O4 run plans, risks, and data release

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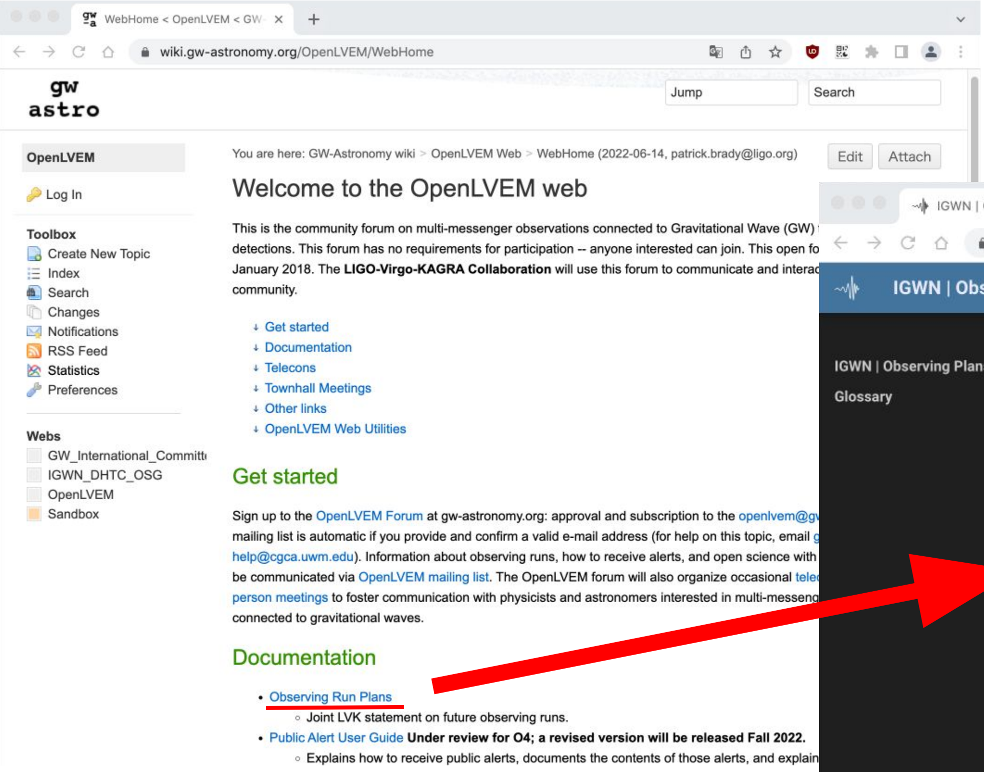
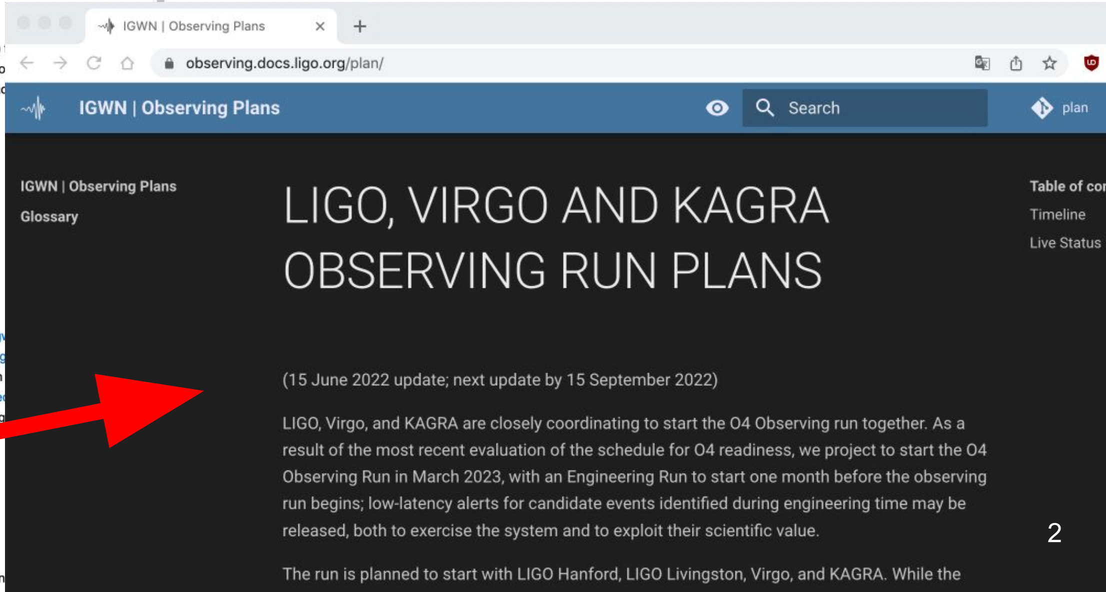
LIGO-G2201173 / VIR-0766A-22 / JGW-G2214183

