LISA in the Gravitational Wave Decade

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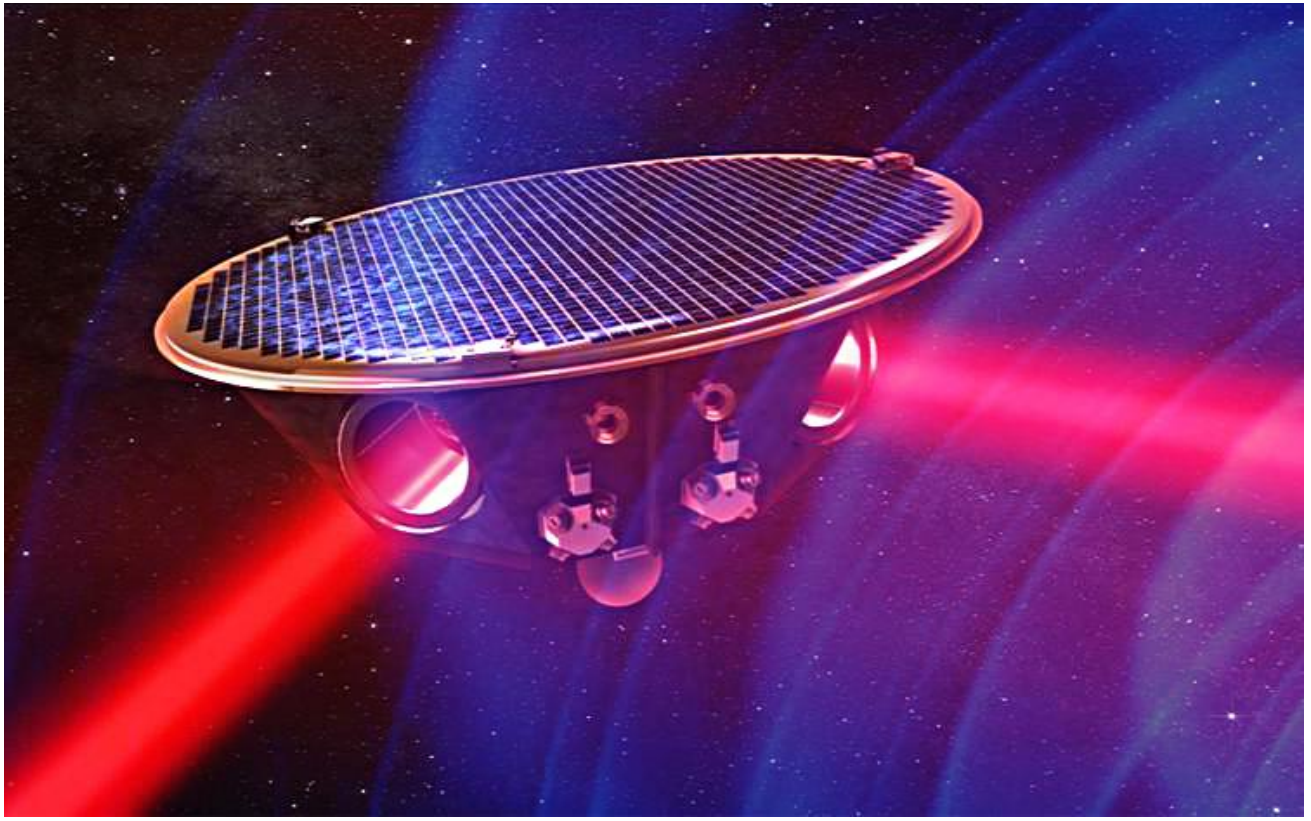
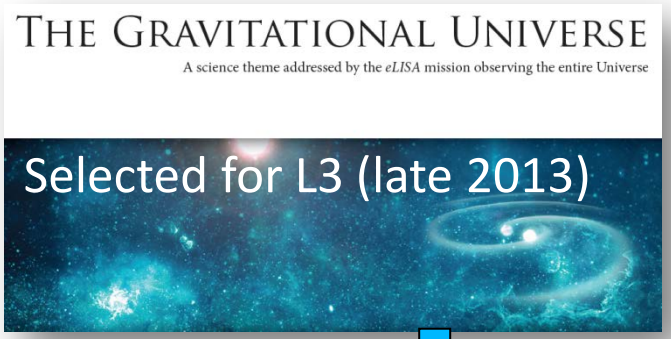
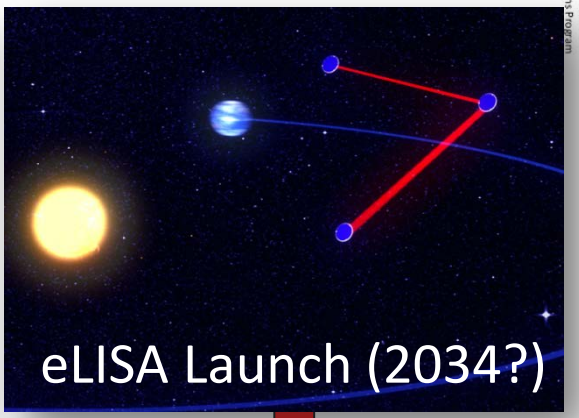


