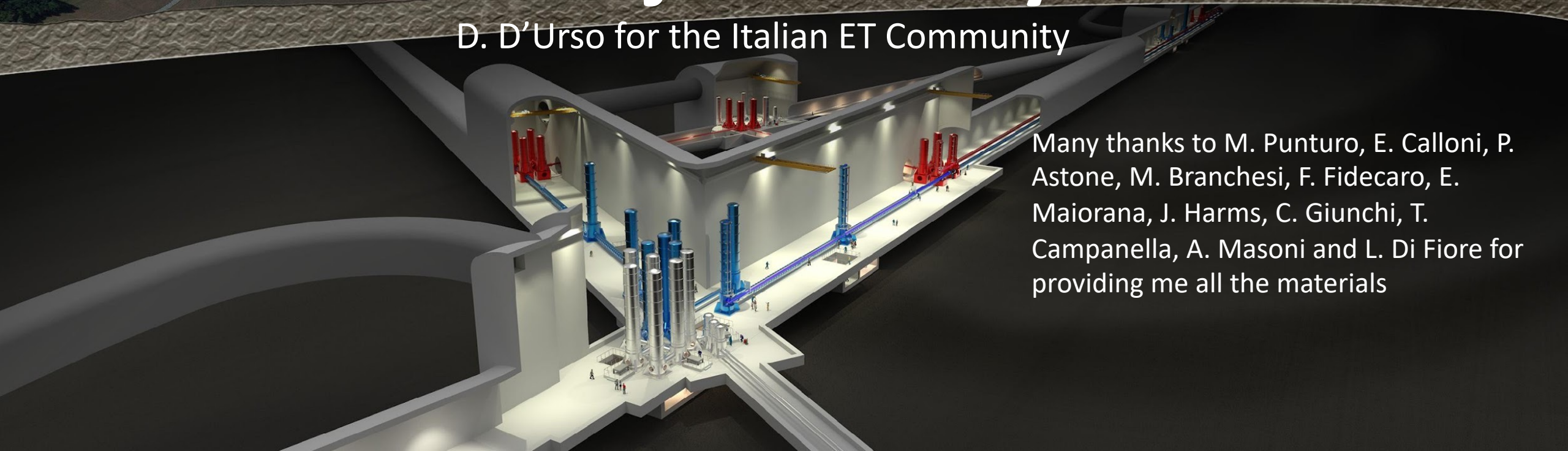


National / multi-national Projects: Italy

D. D'Urso for the Italian ET Community

Many thanks to M. Punturo, E. Calloni, P. Astone, M. Branchesi, F. Fidecaro, E. Maiorana, J. Harms, C. Giunchi, T. Campanella, A. Masoni and L. Di Fiore for providing me all the materials



ET related projects @ ITALY

- National and Regional authorities supported the Italian Candidature to host the Einstein Telescope since a long time
 - Characterization studies
 - Feasibility studies
 - Research Infrastructures and R&D
 - modeling and data analysis
 - science case definition
 - ...
- ET Synergic projects

Italian Government Support

17 Meuros for AdV+, ET R&D and support of the Sos Enattos candidature

ONDE GRAVITAZIONALI: MIUR, INFN E UNISS CANDIDANO LA REGIONE SARDEGNA A OSPITARE IL FUTURO OSSERVATORIO INTERNAZIONALE

Financial support, since 2018 to the Italian ET Community Site Characterization R&D

📅 Pubblicato: 22 Febbraio 2018



COMUNICATO CONGIUNTO MIUR/INFN/REGIONE SARDEGNA/UNISS_Il Ministero dell'Istruzione, dell'Università e della Ricerca sosterrà la candidatura della Regione Sardegna a ospitare un Centro europeo per l'Osservatorio delle onde gravitazionali nella miniera di Sos Enattos a Lula. Il MIUR, la Regione, l'Istituto Nazionale di Fisica Nucleare e l'Università di Sassari hanno firmato un



Ministero dell'Istruzione
dell'Università e della Ricerca



REGIONE AUTONOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA



Istituto Nazionale di Fisica Nucleare



uniss
UNIVERSITÀ DEGLI STUDI DI SASSARI



The Sar-Grav Laboratory @Sos Enattos

The **Sar-Grav Laboratory** is funded with 3.5 M€ by the **Regione Autonoma della Sardegna (RAS)**

It is located in **Sardinia** (Italy) close to **Lula** (Nuoro) in the area of the **Sos Enattos mine candidate to host Einstein Telescope (ET)** (**Sos Enattos: former mine** with underground access guaranteed through tunnels and shaft)

The **laboratory**, a seed of ET, aims to host underground experiments, cryogenic payloads, low frequency and cryogenic sensor development that need low seismic and anthropogenic noise

SAR-GRAV and ET: Underground Measurement stations

From E. Calloni's talk

Sos Enattos measurement stations (since Aug. 2020)

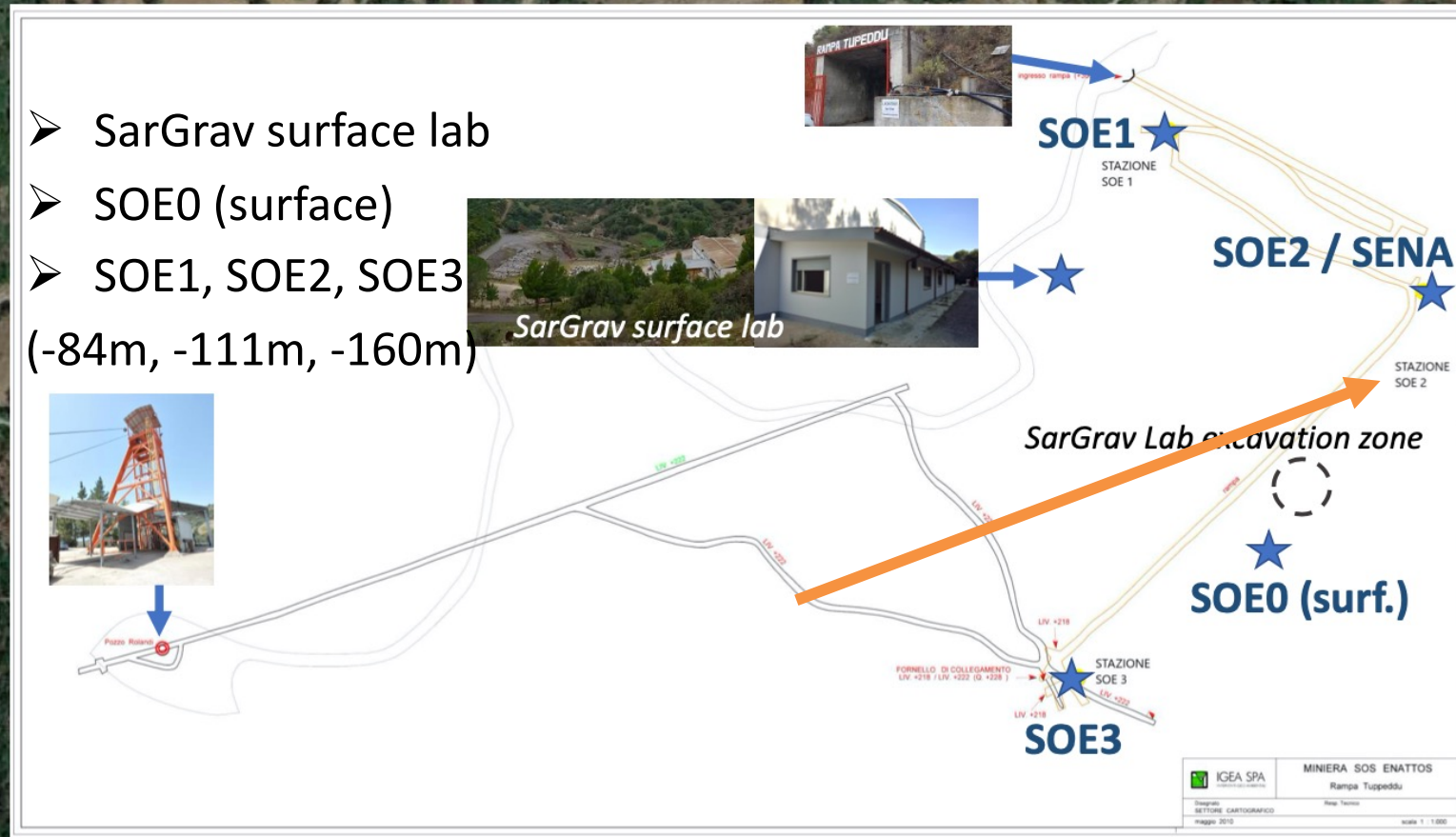
- SarGrav surface lab
- SOE0 (surface)
- SOE1, SOE2, SOE3
(-84m, -111m, -160m)



