GWSIG Update

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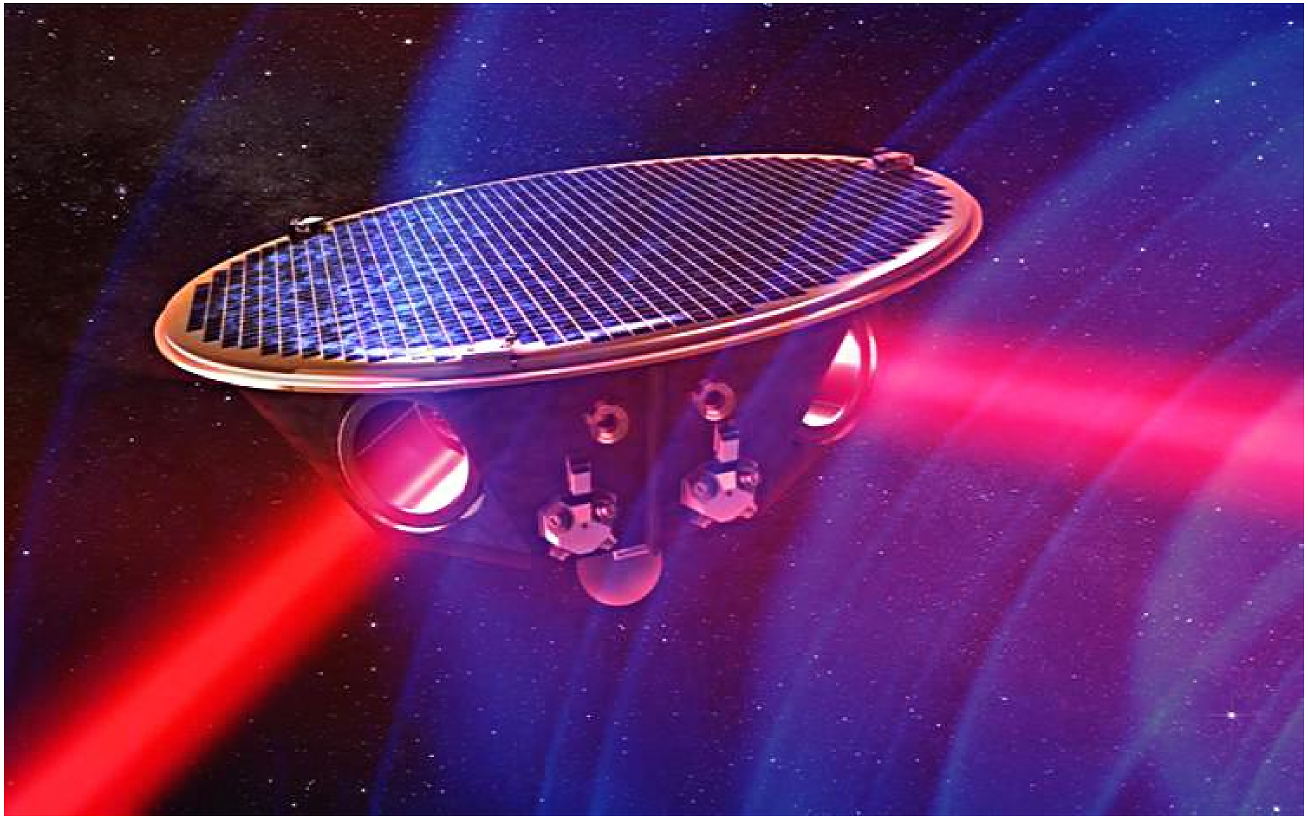
