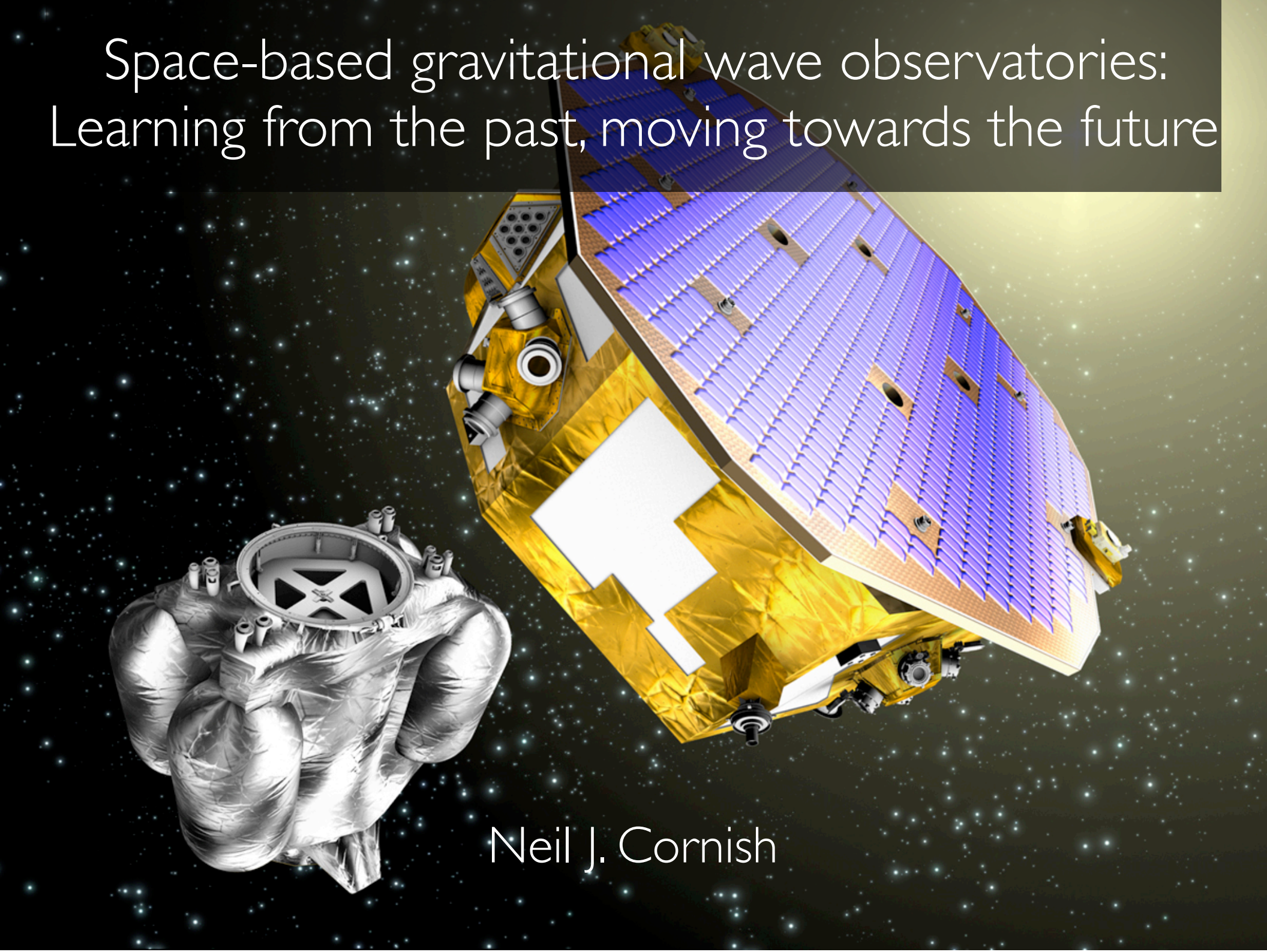
Space-based gravitational wave observatories: Learning from the past, moving towards the future



