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Italiadomani  
PIANO NAZIONALE  
DI RIPRESA E RESILIENZA



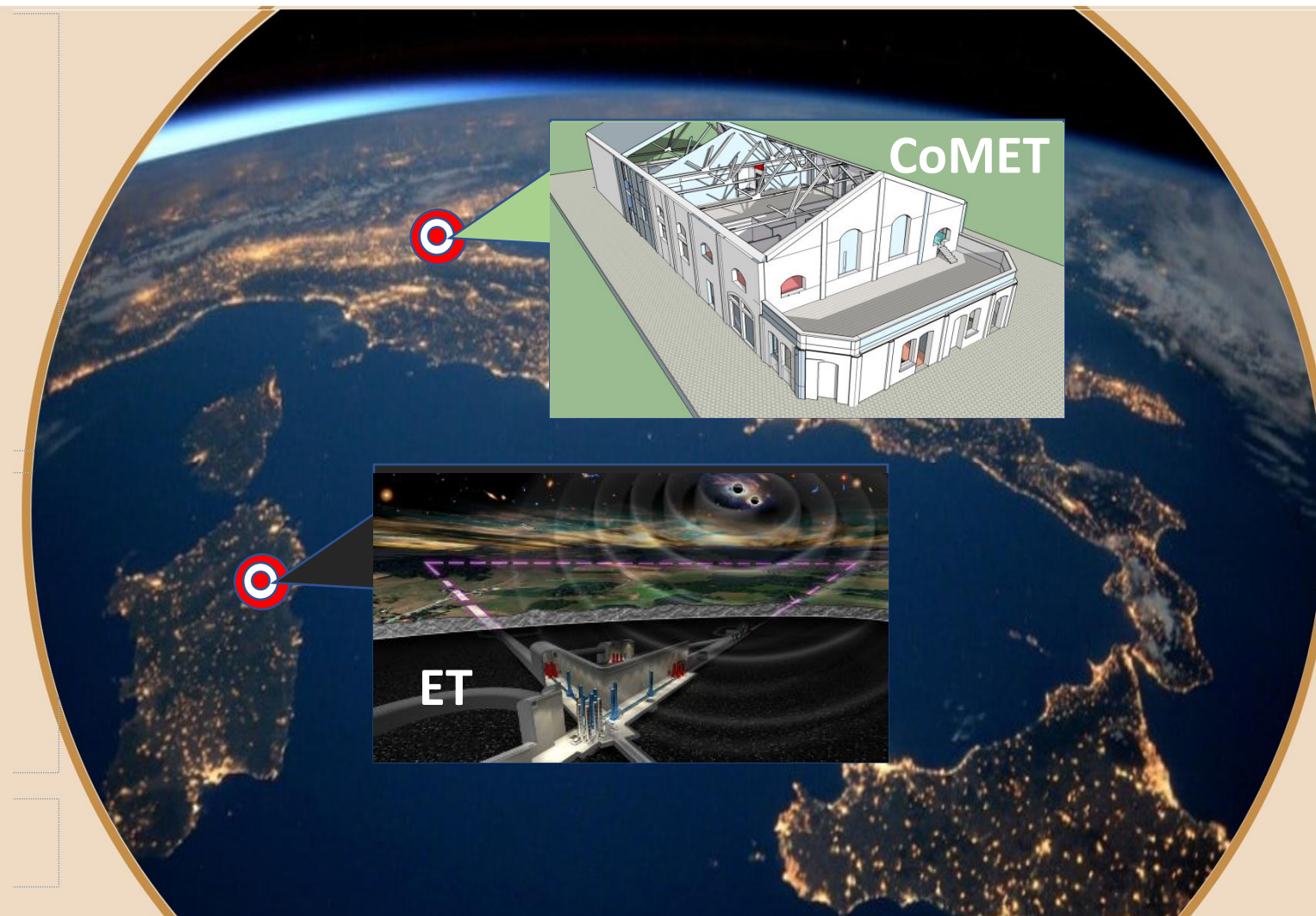
