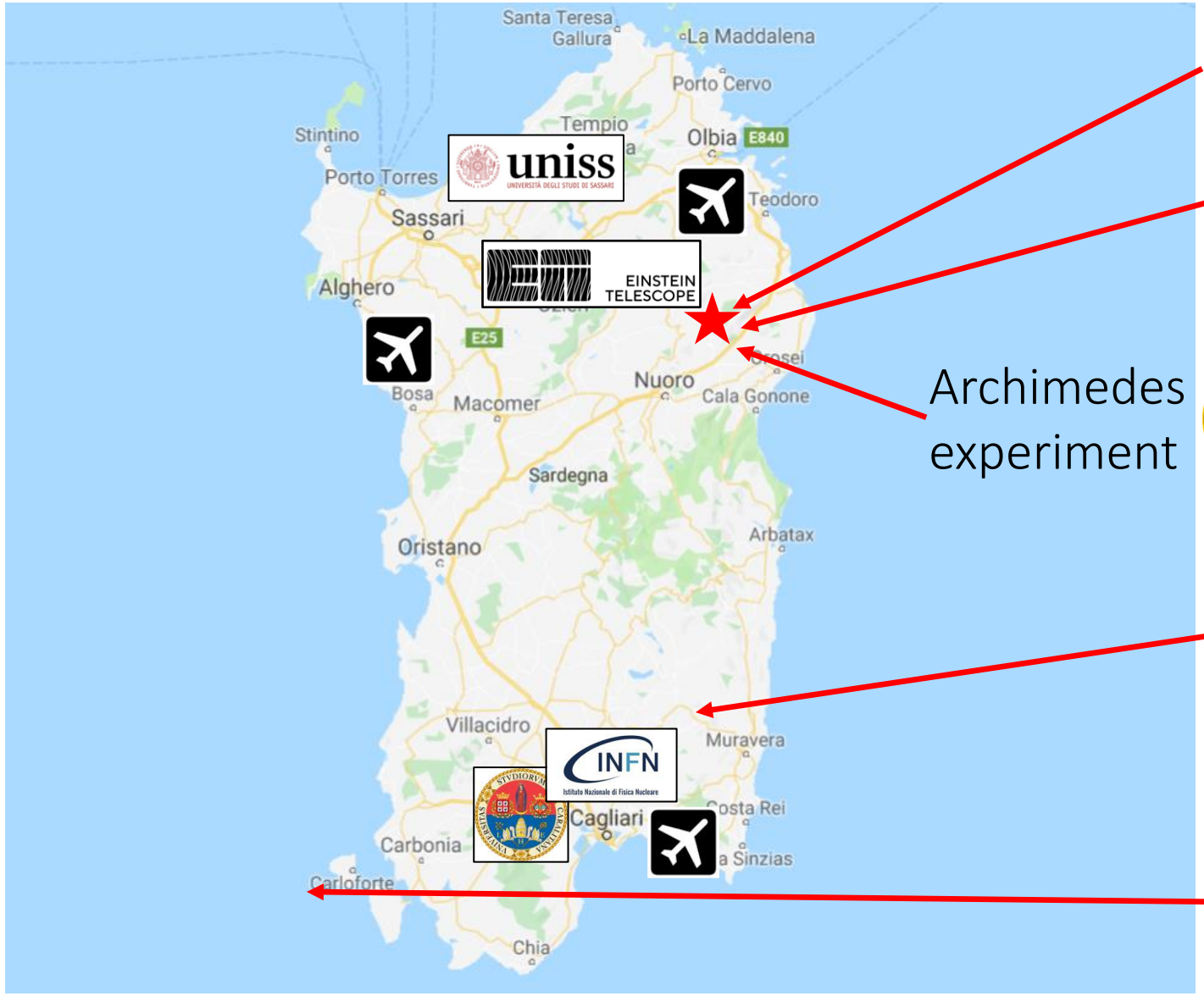
Europe seismic hazard map
(→ seismic noise)

European SHARE map,
past 475 years
Giardini et al, 2013



Einstein Telescope: the Italian site in Sardinia – ARC day - 4 April 2025

Sardinia: towards an island of science



Site access: ~50 min (85km) highway from Olbia Airport (SS 131)

SarGrav Laboratory → SUnLAB

Archimedes experiment

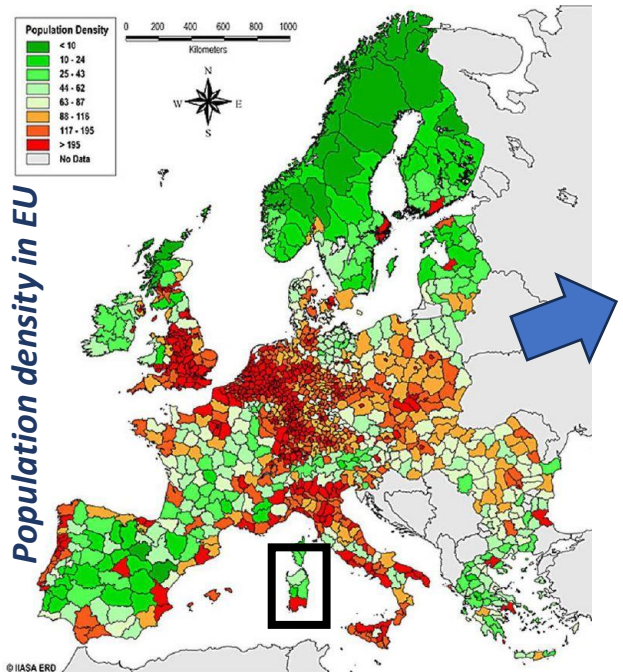
Sardinia Radio Telescope

"ARIA" Project (*DarkSide experiment*)

ET: Why in Sardinia

Sardinia is made of:

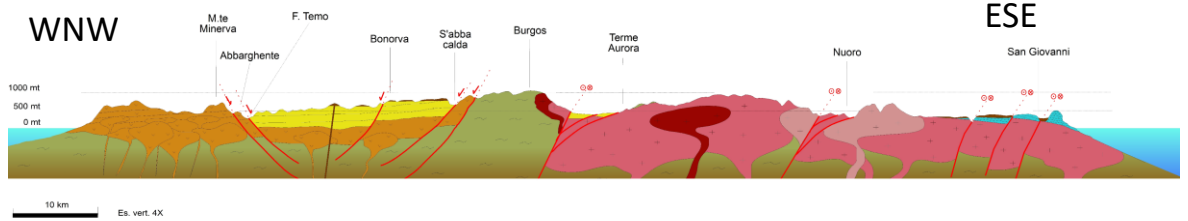
- Quaternary alluvial deposits and reduced intraplate volcanism
- Tertiary sedimentary basins with volcanic units
- Deeply eroded Mesozoic sedimentary rocks
- Metamorphic basement widely intruded by Carboniferous-Permian granitoids (Variscan orogeny; 360-290 Ma)

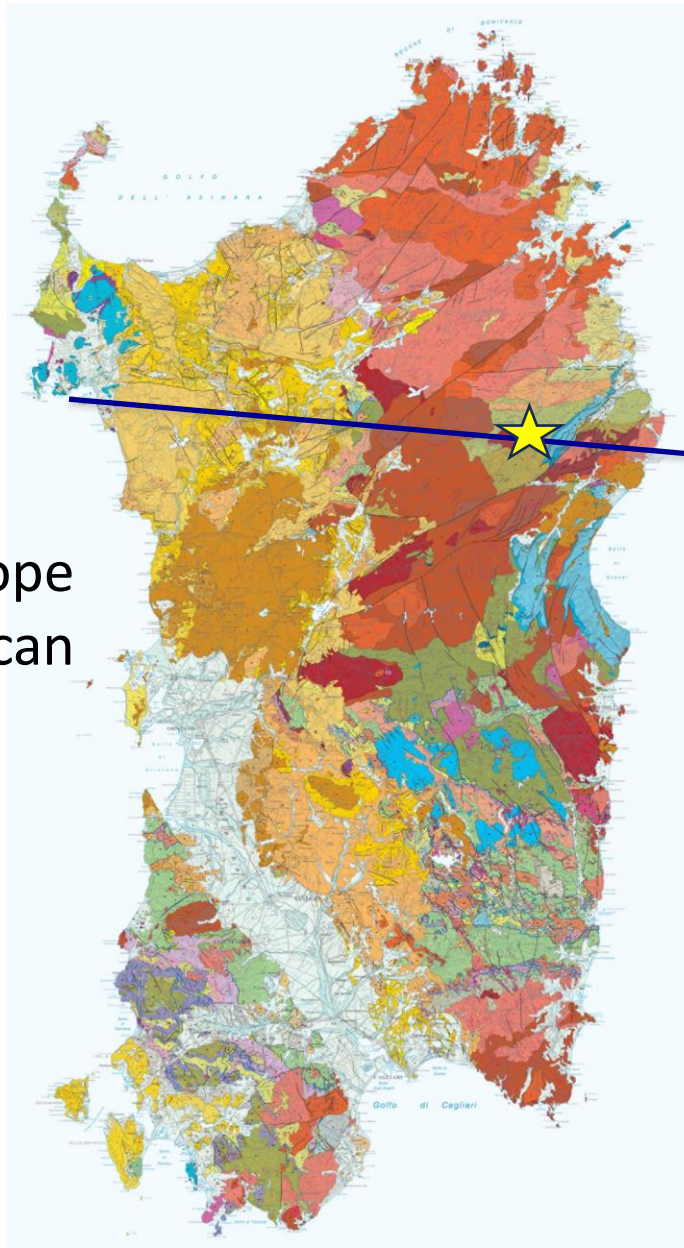


The proposed site for hosting the Einstein Telescope (ET) in Italy is located in the stable Variscan basement of Sardinia