SarGrav surface lab

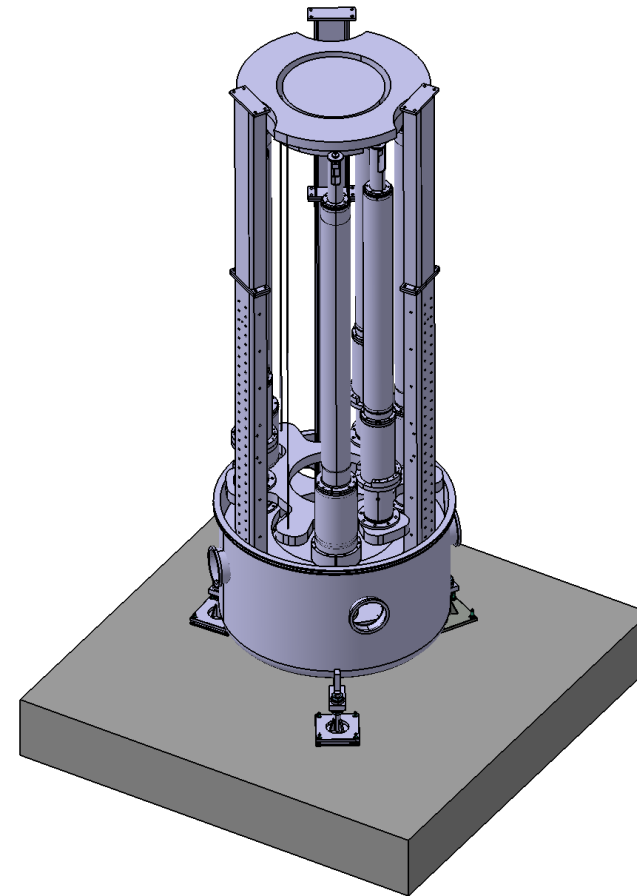


ingresso rampa Tapeddu



SAR-GRAV and ET

- SAR-GRAV provides the caverns in the mine and the infrastructures to host the instruments for environmental measurements
- It offers the support for instruments installed in the surrounding areas
- It collects the data from the various sensors, both in the mine and in the surrounding areas
- It hosts a tiltmeter on the surface lab
- It is planned to test at least partially a preliminary version of the double-suspended inverted pendulum to study it in a quiet environmental condition



*Double inverted pendulum: see
L. Di Fiore talk on Tuesday*

Characterization of the Sos Enattos mine in Sardinia as the site for the Einstein Telescope GW observatory

4 RU: PI E. Coccia/ J. Harms (GSSI),

co-PI D. D'Urso (UniSS), E. Calloni (UniNa), L. Di Fiore (INFN-NA)

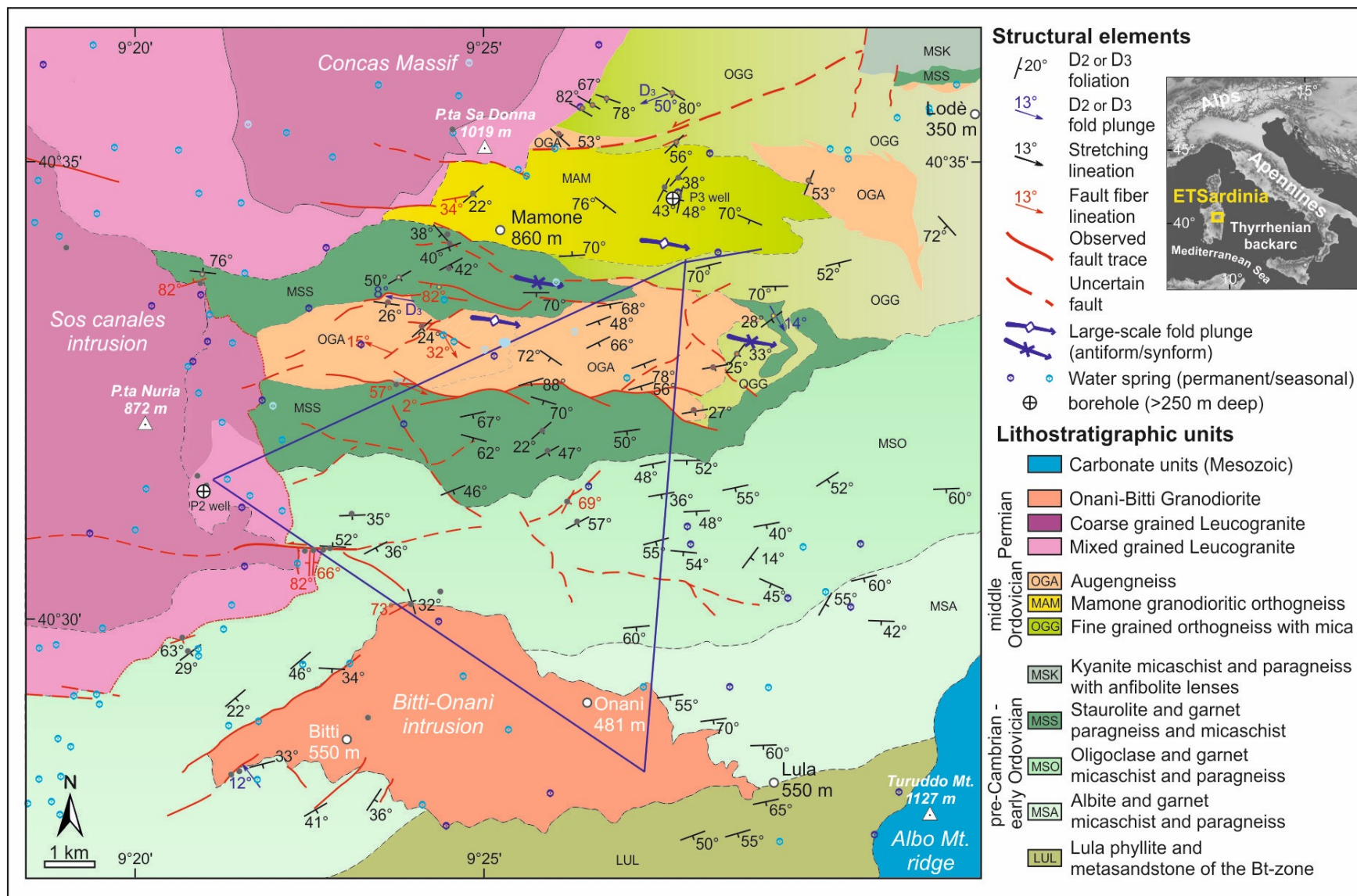
Funded with 1M euro

Timeline: 2019 - 2023

Project Goal

- geological investigation to prove the feasibility of infrastructure
- complete measurement of seismic and environmental noise
- an optical design of the ET interferometer fully compatible with the geological composition,
- the proposal of a suitable Newtonian-noise reduction strategy
- the computation of the ET sensitivity curve, particularly at low frequencies, attainable at the Sos Enattos site.

A NEW STRUCTURAL MAP

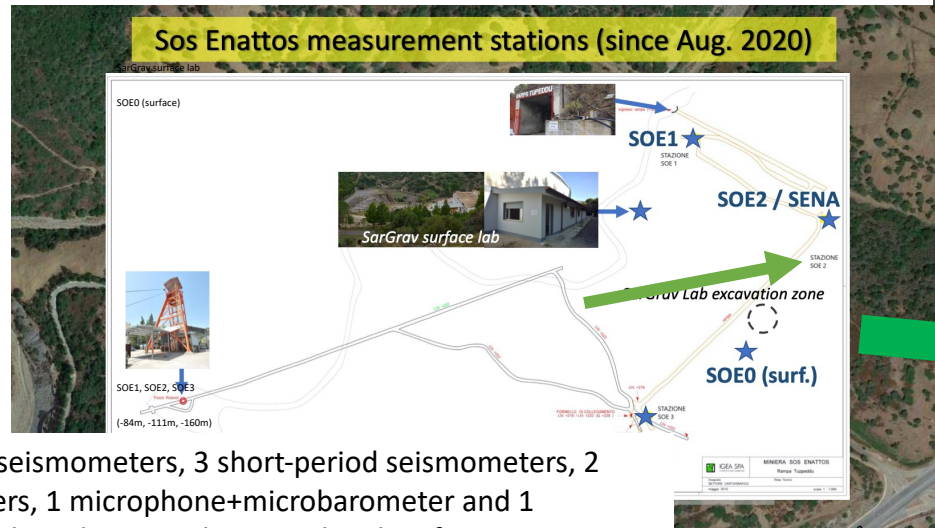
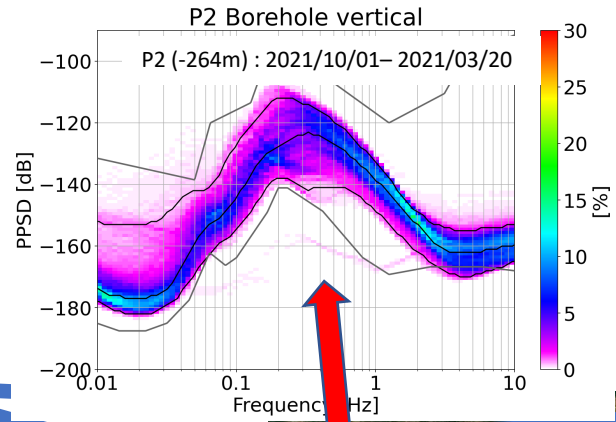


We have merged the lithologic information from published maps (also by comparing satellite images) and added new data collected in the field.

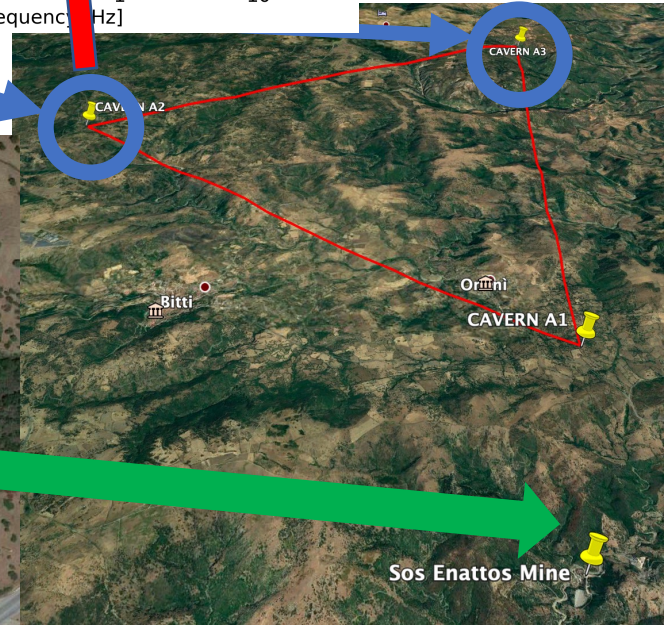
Courtesy of G.L. Cardello et al.

