

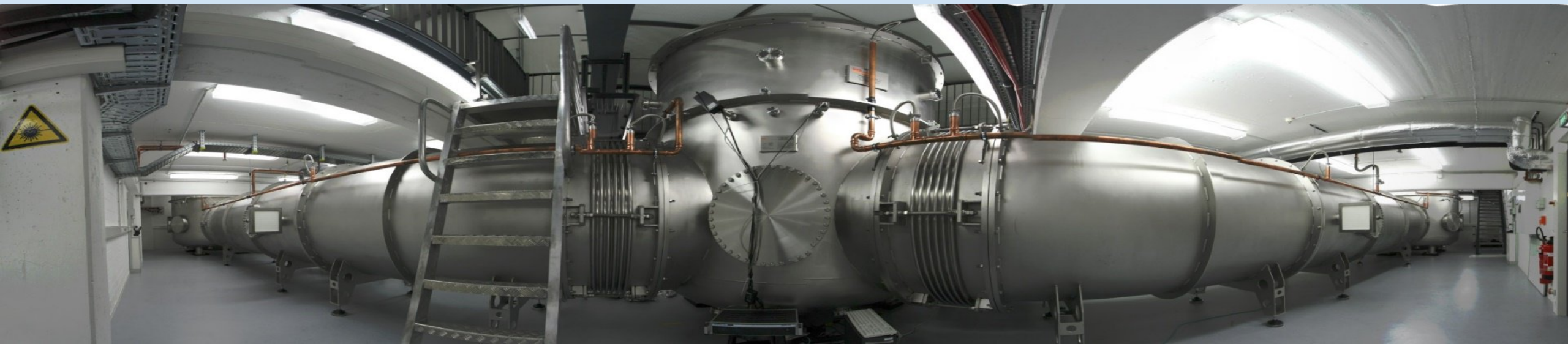


# The AEI 10 m Prototype Facility

David Wu (on behalf of the AEI 10 m Prototype team)

Leibniz Universität Hannover  
Albert Einstein Institute, Hannover, Germany

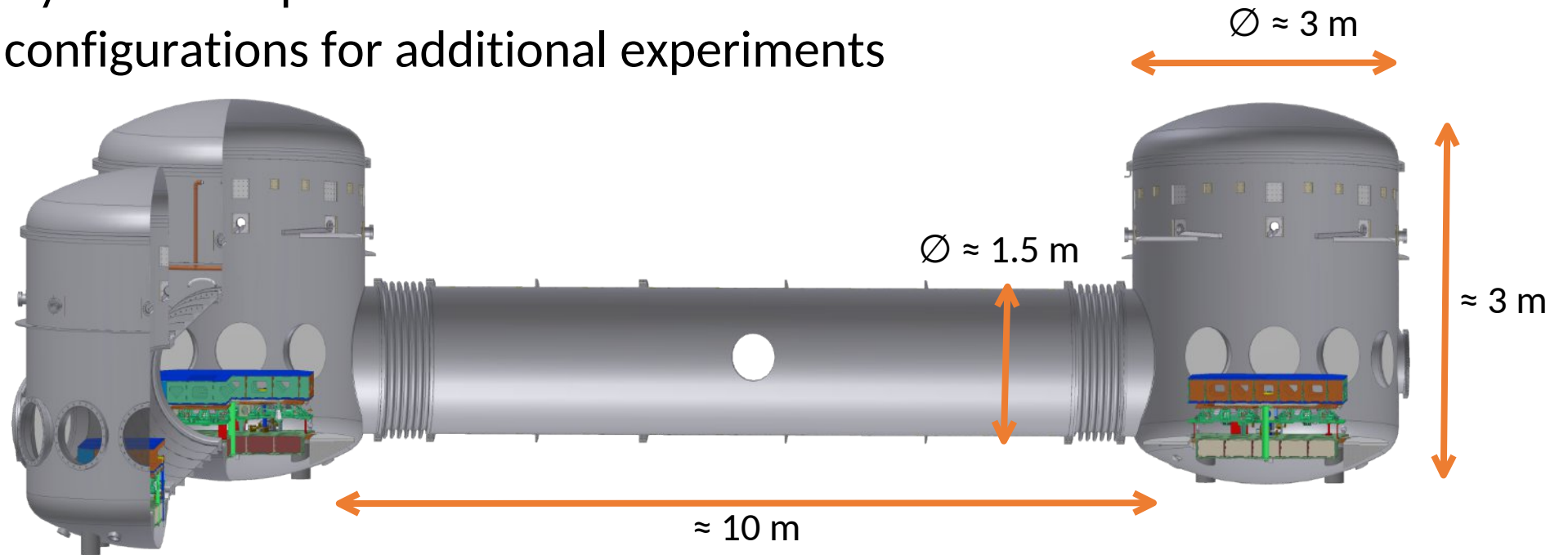
XIII ET Symposium, Cagliari, Italy  
08.05.2023  
ET-0156A-23/LIGO-G2300939





