# LISA
## The Instrument

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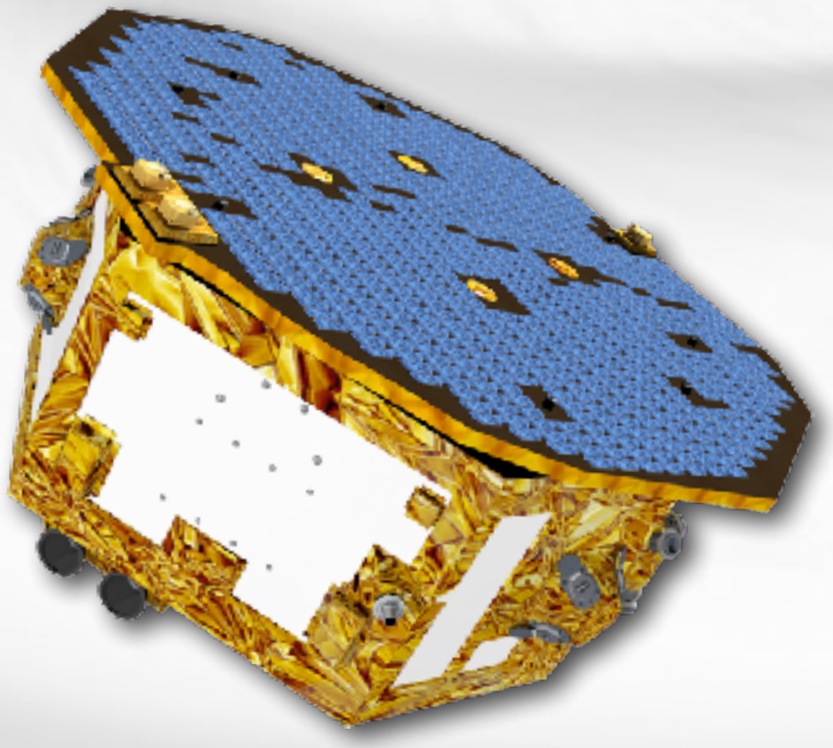
LISA CONSORTIUM

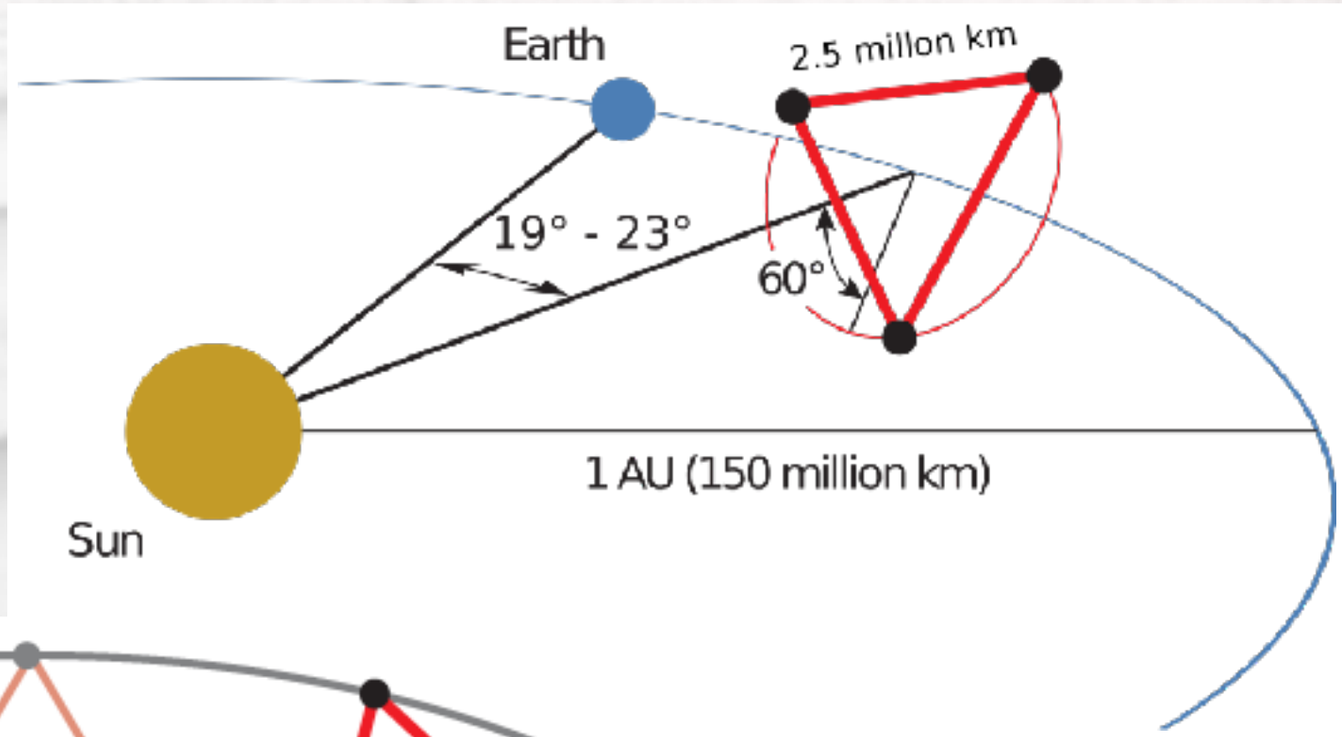
LISA

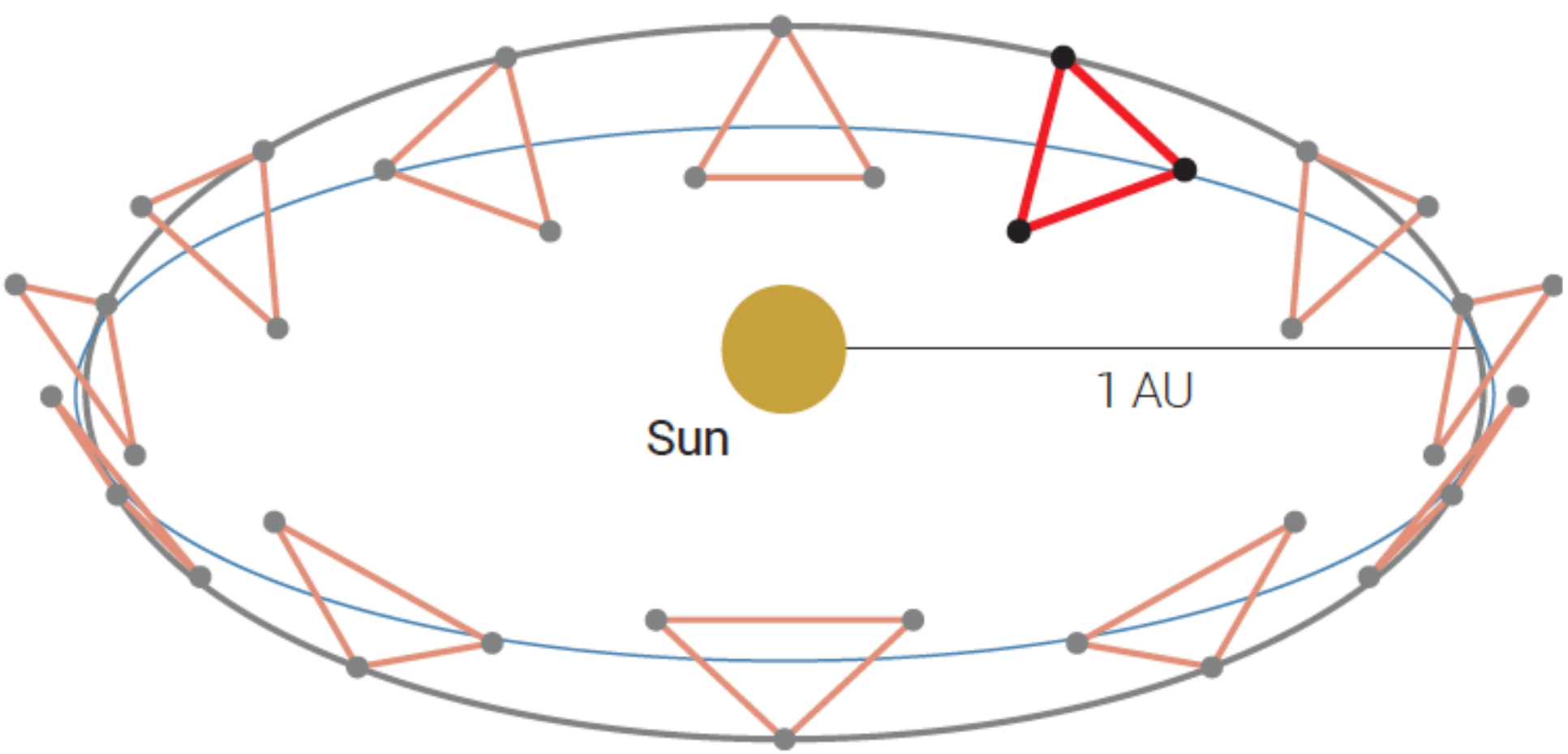
# LISA
# Mission Profile



# LISA mission profile

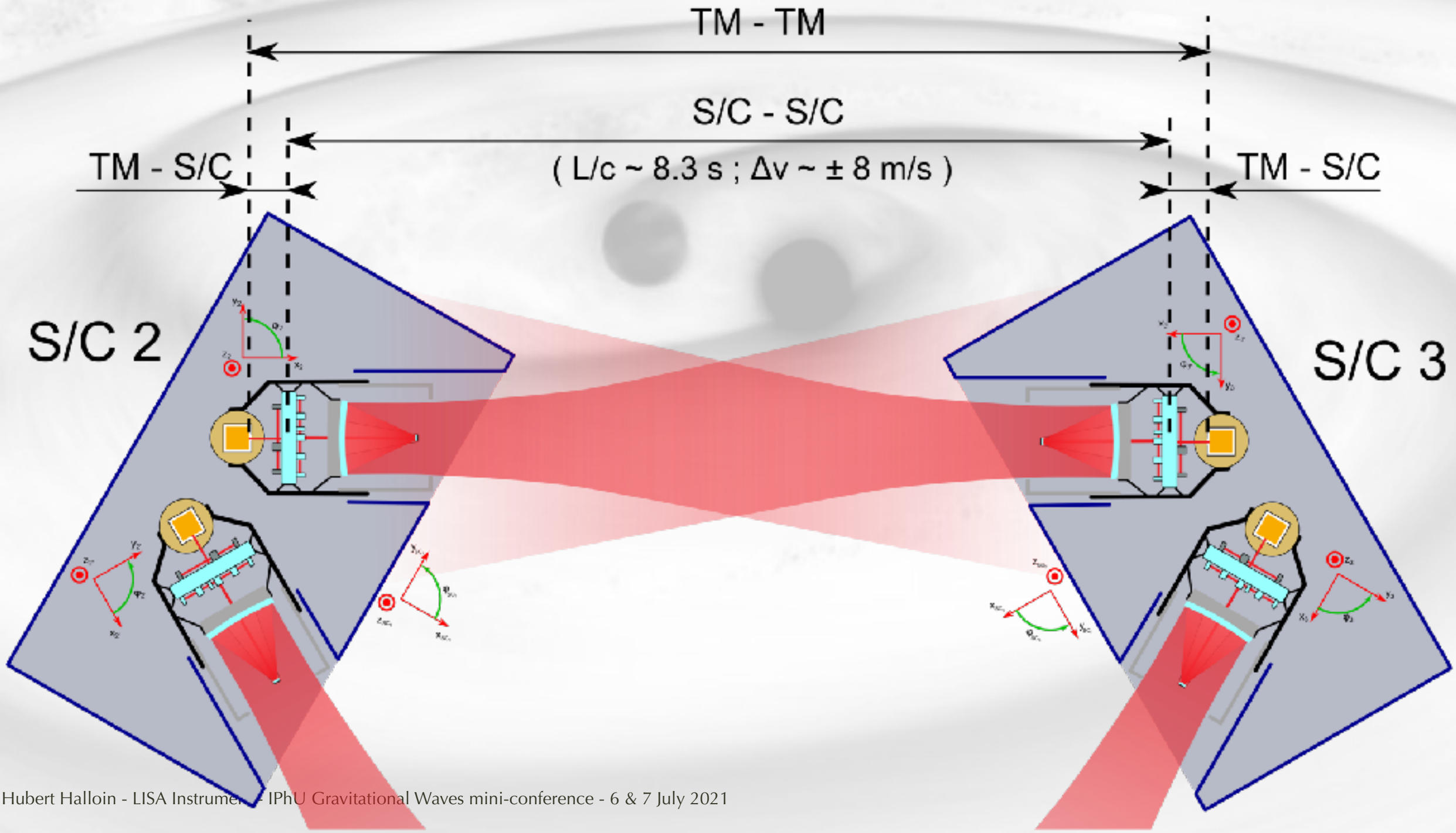
- Long arms interferometer
  - Earth-like orbit, 19° to 23° trailing
  - Mission duration : minimum 6 years
    (consumables and orbit stability for 10 years)
  - 3 arms / 6 links ; 2.5 Mkm



