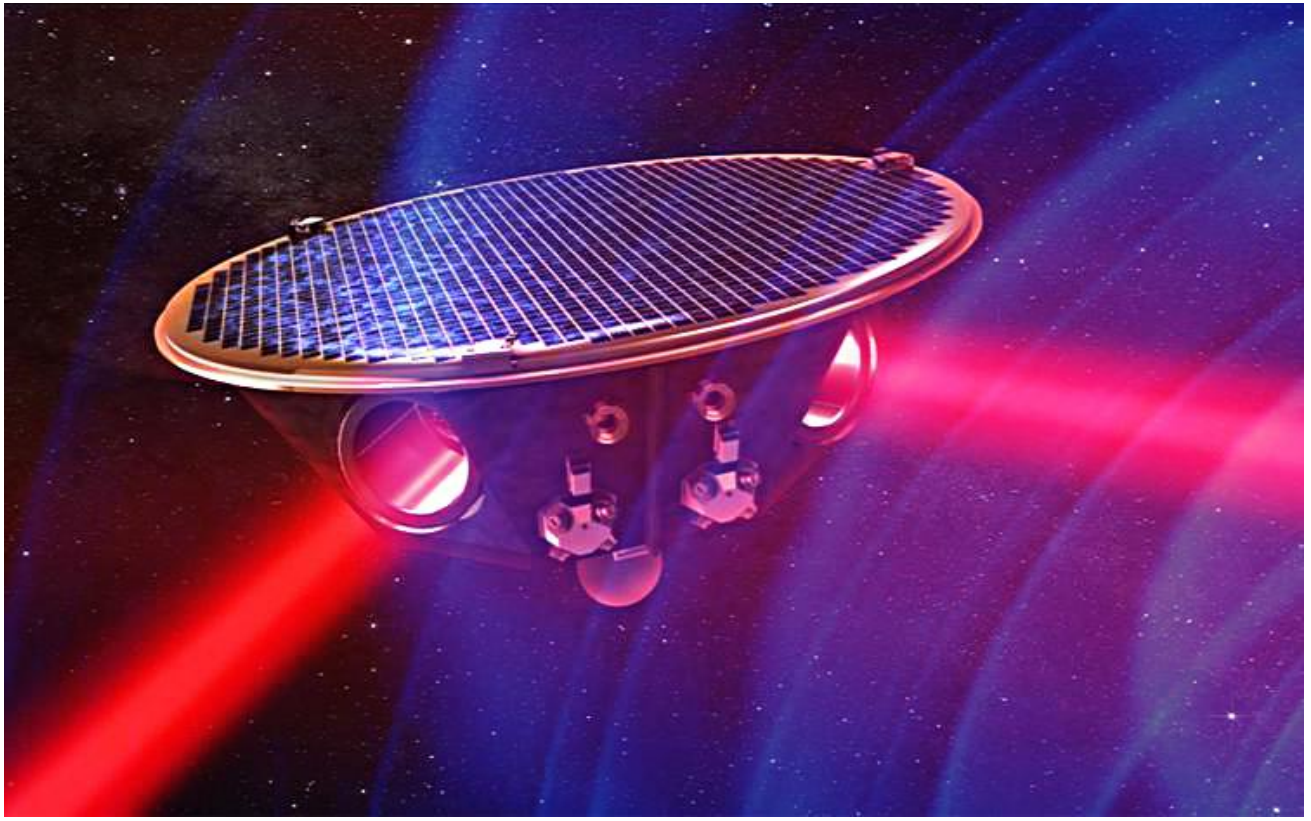
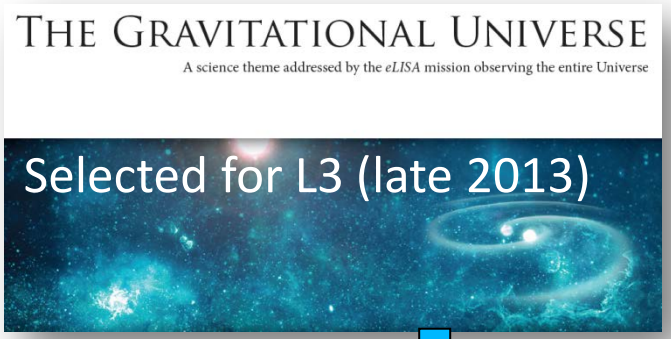
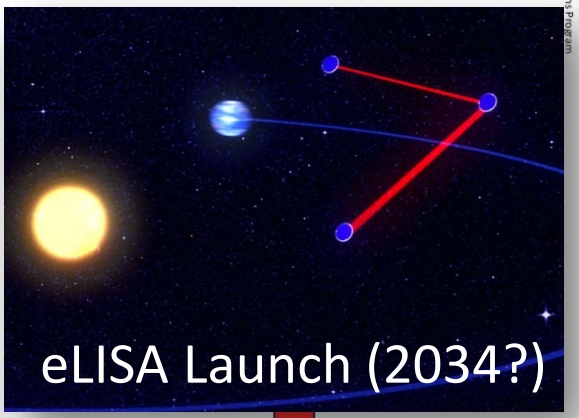
Gravitational Wave Observation from Space