The Gravitational Wave Decade



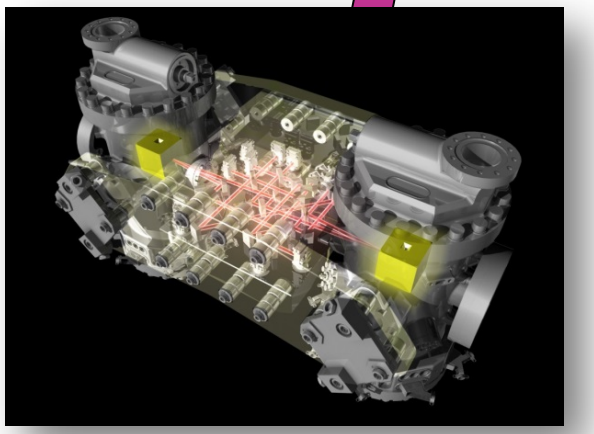
aLIGO/VIRG0 detection



2010 2020 2030

LISA ranked 2nd after WFIRST in NWNH

2020 Decadal

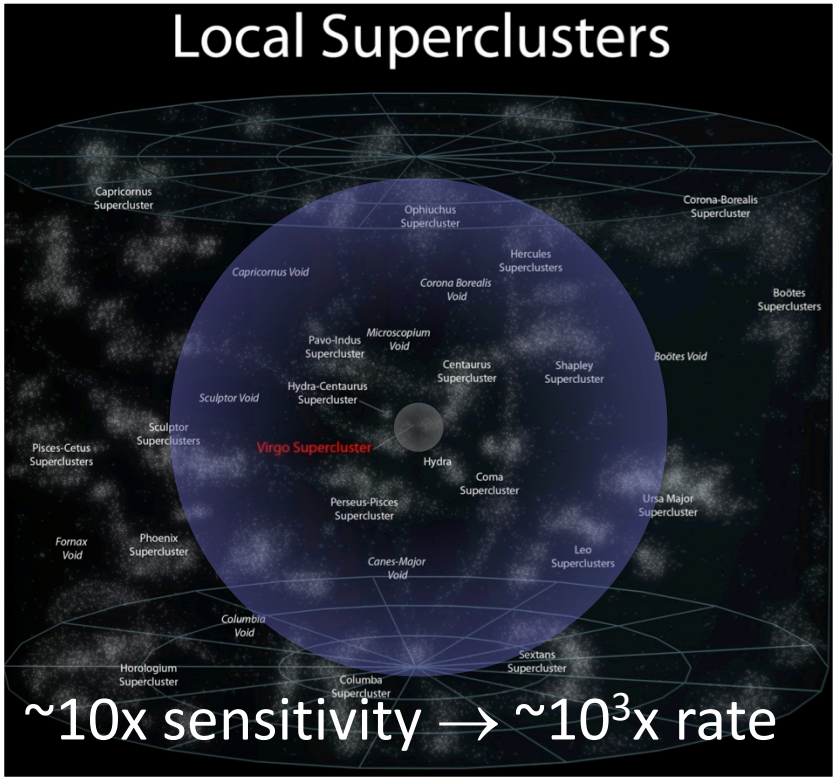


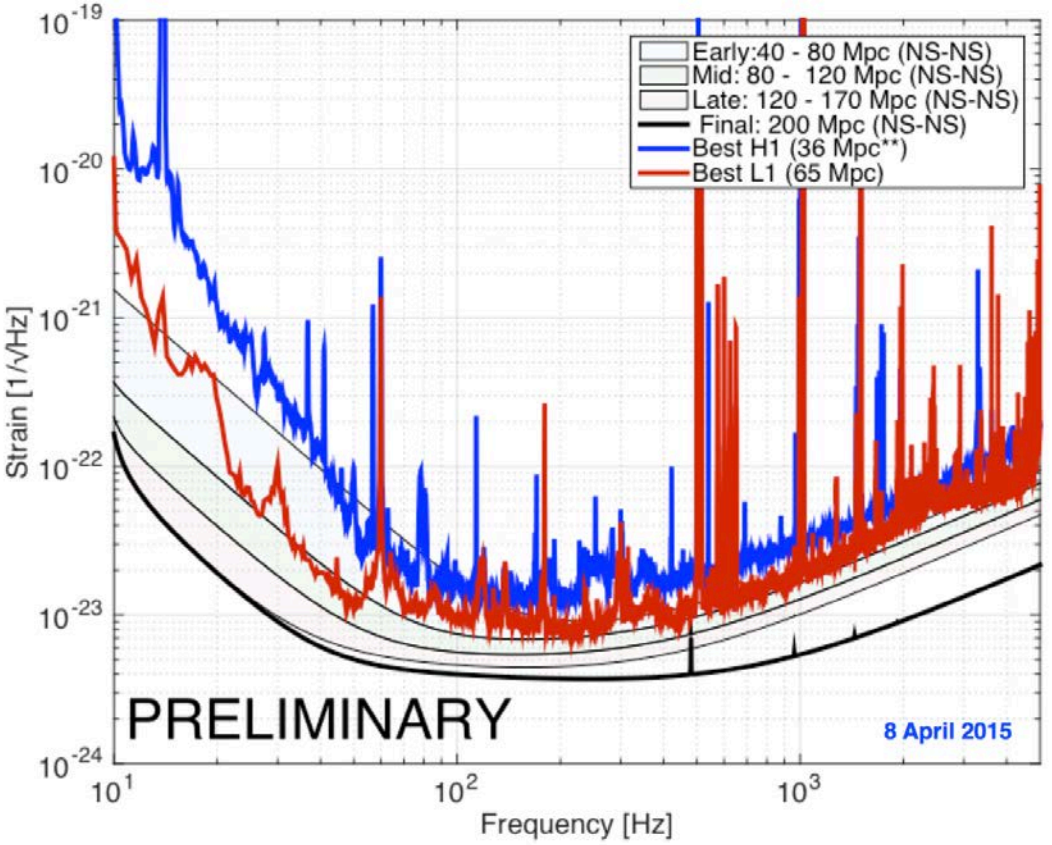
LISA Pathfinder (Oct 2015)

PTA detection

Advanced LIGO

- Advanced LIGO construction completed on-time & on-budget
- Hanford & Livingston handed over to LIGO Operations
- First aLIGO observing run expected Summer/Fall 2015

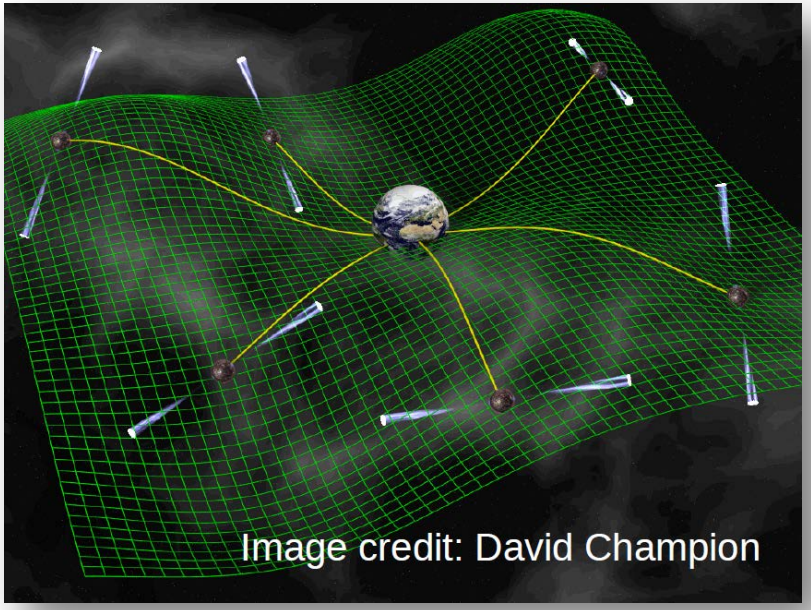




Credit: LIGO Lab

Milli-second Pulsars

- GWs at the Earth cause correlation between arrival times of radio waves from MPSs.
  - SMBH-SMBH
  - Primordial, Cosmic strings, …



