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PIANO NAZIONALE
DI RIPRESA E RESILIENZA



ISTITUTO NAZIONALE
DI GEOFISICA E VULCANOLOGIA

WP 7 Sardinia FABER

Coordinators:

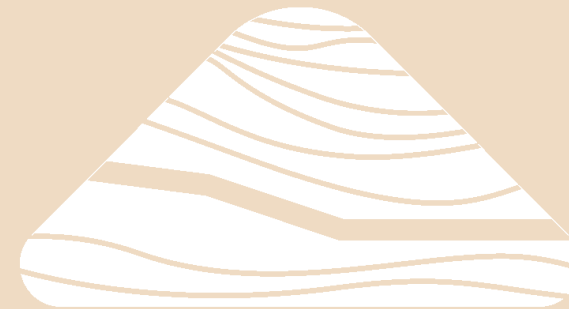
Carlo Giunchi, Marco Olivieri

WP Leaders:

Fabio Di Felice, Irene Molinari

The Sardinia Far Fault Observatory

Assigned Budget: 2.5 M€



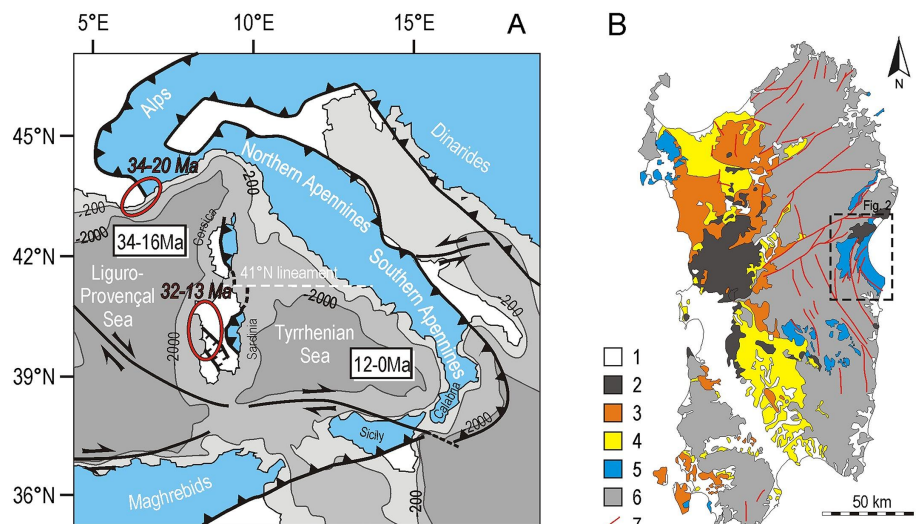
S A R D I N I A

FABER

FAR FAULT OBSERVATORY

The context: Sardinia Island and Sos Enattos Mine

Sardinia is part of the Corsica-Sardinia micro block. Known for its seismic quiescence, has been stable for 15 million years. It is not affected by the active geodynamic processes observed in the Southern Tyrrhenian Basin as the subduction of the lithosphere underneath the Calabrian arc and the volcanic activity of Mount Etna and Aeolian Islands.



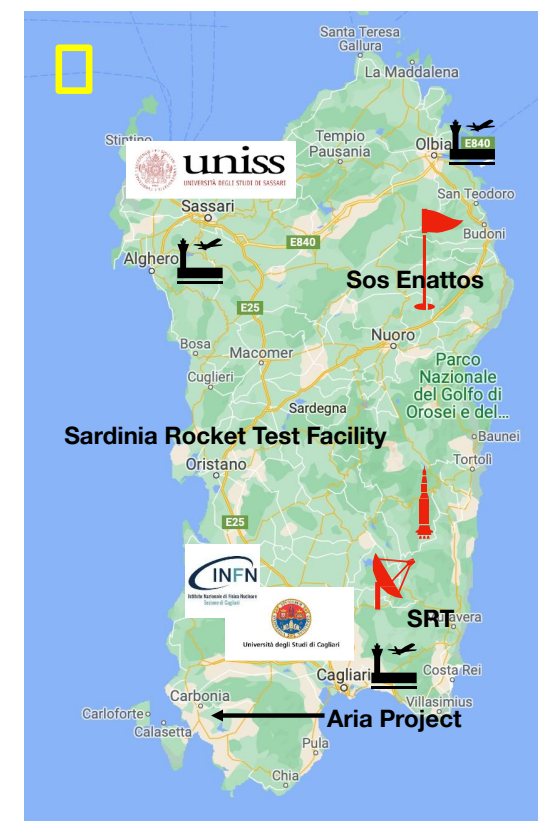
Tectonics, Volume: 35, Issue: 6, Pages: 1404-1422, First published: 20 May 2016, DOI: (10.1002/2015TC004004)



Lead and zinc mine, dismissed in late 90s but still maintained by IGEA SpA.

