Gravitational-wave Detectors: The US Landscape 2020–2030 and Beyond (A Personal Perspective)

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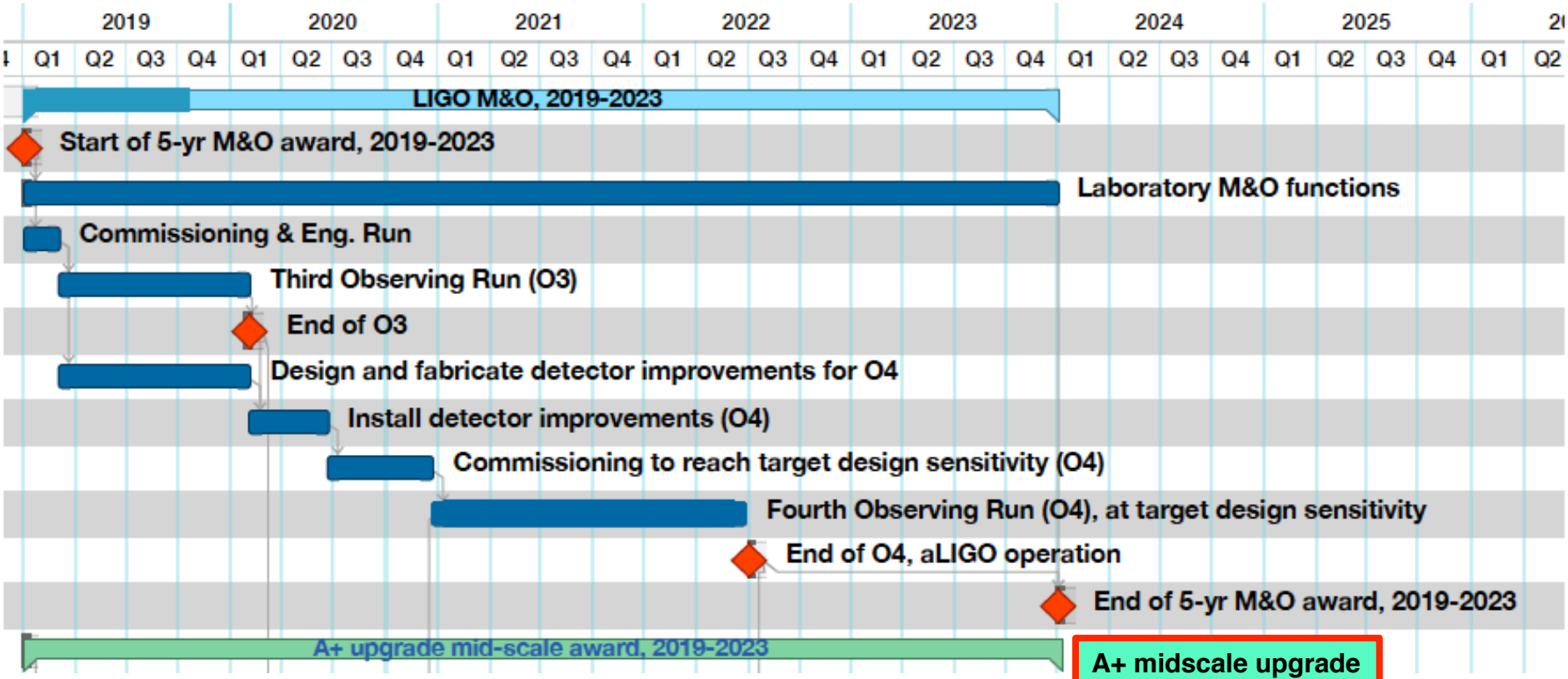
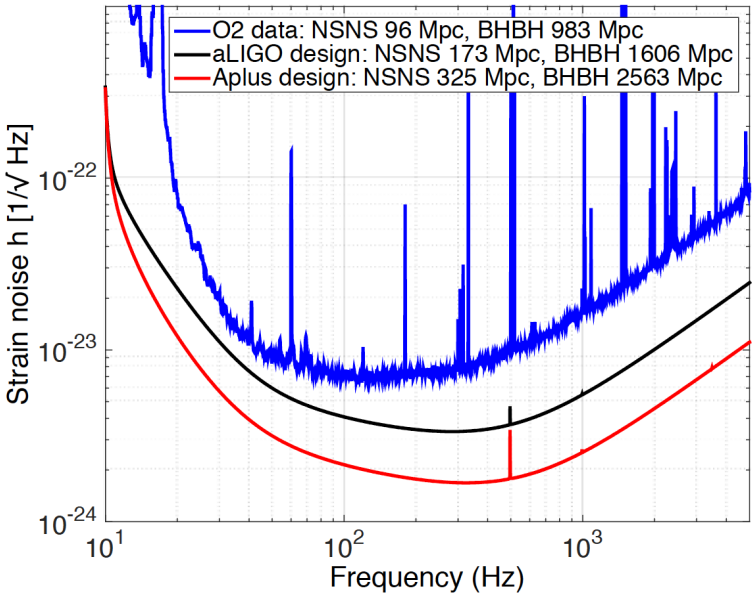
LIGO Laboratory Operations Plan for 2019-2023

