



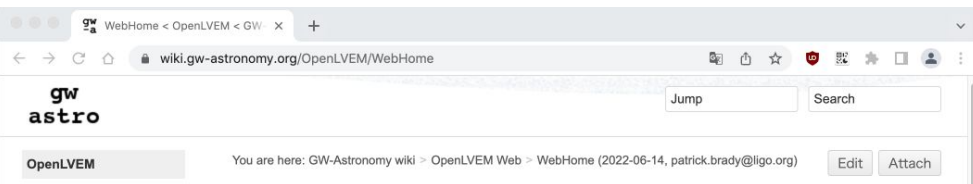
O4 run plans, risks, and data release

A. Rocchi, B. O'Reilly, T. Sawada for the LVK collaboration

Observing Run Plans (Last updated on 15 June 2022)

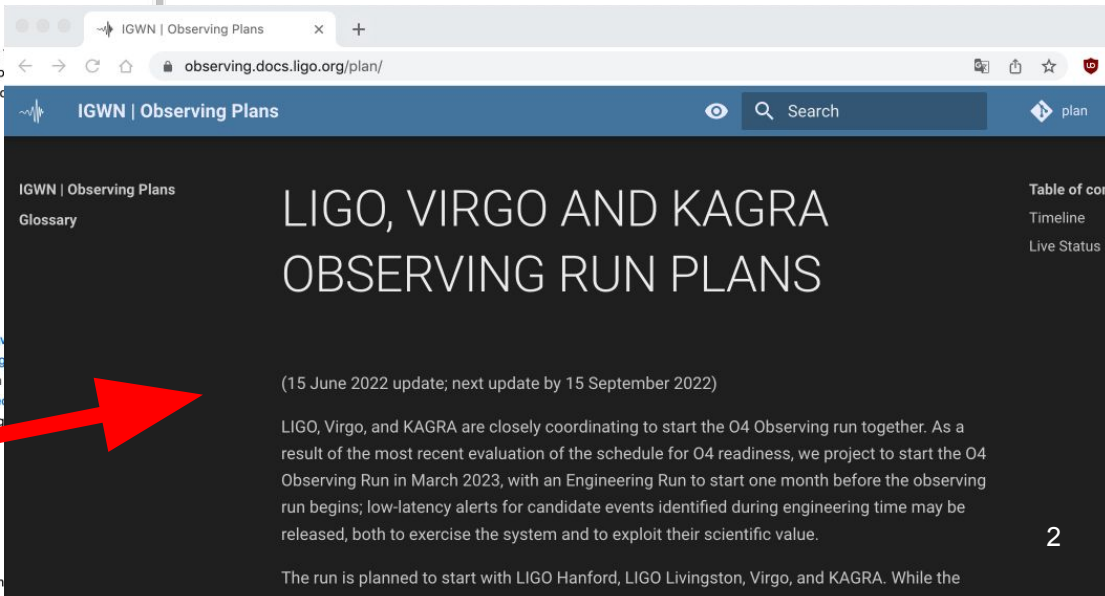
OpenLVEM web home

<https://wiki.gw-astronomy.org/OpenLVEM/WebHome>



Latest announcements on observing run plans

<https://observing.docs.ligo.org/plan/>



Welcome to the OpenLVEM web

This is the community forum on multi-messenger observations connected to Gravitational Wave (GW) detections. This forum has no requirements for participation -- anyone interested can join. This open for January 2018. The **LIGO-Virgo-KAGRA Collaboration** will use this forum to communicate and interact with the community.

- Get started
- Documentation
- Telecons
- Townhall Meetings
- Other links
- OpenLVEM Web Utilities

Get started

Sign up to the [OpenLVEM Forum](#) at gw-astronomy.org: approval and subscription to the openlvem@gw-astronomy.org mailing list is automatic if you provide and confirm a valid e-mail address (for help on this topic, email help@cgca.uwm.edu). Information about observing runs, how to receive alerts, and open science will be communicated via [OpenLVEM mailing list](#). The OpenLVEM forum will also organize occasional [telecon person meetings](#) to foster communication with physicists and astronomers interested in multi-messenger observations connected to gravitational waves.