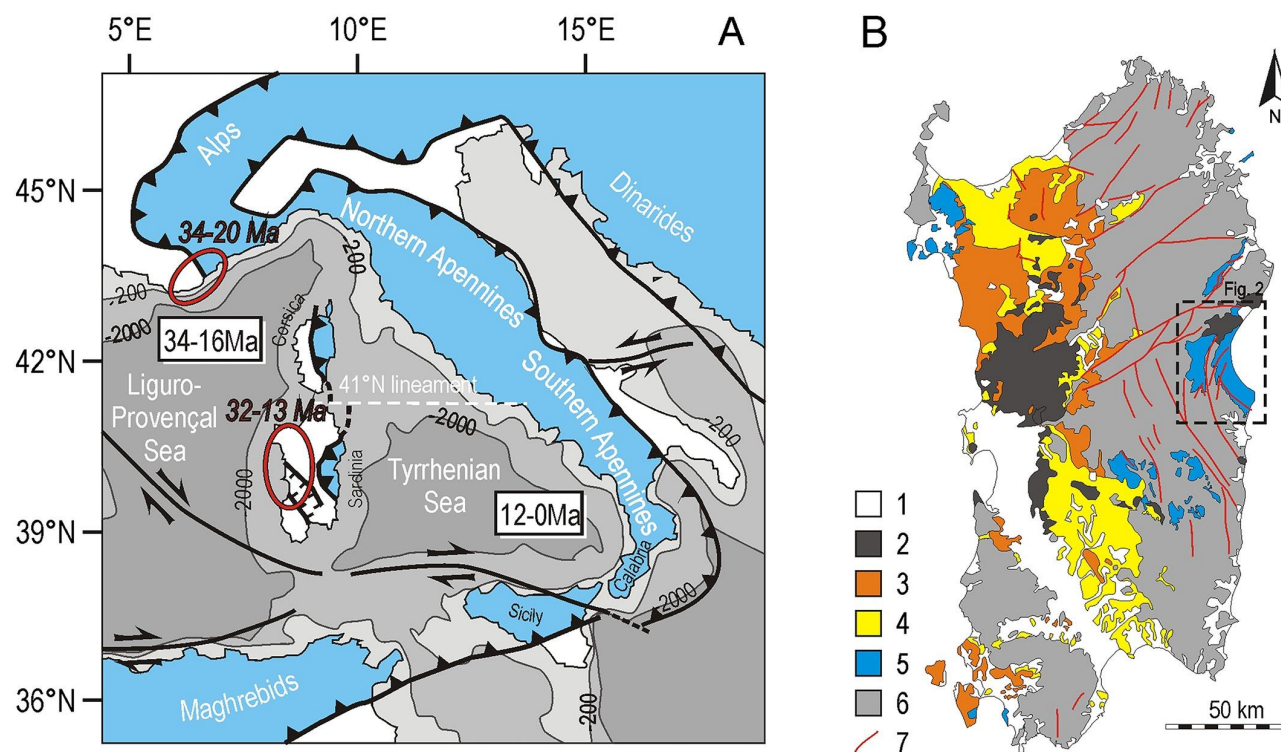
Some of the Sos Enattos tunnels already host scientific instruments in the framework of the SarGrav agreement (2017-2021) promoted by Regione Sardegna in partnership with INFN, University of Sassari, Cagliari and INGV.

4 seismic stations has been operating in the area since late 2019. The results show exceptionally low levels of seismic noise. We could also observe a quiet environment from the magnetic point of view.





Sardinia Island is a unique place in the Mediterranean Sea



Tectonics, Volume: 35, Issue: 6, Pages: 1404-1422, First published: 20 May 2016, DOI: (10.1002/2015TC004004)





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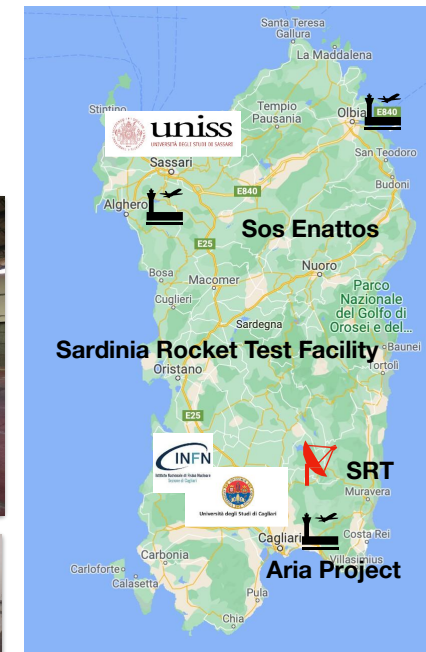
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Sos Enattos Mine

- Sos Enattos is a lead and zinc mine dismissed since late 90s.
- Site maintenance and security is managed IGEA/RAS.
- Hosts SarGrav consortium and Archimedes experiment