Sardinia Site: Long-term measurements

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



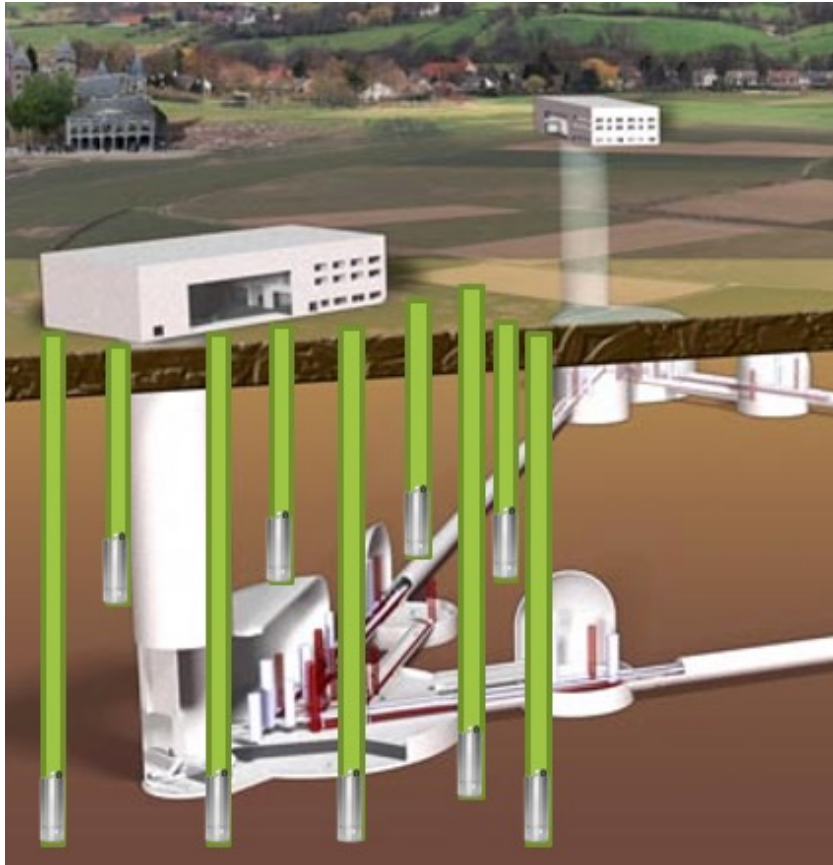
4 broadband seismometers, 3 short-period seismometers, 2 magnetometers, 1 microphone+microbarometer and 1 tiltmeter distributed over underground and surface stations



Credits to L. Naticchioni

Newtonian Noise Cancellation Planning

Placement of boreholes and sensors must be optimized



Achievements 2022

- Simulation of two-point correlations of full 3D seismic field (GSGC)
- Improving optimization algorithm (INFN Genova)

Plans for 2023

- Include Sardinia geological model in simulations (topography already included)
- Run full finite-element simulation and array optimization (if everything works as expected, the outcome would be a first design of an ET NNC system)

Credits to J. Harms

PRIN2020

LoVeC-ET

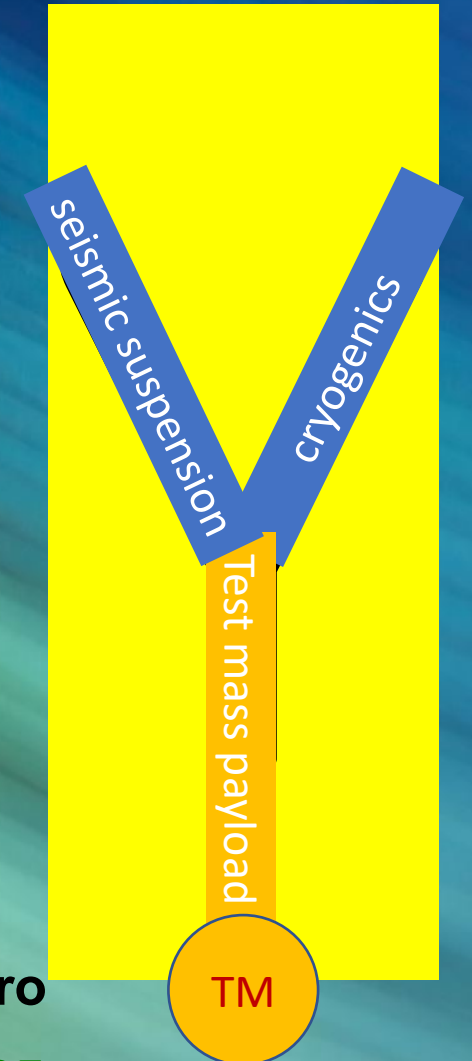
Low-frequency Versus Cryogenics for ET

E. Majorana

- PERUGIA University
- ROMA Sapienza University
- ROMA TorVergata University
- URBINO Carlo Bo University
- INFN

Funded with 725 keuro

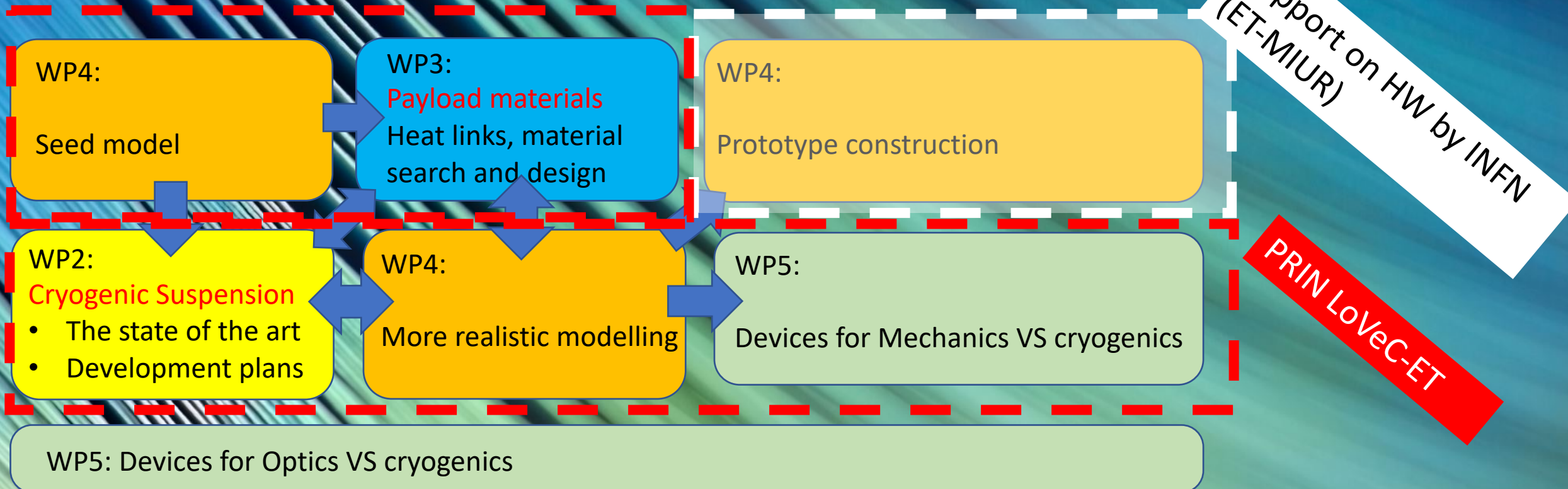
Timeline: 2022 - 2025



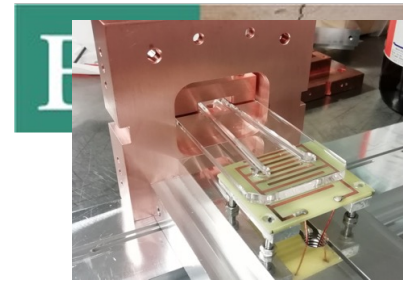
Our **first task** is envisaging viable solutions for the test-mass payload as a hardware system integrated in two very different apparatuses:

- The seismic attenuator
- The cryogenic system

Our **second task** is envisaging viable compliance of the payload system with the interferometer

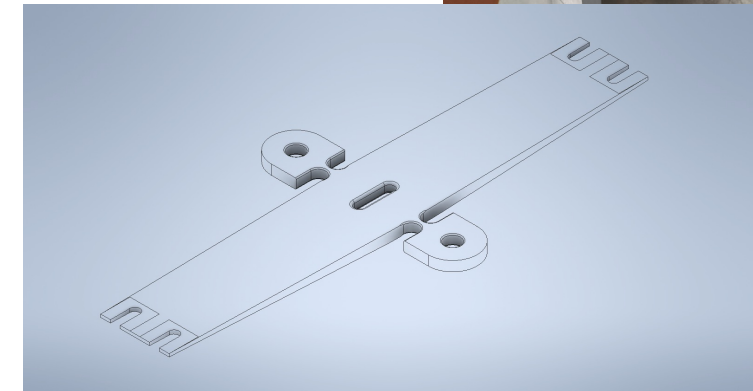
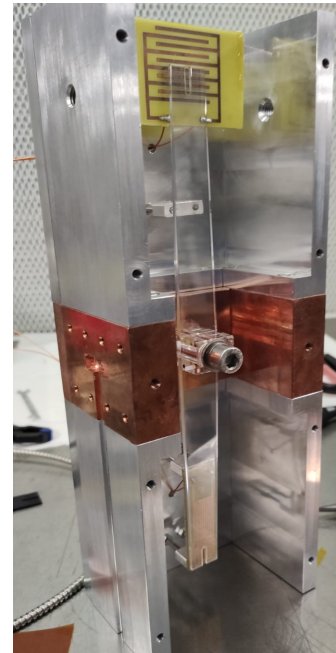


