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Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
INFN Istituto Nazionale di Fisica Nucleare

The status of CAOS laboratory

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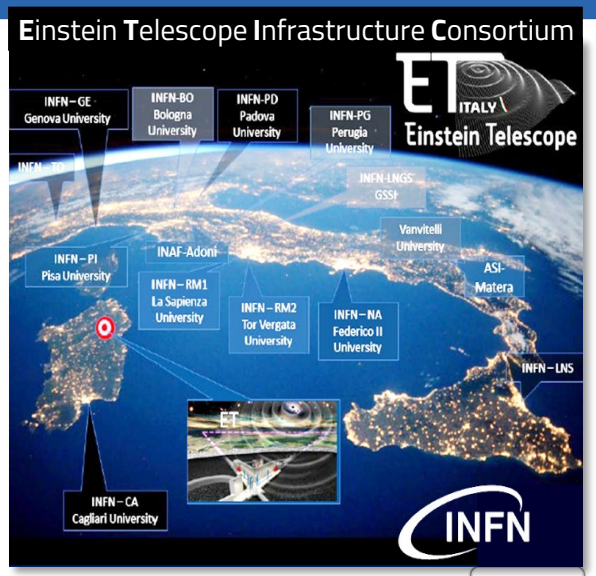
PNRR ETIC IR0000004, "EINSTEIN TELESCOPE INFRASTRUCTURE CONSORTIUM", CUP I53C21000420006,M 4, C 2, I 3.1

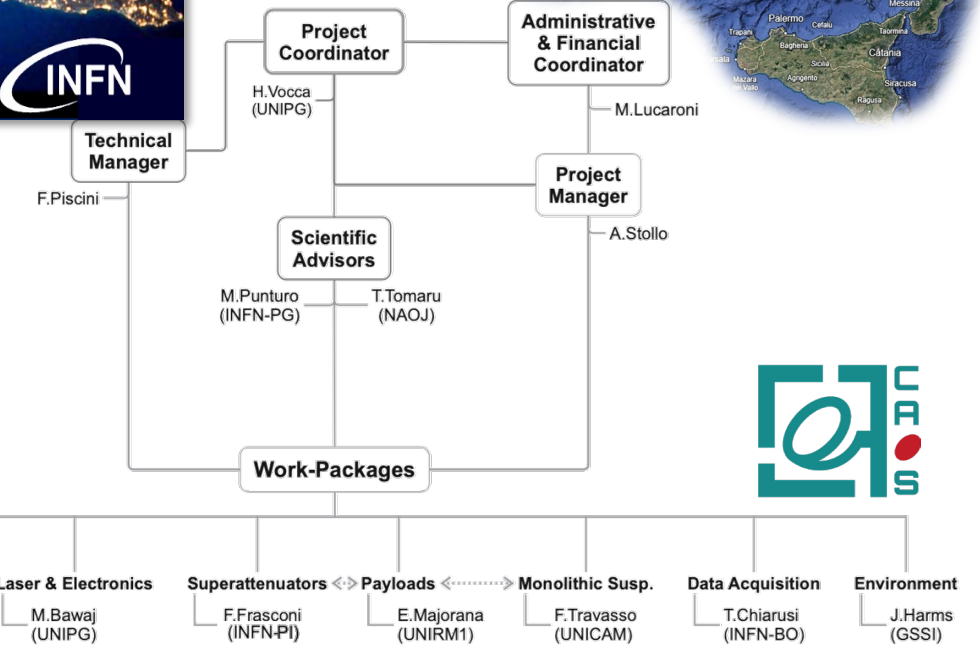
CAOS: General

CAOS is the main ETIC infrastructure, and it is under realization in Perugia, near the Engineering Department of the University. It serves as a specialized lab for testing mechanical and optical systems for the Einstein Telescope (ET).
The project draws on the **expertise of the Italian and international gravitational wave community**. It will be a testing facility suited to worldwide collaborations, like a sort of **gym for GW technologies**.

CAOS will host:
- A seismic-isolated Fabry-Perot cavity (6.6 mt lenght);
- **ET's full-sized towers** – 15 mt height;
- **ET's full-sized Super Attenuators** (SAs) – 13 mt height;

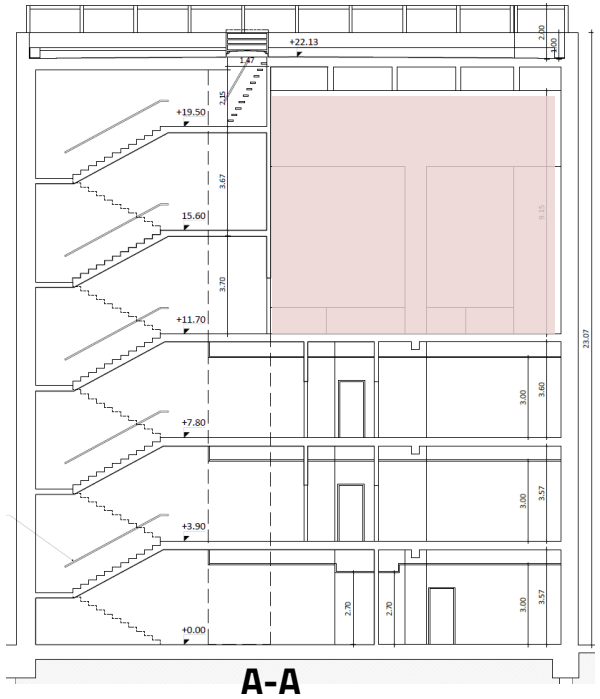
CAOS will be a fertile ground to:
- Test of NEG pumps in a SAs environment;
- Refine numerical and FE models on ET full size towers and SAs;
- Explore the potentiality of the lateral entrance for the PAY;
- Test Low Noise control systems;
- …
- **New Collaborations**;
- **New Ideas**;

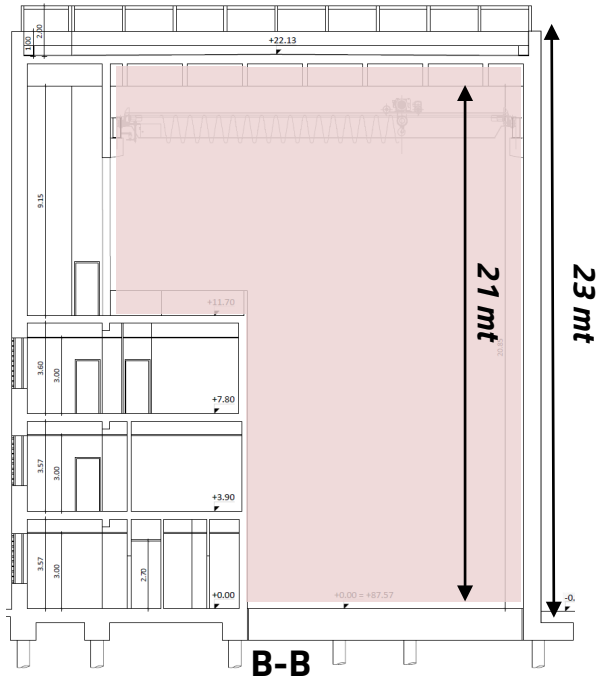


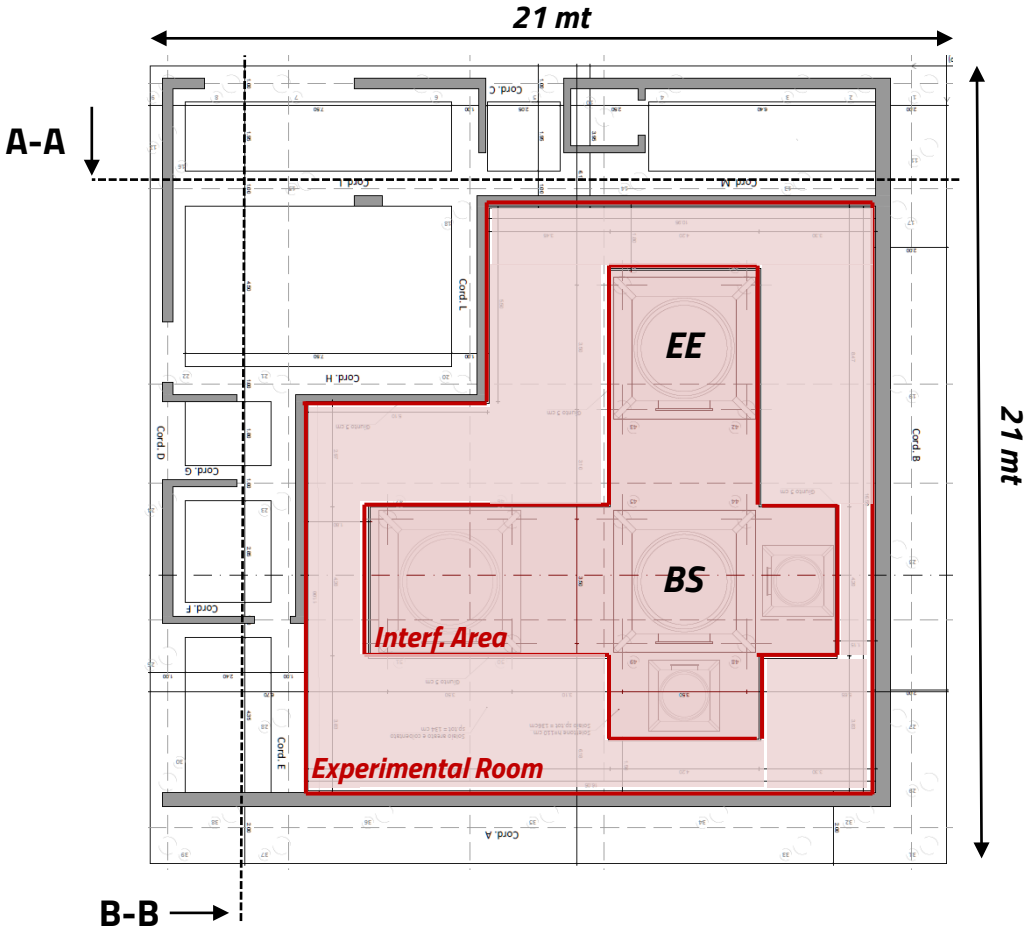


CAOS: *Infrastructure* Vacuum SuperAttenuators Payload & Monolytic Susp. DAQ Environment

