LIGO-Virgo-Kagra Status Report

GWANW 2023

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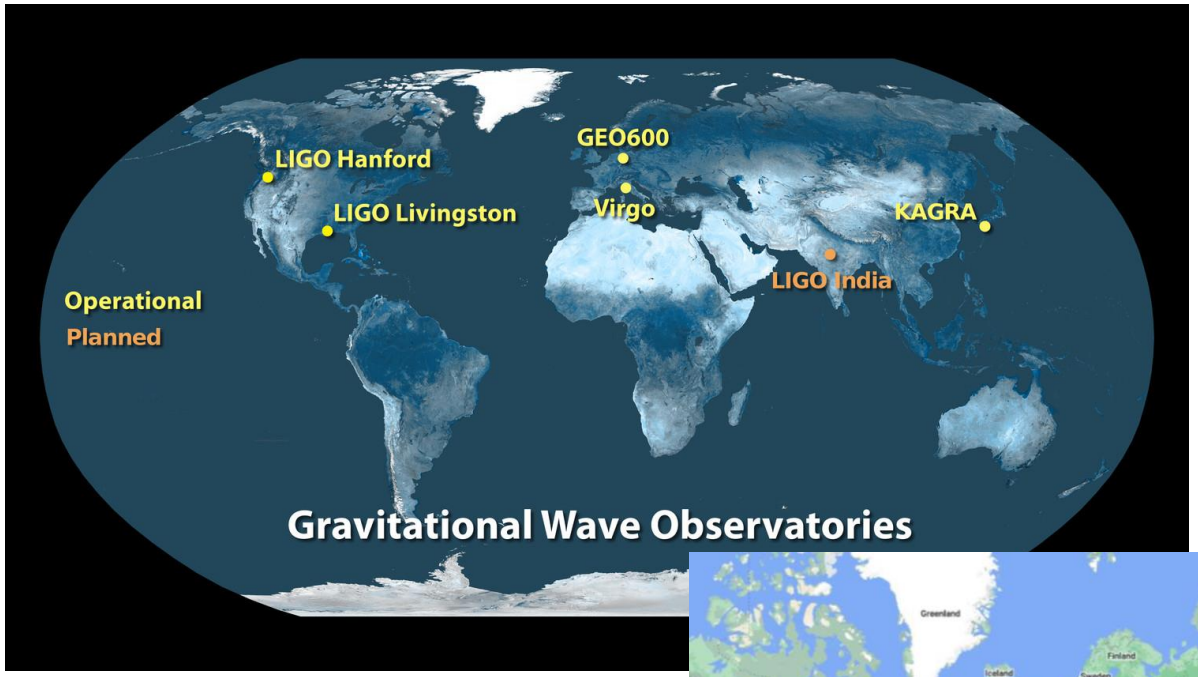
Network



Collaborating Institutions

Worldwide network of gravitational wave observatories

Multiple far-flung sites allows for better source localization and polarization studies