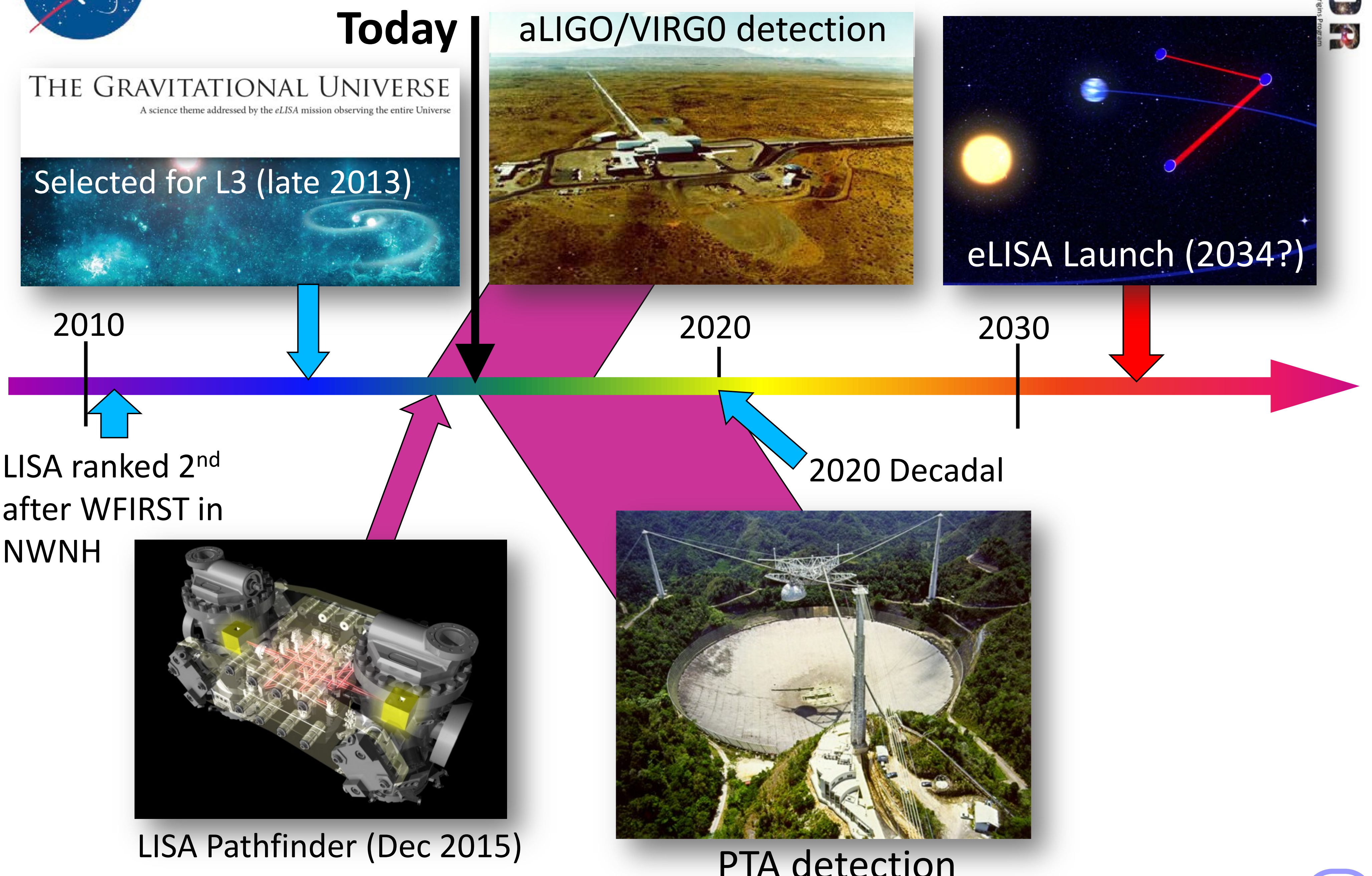
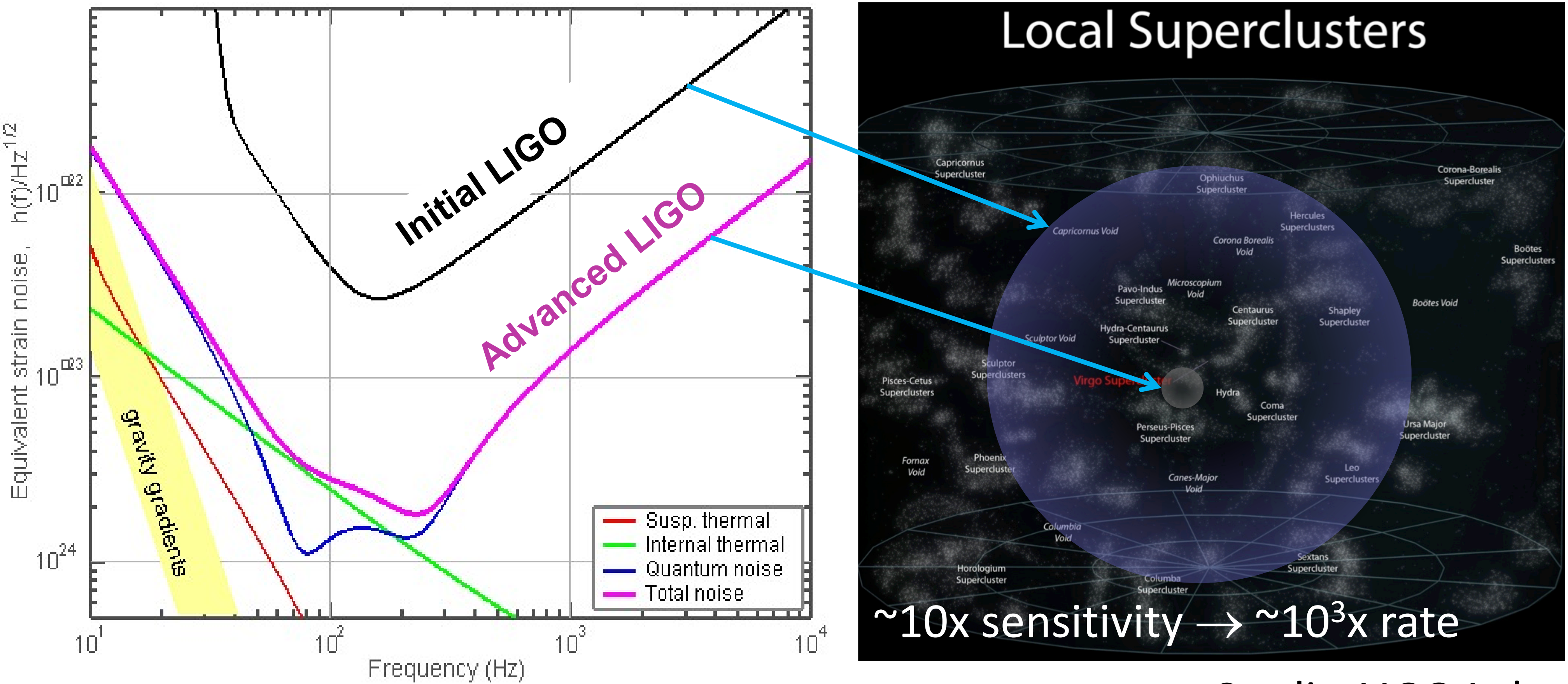