Particular attention has been given to the foundations to minimise seismic noise: since the first layer of concrete was laid for the foundations, three zones in the laboratory have had separate foundations with a **5 cm gap**. (——)
The Experimental Room is 21 mt height ( )







CAOS: *Infrastructure* Vacuum SuperAttenuators Payload & Monolytic Susp. DAQ Environment

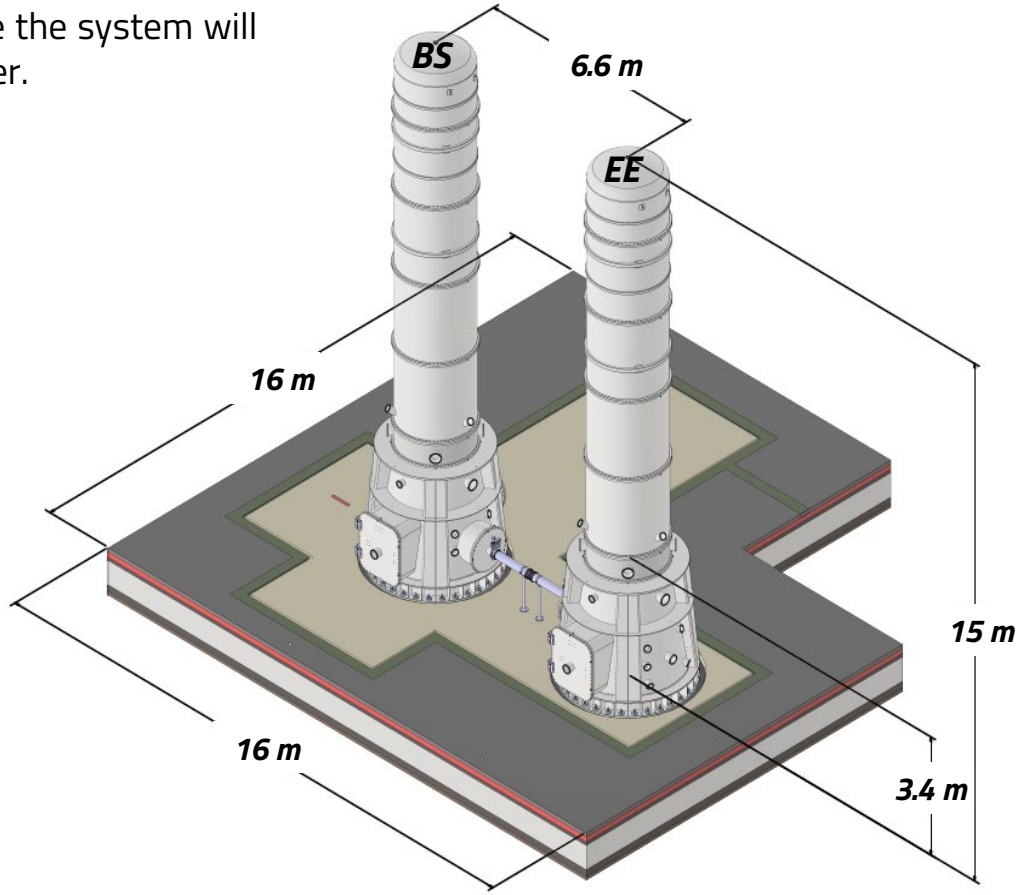
TimeLine:

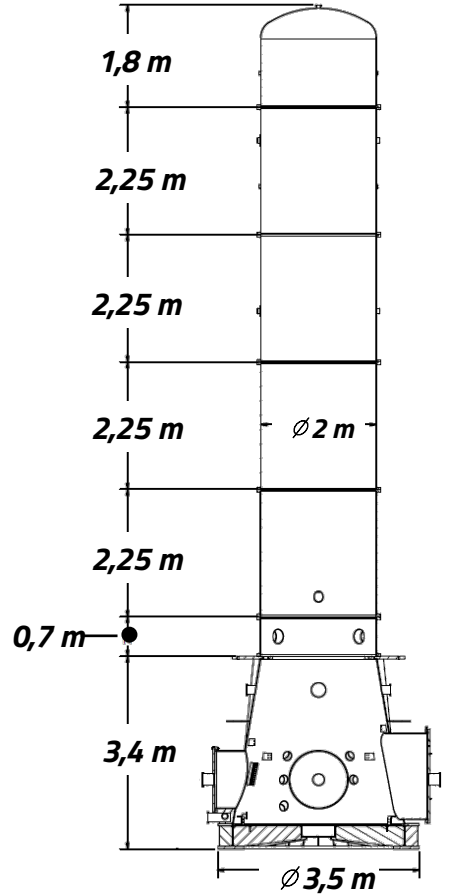
CAOS: Infrastructure *Vacuum* SuperAttenuators Payload & Monolytic Susp. DAQ Environment

CAOS vacuum system consists of two towers but in the future the system will be upgraded to three towers to host a Michelson interferometer.

The macroscopic features of the towers are reported below:

Feature	Description
Height	15 m
Tower Spacing	6,6 m
Material	AISI 304 L
Operational Pressure	≤ 10^{-7} mbar
Tower Weight	~20 ton each
Base Weight	~14 ton each
# Main Ferrule	4
Main Ferrule Height	2,25 m
Entrance	Lateral – 1,2 m x 1,5 m
Base Geometry	Truncated cone





Please look at *Francesco Bianchi's* talk [ET-0632A-24] for more details.

Please look at *Gabriele Capoccia's* talk [ET-0292A-25] for more details.

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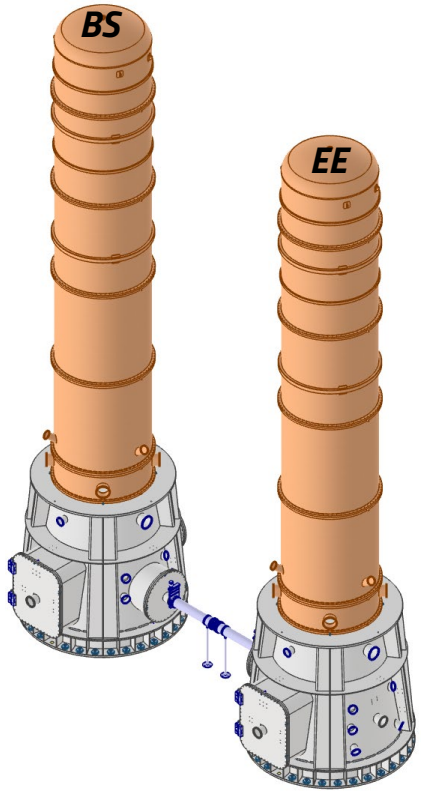
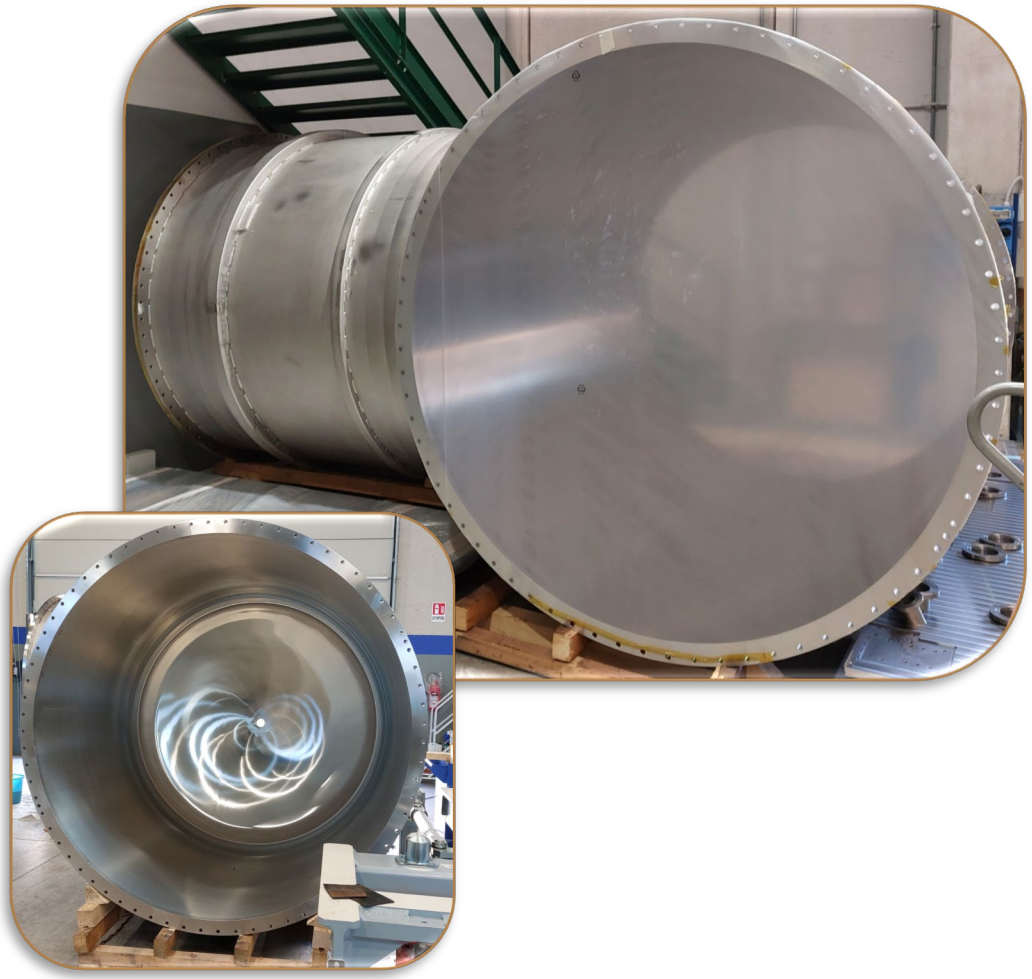
CAOS: Infrastructure *Vacuum* SuperAttenuators Payload & Monolytic Susp. DAQ Environment