Neil J. Cornish

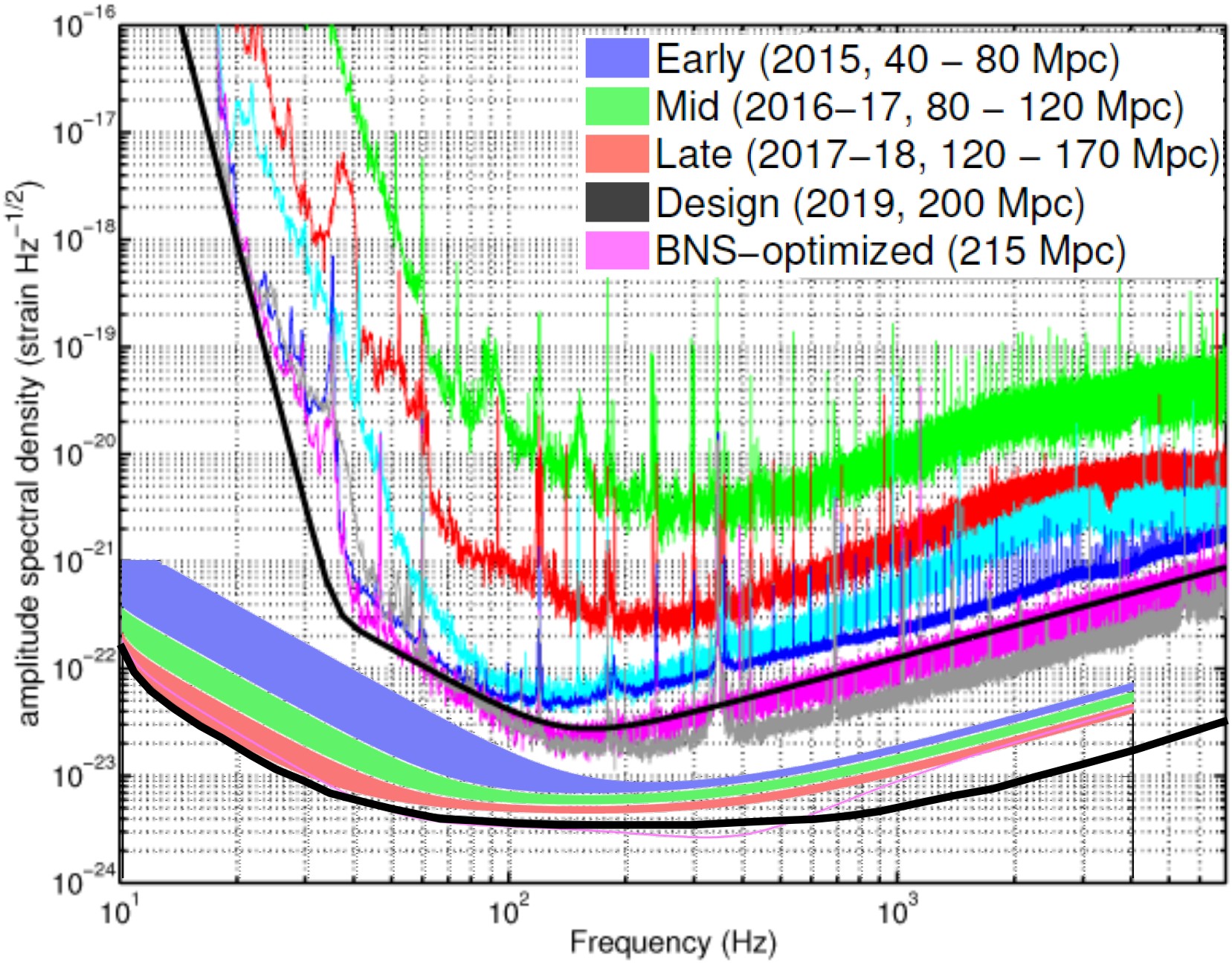
Outline

- We are in the Gravitational Wave decade!
- Status of Space GW detection in Europe & US
- LISA Technology developments in US
- LISA Science development in US