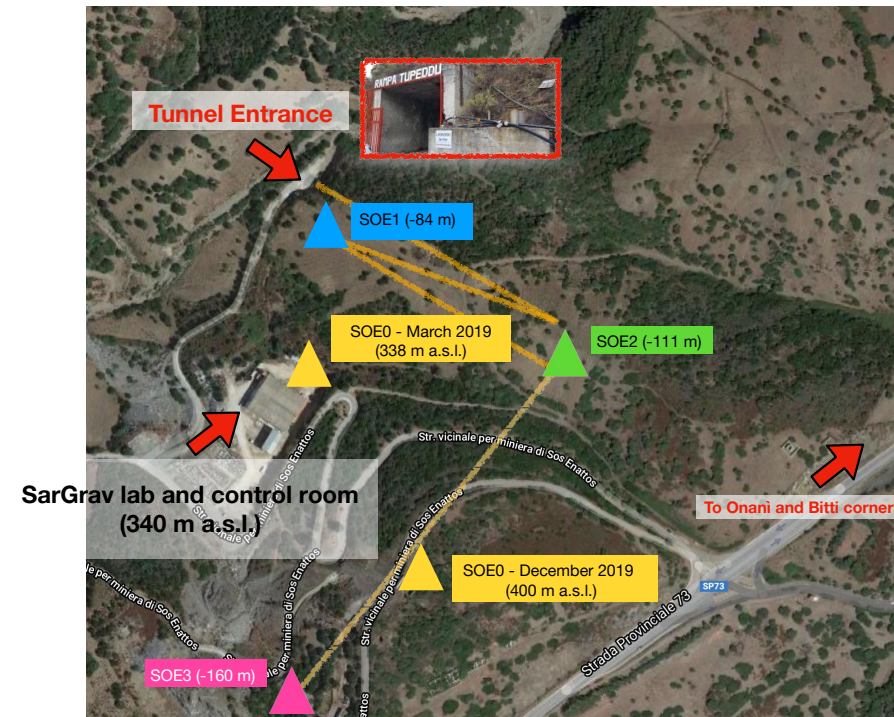




Seismic Network by INGV et al.