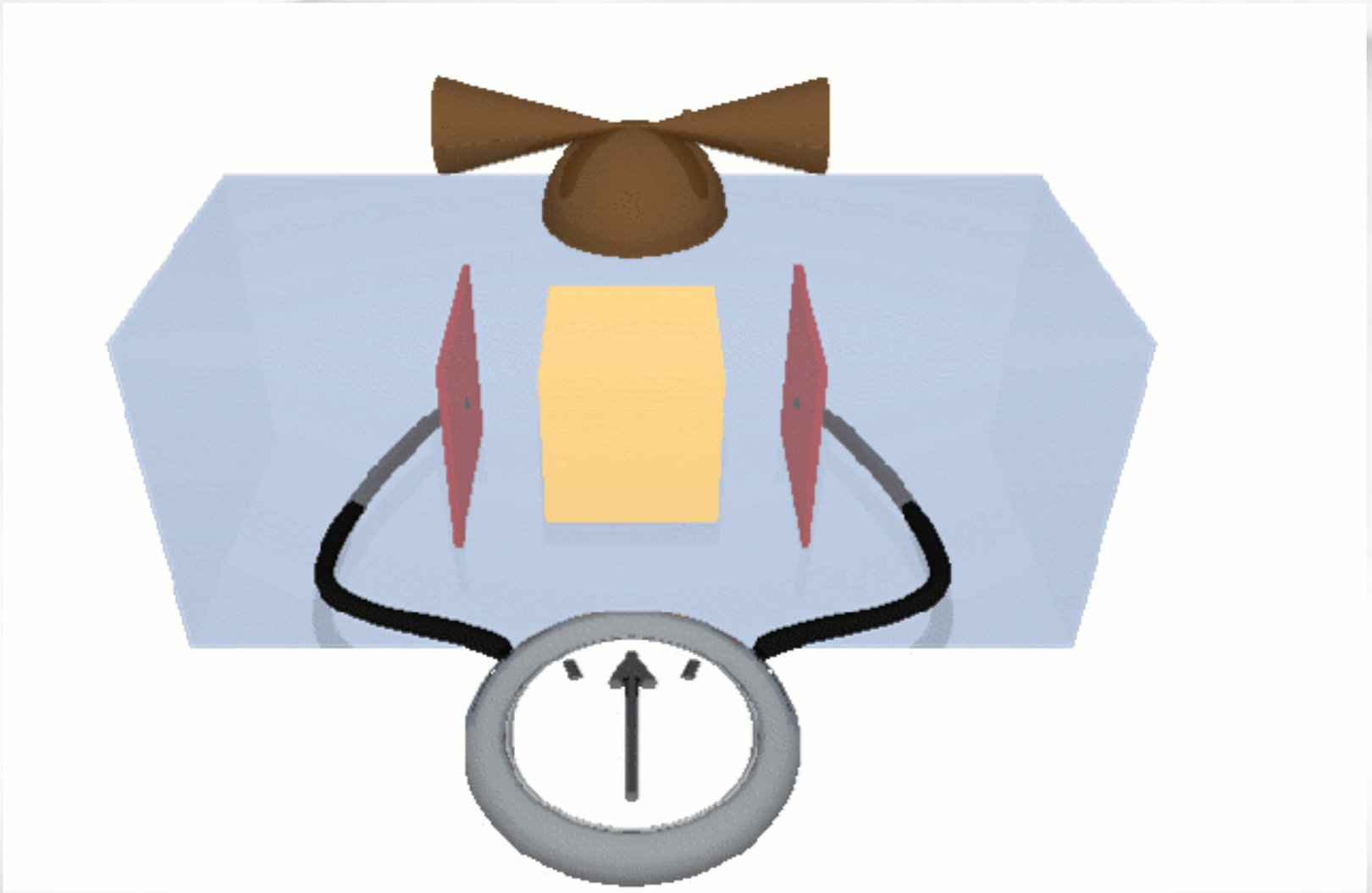
# Measurement principle

- 2 TM / satellites (direct heritage from LISA Pathfinder)
- 2 steerable optical benches / satellite



# Drag-free flying ?

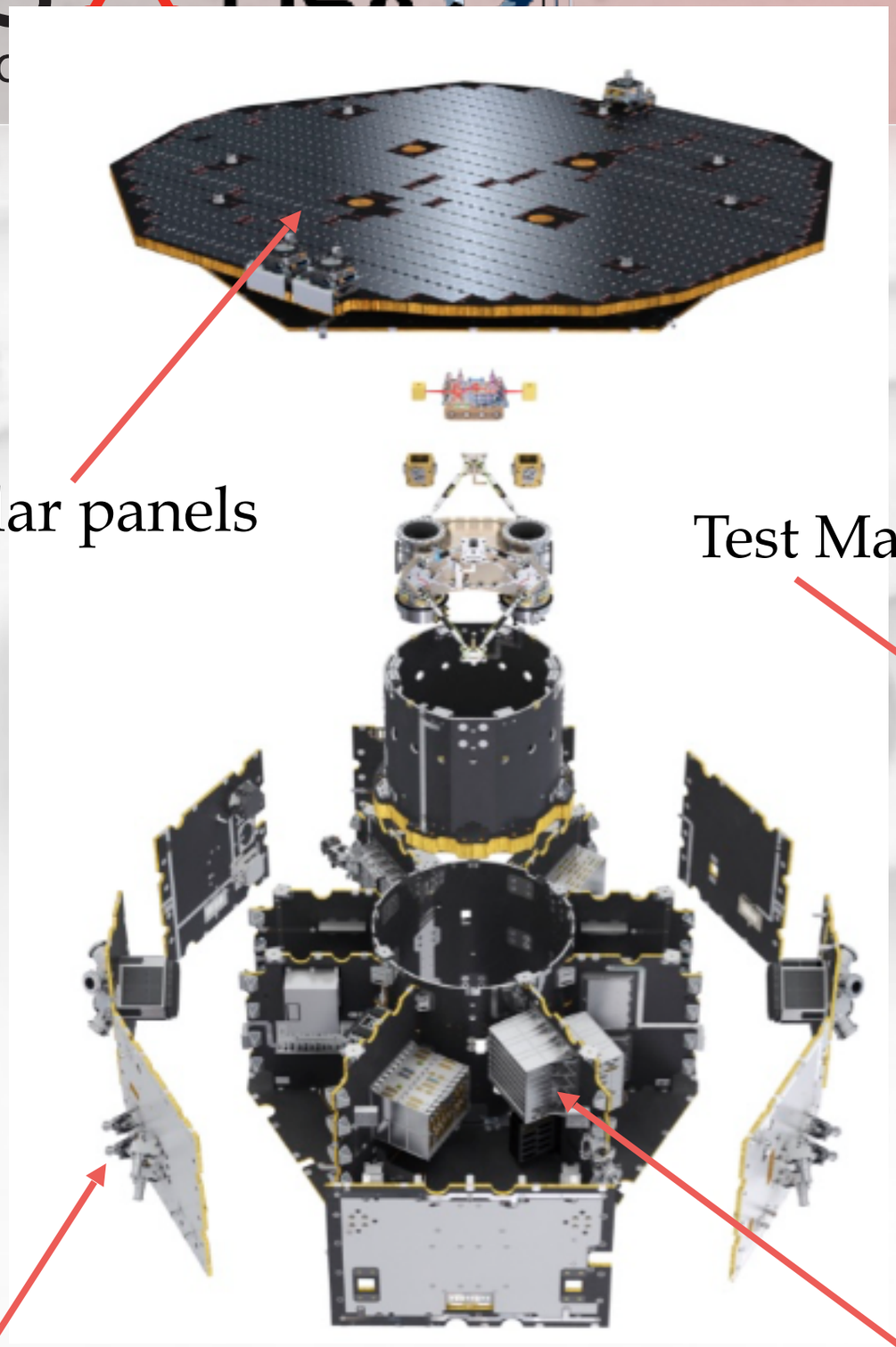
- Test masses must be protected from external perturbations (mainly solar wind)
- Technology demonstrator : LISA Pathfinder (2015-2017)

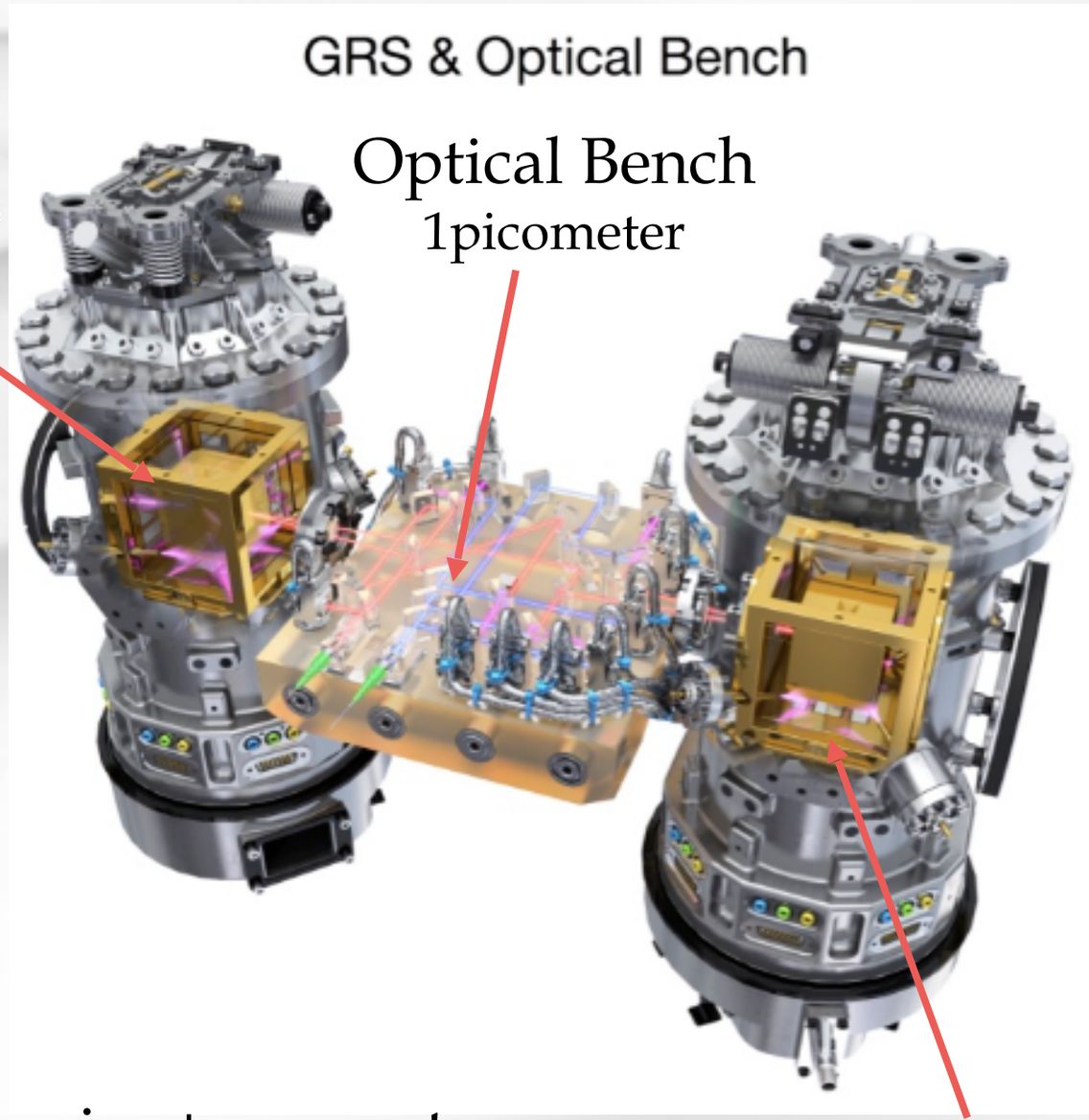


# LISA Pathfinder

- **Main goal**: demonstrate the possibility of "Free Fall" in space at the level of ≈ $10^{-14}$ m.s$^{-2}$/√Hz, around 1 mHz
- A number of effects have to be minimized:
  - The static gravitational potential between the TMs and the SC,
  - Residual links of the TMs w.r.t the SC via the residual vacuum,
  - Cross talk between various electrostatic actuators,
  - TM charging by cosmic rays that is eliminated by UV illumination,
  - Temperature fluctuations ,
  - Magnetic field fluctuations,
  - …

