

PLaNET

Physics Laboratory in Naples for Einstein Telescope

Luciano Di Fiore
On behalf of the Napoli ET group

Talk summary

- Introduction
- The PLaNET Research infrastructure
- Present status of the project
- ISB activities in the PLaNET labs
- Next steps and conclusions

Introduction

- The Naples group has a decades long experience in experimental GW research, participating to the Virgo experiment since its foundation, to the LISA-Pathfinder Project and to the development of the ET project
- The PLaNET project in Naples is part of the PNRR-ETIC National project
- ETIC (Einstein Telescope Infrastructure Consortium) is one of the projects, funded within the Italian Recovery Plan (PNRR), for the realization of a network of research infrastructures
- The ETIC goal is to crating new research infrastructures, or upgrading exiting ones, specifically devoted to the development and realization of the ET project
- ETIC was selected in 2022 and it formally started at the beginning of 2023

PLANET is a joint project of INFN-Napoli and Università degli Studi di Napoli “Federico II”

Financial resources from the PNRR-ETIC project :

UniNA

- Infrastructure: 978.000 €
- Personnel: 232.500 € → 2 RTDa (fixed term researchers) for 24 months (extended to 36 with University funds)
- Training: 98.155 € (two PhD positions)
- Other expenses: 91.600 €

Total UniNA: ~ 1.400 M€

INFN-NA

Scientific and technical equipment: 1.473.600 €

Personnel: 113.500 € 1 Technologist (fixed term research engineer) x 24 months

Other expenses: 111.100

Total INFN-NA: ~ 1.7 M€

Goal of the PLaNET project

The objectives of Planet are synthetized in two main tasks:

- ❑ Renovation and refurbishment of the already existing Gravitational Physics laboratory in Naples
 - This lab is presently used for research on AdVirgo, ET and other gravity experiments (Archimedes, LAG, MAG)

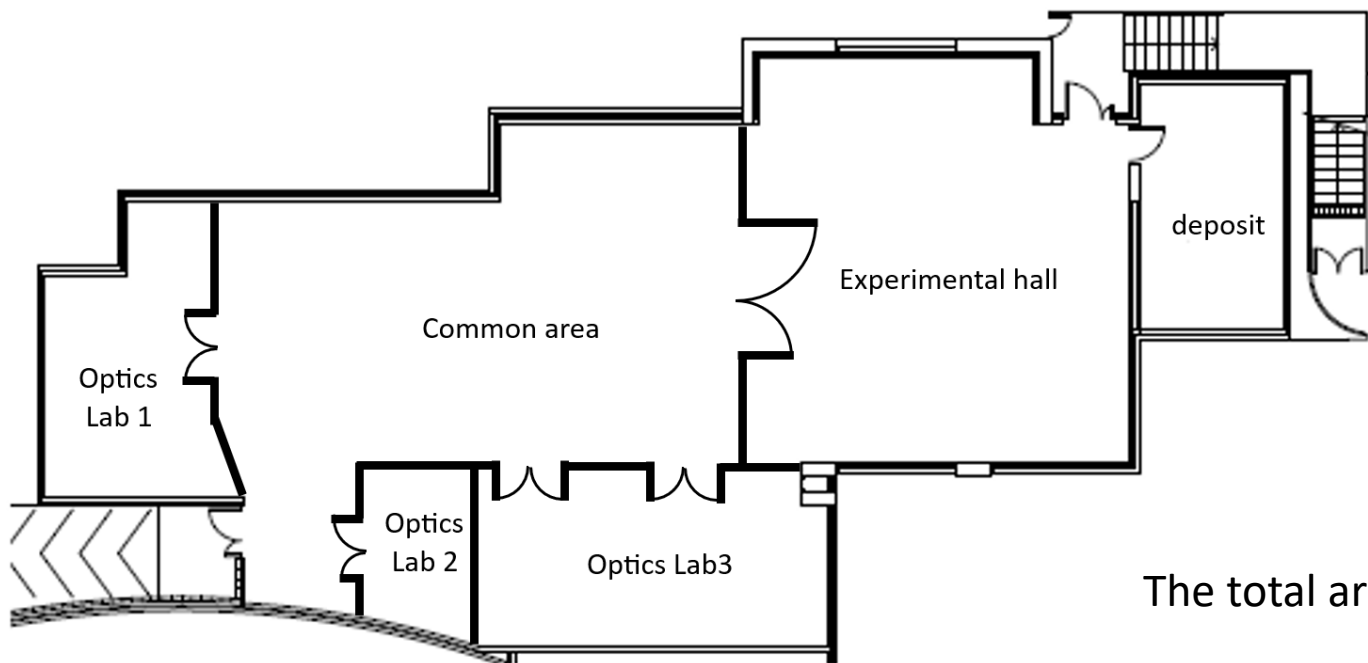
- ❑ Acquisition, renovation and equipment of a new lab, fully devoted to R&D and preparatory works for Einstein Telescope
 - The new lab ($\sim 170 \text{ m}^2$) will occupy part of the area of an old particle accelerator for nuclear physics research, that was recently decommissioned

