LIGO- G1602258-v1

LIGO Voyager Project of Future Gravitational Wave Detector

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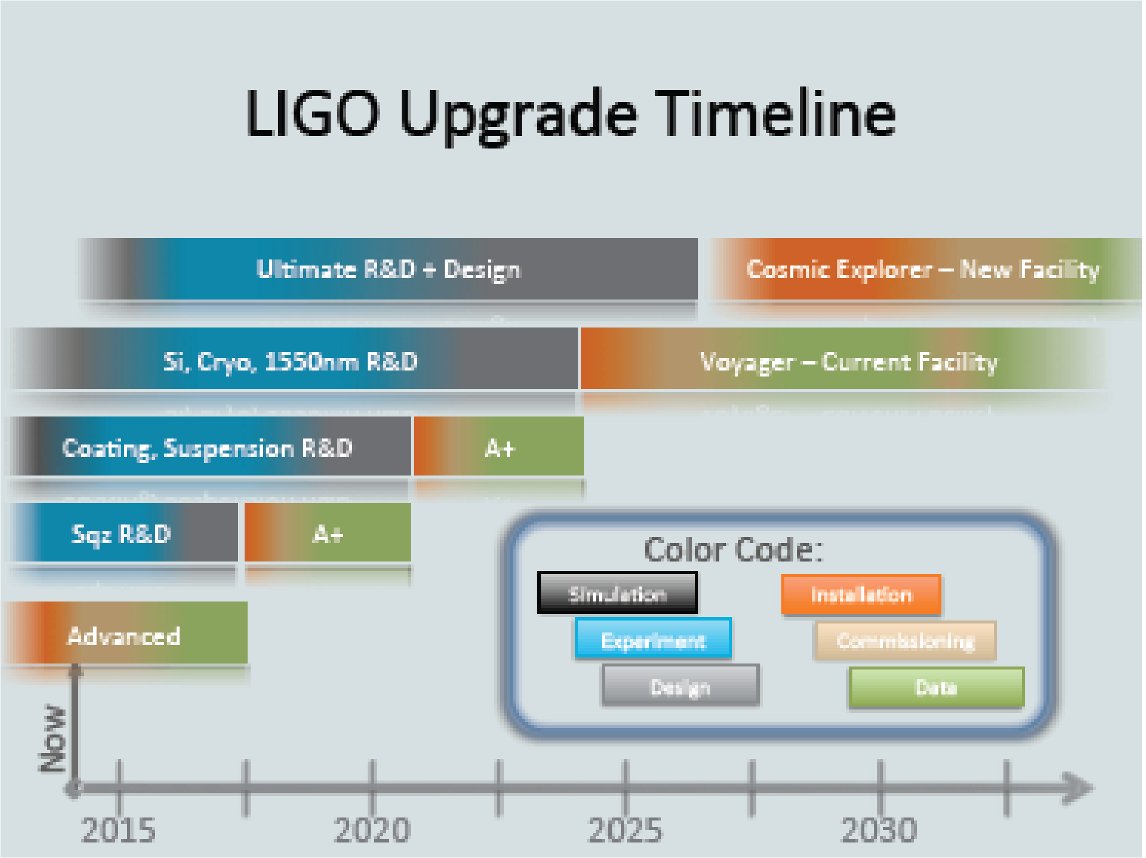
LP Grishchuk memorial conference