The Gravitational Wave Decade



Advanced LIGO

- A 2^{nd} generation detector
- Advanced LIGO construction completed on-time & on-budget



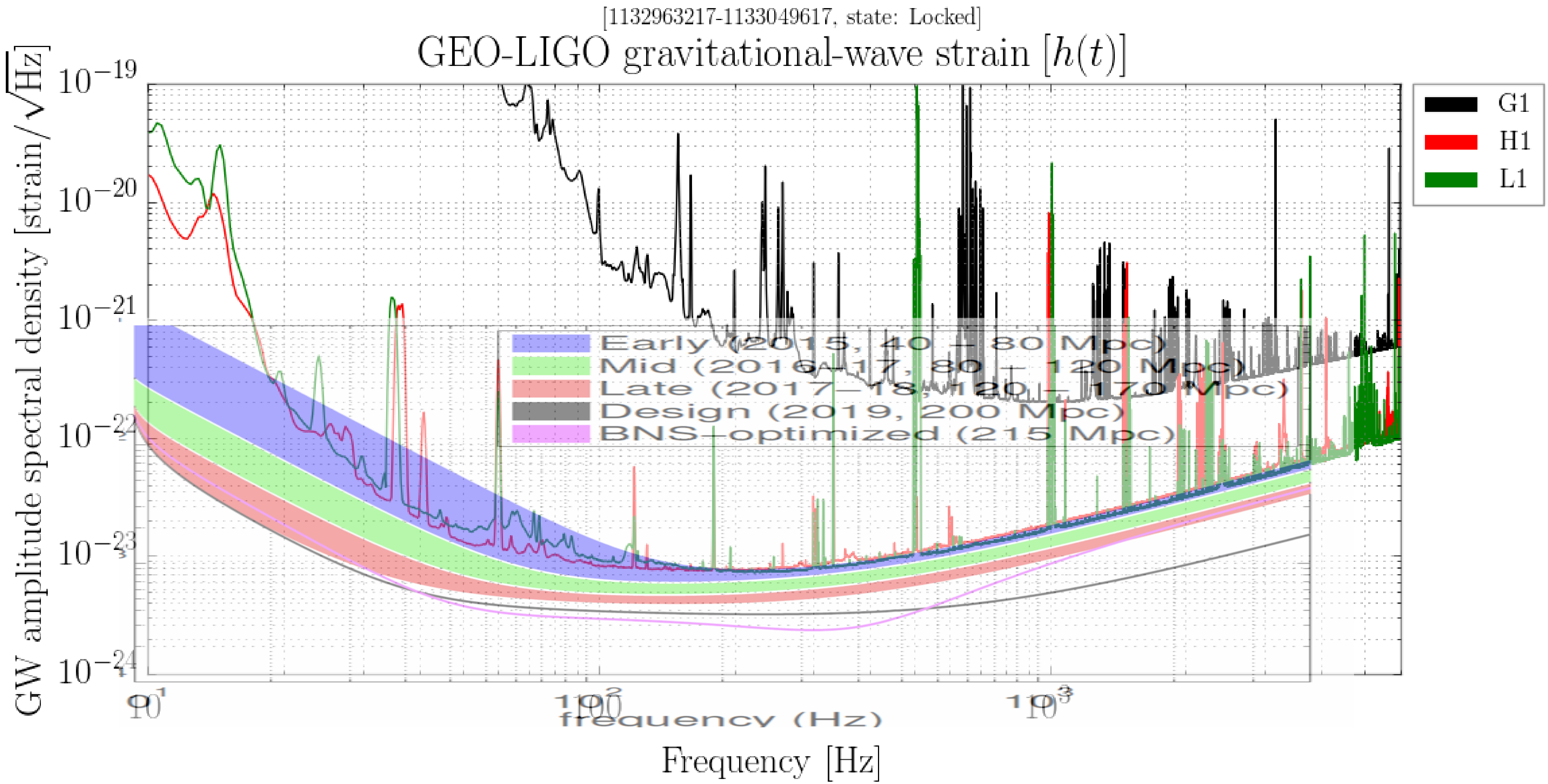
Credit: LIGO Lab

BNS Range versus Date

Epoch	Estimated Run Duration	$E_{GW} = 10^{-2} M_{\odot} c^2$ Burst Range (Mpc) LIGO	Virgo	BNS Range (Mpc) LIGO	Virgo	Number of BNS Detections	% BNS Localized within 5 deg^2	20 deg^2
2015	3 months	40 – 60	–	40 – 80	–	0.0004 – 3	–	–
2016–17	6 months	60 – 75	20 – 40	80 – 120	20 – 60	0.006 – 20	2	5 – 12
2017–18	9 months	75 – 90	40 – 50	120 – 170	60 – 85	0.04 – 100	1 – 2	10 – 12
2019+	(per year)	105	40 – 80	200	65 – 130	0.2 – 200	3 – 8	8 – 28
2022+ (India)	(per year)	105	80	200	130	0.4 – 400	17	48