# LisaPathfinder : A technology demonstrator



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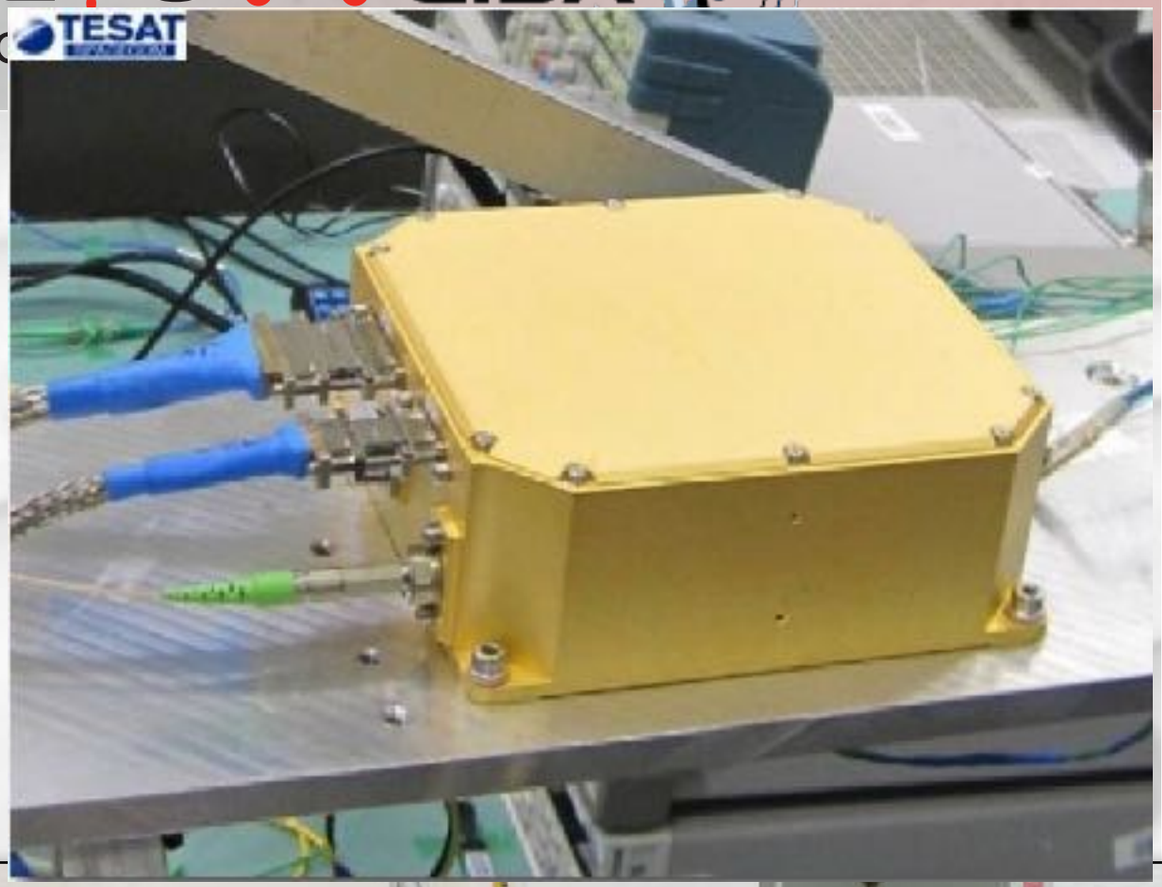