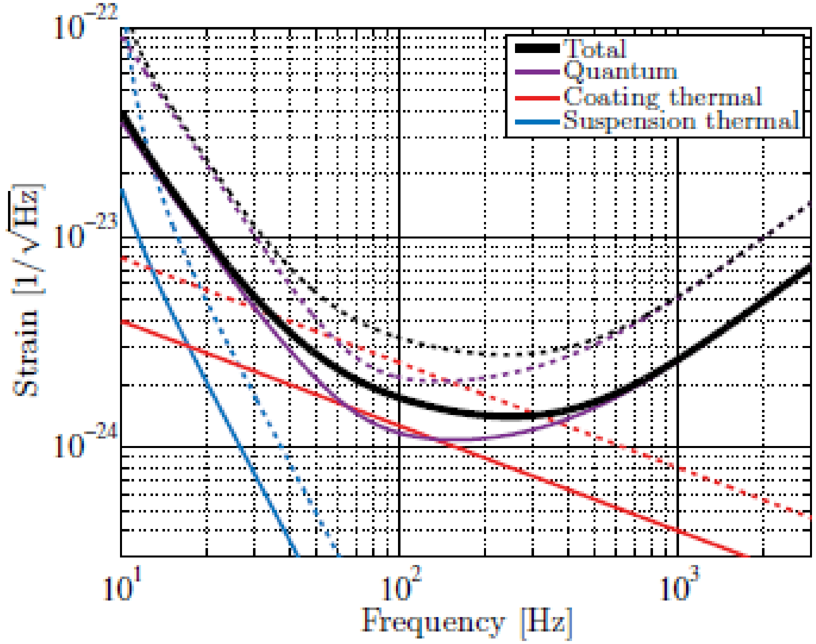
Moscow, SAI, 16-18 November 2016

Towards future more sensitive GW detectors and GW astronomy



https://dcc.ligo.org/LIGO-T1500290/public

A^{+} LIGO – an upgrade to aLIGO

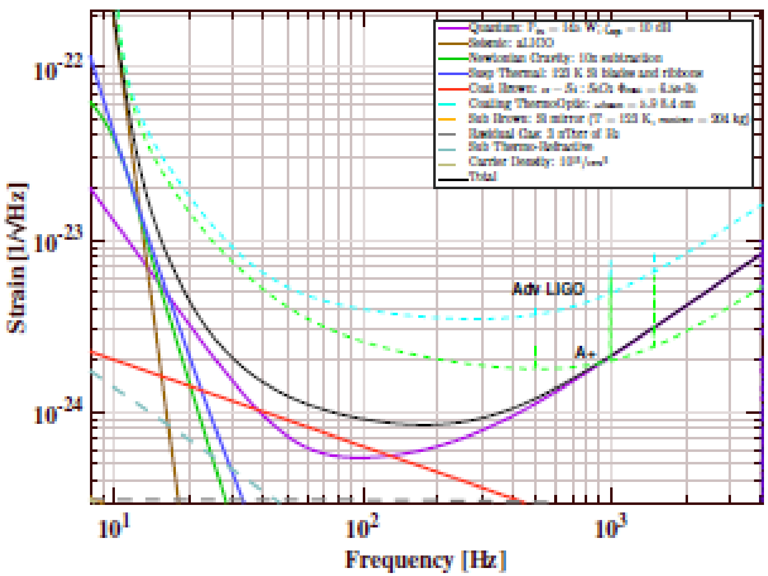


Frequency dependent squeezing, bigger masses, bigger laser beam sizes better mirror coatings

Strain sensitivity (binary neutron star inspiral range 320 – 460 Mpc)

Installation - 2022

LIGO Voyager - a more major upgrade within existing vacuum envelope



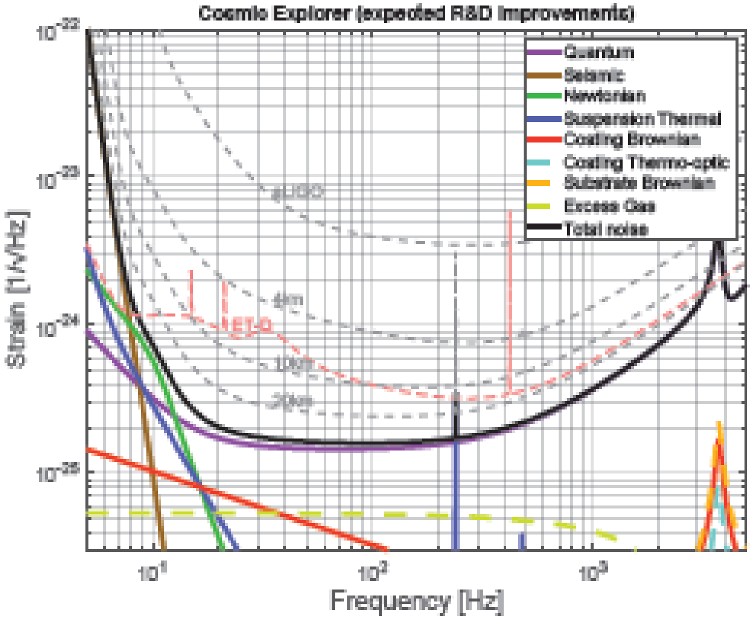
Low temperature (123 K) operation of the 150 kg Silicon test masses