Some production pictures of the towers are reported below:





CAOS: Infrastructure *Vacuum* SuperAttenuators Payload & Monolytic Susp. DAQ Environment

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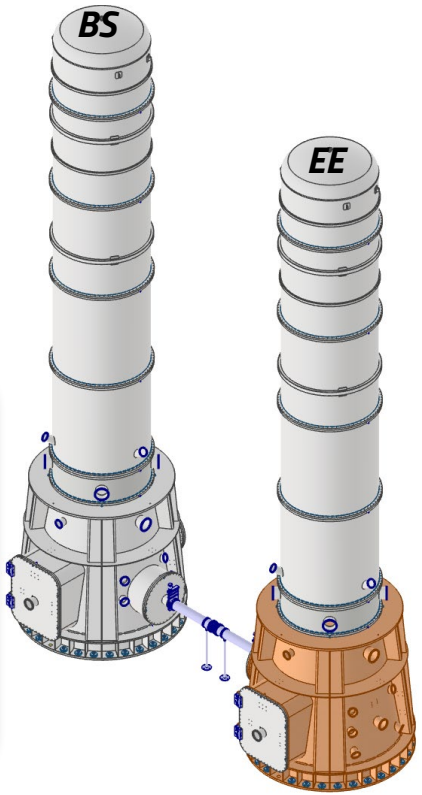

CAOS: Infrastructure *Vacuum* SuperAttenuators Payload & Monolytic Susp. DAQ Environment

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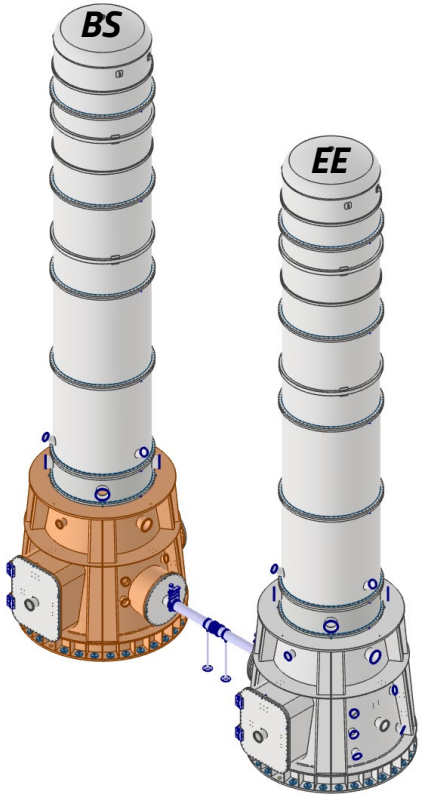
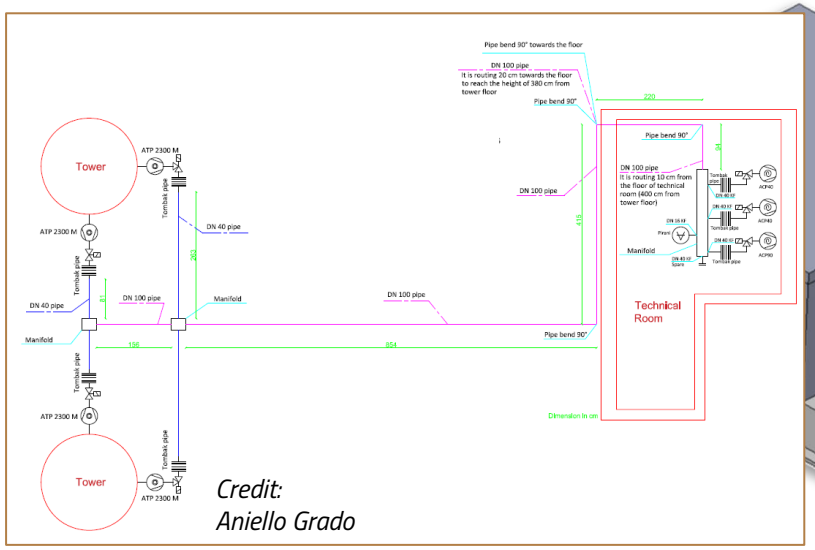
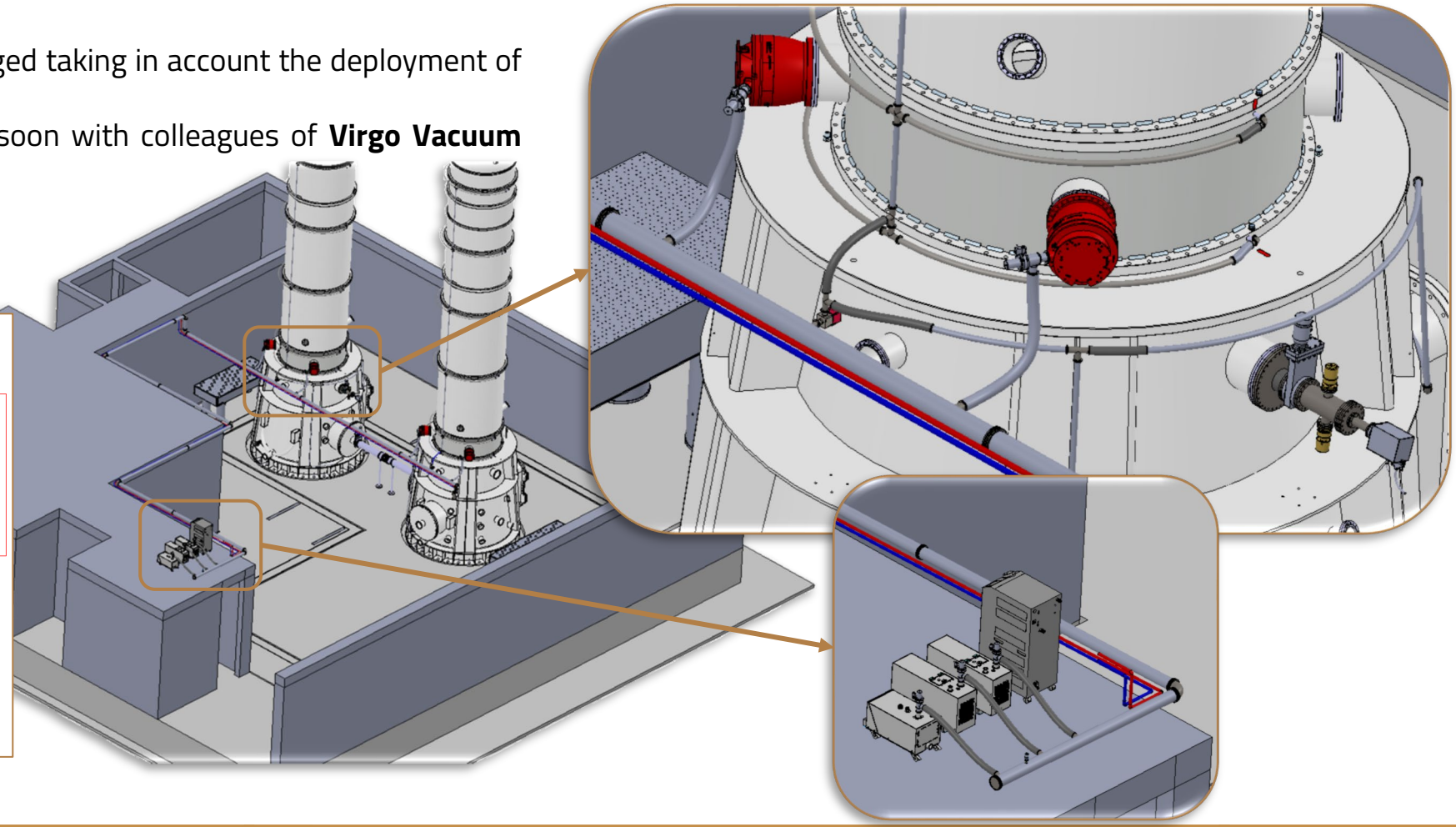