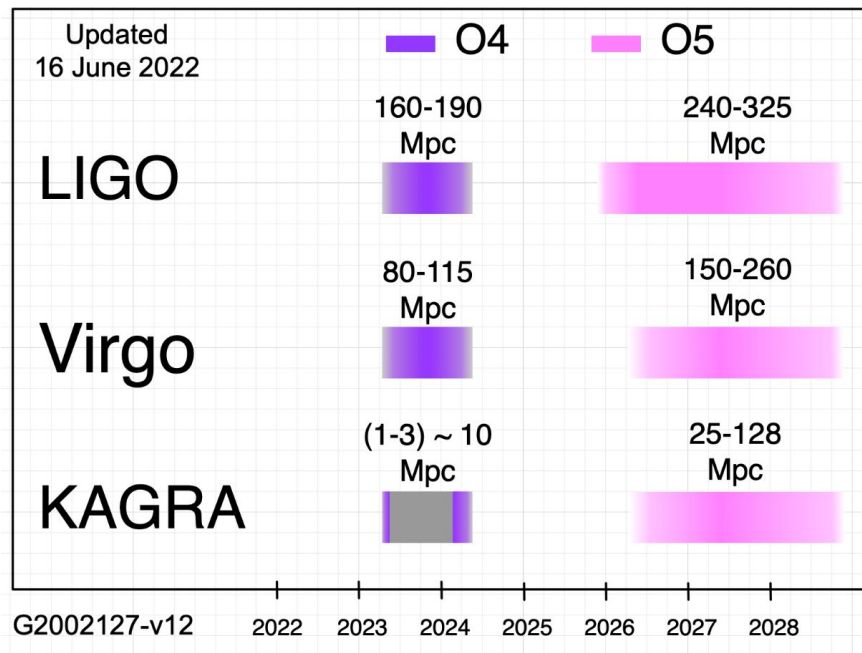
Documentation

- [Observing Run Plans](#)
 - Joint LVK statement on future observing runs.
- [Public Alert User Guide Under review for O4; a revised version will be released Fall 2022.](#)
 - Explains how to receive public alerts, documents the contents of those alerts, and explains how to respond to them.

Observing Run Plans (Last updated on 15 June 2022)

O4

- Move the start of O4 observing run to **March 2023**.
- 1 year observation with 1 month mid-run commissioning break.
- The projected sensitivity of the detectors remains unchanged.
- Alerts may be released during engineering running that precedes O4.



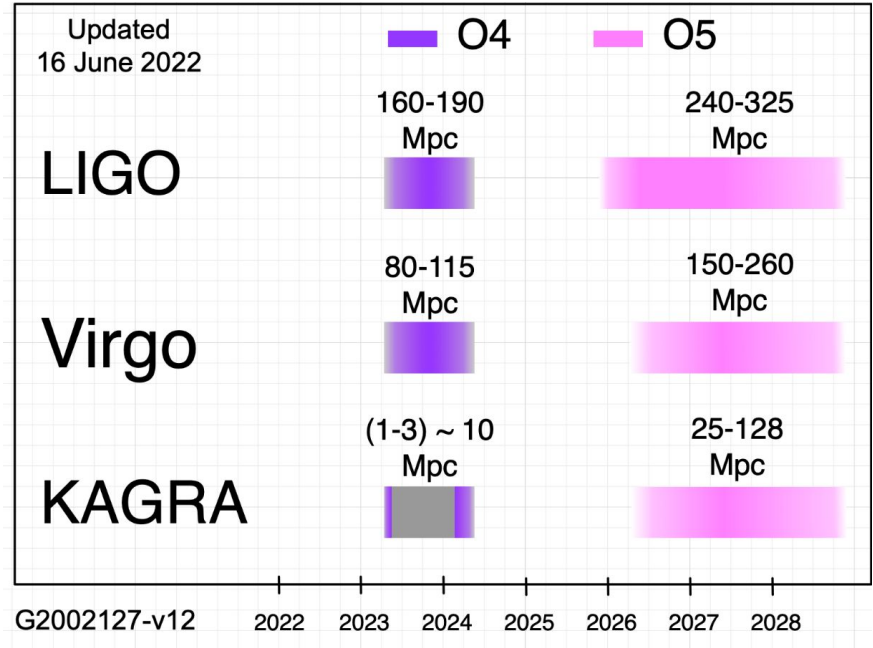
Observing Run Plans (Last updated on 15 June 2022)

Beyond O4

- O5 schedule is still tentative.
- We anticipate the need in O5 for one or more commissioning breaks of a few months duration each.
- Post-O5 plans are being developed; observations will continue (subject to funding)

Next Update: 15 September 2022

- LVK will continue to review and update observing run plans periodically.