Collaboration spanning across five continents

Share knowledge and sync observing runs to maximize science

Interferometers

Each observatory is a Fabry-Perot Michelson interferometer

Measures differential strain across the two arms of the interferometer

Lots of optics to maximize sensitivity

Sensitive to GWs between 30 Hz – 8 kHz

Low frequency limited by being on the Earth's surface

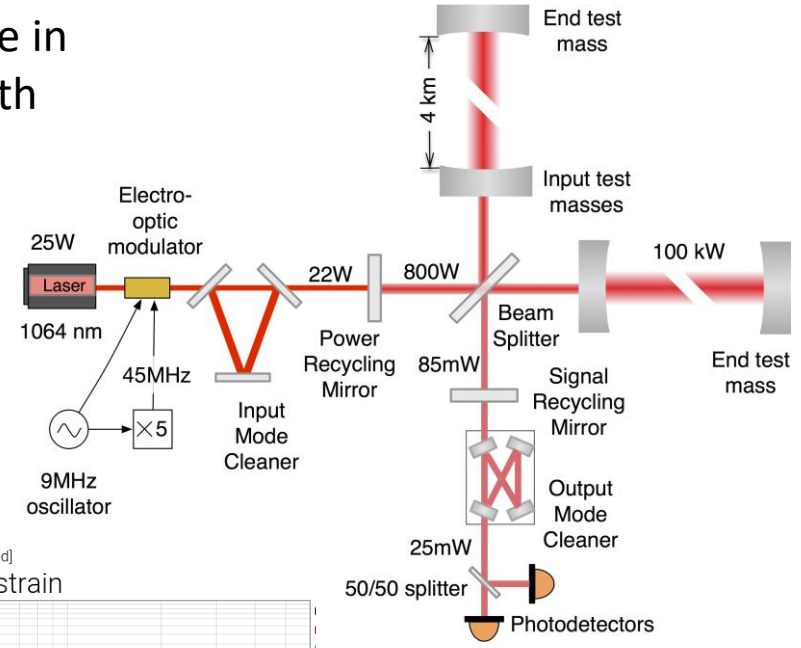
Primarily sensitive to stellar-mass binary black holes and binary neutron stars

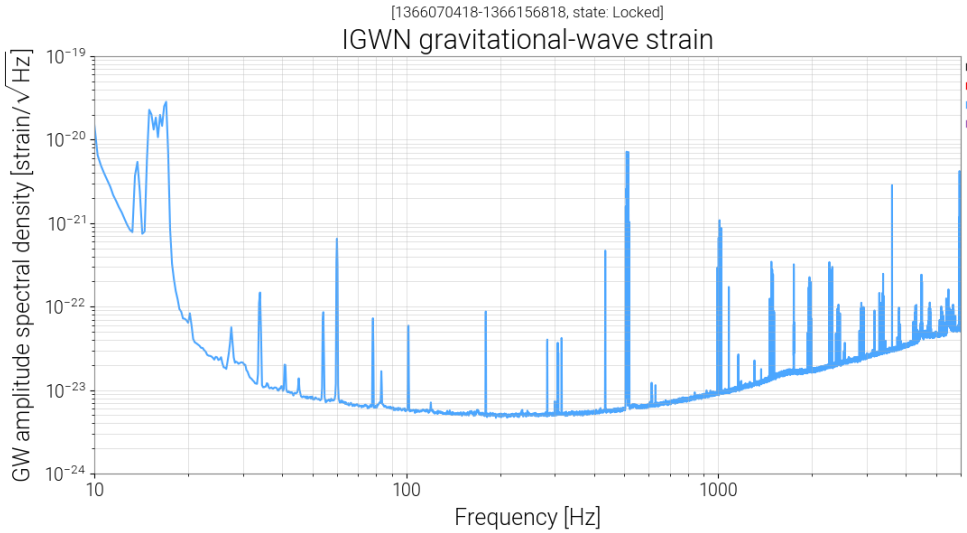
Strain

Change in Length

$$h = \frac{\Delta L}{L}$$

Arm Length





Observatories

LIGO (US)**:**

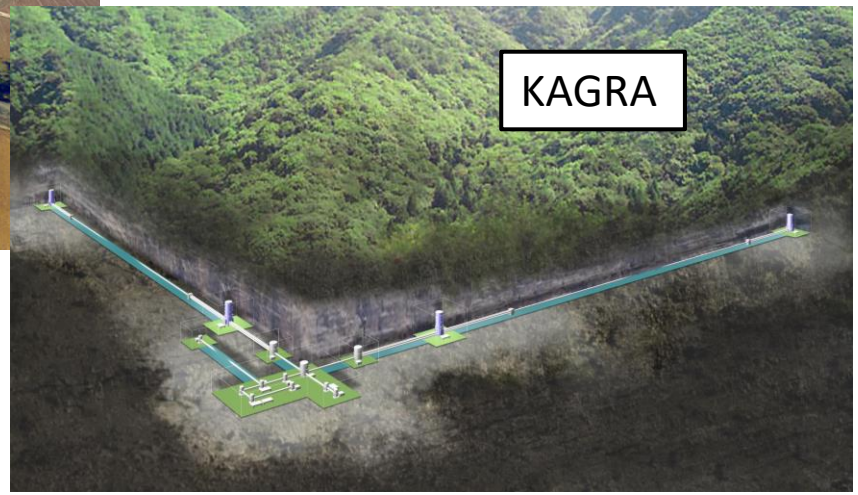
- Pair of 4-km long interferometers
- Active seismic isolation + quadruple pendulum