CAOS: Infrastructure *Vacuum* SuperAttenuators Payload & Monolytic Susp. DAQ Environment

CAOS pumps and vacuum pipes have been arranged taking in account the deployment of the scaffolding.
Work on building the control system will begin soon with colleagues of **Virgo Vacuum dept.**



Credit:
Aniello Grado



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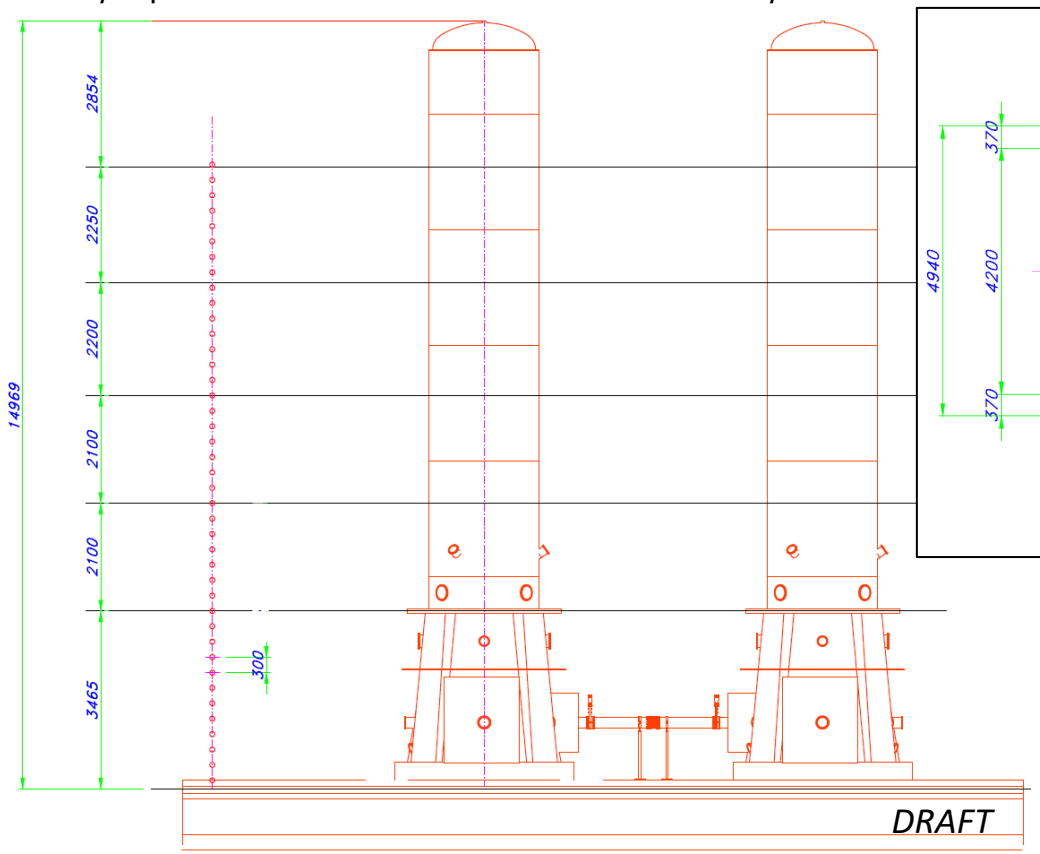
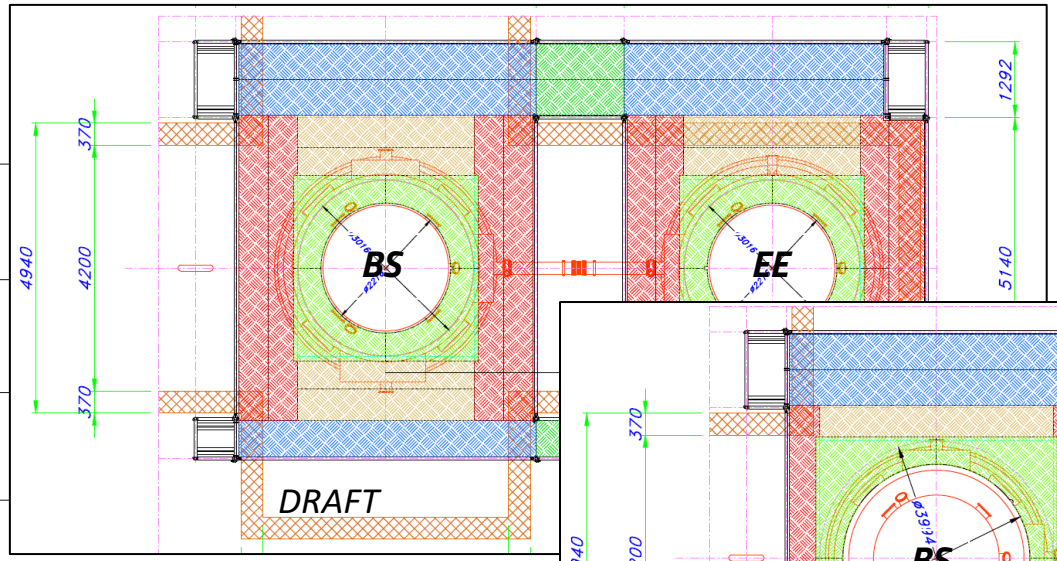
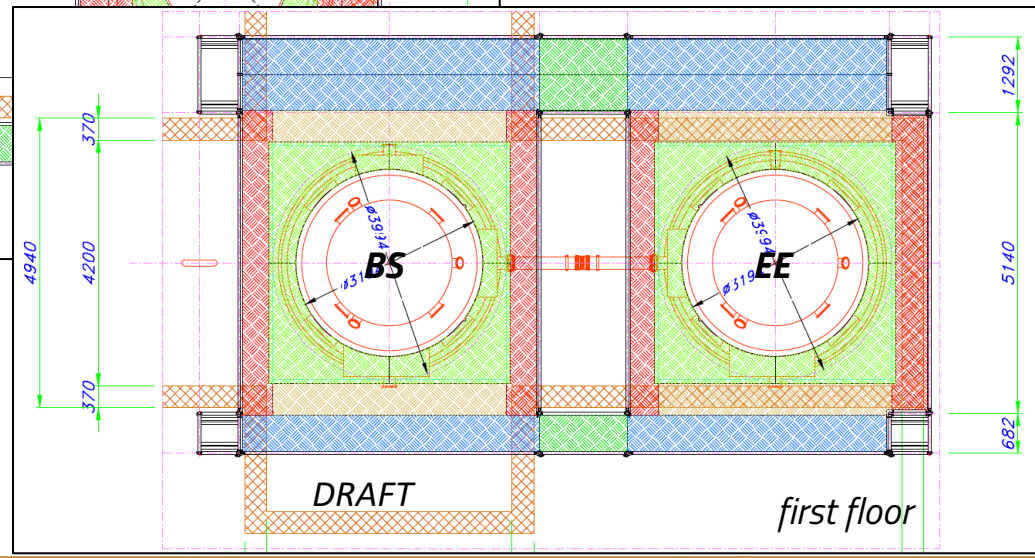
CAOS: Infrastructure *Vacuum* SuperAttenuators Payload & Monolytic Susp. DAQ Environment

The scaffolding around the towers was designed in line with Virgo's style: modular and versatile, integrating them with the equipment provided in the laboratory (optical tables, overhead crane, vacuum system, etc.).