Detectors' status

- Scientists, Engineers, Technicians, and Students at LIGO, Virgo and KAGRA working to:
 - Finalize the installation of upgrades;
 - Commission the detectors to reach the expected sensitivities;
- Some technical uncertainties still remain, which may impact our schedule. (Potential risks)
- A brief summary can be found in the latter part of this slide, but for more details, please watch or see the last **LVK webinar** held on **28 April 2022**:

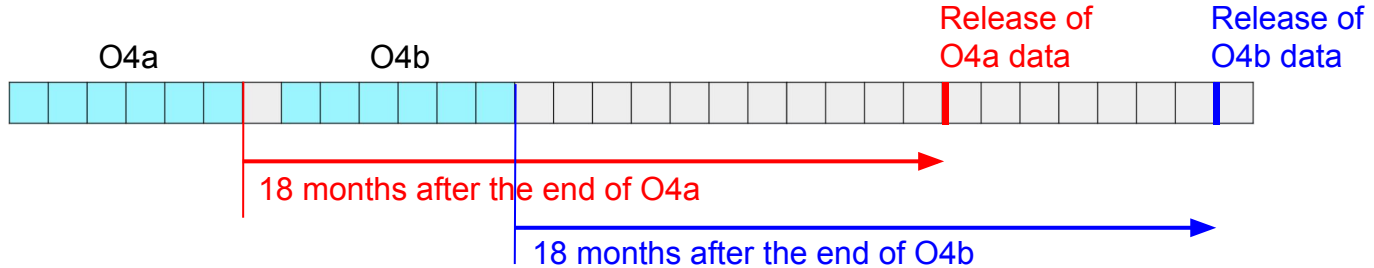
Recorded Video: https://www.youtube.com/watch?v=Ut7Ef5AiA_M

Slides: <https://dcc.ligo.org/LIGO-G2200736/public>

*N.B. Dates and status in the video/slides are as of 28 April 2022.

Data Release Plan

The calibrated strain data and data quality flags will be released 18 months after each 6-month long observation period.



- **O4a**
Observing Run: Mar. 2023 - Sep. 2023 → Data Release: Mar. 2025
- **O4b**
Observing Run: Oct. 2023 - Apr. 2024 → Data Release: Oct. 2025

Thank you for your time and attention.

Spares

Here is a brief summary of the status of each detector.

For more details, please watch or see the last **LVK webinar** held on **28 April 2022**:

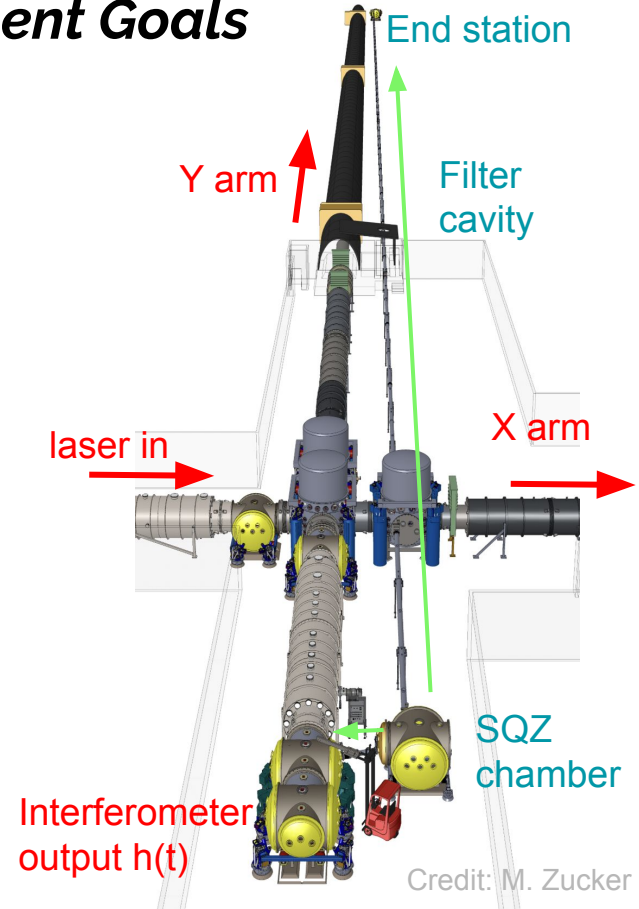
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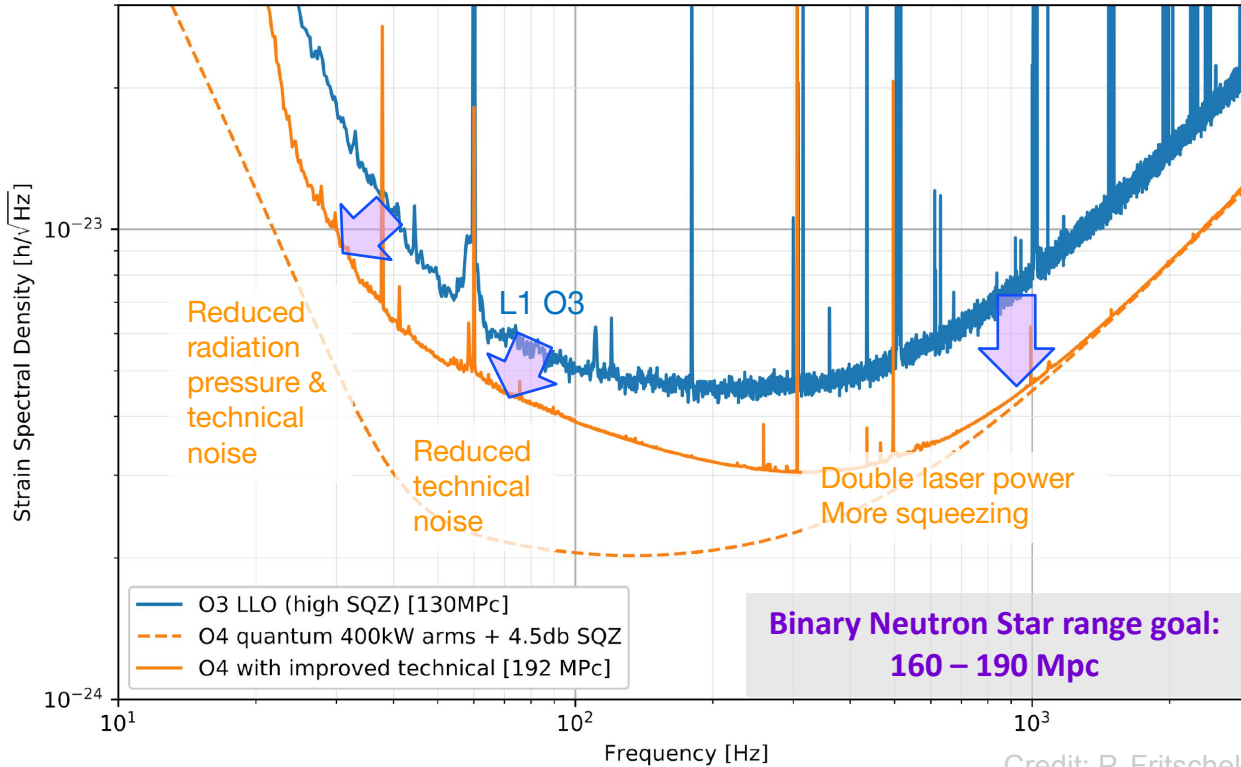
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LIGO (1/5) *Summary of LIGO Improvement Goals*

- **400kW circulating arm power**
(compare to ~200 kW in O3)
- **Squeezed light efficacy 4.5dB**
(compare to 2-3dB in O3)
- **300m filter cavity** for frequency dependent squeezing
- **Low frequency technical noise reduction**
< 100 Hz



LIGO (2/5) *O4 Performance Potential*



$$h \sim 1/r$$

$$\text{rate} \sim r^3 * T$$

LIGO (3/5) *Upgrades*

Reduce Quantum Noise: Double arm power to 400 kW

- Higher power laser (complete rebuild)
- Better test masses (point absorber issues)
 - One input test mass at H1
 - Both end test mass at L1

Reduce Quantum Noise: Freq. dependent (more) squeezing

- 300m filter cavity -> also squeeze at low frequency!
- Better Faraday Isolators with lower losses
- Active mode matching