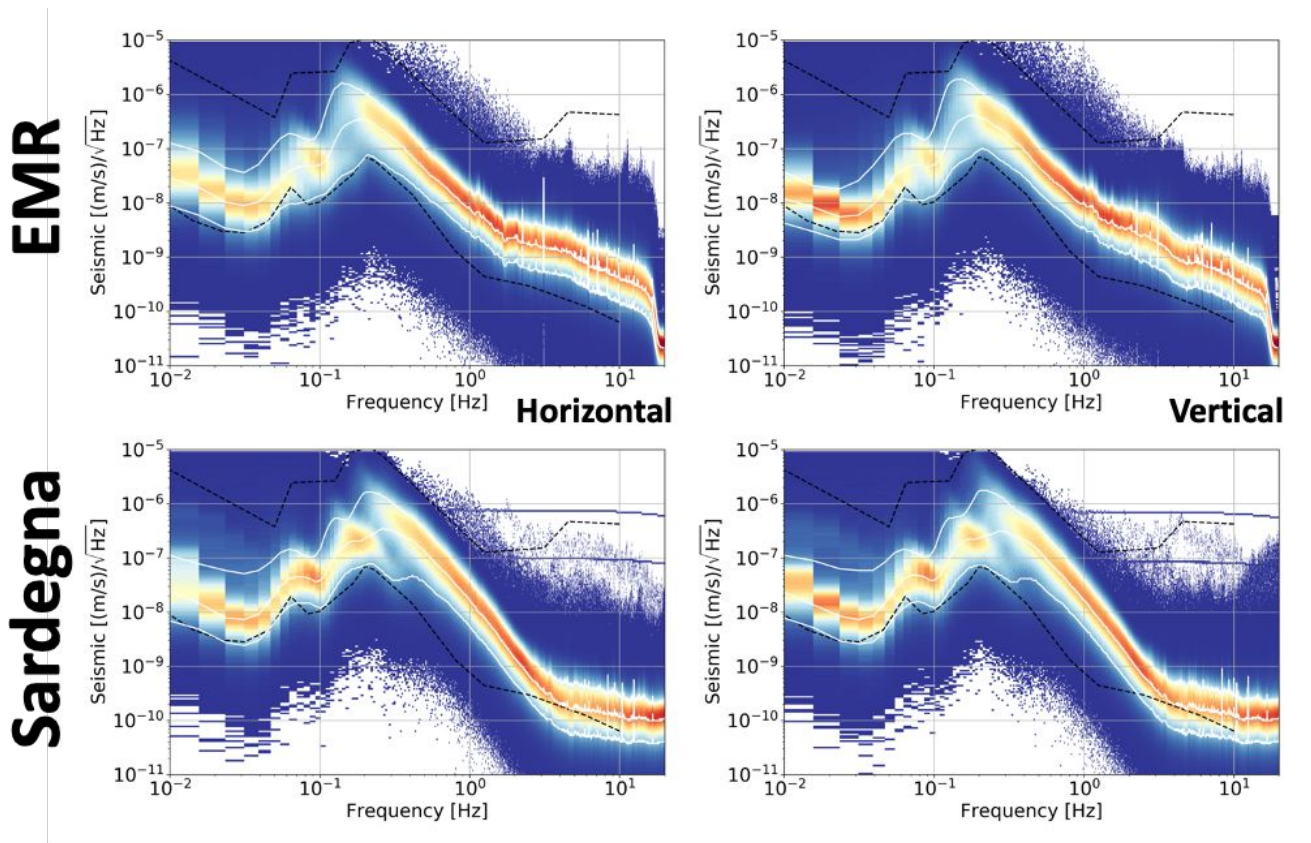
Permanent seismic stations

- Seismic characterization of Sos Enattos started in 2010 with temporary installations;
- Since 2019, there are 4 permanent seismic stations for long term studies:
 - Surface: SOE0;
 - Underground: SOE1, SOE2, SOE3;
- All permanent seismic stations are provided with broadband seismometers (Trillium 240, 360 and 120 Horizon, Guralp 360);
- Plus weather station, 2 magnetometers, high precision tiltmeter (Archimedes experiment)...





Results: Sardinia shows exceptionally low levels of seismic noise



An ideal place to:

- make low noise physical measurements
- install high quality instrumentation
- build a geophysical observatory???



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FABER purpose is to provide high quality, long, stable time series of geophysical observables from a quiet, underground and remote location away from natural and anthropic disturbances.



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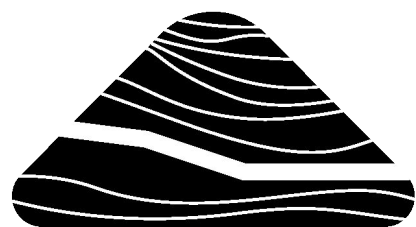
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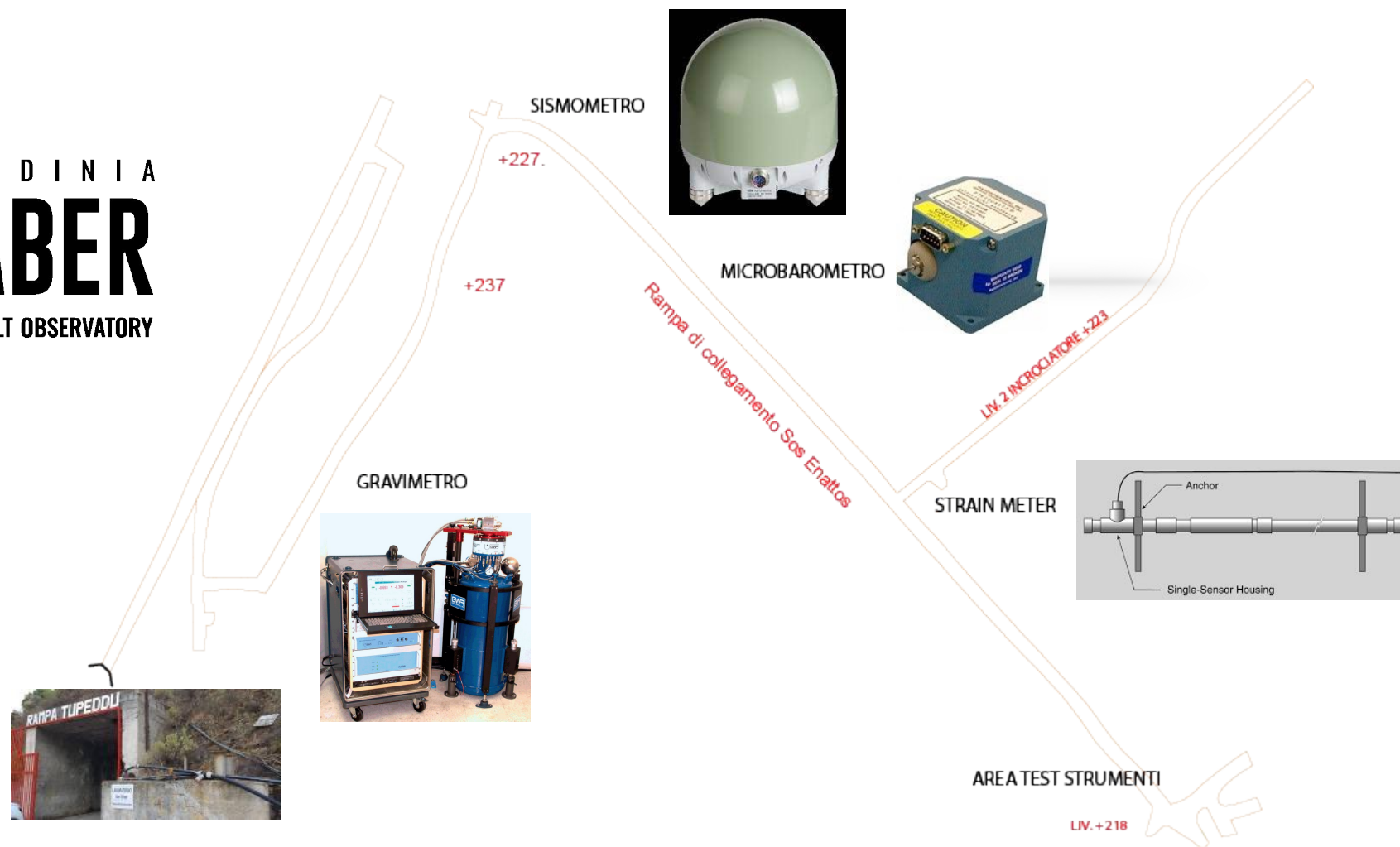
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FABER budget distribution