# Current status and goals of CoMET

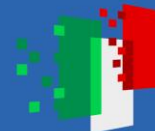
Marco Bazzan  
Giacomo Ciani



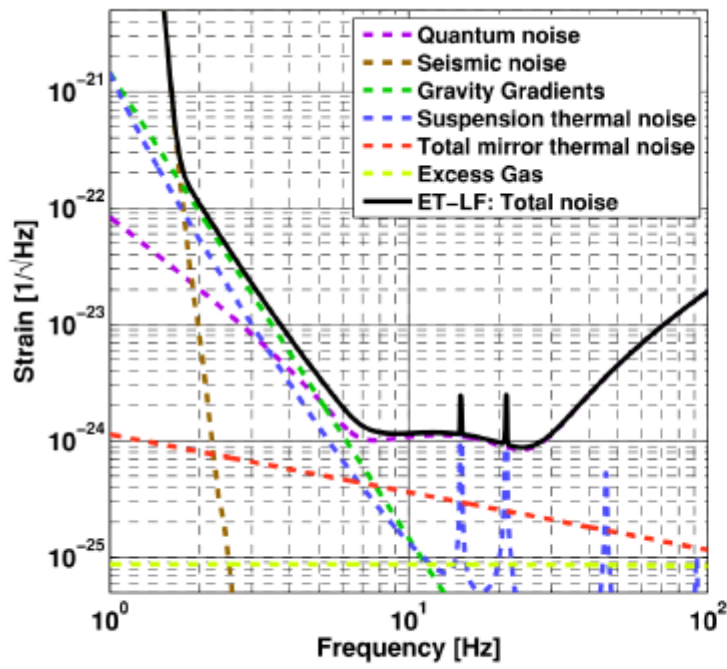
UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA

ET-Symposium Cagliari 10/05/2023

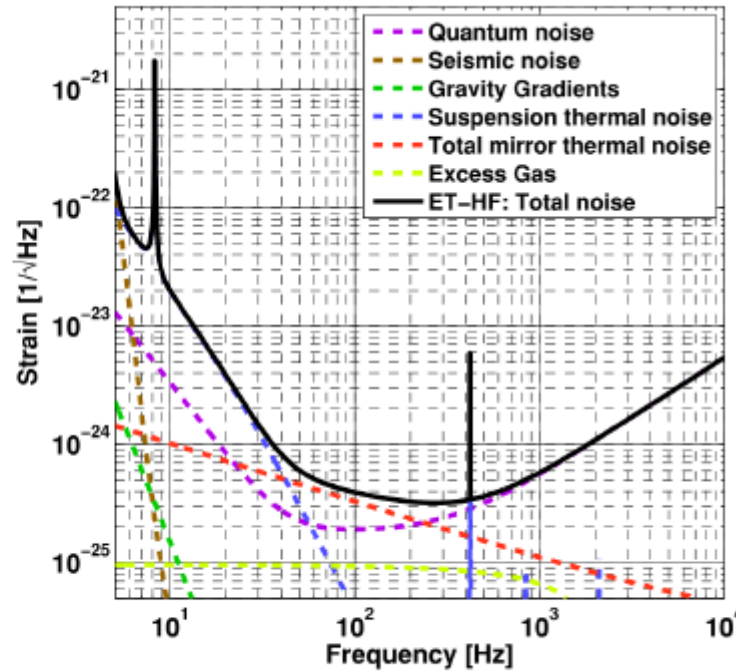




## Coating Thermal Noise in ET



(a) ET-LF



(b) ET-HF

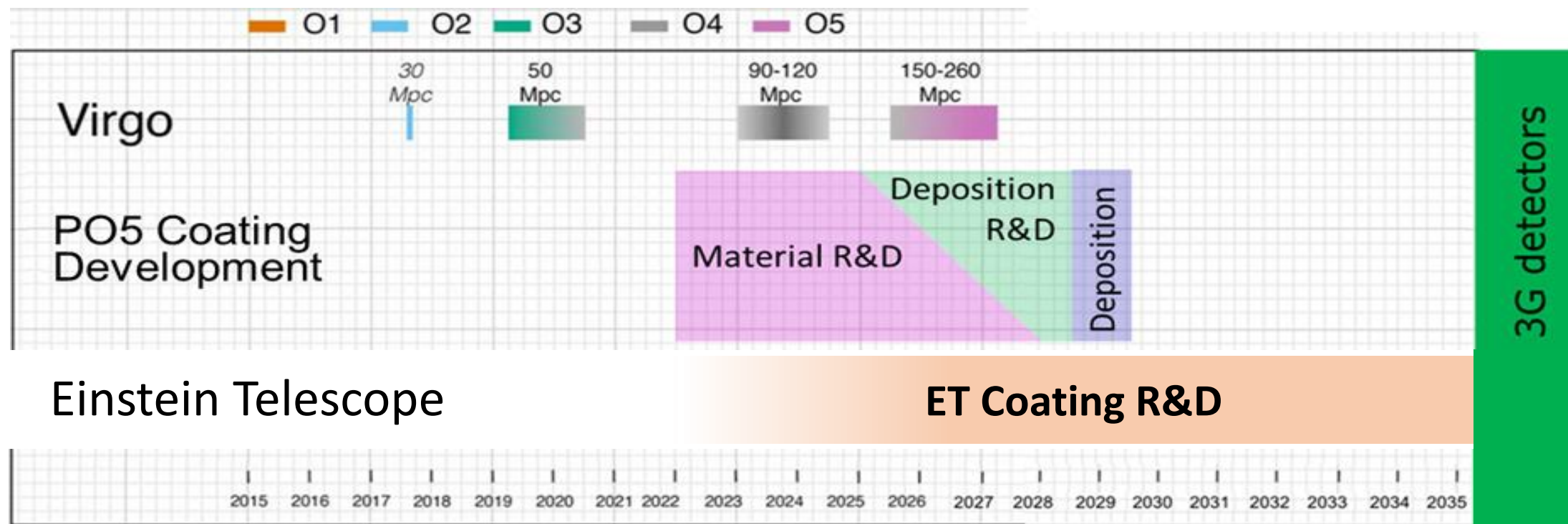
- Mirror thermal noise and quantum noise are the limiting factor in the ET middle frequency range.
- For ET, new and poorly known aspects:
  - different wavelengths
  - operation in cryogenic conditions
  - new substrates

**Coating research is mandatory!**

S. Hild et al., "Sensitivity studies for third-generation gravitational wave observatories", DOI:10.1088/0264-9381/28/9/094013