second, third, fourth, fifth floor



first floor

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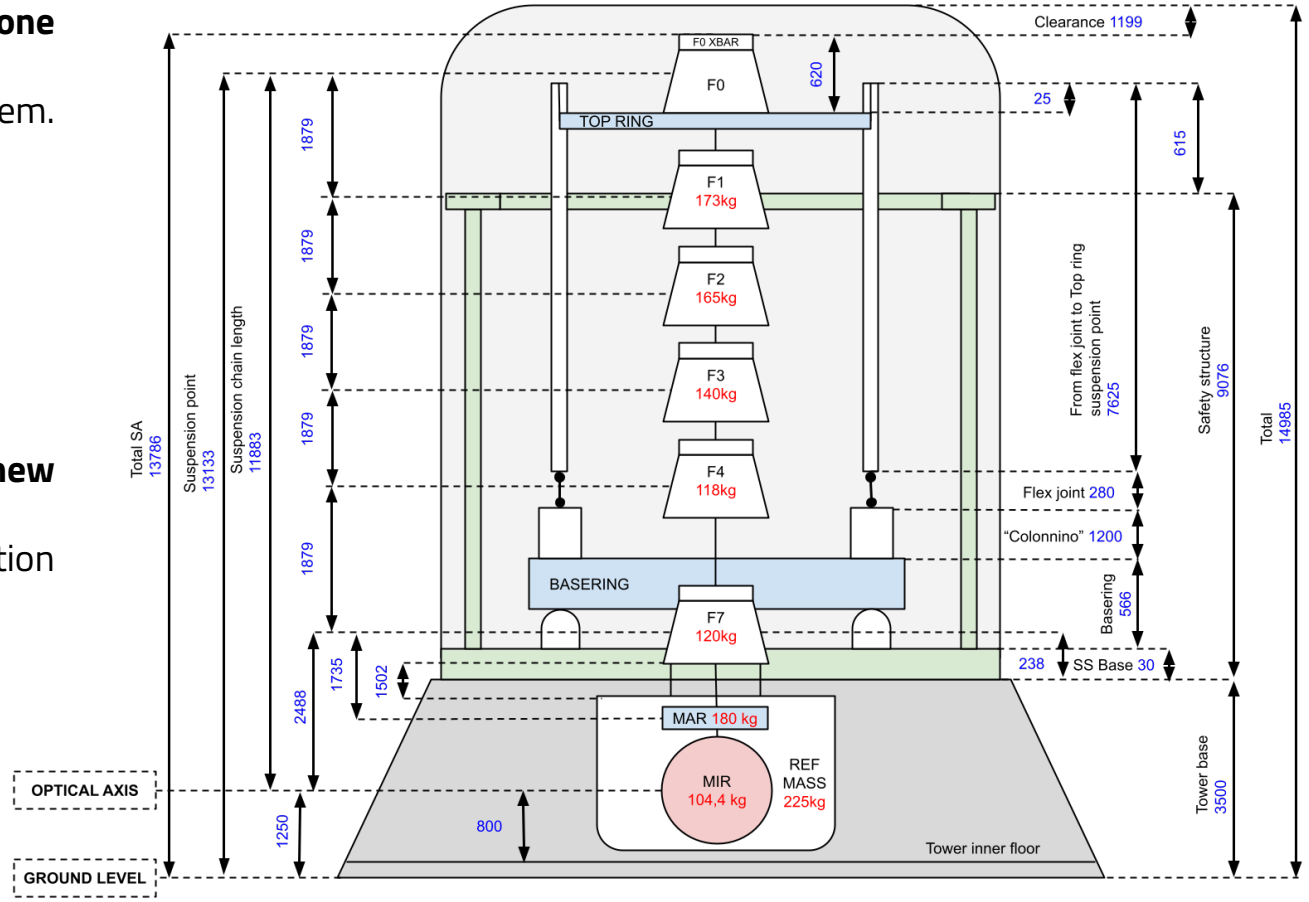
CAOS: Infrastructure Vacuum *SuperAttenuators* Payload & Monolytic Susp. DAQ Environment

- The "Beam Splitter" (BS) SA will be very **similar to the present AdV one** (except for the height);
- The "East End" (EE) SA will be used to perform **dedicated R&Ds** on them. So far we foresee to test:
  - New active platform – IP basering;
  - New accelerometers;
  - Filter 0 different approach;
  - New filters crossbar;
  - New epicycloidal Vertical Hoist;
  - Filter 7 modified;
- All the mechanical filters for both SAs will be equipped with **new Magnetic Anti Springs** (nMAS-SmCO);
- Studies are ongoing to explore **new materials** for vertical attenuation (blades) due to the difficulty of finding maraging steel.

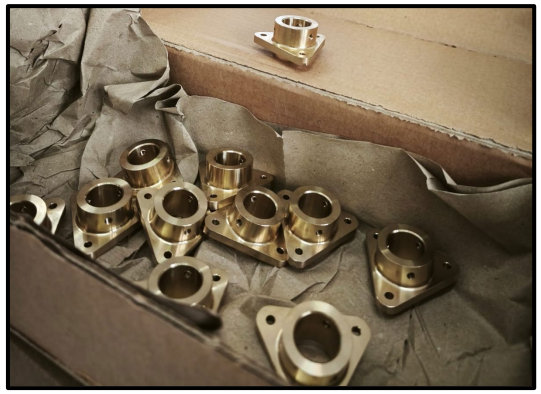


Please look at *Leonardo Lucchesi's* talk [ET-0638A-24] for more details.

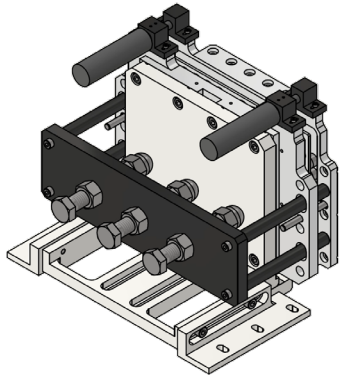
Please look at *Leonardo Lucchesi's* poster @ET Symposium of Bologna for more details.

CAOS: Infrastructure Vacuum ***SuperAttenuators*** Payload & Monolytic Susp. DAQ Environment

