EINSTEIN TELESCOPE

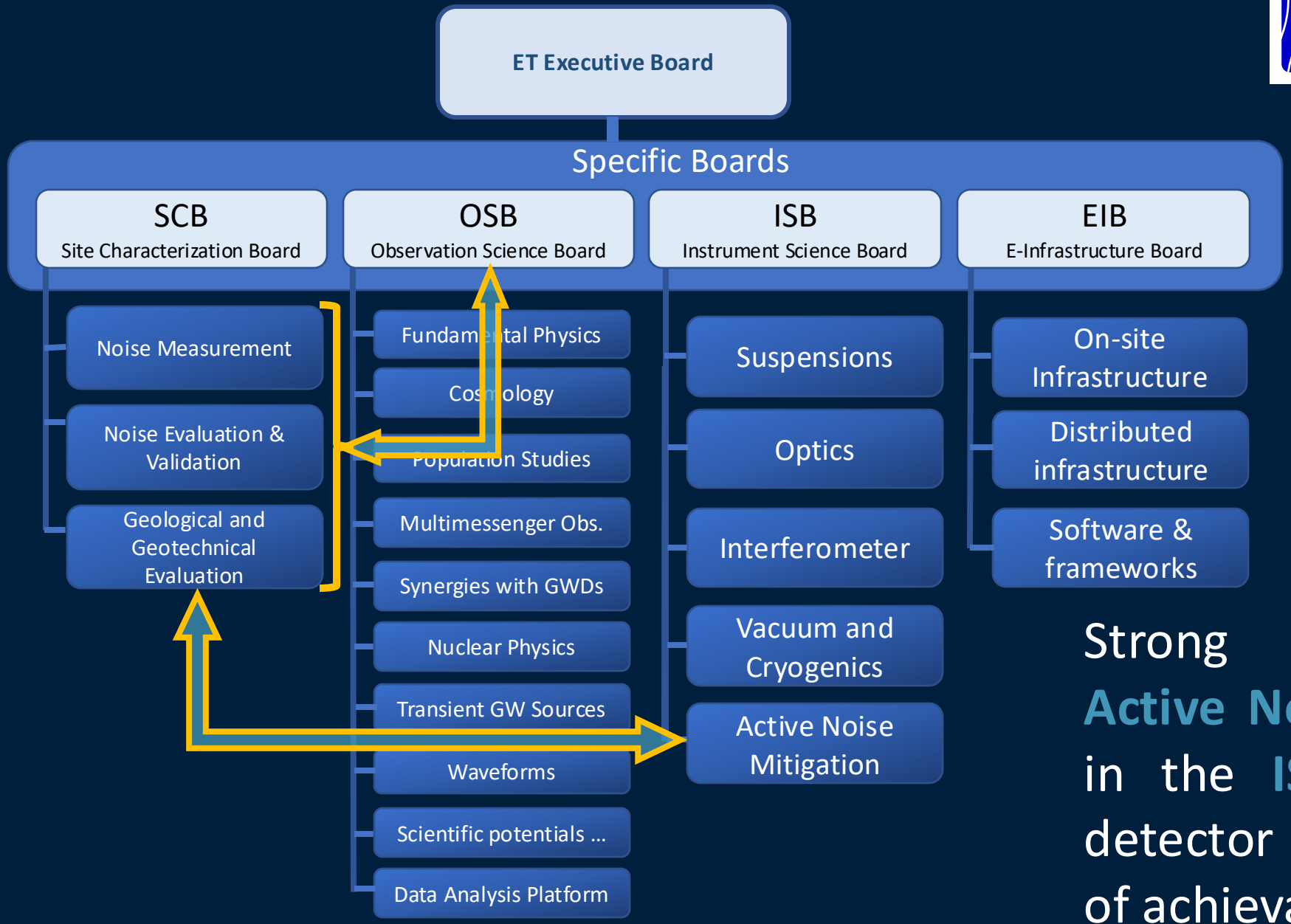
XV Einstein Symposium
May 26-30, 2025

INFN
Istituto Nazionale di Fisica Nucleare

ET ITALY
Einstein Telescope

Status Update of Sardinia activities

Davide Rozza
on behalf of the Sardinian site characterization team



EINSTEIN TELESCOPE

Strong interaction with the **Active Noise Mitigation** division in the **ISB** and with **OSB** for detector performance in terms of achievable physics goals

We are in the **SOS ENATTOS** former mine area, where the **SARGRAV laboratory** can host:

UNDERGROUND EXPERIMENTS	CRYOGENIC PAYLOADS	LOW FREQUENCY AND CRYOGENIC SENSOR DEVELOPMENT

that need **LOW SEISMIC** and **ANTHROPOGENIC NOISE**

Action lines

Two Geometrical Options: Δ vs 2L

Legal Framework and authorization

Socio-economic impact

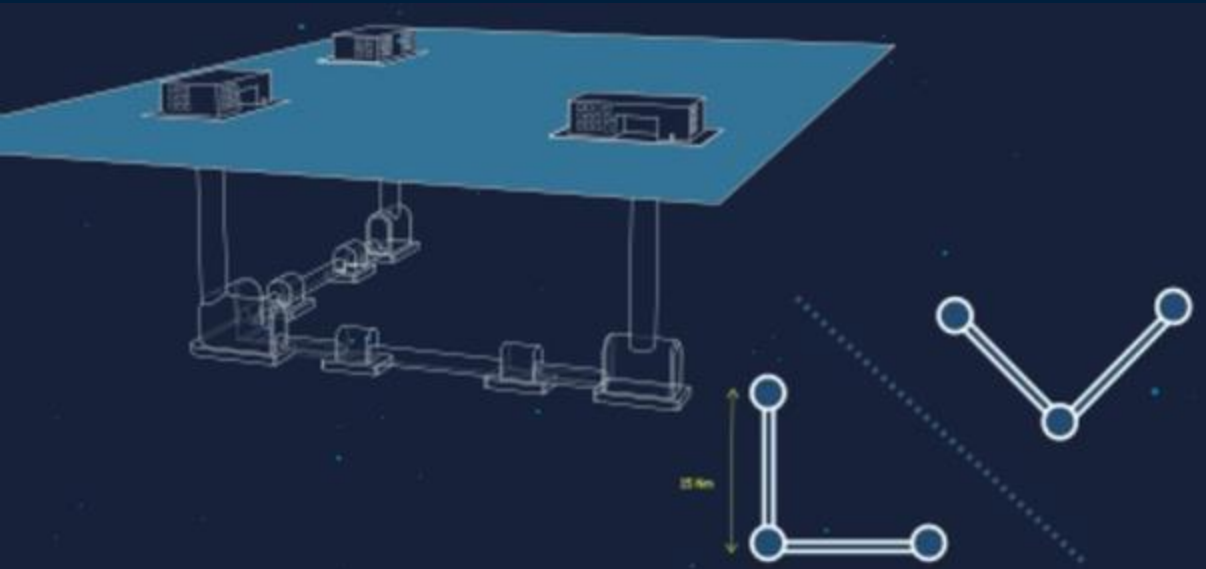
Geological studies

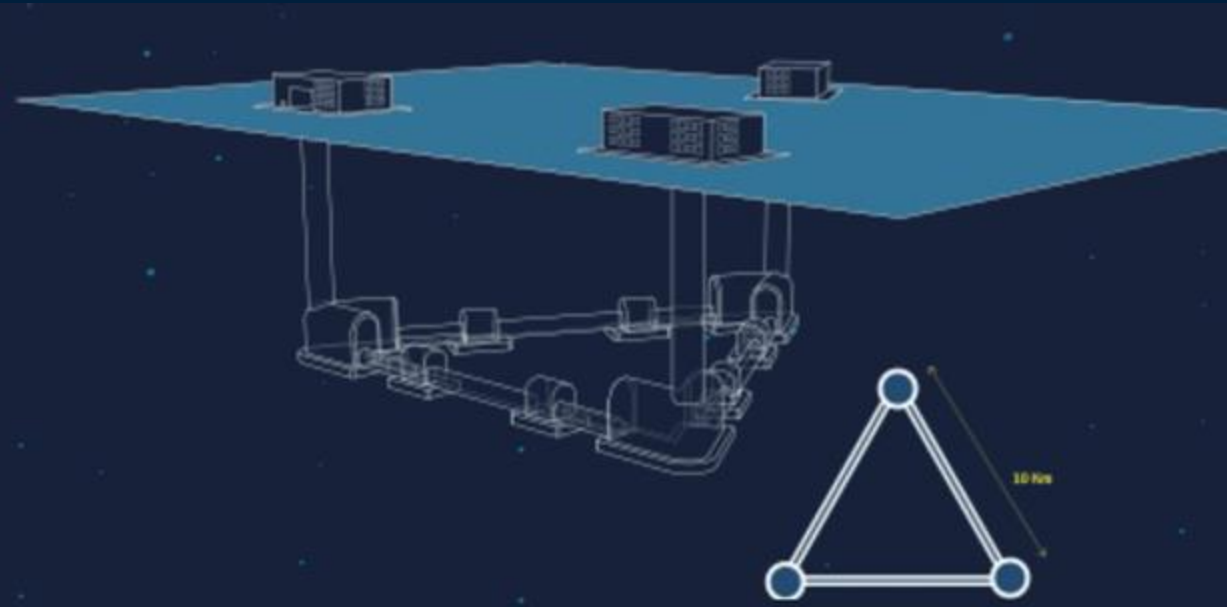
Site monitoring

Noise impact Evaluation

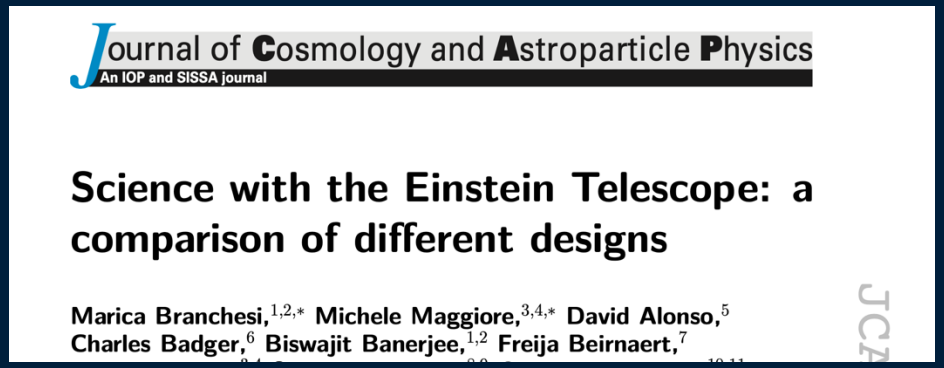
Engineering studies

cost and time estimation





Optimised Science Return



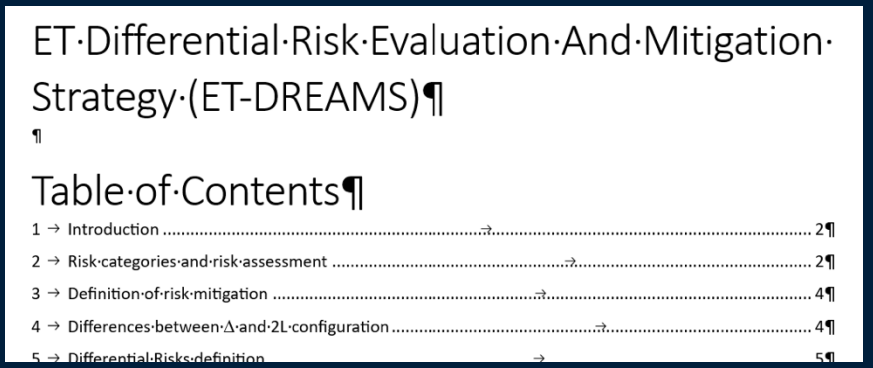
Journal of Cosmology and Astroparticle Physics
An IOP and SISSA journal

Science with the Einstein Telescope: a comparison of different designs

Marica Branchesi,[1,2,*] Michele Maggiore,[3,4,*] David Alonso,[5]
Charles Badger,[6] Biswajit Banerjee,[1,2] Freija Beirnaert,[7]

The 2L 15 km geometry shows, wrt 10km Δ shape, an improved science return in the majority of science targets

Differential Risk Evaluation



ET·Differential·Risk·Evaluation·And·Mitigation·Strategy·(ET-DREAMS)¶

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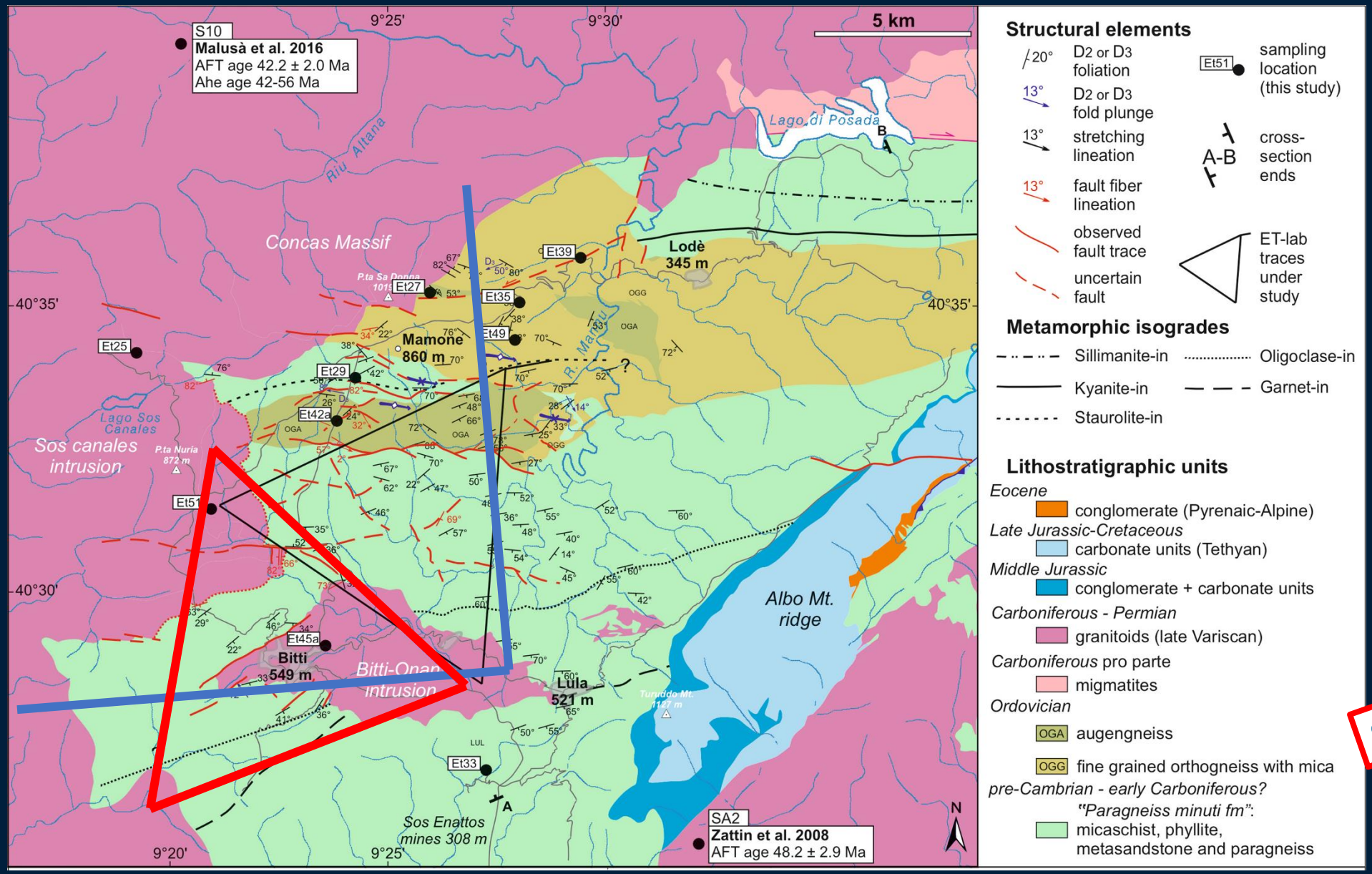
Table·of·Contents¶