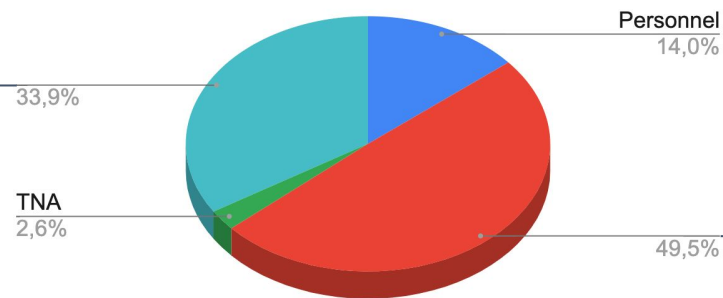
Infrastructure

- power supply and LAN improvement
- Solar power plant
- electrical vehicles

Surface lab

- data acquisition, archiving and distribution
- instrument maintenance and test facility

WP7 FABER Budget



Instruments

- VBB seismometers
- magnetometer
- gravimeter
- strainmeter
- tiltmeter
- microbarometer
- meteo and micro-climate sensors

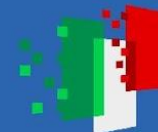




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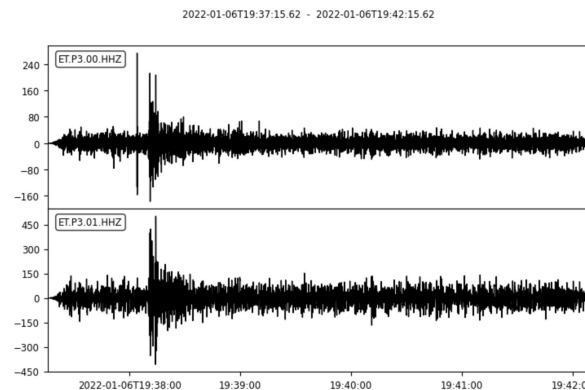


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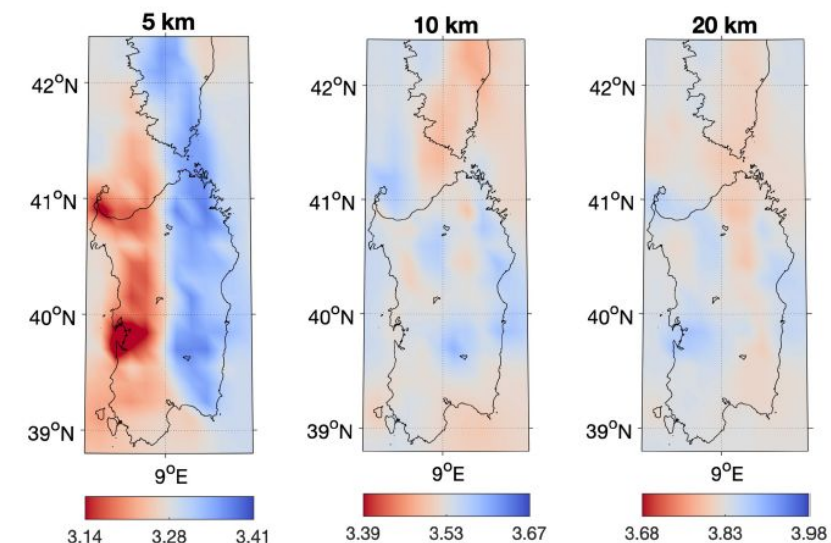
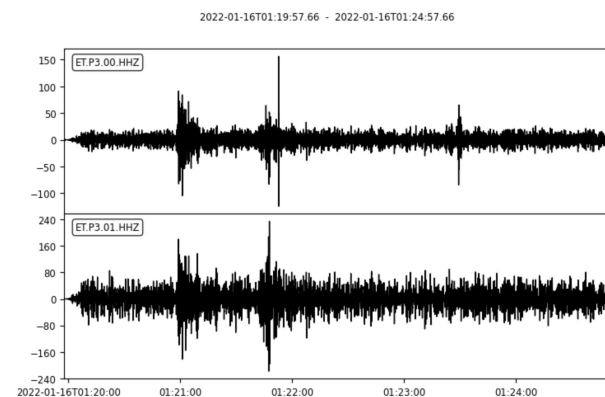
Scientific objectives