Strain sensitivity (binary neutron star inspiral range about 700 - 1100 Mpc)

To be operational by 2027-28

https://dcc.ligo.org/LIGO-T1400226

LIGO Cosmic Explorer



Extrapolations of techniques from previous instruments, as well as innovations to the new infrastructure
It may be on the surface or it may be underground

Will be capable of detecting compact binary sources at high redshift (z > 10).

Operation 2035

The solid curves are for a 40km long detector

LIGO Scientific Collaboration,arXiv:1607.08697 [astro-ph.IM]

Concept of LIGO Voyager design

Single crystalline silicon test masses (of about 200 kg) operated at 123 K

- low mechanical loss which decreases with temperature – low thermal noise
- zero thermal expansion coefficient at about 123 K eliminate thermoelastic loss and thermoelastic noise
- zero thermal expansion coefficient minimizes radius of curvature changes induced by temperature gradients
- high thermal conductivity permits higher laser powers because reduces thermal lensing

48 cm ingots commercially
grown via Czochralski or process

Shin-Etsu

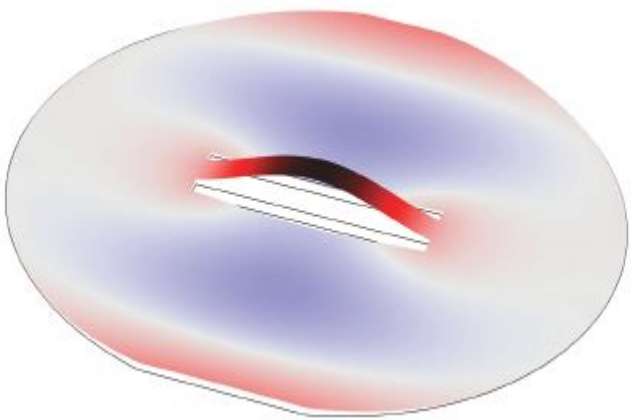
Quasi-monolithic silicon suspension

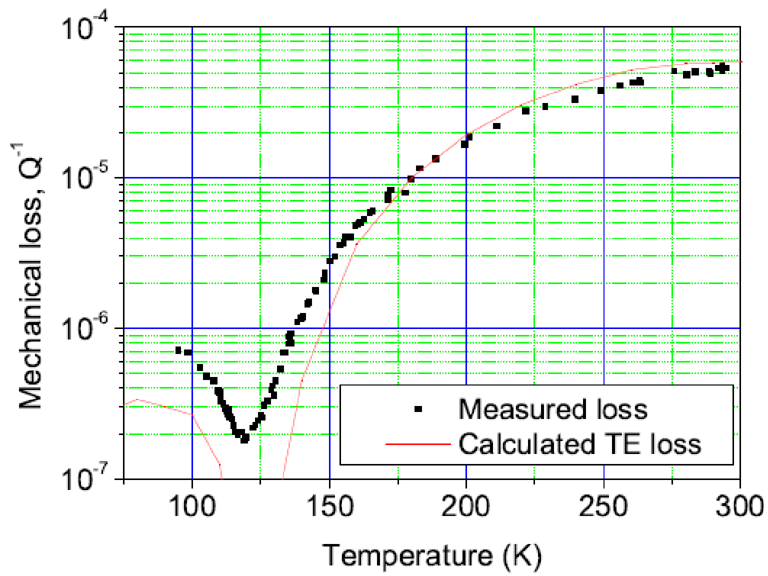
Silicon suspension elements

(Key parameters: high breaking strength and low mechanical loss)

- Fibers fabricated by the laser heated pedestal growth

- Ribbons fabricated from silicon wafers using wet or dry chemical etching technique