- Geodynamic stability
- Low anthropic noise
- Low E.M. noise

Low seismic noise

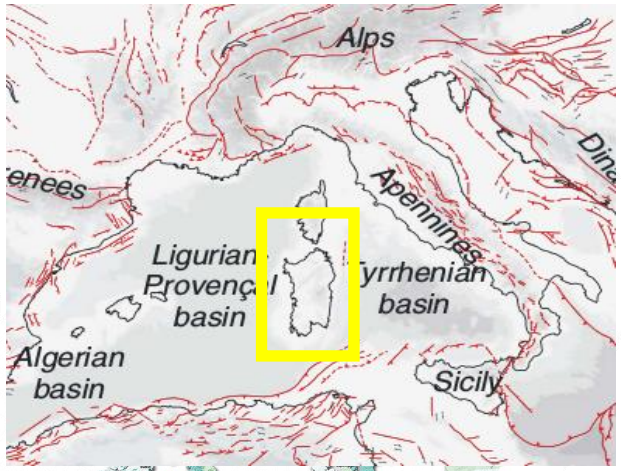


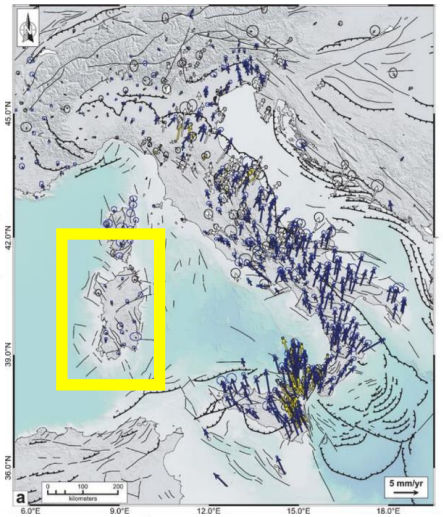


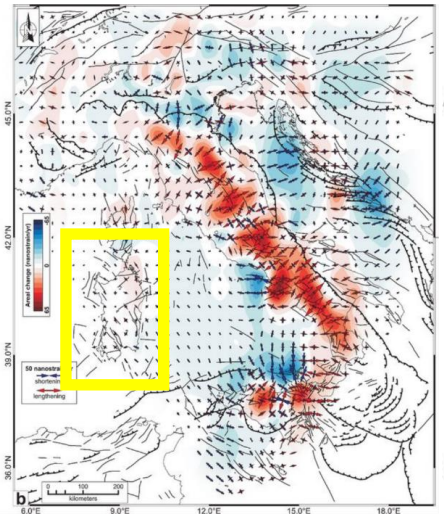
ET: Why in Sardinia

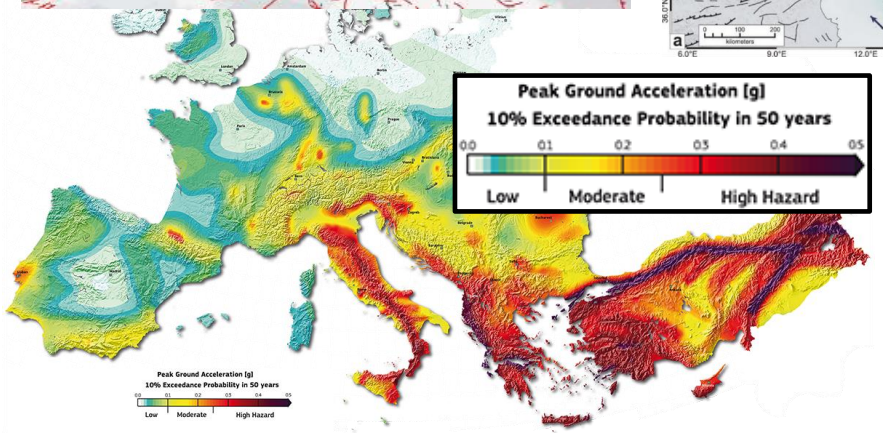
Sardinia, the geological framework

Far from active fault lines, the Corsica-Sardinia microplate is very stable → low crustal deformation.

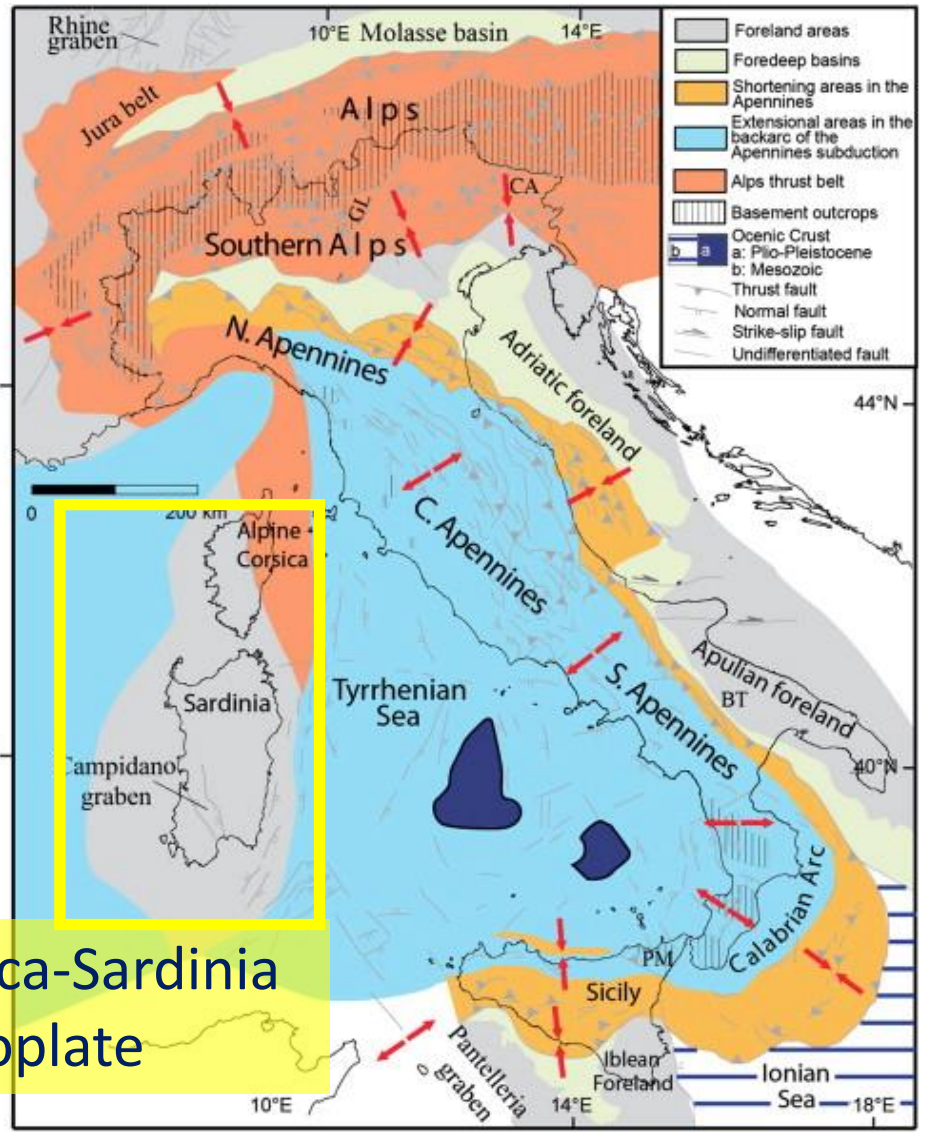








Unaffected by significative seismic activity.