- **Local**
 - Sardinian crustal structure
 - low magnitude EQ detection
- **Regional**
 - Seismic activity
 - Tyrrhenian subduction
 - Eolian and Tyrrhenian volcanism
- **Global**
 - Deep structure of the Earth
 - Lower mantle, D'', core

ML 2.5 Campi Flegrei (410 km)



ML 2.1 Salaparuta (420 km)



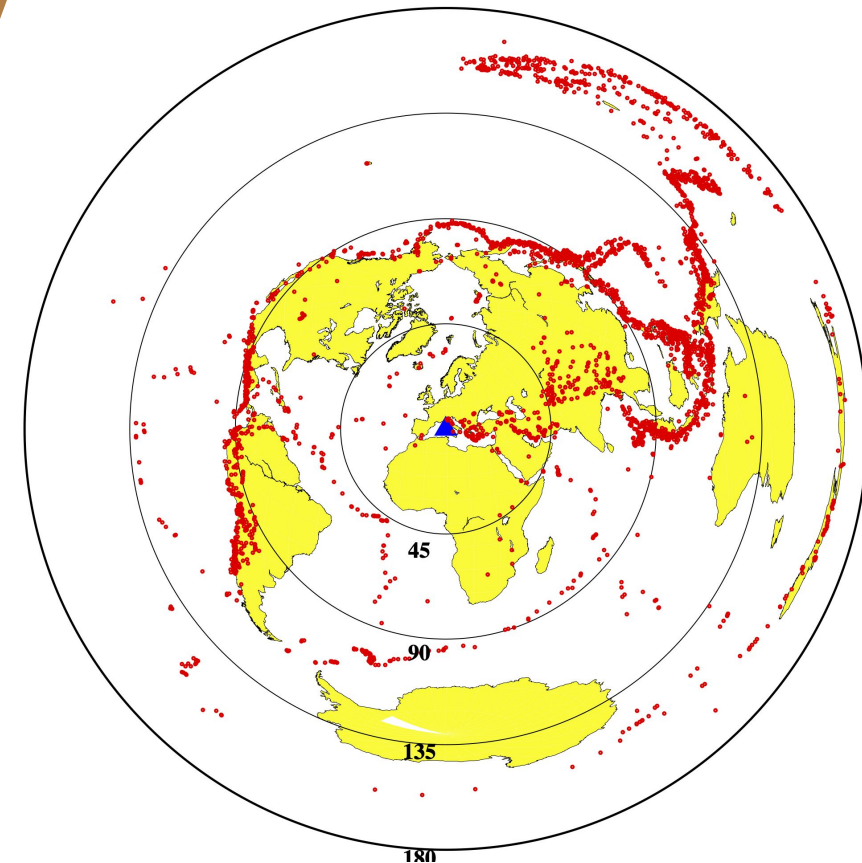
Magrini et al., 2020





Scientific objectives: body waves seismology

target	phase	distance (deg)
CMB	PcP ScS	65-80
ULVZ	PcP ScS	10-30
Inner Core	PKJKP	116-180
Outermost core	SmKS	140-170
410 and 670 topography	PP precursors	100-120 125-140