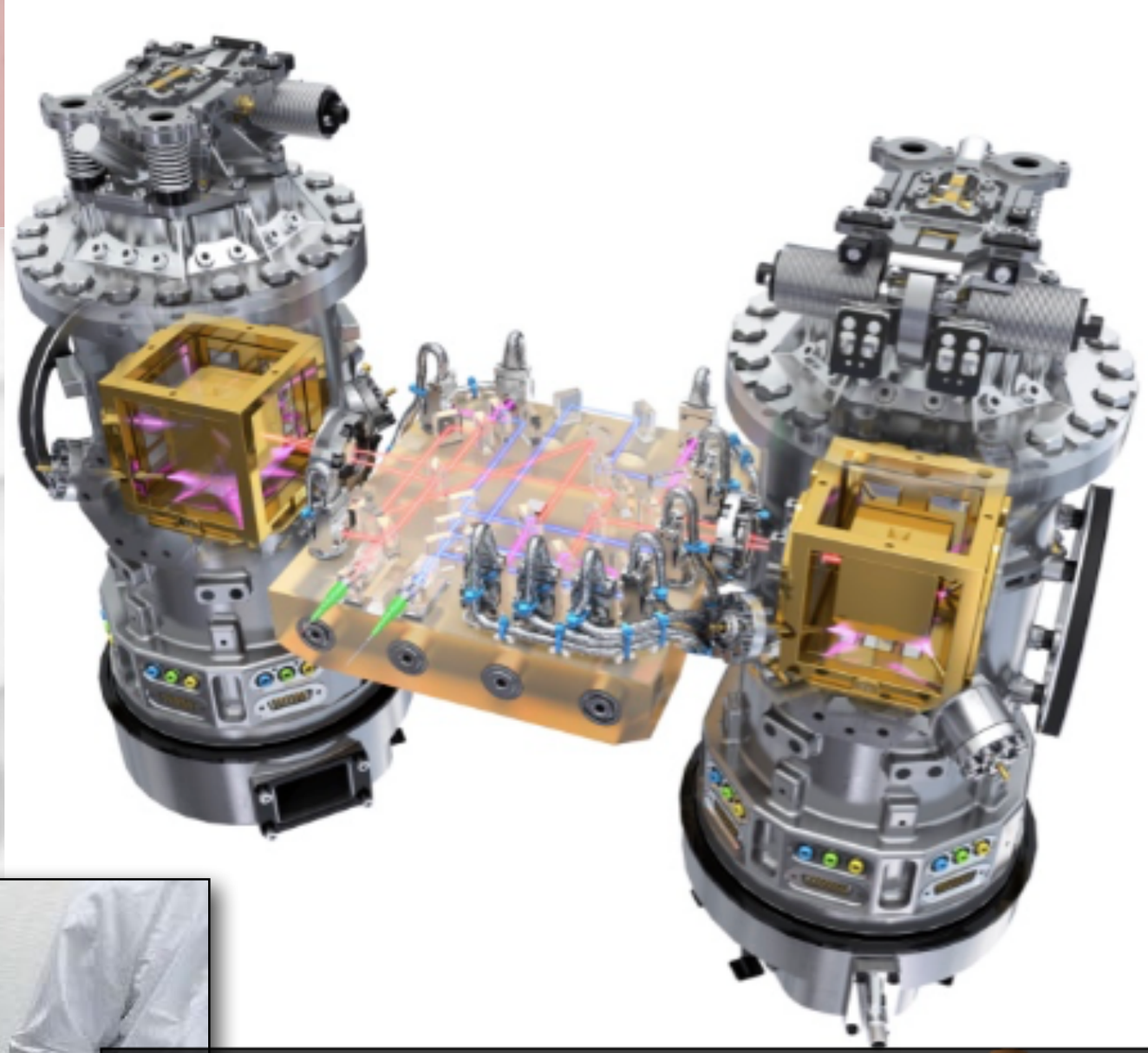

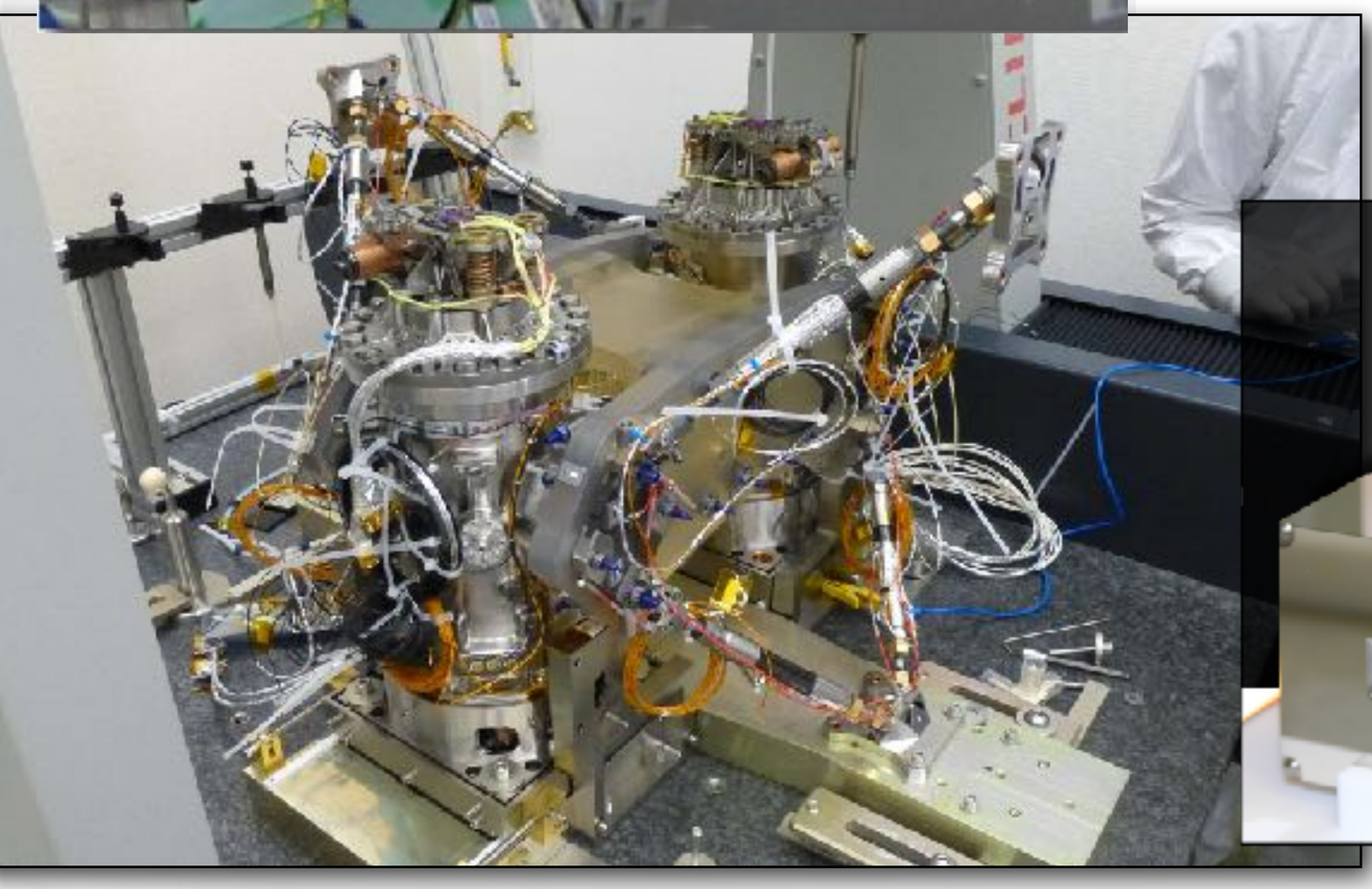

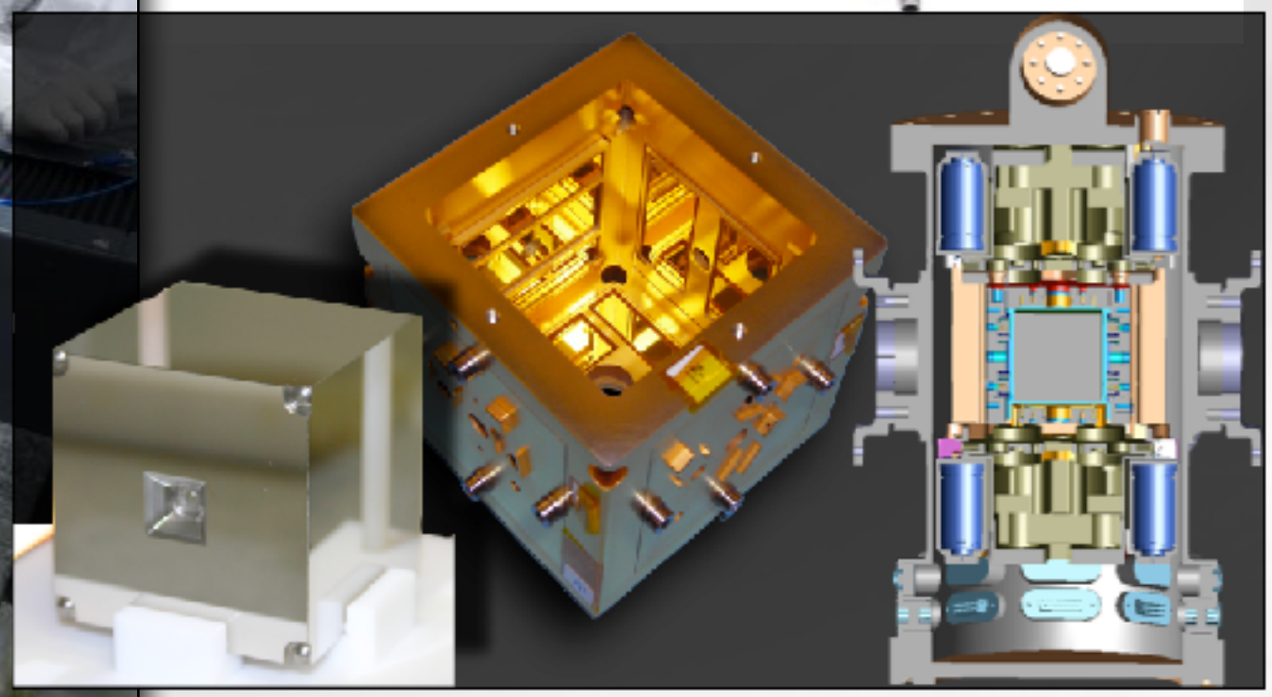


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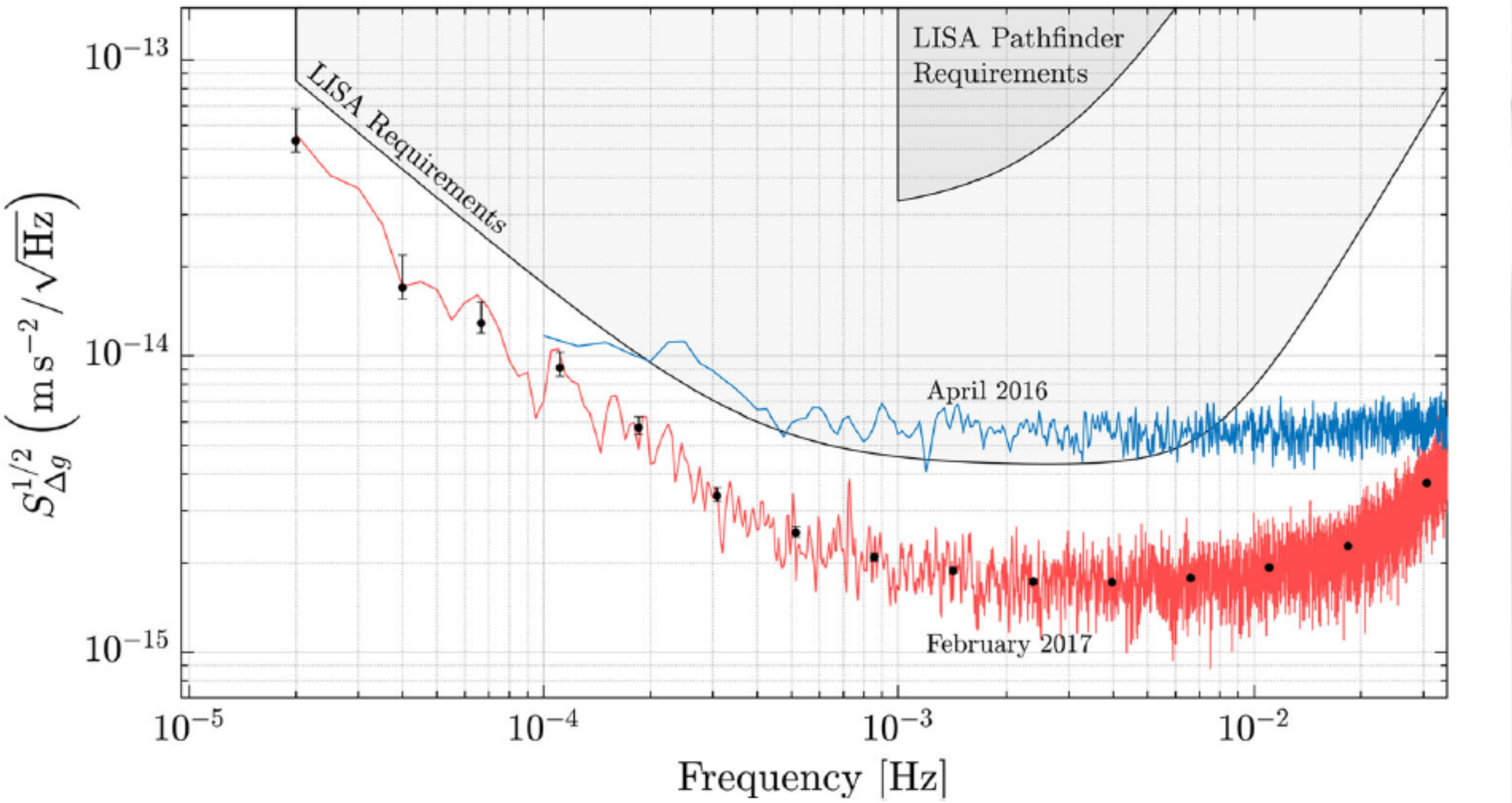
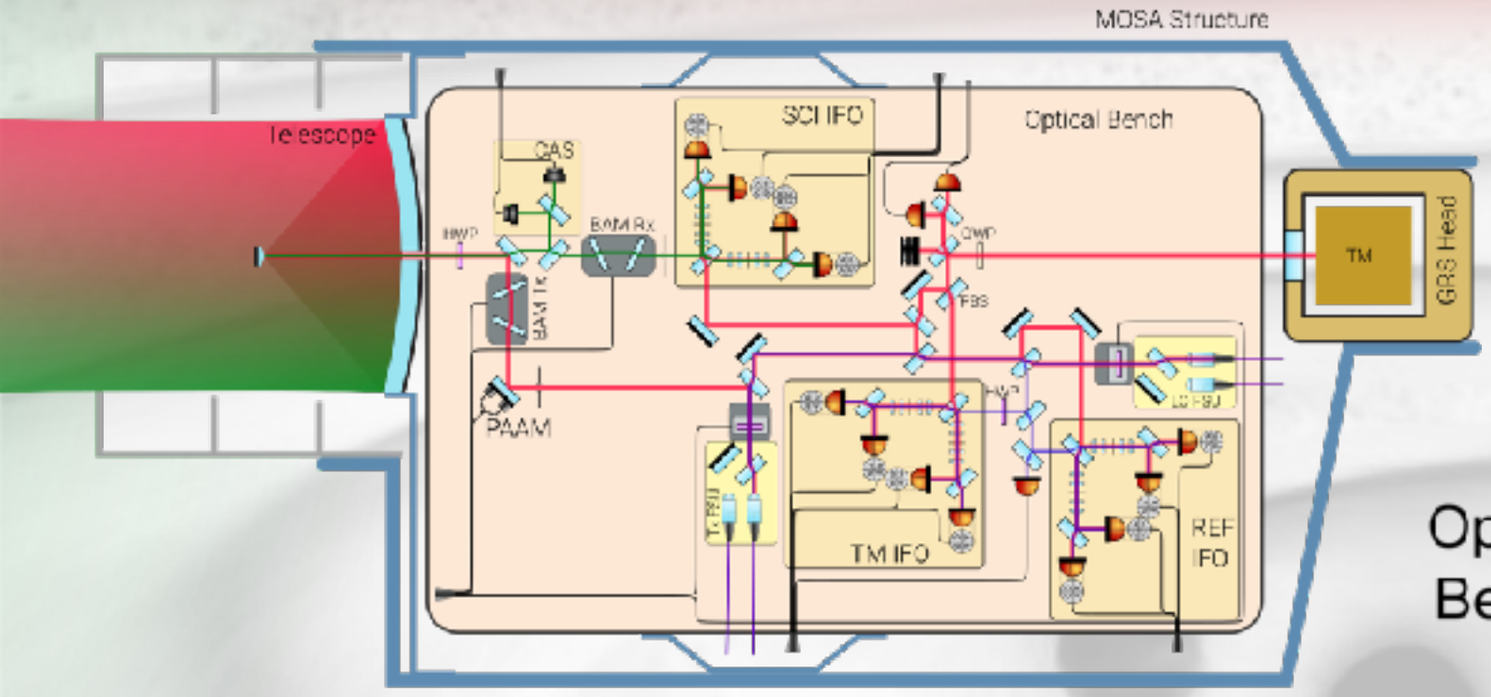
PHYSICAL REVIEW LETTERS 120, 061101 (2018)

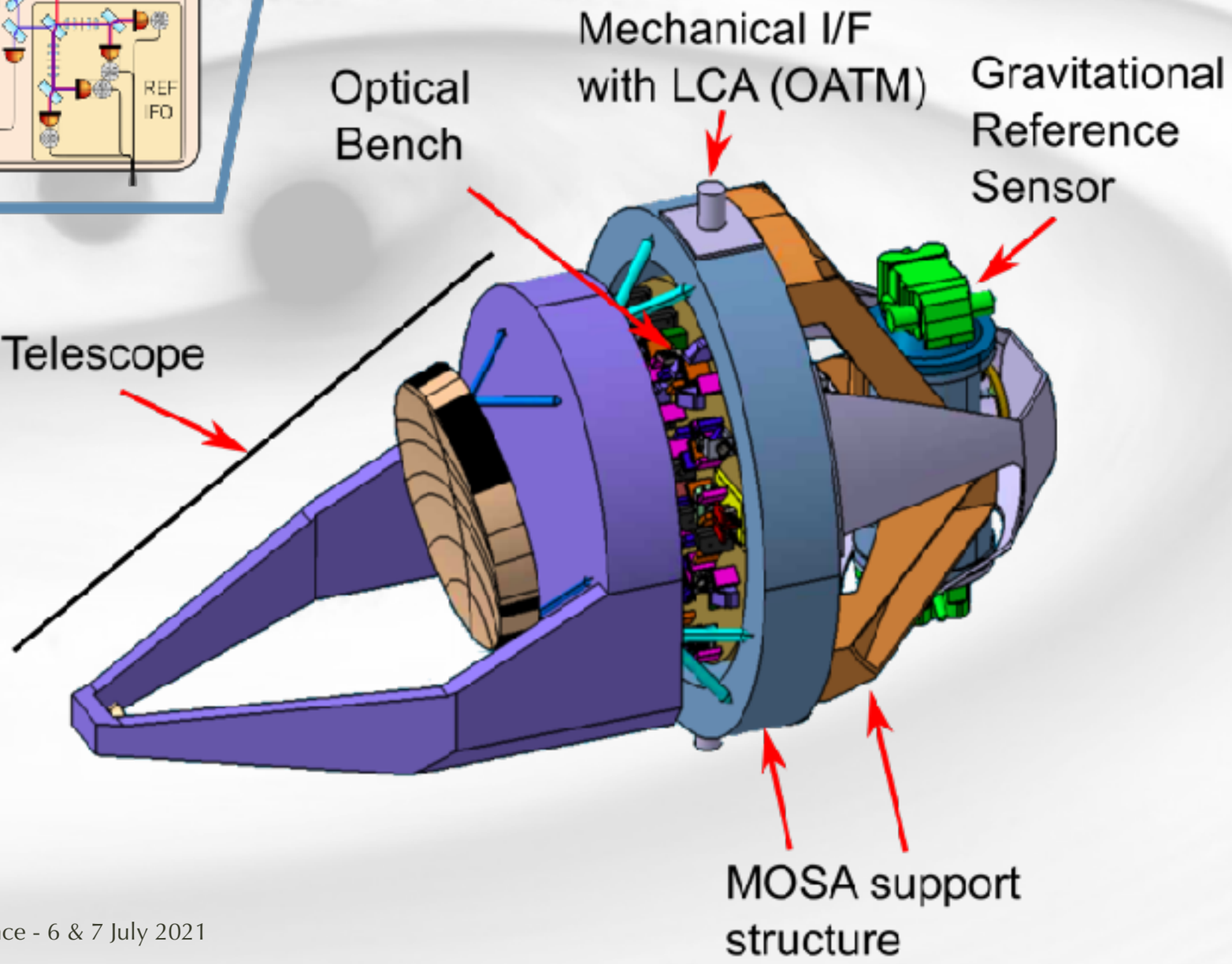
Editors' Suggestion | Featured in Physics