Table 1: Summary of a plausible observing schedule, expected sensitivities, and source localization with the advanced LIGO and Virgo detectors, which will be strongly dependent on the detectors' commissioning progress. The burst ranges assume standard-candle emission of $10^{-2} M_{\odot} c^2$ in GWs at 150 Hz and scale as $E_{GW}^{1/2}$. The burst and binary neutron star (BNS) ranges and the BNS localizations reflect the uncertainty in the detector noise spectra shown in Fig. 1. The BNS detection numbers also account for the uncertainty in the BNS source rate density [28], and are computed assuming a false alarm rate of $10^{-2}\,\mathrm{yr}^{-1}$. Burst localizations are expected to be broadly similar to those for BNS systems, but will vary depending on the signal bandwidth. Localization and detection numbers assume an 80% duty cycle for each instrument.

Snapshot: 01 Dec 2015



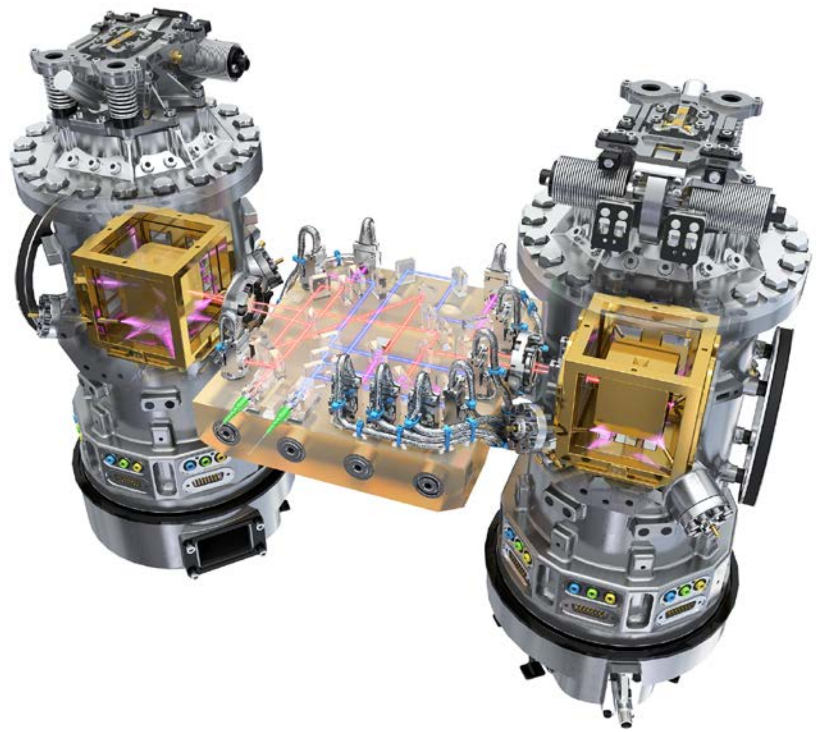
Credit: LIGO Lab

Advanced LIGO Observations

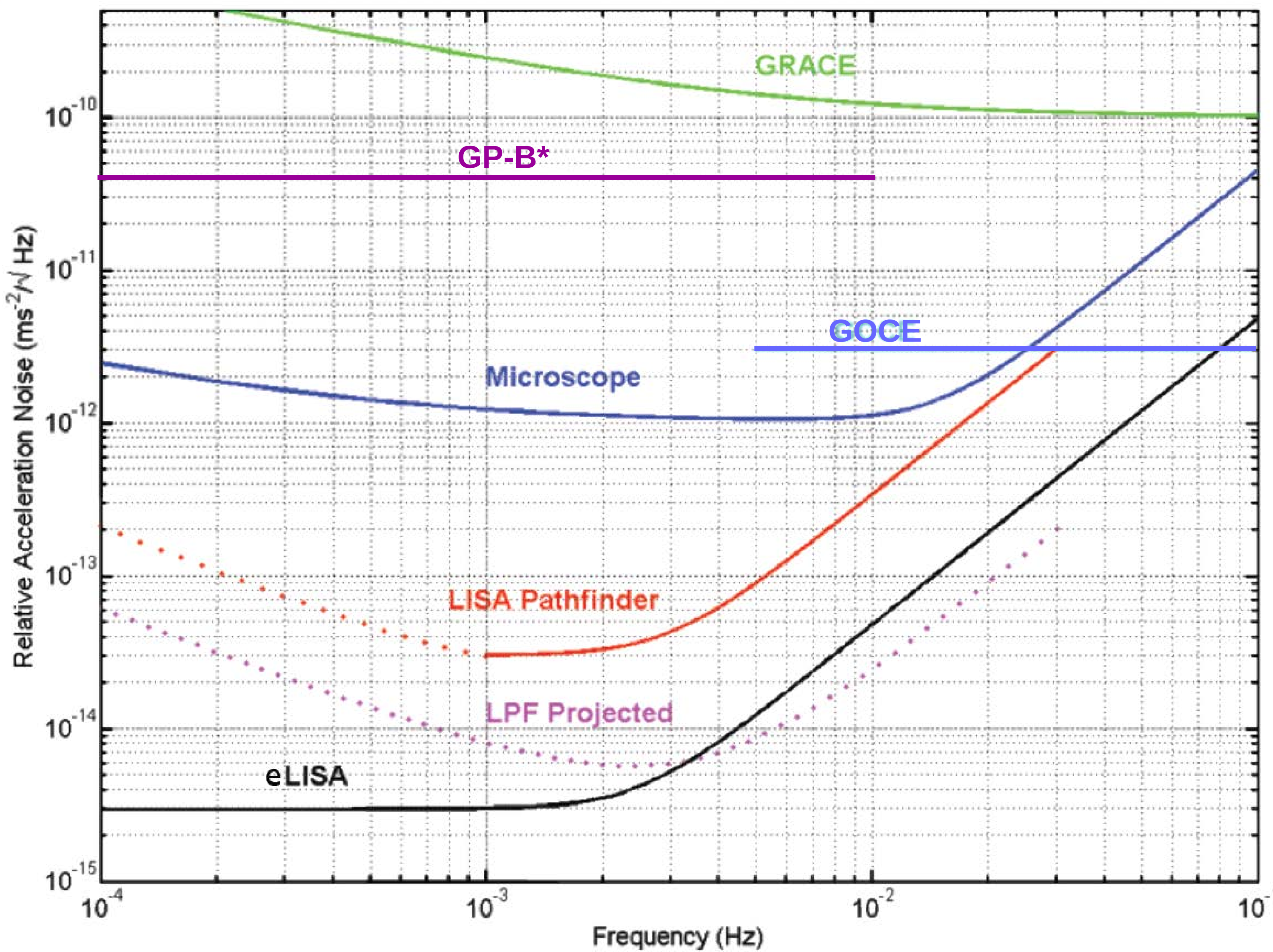
- O1 will run through 12 January 2016
- Sensitivity near the upper end of the prediction from 2013
- After O1, planned period of commissioning, improvements
  - Focus will be on improving mid- to low-frequency performance
- Plan to begin a longer run O2 at sensitivity ~ 100+ Mpc
  - Start: Fall of 2016
- Virgo should be able to join O2
  - 3rd node in network is critical for localization

LISA Pathfinder

- Technology goal:
  - $S_a^{1/2} < 3\times10^{-14}$ m/s²Hz$^{1/2}$
  - $S_{oms}^{1/2} < 9\times10^{-12}$ 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