2010-2020 global seismicity ($M > 6.0$) from Sos Enattos



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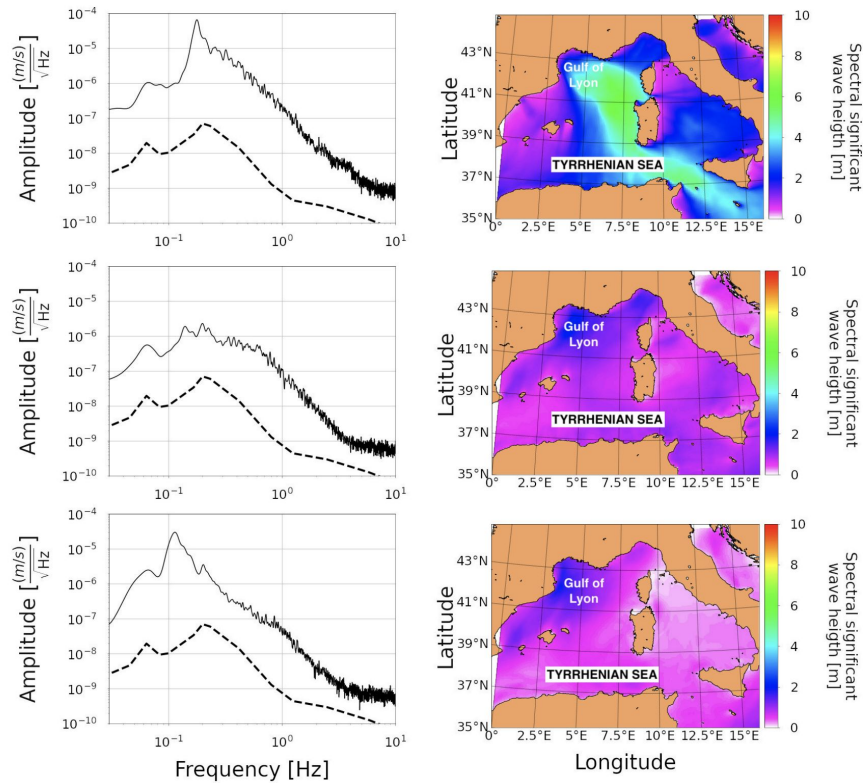
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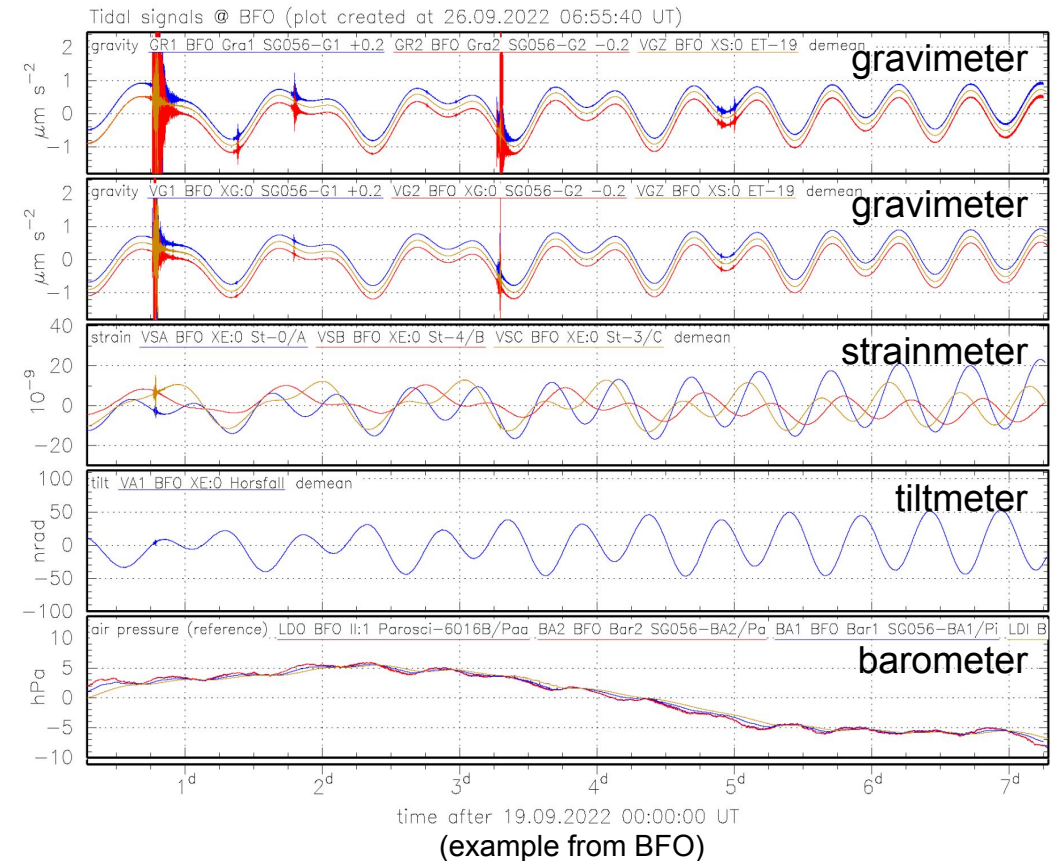
Scientific objectives

Climate induced noise



Di Giovanni et al., 2022

Earth tide measurement



Archimedes experiment

Report on Archimedes

- INFN sezione di Naples – Laboratorio Fisica della Gravitazione Univ. Federico II
- INFN sezione di Roma1 – Univ. La Sapienza Roma
- INO – sezione di Napoli
- UNISS – Università degli Studi di Sassari
- EGO – European Gravitational Observatory
- Université de Aix-Marseille Centre de Physique Théorique de Luminy Institut Universitaire de France

The Laboratory

- During these years a LAB has been created, inside a mine hangar: A **main experimental hall** (named Planck) – A **small experimental hall** (named Bekestein) – an **auxiliary hall** (named D'Urso) - a **Control room**, a small meeting room and a small warehouse.