# Beyond the Required LISA Free-Fall Performance: New LISA Pathfinder Results down to 20 $\mu$Hz



# Scheme of a instrument

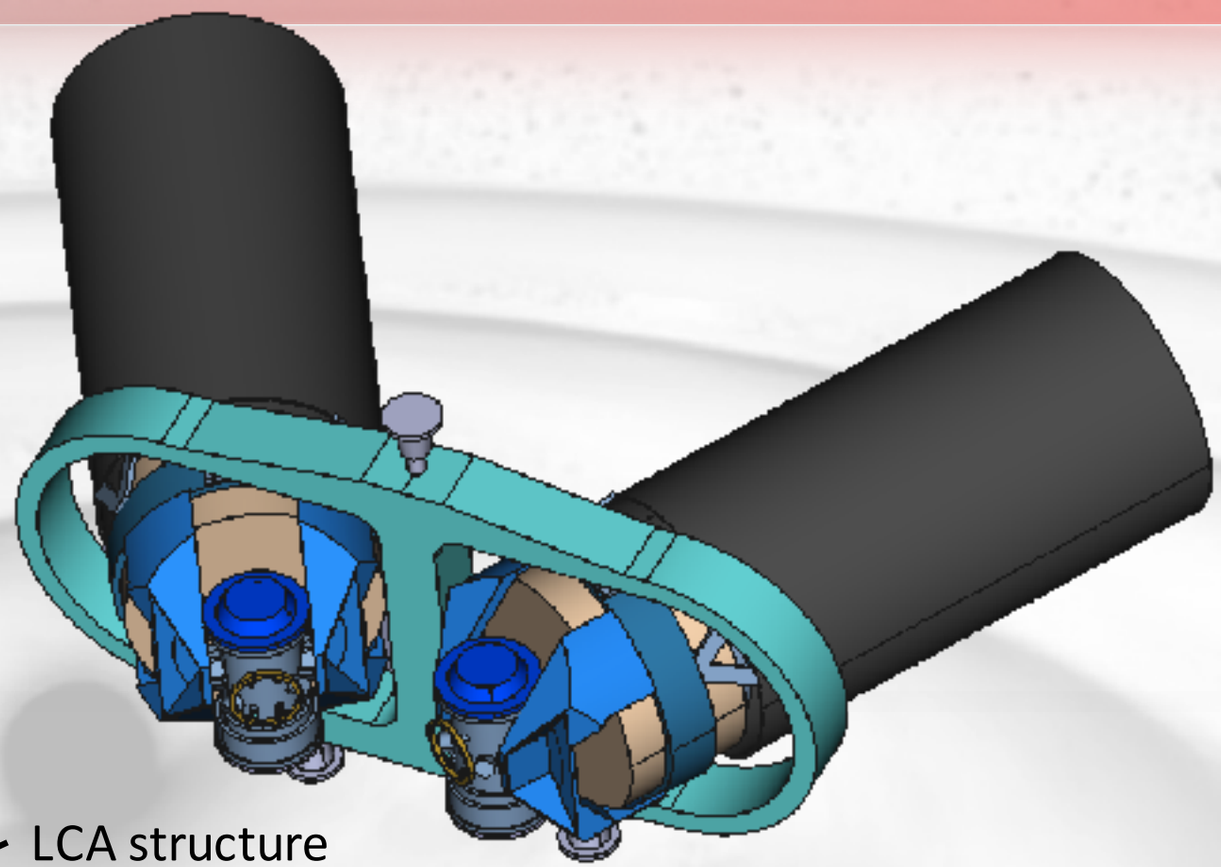


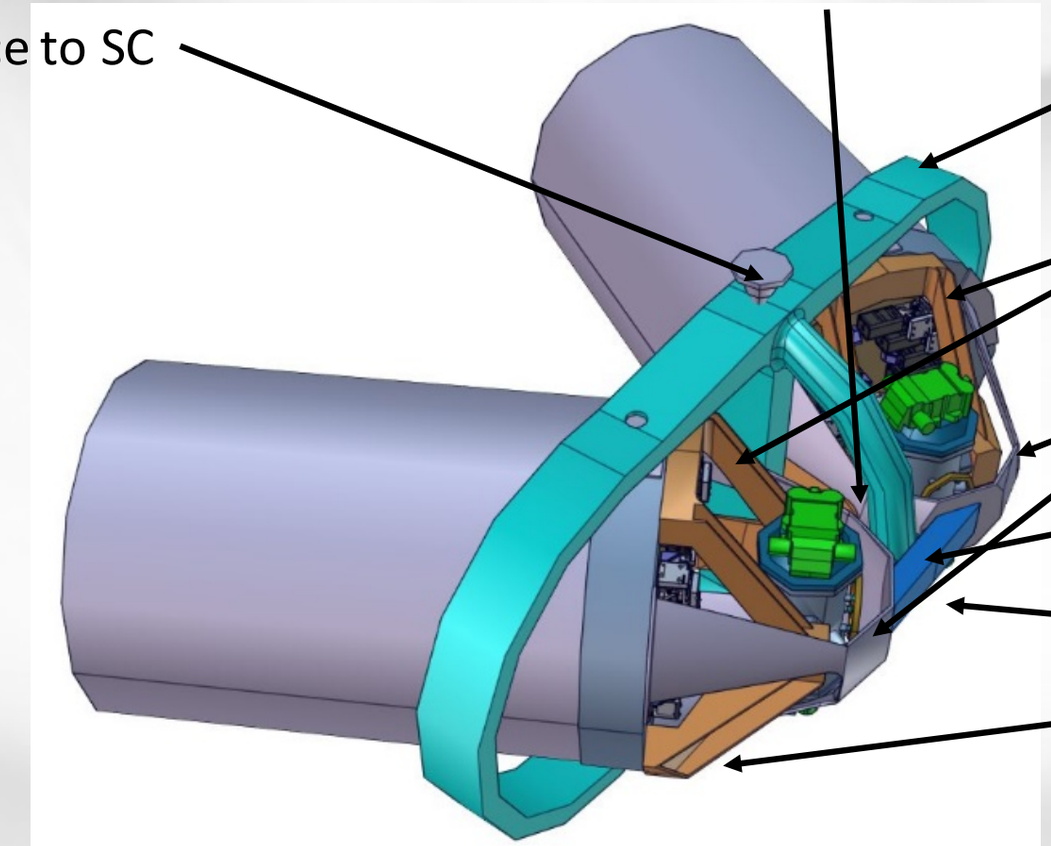




- MOSA = Movable Sub-assembly

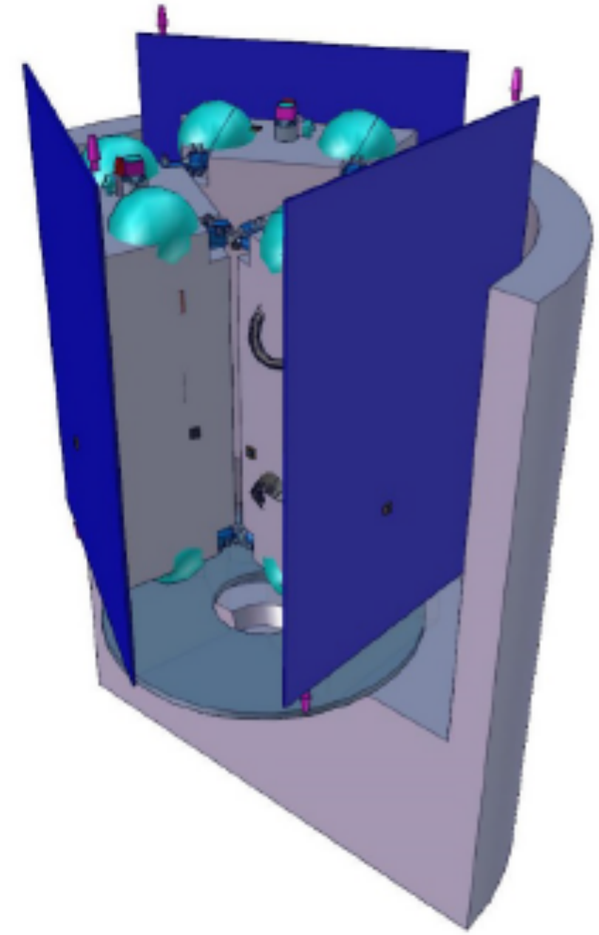
# Two MOSAs form an LCA …

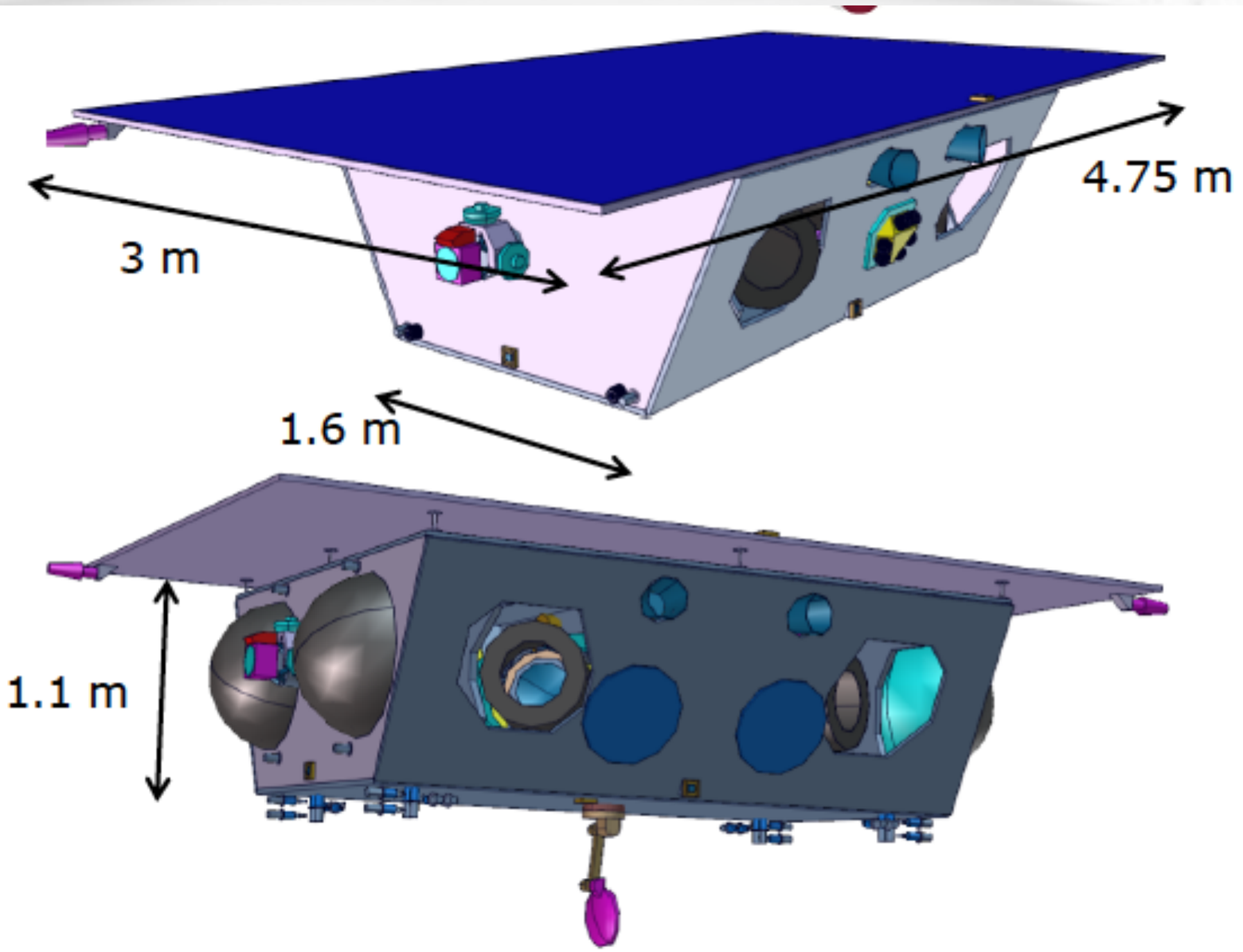
LCA = LISA Core Assembly





# Three S/C fit into an Ariane 6.4





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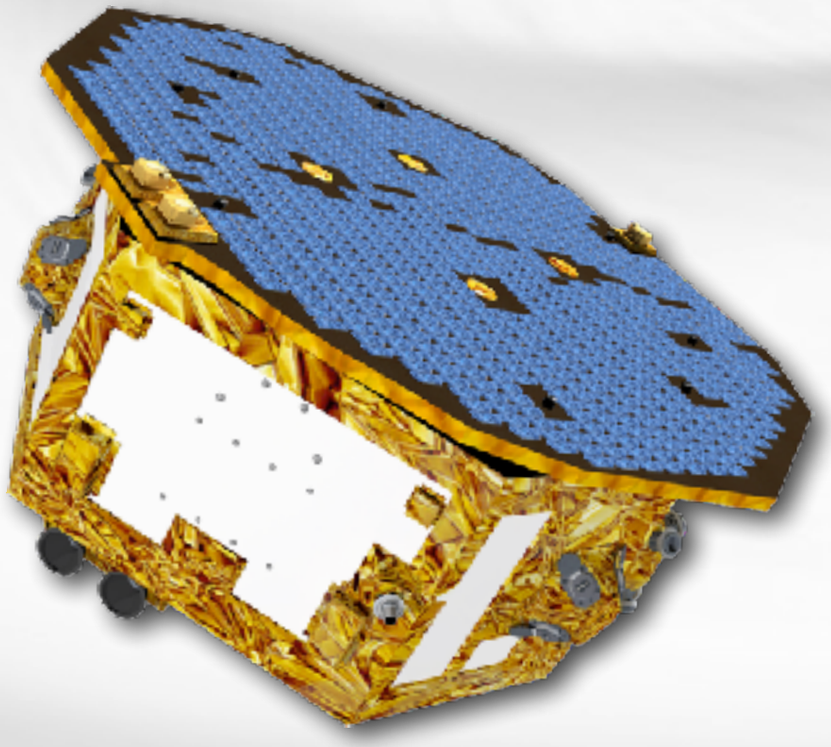
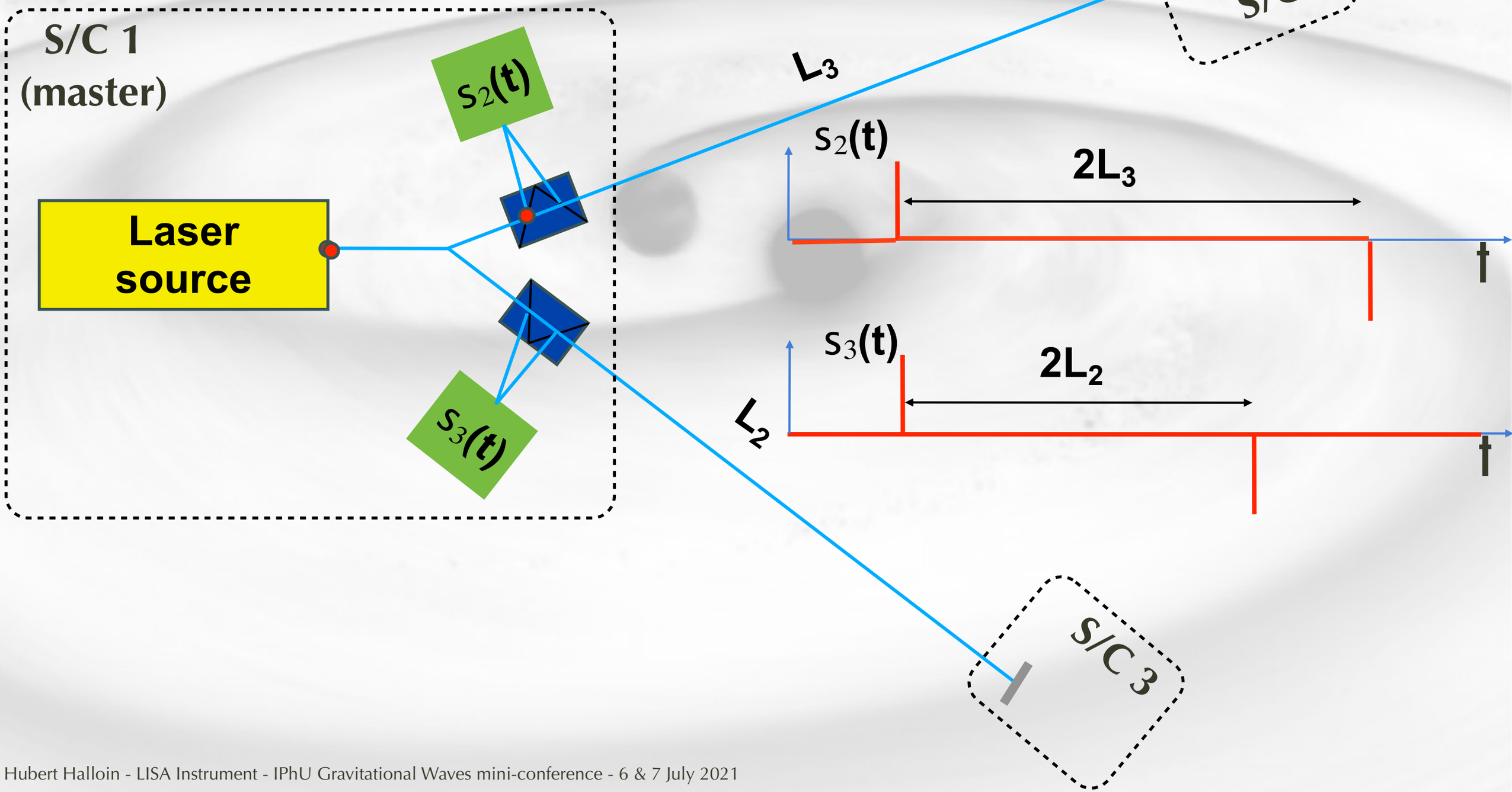
# LISA
# Measurement Scheme

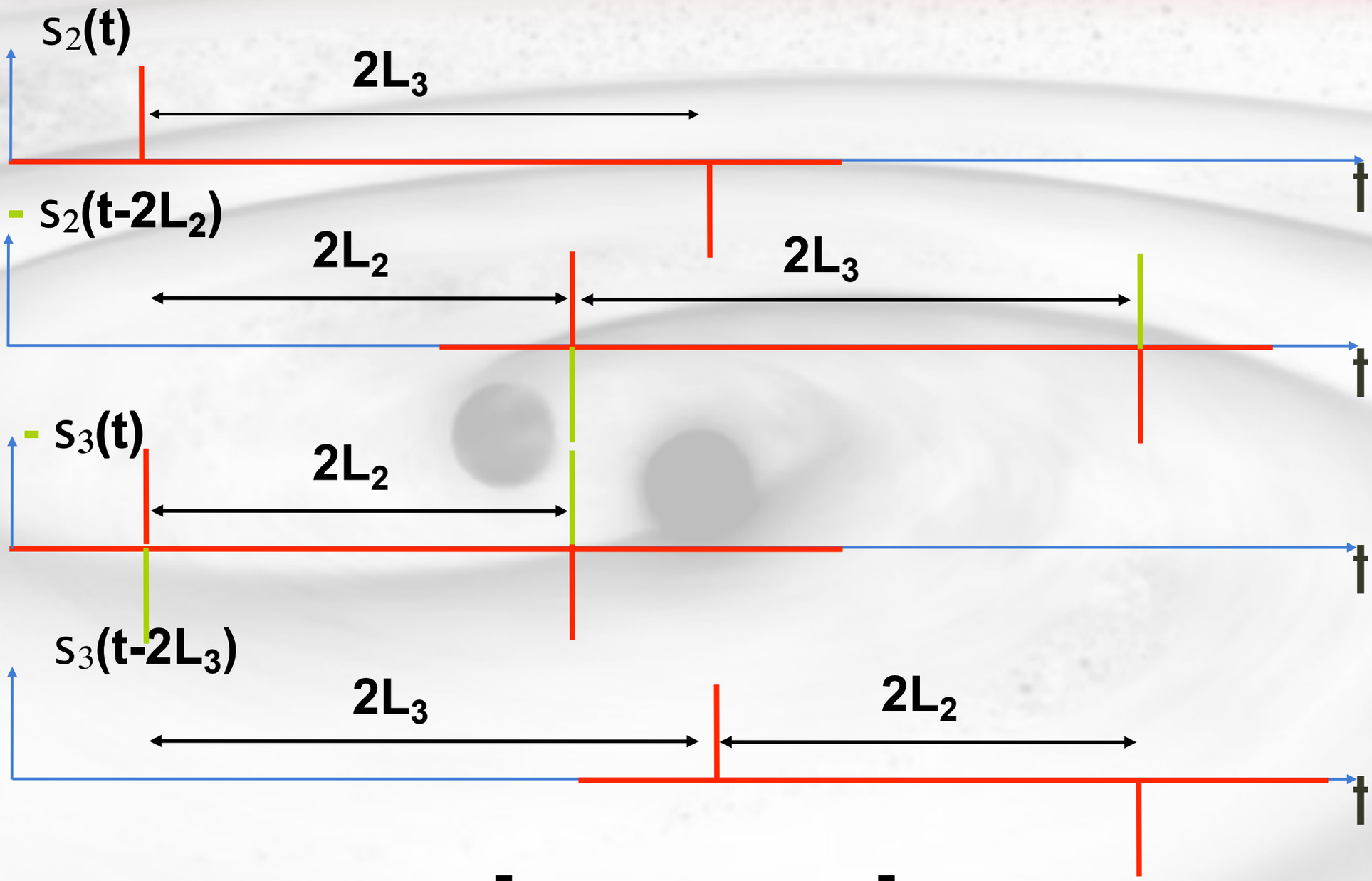


# Time Delay Interferometry

Not a Michelson : unequal propagation delays



# Time Delay Interferometry




$$s_2(t) + s_3(t-2L_3) - [\, s_3(t) + s_2(t-2L_2) \,] = 0 \ldots$$