## Coating roadmap: towards ET

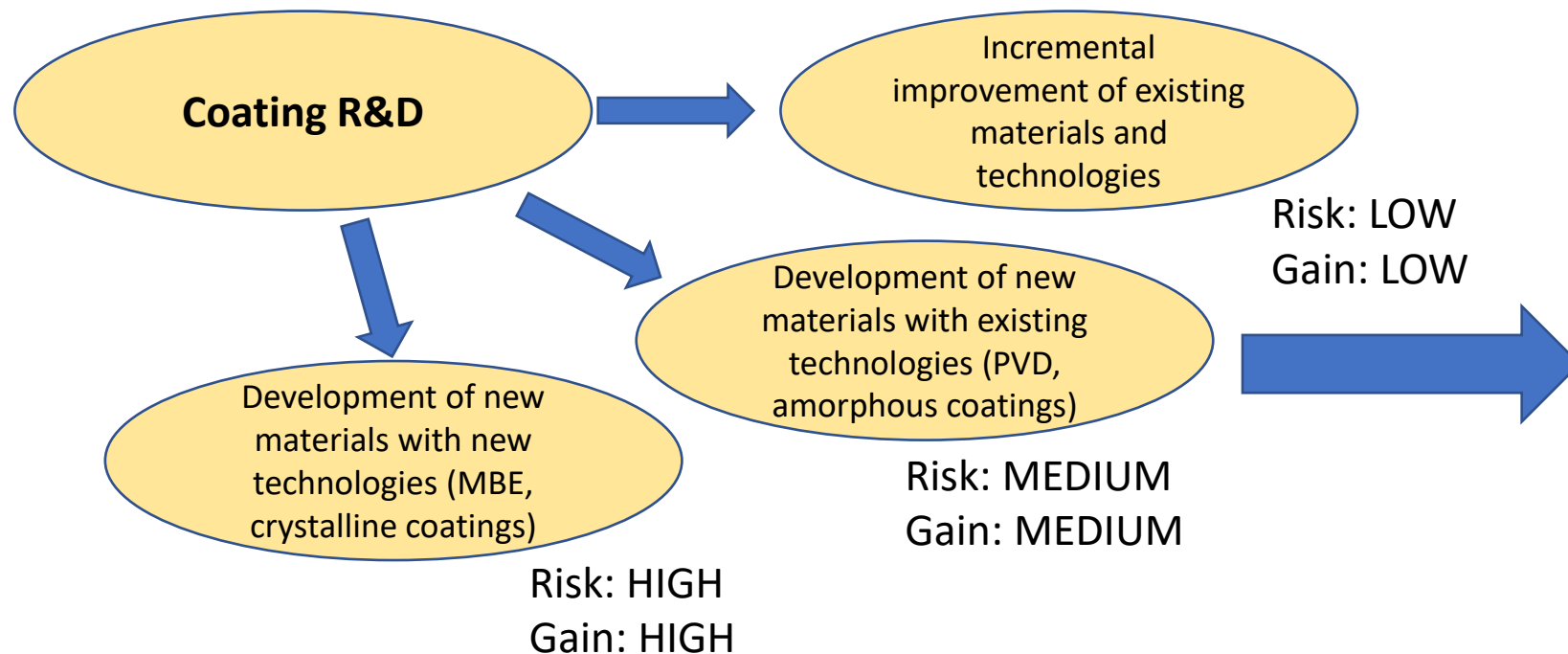
### The Virgo Post-O5 scenario



- A large research effort is scheduled in Virgo for the next years.
- This will also pave the way to ET coating research.



## A long list of materials to be investigated



A large coordinated effort not only to test, but to perform a **fundamental investigation of structure-property relations**

Many research efforts in the GW community, but limited number of facilities able to produce high quality samples to explore new ideas

- Mixed Oxides
  - Zr:Ta<sub>2</sub>O<sub>5</sub>
  - Hf:Ta<sub>2</sub>O<sub>5</sub>
  - Ti:GeO<sub>2</sub>
  - Ti:SiO<sub>2</sub>
  - Ternary Oxides
  - ...
- Mixed Nitrides
  - SiN<sub>x</sub>
  - GaN<sub>x</sub>
  - Ternary Nitrides
  - ...
- Amorphous Semiconductors
  - a-Si
  - GaP
  - ...
- **Etc. Etc. Etc.**