# AEI 10 m Prototype

- Provide a prototyping facility closely resembling a gravitational wave detector to study methods to overcome the standard quantum limit (SQL)
  - Volume:  $100\text{m}^3$
  - High vacuum:  $O(10^{-7})$  mbar
  - Seismically isolated optical tables
  - Flexible configurations for additional experiments

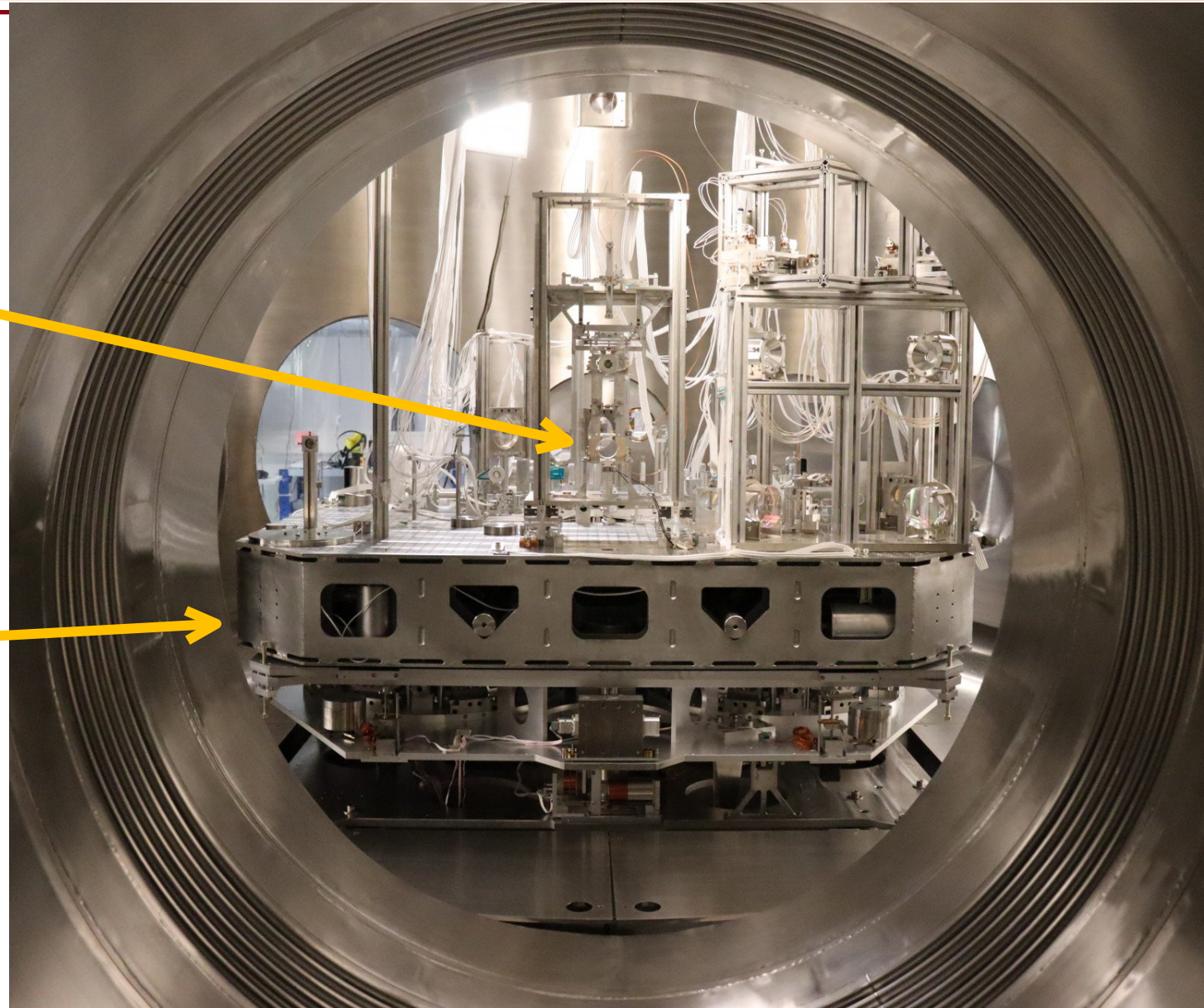




# AEI 10 m Prototype

Suspended optics

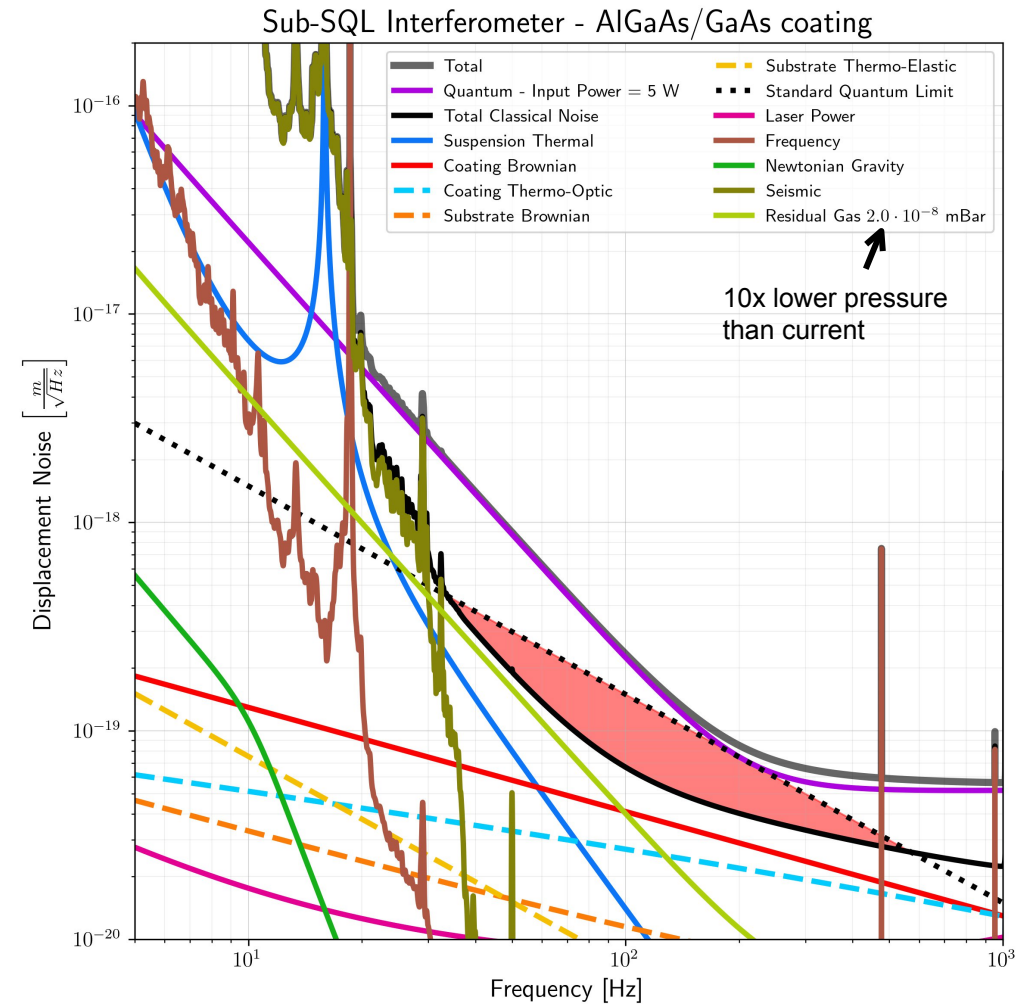
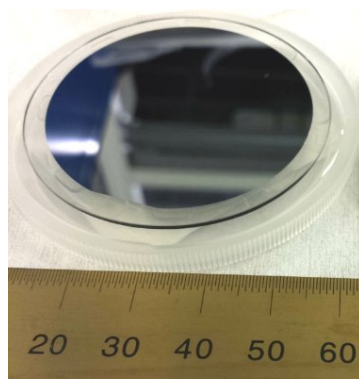
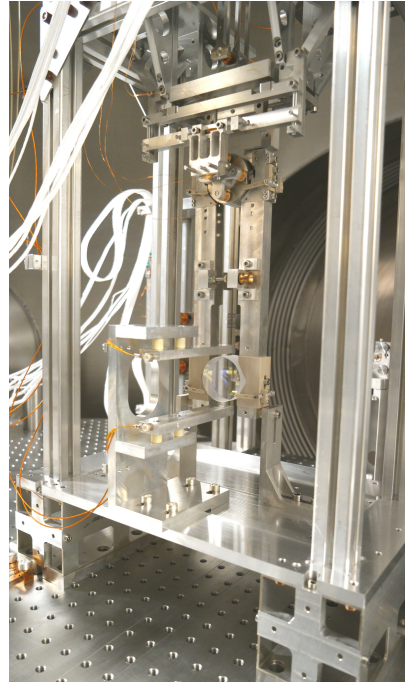
AEI-SAS