Virgo (Italy)**:**

- 3-km long
- Passive isolation

KAGRA (Japan):

- 3-km long
- Underground
- Cryogenic
- Passive isolation



Observing Schedule

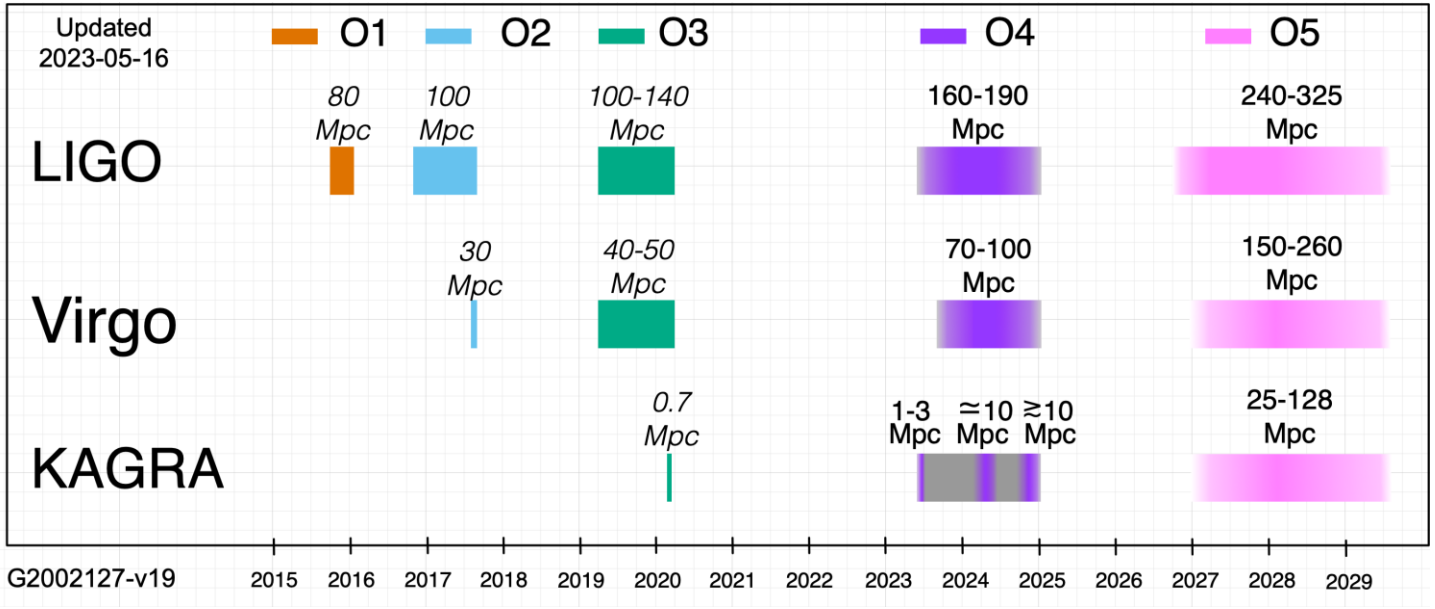
Alternating periods of observing and upgrades