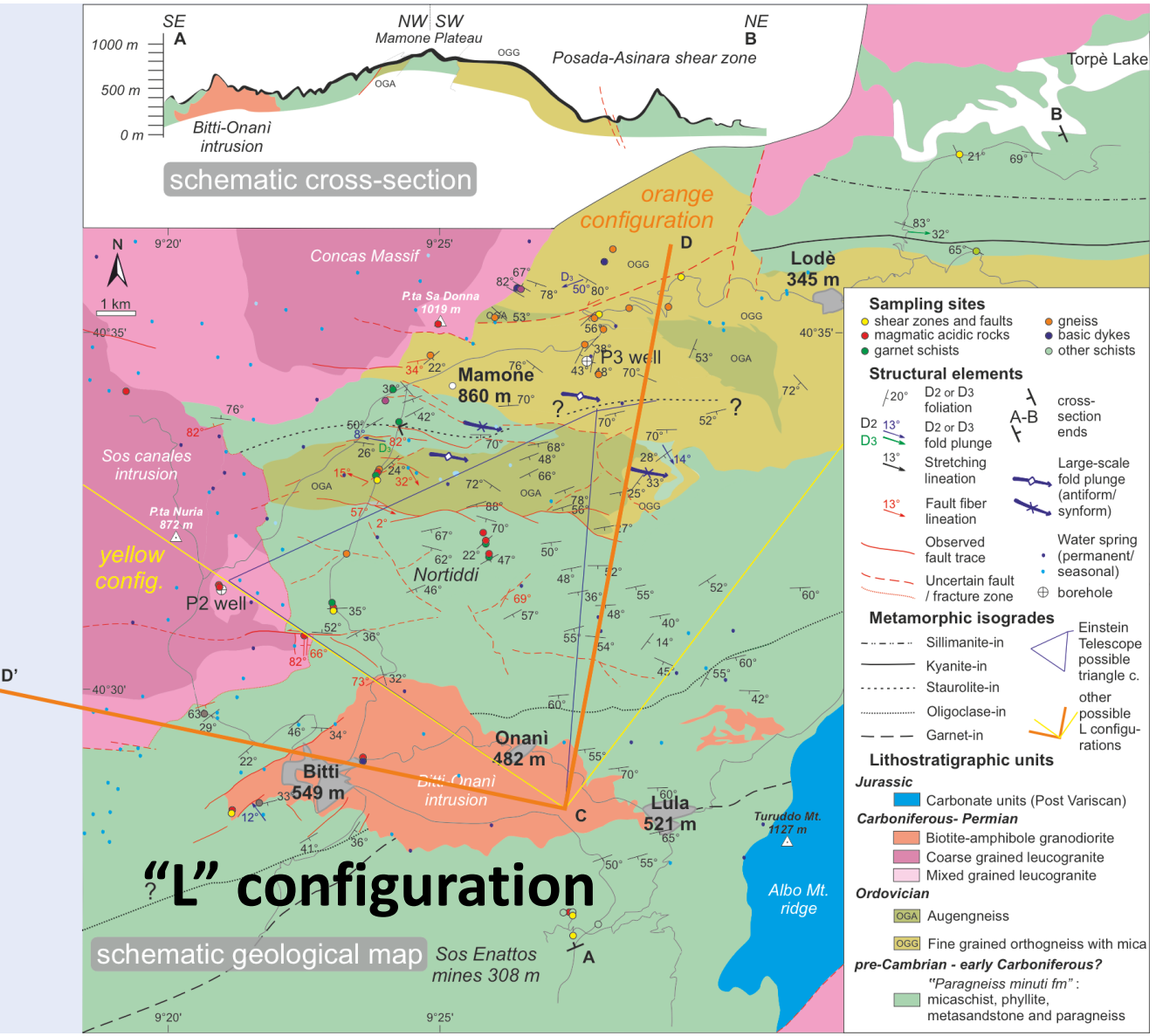


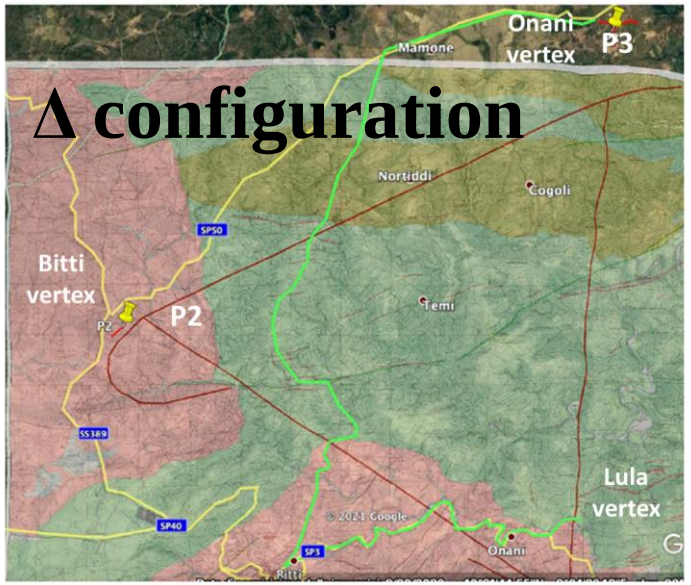
Corsica-Sardinia microplate

ET: Why in Sardinia

Good quality rocks

Lithologies: orthogneiss, granitoids, mica schists. The red triangle represents the Δ configuration of the Einstein Telescope (ET). One of the possible L configurations is also indicated. P2 and P3 are the positions of the boreholes. Ongoing activities include geological investigation of the area and revision of geological maps.





The Sos Enattos site

how did we arrive at the former Sos Enattos mine?

A bit of history…

It's 2010, and for the writing of the Conceptual Design Study of the Einstein Telescope (ET), seismic noise measurements are taken at various European sites. Sardinia, known for being aseismic and sparsely populated, appears to be an ideal option: F. Ricci (INFN Roma) contacts several former mines to conduct an underground measurement, but only one responds positively... fortunately located in what turns out to be the best spot in Sardinia!

2010: first seismic measurement at Sos Enattos

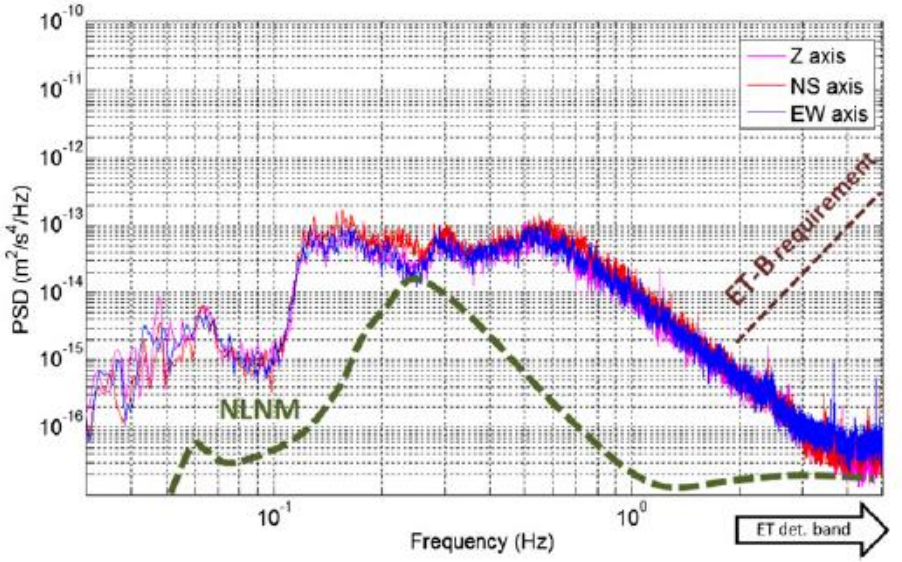
2012: first permanent station at Sos Enattos

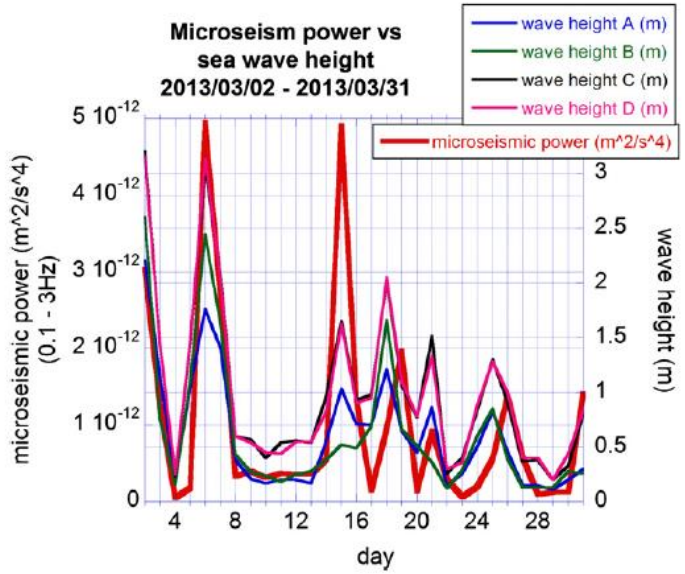
2014: first characterization results published

IOP Publishing — Classical and Quantum Gravity
Class. Quantum Grav. **31** (2014) 105016 (20pp) — doi:10.1088/0264-9381/31/10/105016

Microseismic studies of an underground site for a new interferometric gravitational wave detector

L Naticchioni[1,2], M Perciballi[2], F Ricci[1,2], E Coccia[3,4], V Malvezzi[3], F Acernese[5,6], F Barone[5,6], G Giordano[5], R Romano[5,6], M Punturo[7], R De Rosa[6,8], P Calia[9] and G Loddo[9]





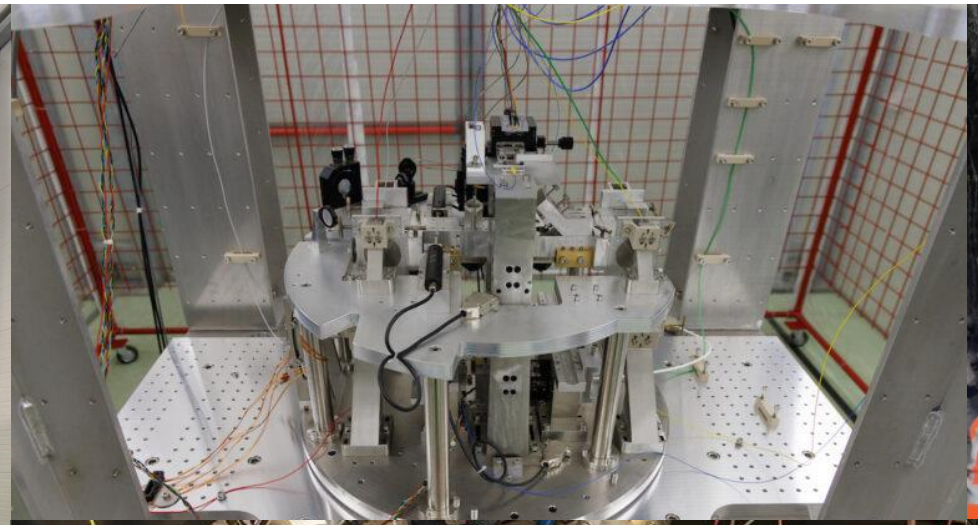
2019: expansion of the Sos Enattos sensor array