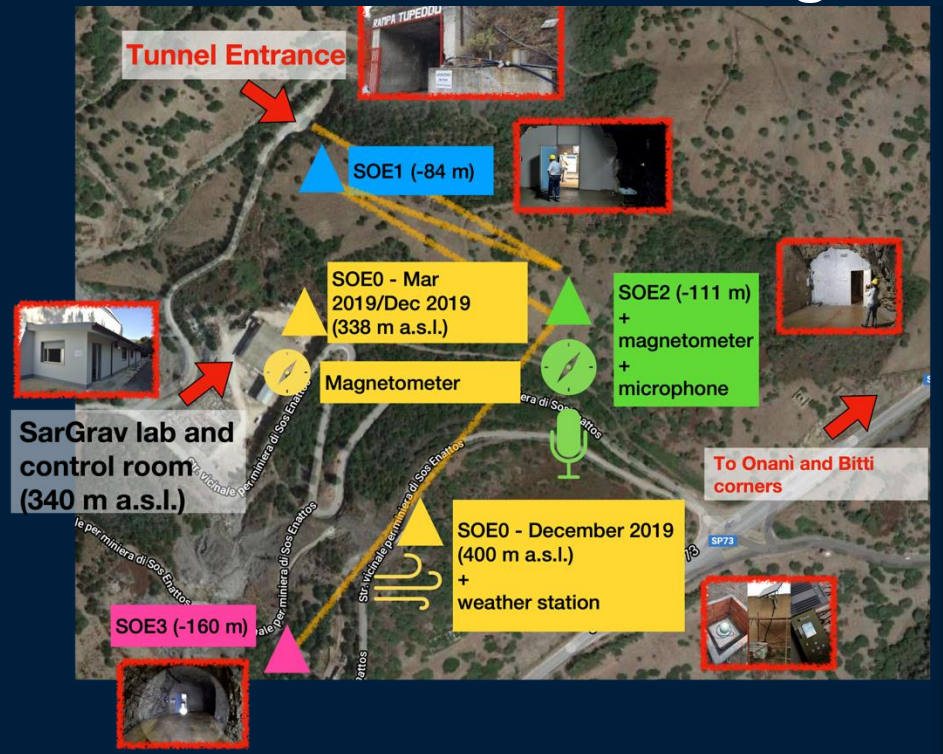
Geology updates



Geological exploration and new configuration selection for the candidate Einstein Telescope site in Sardinia (Italy)

See G.L. Cardello talk

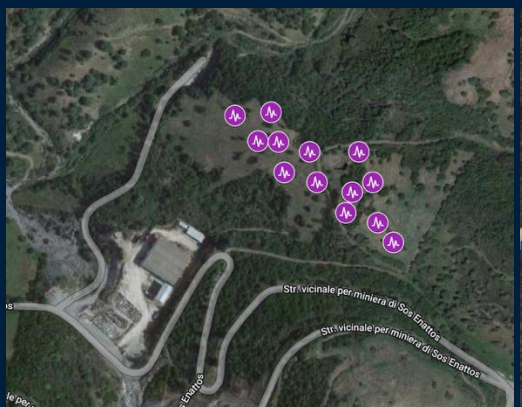
Site Monitoring



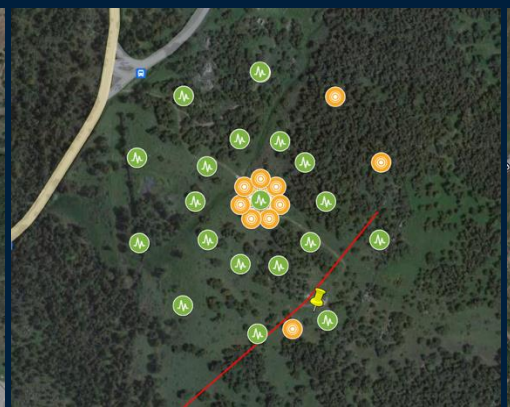
See G. Diaferia talk

Permanent and temporary ARRAY for characterization and Newtonian noise purposes

Sos Enattos broadband array (January 2021)

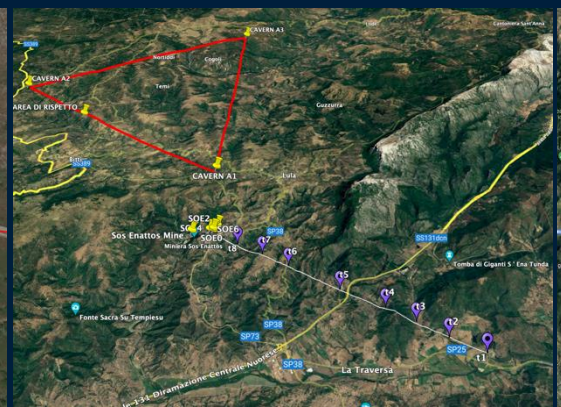


P2 broadband array + geophones (September 2021)

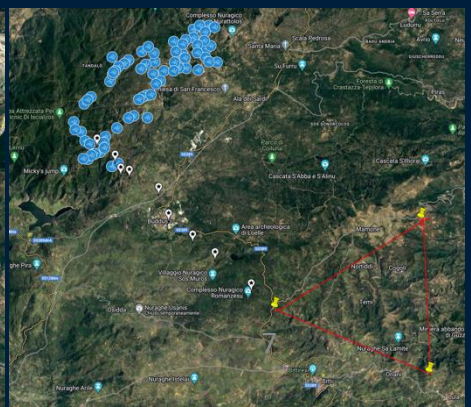


P3 broadband array + geophones (July & Oct 2021)

Explosion broadband array (early 2022)



Wind Park broadband array (early 2023)



Site Monitoring

Permanent array since 2019 at Sos Enattos

Since 2021, more permanent sensors have been installed at two of the proposed vertices (P2, P3)

2 broadband seismometers on surface;

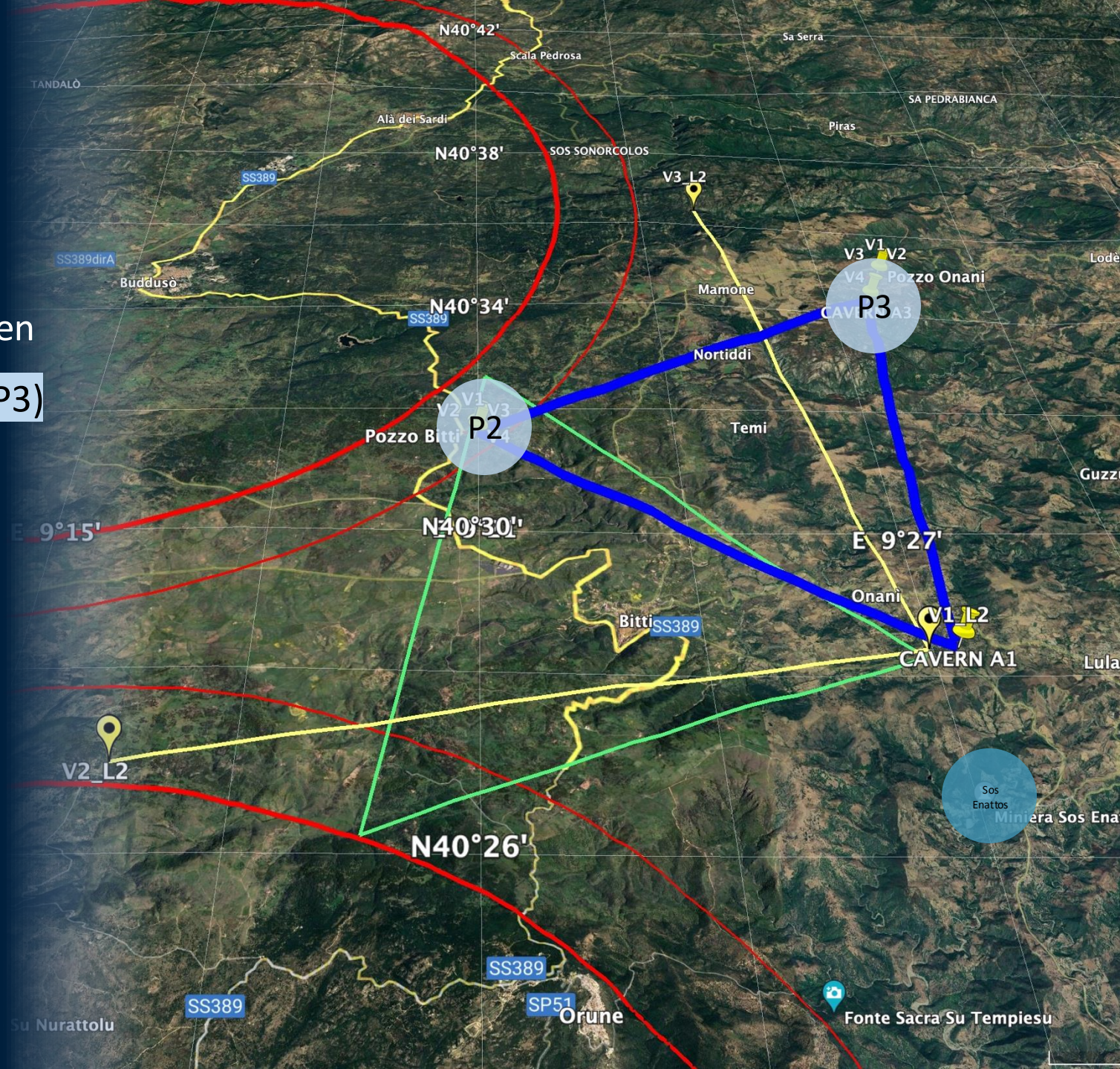
2 broadband seismometers in boreholes;