John W. Conklin
University of Florida, jwconklin@ufl.edu

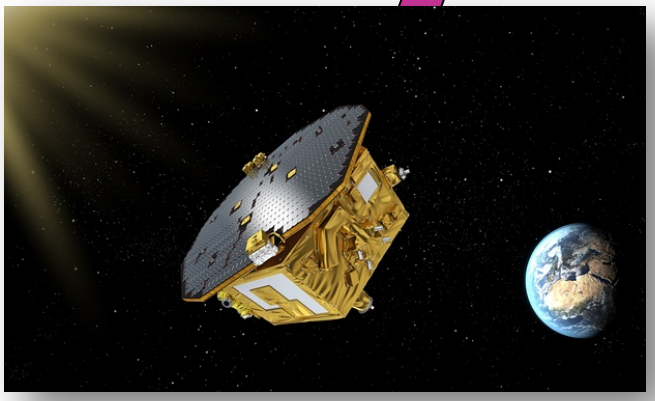


The Gravitational Wave Decade





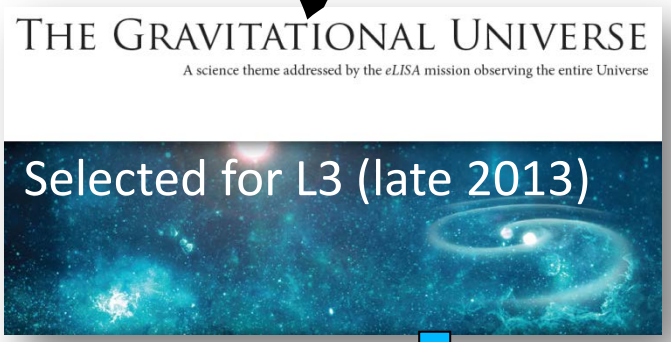
2010 2020 2030

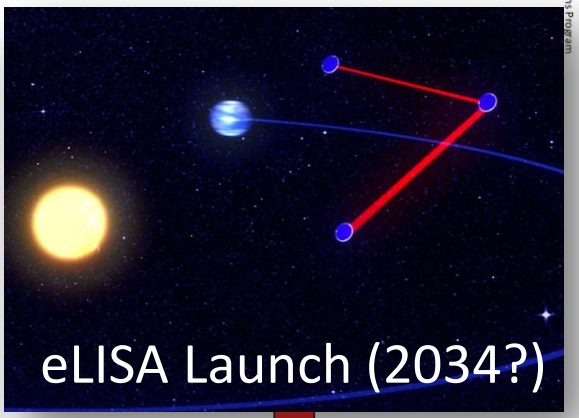


LISA Pathfinder (Dec 2015)

PTA detection

The Gravitational Wave Decade





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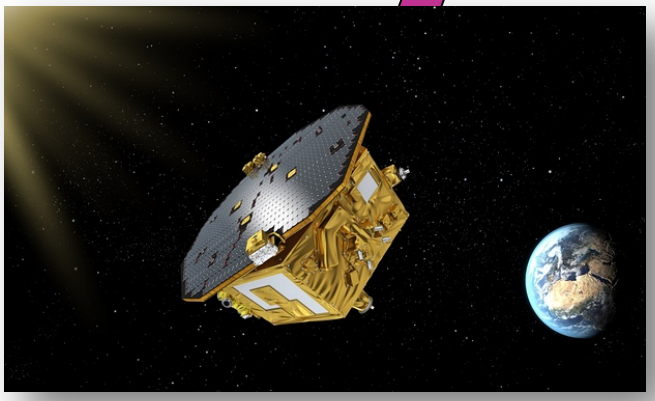
2020

2030



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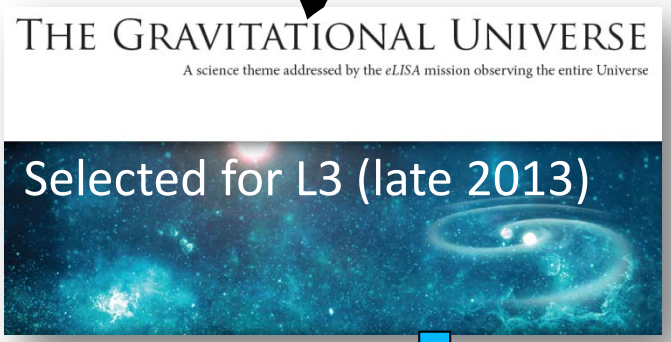