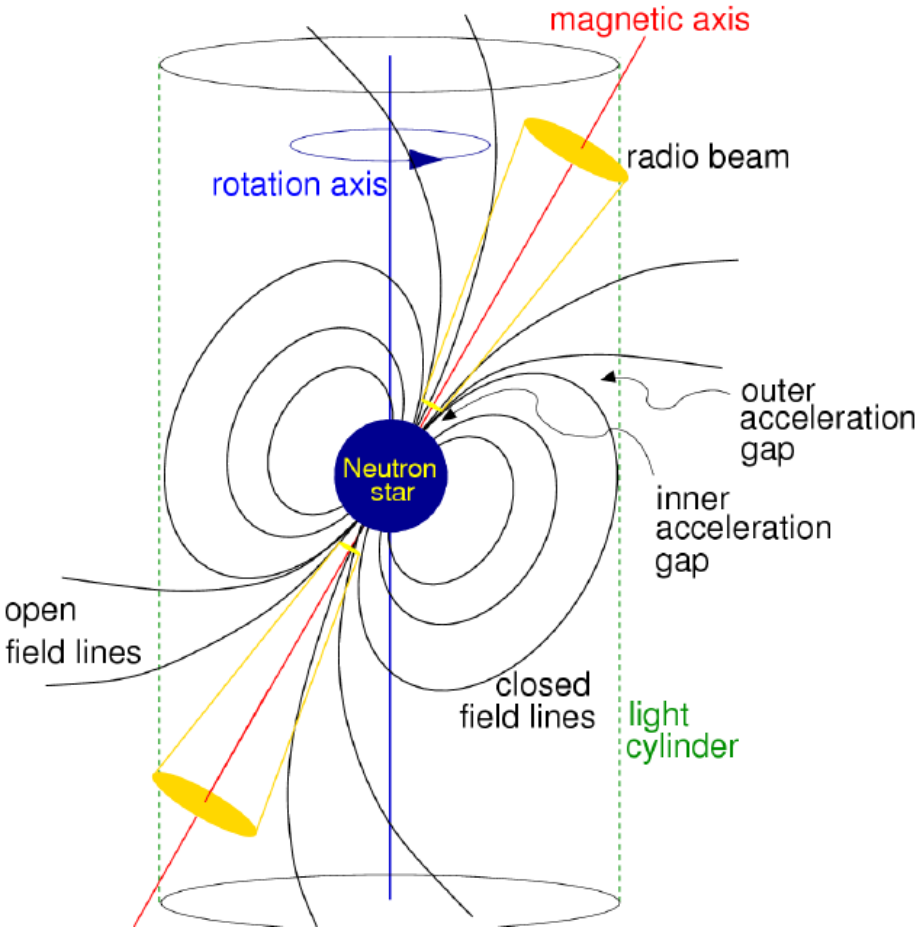


Image credit: *Handbook of Pulsar Astronomy* (Lorimer and Kramer)

Pulsar Timing Arrays

- Currently: ~50 MSPs (IPTA) with 10-100 ns timing residuals
- Detection within current decade plausible

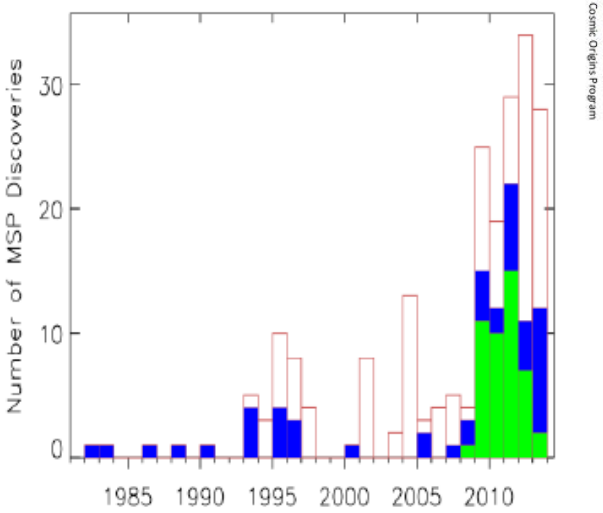
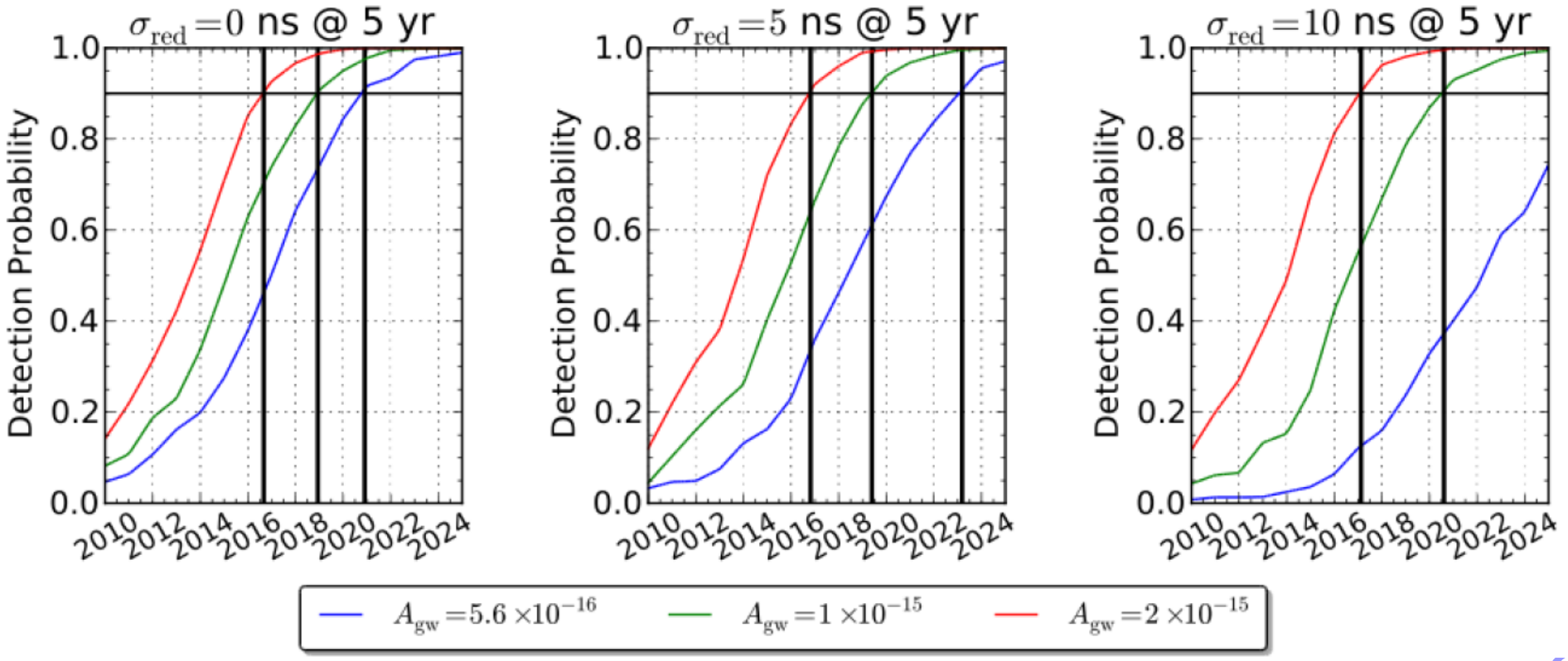


