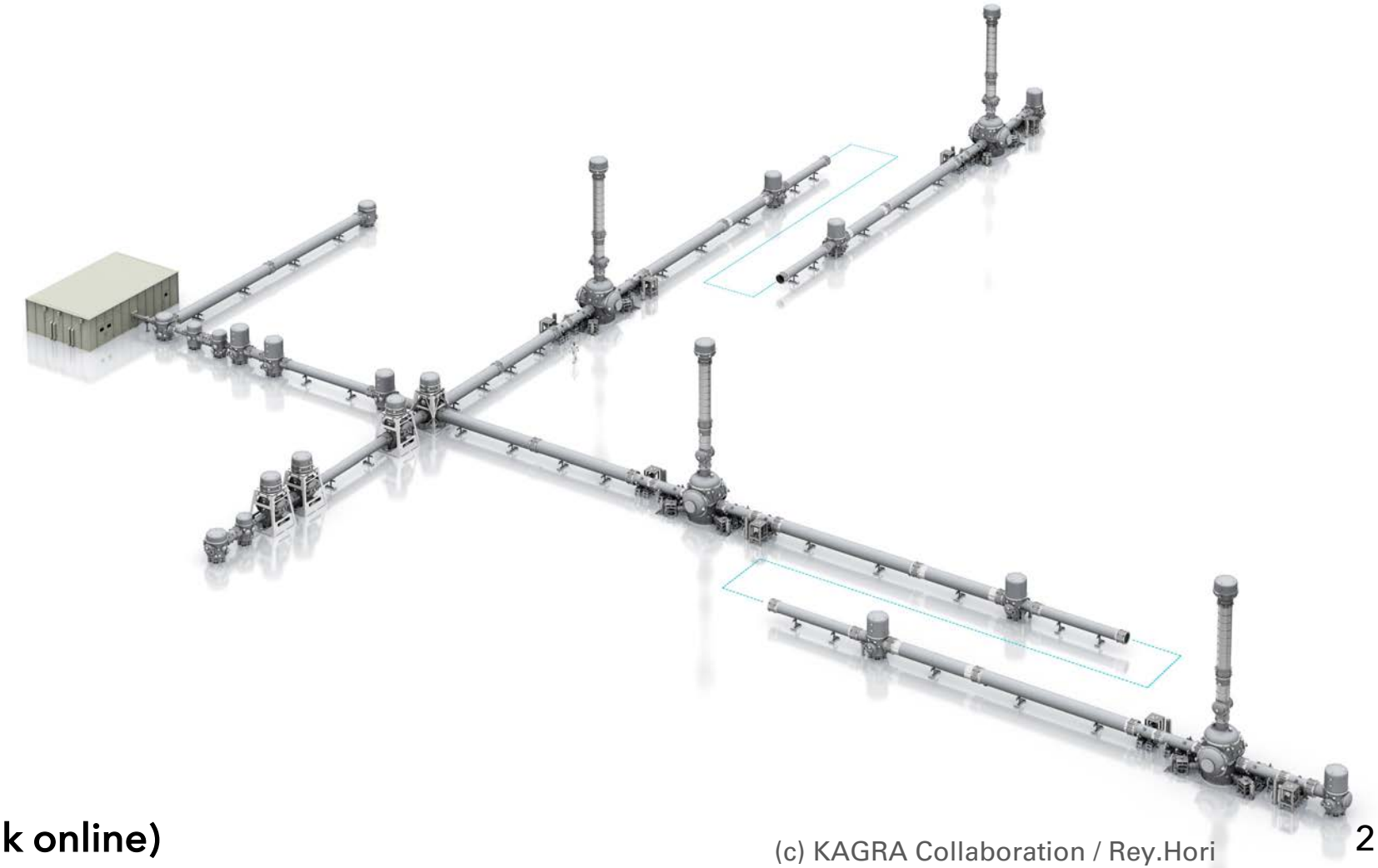