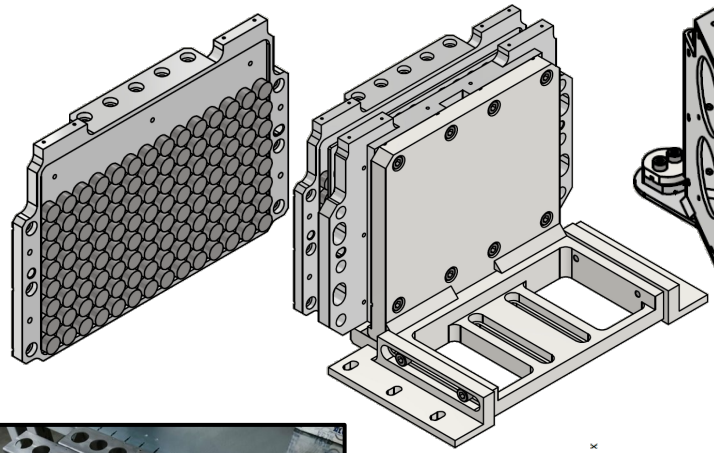
Brass comp. LVDT



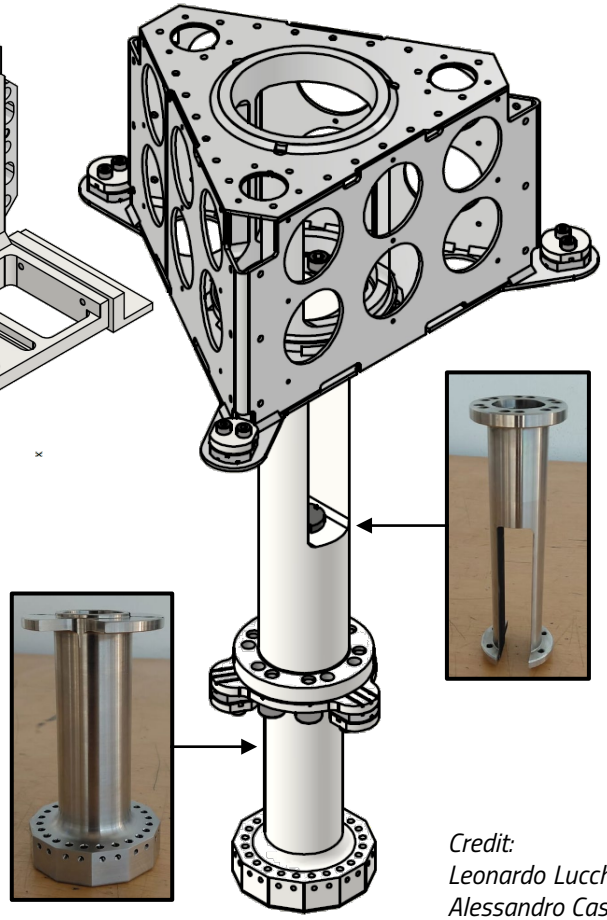
nMAS Assembly Tool

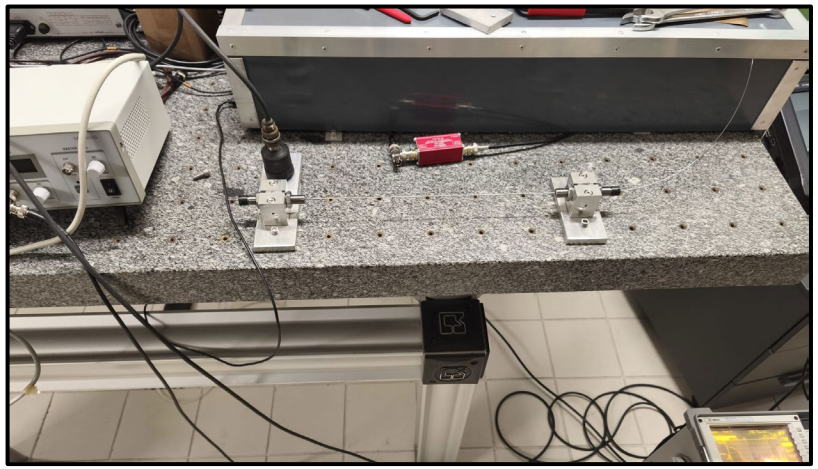


nMAS



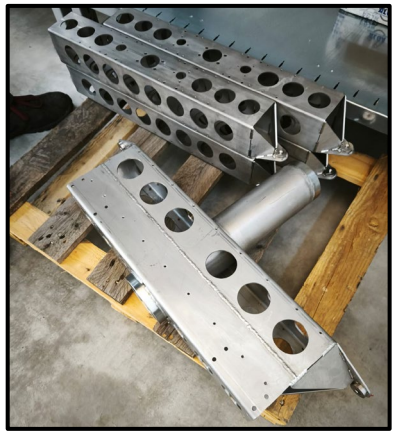
EE F1 Crossbar





Centering system test @ INFN-PI

Filter Bodies



BS Crossbar

Credit:
Leonardo Lucchesi
Alessandro Casella

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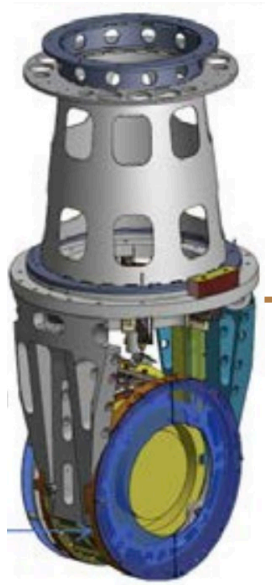
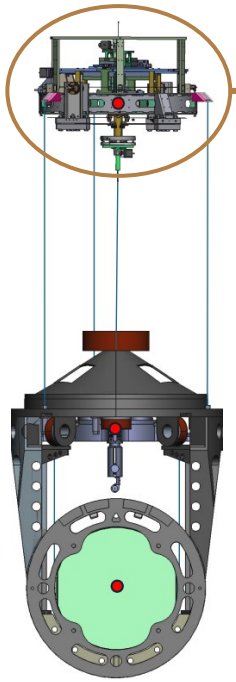
CAOS: Infrastructure Vacuum SuperAttenuators *Payload & Monolytic Susp.* DAQ Environment

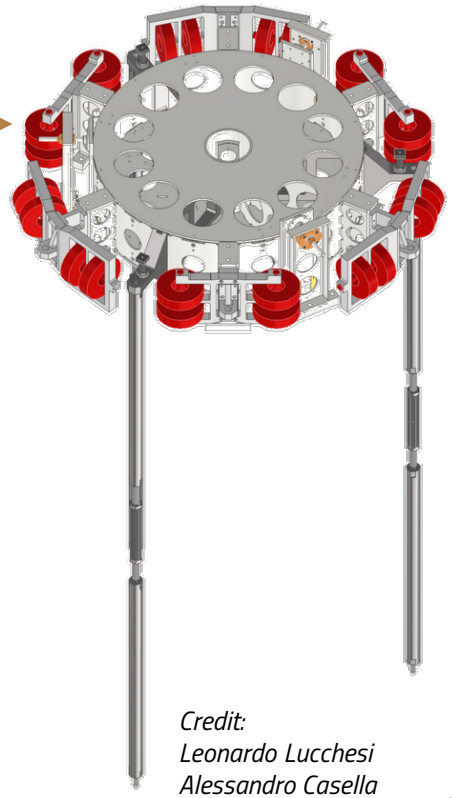
The payload design is based on the AdV Phase 2 Large Masses one designed by INFN-RM1 and University *La Sapienza*. A different suspension system is under design. Thanks to the extensive experience of the Perugia group, the mirrors will be suspended using 0.7m and then 0.9m fibers.

Advanced Virgo



CAOS

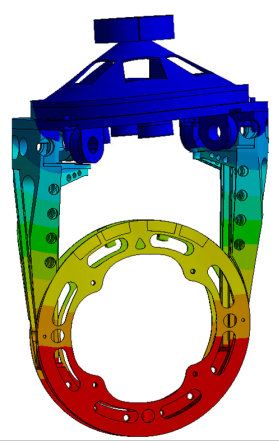




Ref. Advanced Virgo Plus Phase II - Technical design report

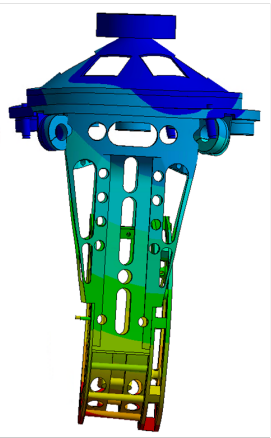
Credit:
Leonardo Lucchesi
Alessandro Casella

Mode 1



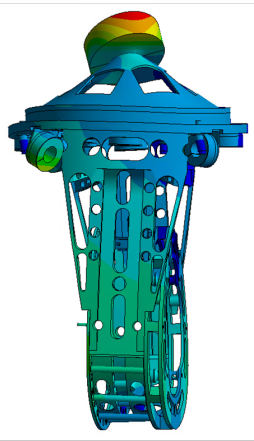
63 Hz

Mode 2



78 Hz

Mode 3



88 Hz

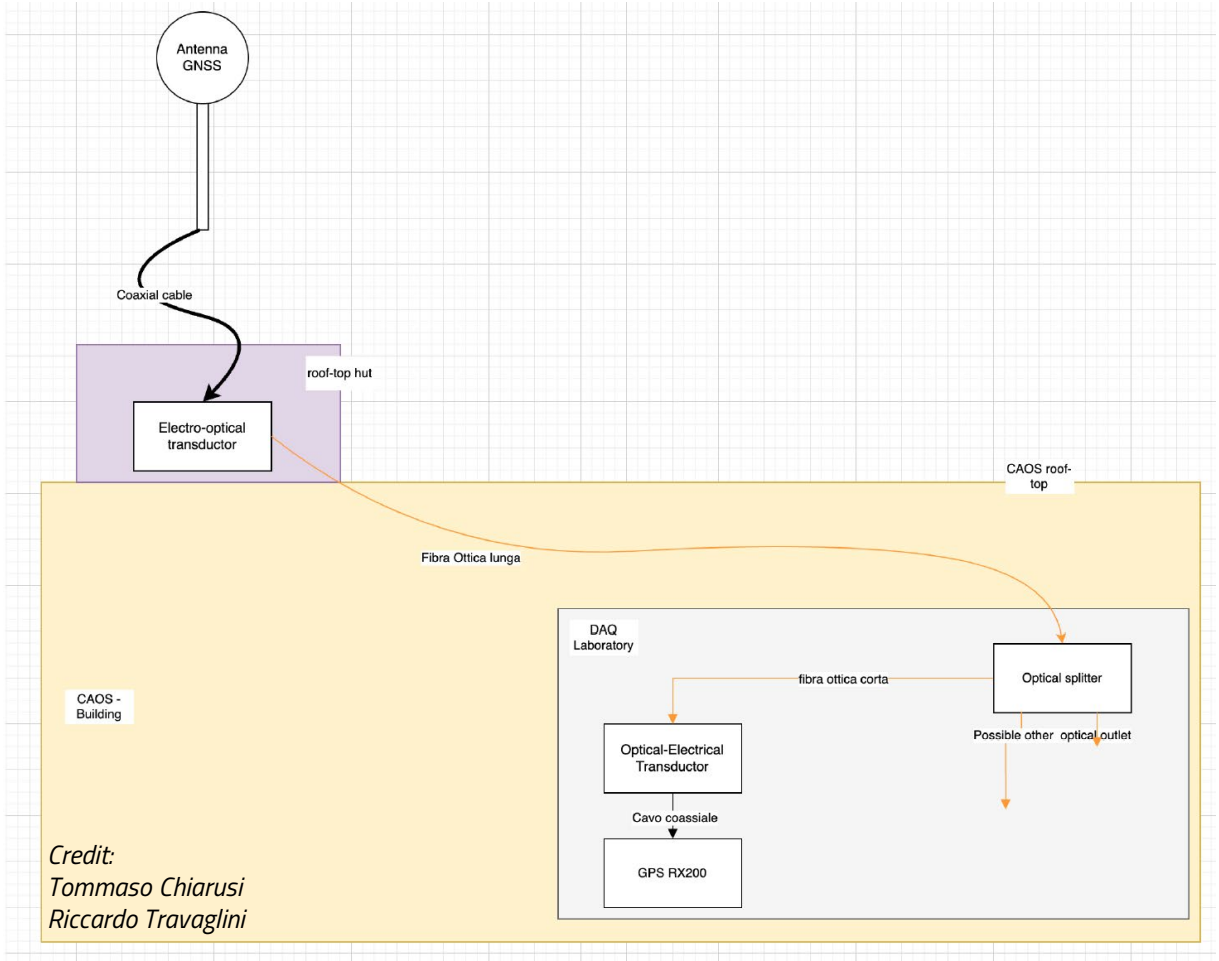
Please look at *Nicolò Baldicchi's* talk [ET-0181A-24] for more details.