The existing lab

It includes a large experimental hall, 3 optics labs, a common area and a deposit

Main interventions:

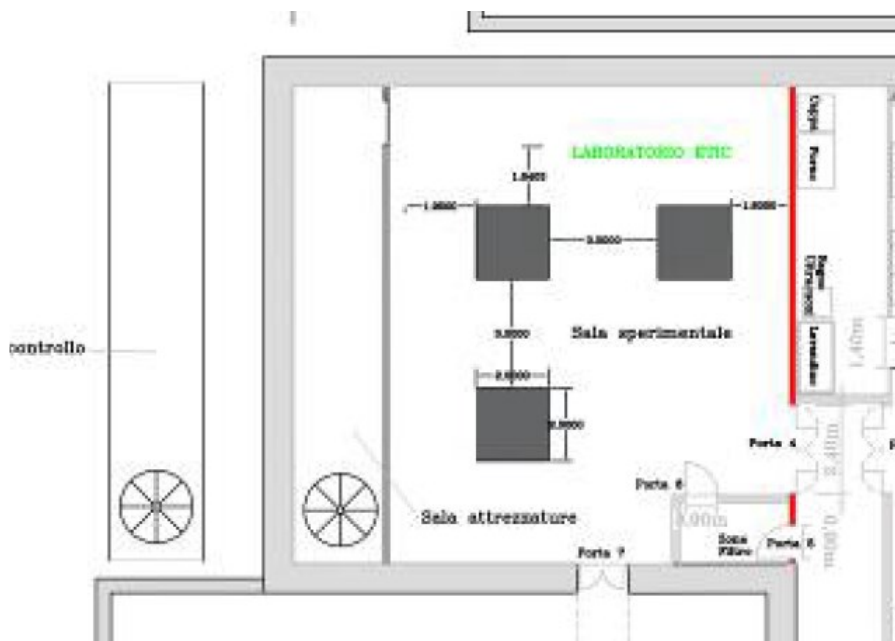
1. New air conditioning system
2. New concrete floor
3. New data acquisition and control systems
4. Upgrading of optics labs and related equipment (clean boxes, optical components and sources, instrumentation etc.)



The total area is about 280 m²

The restoration and upgrading works will include:

- A general renovation of the area
- A new air processing system providing:
 - Climatization for stable thermal condition
 - Small overpressure for avoiding dust contamination form outside (gray area)
- A new crane with free eight under the hook of 5 m
- Realization of 3 reinforced concrete plinths (4 m² each) with foundations independent of the building
- Complete equipment of the lab (optics and electronic instrumentation, optical benches, data acquisition and control systems, cleaning equipment, vacuum systems ...)



Present status of the project

Call for tenders for civil works have been awarded and works will start soon

We expect that the labs will be available in the second half of 2024

Call for tenders and orders for equipment and instrumentation are done to about 85 % and still progressing.