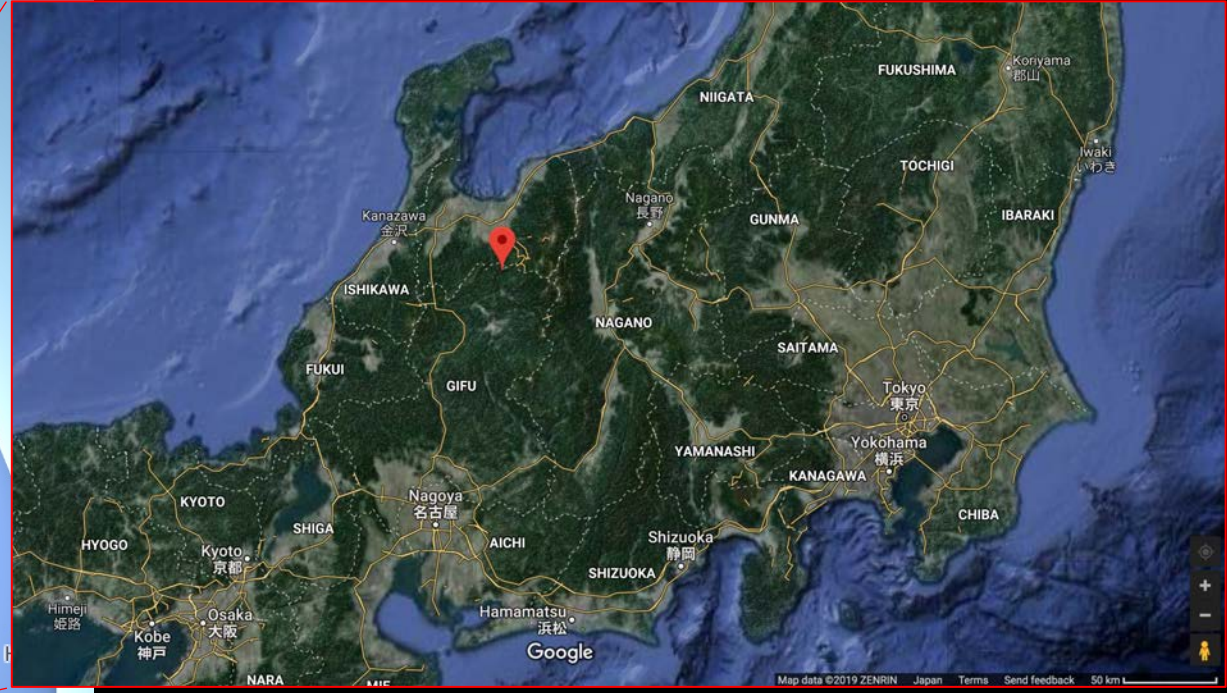
KAGRA
status and prospects