The front view of Planck hall (in this hall the Archimedes balance is located)

The auxiliary D'Urso hall

Bekestein hall (in this hall the prototype is located)

The control room



Prototype: Seismological Fall out

Activities (1): Prototype

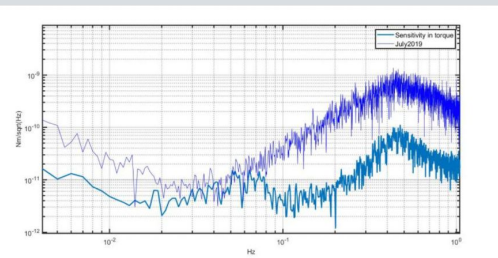
Realized during 2018/19 – used for a while as a tiltmeter in Virgo in the run O3 and since 2020 used in Sos Enattos for sensitivity studies to help construction and commissioning of the Final Balance



- Tiltmeter: used in **Virgo** in O3; a new one is under construction to be installed for the run O4
- Tiltmeter: a second is also in construction for sos enattos possibly to be placed underground
- Tiltmeter: remarkable interest by INGV and hopefully a collaboration with **FABER**

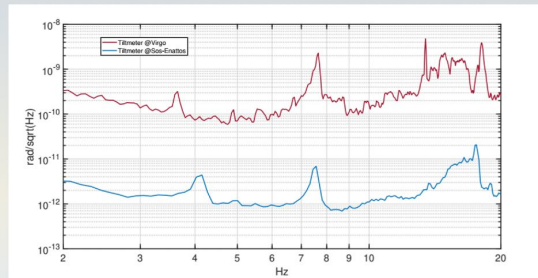
Main achievements

Best balance in the 10-50 mHz frequency region



Prototype torque sensitivity in 2021 (light blue) with respect to 2019 (blue)

Best tiltmeter in the 1-20 Hz frequency region

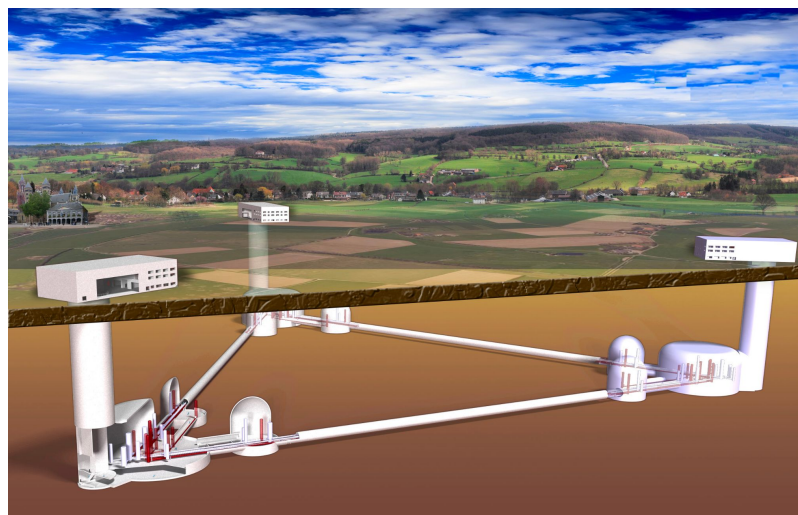
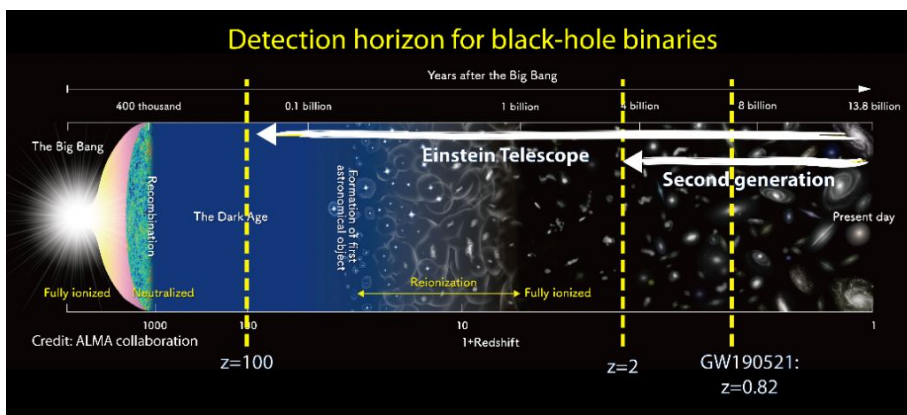


Prototype tilt sensitivity in 2021 (light blue – sos enattos) with respect to 2019 (red – Virgo site)



Einstein Telescope

- Sos Enattos area is the italian site candidate to host ET
- ET is a third generation gravitational waves detector
- ET has been included in the ESFRI roadmap
- ET collaboration officially started on July 2022 (about 1,300 members)
- Building will start in 2026
- Site competition open till 2024





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FABER take home messages

- FABER is a **new** low noise, underground geophysical observatory
- **Collaborative environment** with many partnerships: UniSS, UniCA, La Sapienza, Federico II, UniTS, UniPI, INFN (RM, CA, NA), INAF, Ego-Virgo, ETHZ, KIT (BFO), plus many other international partner affiliated to ET collaboration
- Synergy with **SarGrav, Archimedes, INFN PNRR project ETIC WP7**
- Support from **Regione Autonoma della Sardegna**
- Open data will boost **geophysical studies** with a wide range of applications (local/regional/global)
- FABER will host the **MEET summer school in 2025**