Please look at *Piero Chessa's* poster [ET-0250A-25] for more details.

CAOS: Infrastructure Vacuum SuperAttenuators Payload & Monolytic Susp. *DAQ* Environment

Activities focused mainly on the instrumentation that defines and regulates the timing of the equipment. The goal is to:

- Implement a local network which harmonises a **White Rabbit part together with a standard network infrastructure;**
- Implement the **WR PTP Core block** of the White Rabbit firmware and embedded software (OHWR project), **on FPGA** that are used for DAQ boards;
- **Calibrating the WR devices;**
- Updating the driver and the firmware for the SPEC board, to get a WR carrier board pluggable via PCIe on standard device;

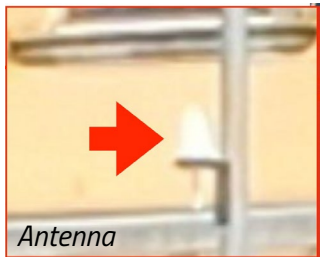


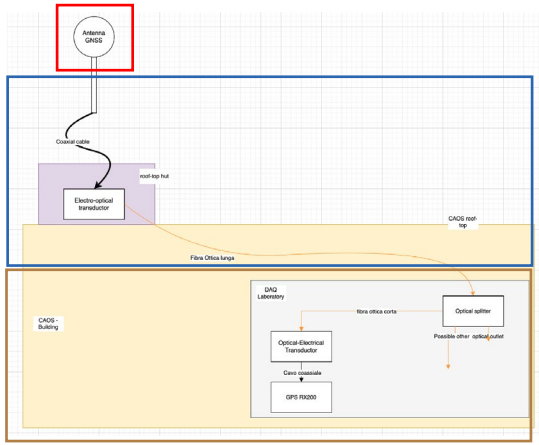
Note: The department of electronic engineering of Perugia is joining the CAOS community;

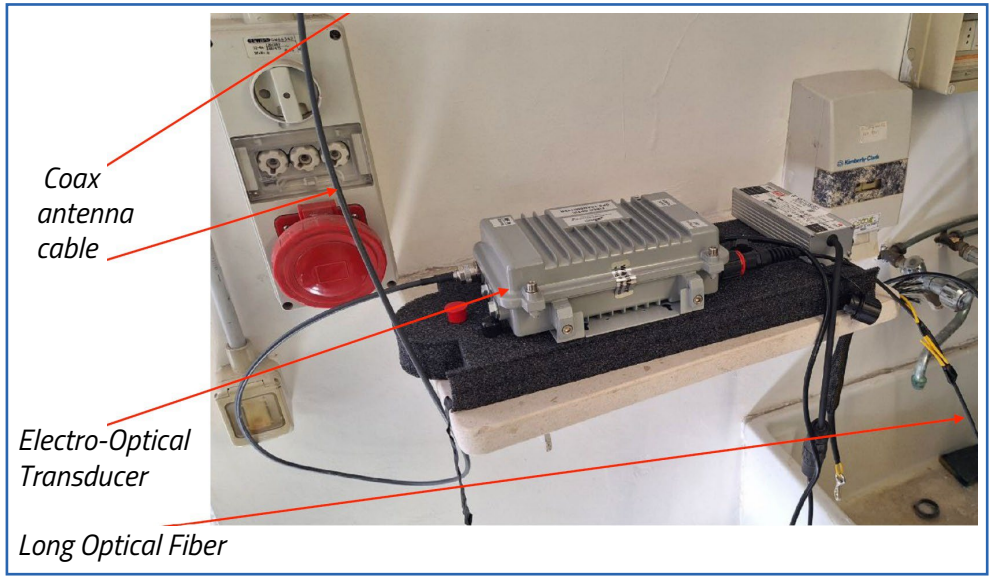
CAOS: Infrastructure Vacuum SuperAttenuators Payload & Monolytic Susp. DAQ Environment

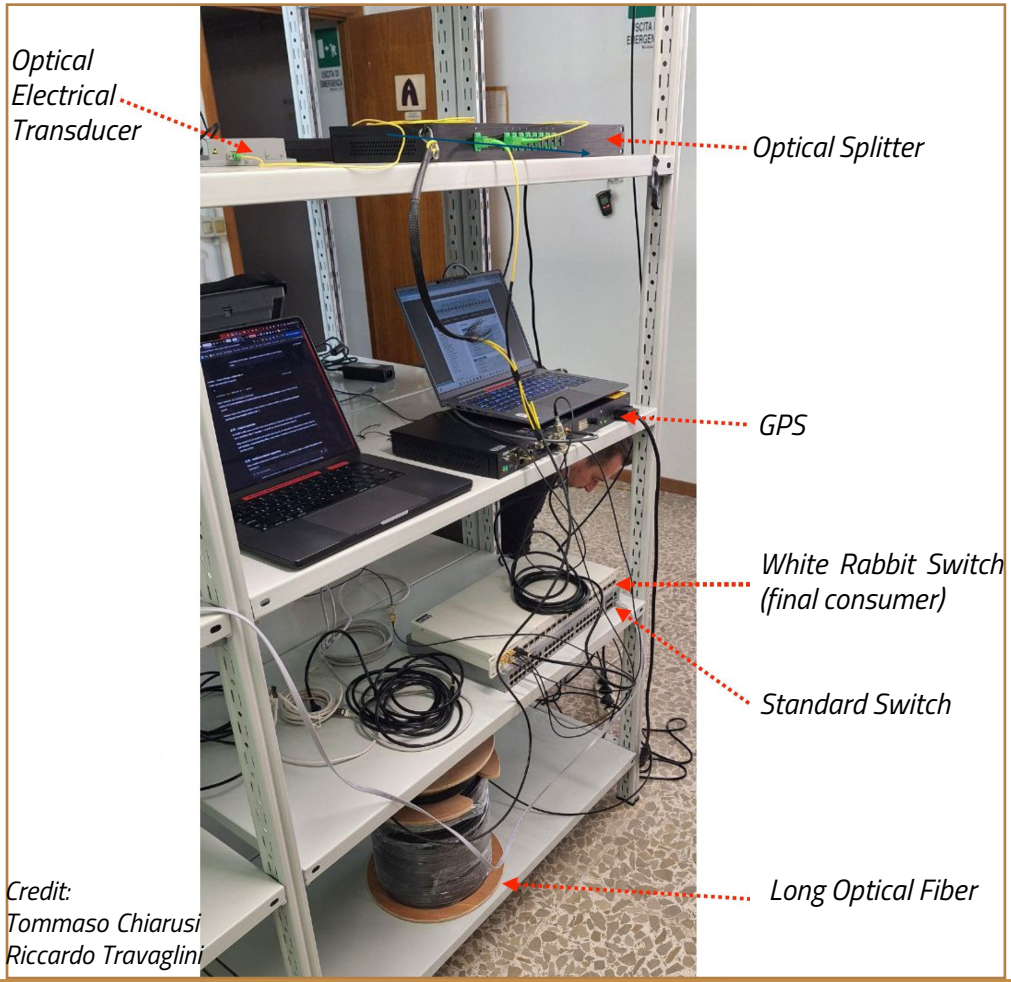
A first test of the equipment was conducted and the results were good:

- **GPS fully operational** (>6 satellites exploited, internal oscillator properly functioning, stable and latched PPS and 10 MHz correctly generated);
- **Antenna, harnesses, fibres and transducer healthy and fully operational;**
- **White Rabbit switch properly synchronised** to the date and time provided by the GPS.