Tomo Akutsu (NAOJ)
for the KAGRA collaboration

Contents

- Introduction
- Towards O4a
- Beyond O4a
- Summary





What is KAGRA?

- At Kamioka, Japan
- Constructed under a mountain
- Using cryogenic main mirrors

Tunnels excavated 2012-2014

Entrance


Mozumi Office

Toyama Plain

Heavy snow site

13th ET symposium (8-12 May 2023, talk online)

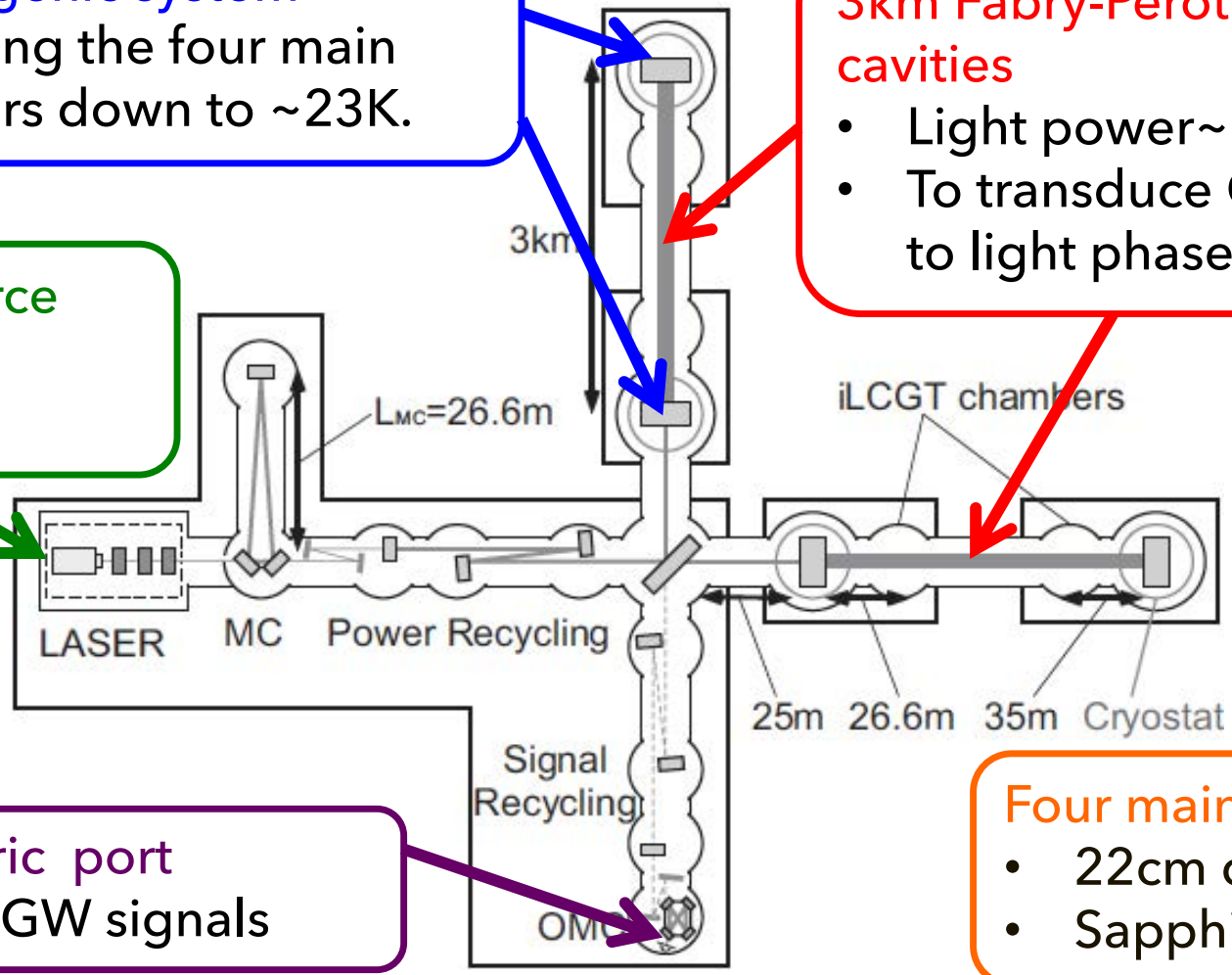
The interferometer

Cryogenic system
Cooling the four main mirrors down to ~23K.

3km Fabry-Perot optical cavities
- Light power~ 400 kW
- To transduce GW signals to light phases

Laser light source
- 100~180W (planned)

Vibration isolation system
- Isolating mirrors from vibrations.