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/

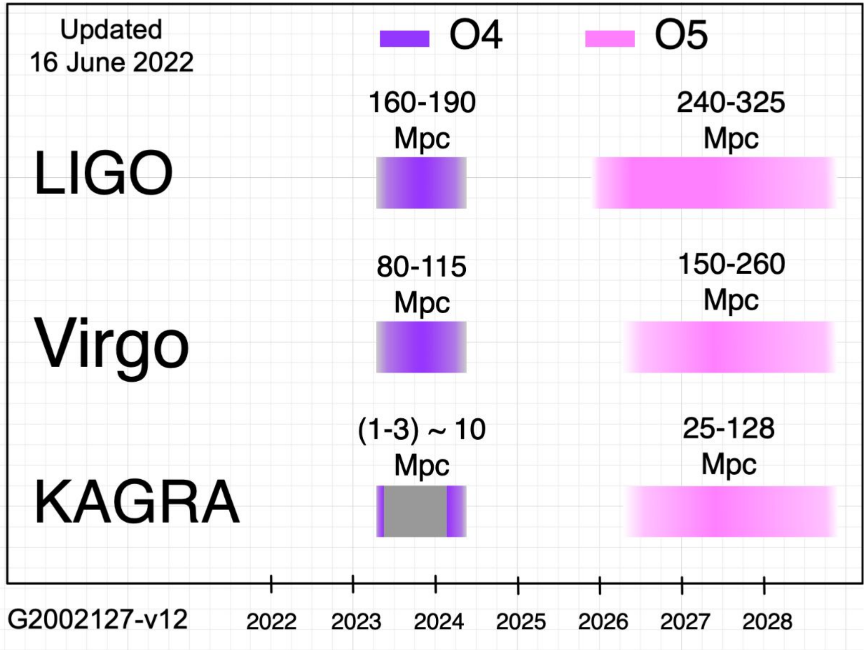




Observing Run Plans (Last updated on 15 June 2022)

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.



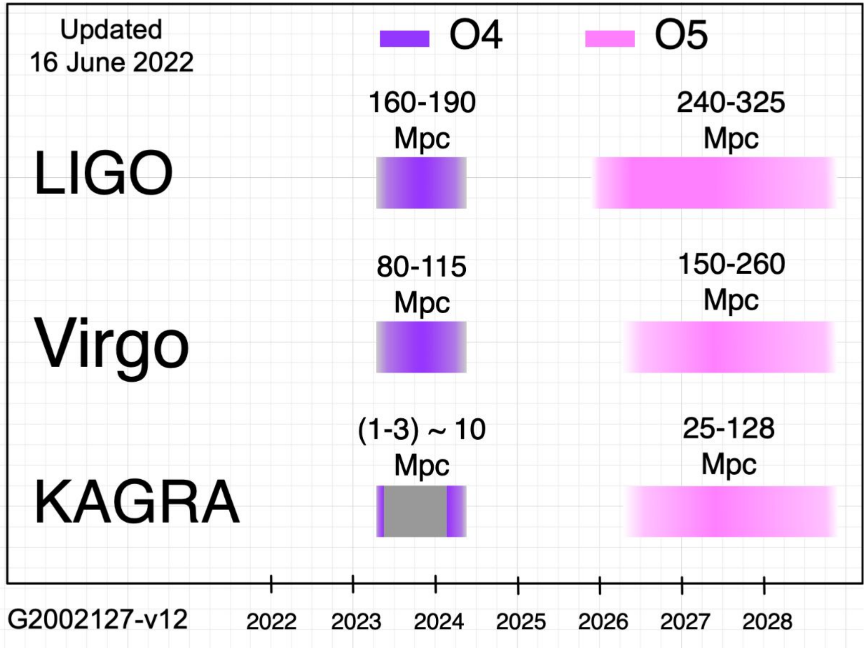
Observing Run Plans (Last updated on 15 June 2022)