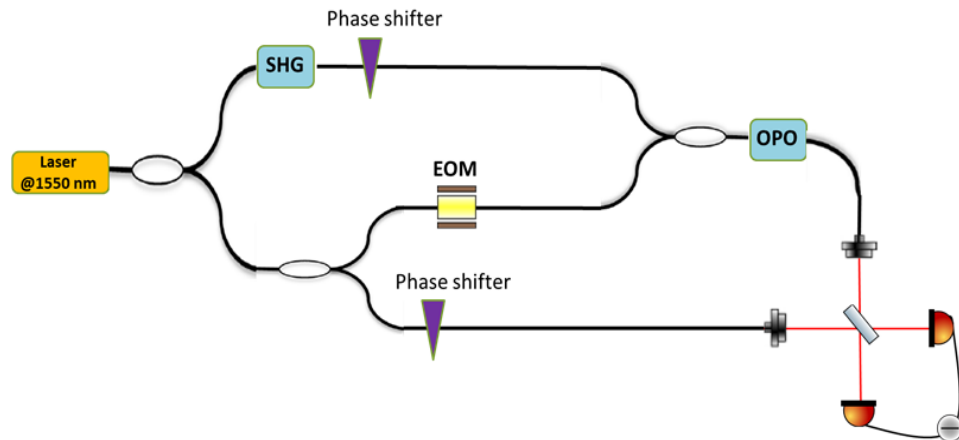
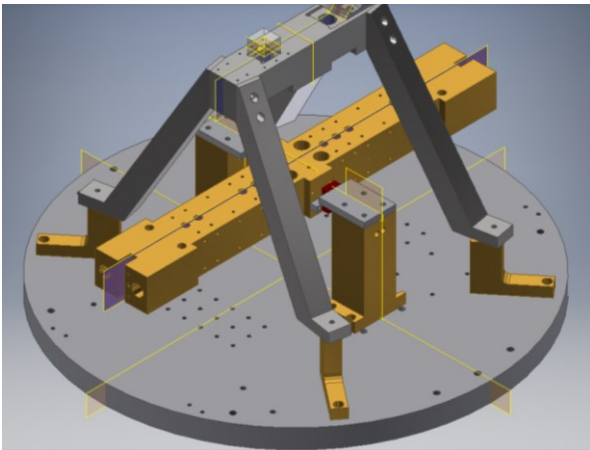
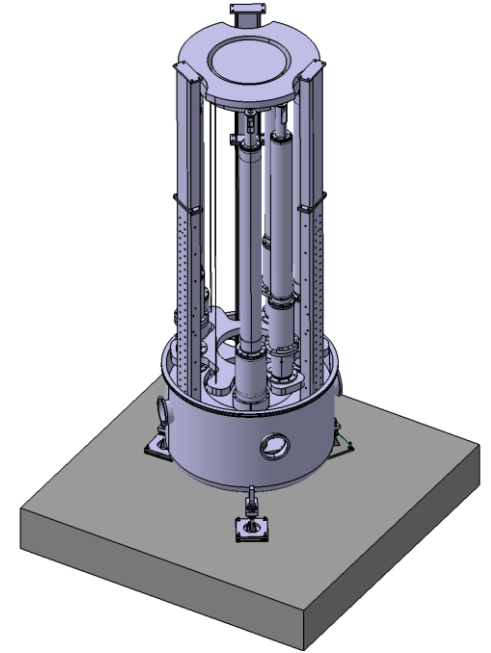
Due to some limited delays, they will be completed by the first months of 2024

The labs will be operative before end 2024.

ISB activities in the PLaNET labs

The R&D activities planned in the PLaNET labs include three main research lines:

- 1) Seismic isolation systems
- 2) Tiltmeters for active noise mitigation and NN cancellation
- 3) Optics and squeezing



Seismic isolation systems

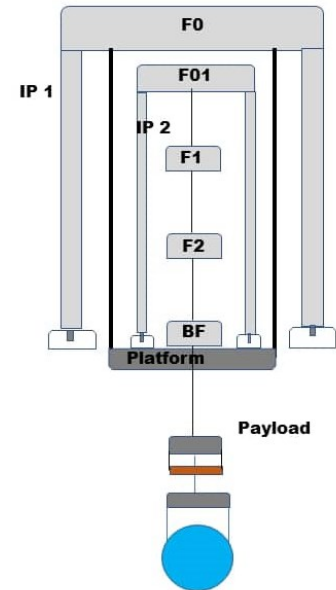
- The new PLaNET lab, will have three isolated basements and a space of 5 meters under the hook of the crane
- It cannot host a full-scale ET-LF seismic isolator including the cryostat, but it allows to test relevant parts of the pre-isolator and seismic filter chains or in scale prototypes.