Reduce low frequency tech. noise

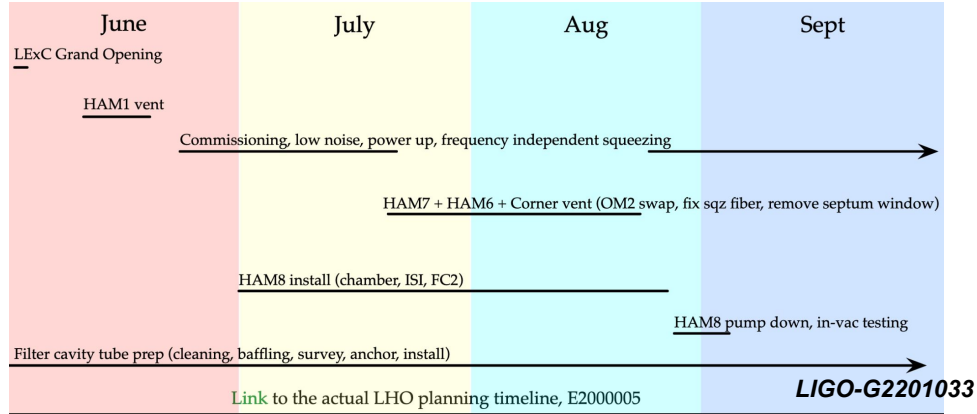
- Scattered light reduction
 - More baffling
 - Removal of output wedged window
 - Damping of highQ resonances of scattering surfaces
- Control noise reduction / subtraction
- Better electronics

Duty cycle improvements

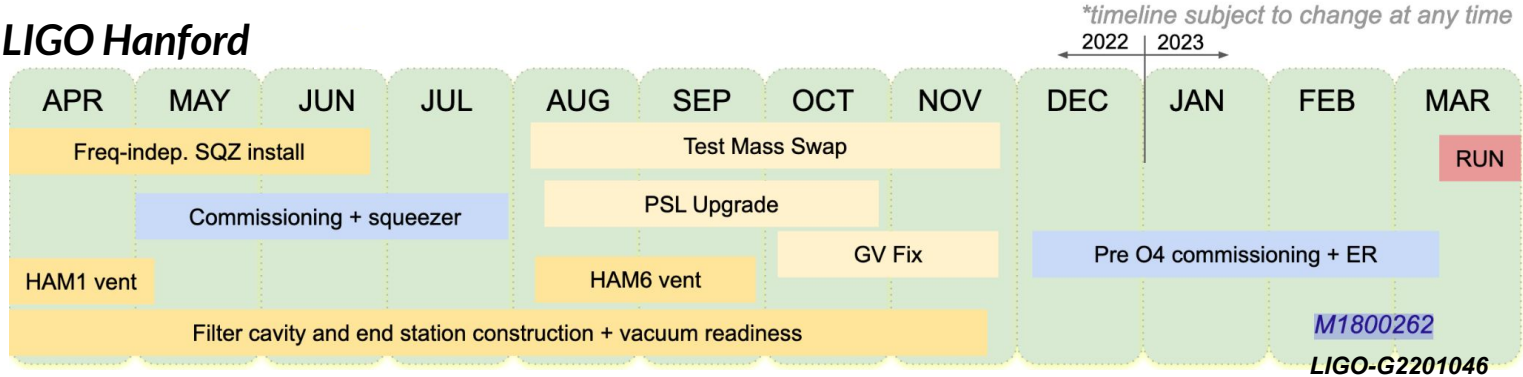
- Damping of high Q resonances of suspensions:
 - Violin modes ~500 Hz
 - Beam Splitter bounce and roll modes: ~16, 24 Hz
- O3b duty cycle: ~ 75%, ~50% triple coverage (very hard to get above 85% per instrument)