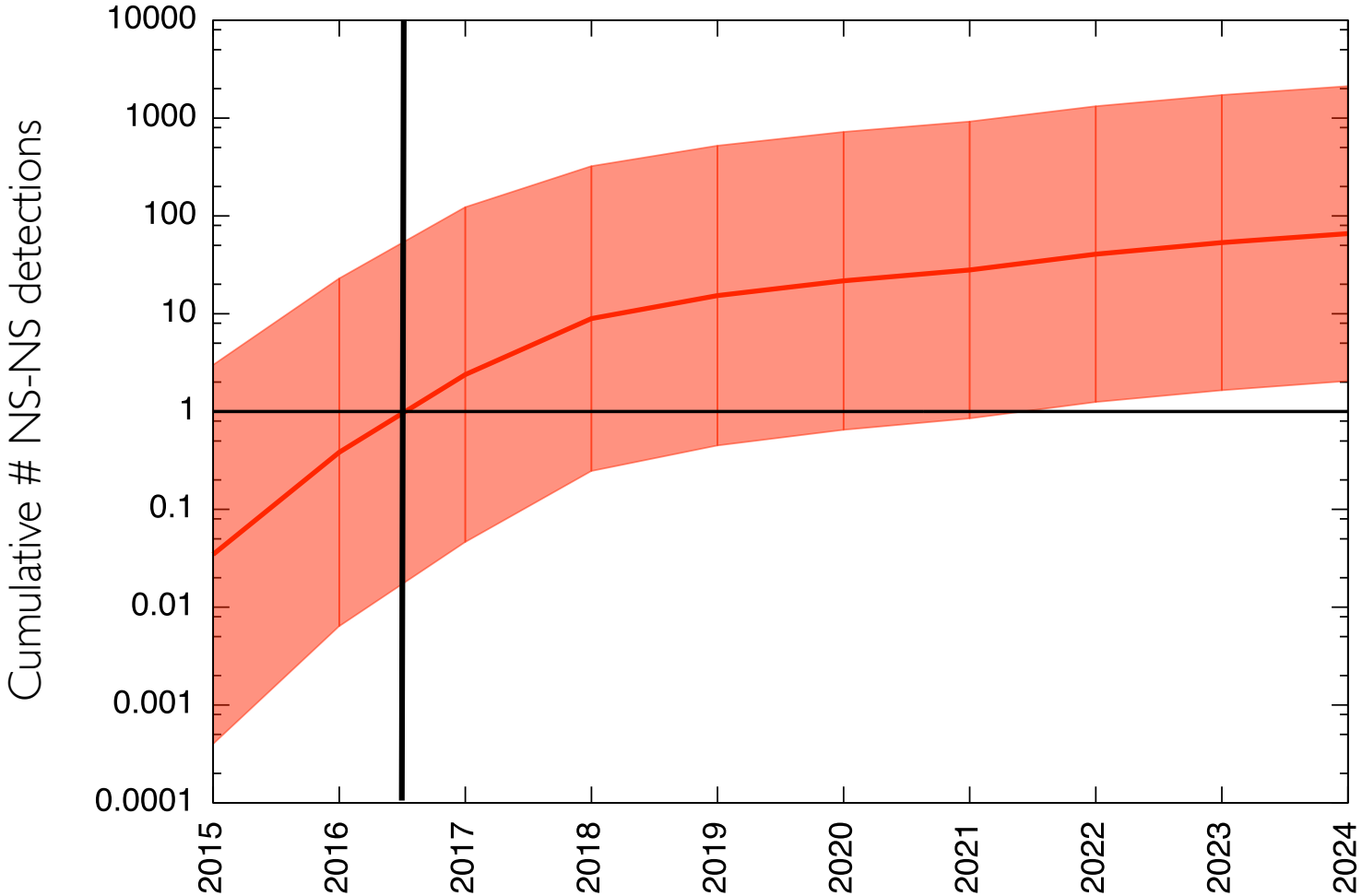
The 10's: Decade of Gravitational Waves

- BICEP2 detection in 2014
- LIGO/Virgo detection in ~ 2016
- IPTA detection in ~ 2018