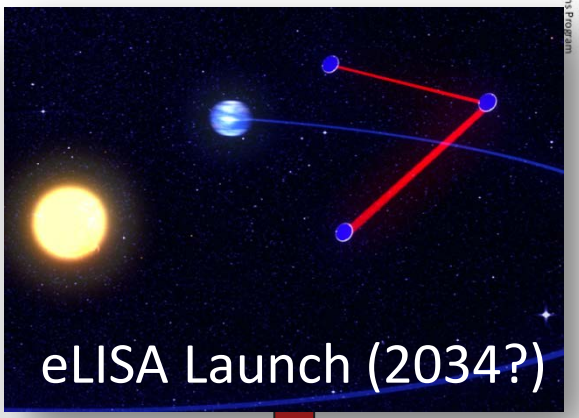

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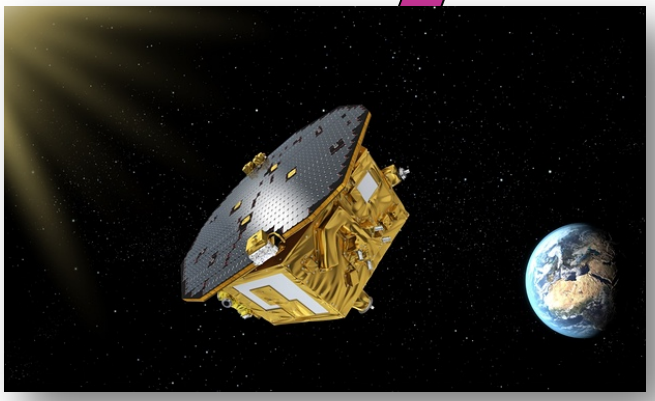

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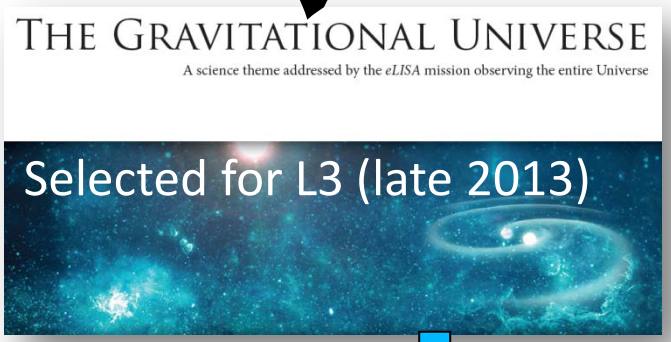

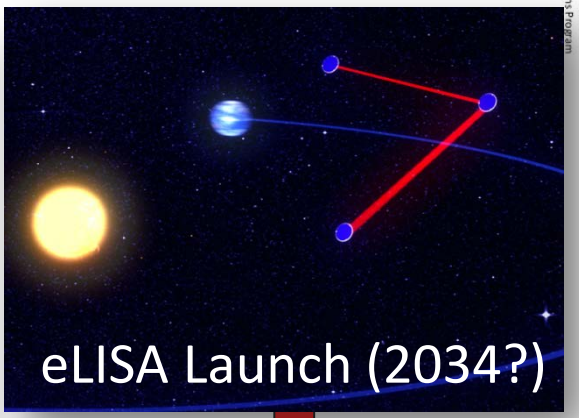

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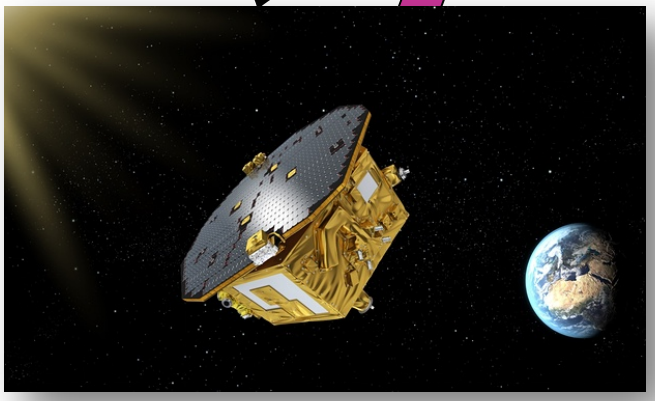
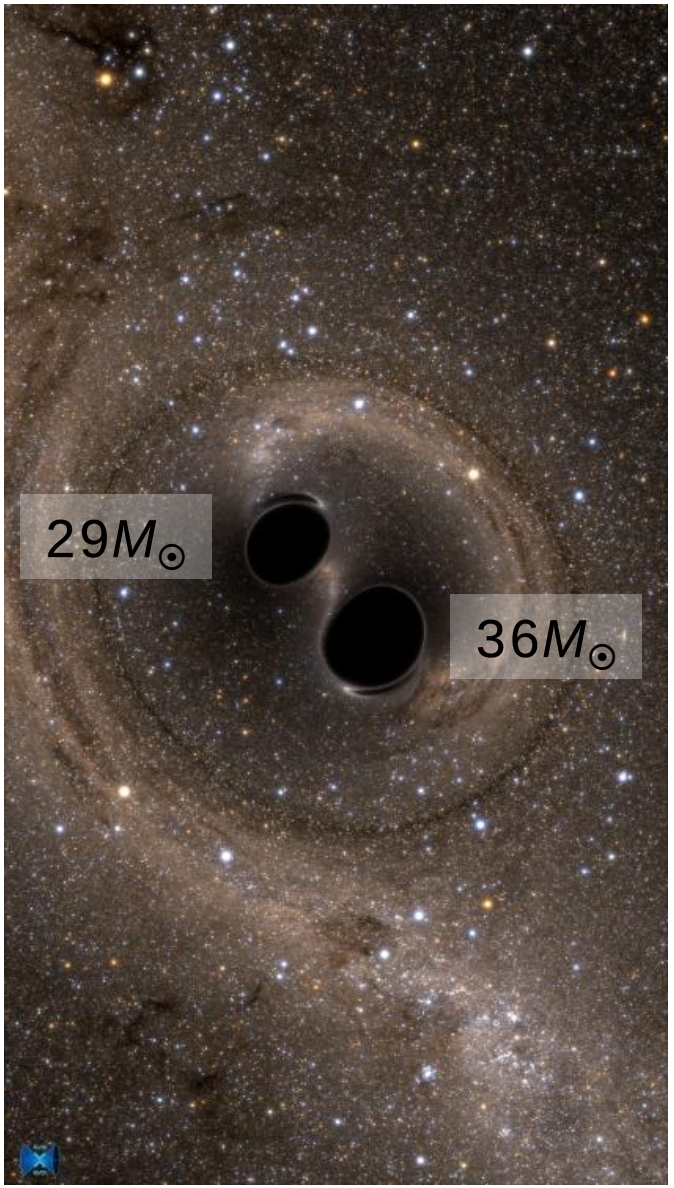