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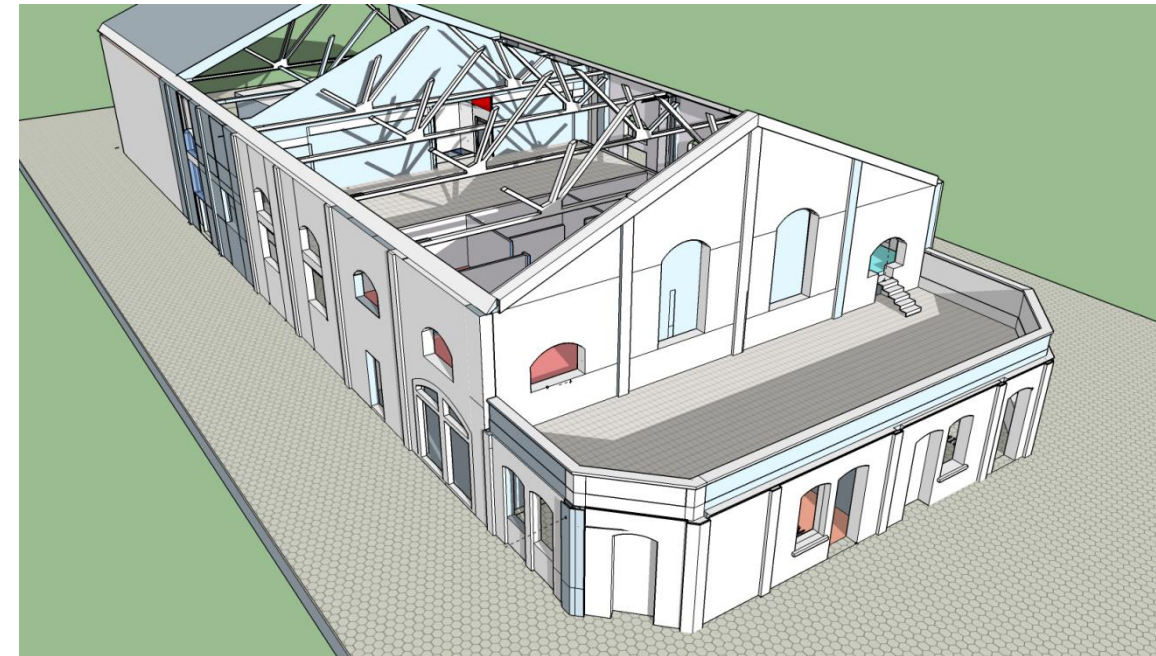
## The CoMET laboratory

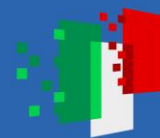
### A source of GW-quality research samples

**CoMET = Coating Materials for Einstein Telescope**

**Mission:** Production of high-quality research samples with highly controlled conditions to enable the study of new amorphous coating materials.

- Facility funded by ETIC
- Managed by the **Padova INFN section** and **University of Padova** (Co-Participant)
- Initial budget: 6.5 M€, lately cut down to ~3 M€
- Additional UniPD in-kind contribution: ~500 k€ (building renovation)
- **Possibility of attracting additional local fundings**