LIGO sensitivity over time

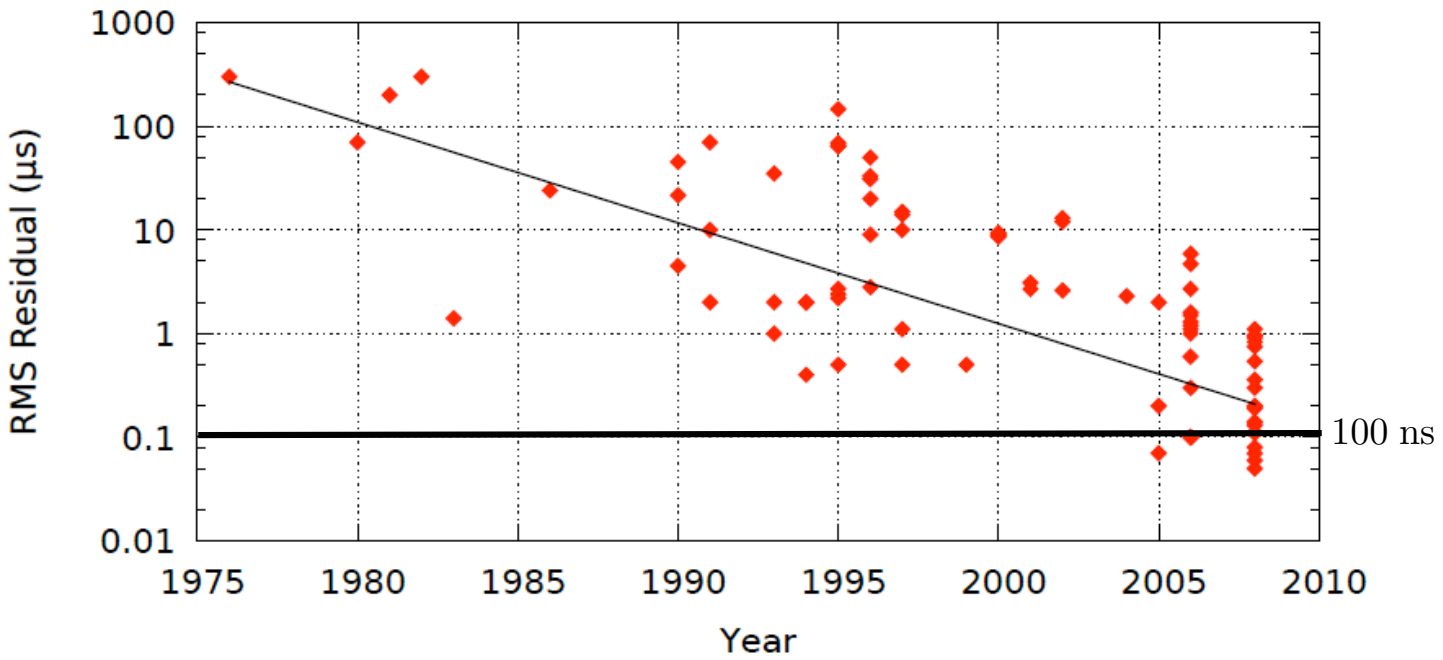


LIGO/Virgo Prediction