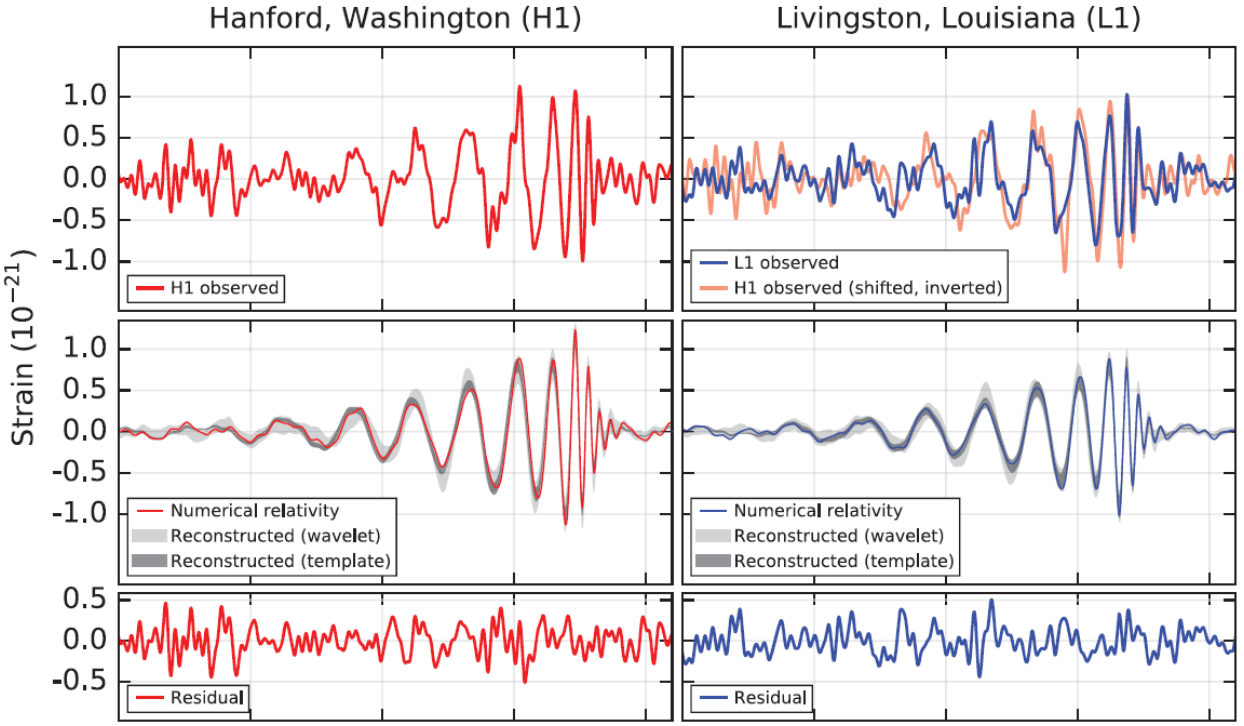
LISA Pathfinder (Dec 2015)