2 magnetometers at P2;

Acoustic measurement campaign at P2 & P3

Gravimetric campaign will start soon

Sos Enattos area will be reached at 1 TB/s



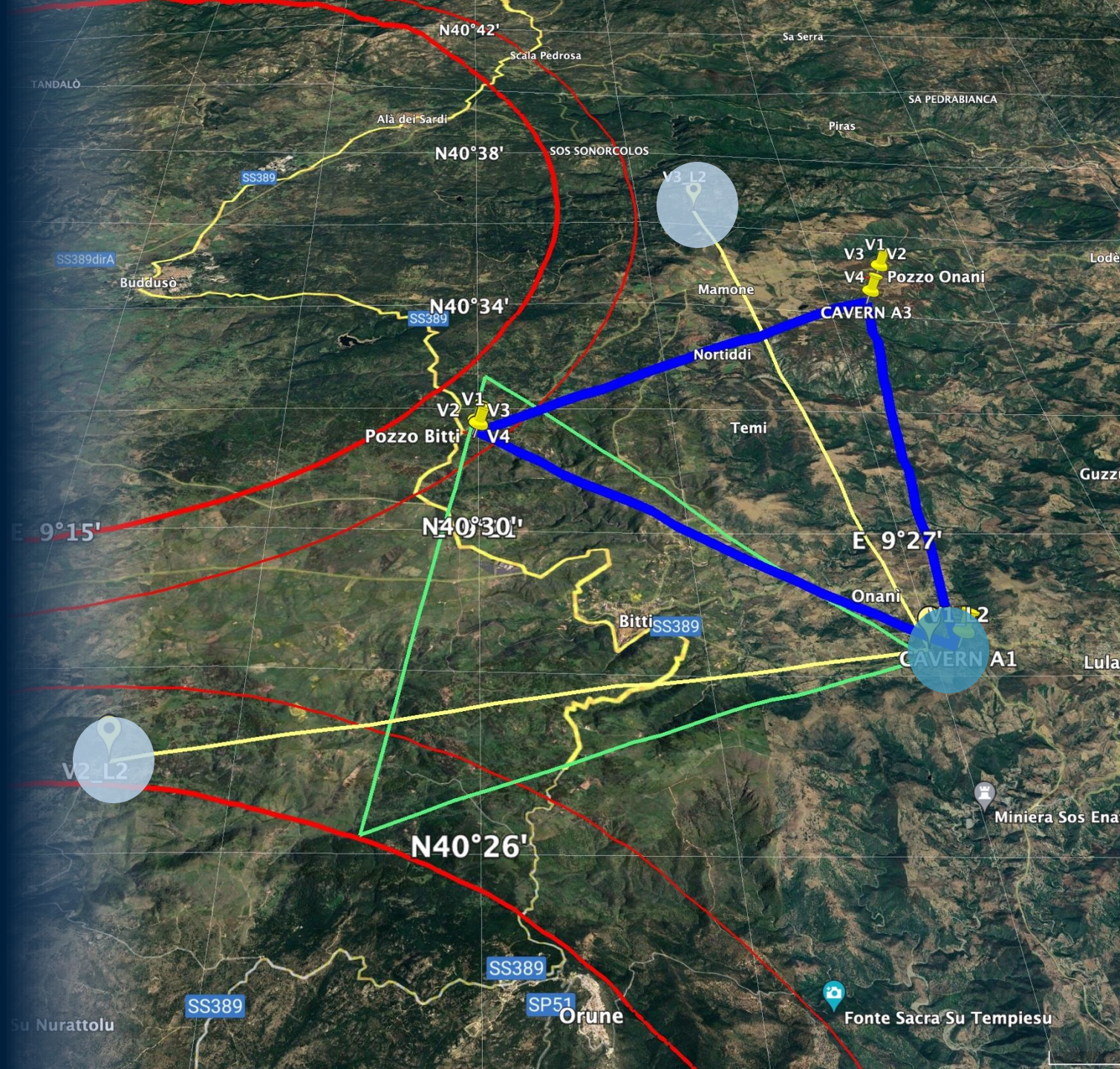
Site Monitoring

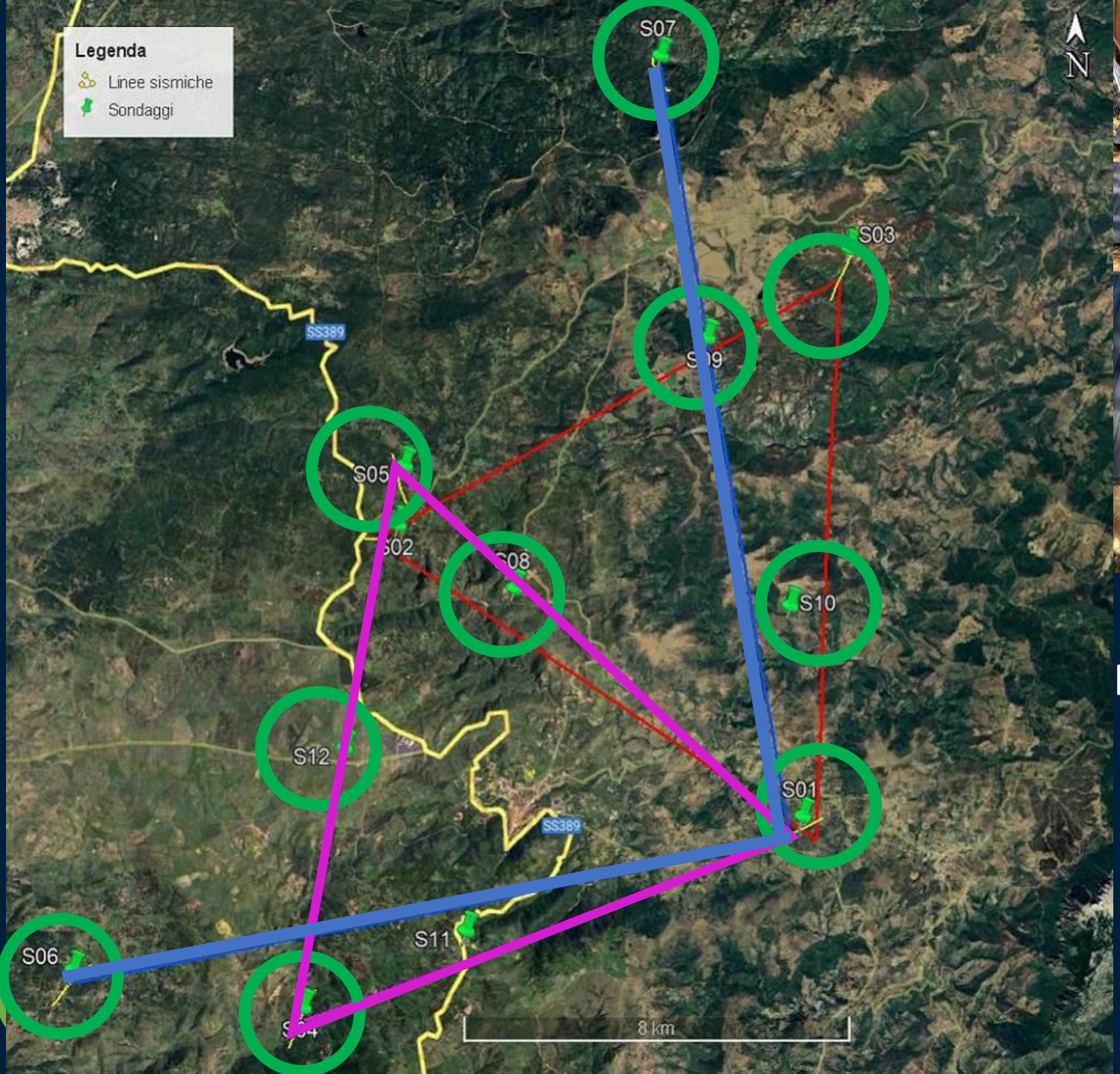
New stations at the other candidate vertices

new surface stations

(10 m underground)

new borehole station





New Drilling Campaign started in July ‘24

- 12 boreholes completed
- **Best Triangle and L identified**

Electromagnetic noise measurements

Magnetometers <u>installed</u> in the Sos Enattos area:

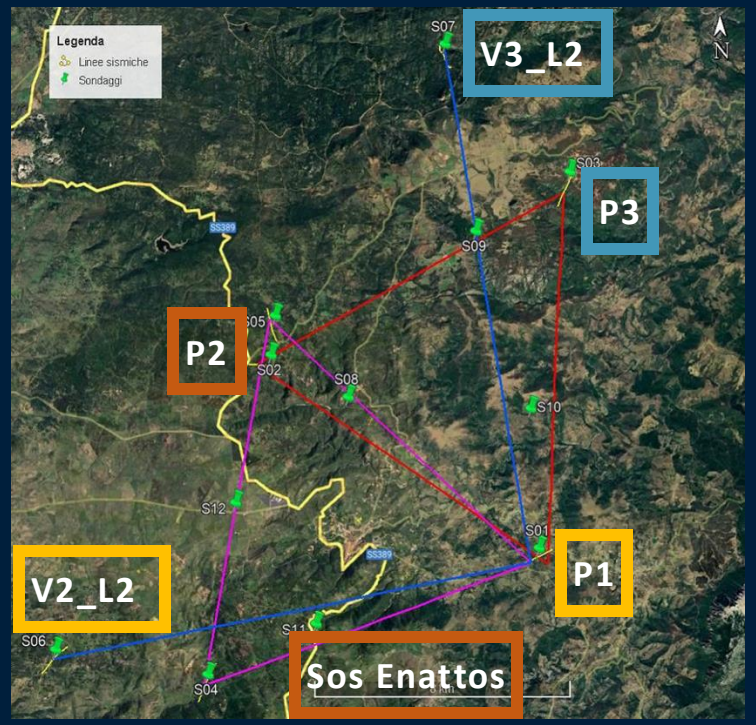
- 1 mag probe (N-S dir.) in surface at Sos Enattos (SOE0)
- 2 mag probes (N-S and E-W dir.) at -111 m underground at Sos Enattos (SOE2)
- 3 mag probes (N-S, E-W, Z dir.) in surface at Bitti (P2)

Ready <u>to be installed</u>:

- 3 mag probes at P3
- 3 mag probes at V3_L2

<u>To be purchased and installed</u>:

- 3 mag probes for V2_L2
- 3 mag probes for P1



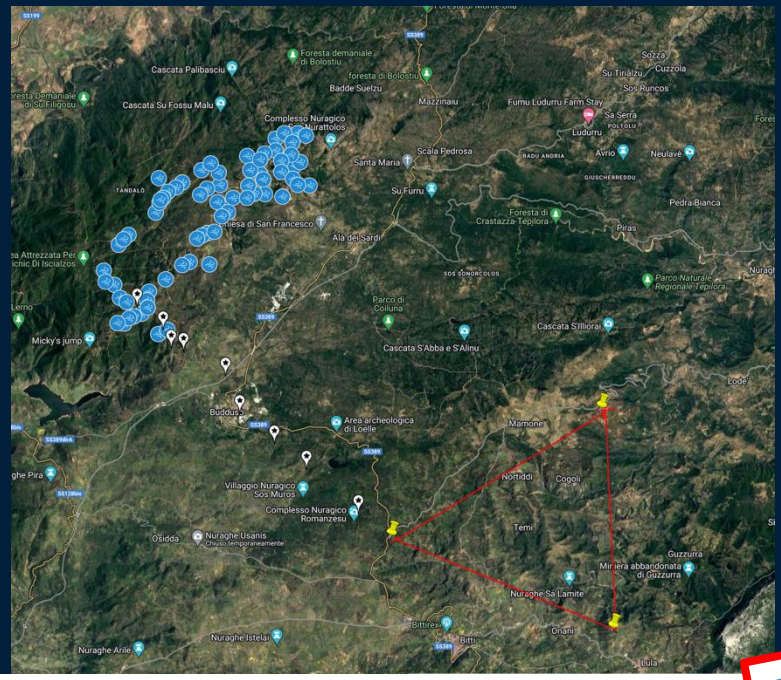
Activities and Timing

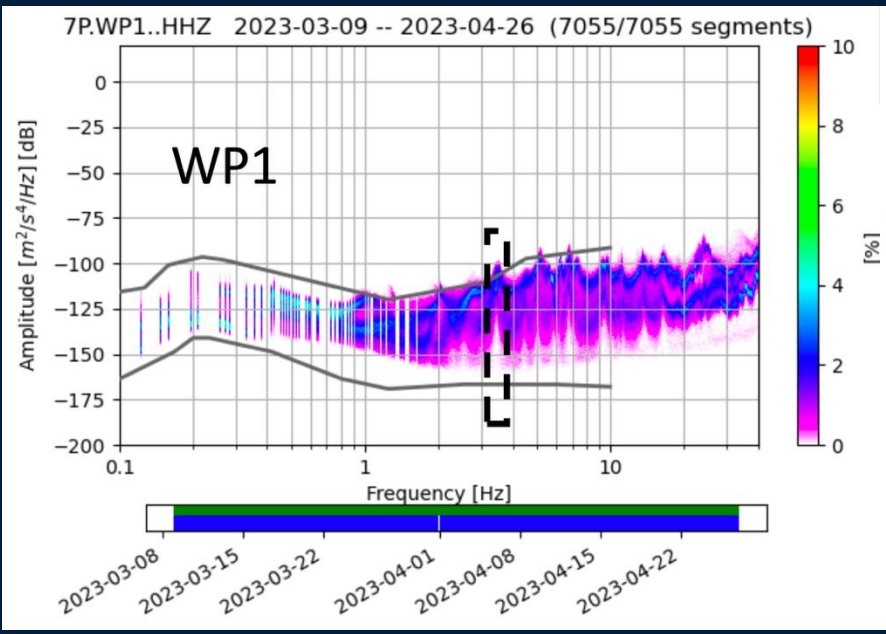
Engineering feasibility study (**12 M€**), company deadline **Q3 2025**

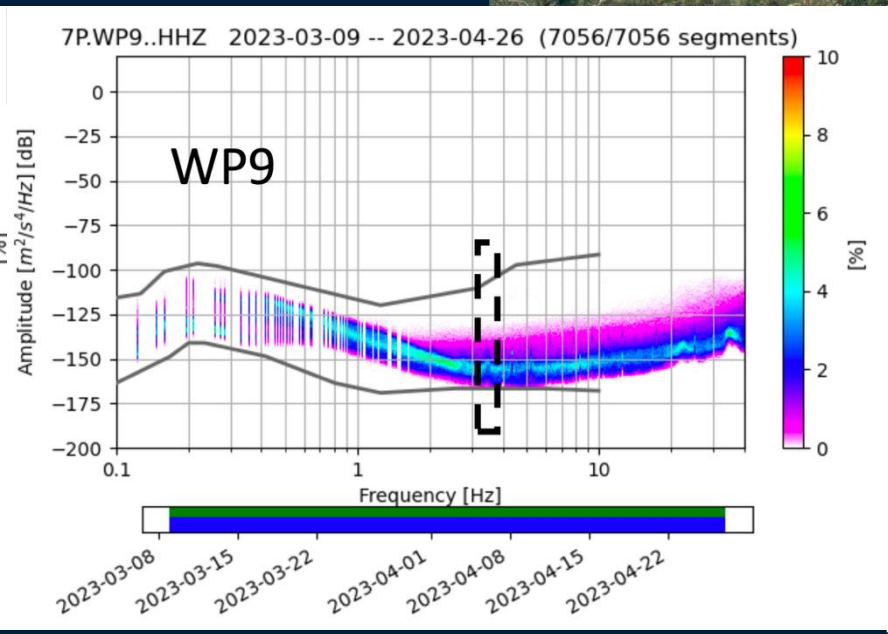
- Technical Studies for Subsurface Assessment and Risk Analysis
- Design and Construction Feasibility Assessment
- Cost and Time Estimation
- Environmental Impact Assessment, Permits, and Noise Mitigation Measures
- Safety and Security Plan
- Technical Infrastructure (Underground and Surface)