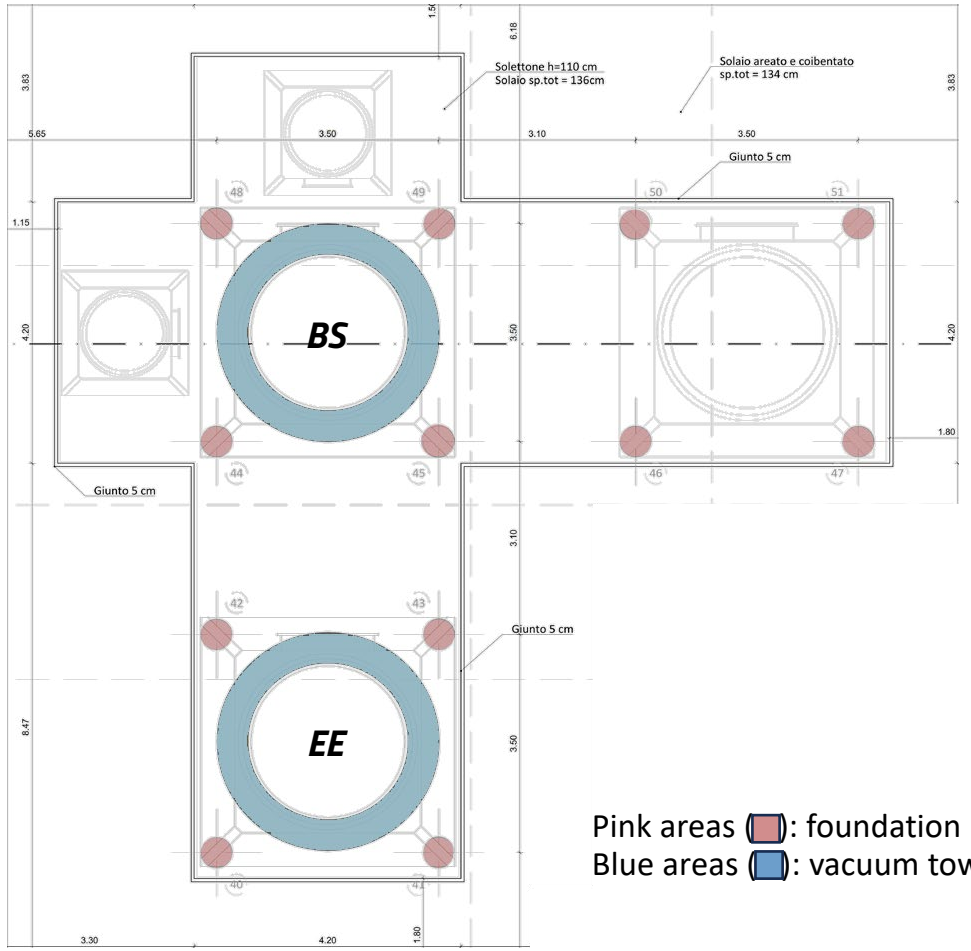


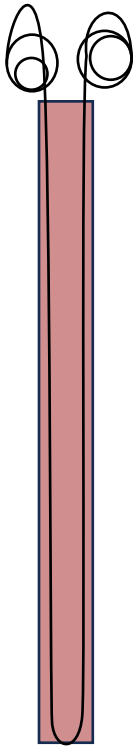




CAOS: Infrastructure Vacuum SuperAttenuators Payload & Monolytic Susp. DAQ *Environment*

The boreholes in the interferometer area were instrumented with **optical fibres.**



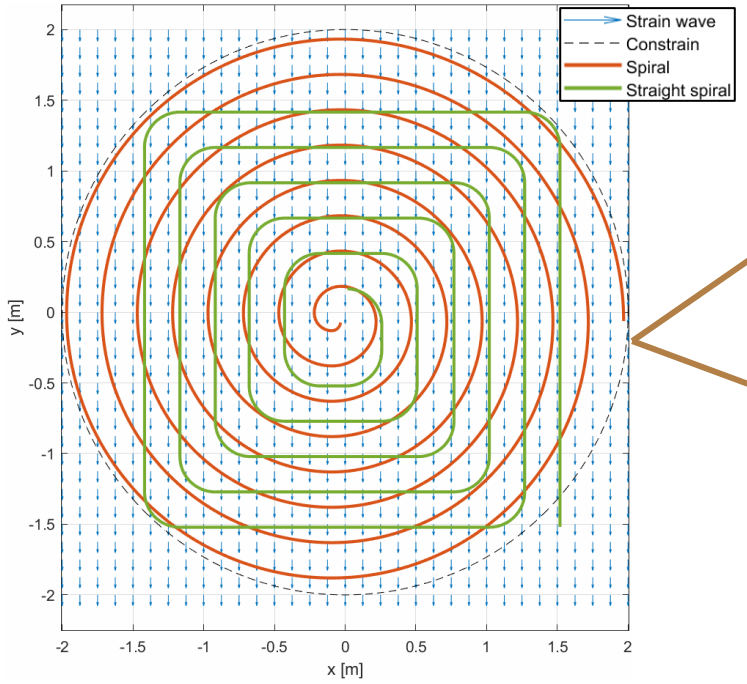


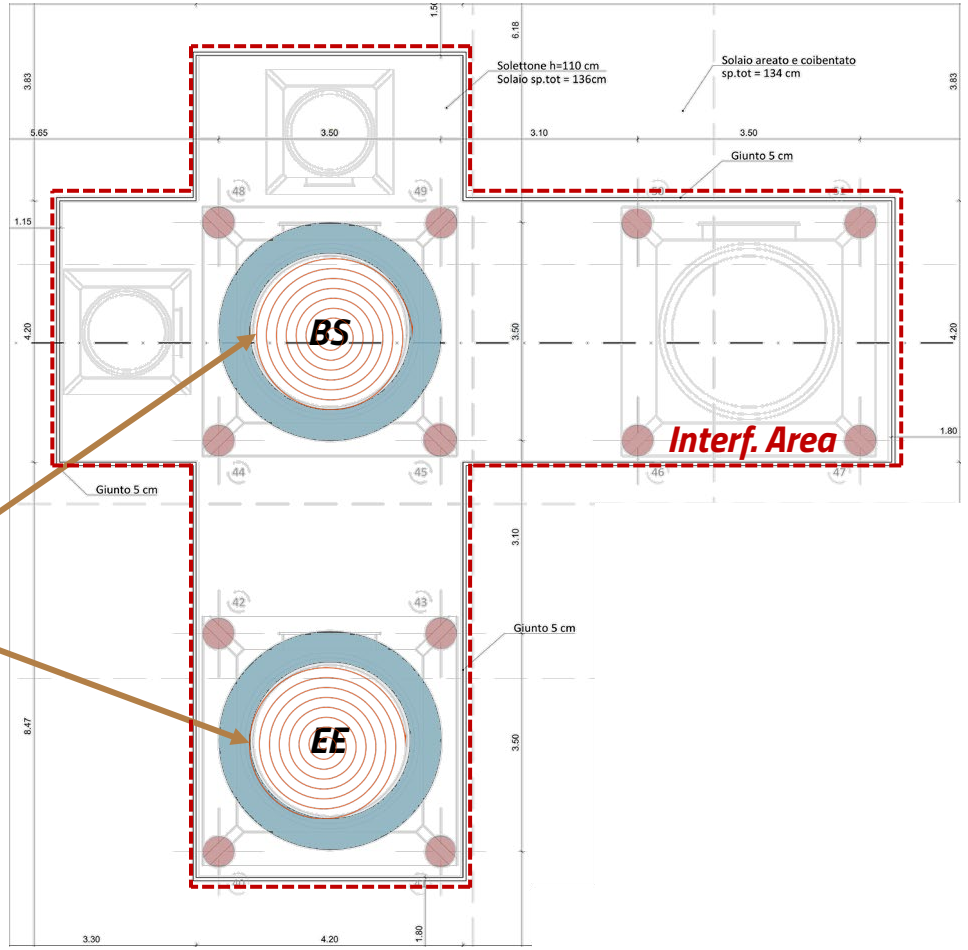
Pink areas (▭): foundation poles with fibers
Blue areas (▭): vacuum tower footprints

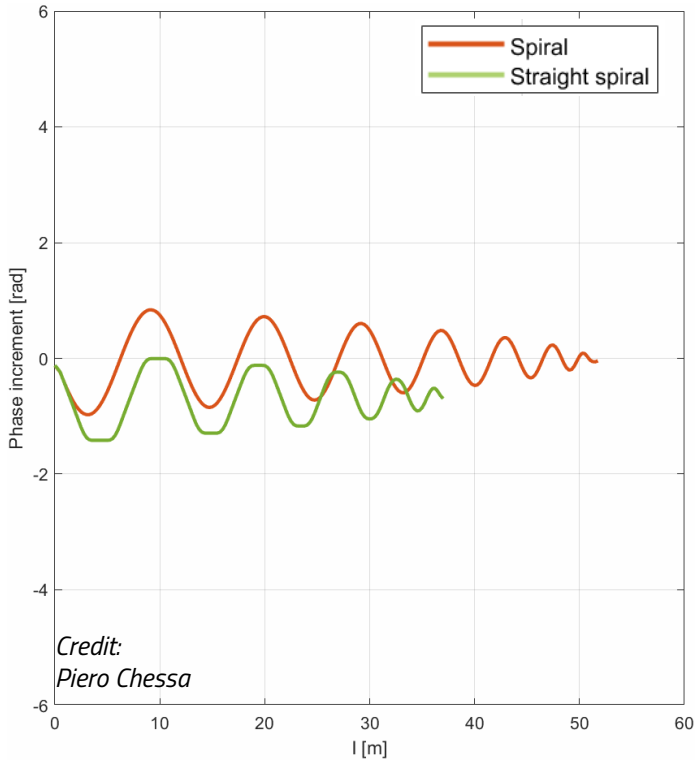
CAOS: Infrastructure Vacuum SuperAttenuators Payload & Monolytic Susp. DAQ *Environment*

Optical Fibers will be laid on the floor of the interferometer area over the next few weeks, before the bases tower are installed.

The DAS interrogator and the appropriate equipment are currently being purchased.







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Conclusion

- Work on the infrastructure is progressing and will soon be completed;
- Thanks to every division efforts, activities are maturing in every work package of the project;
- CAOS aims to be a technological training ground looking towards the third generation of gravitational wave interferometers:
  - ❖ A place where researchers, technicians, ideas, and collaborations can grow **together**.

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Thank You!