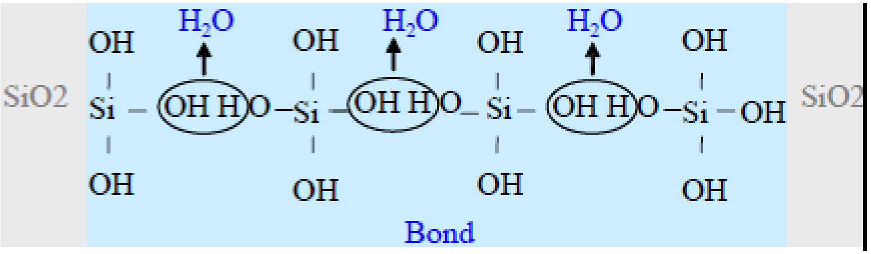


L.G. Prokhorov, V.P. Mitrofanov, Class. Quantum Grav. 32 (2015) 195002

Quasi-monolithic silicon suspension

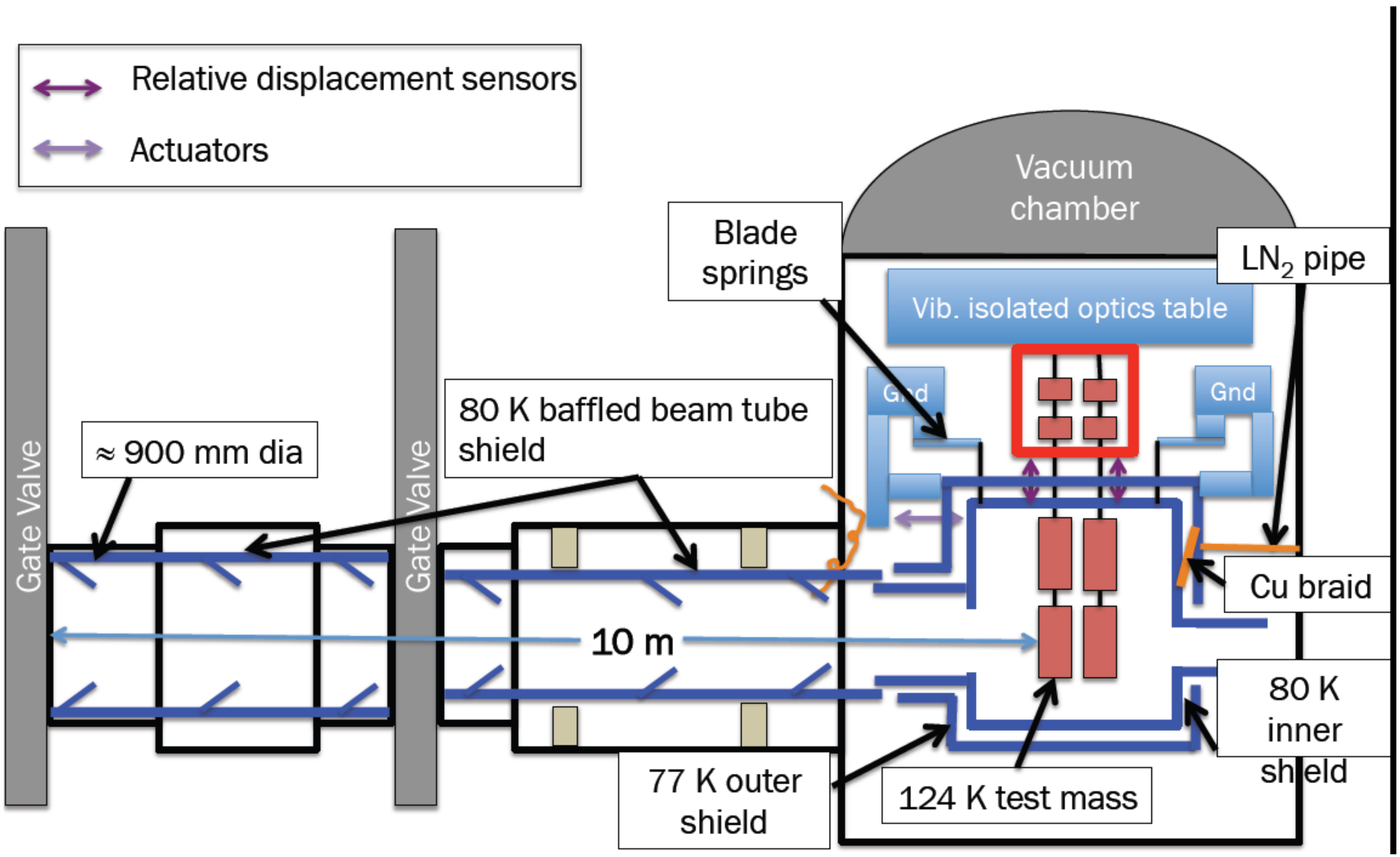
Silicon-silicon attachment technique
Key parameters: high bond strength, low bond mechanical loss