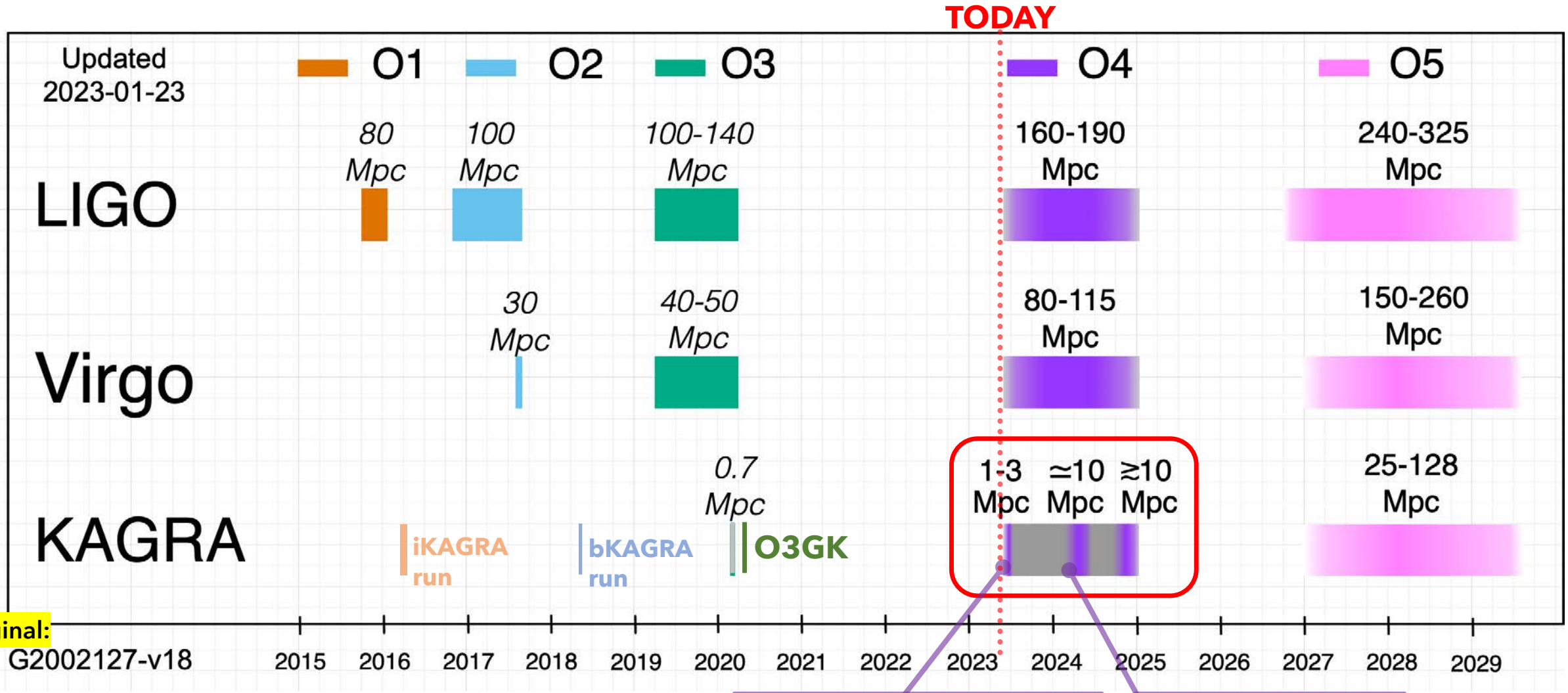


Anti-symmetric port
- To extract GW signals

Four main mirrors
- 22cm diameter
- Sapphire

K. Somiya et al., Class. Quantum