With each upgrade we have larger range, number of events goes like range cubed

Moving towards longer observing runs with each upgrade phase

Break between O3 and O4 was extended due to COVID

O4 started in May and will continue for a year and a half



Previous Results

Observations have been rapidly increasing in the last 8 years

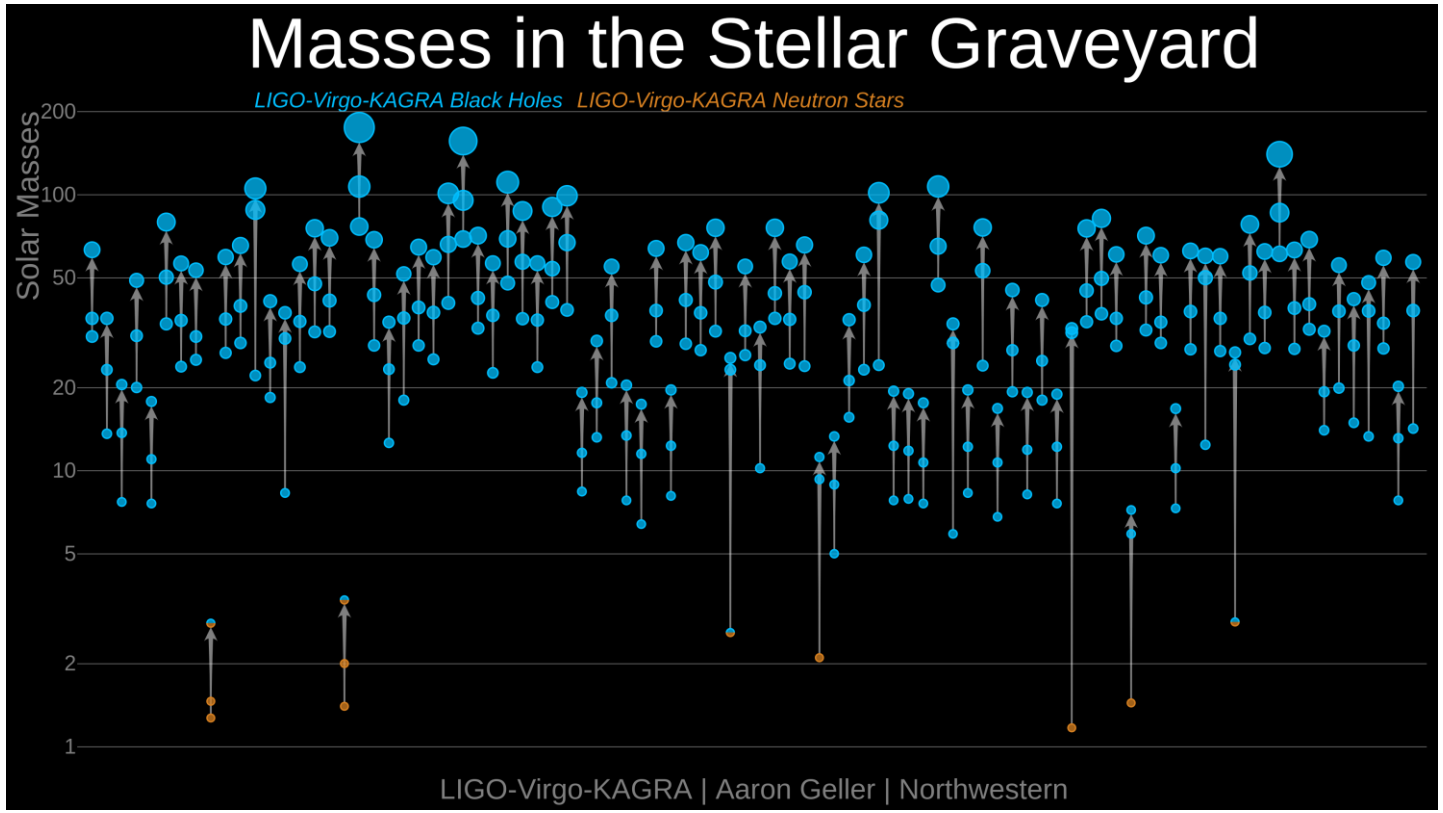
- First GW detection in 2015
- First multimessenger (GW170817) in 2017
- 90 significant events in O1-O3

Novel Hubble constant measurement

Binary black hole population studies

Tests of general relativity

Neutron star equation of state



Recent Upgrades

Frequency Dependent Squeezing

LIGO:

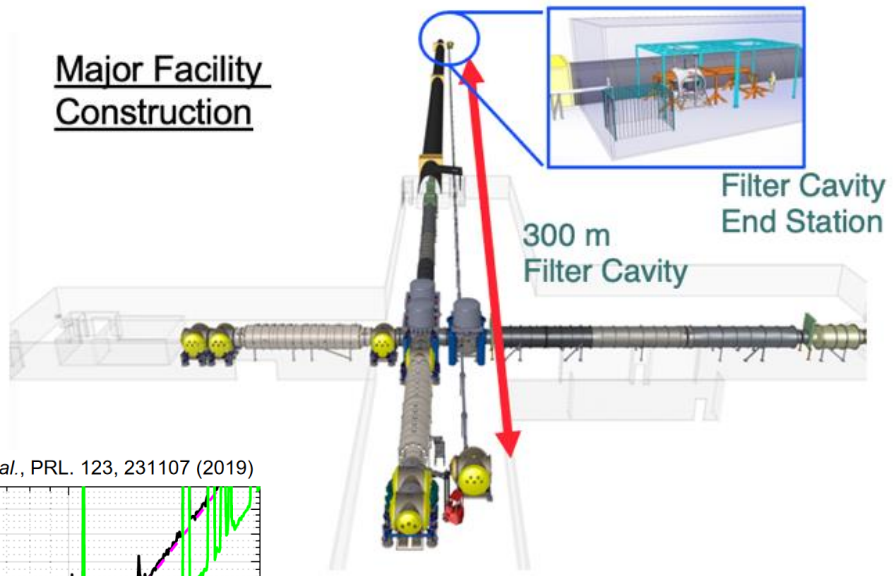
- New laser + clean test masses = 400 kW circulating power
- More stray light baffles

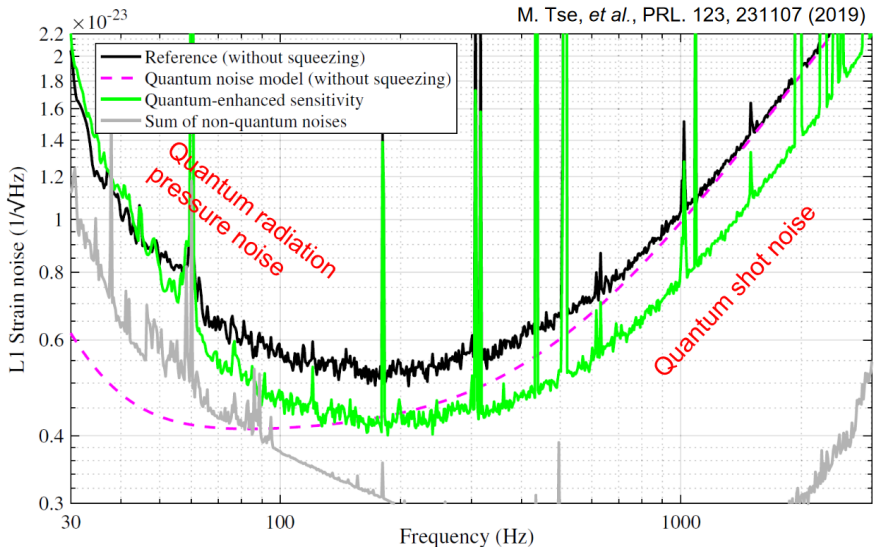
Virgo:

- Also new laser
- Stray light mitigation
- New output mode cleaner

KAGRA:

- 30 W laser
- Implemented angular sensing and control
- Mirrors at cryo temperature
- More baffles!





So Far in Observing Run 4

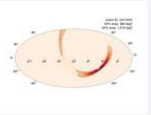
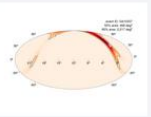
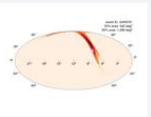
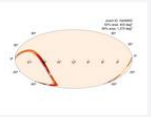
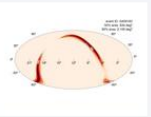
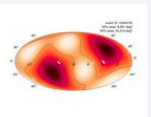
Six significant event seen in O4

Most are binary black hole mergers

One contained a ~6 $M_{\odot}$ object, heavy neutron star or light black hole?