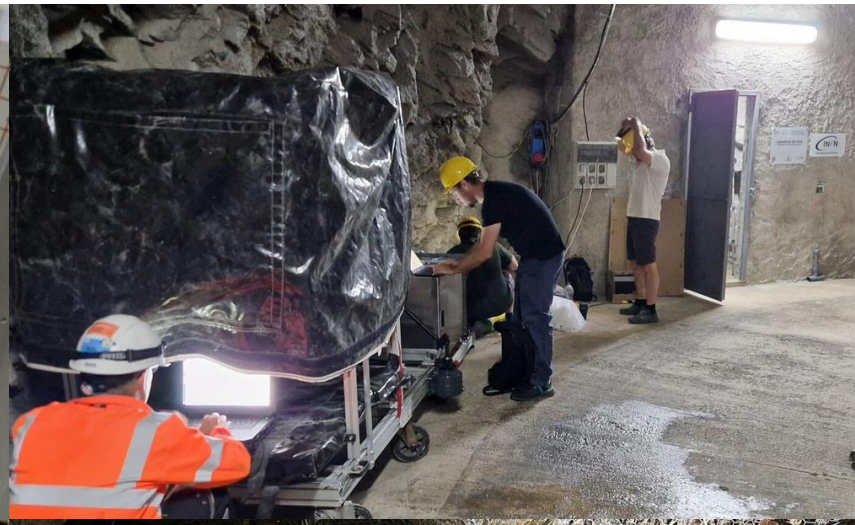


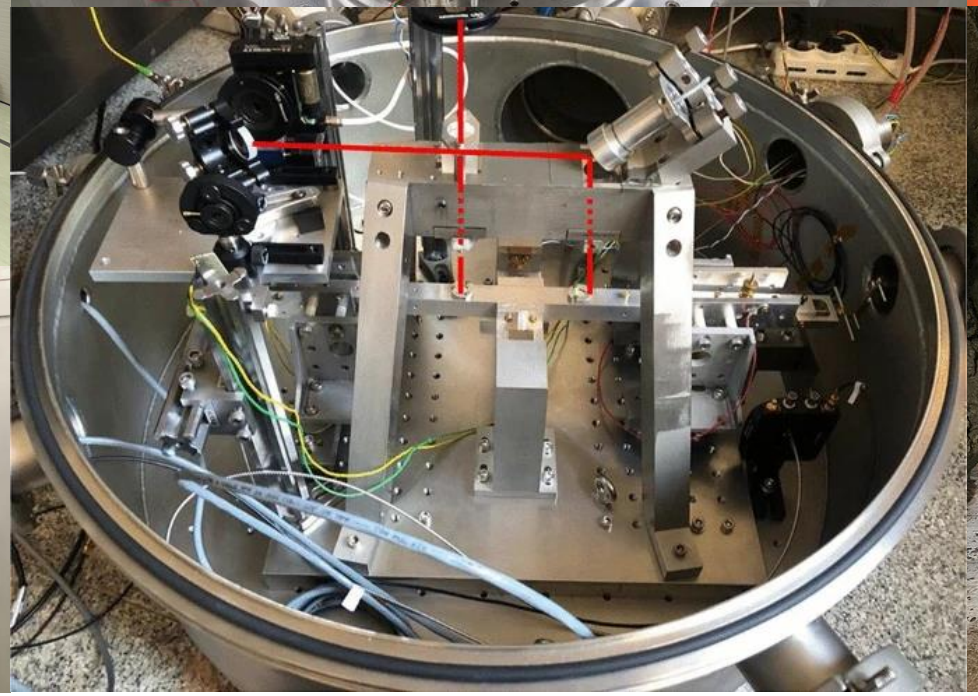


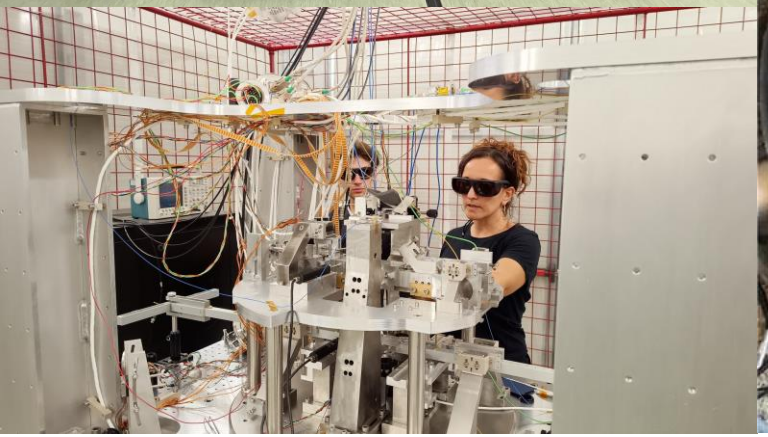

2019: The SarGrav Lab

2020.. : Archimedes and new sensors at Sos Enattos









2021.. : Boreholes and measurements in the candidate area

Sinergy with INGV

SUnLab @ Sos Enattos

INFN

Istituto · Sedi · Ricerca · Fisica · Tecnologia · Cultura · News & Multimedia

Home / COMUNICATI INFN / COMUNICATI STAMPA 2025 / Presentato a Lula il progetto ET-SUnLab, il primo "seme" di Einstein Telescope