PTA detection

GW150914

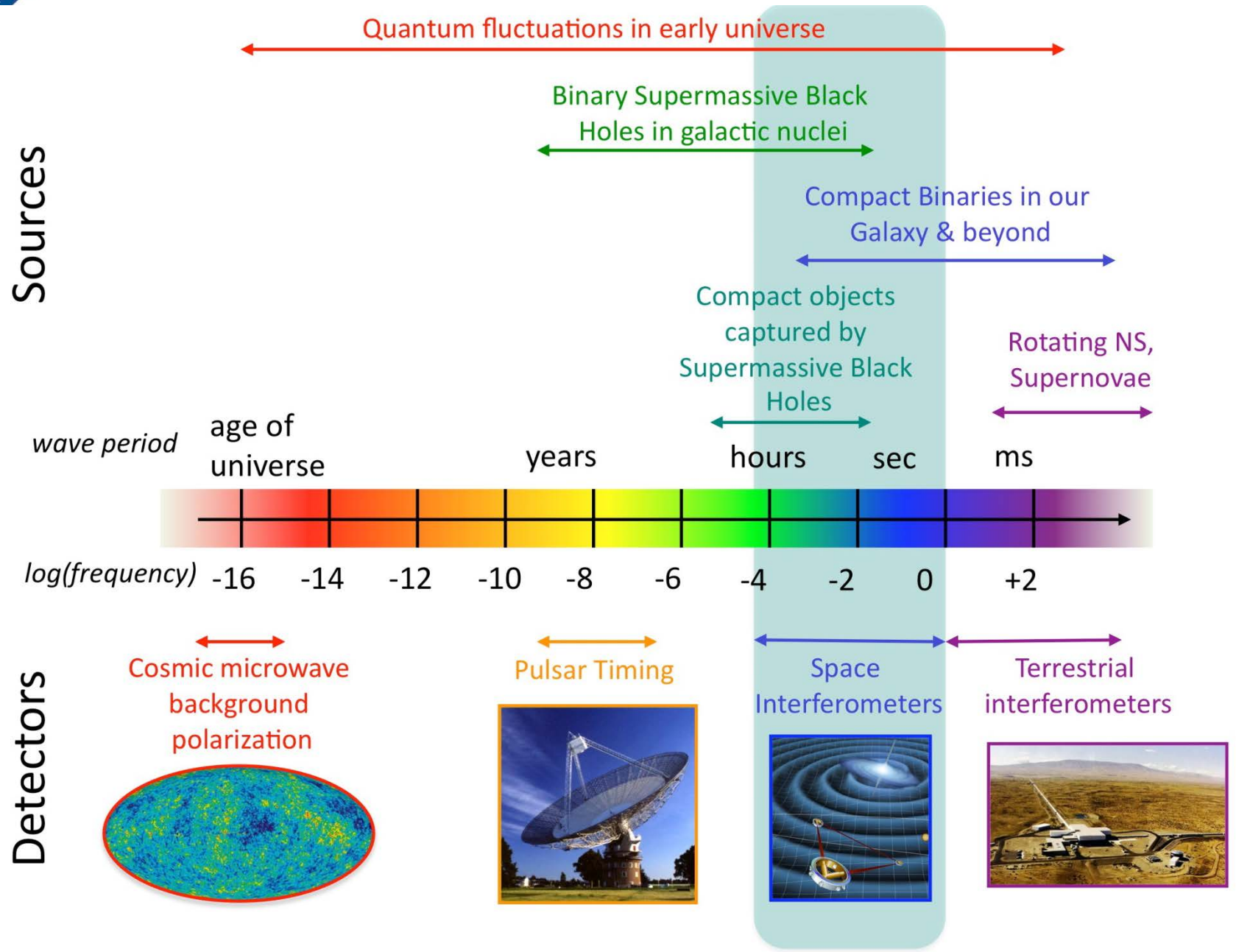
[PRL **116**, 061102 (2026)]





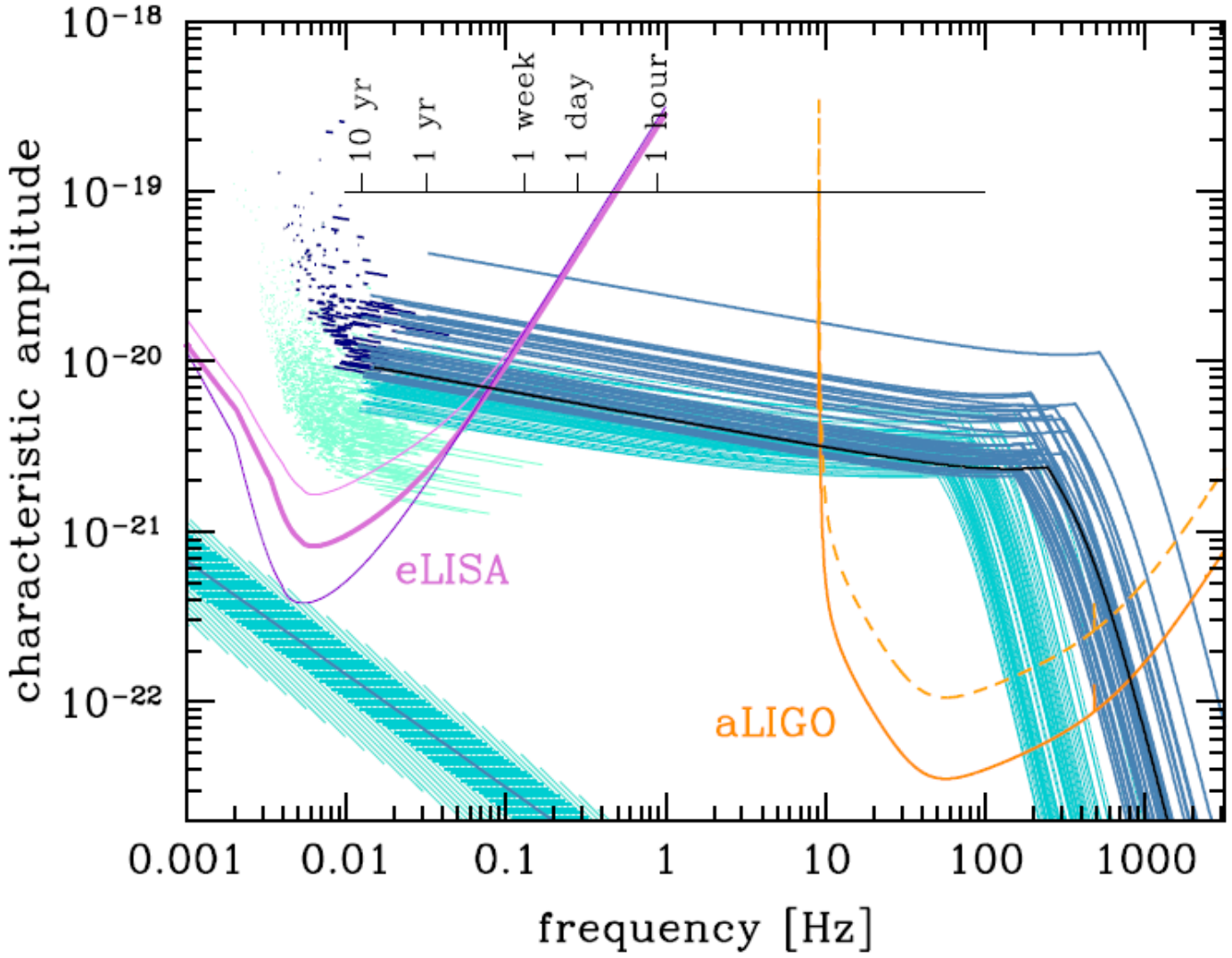
Primary black hole mass	$36^{+5}_{-4}M_\odot$
Secondary black hole mass	$29^{+4}_{-4}M_\odot$
Final black hole mass	$62^{+4}_{-4}M_\odot$
Final black hole spin	$0.67^{+0.05}_{-0.07}$
Luminosity distance	410^{+160}_{-180} Mpc
Source redshift z	$0.09^{+0.03}_{-0.04}$