Roma Sapienza (main WP1/4, hired personnel 1 PhD + 1y Engineer contract)



Hardware developments:

- Realization of **new Viable sapphire blades integrated** in the marionette starting from KAGRA model, purposes:
 - ✓ **Investigating low quality factors** measured with the original (highest $Q=1.5e5$ in Roma)
 - ➔ cause reasonably identified in the non monolithic structure at the clamp
 - ✓ **Investigating Breaking strength**
 - ➔ very promising results of bending breaking strength (ISO certified)
 - ✓ **Developing a new**, larger blade meant for ET size ➔ manufacturing inquire
- Ongoing **realization of Marionette suspension** clamp for a sapphire rod
- **NEXT** ribbon suspension studies
(with PG and URB, targeted to prototype payload realization)



INFN (main WP3, hired personnel 2 post-doc + 1y contract pending)

Seed modelling for payloads:

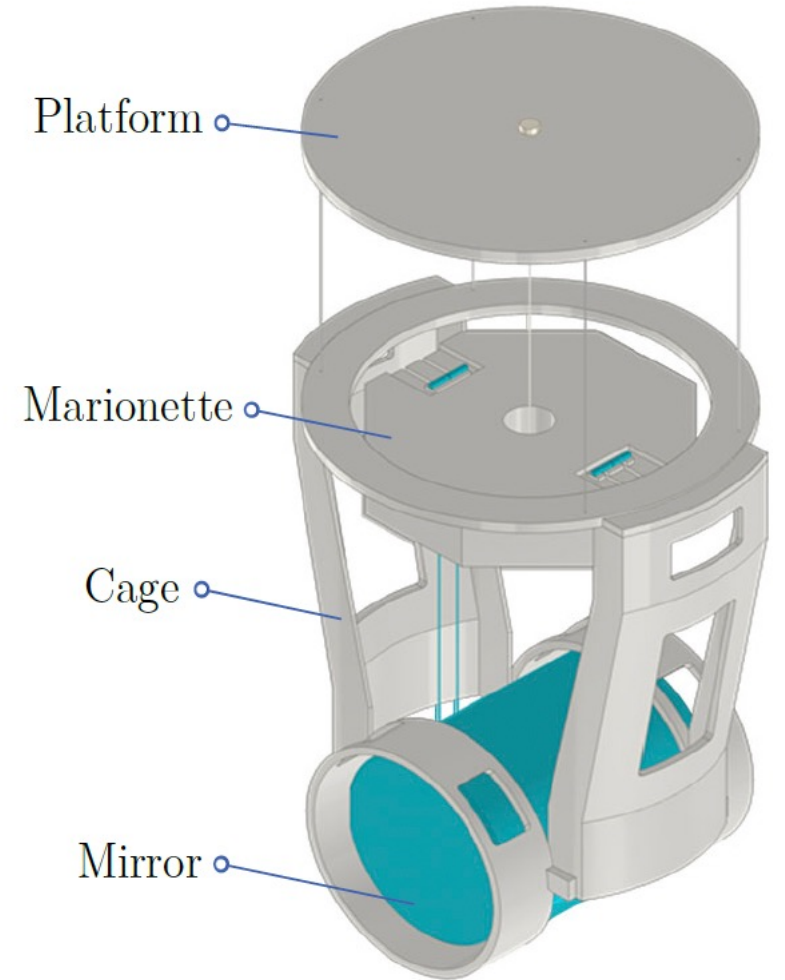
Thermal extraction modelling using Sapphire and Silicon

- X. Korovesi et al. *Cryogenic payloads for the Einstein Telescope – Baseline design with heat extraction, suspension thermal noise modelling and sensitivity analyses* arXiv:2305.01419v1

- ✓ ET final targeted 220 kg
- ✓ Prototype targeted 150 kg (PF-Ma ~ Ma-Mi = 90 cm)

Materials for soft links:

- ✓ Material RRR measured as done at KEK
- ✓ Model for heat duct links done => manufacturing inquires



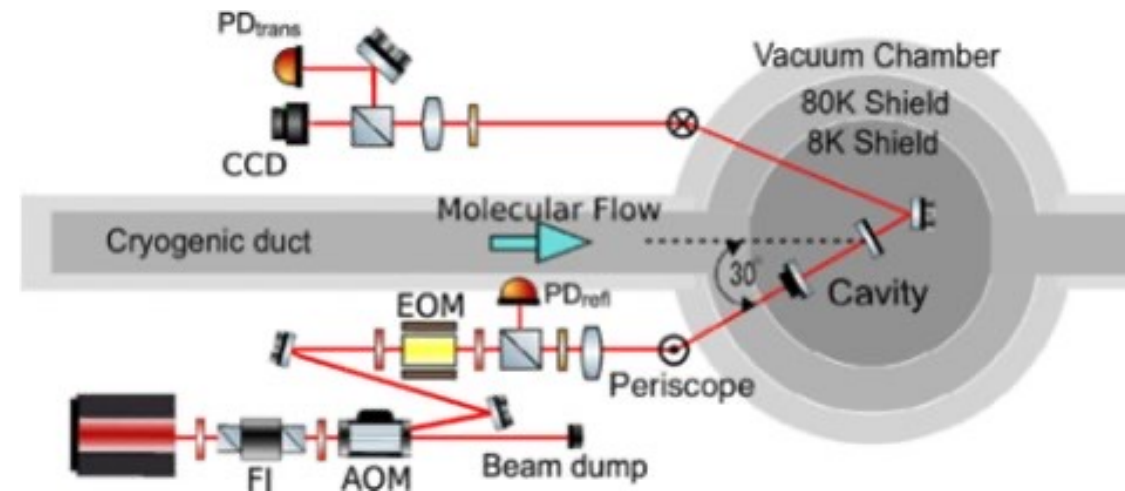
1. Payload sensing and actuation: design of a cryogenic facility for the characterization of sensors
2. Auxiliary sensing on cooling parts
3. Diagnostics of the test mass surface: design of a dedicated cryogenic FP readout scheme
4. Conditioning of the test mass surface: design of a conditioning scheme based on CO₂ beam shaping

Cryo facility for testing sensors:

Now at room temperature, then move to cryogenics
FODS sensors as witnesses
Hamamatsu InGaAs QPDs+1550 nm source scheme

Cryogenic surface diagnostics/conditioning:

Pulse tube Cryostat hosting the surface + FP
optical cavity readout scheme on bench (see
figure as reference)
Surface conditioning strategy requires shaping
a CO₂ beam source for localized heating



Hasegawa K et al, Phys Rev D 99, 022003 (2019)

PERUGIA (main WP2, called co-funded 3-y university position)

Hardware developments: (presentation by F. Travasso)

- ✓ Silicon suspensions quality factor
- ✓ HCB
- Ongoing **DETACHABLE materials** in semi-monolithic suspension clamping

URBINO (main WP2, co-funded 2y contract)

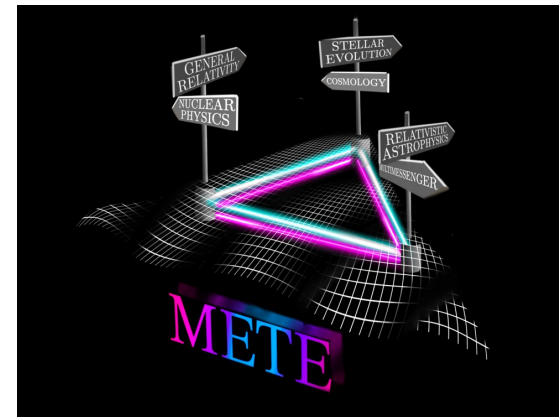
Hardware developments:

- Ongoing **CO2 suspension head** studies (presentation by M. Montani)



Multimessenger astronomy in the Einstein Telescope Era (METE)

Four RU: PI M. Branchesi (GSSI), co-PI E. Cappellaro (INAF),
co-PI M. Mapelli (Università di Padova), co-PI Michele Punturo (INFN)

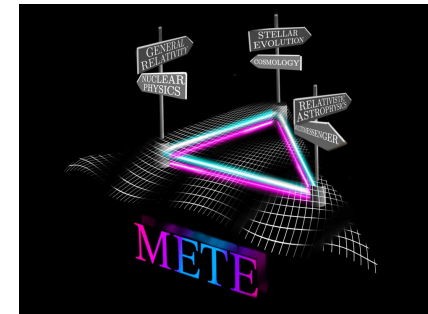


METE aims at:

- develop the GW and the multi-messenger ET science cases to drive the instrument scientific requirements in terms of technical development, implementation and operations;
- build and strengthen the Italian ET scientific community, bringing together theorists and experimentalists from different fields;
- develop public tools for astrophysical predictions which will set the base for observations, data analysis and interpretation for the ET era;
- generate broad public interest in the ET and MM instruments and science.