# The Sub-SQL Interferometer

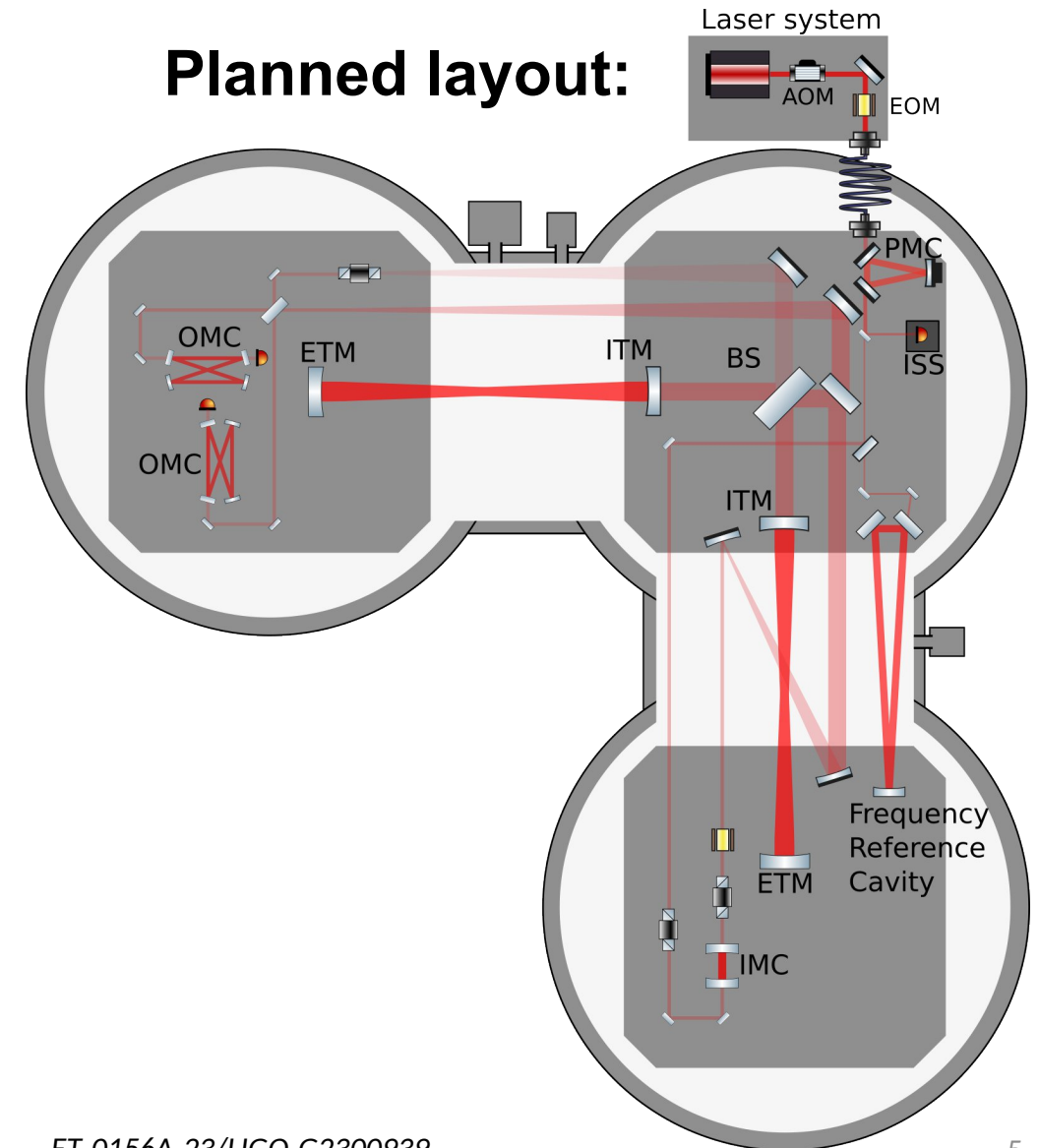
- Fabry-Perot Michelson, 1064 nm
- Aiming to be limited by the SQL between approx. 50 and 500 Hz
- Small 100 g test masses to enhance the SQL
- Dominant classical noise sources:
  - Residual gas (damping)
    - 10x lower pressure needed
  - Coating thermal noise
    - Crystalline coatings (AlGaAs/GaAs)