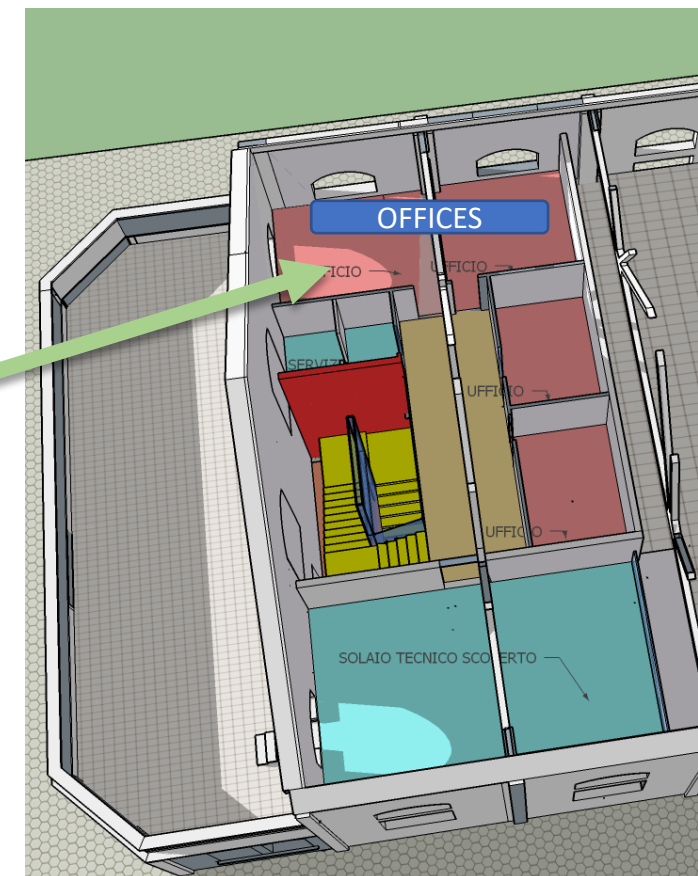
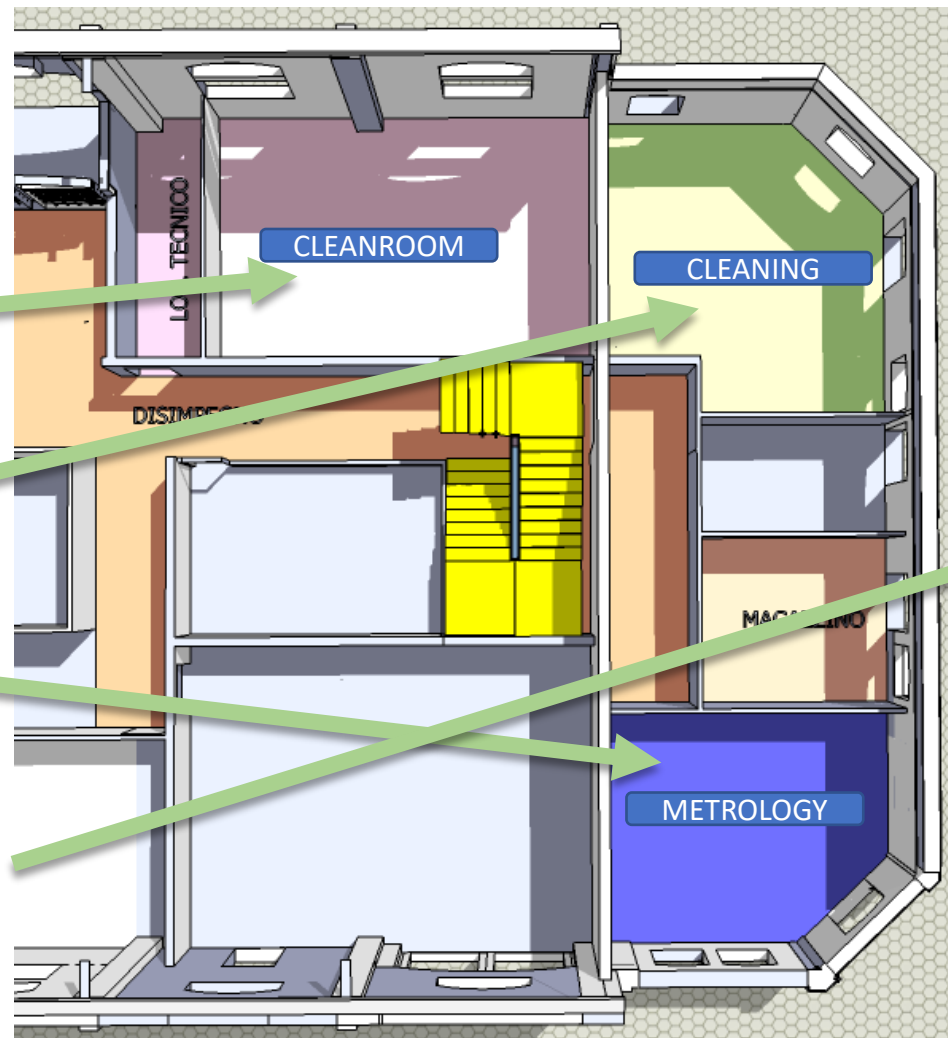




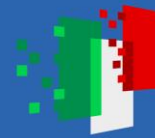
## CoMET's goals

CoMET is designed to:

- Deposit **different materials** with **various technologies** (up to 4 deposition machines)
- Keep **tight control of cross-contaminations**.
- **Supply each produced sample with a «characterization chart»** where all meaningful parameters will be routinely measured.
- Be open to **collaboration and proposals**: guest scientist will be encouraged to request sample production and/or visit for direct access to the equipments







## Initial Deposition facilities

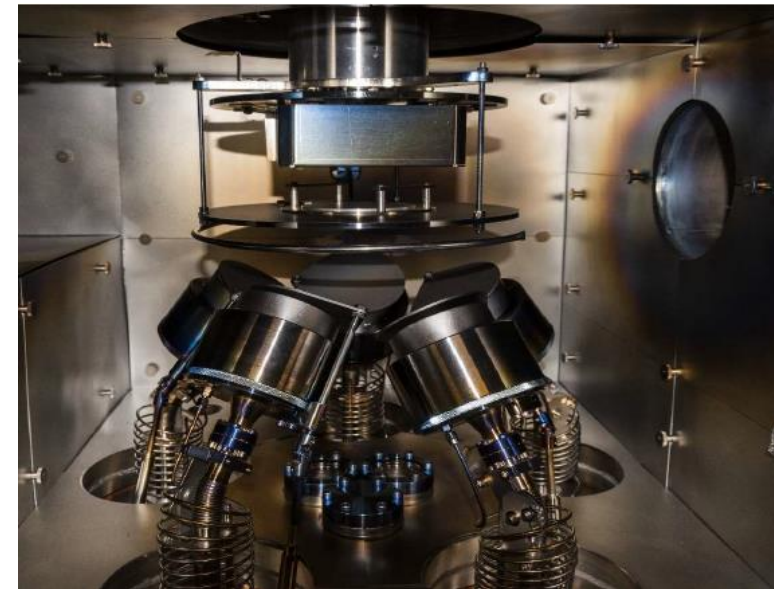


### Custom Ion Beam Sputtering

- Multimaterial deposition with compositional control up to 3 different metals
- Substrate Rotation/Heat/Bias
- In-situ diagnostics
  - ✓ Plasma mass spectrometer
  - ✓ Ellipsometer
  - ✓ Stress monitor
  - ✓ Gas analyzer
- Assistance ion source
- High vacuum ( $< 1 \times 10^{-7}$  mbar)
- multiple assistance and reactive, high purity gas lines

### Goals:

- Capability to deposit virtually all the (amorphous) materials of interest for the GW community with the needed level of control.
- Ability to explore different process ranges (energies, growth kinetics etc.)
- Study of the physical processes occurring during deposition



### Magnetron Sputtering

- 2 DC and 2 RF torches for co-deposition
- Substrate Rotation/Heat/Bias
- Optical In-situ diagnostics (both plasma and sample)
- Assistance ion source
- High vacuum ( $< 1 \times 10^{-7}$  mbar)
- multiple assistance and reactive, high purity gas lines



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## Characterization facilities

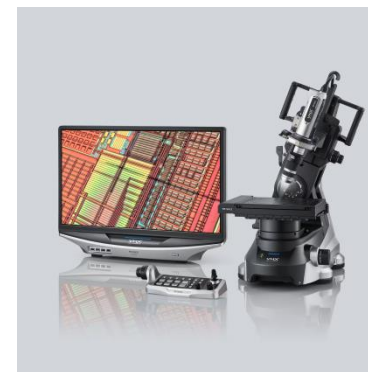
Sample «characterization chart»:

- Optical properties (refractive index, absorption...)
- Surface topography
- Surface and interface roughness
- Thickness
- Crystallization status
- Optical defects (bubbles, scattering centers...)
- Scattering losses

Some equipment are available in nearby labs, and will be eventually integrated into CoMET



AFM



Digital microscope



Ellipsometer



Integrating sphere



SEM



XRD/XRR





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## Auxiliary facilities



Washing machine for  
deposition chamber screens



Sand-blasting  
machine

Deposition chambers maintenance and cleaning

## Sample processing and preparation



Annealing oven



Ion-milling



Lapping machine

## The Padova thin film science ecosystem

CoMET will be located in a favorable environment, benefitting from the interaction with local high-class infrastructures and know-how.