The GW Spectrum



Multi-band GW Astronomy

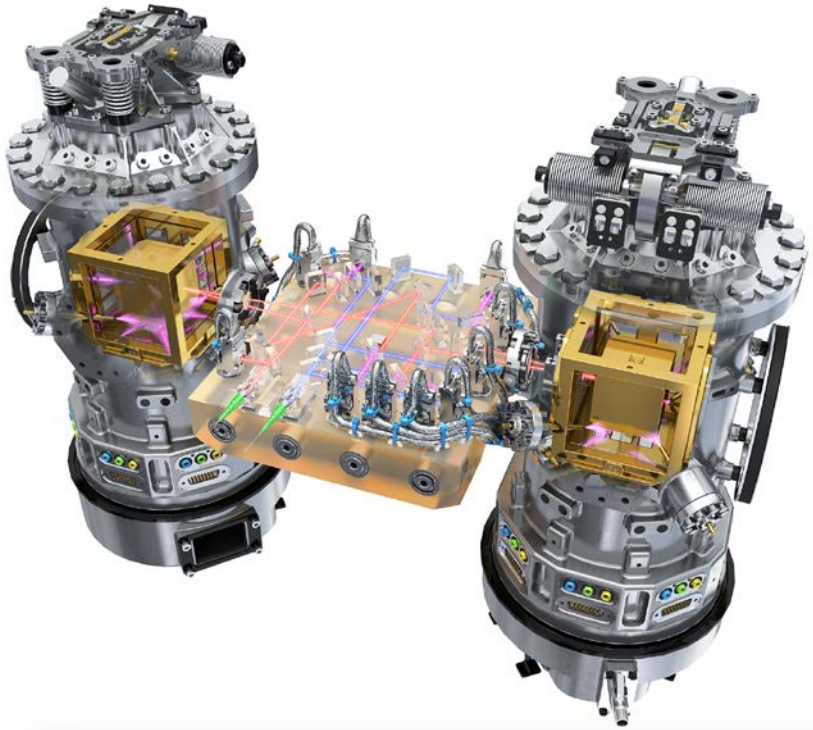
(see Cornish, Larson talks)



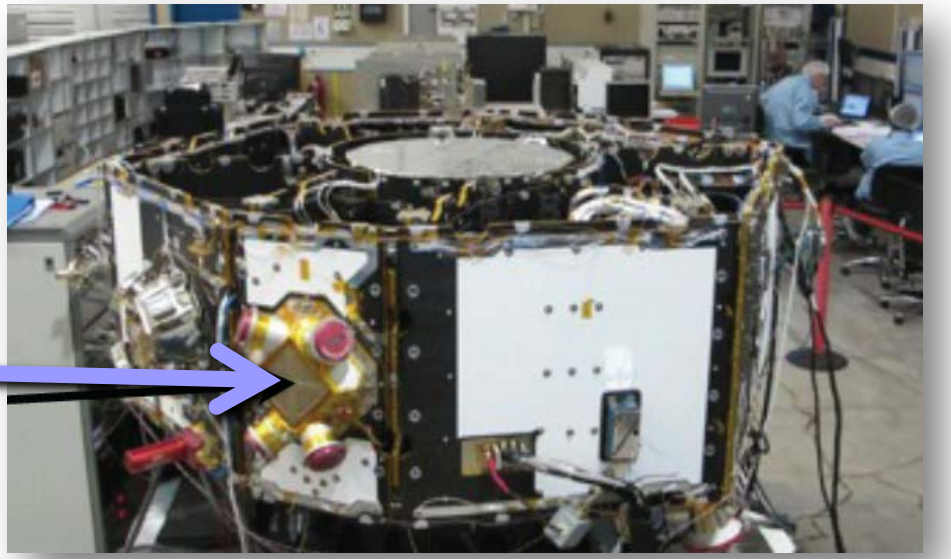
[Sesana arXiv:1602-06951 (2016)]