# Current Status

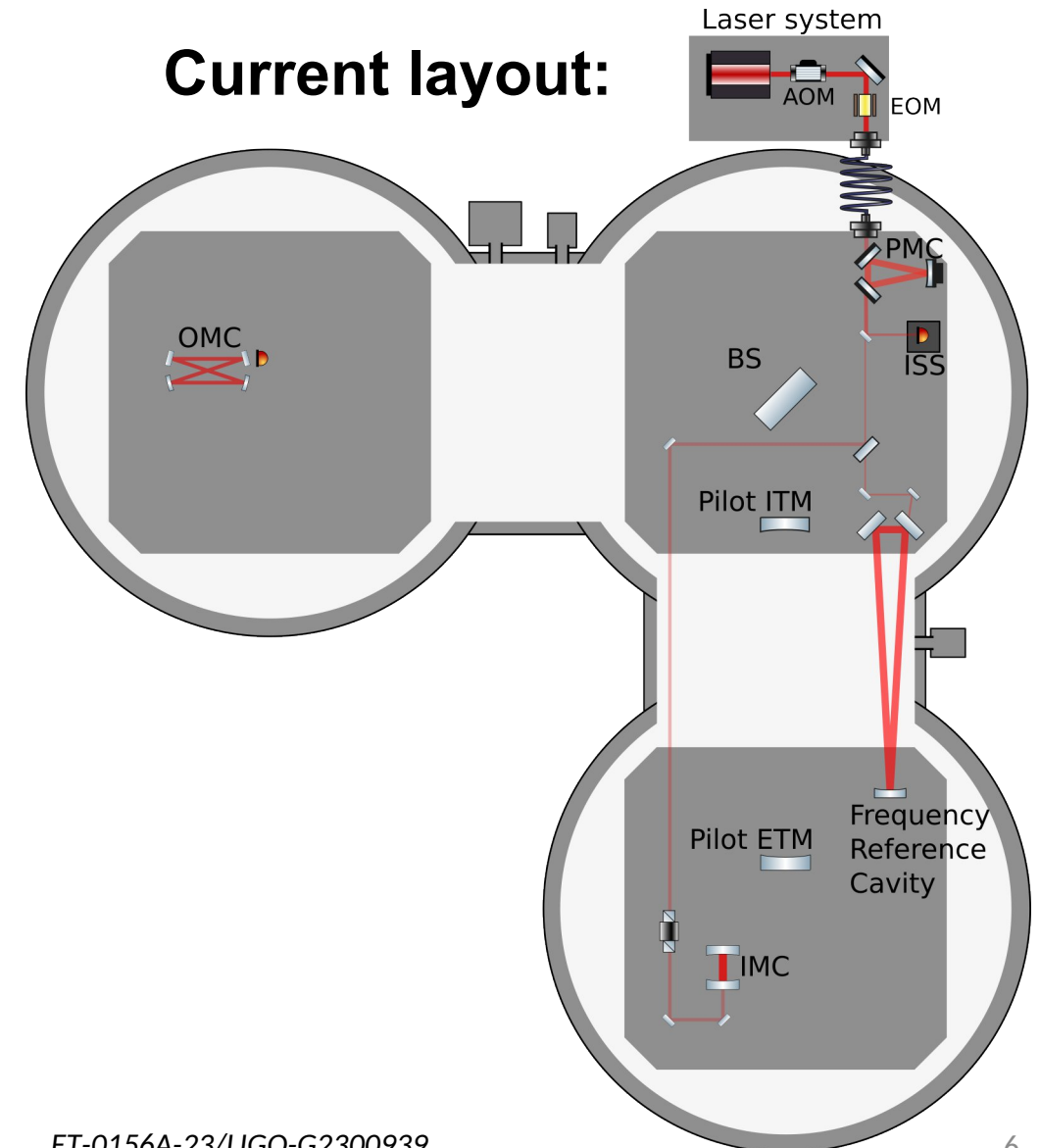
- Seismic Attenuation System (AEI-SAS)
  - Suspension platform interferometer (SPI)
  - Optical levers
- Pre-Stabilised Laser
  - Power stabilisation (aLIGO style PD array)
  - Frequency stabilisation (10 m suspended reference cavity)
- Beam splitter installed
- Output Mode Cleaner OMC #1





# Current Status

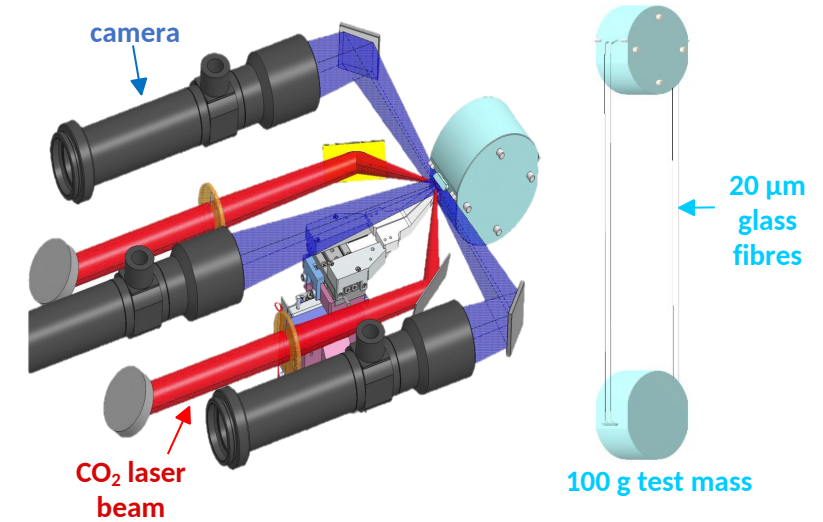
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# Welding Machine