Virgo has had technical issues and has yet to begin observing

48% double interferometer duty cycle, 40% single interferometer

Event ID	Possible Source (Probability)	Significant	UTC	GCN	Location	FAR	Comments
S230609u	BBH (96%), Terrestrial (4%)	Yes	June 9, 2023 06:49:58 UTC	GCN Circular Query Notices | VOE		1 per 3.1557 years	
S230608as	BBH (>99%)	Yes	June 8, 2023 20:50:47 UTC	GCN Circular Query Notices | VOE		1 per 231.43 years	
S230606d	BBH (>99%)	Yes	June 6, 2023 00:43:05 UTC	GCN Circular Query Notices | VOE		1 per 2.7789 years	
S230605o	BBH (99%), Terrestrial (1%)	Yes	June 5, 2023 06:53:43 UTC	GCN Circular Query Notices | VOE		1 per 7.0086 years	
S230601bf	BBH (>99%)	Yes	June 1, 2023 22:41:34 UTC	GCN Circular Query Notices | VOE		1 per 1.8492e+07 years	
S230529ay	NSBH (62%), BNS (31%), Terrestrial (7%)	Yes	May 29, 2023 18:15:00 UTC	GCN Circular Query Notices | VOE		1 per 160.44 years	

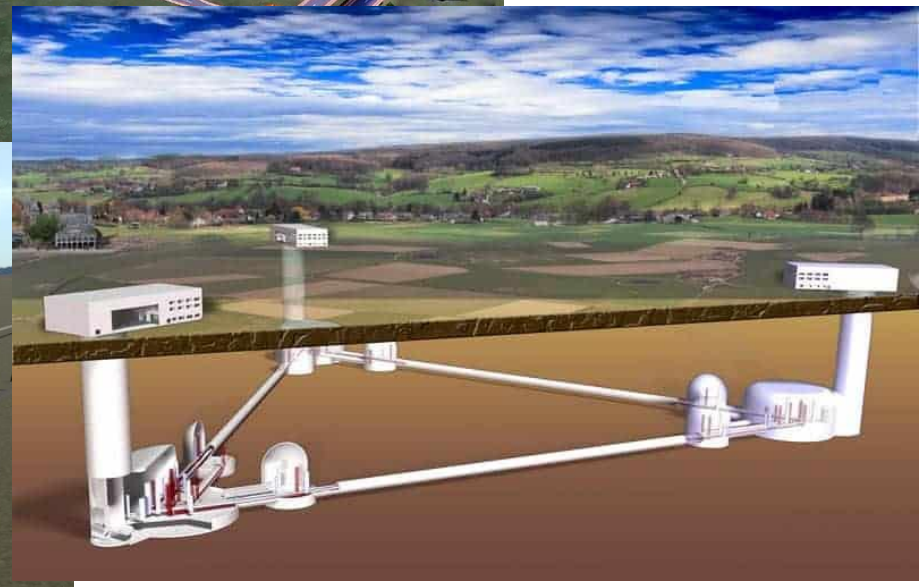
Future

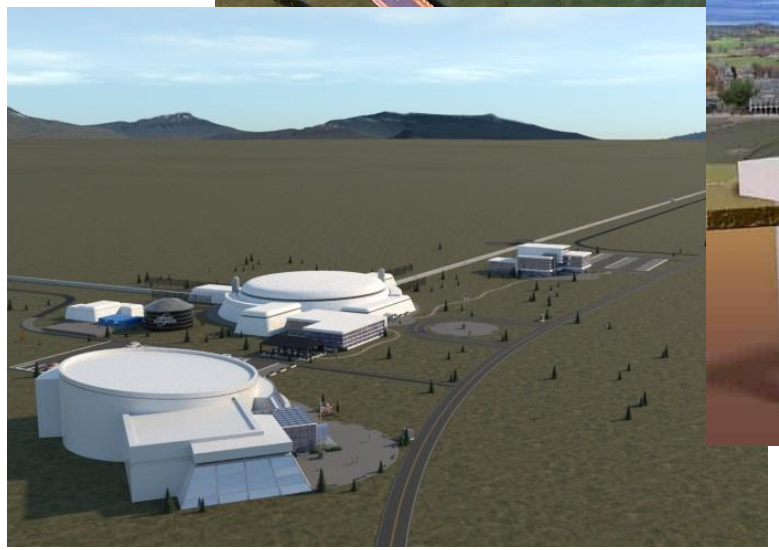
After O4 is complete, we plan to undergo another set of upgrades before a longer O5 run

LIGO India is being built and will come online in the future

Further down the line, we look forward to third generation observatories

- Einstein Telescope (Europe)
- Cosmic Explorer (US)





Thanks