COMUNICATI STAMPA 2025

PRESENTATO A LULA IL PROGETTO ET-SUNLAB, IL PRIMO "SEME" DI EINSTEIN TELESCOPE

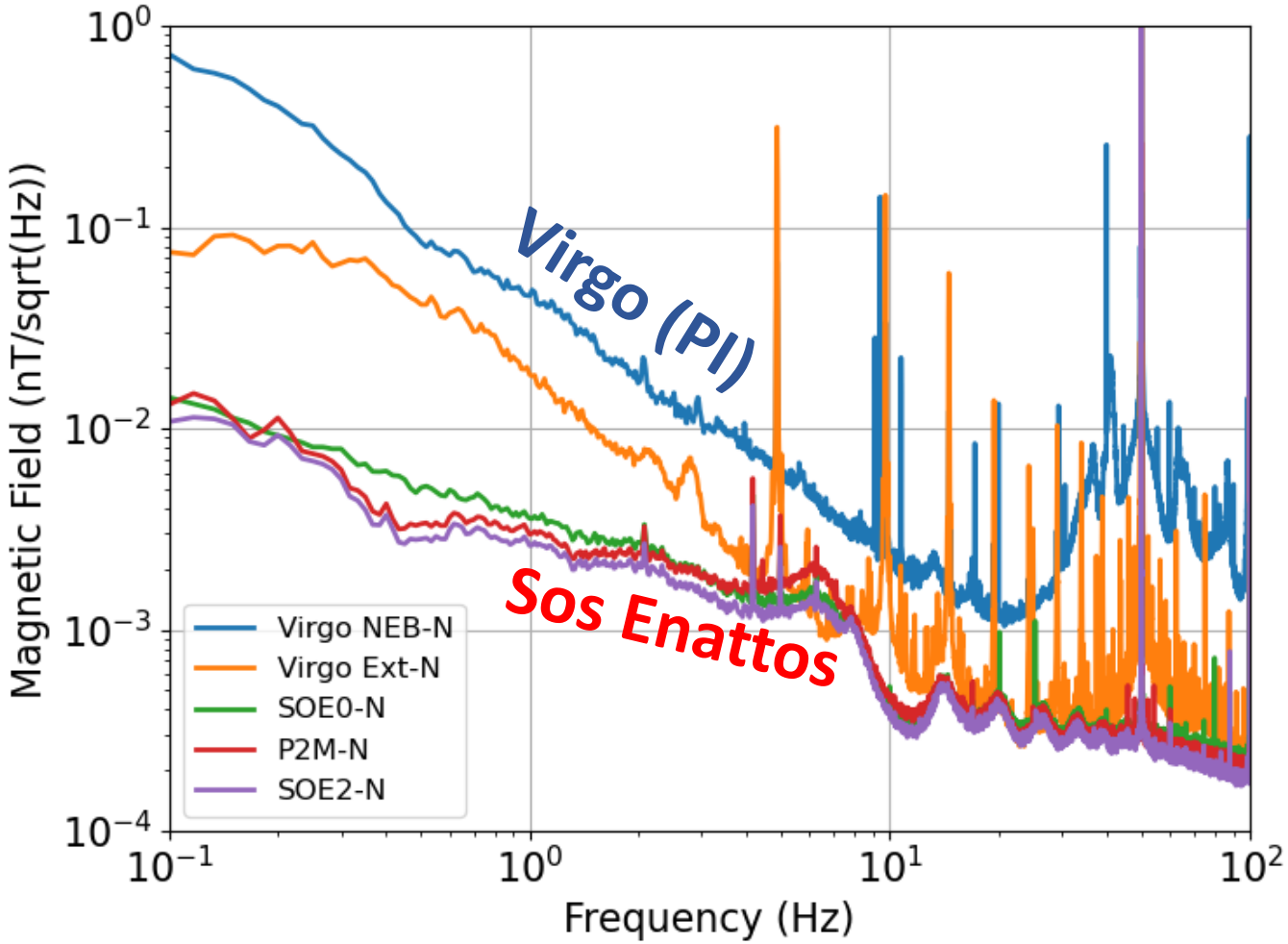
20 Marzo 2025

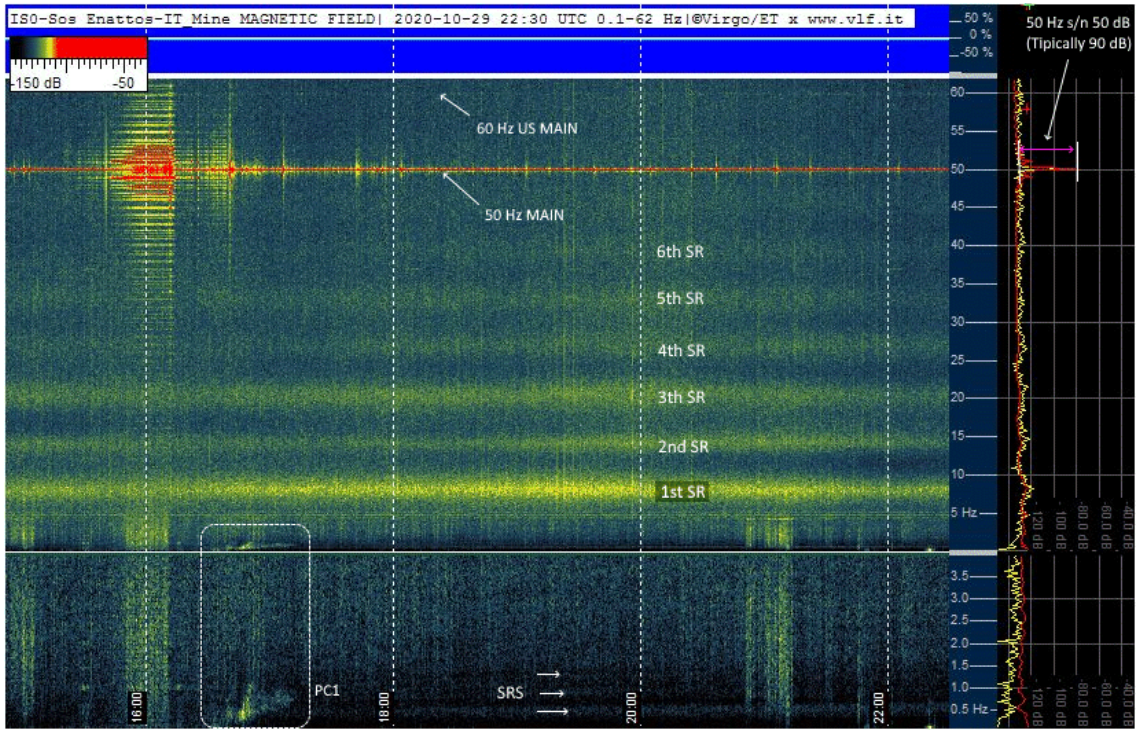
Nel pomeriggio di giovedì 20 marzo, alla Palestra Comunale di Lula (NU), è stato presentato pubblicamente il progetto ET-SUnLab (Einstein Telescope Sardinia Underground Laboratory), futuro centro di ricerca che sarà costruito nell'area della miniera di Sos Enattos, candidata a ospitare l'osservatorio di onde gravitazionali Einstein Telescope (ET).

L'evento è stato aperto dai saluti del sindaco di Lula, Mario Calia, e della presidente della Regione Sardegna, Alessandra Todde, seguiti dagli interventi del presidente dell'Istituto Nazionale di Fisica Nucleare (INFN), Antonio Zoccoli, del consigliere di amministrazione dell'Istituto Nazionale di Astrofisica (INAF), Andrea Comastri, del direttore del dipartimento Ambiente dell'Istituto Nazionale di Geofisica e Vulcanologia (INGV), Massimo Chiappini, del Pro-rettore alla ricerca dell'Università di Cagliari, Luciano Colombo, del Rettore dell'Università di Sassari,

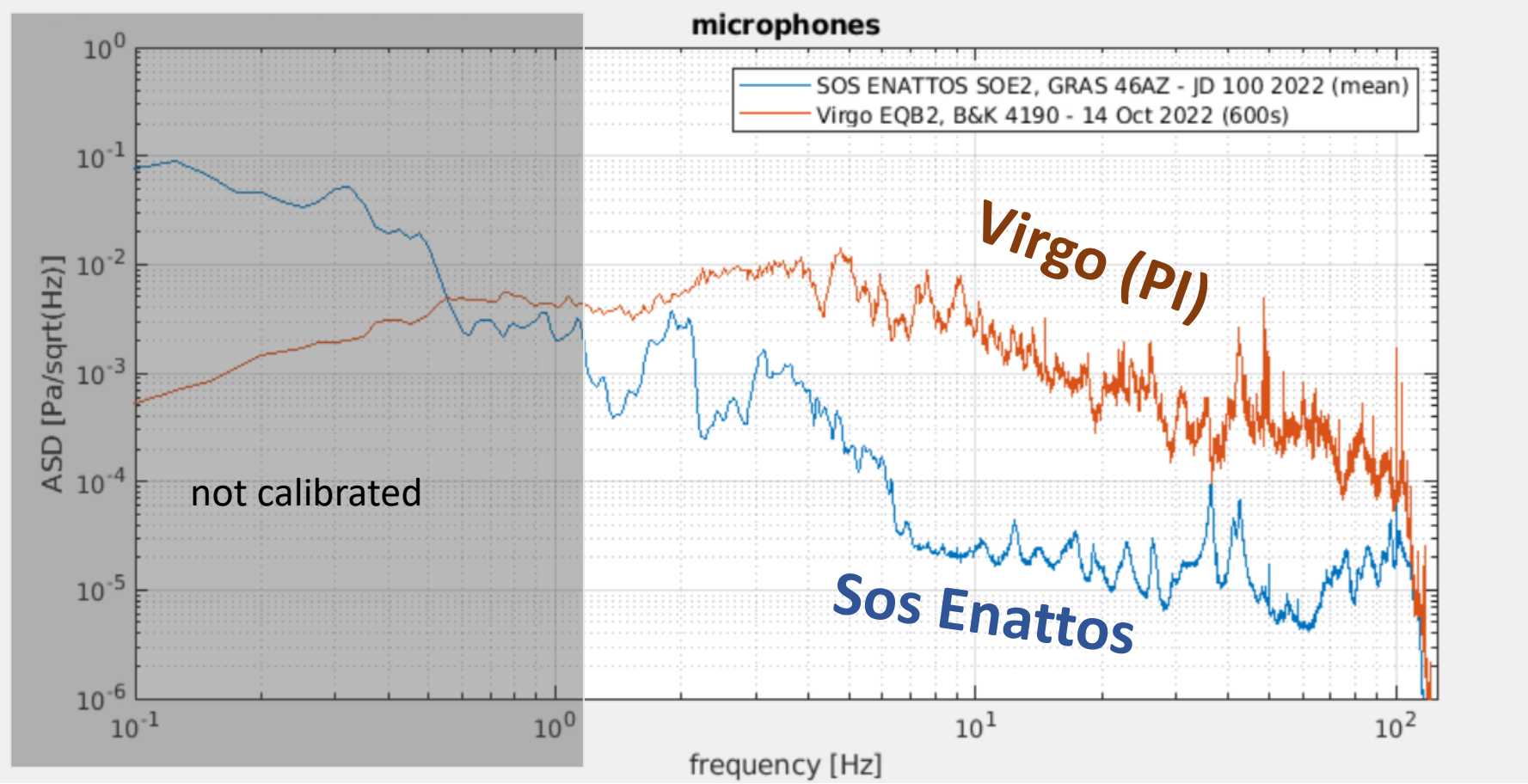
The SUnLab will replace the old industrial building currently hosting the SarGrav Lab. Construction works will start in 2025, SUnLab is expected to be completed by 2026.