Image credit: NANOGrav



The Gravitational Universe

A science theme addressed by the *eLISA* mission observing the entire Universe

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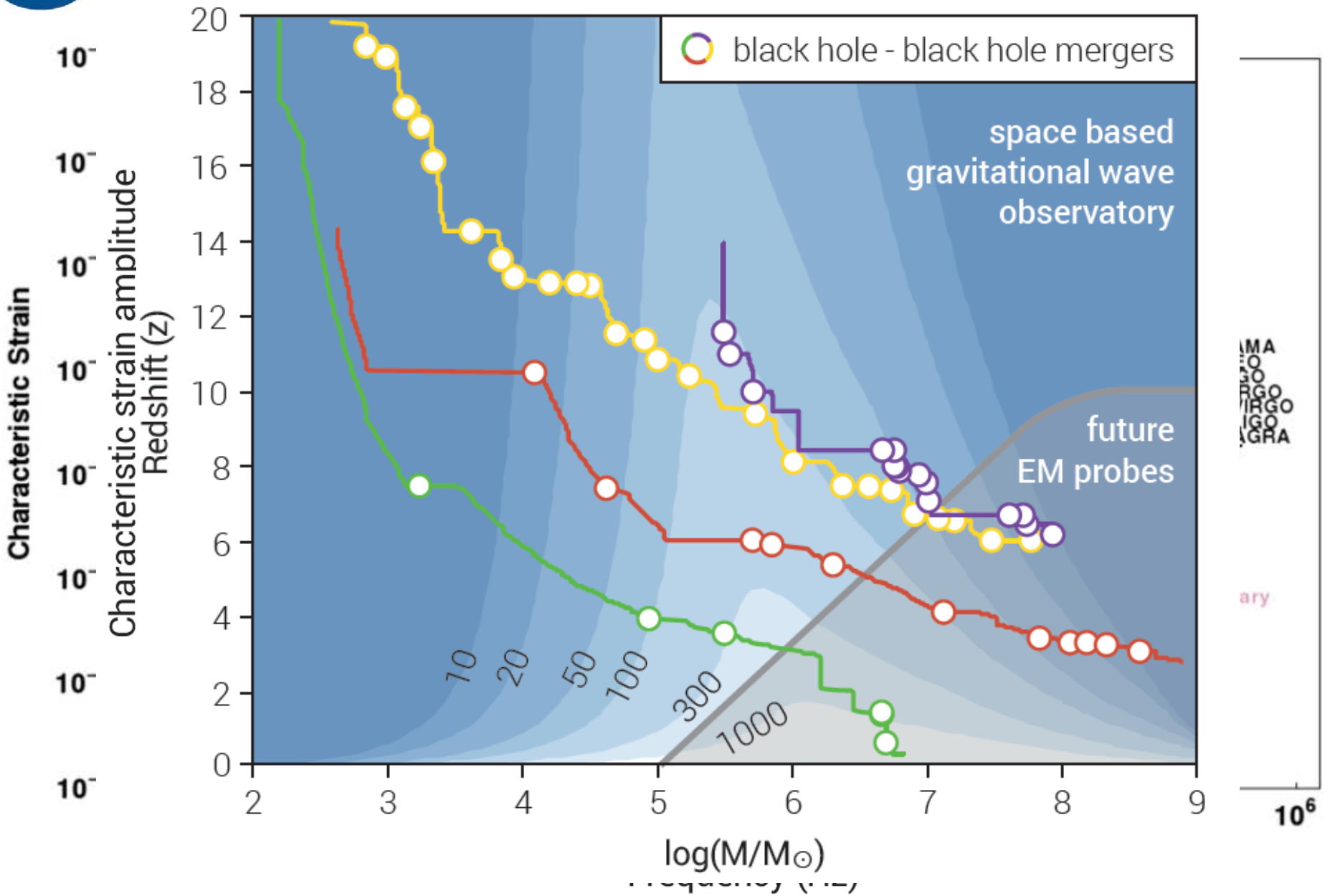
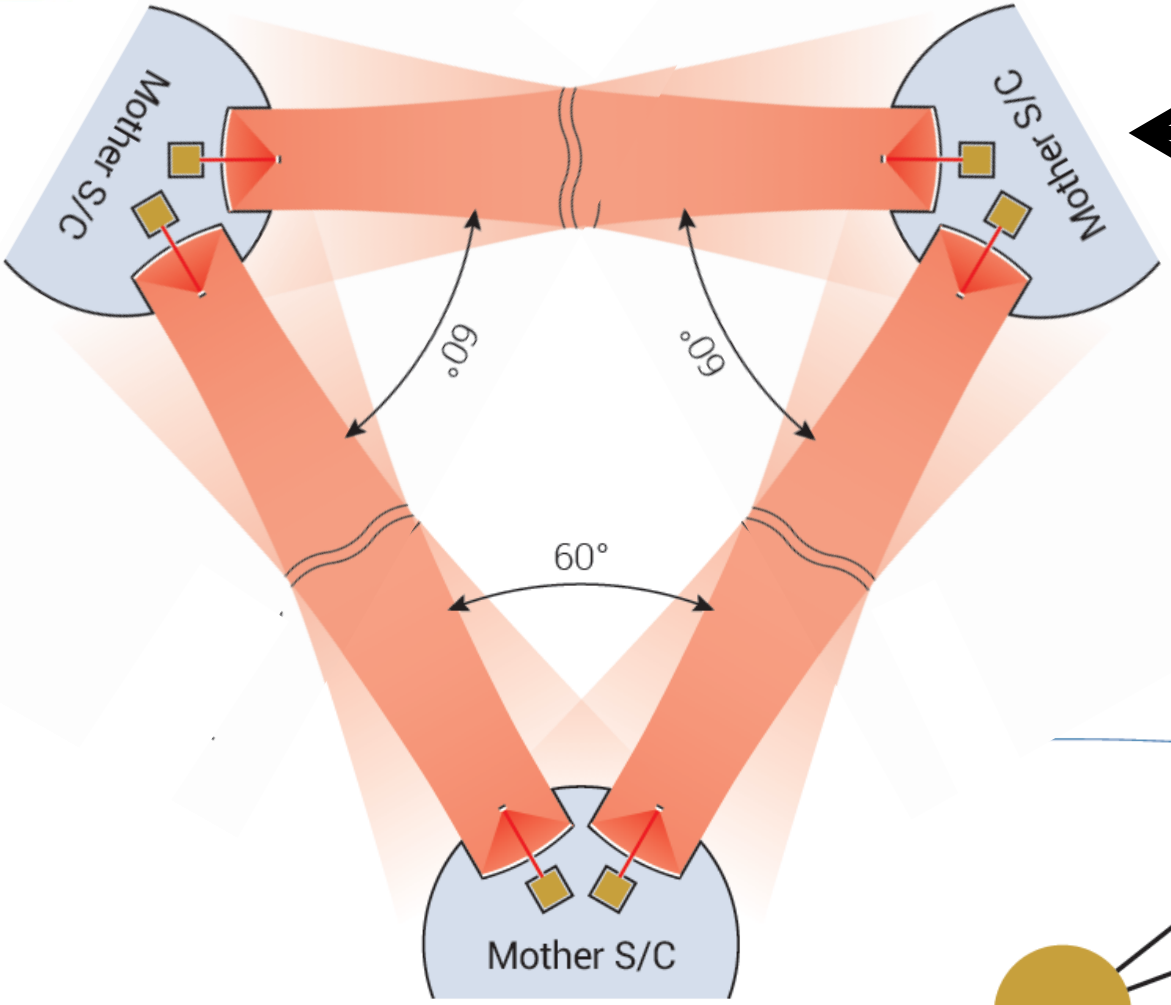
The last century has seen enormous progress in our understanding of the Universe. We know the life cycles of stars, the structure of galaxies, the remnants of the big bang, and have a general understanding of how the Universe evolved. We have come remarkably far using electromagnetic radiation as our tool for observing the Universe. However, gravity is the engine behind many of the processes in the Universe, and much of its action is dark. Opening a gravitational window on the Universe will let us go further than any alternative. Gravity has its own messenger: Gravitational waves, ripples in the fabric of spacetime. They travel essentially undisturbed and let us peer deep into the formation of the first seed black holes, exploring redshifts as large as z ~ 20, prior to the epoch of cosmic re-ionisation. Exquisite and unprecedented measurements of black hole masses and spins will make it possible to trace the history of black holes across all stages of galaxy evolution, and at the same time constrain any deviation from the Kerr metric of General Relativity. eLISA will be the first ever mission to study the entire Universe with gravitational waves. eLISA