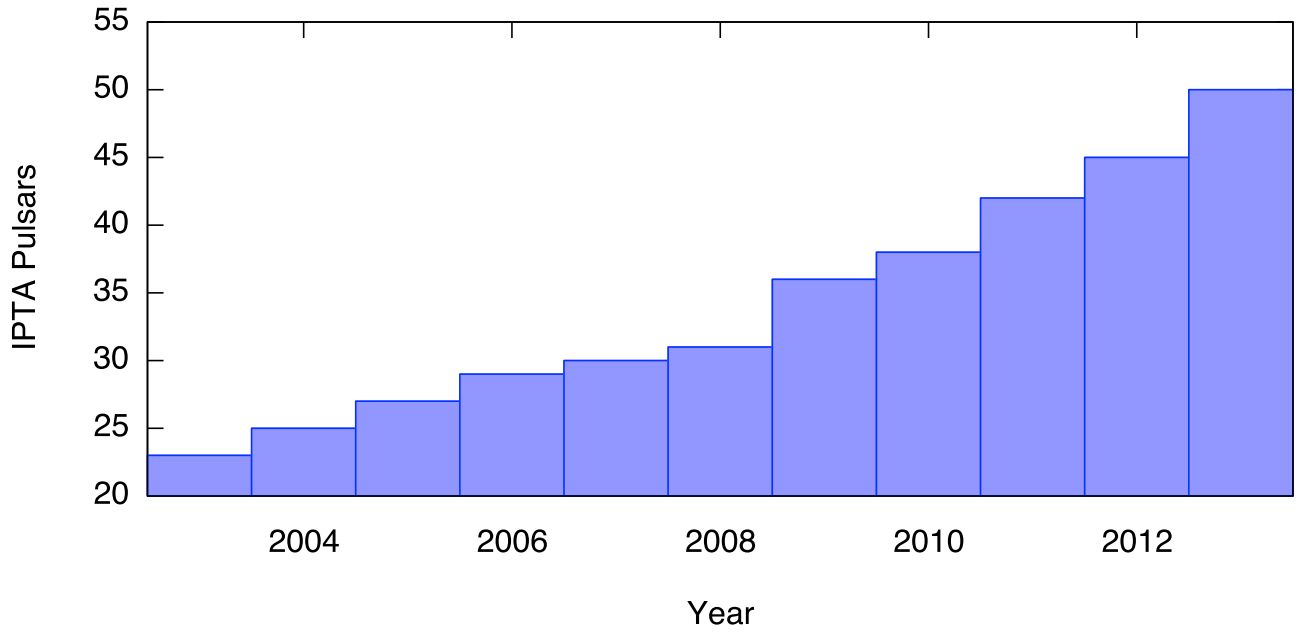


[LIGO & Virgo Collaborations, arXiv:1304.0670 (2013)]