LISA Pathfinder

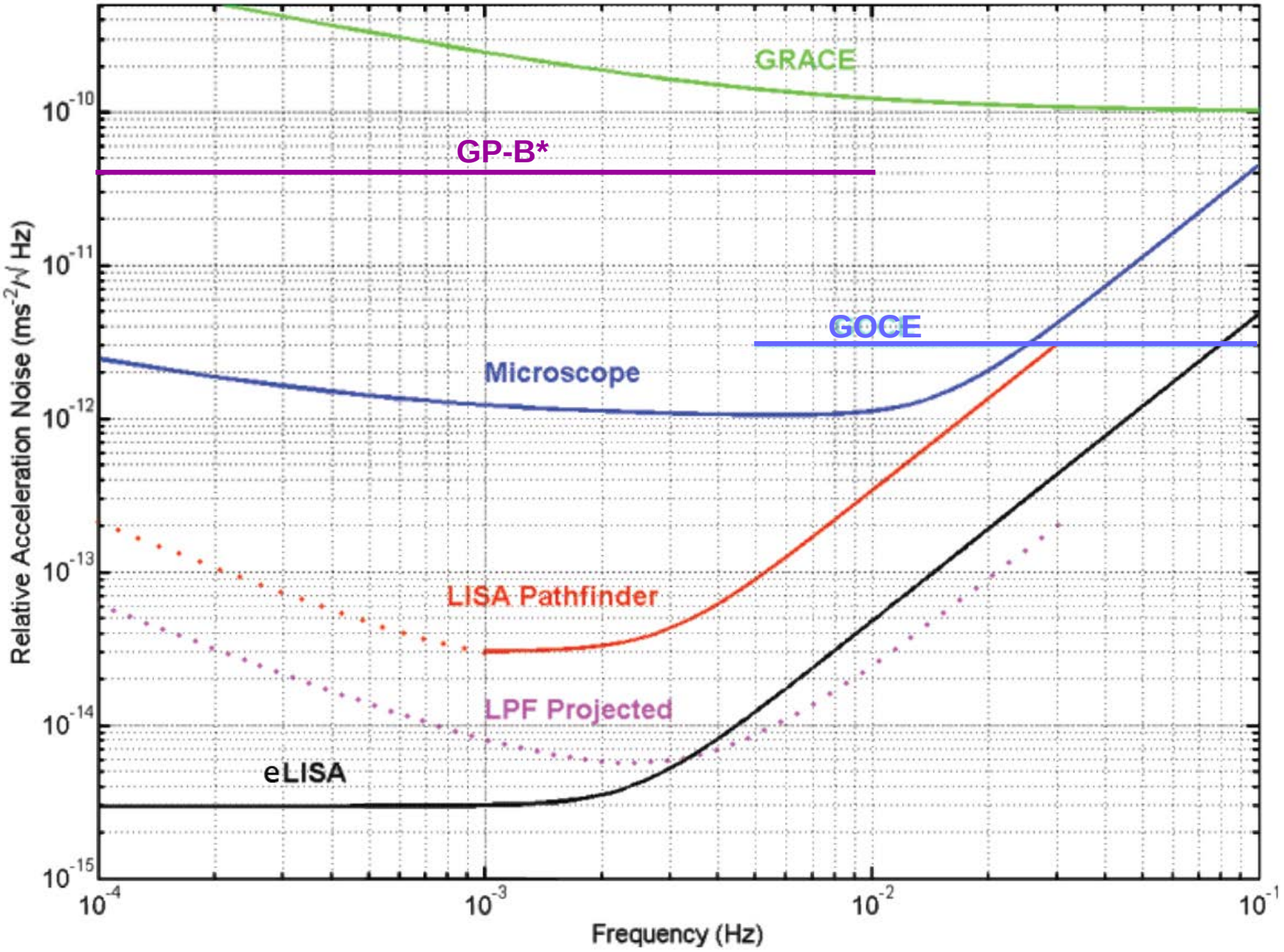
(see Hewitson talk)