Hunting the noise source

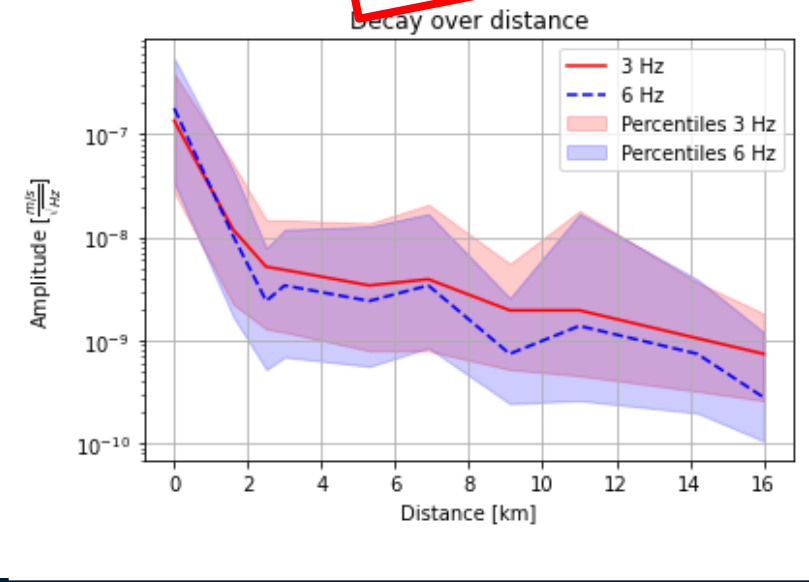
Seismic noise characterisation for the Buddusò – Ala dei Sardi wind park (Sardinia, Italy) and its impact on the Einstein Telescope candidate site







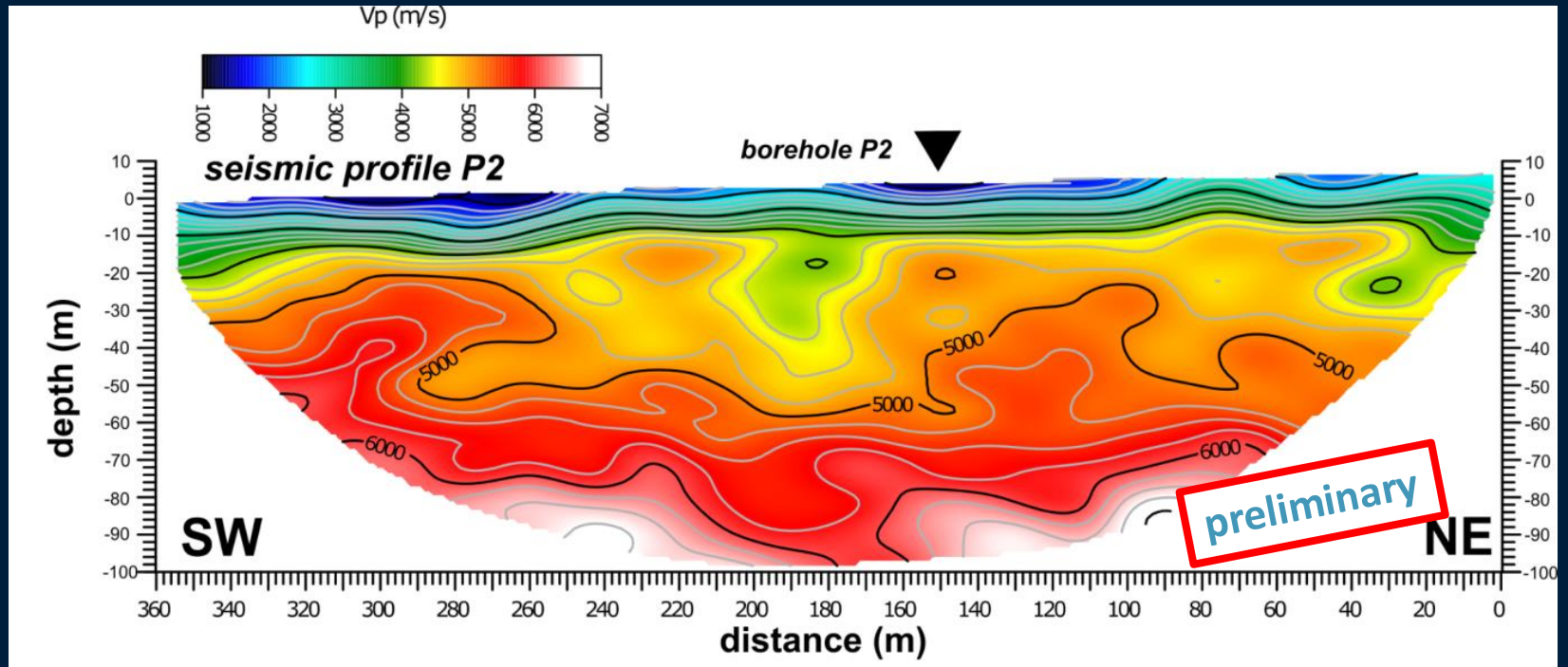
See Diaferia paper



Active noise campaign

Subsurface characterization of crystalline rocks at the Einstein Telescope candidate site (Italy): Insights from seismic tomography, geoelectrical and morphostructural surveys

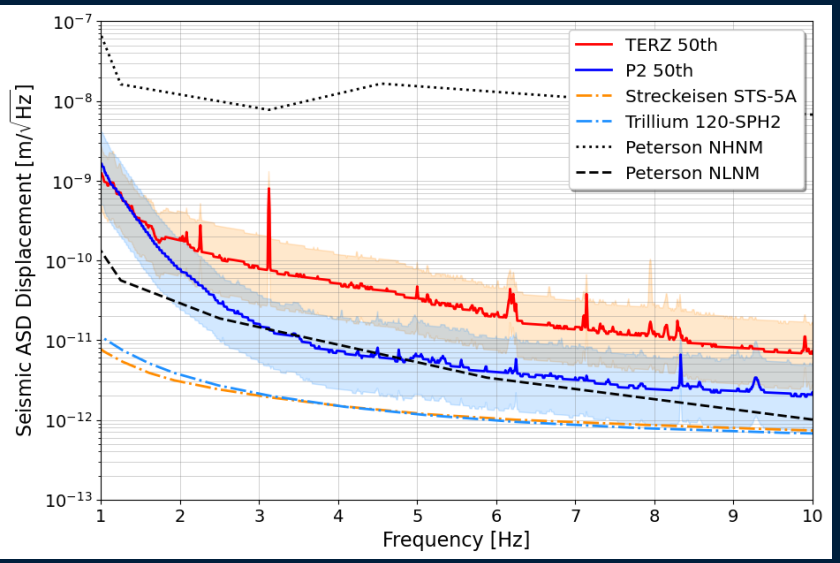
See Villani paper



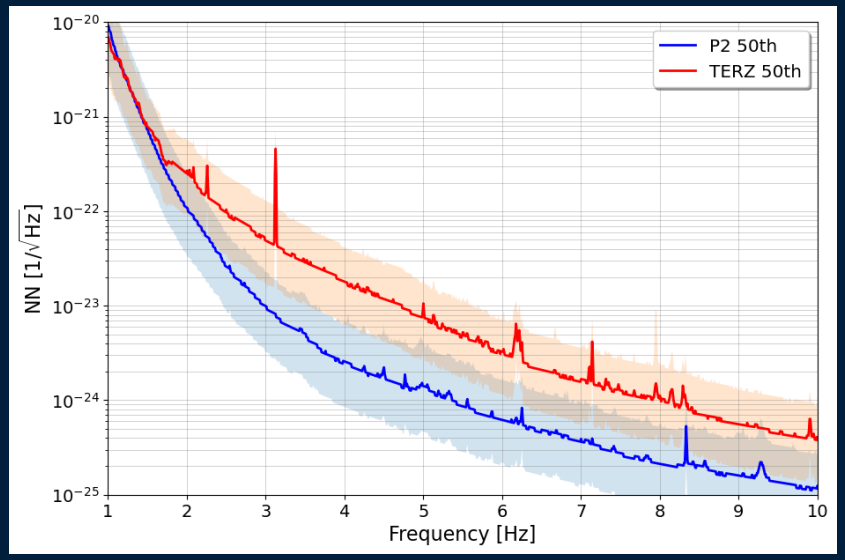
Impact of the Newtonian Noise on Einstein Telescope science