Funded with 727 keuro

Timeline: 2022 - 2025



JRA/WP12- Multimessenger Astronomy Exploitation and Tools WP leader M. Branchesi

Task 12.7 Task coordinator M. Punturo develop pilot science studies able to drive the design of new facilities and operation for the new generation of multi-messenger observatories.

Funded with **200 keuro for personnel**

Timeline: 2020 - 2024

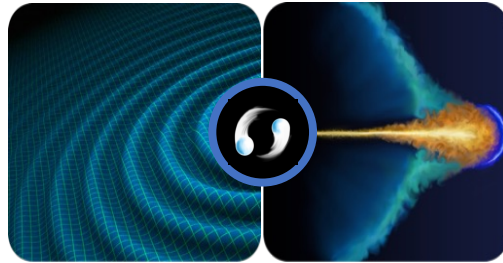
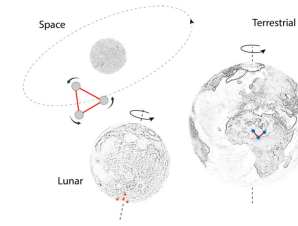


Some example of works

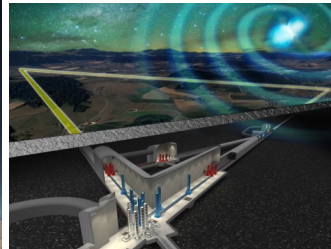
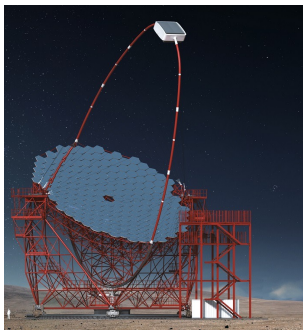
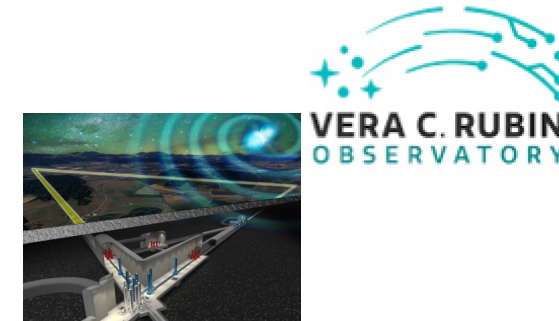


A Fisher-Matrix code to evaluate parameter-estimation capabilities of gravitational-wave detector networks!

Dupletsa et al. 2023 Astronomy and Computing



Ronchini et al. 2022 A&A
Perspectives next generation of GW detectors and high-energy satellites



Banerjee et al. A &A (under review)
Perspectives joint detection ET/CTA Early-warning alerts!

Loffredo, Dupletsa Hazra et al. in prep
Perspectives joint kilonova/GW detection VRO/ET

+ COBA study: Branchesi, Maggiore et al. arXiv:2303.15923

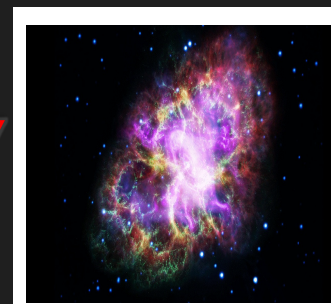
Science with the Einstein Telescope: a comparison of different designs



CUTTING-EDGE STRATEGIES TO IDENTIFY NEW GEMS

-GRAVITATIONAL AND ELECTROMAGNETIC WAVE SOURCES-

IN THE UNIVERSE WITH CURRENT AND NEXT-GENERATION DETECTORS



PIA ASTONE

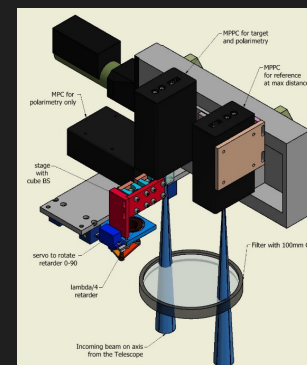
FOR THE NEW-GEMS PRIN2020 GROUP

INFN SEZIONE DI ROMA



Virgo, Cascina

2022, March 7th Seminario INFN



SIFAP2

CNAF

Silicon Fast
Astronomical
Photometer

**Progetto: Cutting-edge strategies to identify new GEMS
(Gravitational- and ElectroMagnetic-wave Sources) in the
Universe with current and next-generation detectors**

PI: Pia Astone, INFN Roma

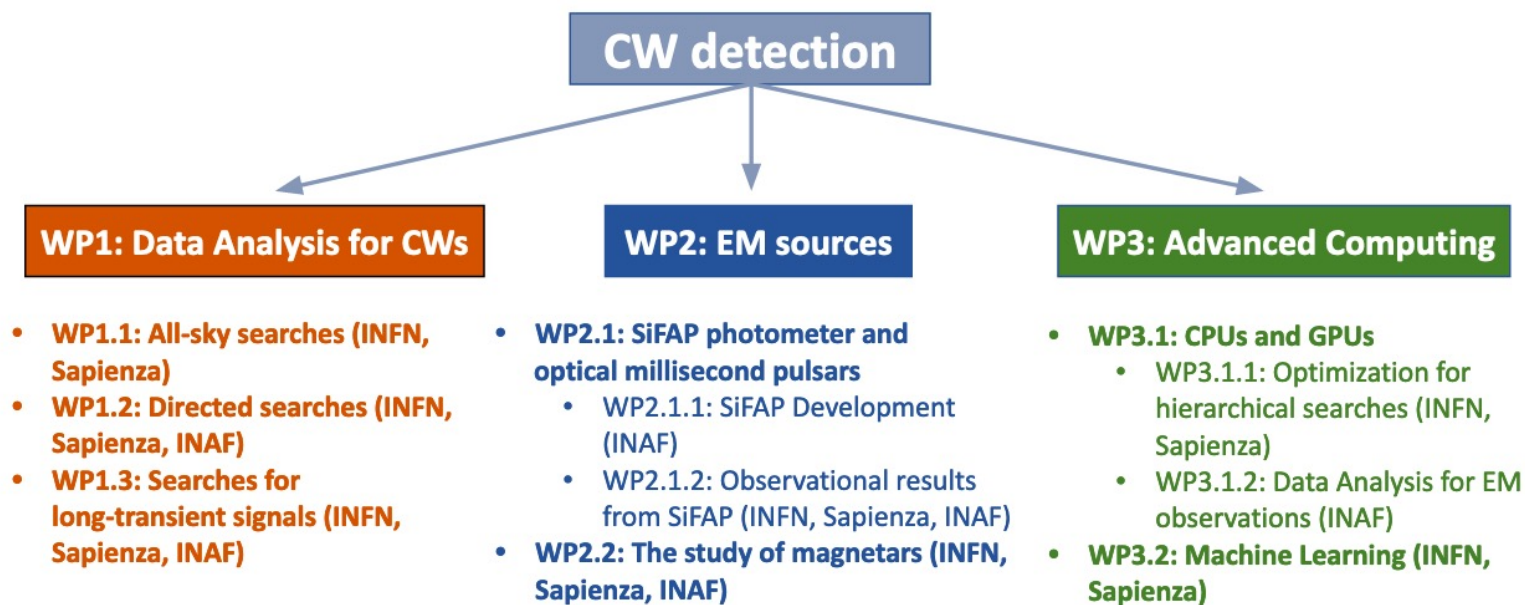


***INAF: Luigi Stella (local coordinator),
Alessandro Papitto***

***INFN: Stefano Dal Pra (CNAF), Sabrina
D'Antonio (RM2), Cristiano Palomba***

Sapienza : Paola Leaci (local coordinator)

Progetto: Cutting-edge strategies to identify new GEMS



Toward high mass and high Z **Black Holes** at Sos Enattos, the **Sardinian** site for the **Einstein Telescope**

BHETSA

A. Allocca, L. Bellizzi, S. Bianchi, V. Boschi, E. Calloni, M. Carpinelli, P. Chessa, D. D'Urso, R. De Rosa, L. Di Fiore, F. Fabrizi, I. Ferrante, F. Fidecaro, A. Fiori, A. Gennai, A. Longo, L. Massaro, M. Montani, L. Papalini, M. Palaia, M. Razzano, D. Rozza, P. Ruggi, L. Trozzo, M. Vacatello, A. Viceré

INFN – Na, INFN – Pi, Uni Napoli, Uni Pisa, Uni Sassari, Uni Urbino



Goals and WPs

Project funding by Ministero dell'Università e della Ricerca. PRIN competitive call

- ❑ Duration 3 years. 840k€ budget, 20% cofunding by salaries

Goal: Develop a system able to isolate mirrors from ground for ET-LF

- ❑ Test it in Sardinia at the Sar-Grav laboratory at the Sos Enattos, due to its unique seismic characteristics.