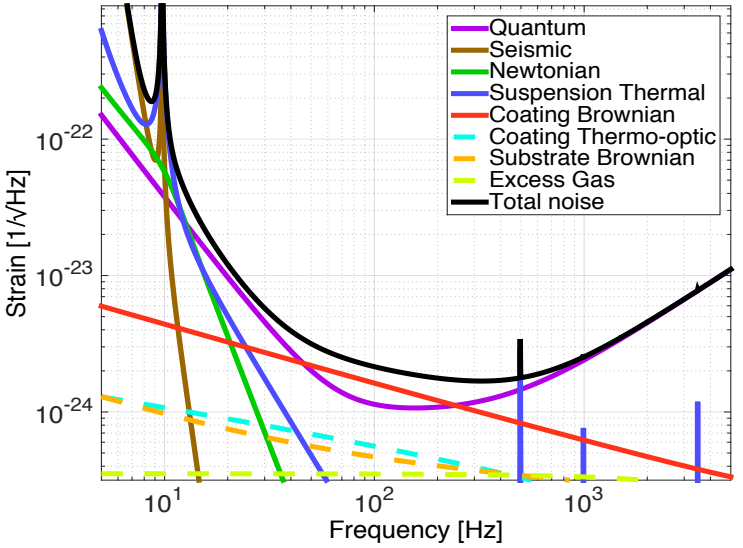
- Plan lays out envisioned run schedules and upgrade/commissioning periods for coming 5 years
- Caveats which could impact this plan: i) A+ Project detailed planning not done, ii) joint run planning with Virgo and KAGRA



A+ Advanced LIGO Upgrade 2019-2026(+)