See M.D. Giovanni talk & paper

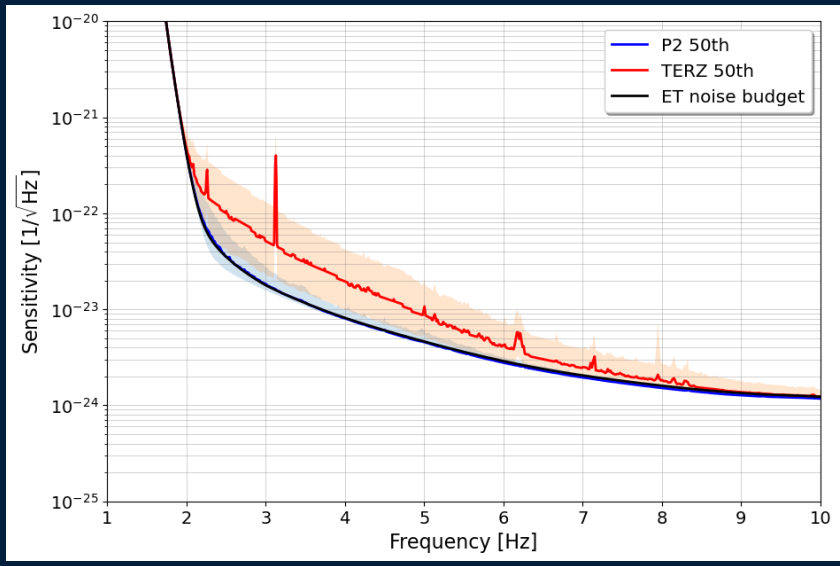
Seismic ASD Displ.



NN ASD



ET sensitivity



Manuscript available at https://arxiv.org/abs/2503.02166

PUBLICATIONS:

- L. Naticchioni et al., ***Microseismic studies of an underground site for a new interferometric gravitational wave detector***, **CQG**, 2014, https://doi.org/10.1088/0264-9381/31/10/105016
- L. Naticchioni et al., ***Characterization of the Sos Enattos site for the Einstein Telescope***, **JPCS** 1468, 2020, https://doi.org/10.1088/1742-6596/1468/1/012242
- M. Di Giovanni et al., ***A seismological study of the Sos Enattos Area – the Sardinia Candidate Site for the Einstein Telescope***, **SRL**, 2020 https://doi.org/10.1785/0220200186
- A. Allocca et al., ***Seismic glitchness at Sos Enattos site: impact on intermediate black hole binaries detection efficiency***, **EPJP**, 2021 https://doi.org/10.1140/epjp/s13360-021-01450-8
- Allocca *et al.,* **Picoradiant tiltmeter and direct ground tilt measurements at the Sos Enattos site**, **EPJP** 136, 1069 2021. https://doi.org/10.1140/epjp/s13360-021-01993-w
- M. Di Giovanni et al., ***Temporal variations of the ambient seismic field at the Sardinia candidate site of the Einstein Telescope***, **Geophysical Journal International**, 2023, https://doi.org/10.1093/gji/ggad178
- G. Saccorotti et al., ***Array analysis of seismic noise at the Sos Enattos mine, the Italian candidate site for the Einstein Telescope***, 2023, https://doi.org/10.1140/epjp/s13360-023-04395-2.

[…]

PUBLICATIONS:

- L .Naticchioni et al., ***Results of the site characterization in Sardinia for the Einstein Telescope***, **PoS Proc. Sci.**, 2023, https://doi.org/10.22323/1.441.0110.
- A. Allocca et al., ***Thermal noise-limited beam balance as prototype of the Archimedes vacuum weight experiment and B-L dark photon search***, **EPJP** 139:158, 2024, https://doi.org/10.1140/epjp/s13360-024-04920-x.
- G. Diaferia et al., **Seismic noise characterisation for the Buddusò – Ala dei Sardi wind park (Sardinia, Italy) and its impact on the Einstein Telescope candidate site**, submitted to journal (2024).
- F. Villani et al., ***Subsurface characterization of crystalline rocks at the Einstein Telescope candidate site (Italy): Insights from seismic tomography, geoelectrical and morphostructural surveys***, published SSRN (2024).
- M. Di Giovanni et al., ***Impact on signal SNR of local ambient noise recorded at the ET candidate sites***, submitted to CQG (2025) https://arxiv.org/abs/2503.02166 .
- R. De Rosa et al., ***Magnetic noise characterization of the ET candidate site in Sardinia***, in preparation (2025)

+ several internal notes, reports and talks

FABER
(INGV)

ET – SUNLab
(INFN + INGV + INAF)

Adria Array
(INGV)

Collateral Activities

Cosmic ray measurement
(INFN)

Seismic noise contribution from wind
(INFN)

ET – SUNLab

(INFN + INGV + INAF)

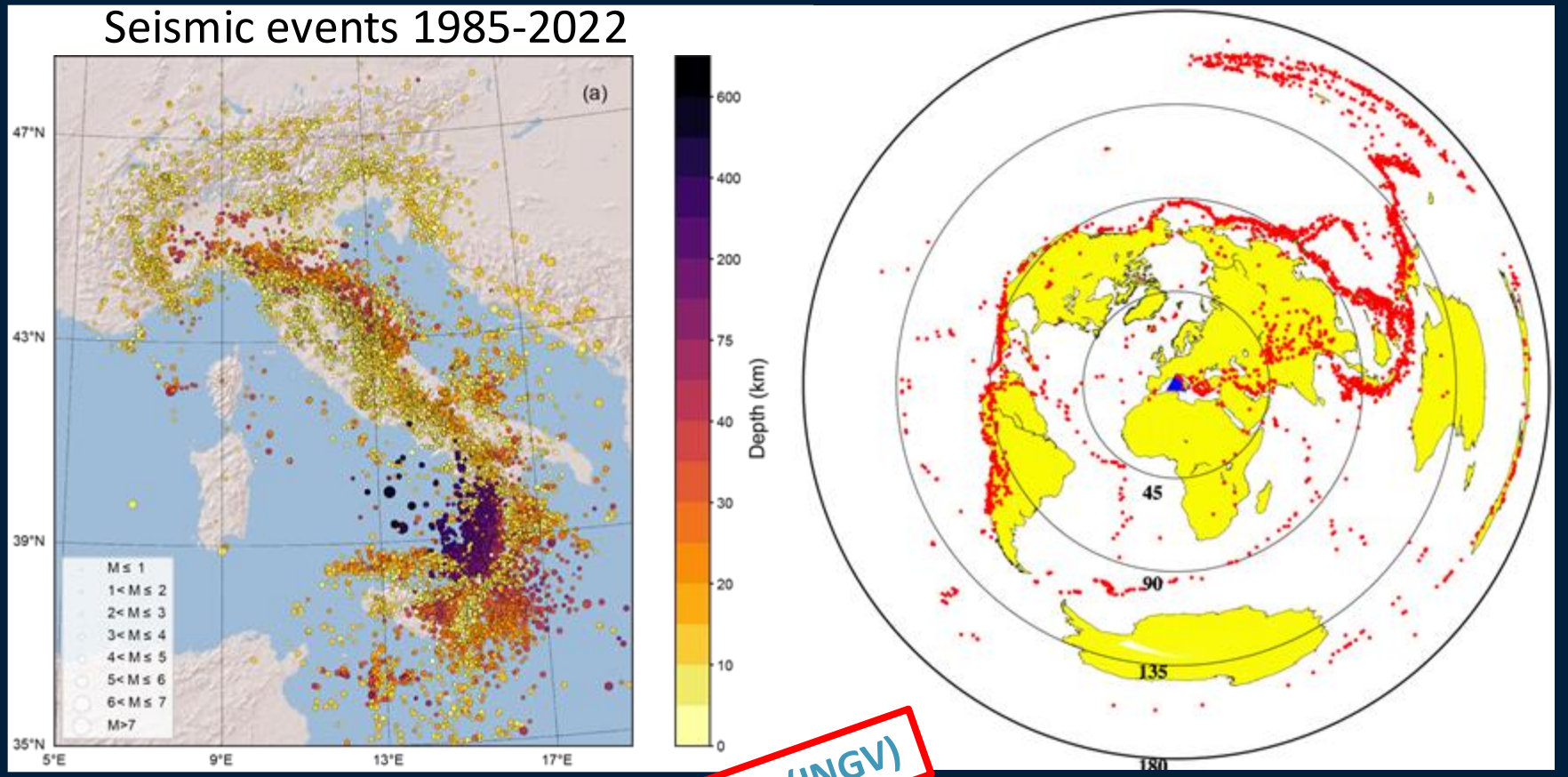
SarGrav will be replaced with the new **SUNLab** Research center building.