# Time Delay Interferometry

$$s_2(t) + s_3(t-2L_3) - [\, s_3(t) + s_2(t-2L_2) \,] = 0 \ldots$$

⇒ Cancellation of propagated noises (mostly laser phase noise)

- required noise reduction >8 orders of magnitude

⇒ Transfer function shaping (no signal at f multiple of 1/(2L) ~60 mHz )

⇒ Requires the knowledge of :

- Armlength at a **few meters accuracy**
- Relative clock jitters at **a few ns**

⇒ (Much) more sophisticated TDI combinations compensate for non commutativity of delay operators (fluctuating arm length), non reciprocity of propagation (Sagnac effect), etc.

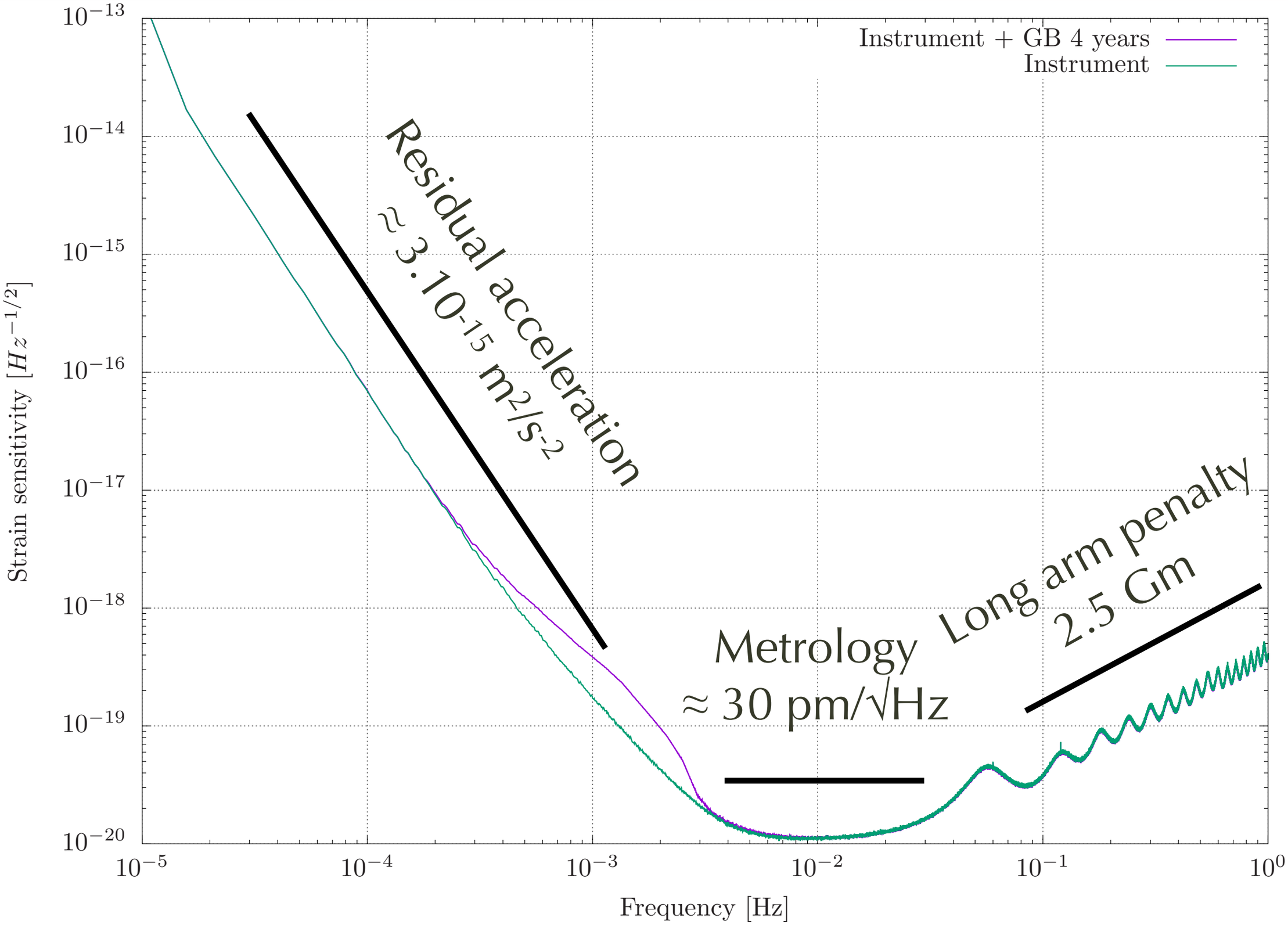
⇒ Residues of TDI combinations put constraints on :

- relative clock drifts
- antialiasing and interpolation filters
- data sampling
- …