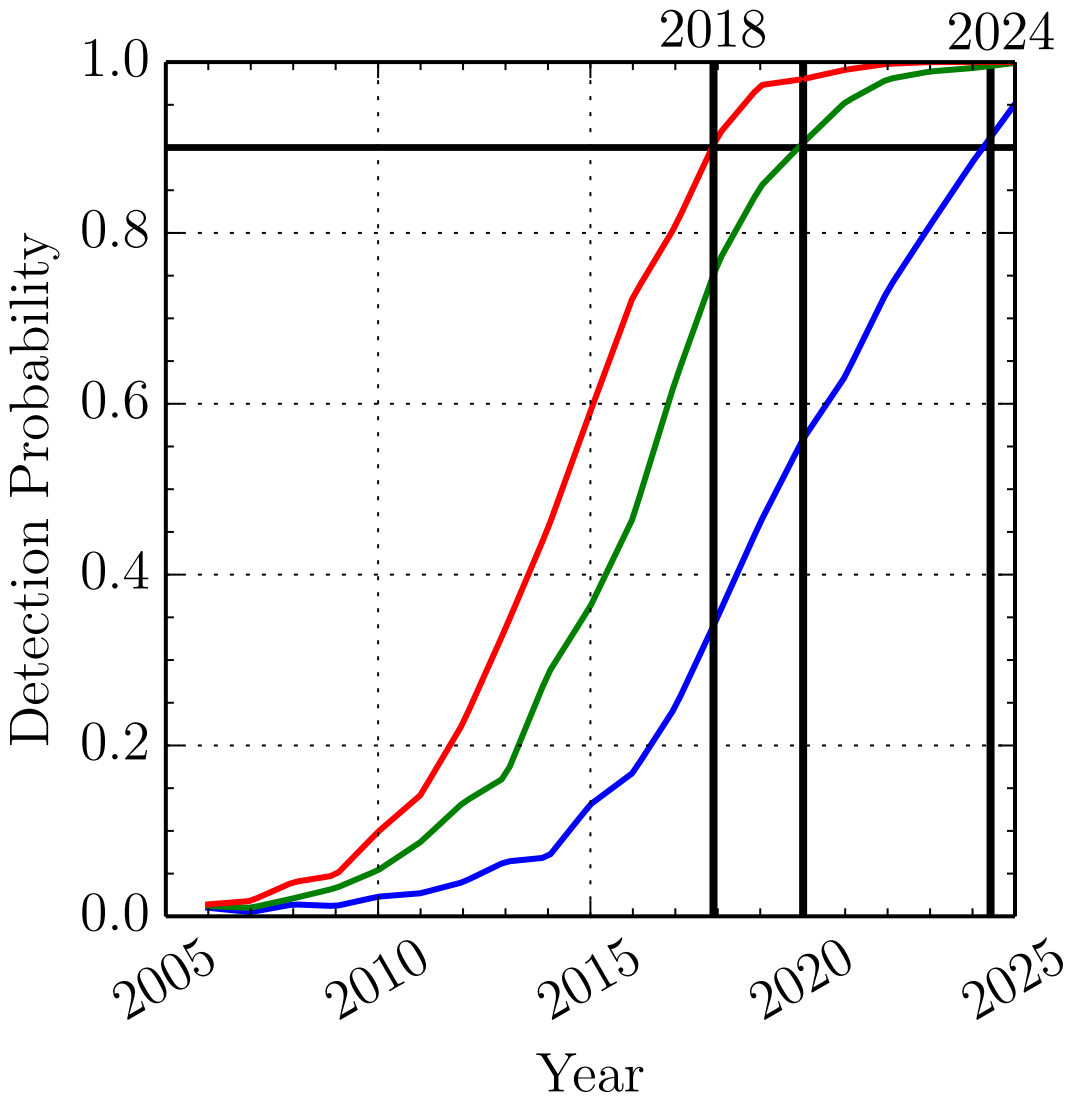
Pulsar Timing in hot pursuit



Likely detection with ~40 pulsars at ~100 ns timing accuracy

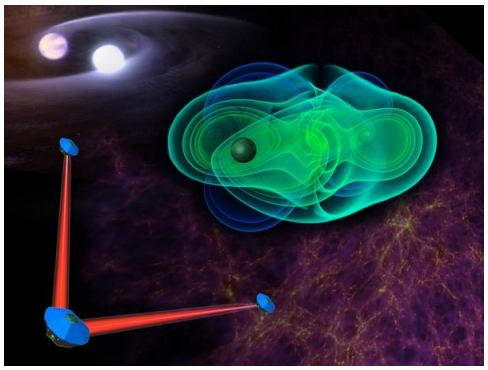


Pulsar Timing: NANOGrav Prediction



[X. Siemens, J. Ellis, F. Jenet, J. Romano, Class. Quant. Grav. 30, 224015 (2013)]

Space GW Status in Europe and U.S.



The "Gravitational Universe" selected as the third large Cosmic Vision (L3) science theme. Mission concept: eLISA (evolved Laser Interferometer Space Antenna).

Launch: 2035+ (~10 years too late)