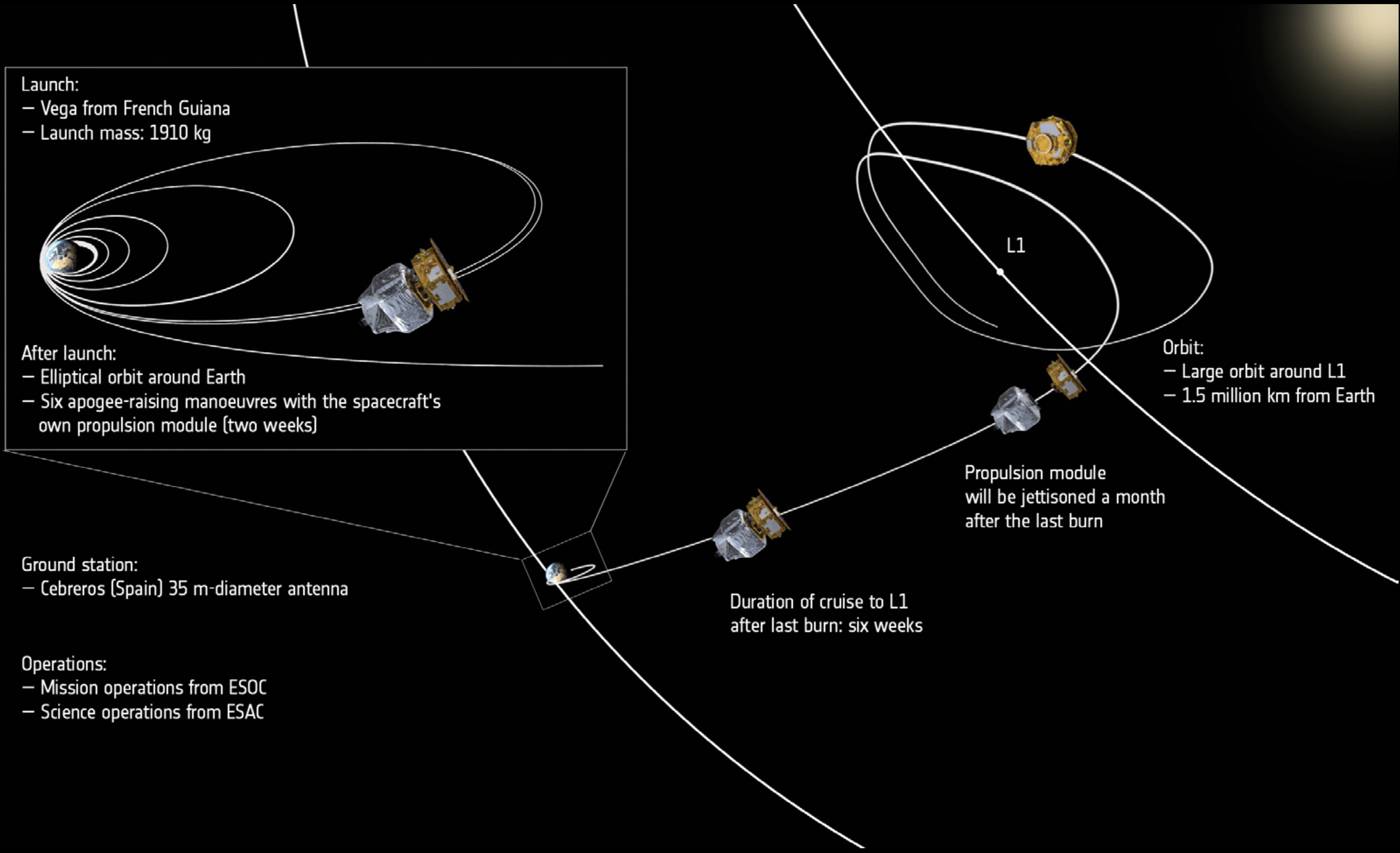
Acceleration Noise Performance



Preparing for Launch

Pathfinder Launch: 2/3 December 2016

Journey to L1



LISA Pathfinder Operations

- Dec 7-11: Apogee-raising burns
- Dec 12: Trajectory trim
- Dec 17-20: Cold Gas Thruster Commissioning
- Jan 2-10: CMNT Commissioning
- Jan 11: LTP Commissioning Begins
- Jan 22: Propulsion module separation
- mid-Feb: Test Mass release
- Feb 28: LTP Commissioning Ends
- Mar 3rd: In-orbit Commissioning Review
- Mar-June: LTP Operations
- Late June: DRS Commissioning
- June-Sept: DRS Operations
- > Sept: Extended Mission / Joint Operations ?