Grav. 29, 124007 (2012)

KAGRA's run history and plan



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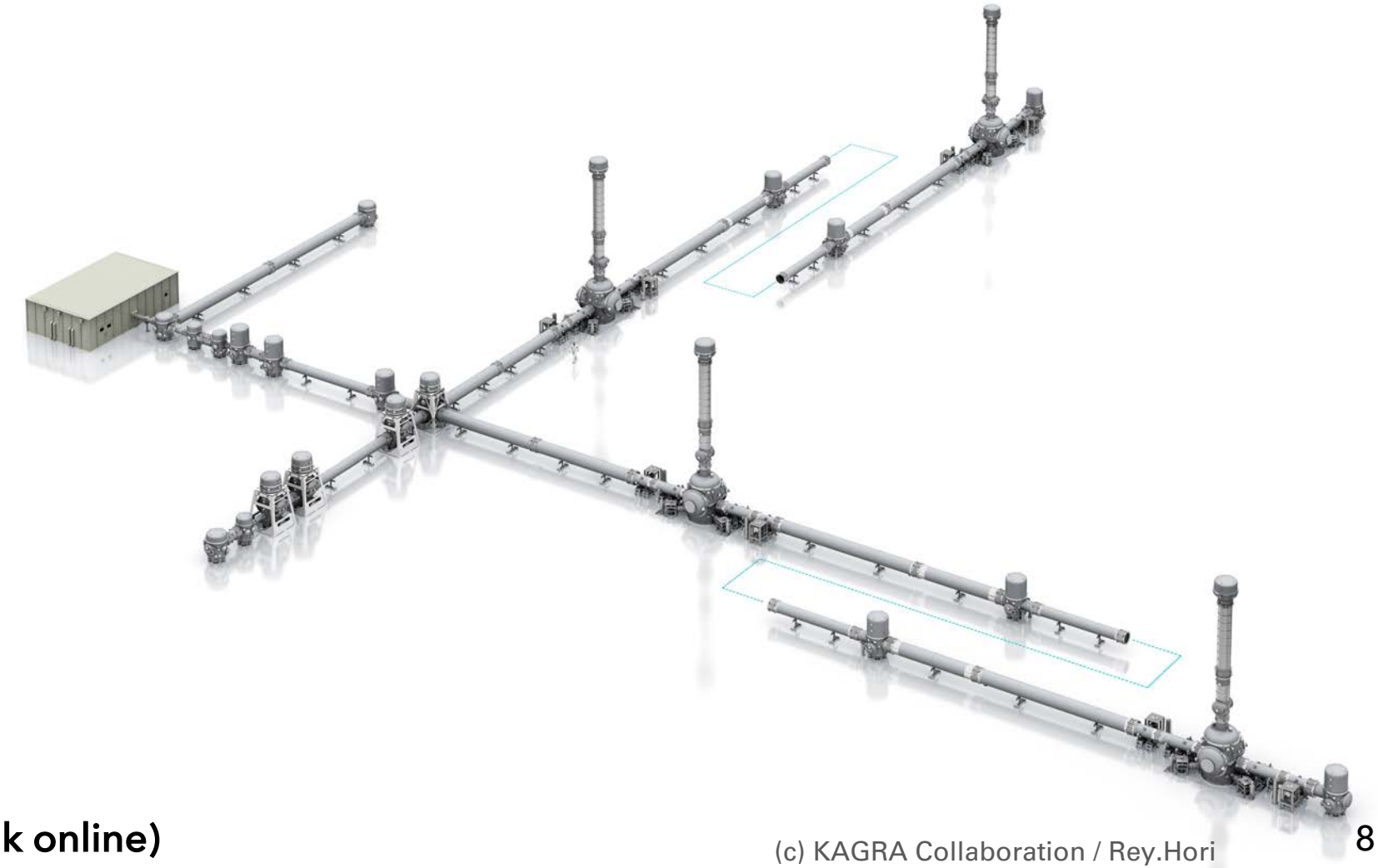