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)

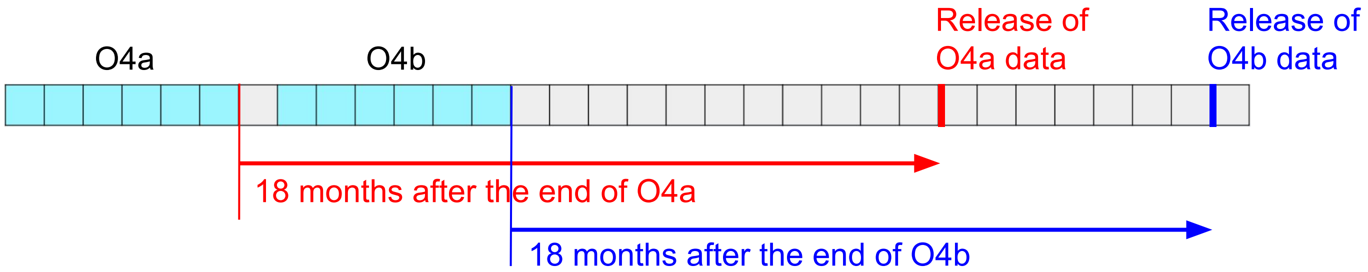
- A brief summary can be found in the latter part of this slide, but for more details, please watch or see the last **LVK webinar** held on **28 April 2022**:

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. 2024**

- **O4b**

  Observing Run: Oct. 2023 - Apr. 2024 → **Data Release: Oct. 2024**

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**:

Recorded Video: https://www.youtube.com/watch?v=Ut7Ef5AiA_M
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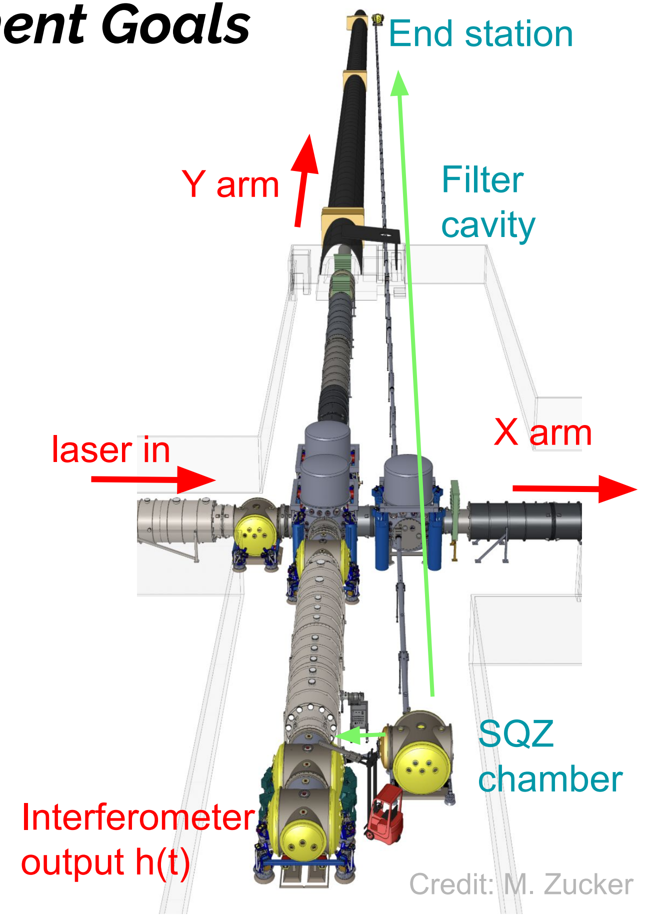
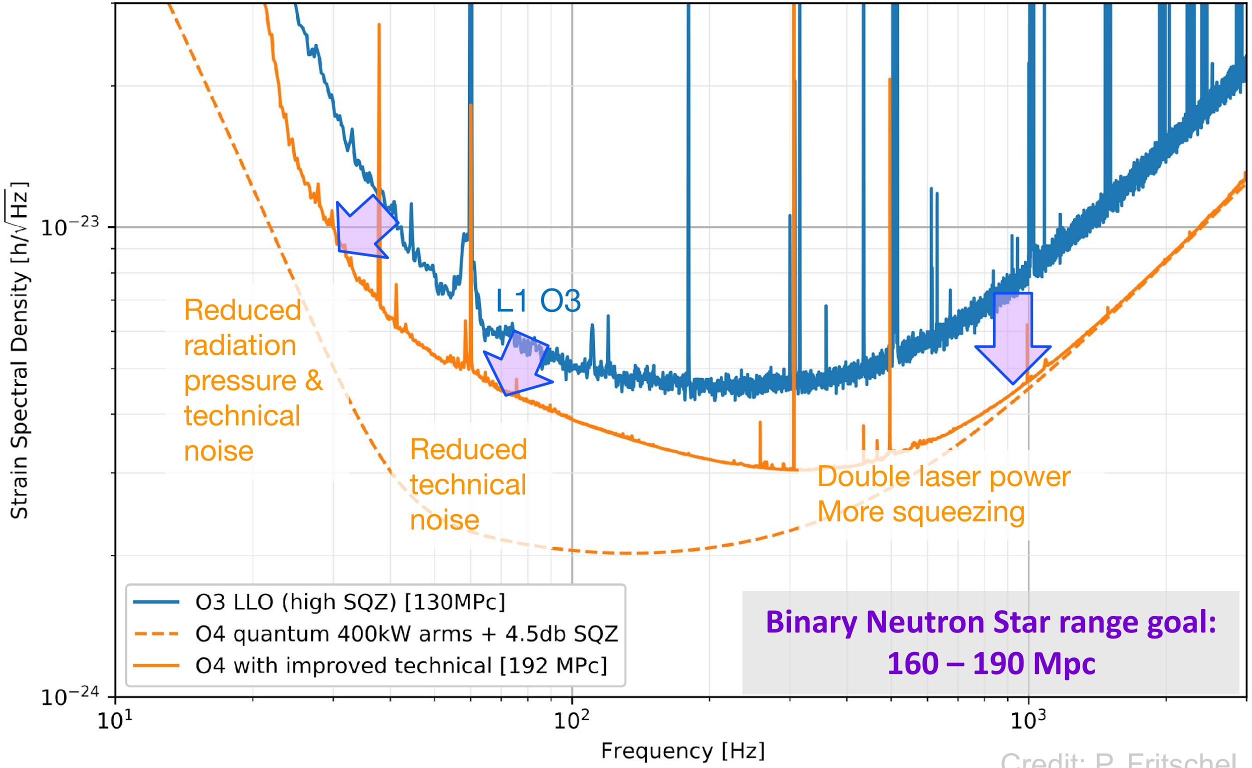
LIGO (1/5) ***Summary of LIGO Improvement Goals***

- **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



Credit: M. Zucker

LIGO (2/5) ***O4 Performance Potential***



Binary Neutron Star range goal: 160 – 190 Mpc

Credit: P. Fritschel

h ~ 1/r

rate ~ 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

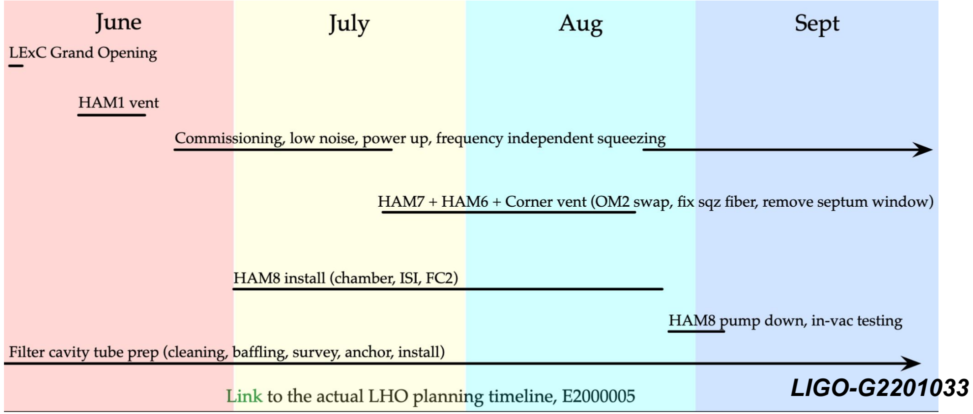
- Scattered light reduction
  - More baffling
  - Removal of output wedged window
  - Damping of highQ resonances of scattering surfaces
- Control noise reduction / subtraction
- Better electronics