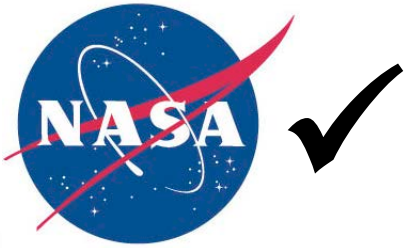
eLISA Science

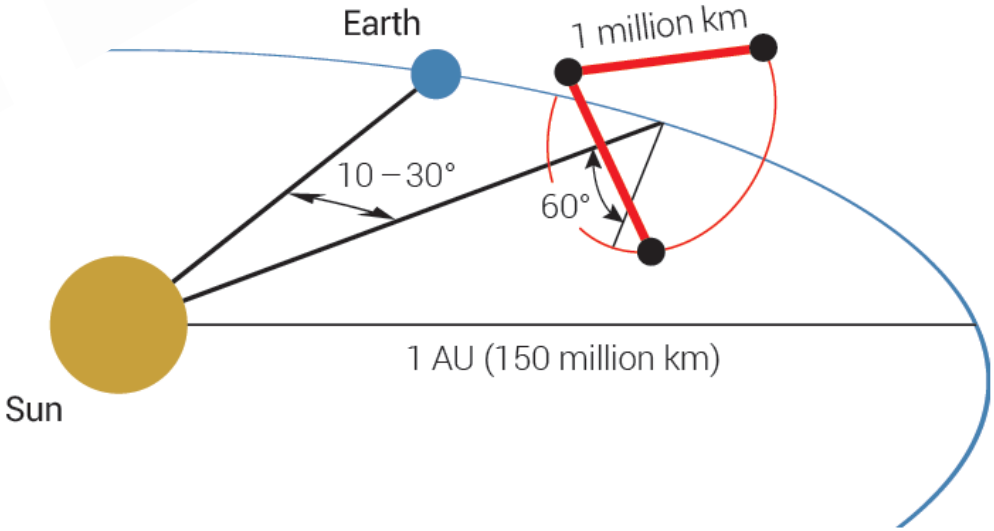


The eLISA Mission



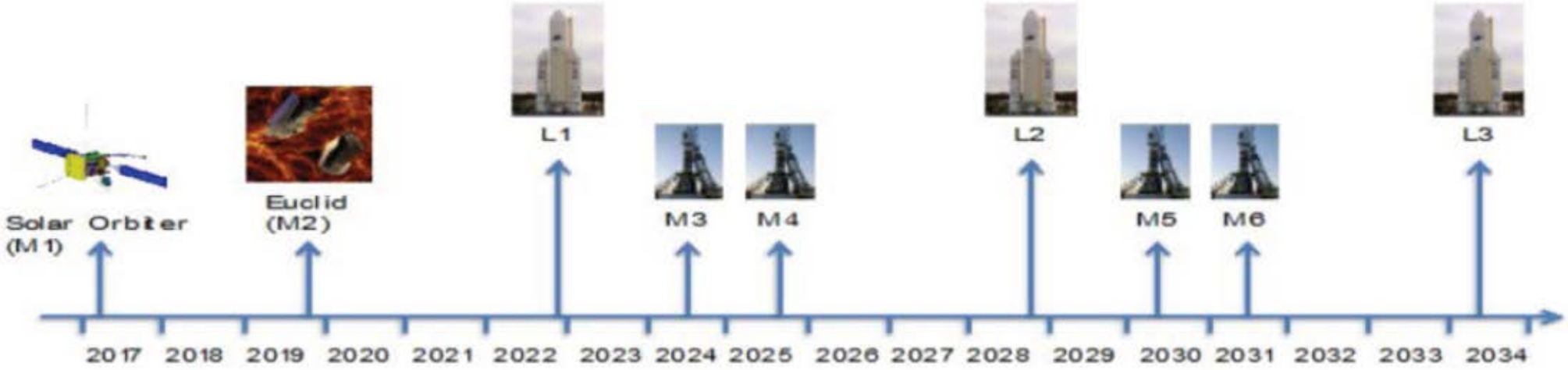
International contribution ;-)