Next year, daily data at the mine will be affected by **working activities**, only data outside working time will be used.

FABER
(INGV)

SARDINIA
FABER
FAR FAULT OBSERVATORY

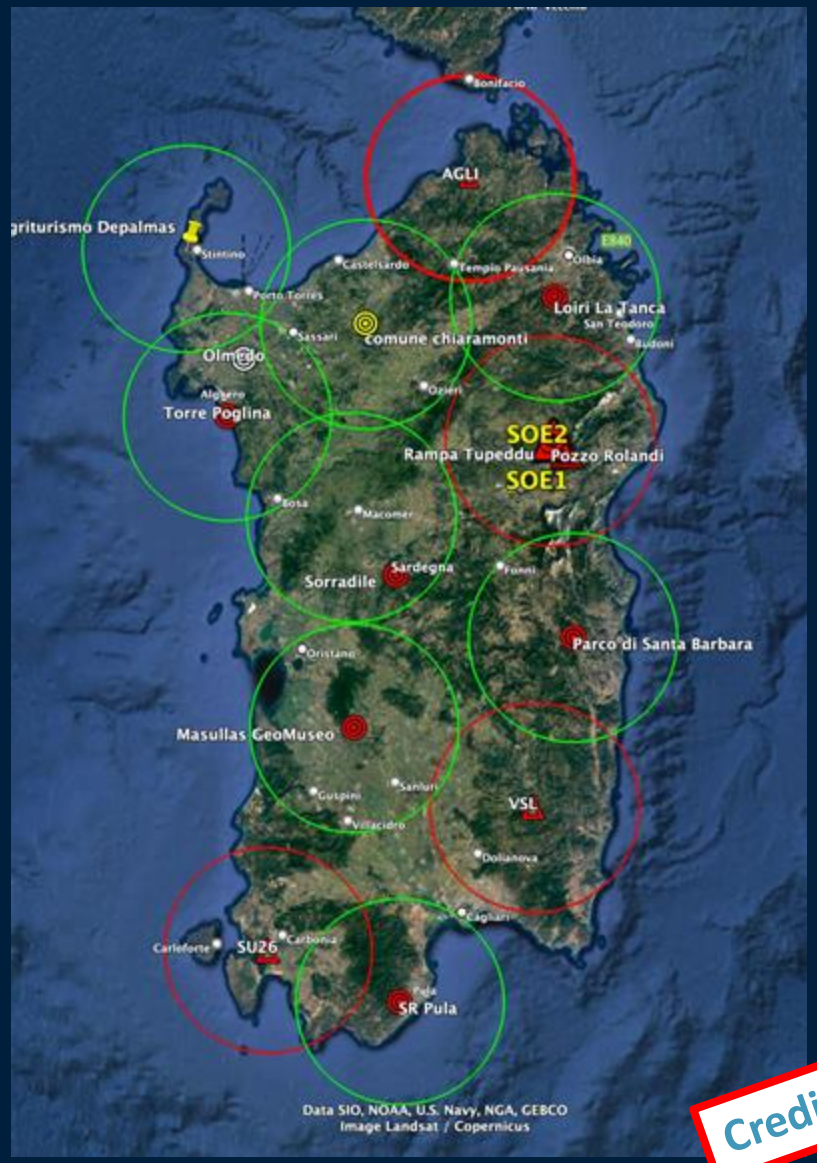
Seismic events 1985-2022



Credits C. Giunchi (INGV)

=> Earth Telescope

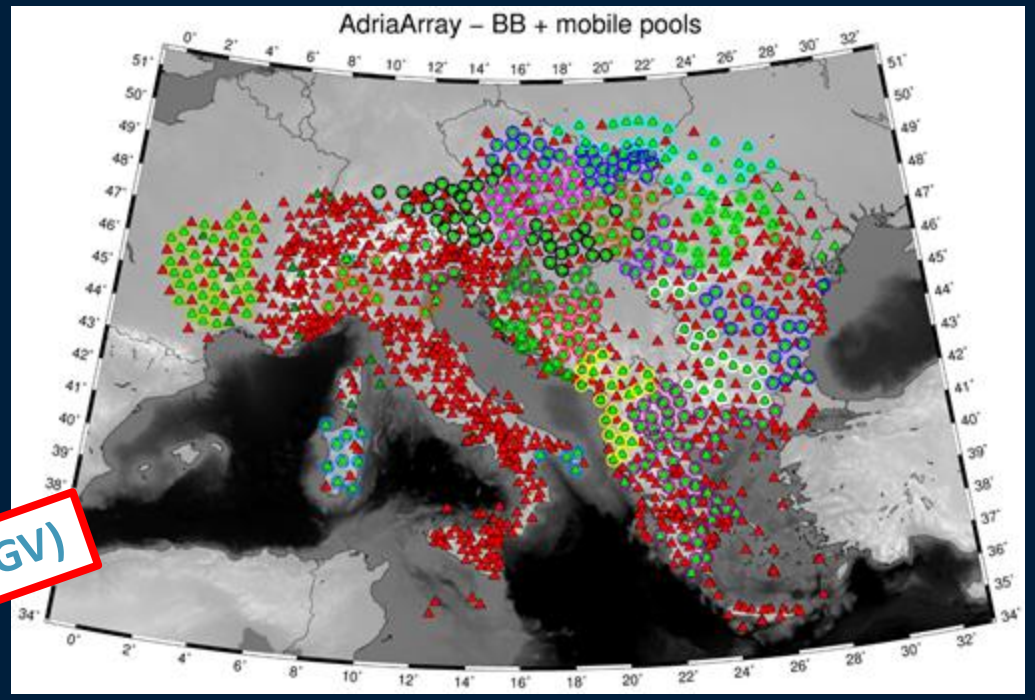
Adria Array
(INGV)



- 8 broadband seismic stations
- 2 years

GOALS

- Improve capability to record earthquakes and quarry explosions in Sardinia
- Improving the crustal velocity model
- Contribute to the AdraArray project to better understand the Adra plate



Credits M. Olivieri (INGV)

Conclusions

Sardinia is **geologically very quiet**, far from active fault lines, and characterized by low anthropic noise.

Since 2019 (and before in 2010-2014), we installed **permanent and temporary arrays** of sensors and **two instrumented boreholes** (operative since 2021).

12 more boreholes are excavated in the other vertices of both Δ and L configuration.

New sensors for seismic, magnetic and acoustic noise analysis will be installed in the next months.

New NN estimation with detailed geological model is ongoing

From the geological and physical point of view, Sardinia is an optimal candidate to host the Einstein Telescope, either in Δ or in L ($\rightarrow$ 2 sites) configuration!

These results is achieved thanks to the great **collaboration** between Italian and International Research Institutes that have brought together **different and complementary skills and expertise**.