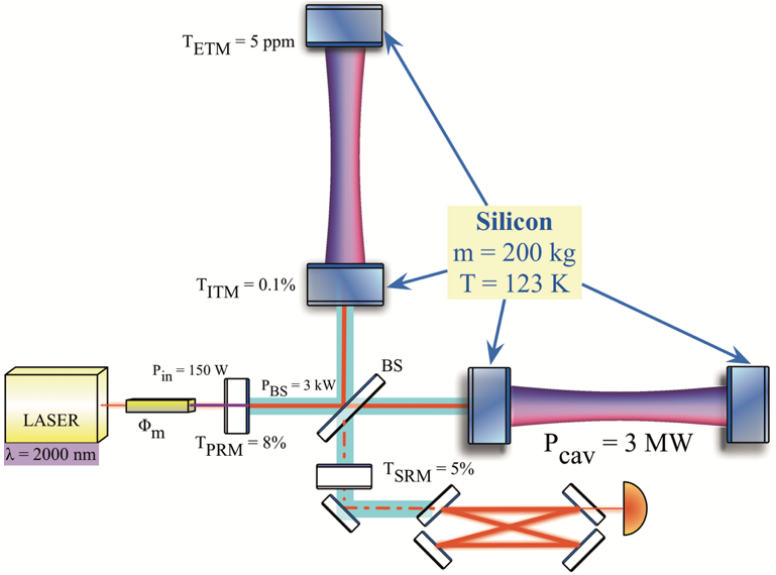
- Mid-scale upgrade of the Advanced LIGO interferometers
  - » Improves binary neutron star inspiral range by ~ 1.9; 30/30 $M_\odot$ binary black hole inspiral range by ~1.6
  - » Frequency dependent squeezing + better coatings w/ lower thermal noise
- US-UK-Australia international collaboration
- Project Status:
  - » US: $20.5M awarded by NSF to begin Oct 1, 2018
  - » UK: ~ £10M requested by STFC; under review
  - » Australia: funded by ARC, have received deliverables
- Construction Project Schedule: 2019-2023
  - » Fabrication/facility modifications/installation/ integration: 2019-2022
  - » Commissioning: 2023
- Operation: currently envision a 1.5-2 year run durations in 2024-2026, perhaps 2027

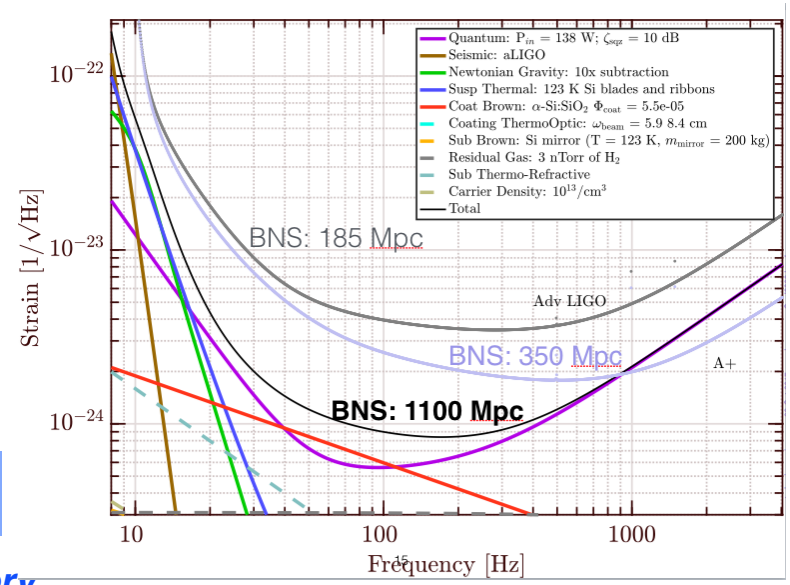




Longer Term I: Voyager

- A 4 km design to exploit the LIGO Observatory facilities limits
  - » Ultimately determined by arm length and vacuum base pressure
- Uses new technologies …
  - » Silicon test masses
  - » 123 K operating temperature
  - » 2 μm 150 W laser, higher quantum efficiency photodiodes
- … but reuses key Advanced LIGO components
  - » Vacuum system
  - » Seismic isolation
- Prototyping effort
  - » 40 m interferometer at Caltech; pending funding
- Cost: O(10^8M)
- Time Scale: ? (but not before late 2020s)