Physics of the Cosmos Program

Cosmic Origins Program

The Gravitational Universe

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

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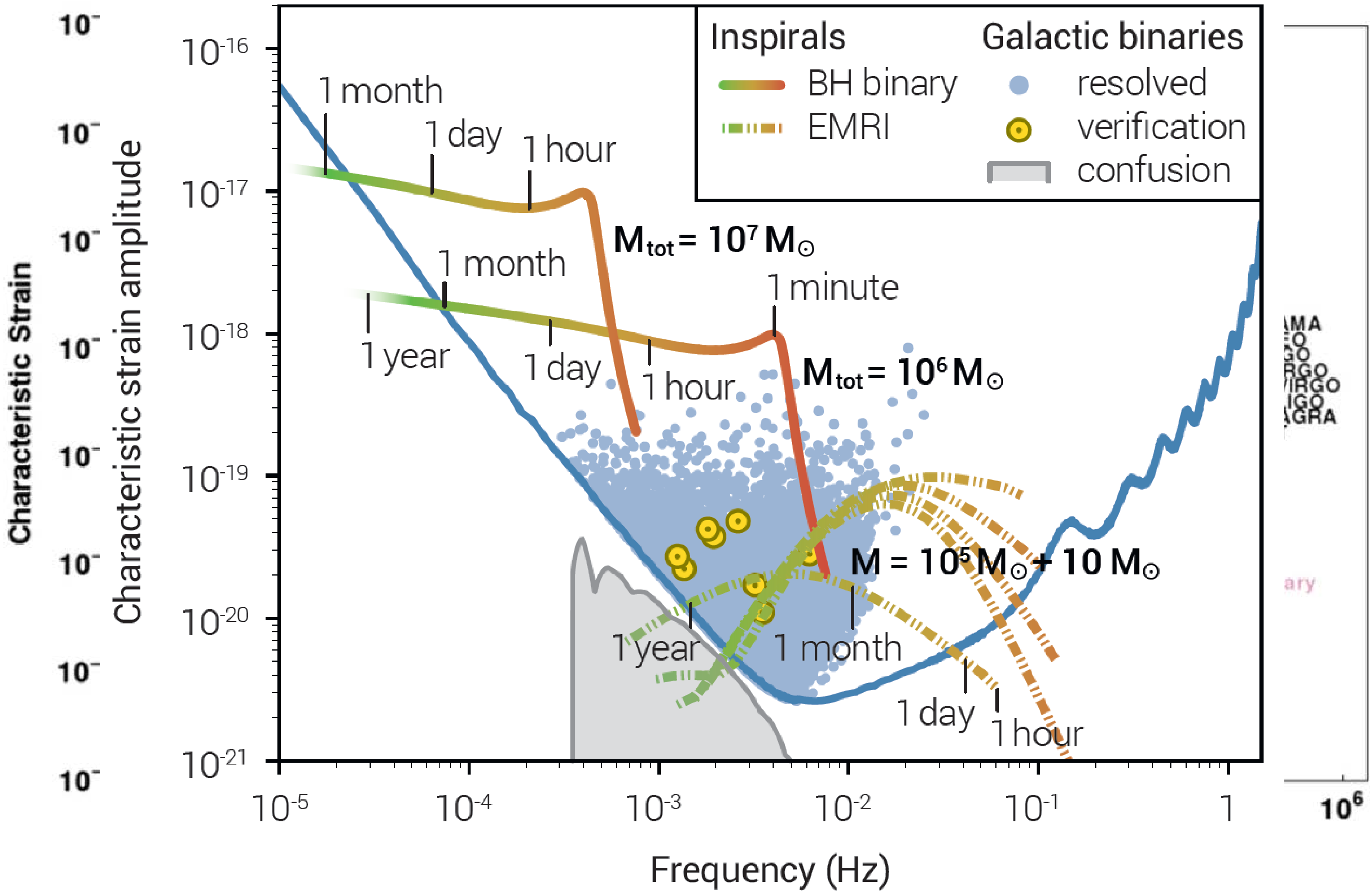
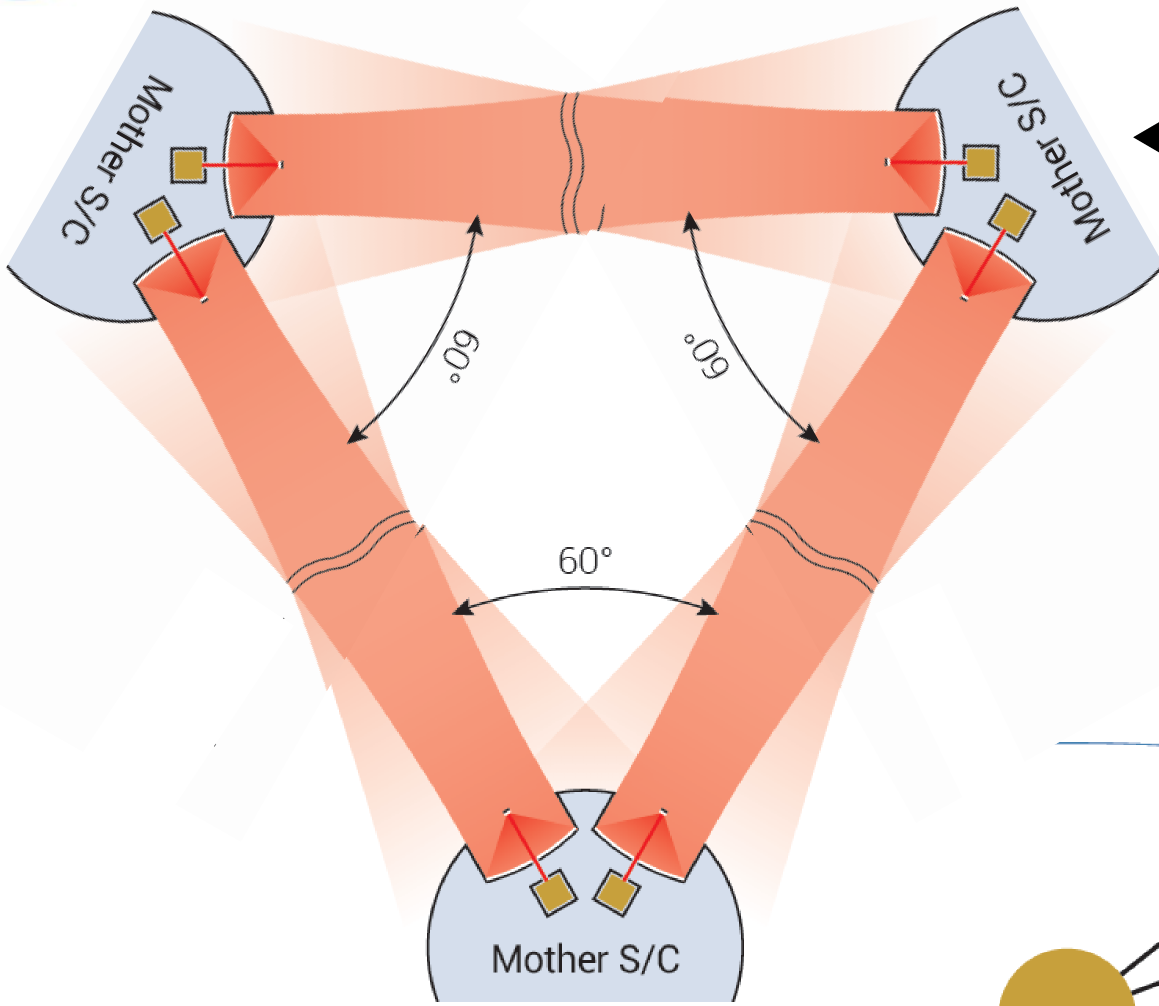
The last century has seen enormous progress in our understanding of the Universe. We know the life cycles of stars, the structure of galaxies, the remnants of the big bang, and have a general understanding of how the Universe evolved. We have come remarkably far using electromagnetic radiation as our 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