WP1: Design: innovation and optimisation

WP2: Simulation: Transmission matrix approach (OCTOPUS) in Python

Project in git, Sphinx, Readthedocs, CI, Unittest

WP3: Inertial and displacement sensors: Improved Accelerometers

WP4: Controls: ML oriented

Computing infrastructure with integrated GPUs, interface data with ML infrastructure

WP5: Installation and test at Sar-Grav: characterisation and optimisation

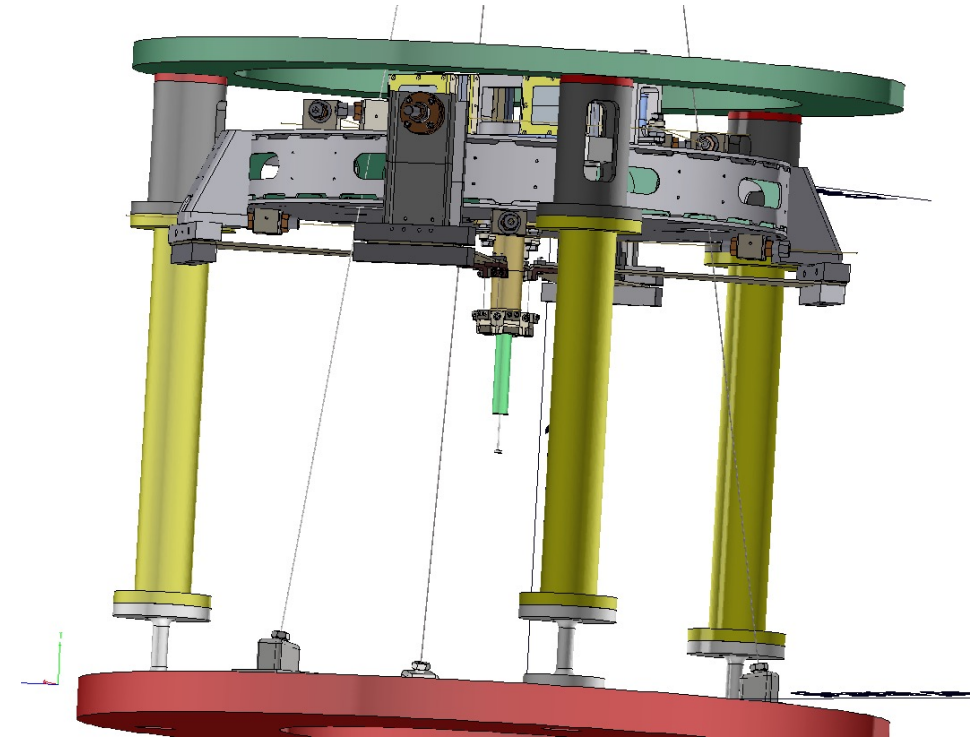
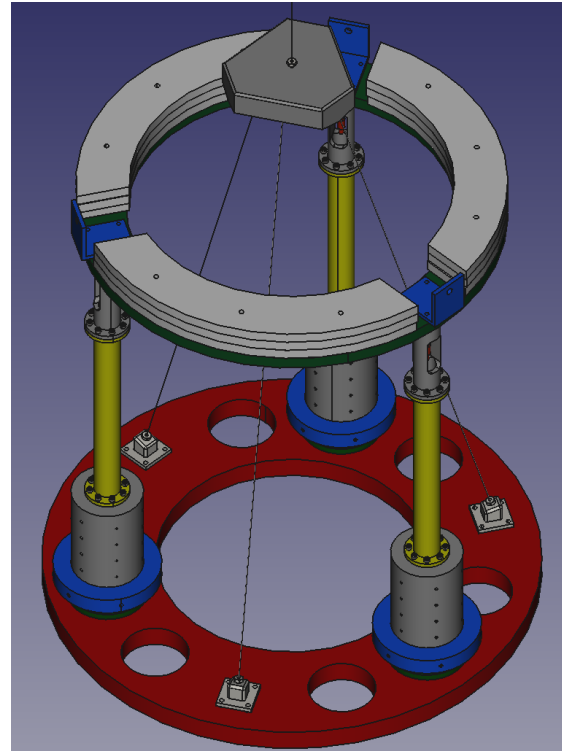
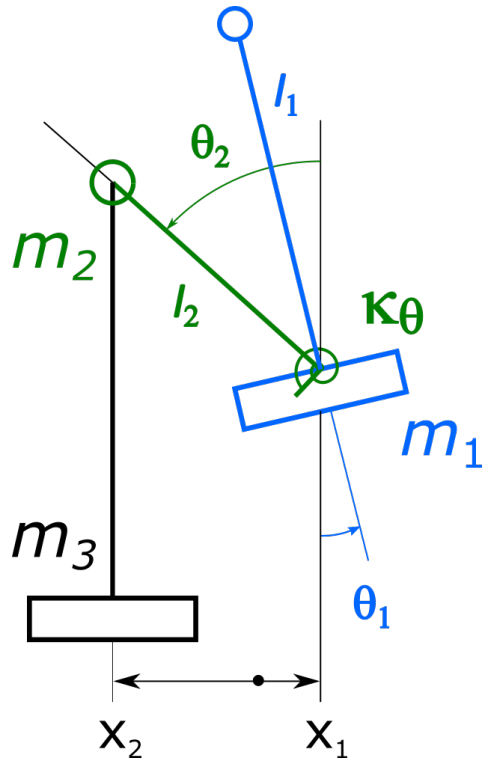
control of the pre-isolator, horizontal and vertical transfer functions

WP6: Public outreach: local and national events

- ❑ schools, public events and exhibitions in the Sardinia region.
- ❑ broader audience, with support of INFN and involved universities

PIP: Pendulum – Inverted pendulum

How to soften a suspension stage



Normal mode frequencies
0.68 Hz 0.74 Hz

Overall length

- A PIP chain can be built
 - Hook of the second PIP **above** the first filter
 - Current PIP length 1.55 m
 - Two PIP can live in $2.60 + 0.40 = 3.0$ m accounting for a dedicated vertical attenuation stage
 - Three PIP can live in 4 m
 - Proximity of different stages for feedback control of normal modes

NGSA

New Generation Super-Attenuator

status report

A. Bertocco, M. Bruno, R. De Rosa, L. Di Fiore, D. D'Urso,
F. Frasconi, A. Gennai, L. Lucchesi, F. Pilo, D. Rozza,
P. Ruggi, V. Sipala, I. Tosta e Melo, L. Trozzo

NGSA

The NGSA project, started at the beginning of 2022, is a competitive proposal, approved and funded by INFN commission 5.

The project is expected to last 3 years. Funds ~700 keuro

The research group includes 3 INFN research units: (INFN-Pisa, INFN-Napoli, INFN-LNS/UniSS) and a participation by EGO.

It is strictly connected to Einstein Telescope (ET): it is devoted to the study of a seismic isolation system for 3rd generation GW antennas.

Main Goal

Reducing the height of the SA tower fulfilling the ET requirements

NGSA

- The NGSA is devoted to the development of a new generation seismic isolation system with the goal to reduce the full height of the SA with respect to the present reference solution
- The project is organized in two research lines:
 - ✓ Optimized SA with the AdV architecture and improved MAS
 - ✓ New architecture SA with a two stage NIP (+ optimized chain and improved MAS)
- A NIP prototype (in 1:2 scale) is under development and will be tested for checking reliability and performance
- The final outcome will be a conceptual design of the Seismic isolation system for the Einstein Telescope (ET)
- Results are expected by the end of 2024

NGSA project Organizzazione : WP

Credits to L. Di Fiore



The project is organized in 4 WP:

WP1 – Simulation and optimization of the Superattenuator

Coordinator: L. Trozzo (INFN-NA)

WP2 – Mechanical filter with improved Magnetic Anti-Spring (MAS)

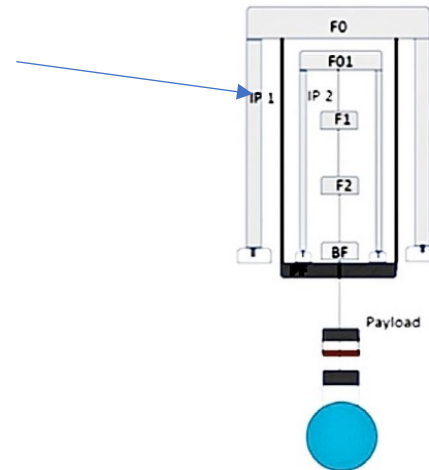
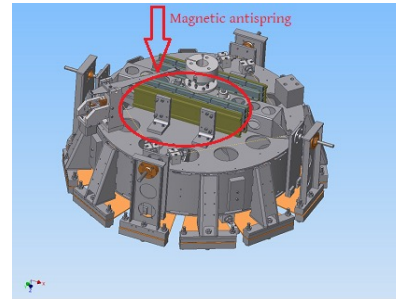
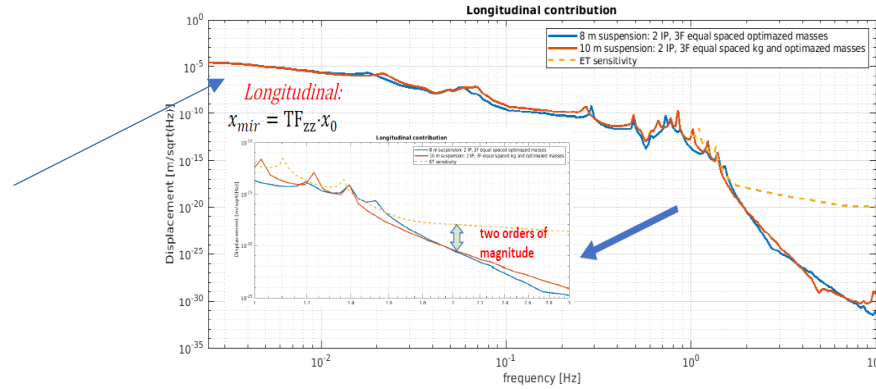
Coordinator: F. Frasconi (INFN-PI)

WP3 – Development and test of a Nested Inverted Pendulum (NIP)

Coordinator: R. De Rosa (INFN-NA)

WP4 – Sensing and Control (S&C)

Coordinator: A. Gennai (INFN PI)