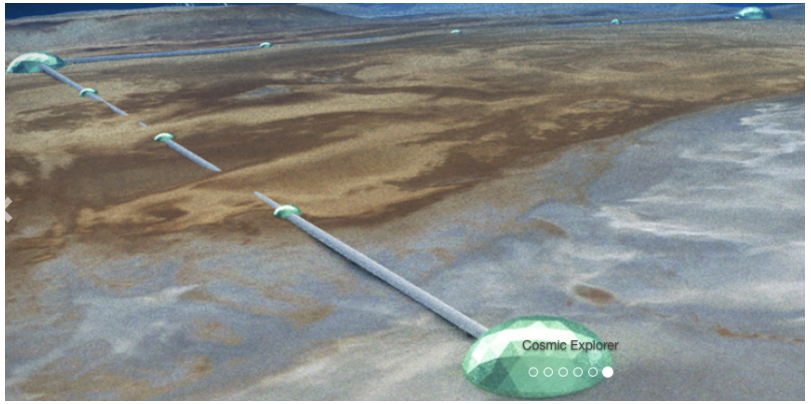


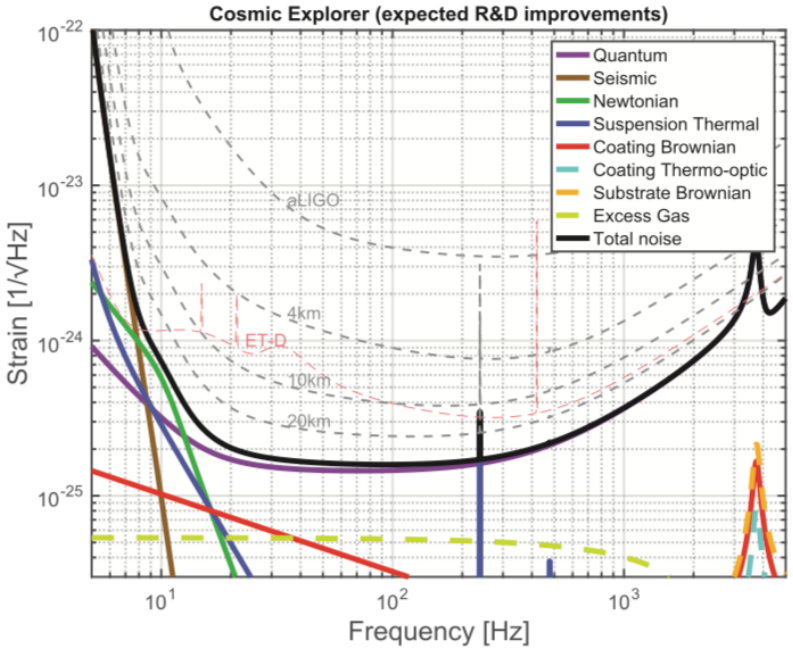


Shapiro, Brett, et al. "Cryogenically cooled ultra low vibration silicon mirrors for gravitational wave observatories." Cryogenics 81 (2017): 83-92.

Longer Term II: Cosmic Explorer

- 40 km L-shaped interferometer design
- A key node of the 3rd generation detector network
- Sensitivity can benefit from new technologies (a la Voyager), but could also use existing 2G technology, appropriately scaled up:
  - Large aperture, 320 kg silica test masses, higher arm powers
- Design effort formally underway
  - Recently funded by NSF, 3 year study
  - Matt Evans (MIT) leading, participation by other US institutions
- Cost: O(10^9)
- Time scale for realization: ?, but not before 2030





B. P. Abbott, et al., (LIGO Scientific Collaboration), "Exploring the sensitivity of next generation gravitational wave detectors", Class. Quantum Grav. 34, 044001 (2017).

The Path to 3G in the US

- Possible paths

1. Field-Specific National Academies Studies
   - » Commissioned by funding agencies
   - » Studies are both comprehensive and intensive
     - – 10-15 study members, membership is a mix of scientists from within the community and objective outsiders
     - – Resulting report and recommendations undergo stringent review

OR

2. Astro2020 Decadal Survey
   - » Astronomy and various fields of Physics conduct Decadal Surveys
     - – Initial LIGO was endorsed in a 1986 study
   - » Chartered by US agencies (NASA, NSF, DOE)
   - » (Complex) Process involves surveying relevant communities and issue report ranking large and mid-scale projects
   - » *Unclear if ground-based GW will be included for ranking*

- Astro2020 call for science papers:
  - » http://sites.nationalacademies.org/cs/groups/ssbsite/documents/webpage/ssb_187932.pdf
  - » Due by Jan 18, 2019

More on Astro2020 this afternoon