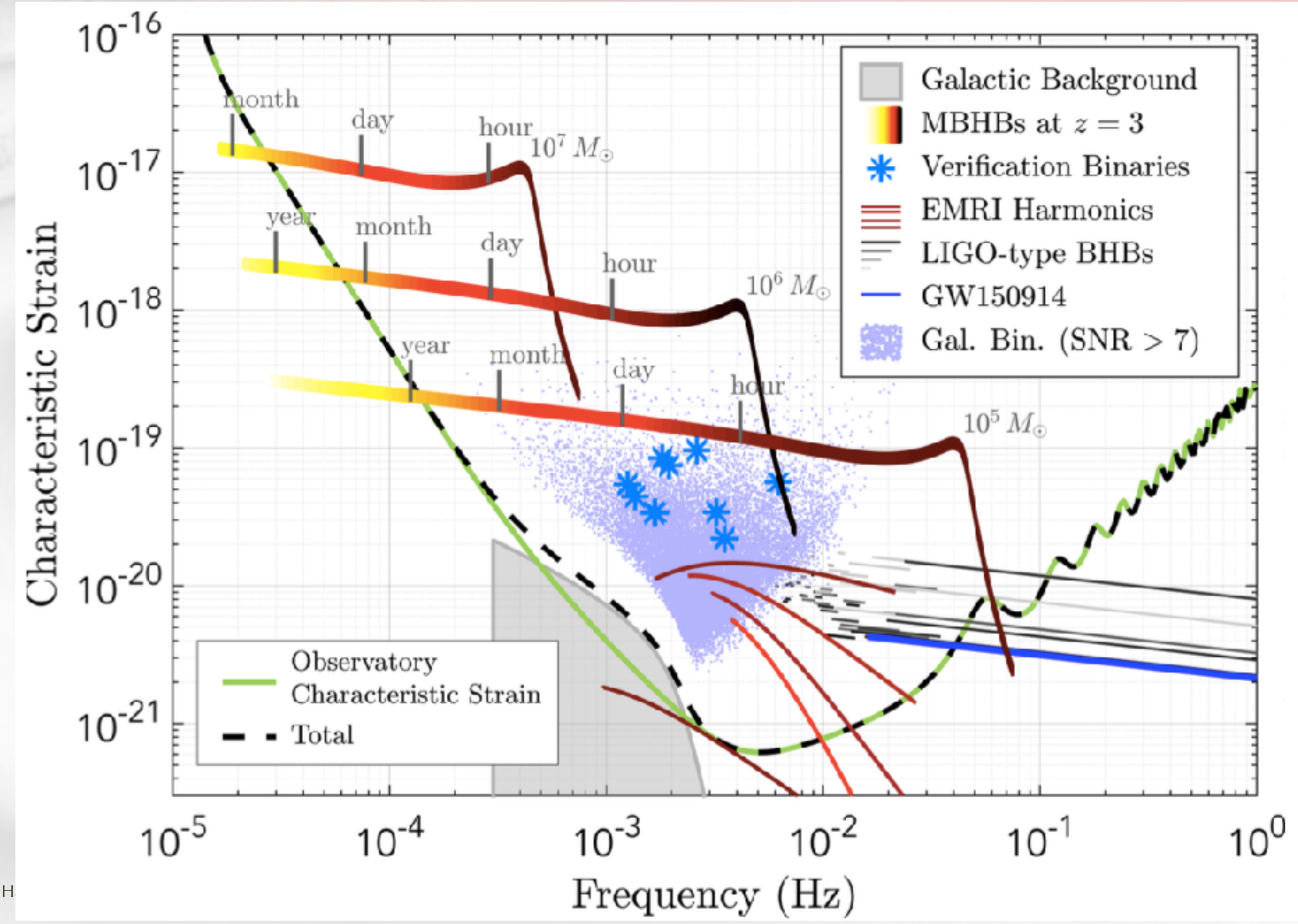
# (Some) key performance values

- Drag free performance : **$3\times10^{-15}$ m.s$^{-2}$/√Hz**
  - DC value: ~$10^{-11}$ m.s$^{-2}$
  - Validated with LISA Pathfinder !
- 6 laser links, 2.5 Mkm
  - Measurement bandpass : [0.1 mHz : 1 Hz]
- Telescopes:
  - ~30 cm diameter,
  - Pathlength stability: ~ 1 pm/√Hz
- Laser
  - Nd:YAG (1064 nm), 1.8 W emitted (received ~400 pW)
  - RIN : <$10^{-8}$ /√Hz above 5 MHz
  - ~100 Hz/√Hz
- Timing jitter in clock distribution: ~$4\times10^{-14}$ s/√Hz
- Absolute ranging accuracy: ~1 m
- Thermal stability (optical bench): < 10 µK/√Hz at 1 mHz
- Laser beam pointing jitter: ~10 nrad/√Hz