Low Electromagnetic Noise…



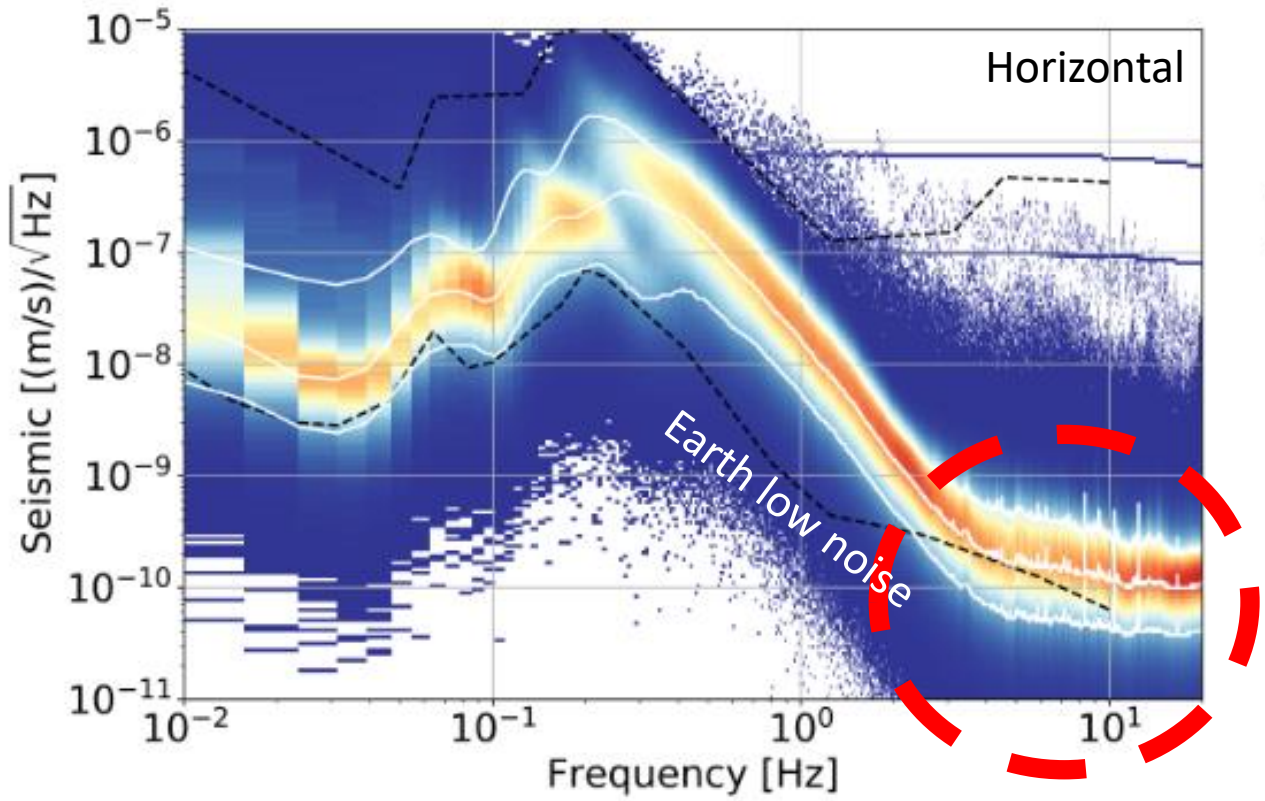


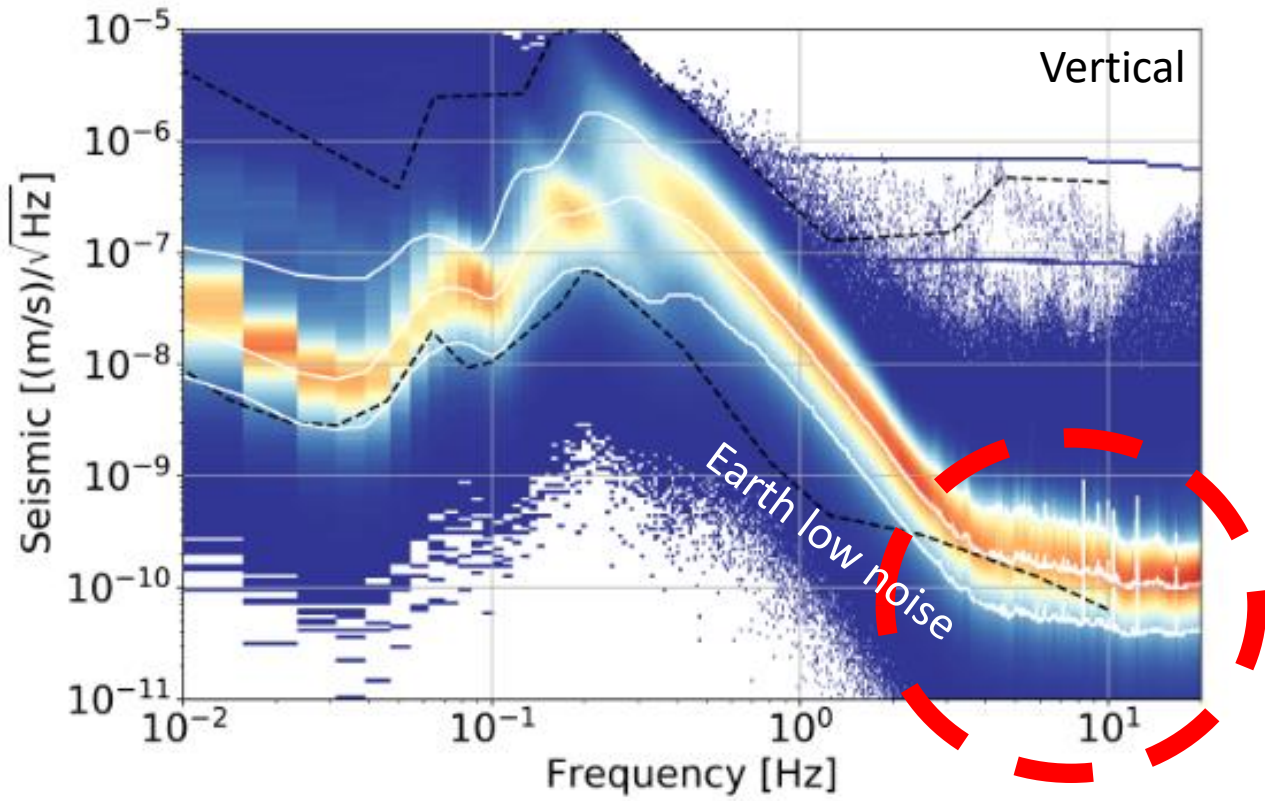
…Low Acoustic Noise…



…Low seismic noise!

Seismic background noise in the borehole (-250 m)





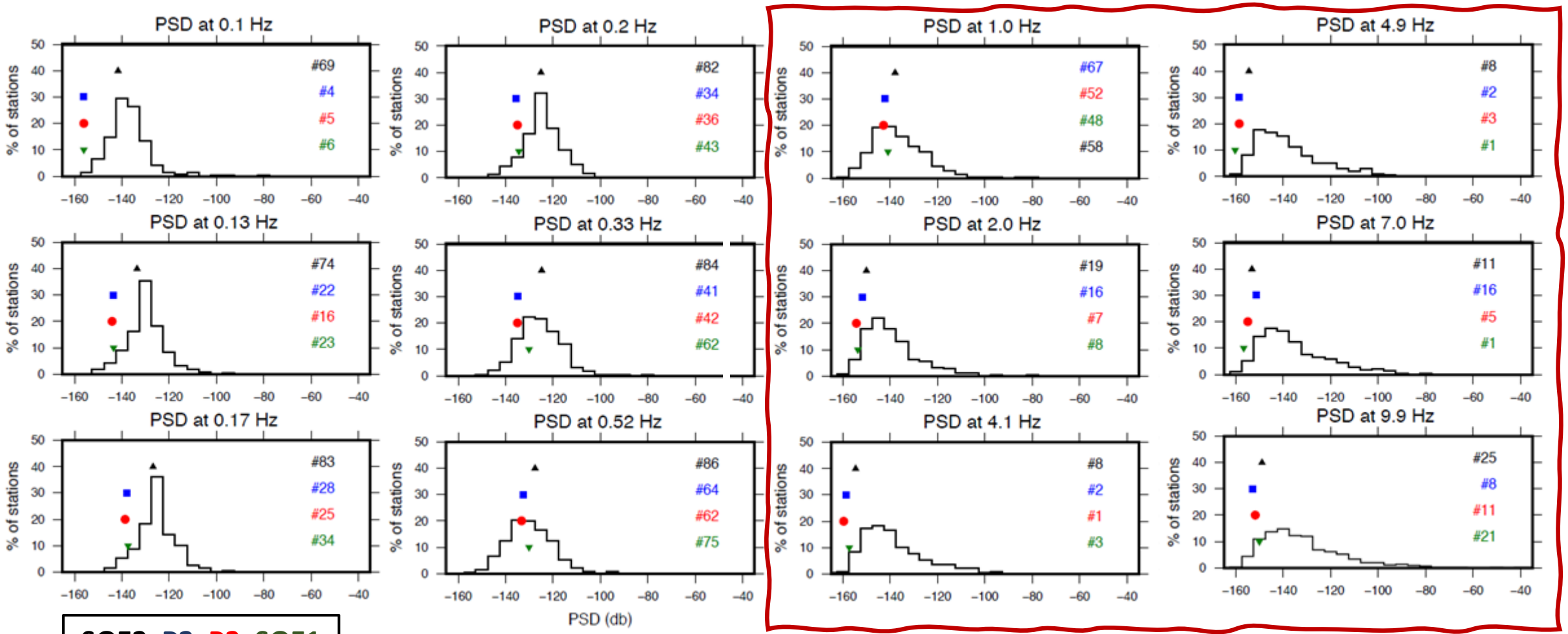
Very low noise background in the 2-10 Hz band, even **below** the Peterson's **New Low Noise Model**!

…Low seismic noise!

Quietest stations in the world

Ranking of Sardinia site compared to the quietest seismic stations (GSN, IRIS network) **worldwide**.