The first experiment that will be hosted in PLaNET is the NGSА Project

NGSA (New Generator SuperAttenuator) is a project funded by INFN commission 5, for the design of new seismic isolators specifically designed for ET.

It is performed in collaboration by the Napoli, Pisa and Sassari/Cagliari units.

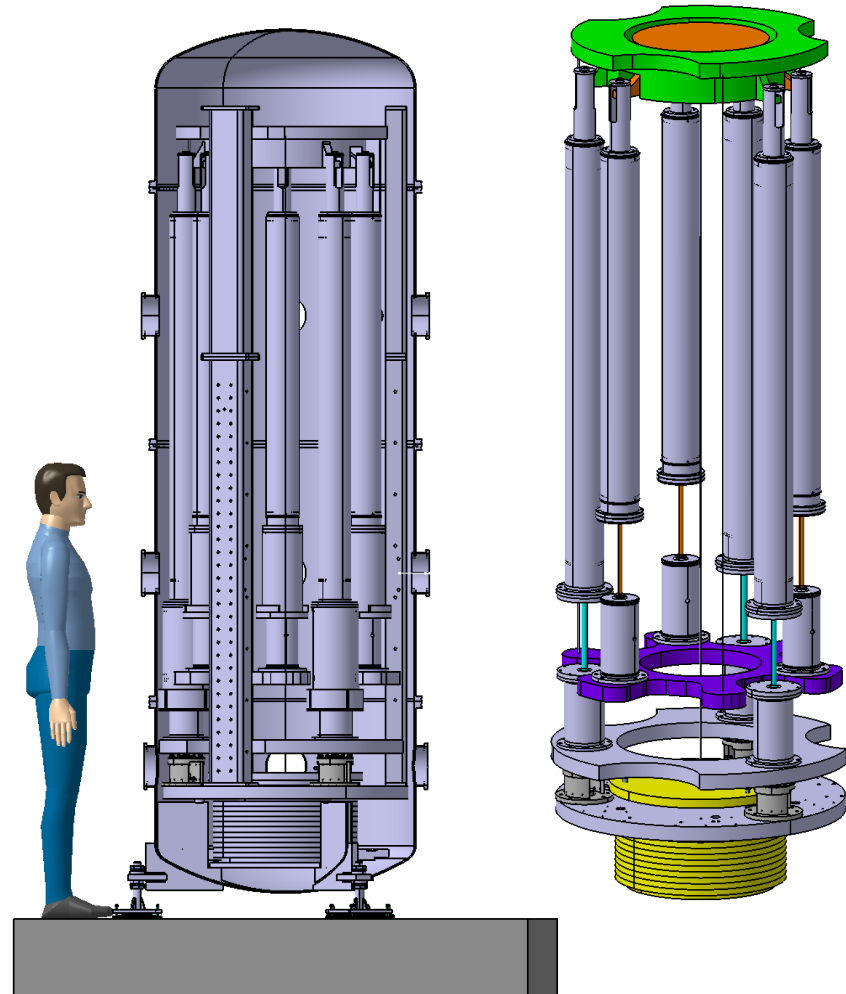
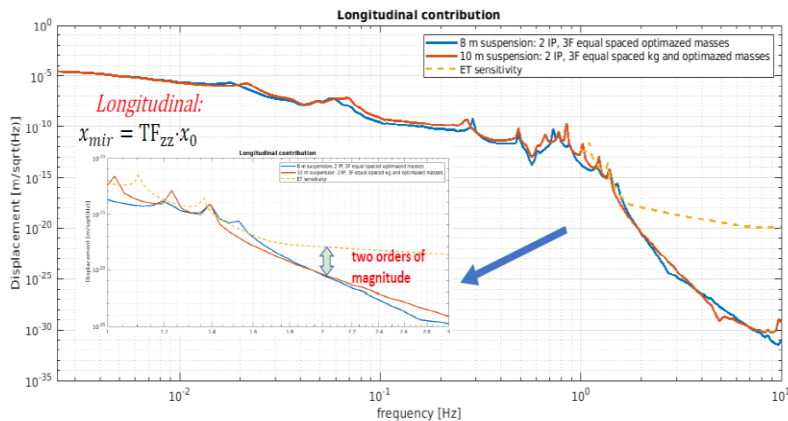
In Naples we will assemble a test a two-fold nested inverted pendulum pre-isolator that, if successful, will considerably improve seismic isolation, allowing to reduce the full attenuator length from 17 m to about 10 m (like the ones of AdVirgo).