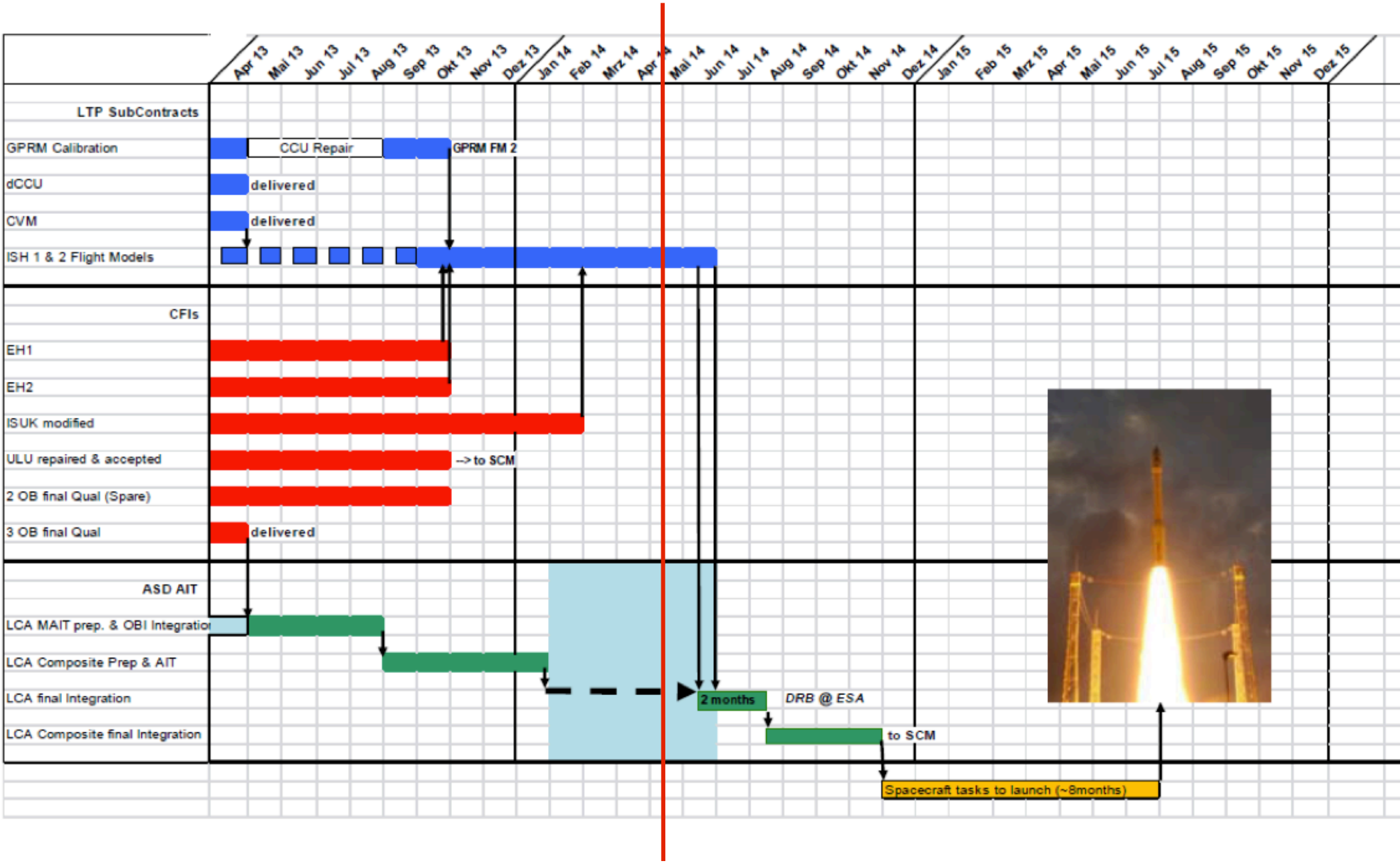
lisa pathfinder

LISA Pathfinder on schedule

Launch: July 31, 2015 (~10 years too early)