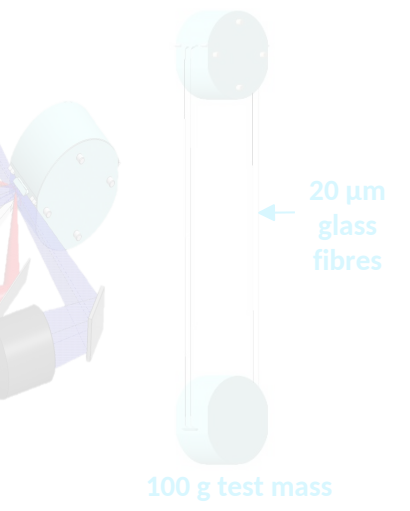
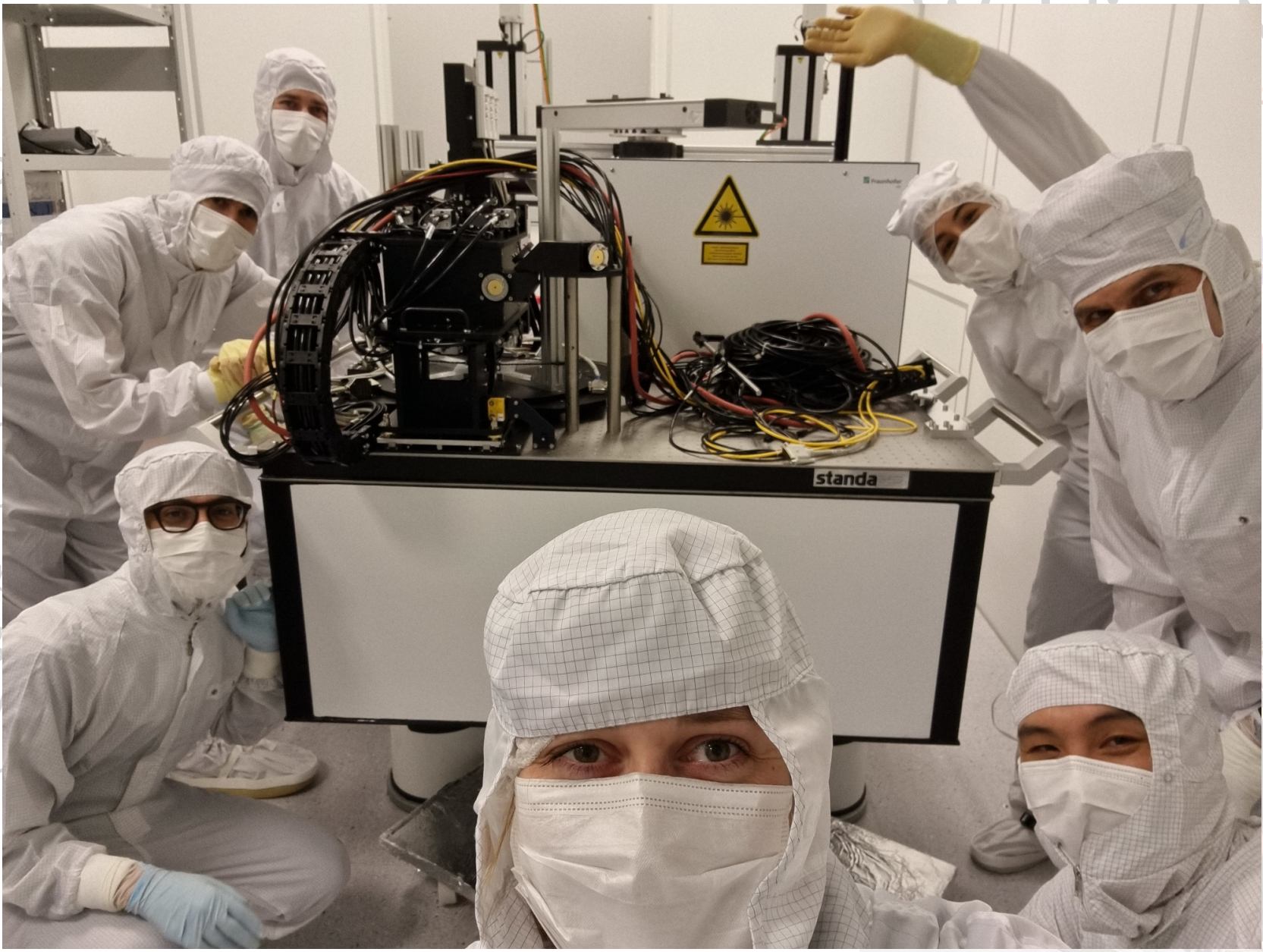
- 100 g suspensions will be quasi-monolithic fused silica for low thermal noise
- Laser welding used to attach fibres to masses
- Project with *Fraunhofer Institute for Applied Optics and Precision Engineering* to build a highly automated and accurate welding system
- Welding machine delivered in April 2023!