- Solid-state physics
- SIMS
- Raman
- FTIR
- AFM
- RTA
- Laser annealing
- UV-Vis spectroscopy
- XPS
- NMR
- Chemical labs



- Ellipsometry

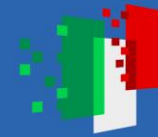


INFN Legnaro National Laboratories



- Reflectometry

- AN 2000 2MeV accelerator for Ion Beam Analysis



## CoMET Timeline

	2023						2024						2025		
Building							M1								
Lab/Cleanroom										M2					
Equipments															M3
Furnitures										M4					
Personnel															

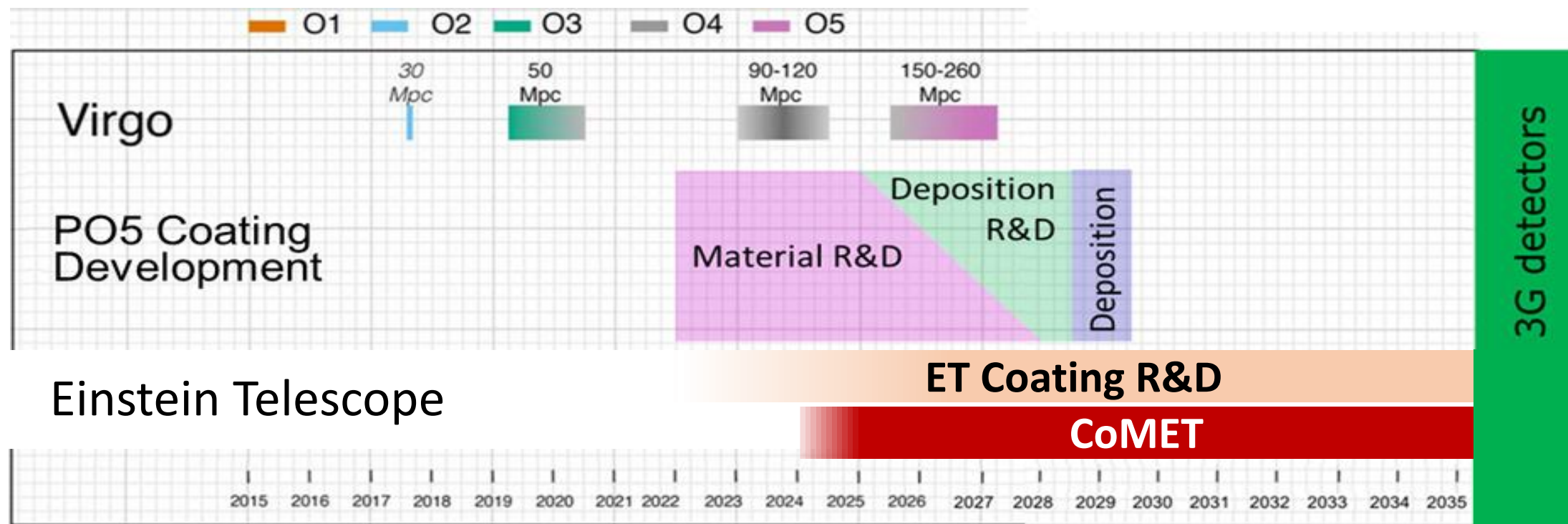
1. Building renovation completed, including plants (HVAC, cooling fluids, electric, technical gases...)
2. Cleanroom and laboratory environment completed
3. Deposition equipments installed and tested
4. Laboratory and office furnitures installed

### Personnel:

- 1 researcher RTDa) + 2 technologists during ETIC project
- **1 dedicated technologist (UniPD) for the laboratory lifespan**



## CoMET and Coating roadmap



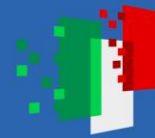
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# Pick your favorite coating recipe!