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

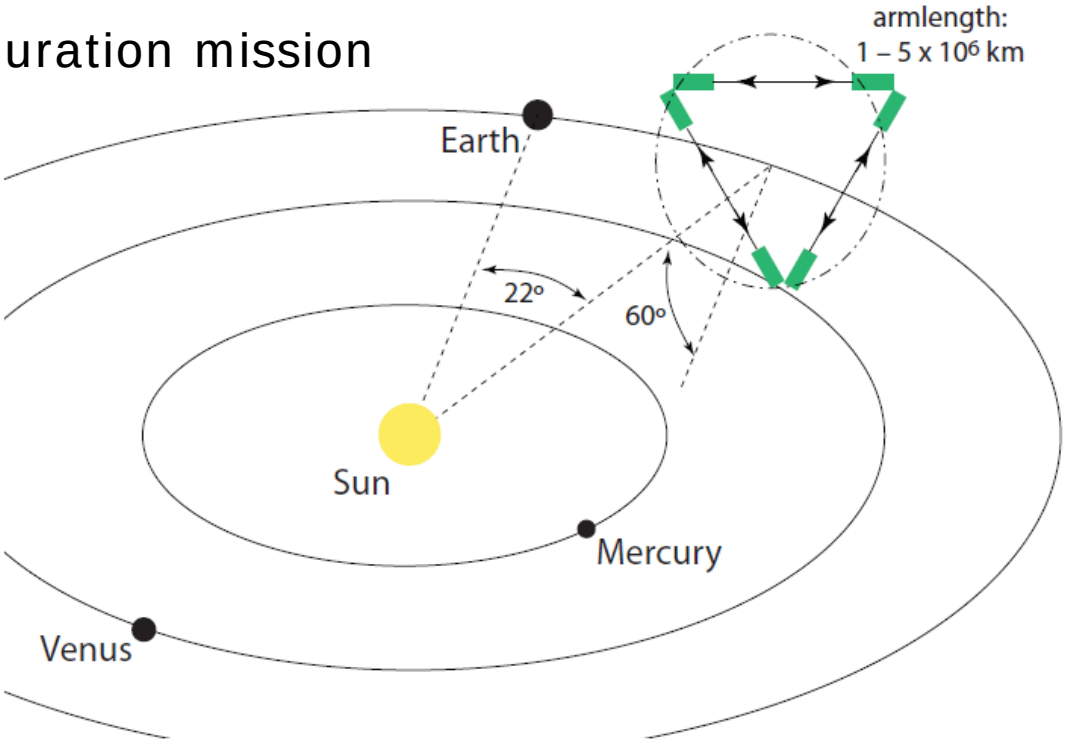
Pathfinder Launch: 2/3 December 2016

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 ?

Gravitational Observatory Advisory Team Final Report (see Mueller talk)

- ESA-appointed external committee to advise on the scientific, technical implementation of L3 (LISA)
  - Late 2014 → Spring 2016
- Conclusions listed in the Executive Summary
  - Laser interferometry responds to science goals & is sufficiently advanced
  - 3 identical spacecraft & longer duration mission
  - Identifies technology challenges
  - Technical, scientific basis permits launch <3034
  - Data analysis funding should resume promptly (risk!)
  - Larger U.S. contribution, re-establish meaningful colaboration



NASA L3 Study (see Stebbins talk)

- The L3 Study is:
  - Realization of the study promised in the plan for NWNH
  - Endorsed by the GWSIG, PhysPAG and Astrophysics Subcommittee
- Purposes of the study:
  - Phase 1 - FY16-17: Analyze the options for NASA participation in the L3 & work with the eLISA consortium on proposals to ESA
  - Phase 2 - FY17-18: Prepare report for 2020 decadal survey on NASA's participation in L3 as a minority partner
- 6th telecon was held last Tuesday
- 1st face-to-face meeting Tuesday-Wednesday here in Salt Lake
  - These are **open meetings**
- ESA's L3 approximate timeline (for reference):
  - Selection of mission concept: ~2017-2018
  - Phase A: 2017
  - Engineering Model: ~2019-2024

L3ST + TAG Members

L3ST

- Baker, John — GSFC
- Bender, Peter — UC Boulder
- Berti, Emanuele — U. Mississippi
- Conklin, John — U. Florida
- Cornish, Neil — Montana State U.
- Cutler, Curt — JPL
- Holley-Bockelman, Kelly — Vanderbilt U.
- Hughes, Scott — MIT
- Larson, Shane — Northwestern U.
- McWilliams, Sean — W. Virginia U.
- Miller, Cole — U. Maryland
- Robertson, Norna — Caltech
- Shoemaker, David (Chair) — MIT
- Thorpe, Ira — GSFC
- Vallisneri, Michele — JPL

- Ex-Officio: R. Sambruna, A. Hornschemeier, R. Stebbins. In addition, A. Parmar has been appointed by ESA as an observer on the L3ST.

Technology analysis Group

- Camp, Jordan — GSFC
- Klipstein, William — JPL
- Livas, Jeffrey — GSFC
- McKenzie, Kirk — JPL
- Mueller, Guido — U. Florida
- Ziemer, John — JPL

Working Groups

- Astrophysical Sources — Shane Larson
- Science Analysis — Scott Hughes
- Instrumentation — Ira Thorpe

Future GWSIG Activities

- GWSIG session @ April APS — 16-19 April 2016
  Salt Lake City, UT
  - Session E12: LISA and LISA pathfinder — 16 April, 3:30 PM-5:00 PM
  - Session J12: GWSIG (focus) — 17 April, 10:45 AM-12:30 PM
    - Revisiting the LISA science case (Cornish), LISA Pathfinder status, preparing for L3 - science, programmatics, and technology, GRACE FO
  - Session S5: Space Based Gravitational Wave Astrophysics (invited)
    18 April, 1:30 PM-3:20 PM
- 11th LISA Symposium — 5-9 September 2016
  Zurich
  - L3ST – eLISA Consortium F2F meeting
- GWSIG Email list:
  http://pcos.gsfc.nasa.gov/sags/gwsag/gwsag-maillist.php
- L3ST website:
  http://pcos.gsfc.nasa.gov/studies/L3/