# Machine

- 100 g suspended silica
- Uni. Glasgow found that not straight
- Project with Applied Optics build a high welding system
- Welding machine

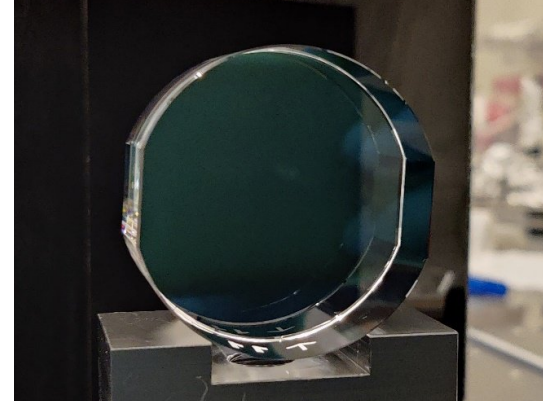




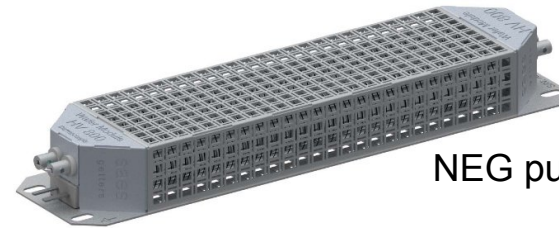


# Towards the Sub-SQL Interferometer

- Core optics
  - Prepare and install monolithic 100 g test mass mirrors
    - Start with IBS silica tantala coated optics
    - Currently acquiring substrates suitable for AlGaAs coating
- Balanced homodyne (BHD) readout
- Gas damping noise: need to improve vacuum
  - Testing non-evaporable getter (NEG) pumps
- Scattered light mitigation
  - Investigating materials for baffles (See Firoz Khan's poster)



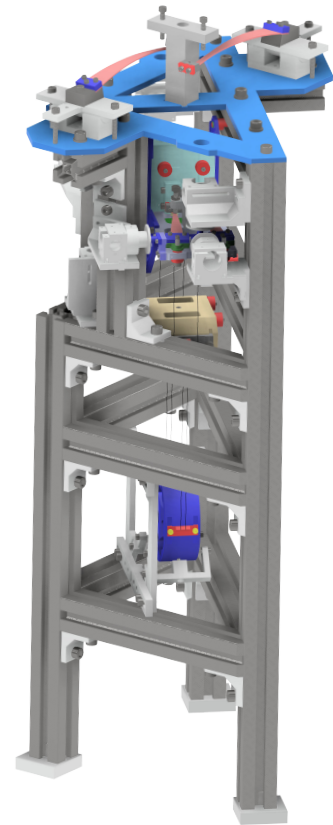
Pre-polished 100g substrate for AlGaAs coating