Duty cycle improvements

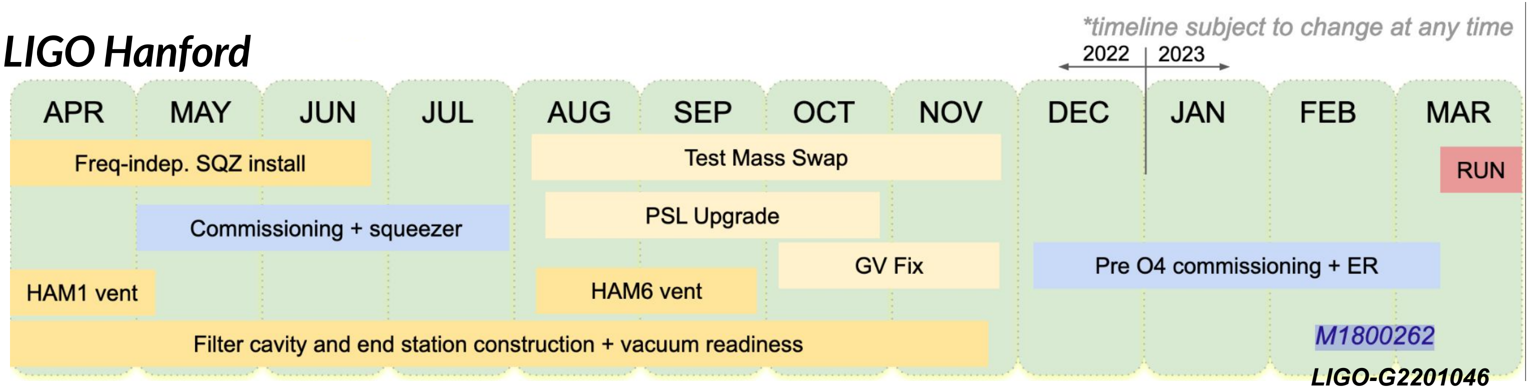
- Damping of high Q resonances of suspensions:
  - Violin modes ~500 Hz
  - Beam Splitter bounce and roll modes: ~ 16, 24 Hz
- O3b duty cycle: ~ 75%, ~50% triple coverage (very hard to get above 85% per instrument)

LIGO (4/5) *Approximate schedule*

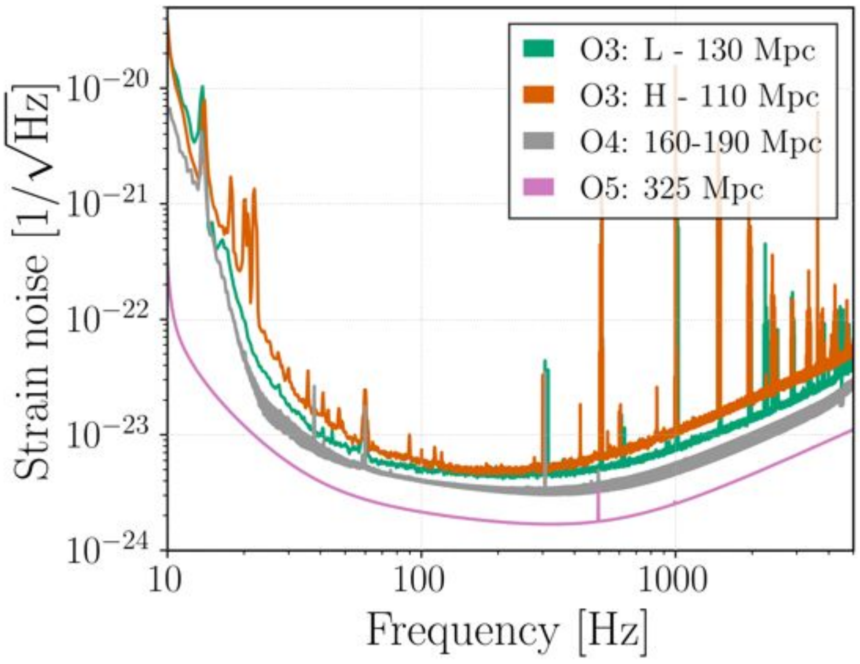
At LIGO Livingston



At LIGO Hanford



LIGO (5/5) ***Potential Resulting Sensitivity***



Credit: B. O'Reilly

Uncertainties:

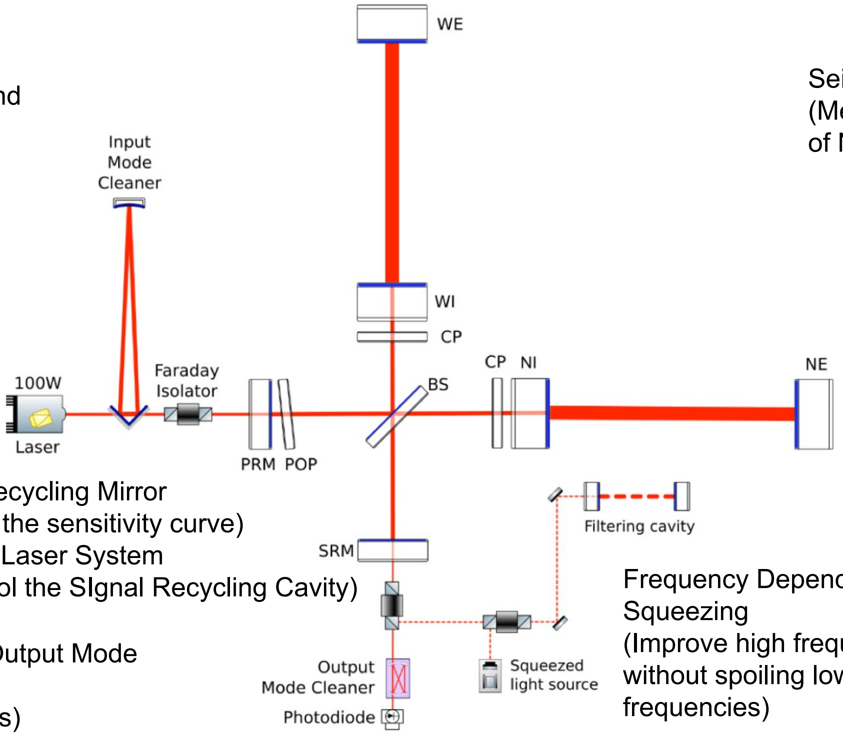
- will new mirror be free of defects?
- will we get the expected technical noise reduction?
- have we abated sufficiently the losses in the whole system to achieve 4.5dB freq. dependent squeezing?

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)

Seismometer Array
(Measurement and cancellation of Newtonian Noise)