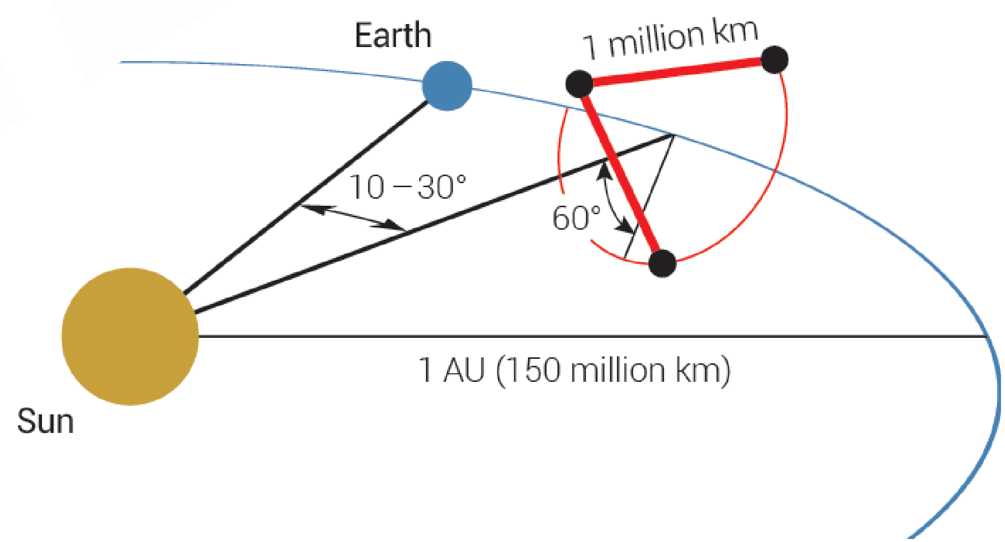
eLISA Science



The eLISA Mission



International contribution ;-)



L3 Schedule and Activities

- Gravitational Observatory Advisory Team (GOAT)
  - Started October 2014 → Final report ~April 2016
- ESA solicited interest from Member States in November 2015
- NASA is continuing technology development support; ESA restarting technology development
- Selection of mission concept: 2017-2018
- Phase A: 2017
- Engineering Model: ~2019-2024

NASA L3 Study

- The L3 Study is:
  - Realization of the study promised in the plan for NWNH
  - The study endorsed by the GWSIG, the PhysPAG and the Astrophysics Subcommittee
- Purposes of the study:
  - Phase 1: Advise Paul Hertz in his negotiations with ESA on a NASA role in L3
  - Phase 2: Prepare a proposal to 2020 decadal for NASA's role in L3
- Received ~30 responses to DCL
- Will select ~15 researchers + Ex-officio ESA observer

- BTW: 2020 Decadal Survey likely to begin late 2018 / early 2019

L3 Study Team (L3ST) Org.

- HASA HQ
  - Dr. Paul Hertz, Director, Astrophysics Division
  - Dr. Rita Sambruna, L3 Program Scientist
  - L3 Deputy Program Scientist - Dr. Wilt Sanders
  - L3 Program Executive - Dr. Shahid Habib
- Physics of the Cosmos Program Office
  - PCOS Chief Scientist - Dr. Ann Hornschemeier-Cardiff (GSFC)
  - PCOS Deputy Chief Scientist - Dr. Peter Bertone (MSFC)
  - Study Manager - Steve Horowitz
  - Study Scientist – Tuck Stebbins
- L3ST
  - Mix of instrumentalists, astrophysicists and relativists/data analysts

L3 Study Timeline

- Dear Colleague Letter soliciting nominations: 7 December
- Charter released: 7 December
  - Draft is focused on the first of two phases
  - Charter will be revised/extended for the second phase.
- Deadline for nominations: 21 December
- Selections announced: ~next week
- Phase 1 - FY16-17: Analyze the options for NASA participation in the L3 & work with the eLISA consortium on proposals to ESA
  - Hardware contributions, Science Team, Data Center, GO program, ...
- Phase 2 - FY17-18: Prepare report for 2020 decadal survey on NASA's participation in L3 as a minority partner
  - Science case, technical readiness, cost, risk; Details TBD

Future Meetings

- GWSIG meeting @ April APS Salt Lake City, UT — 16-19 April 2016
  - Neil Cornish
  - Martin Hewitson
- 11th LISA Symposium Zurich — 5-9 September 2016
- Email list: http://pcos.gsfc.nasa.gov/sags/gwsag/gwsag-maillist.php