Revisit: O3GK commissioning issues

Sensitivity

- "Time-up" for satisfactory noise hunting before starting O3GK

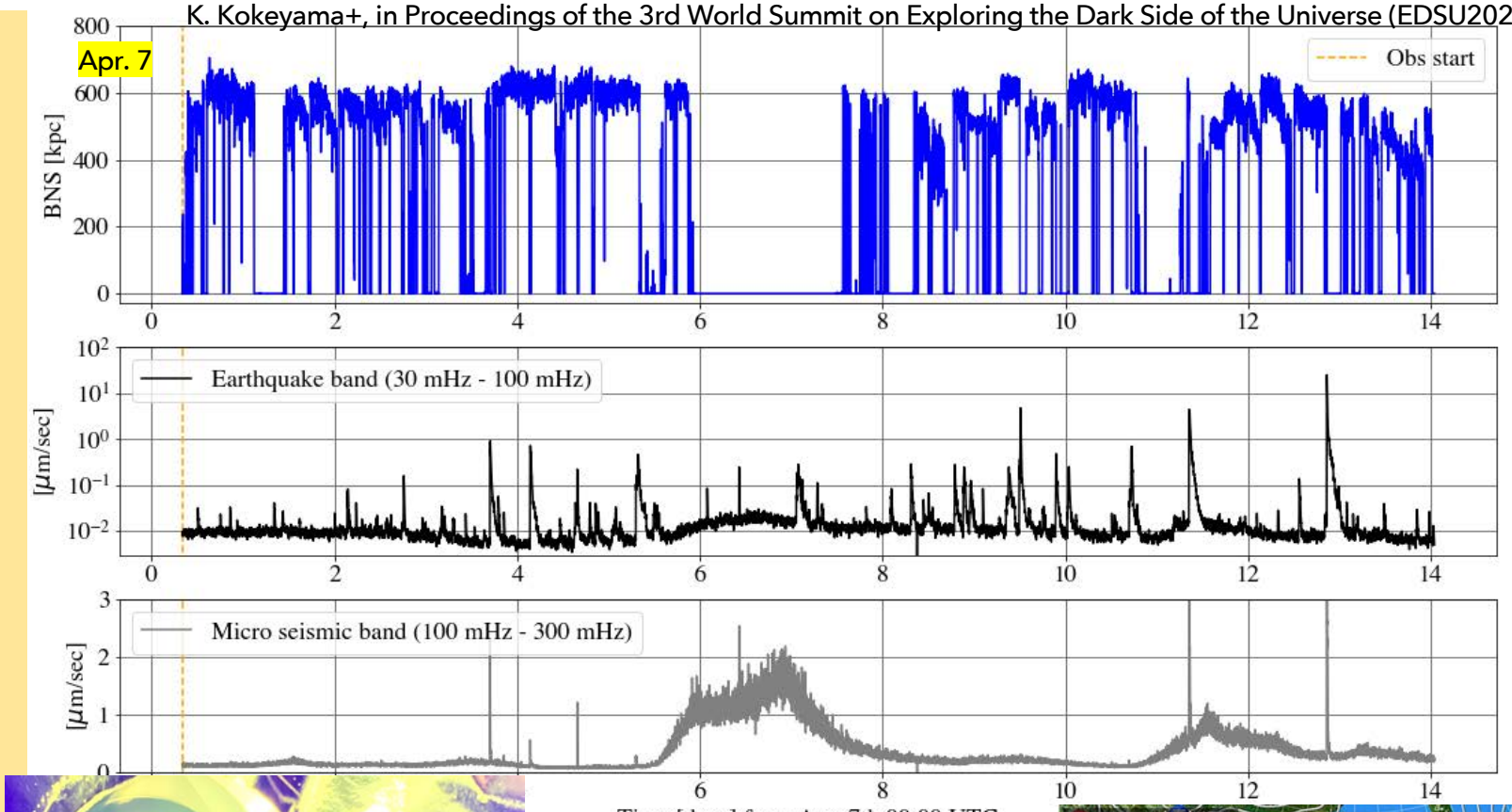
Stability / repeatability

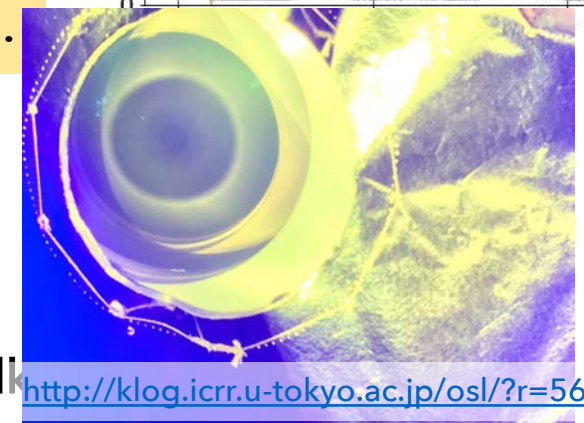
- BNS range drifting
- Frequent lock loss
- Lock acquisition failing due to storms

Reliability

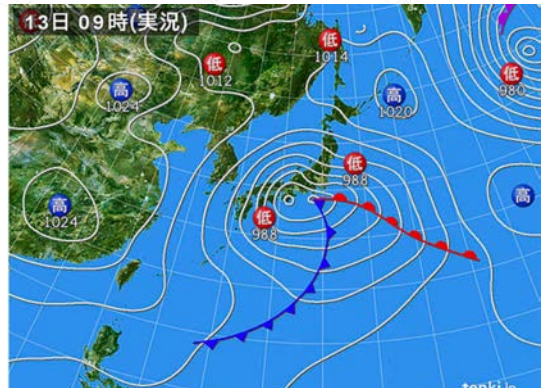
- Frost on cryogenic optics → gave up cooling for O3GK
- Unexpected power loss ← beam clipping(?), dead OMC-PD, unused SRM…