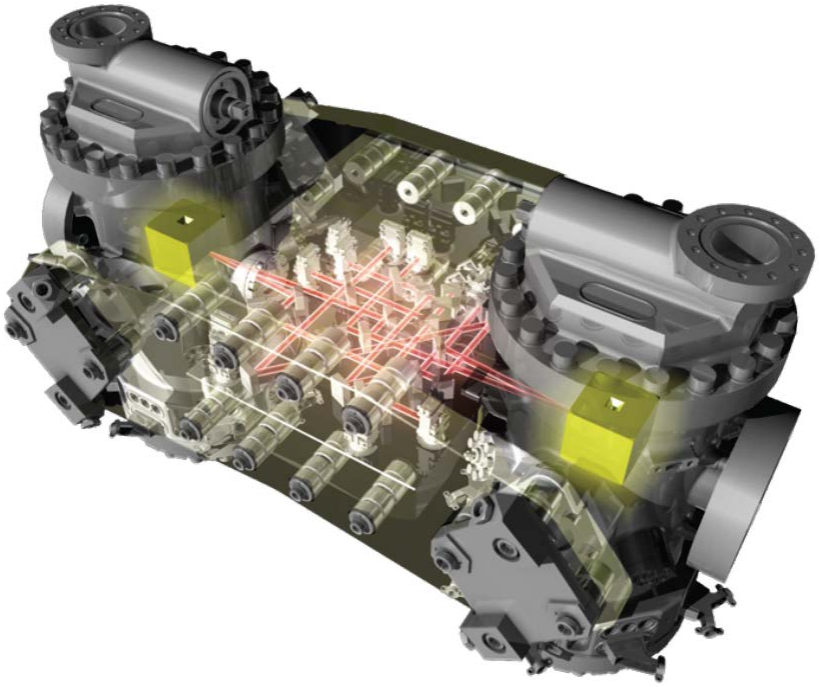


L3 Schedule and Activities

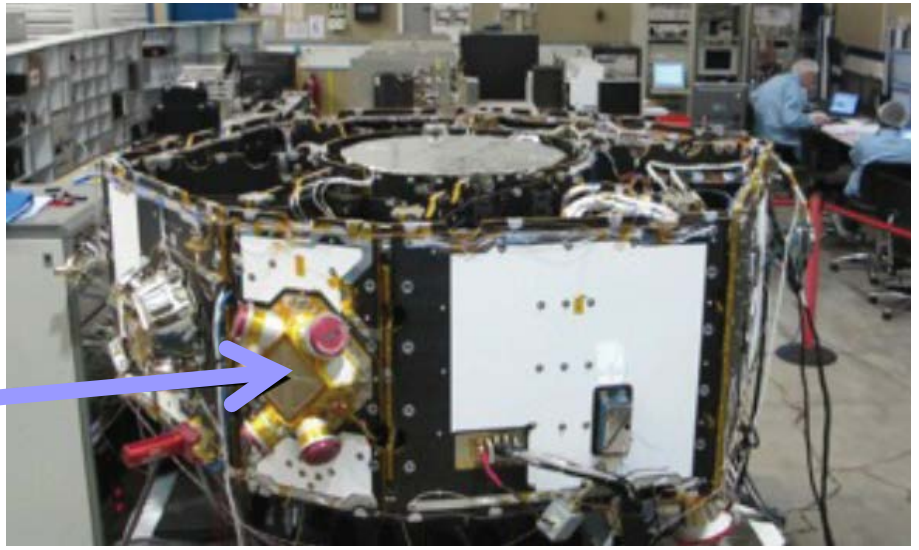
- eLISA system study (Airbus, financed by DLR)
  - System trade-offs & technology roadmap; report out soon
- Gravitational Observatory Advisory Team (GOAT)
  - 3 meetings so far; intermediate report in June
- Selection of mission concept: 2017-2018
- Start EM: 2021-2024
- Start of phase B1: 2026