ETIC – Einstein Telescope Infrastructure Consortium



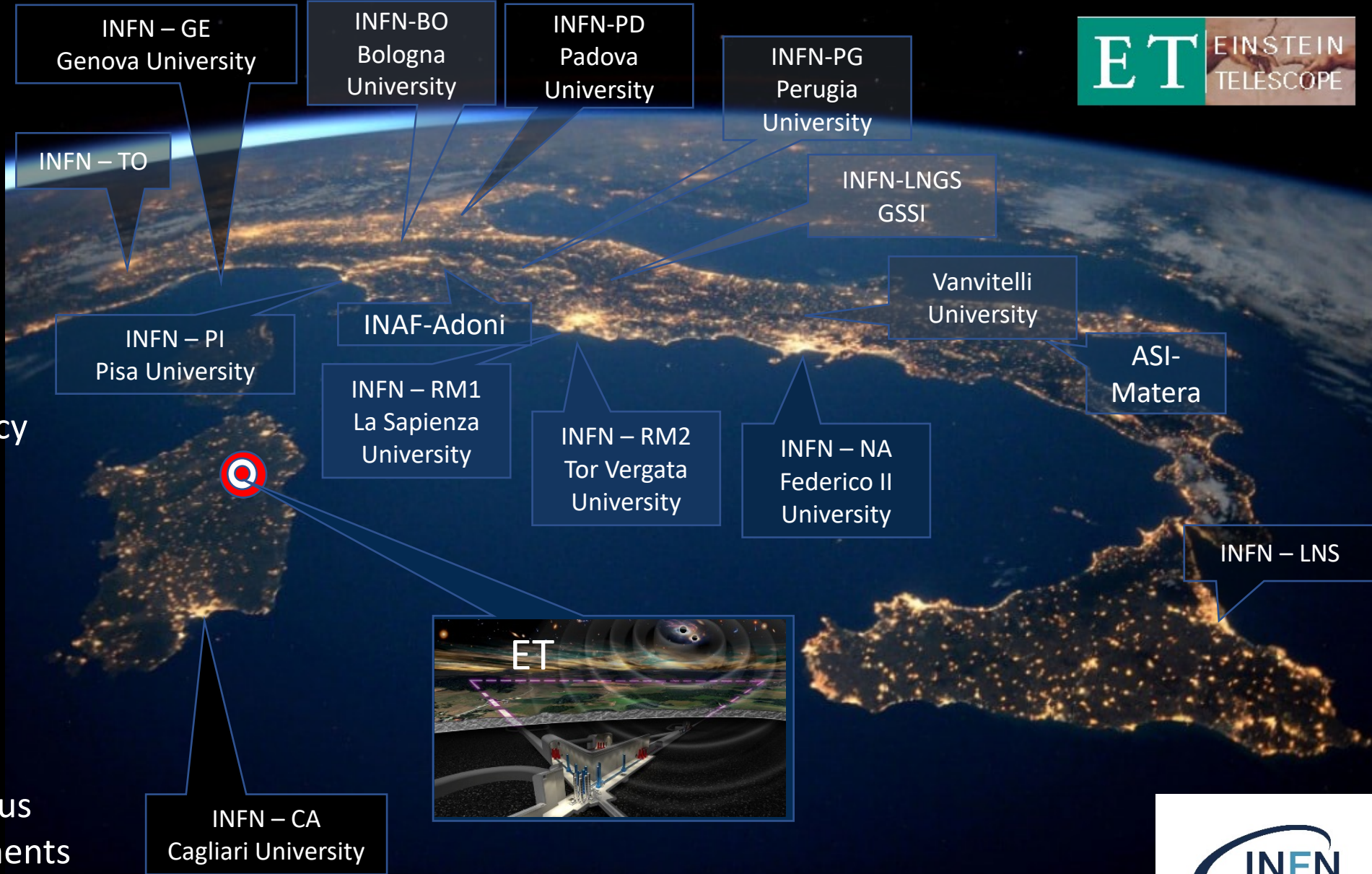
Next Generation EU (PNRR)
Investment focused on ET
enabling technology and
Sardinian site candidature
support

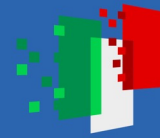
Led by INFN,
Partners:
11 Universities
INAF and Italian Space Agency

Budget 50M€

Start of the project:
1st January 2023

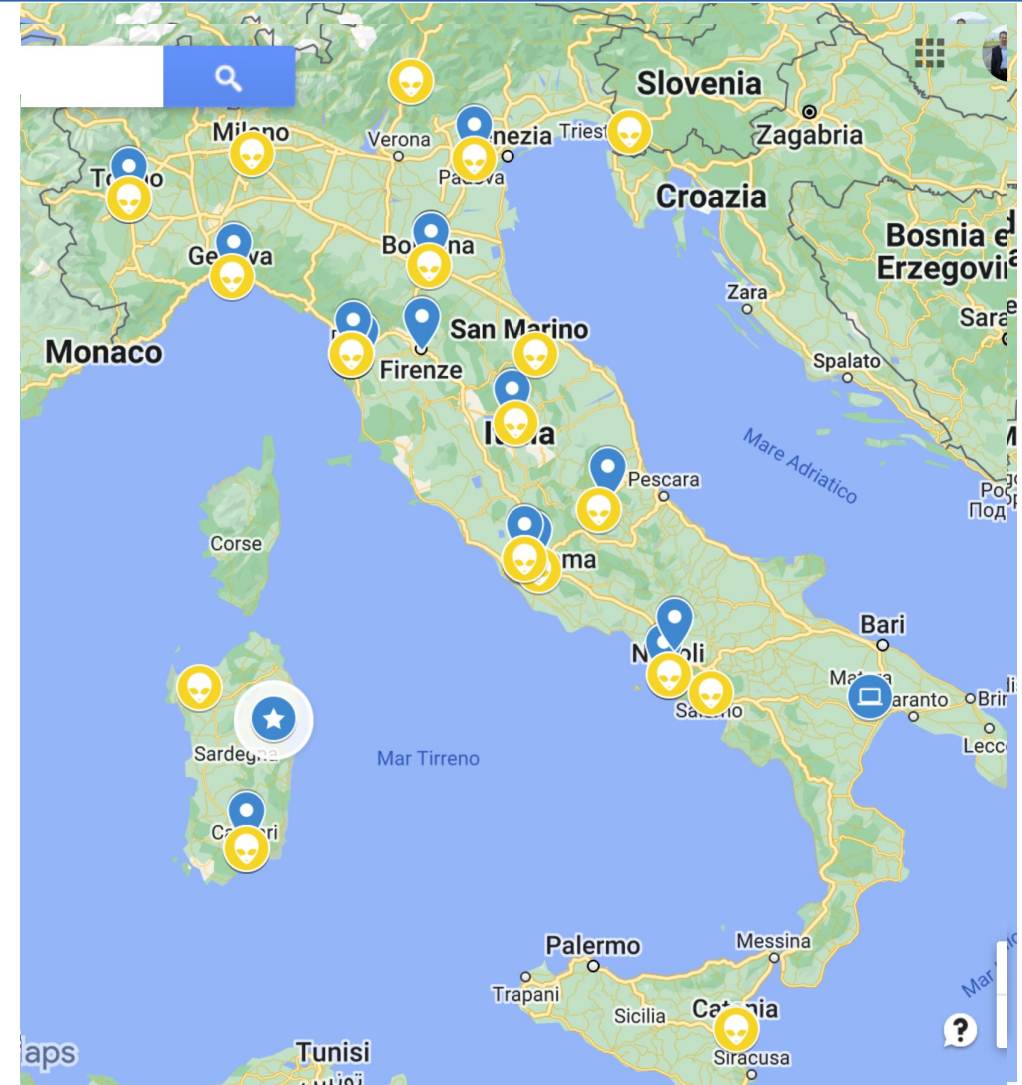
Full support from the previous
and present Italian Governments
on the Italian site candidature





ET-ETIC

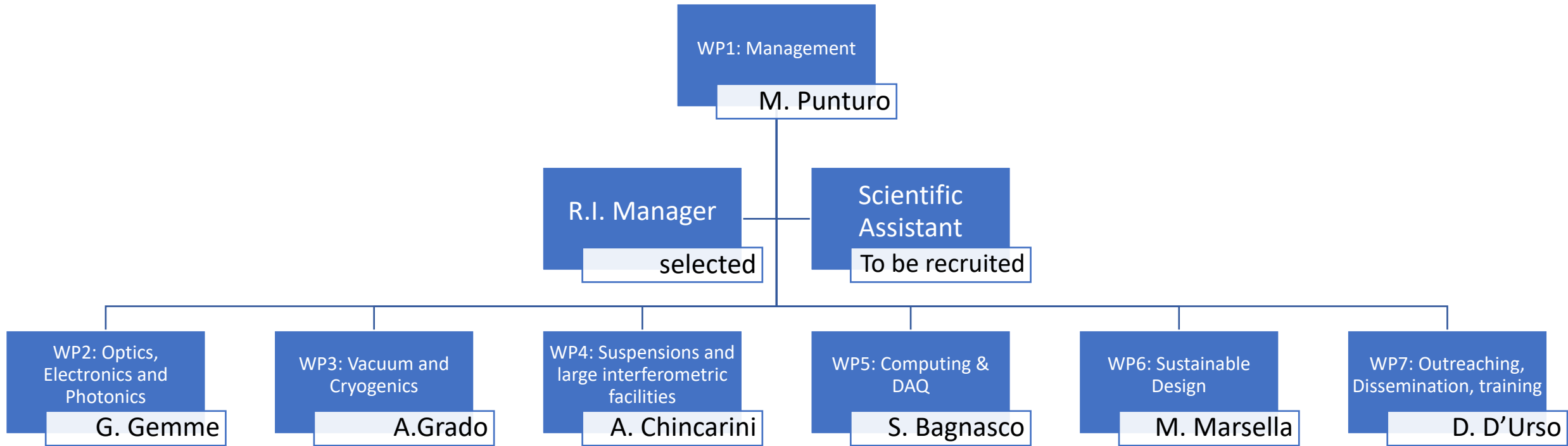
- Operative Units and Research Infrastructures
- 20M€ Preparatory studies for ET design
- 30M€ R&D Research Infrastructures
(see ISB talks on R&D Infrastructures)
- Timing: 30 months (+6) from Jan 2023