LIGO (4/5) *Approximate schedule*

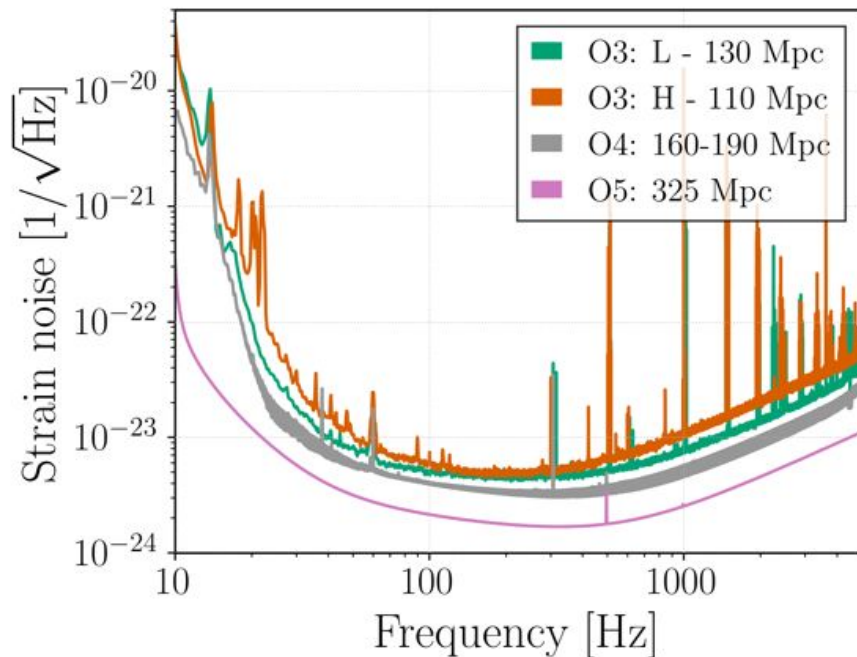
At LIGO Livingston



At LIGO Hanford



LIGO (5/5) *Potential Resulting Sensitivity*



Uncertainties:

- will new mirror be free of defects?
- will we get the expected technical noise reduction?
- have we abated sufficiently the losses in the whole system to achieve 4.5dB freq. dependent squeezing?

Virgo (1/4) *Advanced Virgo Plus for O4*

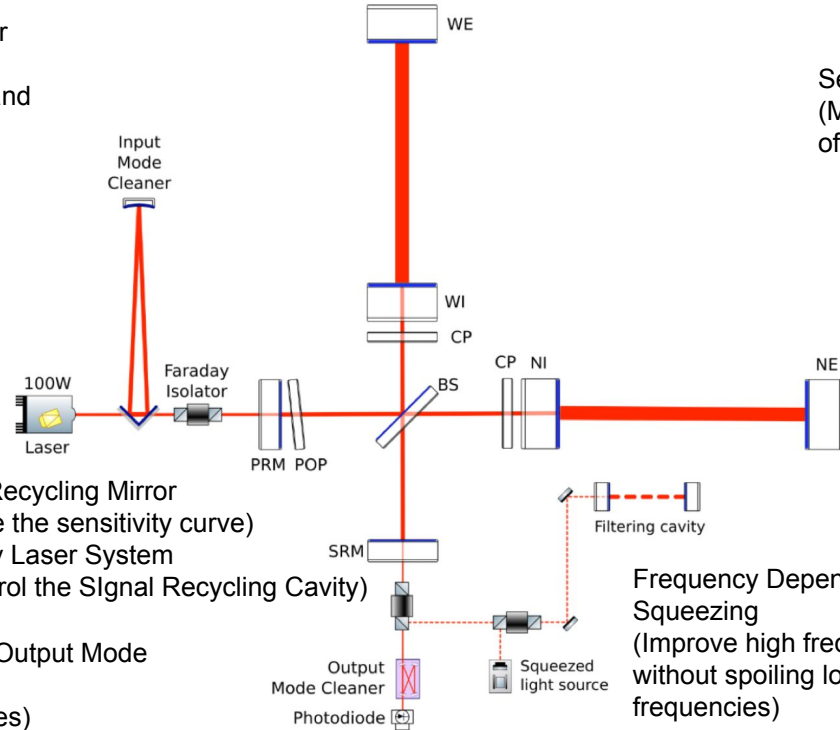
New Input Mode Cleaner
Payload
(Improve controllability and stability)
Instrumented Baffle
(Direct measurement of scattered light)

High-power Laser
(Increase the circulating power)

Signal Recycling Mirror
(Change the sensitivity curve)
Auxiliary Laser System
(To control the Signal Recycling Cavity)