Hydroxy catalysis bonding is prospective technique
Silicon surfaces are oxidised to facilitate reliable bonding



N.L. Beveridge te al, Class. Quantum Grav. 30 (2013) 025003

Cryogenics for LIGO Voyager



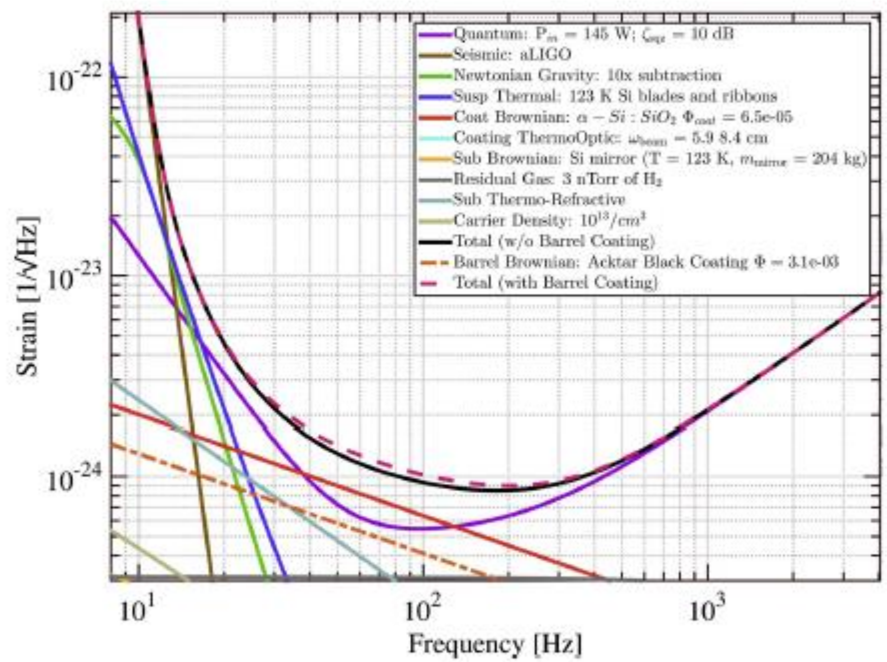
https://dcc.ligo.org/LIGO-T1400226

Black coating of the test mass barrel

Bare silicon emissivity (≈ 0.1) is insufficient to extract up to 10 W of heat absorbed by the test mass from the laser beam

Acktar Black coating (emissivity of 0.85 at 120 K) of the test mass barrel provides necessary radiation cooling and acceptable increase of the total strain noise

M R Abernathy, N Smith, W Z Korth, R X Adhikari, L G Prokhorov, D V Koptsov and V P Mitrofanov, Class. Quantum Grav. 33 (2016) 185002



Optical properties of silicon test masses

Choice of the laser wavelength λ

Key requirements:

- Low optical absorption at 123 K
- Availability of high-stable powerful (200 W) lasers
- Availability of photodiodes with high quantum efficiency (up to 99%)

λ = 1.5 – 2 microns ???

Choice of low optical and low mechanical loss test mass coating

α-Si/SiO_2 or other coating?

https://dcc.ligo.org/LIGO-T1500290,
https://dcc.ligo.org/LIGO-T1400226

Summary

LIGO Scientific Collaboration is now concentrating efforts on maximization of the scientific potential of gravitational-wave astronomy and is developing concepts of new detectors.

Some aspects of the LIGO Voyager design were considered. They allow us to estimate the scale and complexity of the challenges facing researchers.