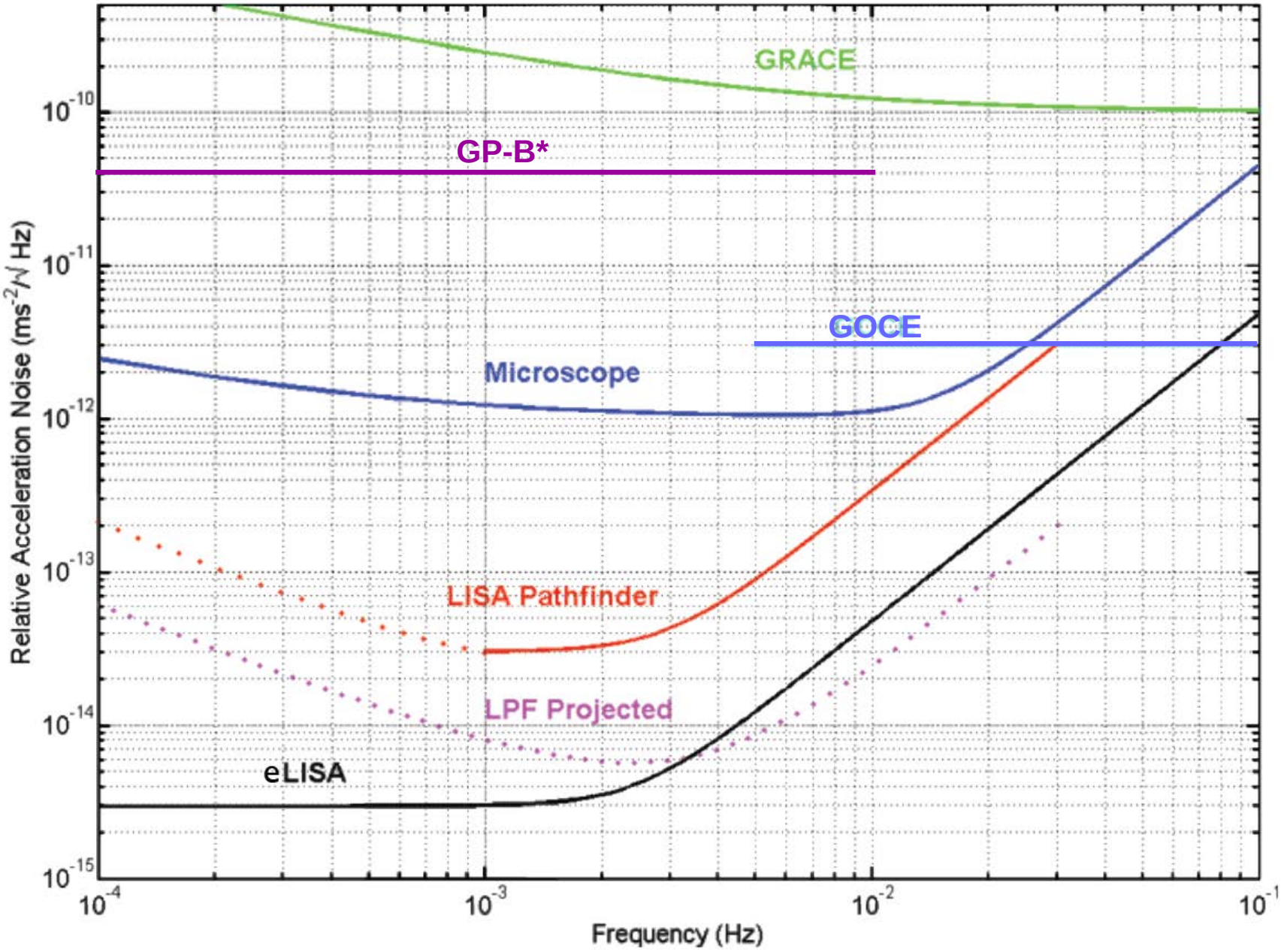
LISA Pathfinder



- Technology goal:
  - $S_a^{1/2} < 3 \times 10^{-14}$ m/s^{2}Hz$^{1/2}$
  - $S_{oms}^{1/2} < 9 \times 10^{-12}$ m/Hz$^{1/2}$
- LISA Technology Package (ESA)
  - Two Gravitational Reference Sensors
  - Local laser interferometers
    - TM-to-TM + TM-to-S/C + …
  - Cold gas propulsion (GAIA)
  - Drag-free control logic
- Space Technology 7 (NASA)
  - Colloid thrusters
  - Drag-free Control logic



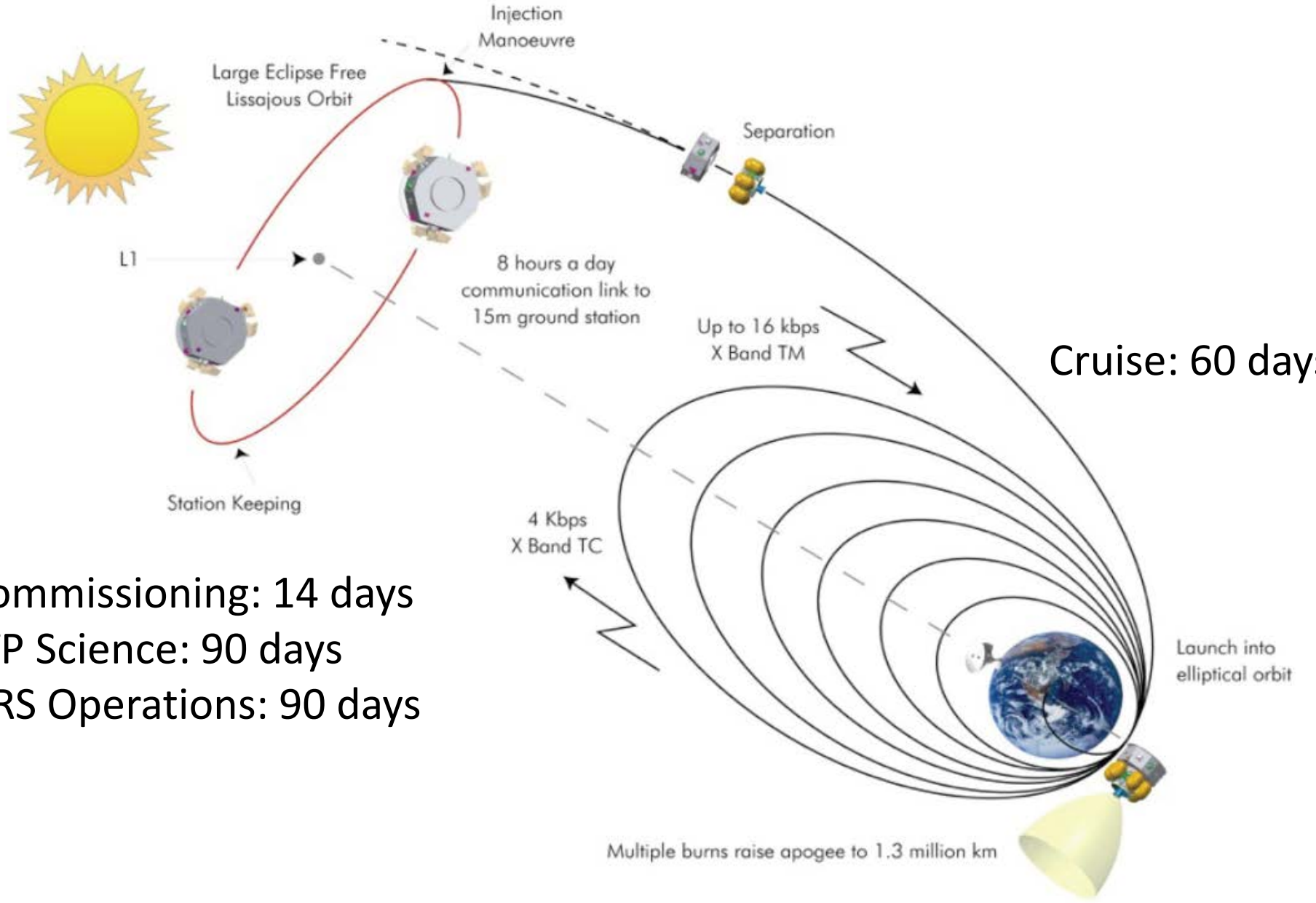
Acceleration Noise Performance



Status of Pathfinder

- Excellent progress towards launch
  - No problems have surfaced
  - Ground ops undergoing extensive tests
- Ready for launch 30 September
  - Celestial mechanics ~2 October