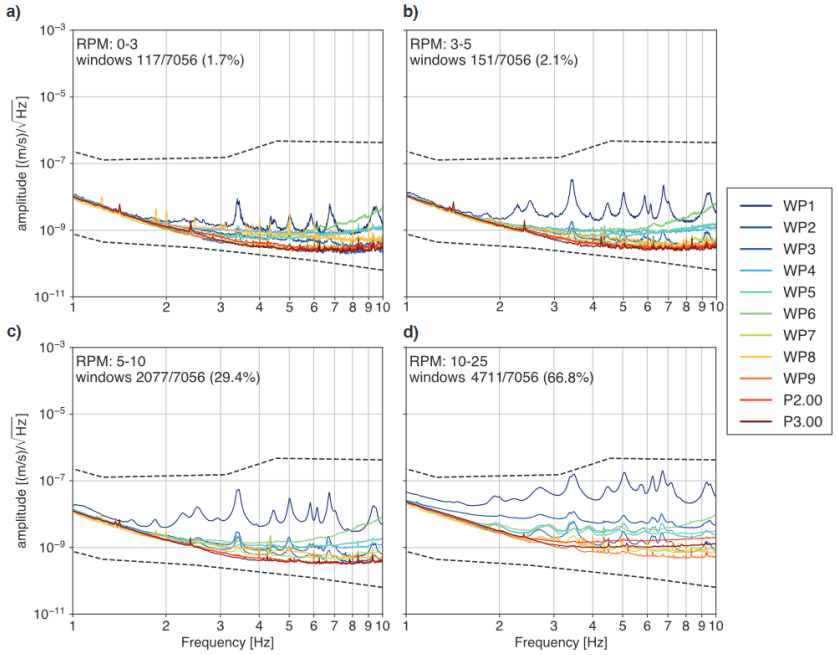
ET LF

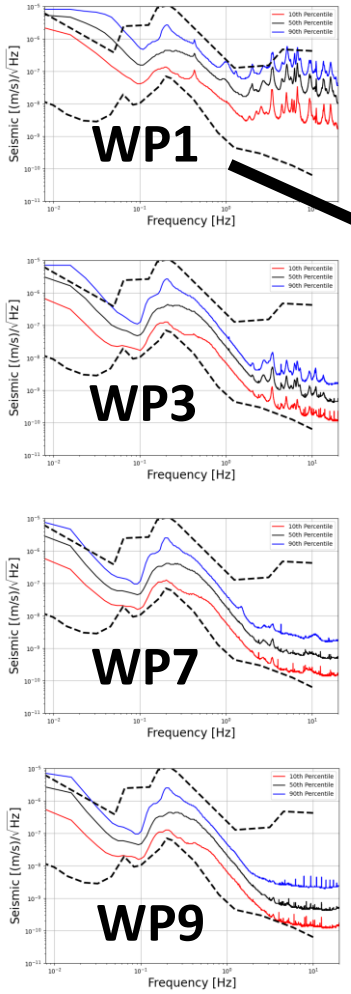


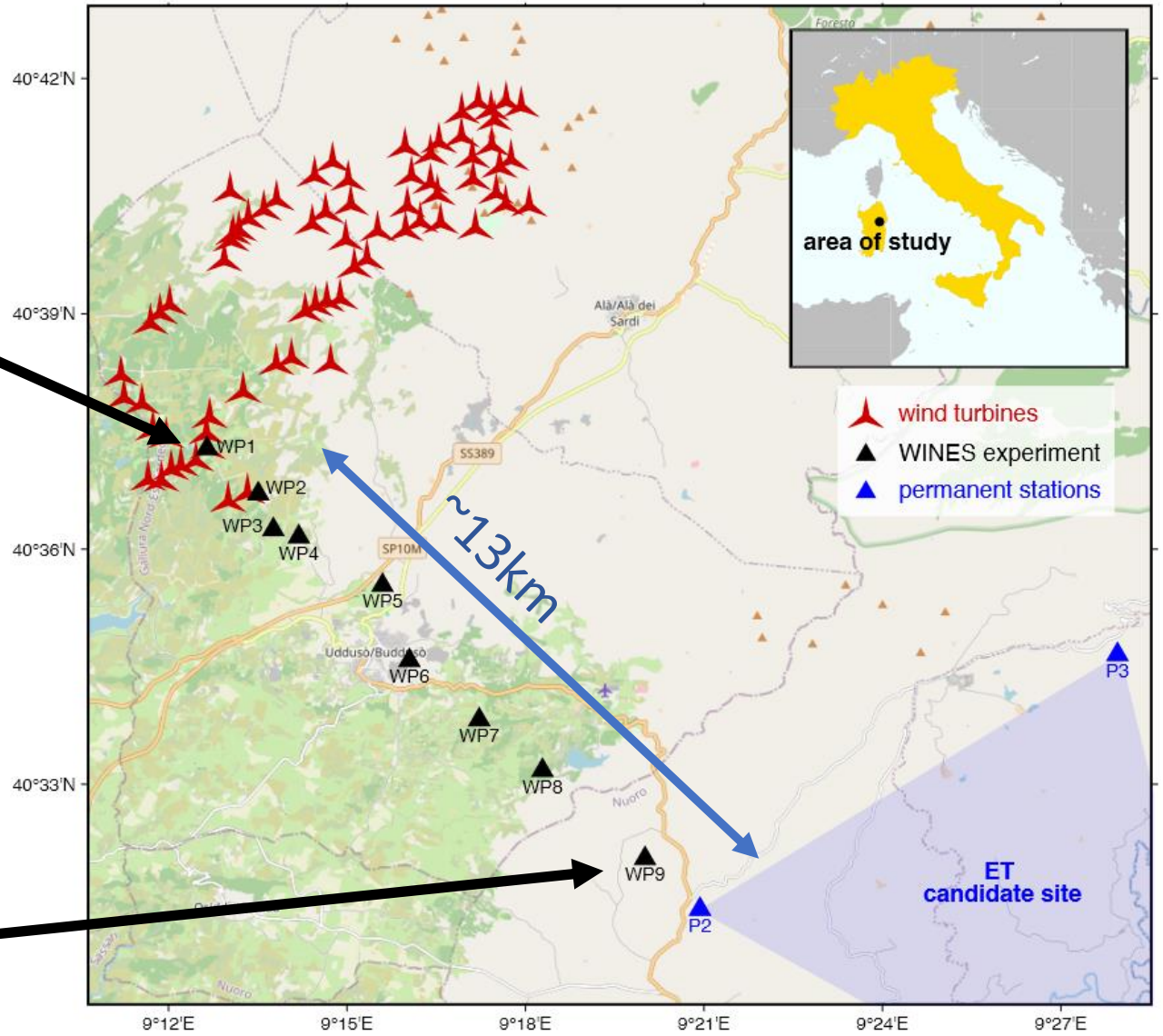
SOE2 P2 P3 SOE1

Studying the local sources of noise

Windparks (e.g. Budussò windfarm)



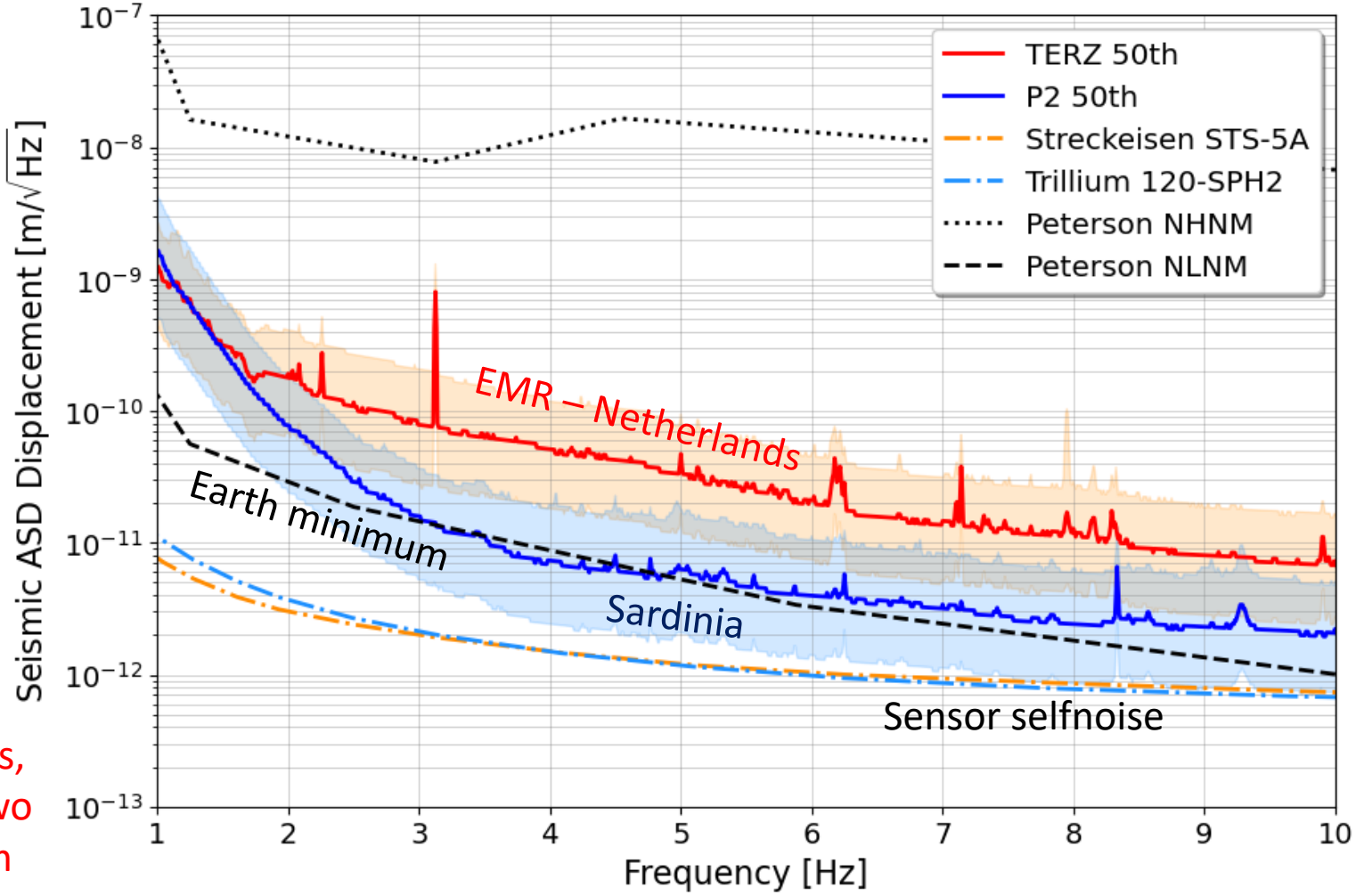




Seismic noise: Sardinia vs EMR

Borehole measurements comparison

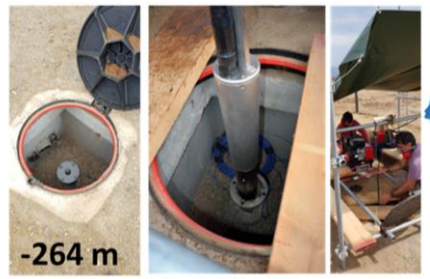
In the crucial few Hz band of ET (2-10 Hz), Sos Enattos area is among the quietest sites in the world and up to a factor 9 better than EMR.