The design is quite advanced and construction of the mechanical parts is already started.

We plan assemble the prototype as soon as the new lab will be available

Simulations show that a full size Superattenuator with a total length of 10 m could fulfil ET-LF seismic noise suppression requirements



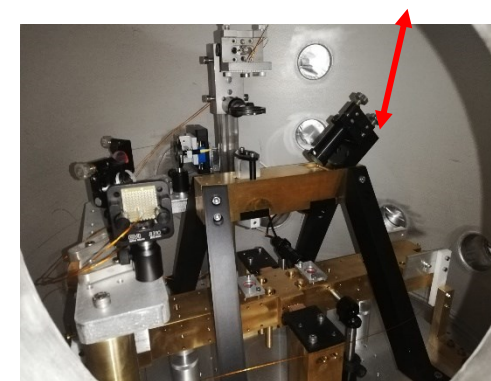
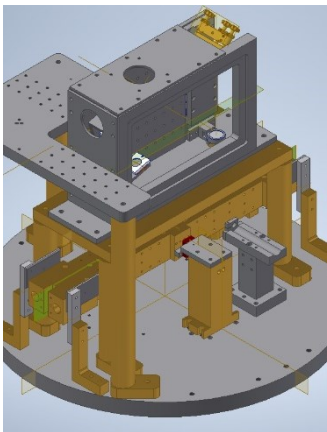
Newtonian Noise cancellation is based on a coherent estimate of NN using data from seismometer array + **tiltmeters**

The Napoli group has developed a tiltmeter that is now installed on the Virgo NEB, used to estimate ground tilt together with a seismometers array

Another, improved tiltmeter is now under design to be used in Sos-Enattos lab (expected installation by mid 2024) and in the future underground lab

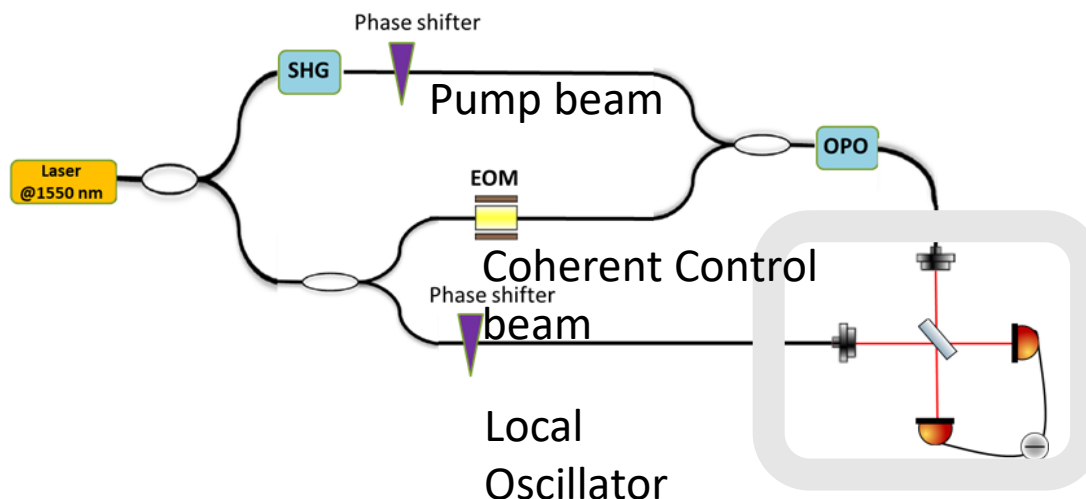
Future steps, to be performed in the new PLaNET lab will be:

- Development of a two DOF system with two stacked tiltmeters perpendicular to each other to measure the tilt along orthogonal directions
- Use of a tiltmeter for active tilt reduction on the NGSA prototype
- Study of a more compact tiltmeter setup to be placed inside the suspension vacuum chamber



Optics experiments for ET will be performed in the optical labs of the old Gravitational Physics laboratory in Napoli

- The first will be the study of a compact fibered squeezing source (NA, GE) to produce the first integrated squeezer in audio-band.



Squeezing source @ET-LF wavelenght

Production and characterization of an OPO cavity @1550 nm. The aim is to build a test-facility to measure parametric and intracavity losses for three kind of crystals (KTP, BBO, LNB) with different dopant concentration. The opto-mechanical design is already tested.

EPR squeezing @ET-LF

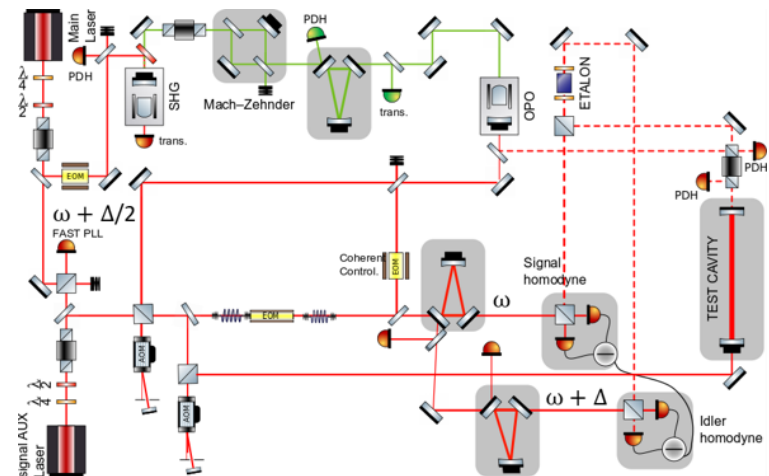
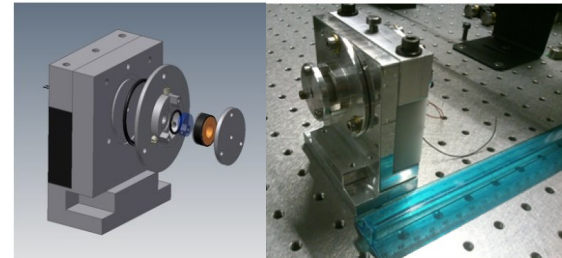
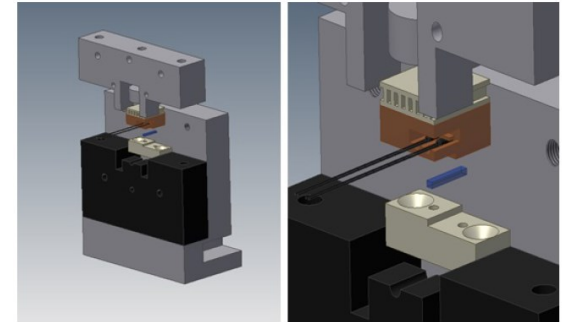
Goal is to reproduce the EPR set-up to produce conditional squeezing at ET low frequency wavelength:

OPO Source (see previous slides):

- PDH locking system
- Fibered EOM (for improved range)
- Fast photodiodes (GHz)

EPR set-up

- Double BHD and Mode cleaner



Conclusion

- ❑ PLaNET is a new research infrastructure in Naples devoted to R&D for development and preparation of the Einstein Telescope project
- ❑ The Laboratories will be operational in the second half of 2024
- ❑ PLaNET will contribute to research on several topics related to ISB, that in the first phase will include:
 - Seismic noise isolation
 - Tiltmeters for active noise mitigation and NN cancellation
 - Optical techniques for compact squeezer in the audio band, Low frequency squeezing and EPR squeezing

Thank you for your attention