Pathfinder Flight Operations

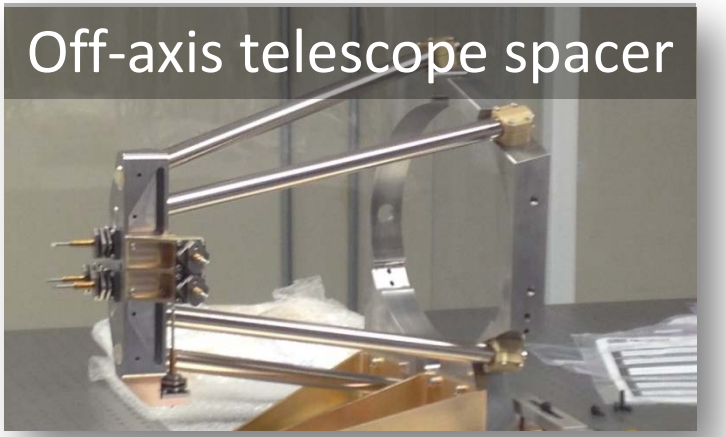


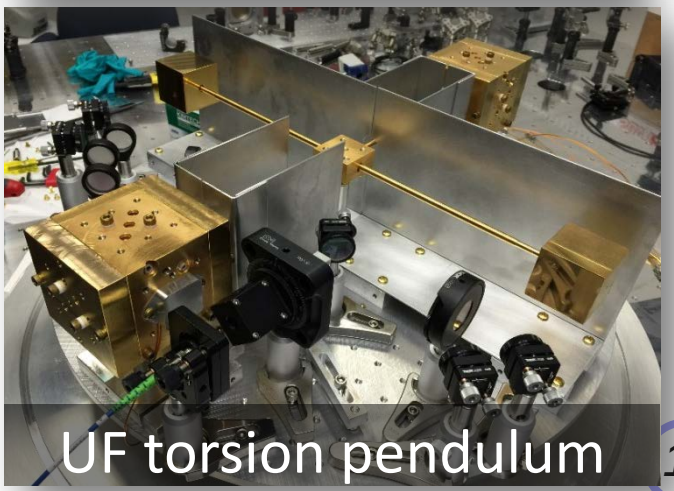
Cruise: 60 days

Commissioning: 14 days
LTP Science: 90 days
DRS Operations: 90 days

U.S. Technology Efforts

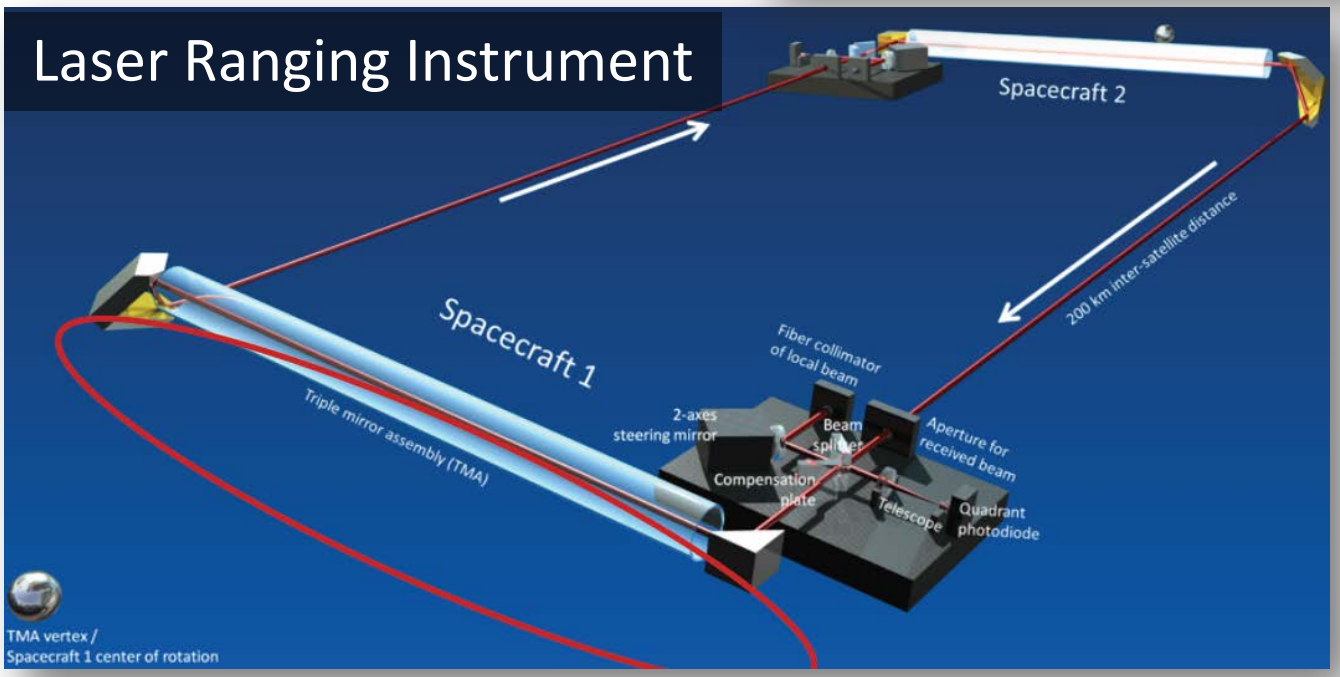
- Telescope (NASA GSFC, J Livas)
  - Prototype off-axis telescope to verify scattered light models
- Laser system (NASA GSFC, J Camp)
  - 2 W ECL in MOPA configuration
- Colloidal thrusters (JPL, J Zeimer)
- Phasemeter (JPL, W. Klipstein)
- Novel optical bench (UF, G Mueller)
- GRS technologies (UF, J Conklin)
  - Torsion pendulum facility: < 10^{-12} m/s^{2}Hz$^{1/2}$
- AI GW observatory technology (Stanford, J Hogan, M Kasavich)





GRACE Follow-on

- Joint NASA-DLR Earth geodesy mission
- Launch in 2017
- First satellite-to-satellite laser interferometer demonstration
- Borrows tech developed for LISA



Future Activities

- Paul Hert'z charge to the PAGs re large missions in 2020s
  - GWSIG meting held this past Saturday
  - June 29-July 1, 2015, HEAD meeting: L & M Space Missions
  - August 2015, IAU-AAS meeting in Honolulu
  - Multiple Virtual Town Hall meetings, TBD
- LISA Pathfinder (Fall 2015)!
- eLISA ramping up

- Email list: http://pcos.gsfc.nasa.gov/sags/gwsag/gwsag-maillist.php