Credits to M. Punturo



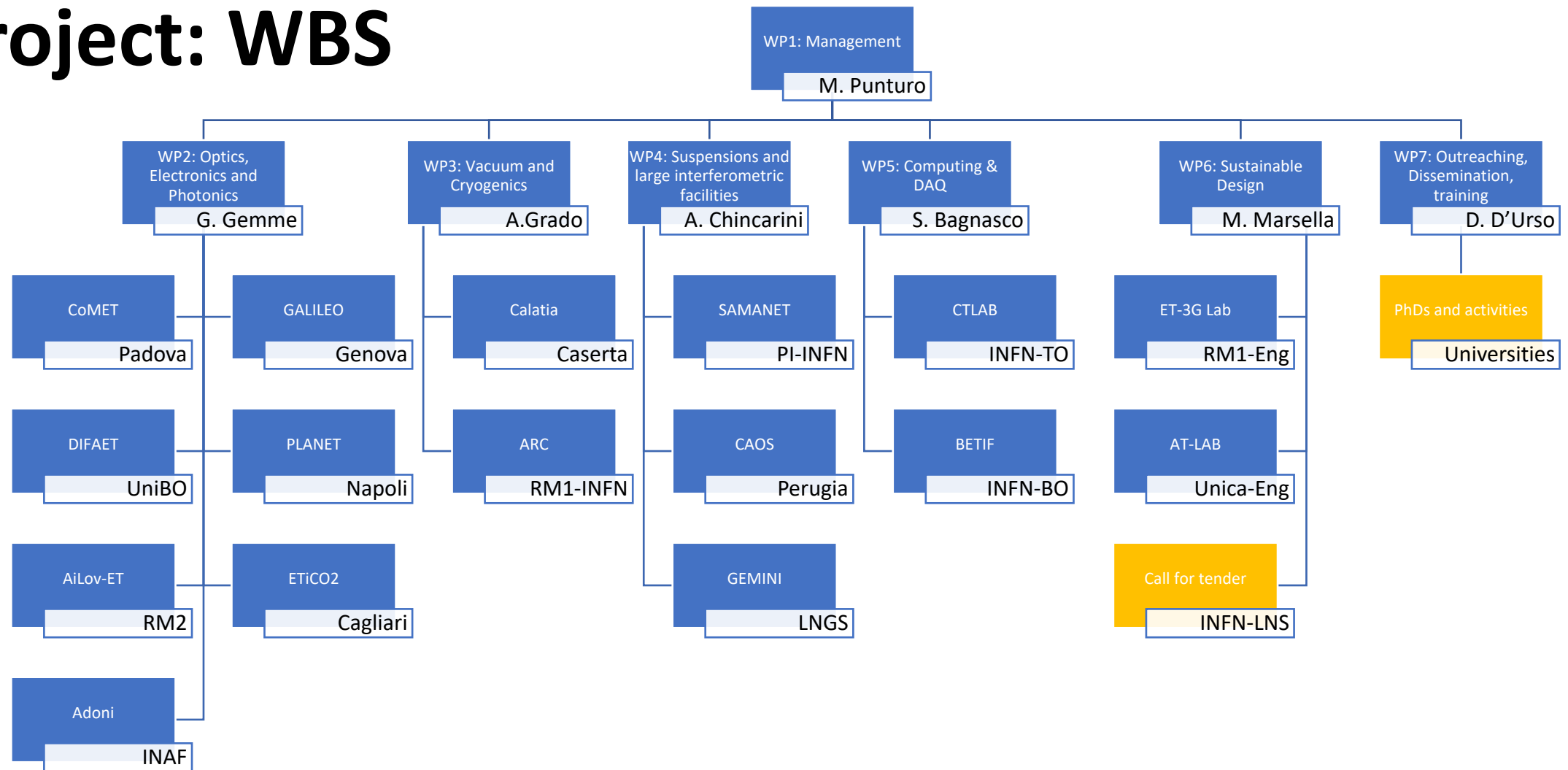
ETIC Project: WBS



Credits to M. Punturo



ETIC Project: WBS





ETIC spill-overs for ET

- ETIC invest on engineering services, modeling labs and higher education jobs for the pre-feasibility phase of the ET civil engineering design
- Call for tenders of the PNRR ETIC project has been published for the preliminary feasibility study for ET in Sardinia (14 Million of euro , to be assigned by dec. 2023 and delivered by dec. 25) in different geometric configurations
- WP6 " Sustainable Design" in ETIC project gathers a multidisciplinary working group to
 - ✓ support the formulation of engineering solutions satisfying scientific requirements
 - ✓ applying environmental sustainable strategies (*talk of Sara Mangifesta tomorrow at 9:30*)
 - ✓ define a shared eapproach for the optimization of the ET geolocalization on the surface and underground (*talk of Wissam Wahbeh today at 16:30*)

Next steps

- share the specialized studies with scientific boards and experts (MOU with CERN)in ETO
- enforce engineering team to consolidate specifications for civil works design (CE – INFRADEV)
- interact with thematic working groups to gather relevant parameters for design, risk identification, maintenance and operations needs

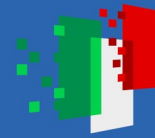
Credits to M. Marsella



Finanziato
dall'Unione europea
NextGenerationEU



Ministero
dell'Università
e della Ricerca



Italiadomani
PIANO NAZIONALE
DI RIPRESA E RESILIENZA



ISTITUTO NAZIONALE
DI GEOFISICA E VULCANOLOGIA

PNRR project “Monitoring Earth Evolution and Tectonics” (MEET)

Principal Investigator: **Giulio Selvaggi, INGV**



framework:

Progetto infrastrutturale finanziato Missione 4 del PNRR “Istruzione e Ricerca”
Componente 2 “Dalla ricerca all’impresa”
Linea di investimento 3.1 “Fondo per la realizzazione di un sistema integrato di
infrastrutture di ricerca e innovazione”

Credits to C. Giunchi

11 WPs national al local seismic and geodetic networks, laboratories, observatories

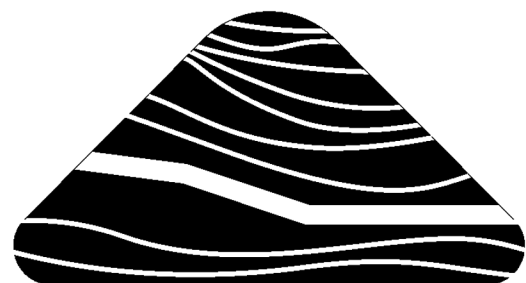
43 M € di budget totale, 2.5 M € for WP7 Sardinia Faber

Objectives:

SPECIFIC OBJECTIVE 1
**Strengthening the Data
Production**

SPECIFIC OBJECTIVE 2
**Implementing Services
for Science and Society**

SPECIFIC OBJECTIVE 3
**Integration in the National and
European Frameworks & FAIR
Data Management**



S A R D I N I A

FABER

FAR FAULT OBSERVATORY

**Sardinia FABER is a geophysical
observatory located at Sos Enattos
Mine**

Infrastructure consolidation

- power line and data line upgrade
- solar power plant and electric vehicles to access the tunnel

Credits to C. Giunchi

New instrumentations

- broadband and very broadband seismometers
- magnetometer
- gravimeter
- strainmeter
- tiltmeter
- micro barometer and other ambient controls

Surface laboratory

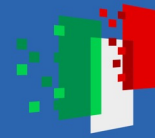
- equipment maintenance and test
- data acquisition, archive and transission
- hospitality (and lodging)



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Credits to M.Campanella
and A. Masoni

Terabit network for Research and Academic Big data in Italy

- PI: Mauro Campanella (INFN/GARR)
- Funds 41M €
- Partners: INFN e OGS and GARR, CINECA
- Timing : 30 months (+6) from Jan 2023

Terabit for ET: Network up to 1 Tb in Sardinia

Link to the SarGrav Lab funded by the Regione Sardegna within the SarGrav Project

- National and Regional authorities supported the Italian Candidature to host the Einstein Telescope since 2017
 - ❑ 17 Meuros for AdV+, ET R&D and support of the Sos Enattos candidature from the Italian Governament
 - ❑ 3.5 Meuros to realize a low noise lab and support Sos Enattos candidature by the Regione Autonoma della Sardegna
 - ❑ 5 Projects funded by Italian Minister of University and Research (PRIN) for a total of about 4.5 Meuros
 - ❑ 50 Meuro funded by the Italian National Recovery and Resilience Plan (PNRR)
- National and Regional authorities supported many synergic projects
 - ❑ 2 project founded by the Italian National Recovery and Resilience Plan (PNRR)

Conclusions

- Site Characterization and Preparatory studies for ET design (core of the Italian Bidbook for the candidature)
- Network of Research Laboratories to support ET R&D
- R&D activities on many items
- analysis and simulation tools
- definition of science cases