NEG pump



Diamond-like carbon (DLC) coated stainless steel sample

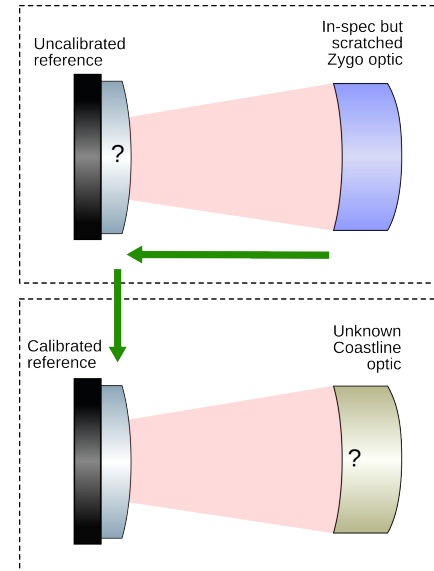
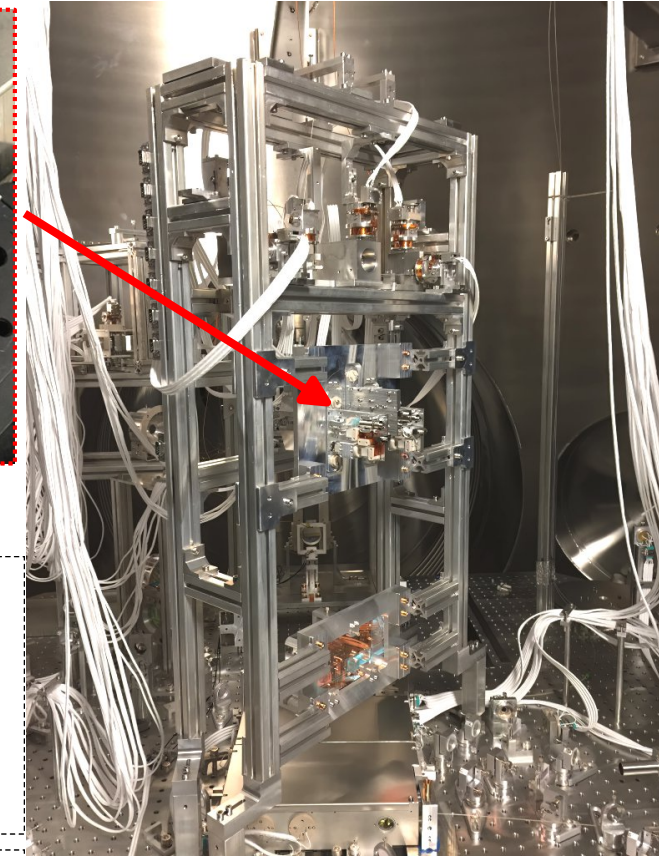
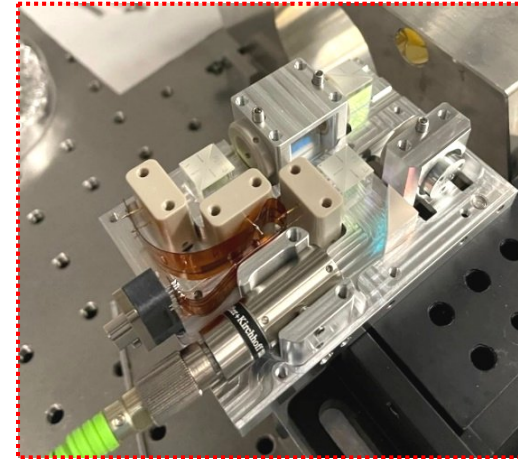


BHD local oscillator suspension based on LIGO HRTS design



# Other topics

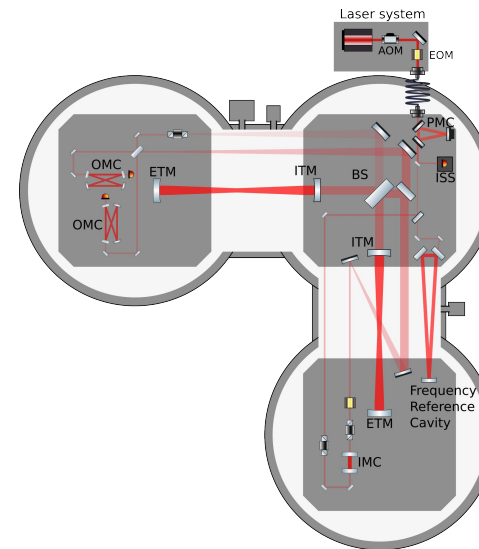
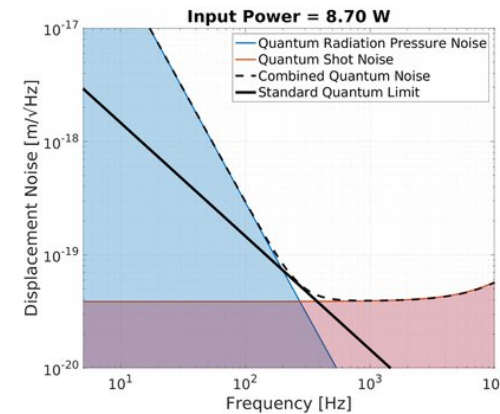
- Homodyne Quadrature Interferometers (HoQIs)
  - Installed on beam splitter to investigate performance with an actual interferometer
  - Collaboration with VU Amsterdam
- Digital Suspension Platform Interferometer
  - Digital interferometry SPI
  - Collaboration with Uni. Hamburg, Helmut Schmidt Hamburg, Stanford
- Optics
  - Computer generated holograms as reference spheres for precision optics





# Ideas for the Prototype?

- Very open to collaboration
  - Testing new technology or techniques for adoption in ET?
  - Sub-SQL techniques?





# The Team

- David Wu
- Harald Lück
- Johannes Lehmann
- Juliane von Wrangel
- Matteo Carlassara
- Firoz Khan (not pictured)
- Sara Al-Kershi
- Paul Hapke (not pictured)
- Joachim Kullmann (not pictured)

Recently left :-)

- *Philip Koch*
- *Janis Wöhler*

Check out our website:  
<https://10m.aei.mpg.de>