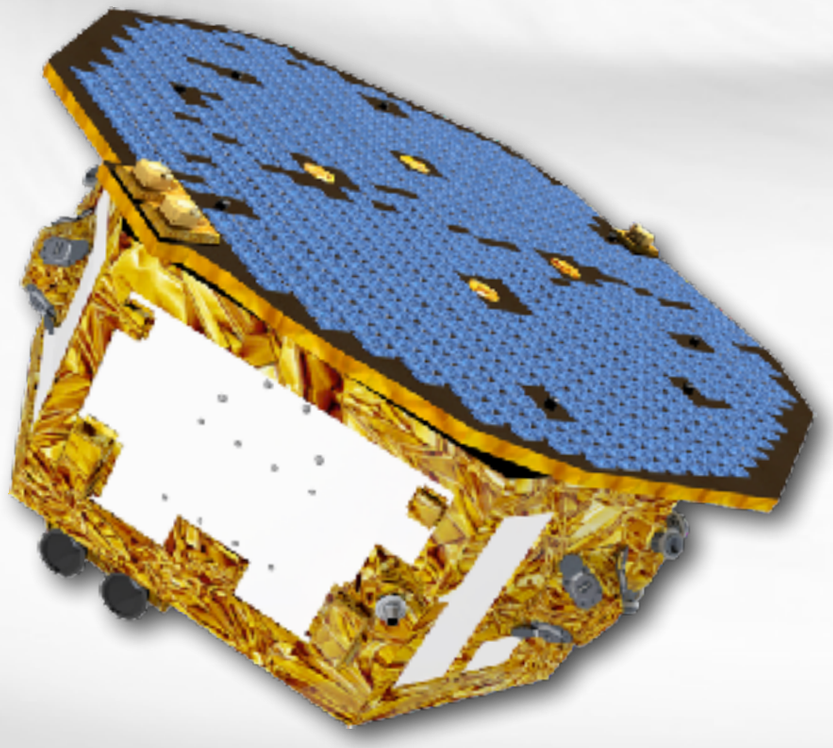
# Global Performance



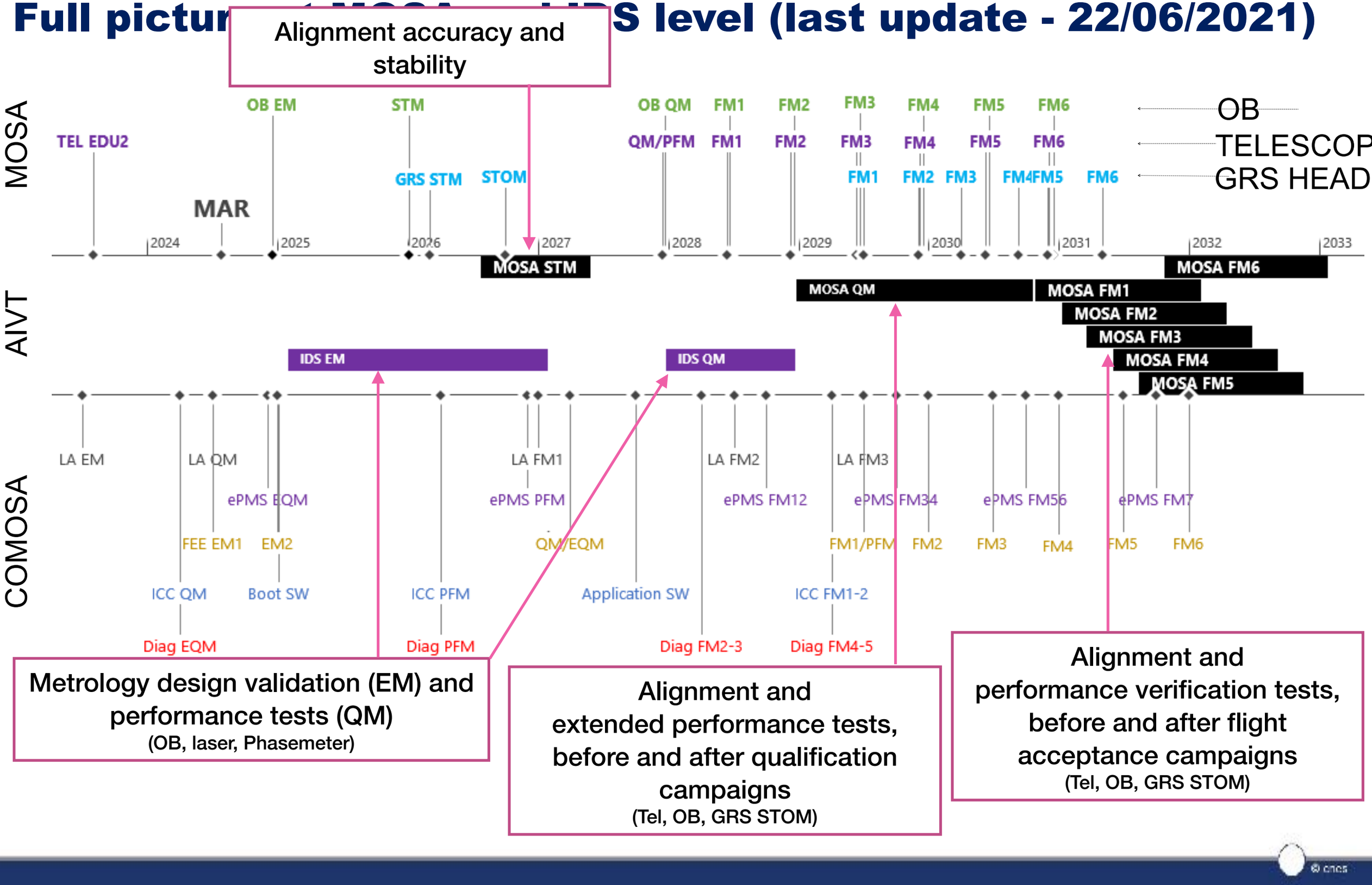
# LISA Strain Sensitivity



# LISA
# Testing the instrument

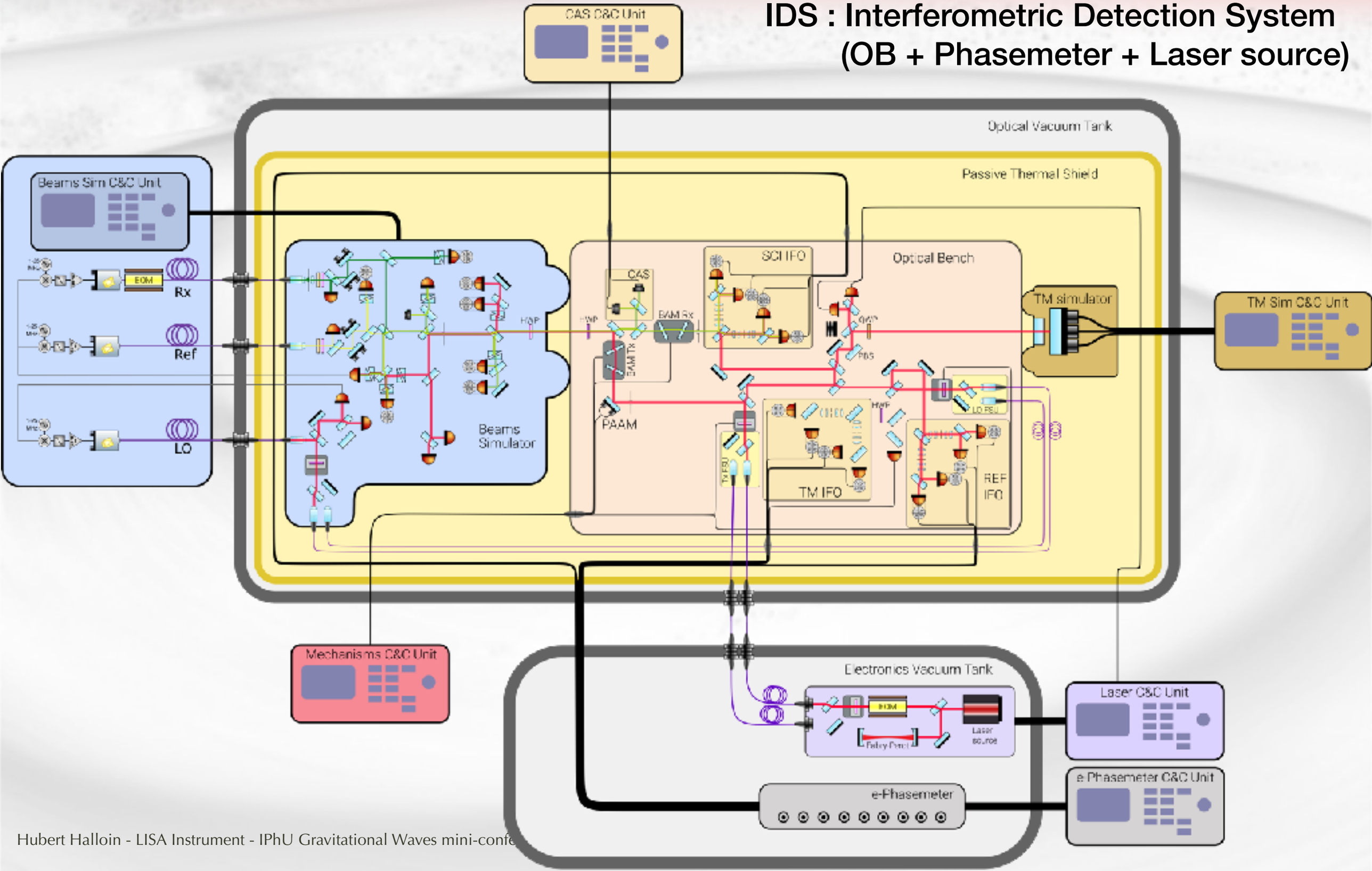


# Full pictur S level (last update - 22/06/2021)



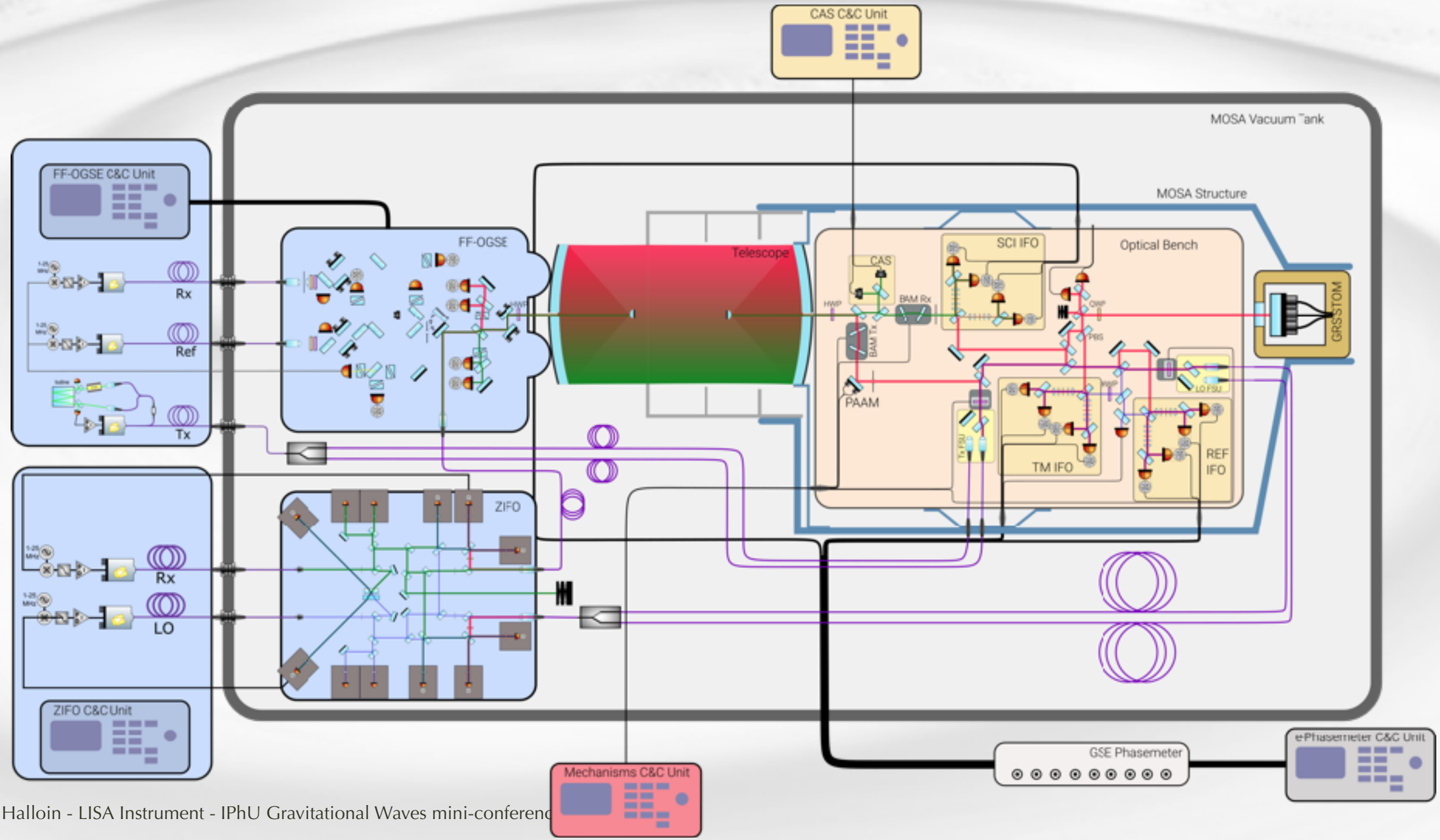
# Test configuration example : IDS

## IDS : Interferometric Detection System (OB + Phasemeter + Laser source)



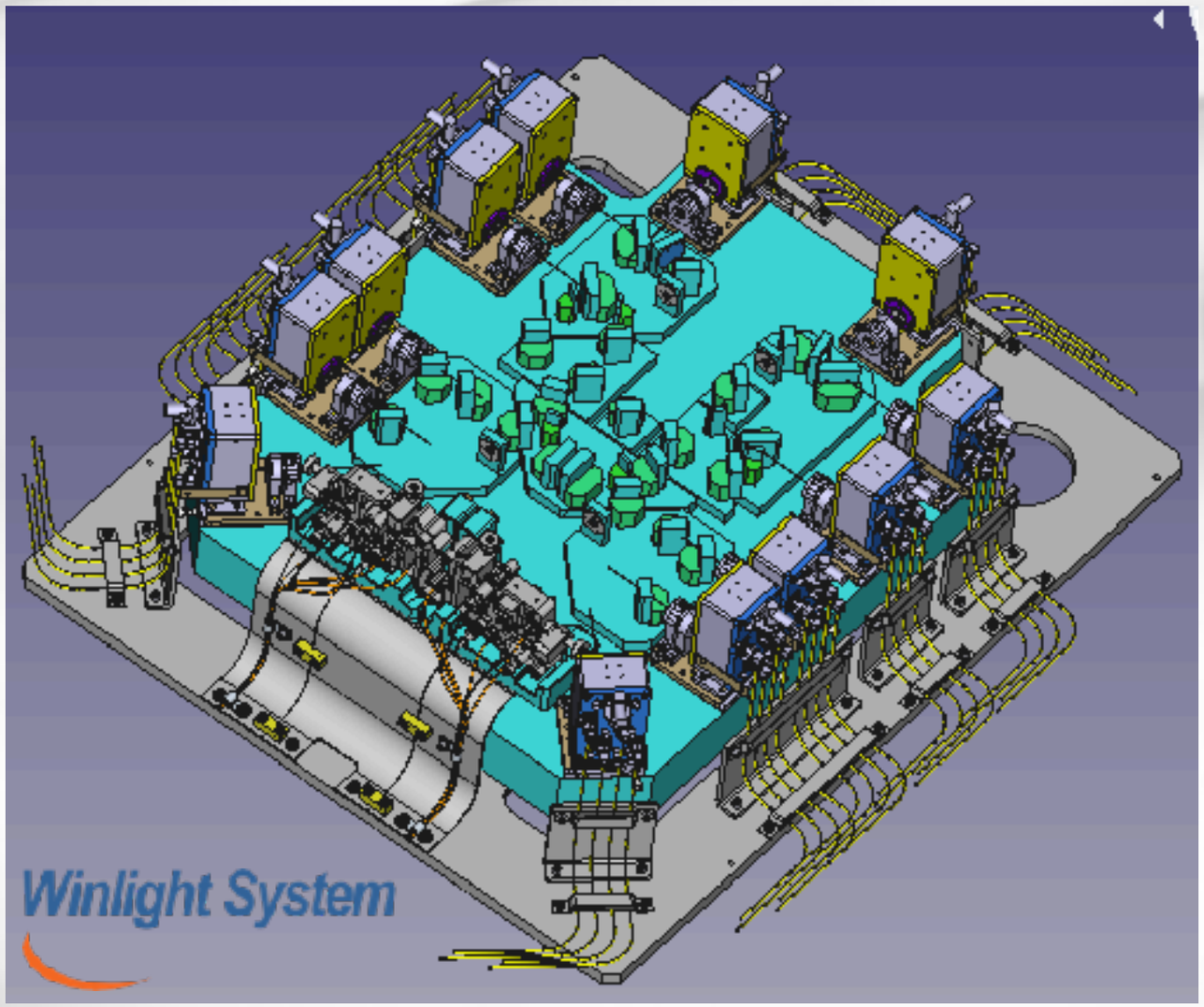
# Test example : MOSA perf tests

- Global performance
  - Differential stability measurements between SCI, TM and Ref IFO
    - Relies on fiber phase noise reciprocity

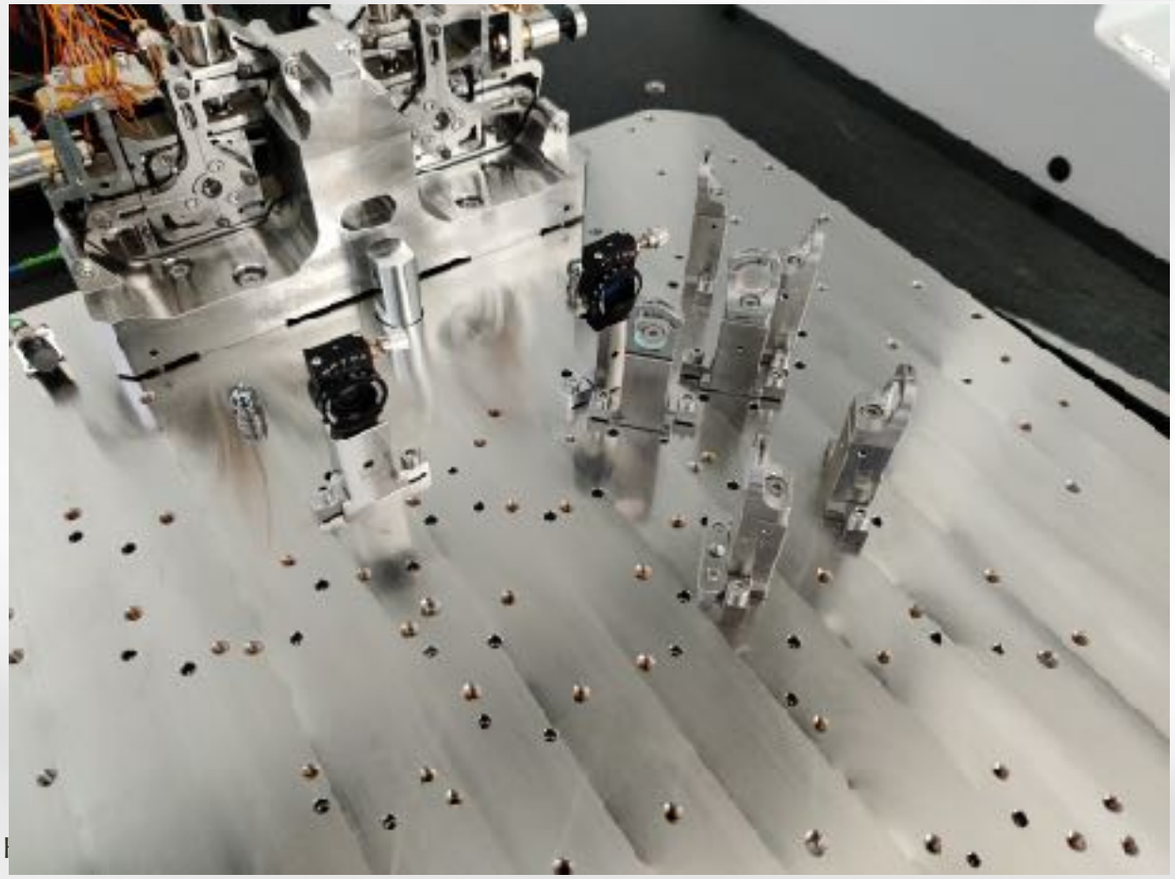


# Preparing the tests : prototyping

- ZIFO
  - Zerodur base plate +optically contacted elements
- MIFO
  - Invar base plate + COTS optical mounts




# Prototype Invar bench



2021

# Thank you !



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