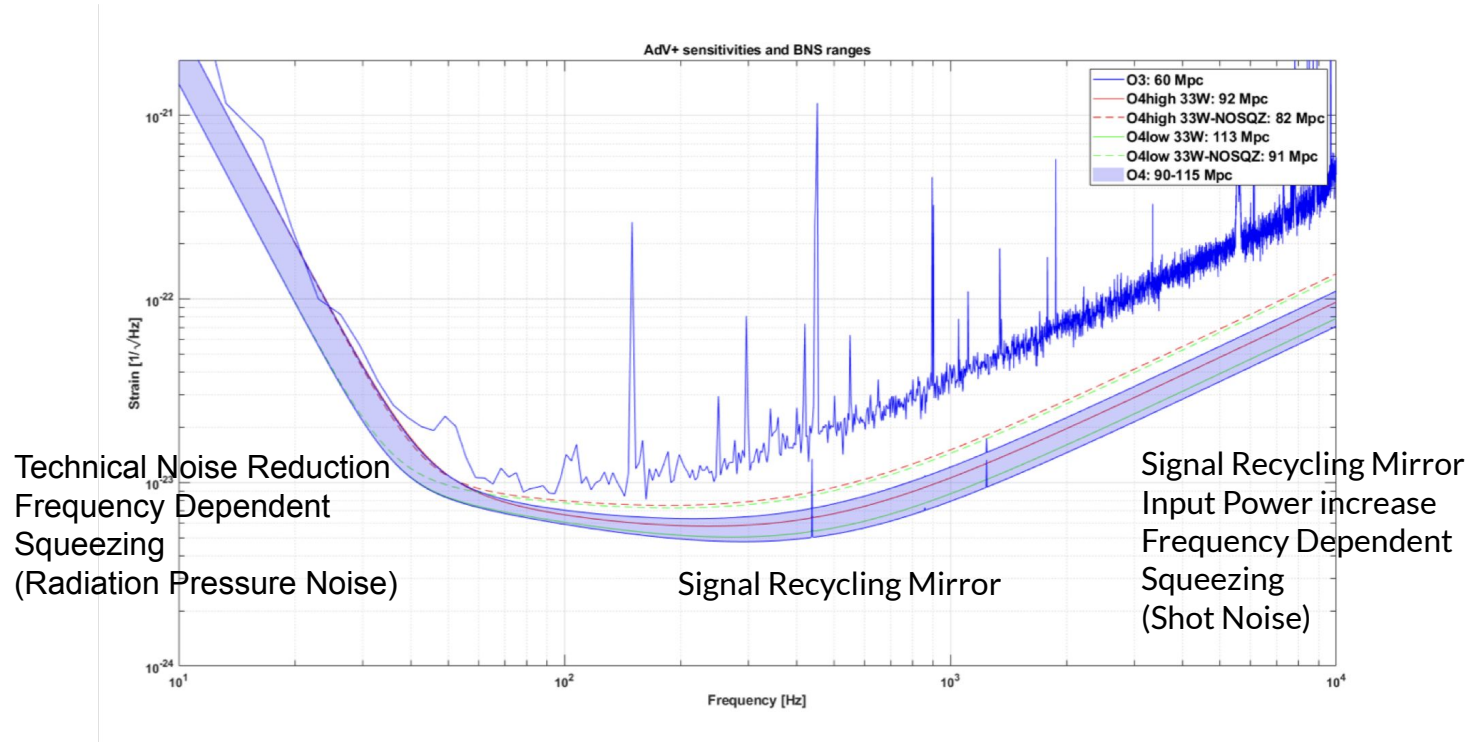
High-finesse Output Mode Cleaner
(Reduce losses)
Low-noise photodiodes
(Reduce the electronic noise)

Seismometer Array
(Measurement and cancellation of Newtonian Noise)



Frequency Dependent Squeezing
(Improve high frequencies without spoiling low frequencies)

Virgo (2/4) *Target Sensitivity Curve*



Virgo (3/4) *Current Status*

- All the major upgrades have been successfully installed.
- Power injected into the interferometer about 33 W.
→ Circulating cavity around 140 kW.
- Full interferometer controlled is not at an optimal working point.
→ Many indications about the current limitations.
- Current main activity on the interferometer: Optimization of the working point (mode-matching, global alignment, thermal state tuning)
- Frequency dependent squeezing commissioned in parallel./
→ Frequency dependent squeezing measured around 40 Hz.

Virgo (4/4) *Next Steps*

- Improvement of the interferometer working point: mode matching, global alignment, reduction of the control noise, fine tuning of the thermal state.
- Have a repeatable estimation of the sensitivity curve.
- Optimization of the frequency dependent squeezing system to improve the stability.
- Noise hunting to reduce the impact of the technical noises and improve the sensitivity.
- Injection of the frequency dependent squeezing into the interferometer.

KAGRA (1/3) *Short Summary*

- Apr. 2020, KAGRA conducted the first joint observation with GEO600 for two weeks (O3GK).
- Toward O4, KAGRA has been upgrading various subsystems to resolve problems identified in O3GK.
- **O4a**
 - KAGRA plans to start O4a from the beginning with LIGO and Virgo, with the sensitivity **better than 1 Mpc (1-3 Mpc)**.
 - **Approx. 1 month** of participation in O4a.
- **mid-break**
 - In the middle of O4a, KAGRA will step away for commissioning to improve the sensitivity toward O4b.
- **O4b**
 - In the middle of O4b, KAGRA will return to observing with a greater sensitivity of **3-10 Mpc**.
 - **Approx. 3 months (or longer)** of participation in the latter half of O4b.