lisa pathfinder

Schedule unchanged for over a year



Key LISA technologies

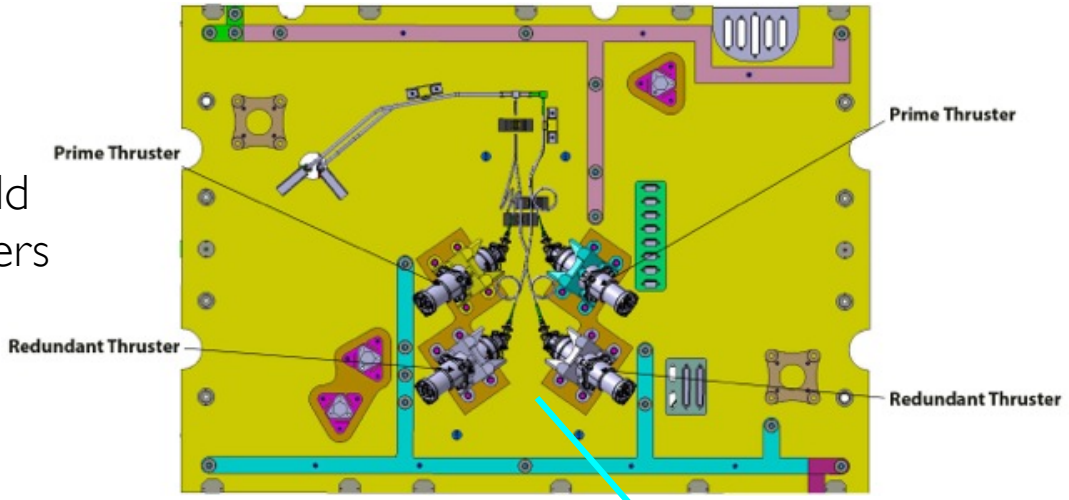
- Free flying test mass subject to very low parasitic forces:
  - Drag free control of spacecraft (non-contacting spacecraft)
  - Low noise microthruster to implement drag-free
  - Large gaps, heavy masses with caging mechanism
  - High stability electrical actuation on cross degrees of freedom
  - Non contacting discharging of test-masses
  - High thermo-mechanical stability of S/C
  - Gravitational field cancellation
- Precision interferometric, *local* ranging of test-mass and spacecraft:
  - pm resolution ranging, sub-mrad alignments
  - High stability monolithic optical assemblies
- Precision 1 million km spacecraft to spacecraft precision ranging:
  - High stability telescopes
  - High accuracy phase-meter
  - High accuracy frequency stabilization
  - Constellation acquisition
  - Precision attitude control of S/C

lisa pathfinder

Elements in red tested by pathfinder

Pathfinder & ST7

GAIA cold gas thrusters



Great opportunity for US scientists to participate in full LPF analysis almost for free (~1/1000 ESA cost)

NASA colloidal thrusters (ST7)

Key LISA technologies

- Free flying test mass subject to very low parasitic forces:
  - Drag free control of spacecraft (non-contacting spacecraft)
  - Low noise microthruster to implement drag-free
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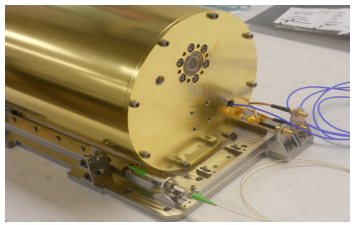
lisa pathfinder

Elements in red tested by pathfinder

LISA technology developments in US

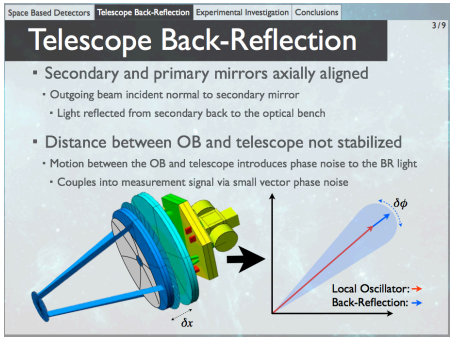
JPL - GRACE Follow on

- High accuracy phase-meter
- High accuracy frequency stabilization
- Constellation acquisition



UF -

- High stability telescope metrology
- Torsion pendulum for DRS studies



Session Y15: Gravitational Wave Experiment
1:30 PM–3:06 PM, Tuesday, April 8, 2014
Room: 103
Y15.00008 The UF torsion pendulum and its role in space-based gravitational wave detectors
Y15.00007 Sensing and actuation system for the University of Florida Torsion Pendulum for LISA

Goddard -

- High stability telescope
- High accuracy frequency stabilization

Stanford -

- UV LED Charge control (on an CUBESAT)

LISA Science developments in US

Parting thoughts

- Is a junior partnership in L3 the best path forward for NASA?
- Should we consider taking the lead in this new branch of astronomy?