Horizontal channels, measured in the two boreholes at -250m

EMR (Terziet) Borehole

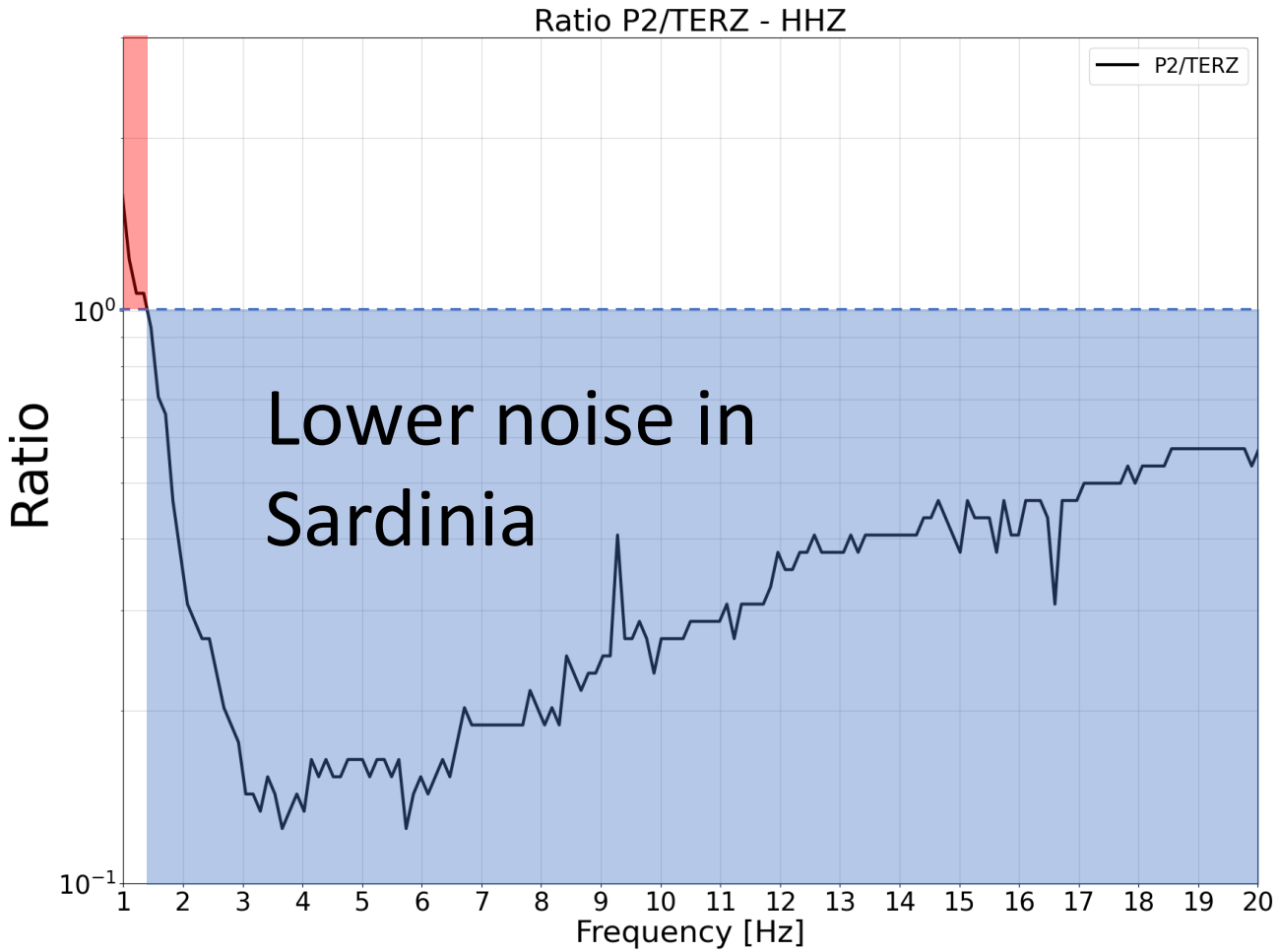
Sardinia (P2) Borehole



Seismic noise: Sardinia vs EMR

Borehole measurements comparison

In the crucial few Hz band of ET (2-10 Hz), Sos Enattos area is among the quietest sites in the world and up to a factor 9 better than EMR.



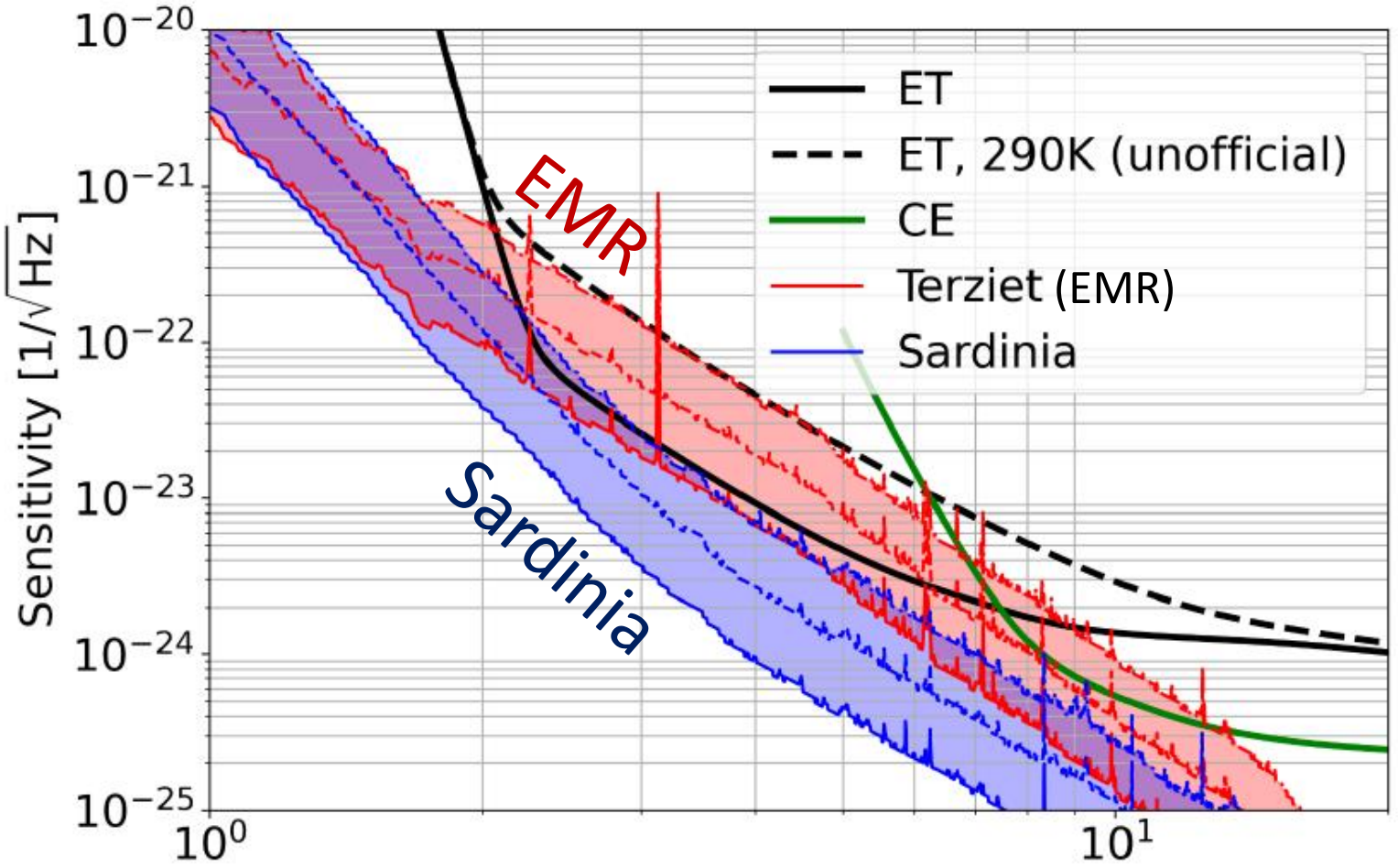
Seismic noise: Sardinia vs EMR

Seismic Newtonian Noise projections

Defining the Newtonian Noise ASD as:

$$\tilde{h}_{NN}(f) = \frac{4\pi}{3} G\rho_0 \frac{2\sqrt{2}}{L} \frac{1}{(2\pi f)^2} \tilde{x}(f)$$

seismic noise displacement ASD



Conclusions

- Extensive **geophysical characterization campaign and environmental noise measurements** in the Sos Enattos area, starting from the pioneering measurements of 2010-2012. Since 2019, a stable measurement network has been installed in Sos Enattos for the measurement of **seismic**, **magnetic**, and **acoustic noise**.
- A network of sensors in the candidate site area with possible vertices of the infrastructure already instrumented, to which new measurement stations will be added at the vertices of the "L" configuration of ET.
- Particular attention to **low-frequency noise** (especially between 2 and 10 Hz), which could limit the scientific capabilities of ET: in this band, the Barbagia area in **Sardinia is among the quietest in the world**.
- Potential "local" noise sources (e.g., wind turbines) are being studied and have led to the definition of a **buffer zone** around the ET infrastructure.
- **Thanks to geological stability, rock quality, and low levels of environmental and anthropogenic noise, Sardinia is the best candidate site to host ET, regardless of its final configuration (Δ or L).**