KAGRA (2/3)

Target Sensitivities for O4a/b

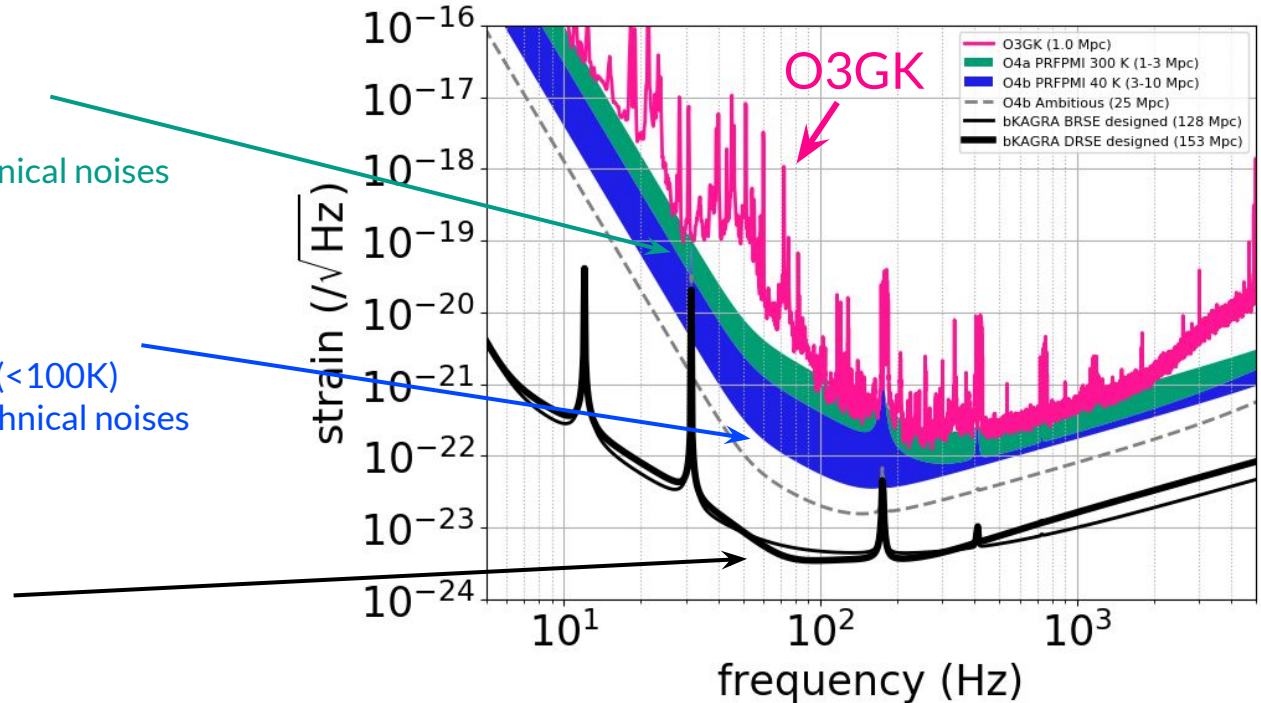
O4a (1-3 Mpc)

- Transparent SRM
- 1/3 reduction of technical noises

O4b (3-10 Mpc)

- Cryogenic operation (<100K)
- 1/25 reduction of technical noises

Design sensitivities (128-153 Mpc)



KAGRA (3/3) *Upgrades toward O4*

- **Suspension Upgrades**

- Fixed mechanical failures.
- Improved various local sensors.
 - Accelerometers
 - LVDTs
 - Optical Levers
- Improved actuator balances.



Better optimization of damping control filters.

- **Scattered Light Noises Reductions**

- Install additional baffles.

- **High Power Laser Installation**

- 40W → 60W
 - Only 5W used during O3GK
- Lower intensity noise than the current laser.

- **Output Mode Cleaner Upgrades**

- Higher transmissivity: 80% → 95%
- Fix the broken DCPD → Double the GW signal.

- **Signal Recycling Mirror Upgrades**

- Install extra gate valve and replace the signal recycling mirror.

- **Vacuum & Cryogenic Upgrades**

- Additional vacuum pumps
 - 12 more ion-pumps
 - 10 more turbo molecular pumps
- Better vacuum
- Avoid molecular adsorption on mirrors during cooling.
- Defrosting heaters