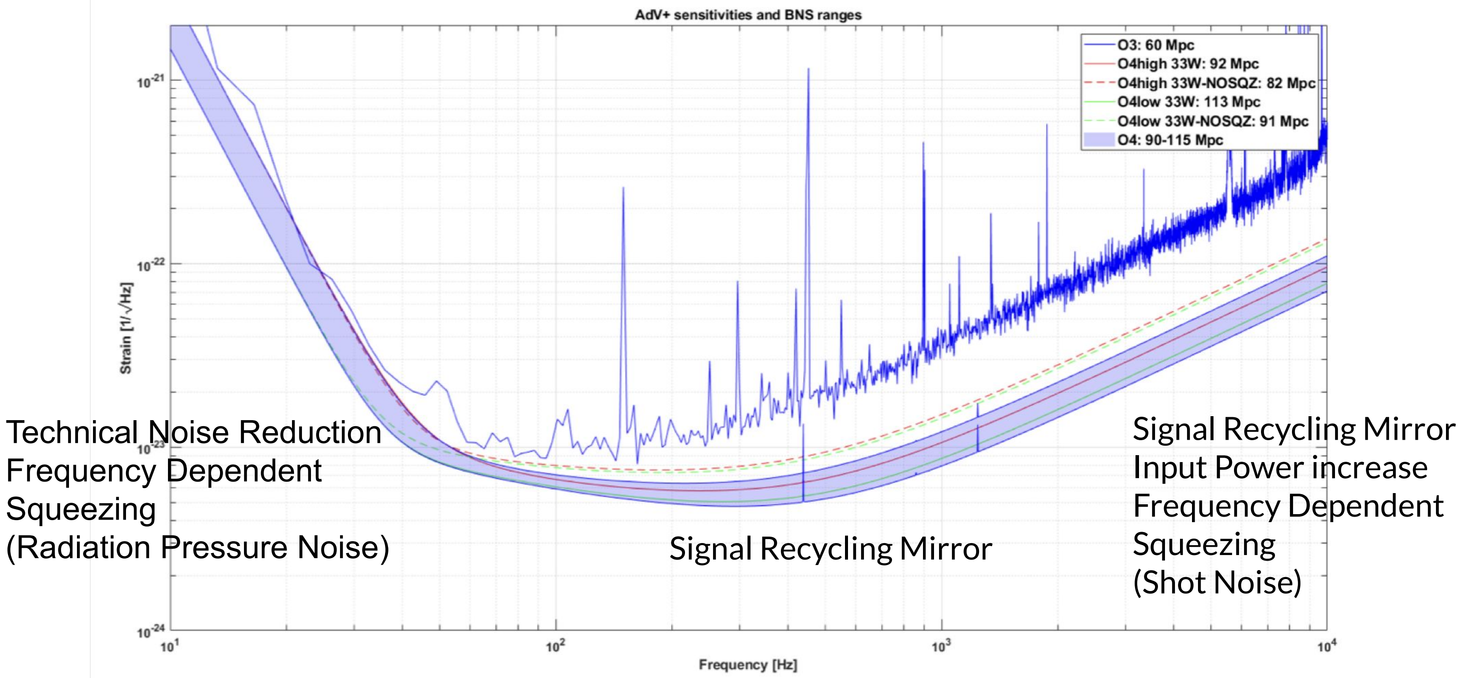


Signal Recycling Mirror
(Change the sensitivity curve)
Auxiliary Laser System
(To control the SIgnal Recycling Cavity)

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

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

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***

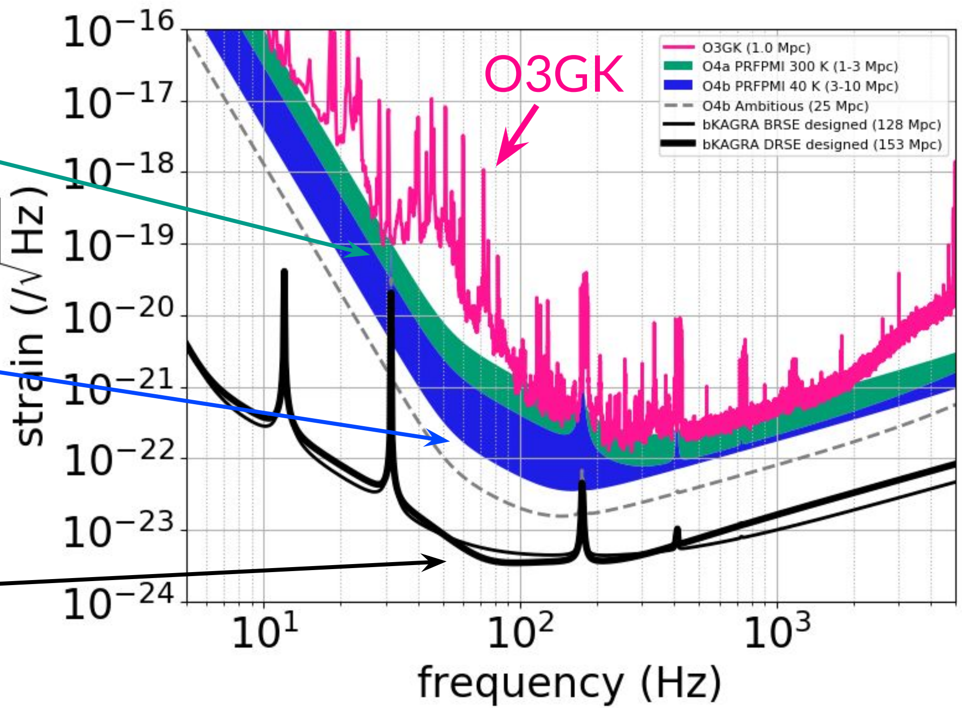
O4a (1-3 Mpc)

- 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