K. Kokeyama+, in Proceedings of the 3rd World Summit on Exploring the Dark Side of the Universe (EDSU2020)





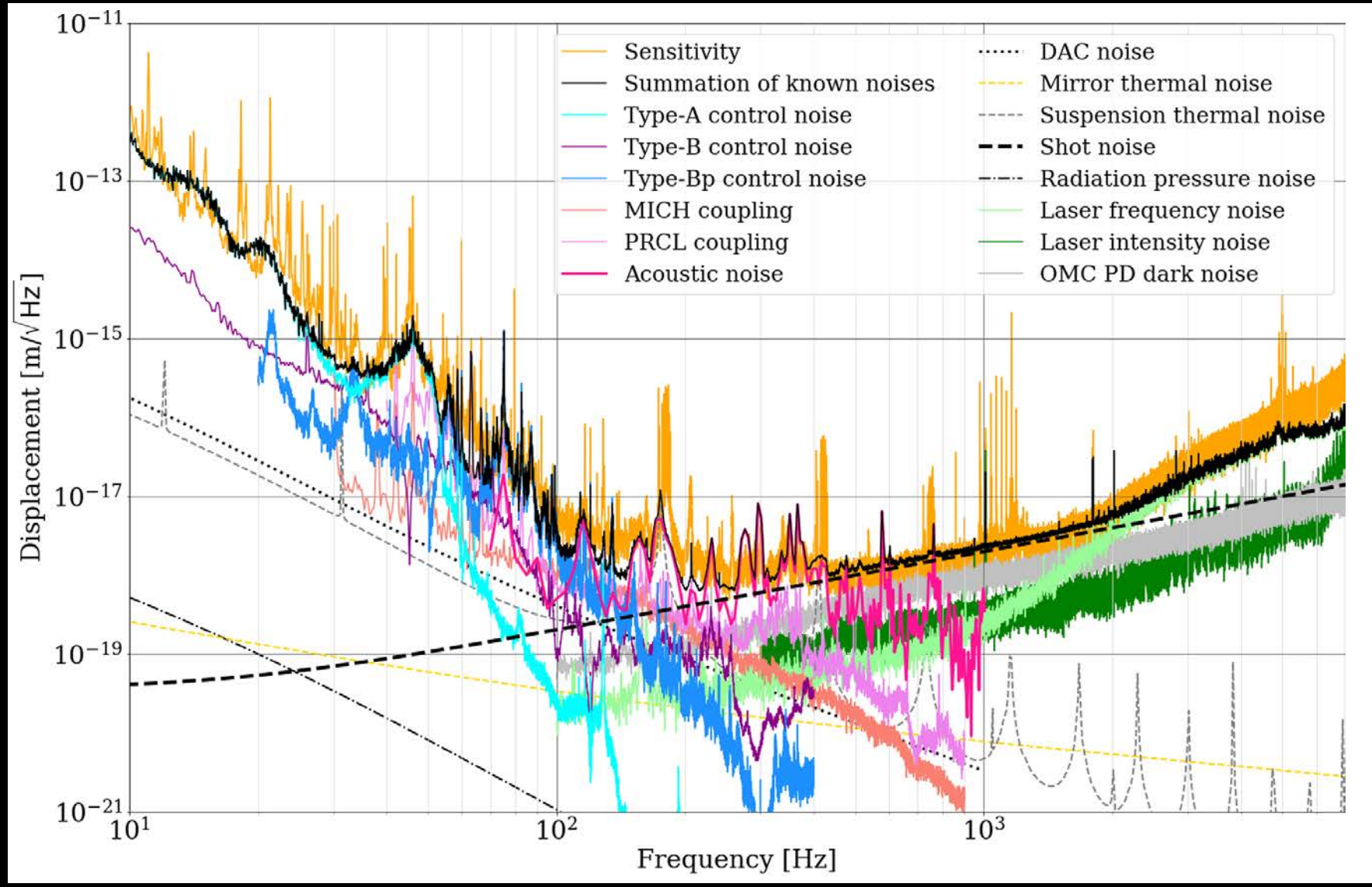
http://klog.icrr.u-tokyo.ac.jp/osl/?r=5663



13th ET symposium (8-12 May 2023, tal

Noise budget estimation right after O3GK

KAGRA collaboration, PTEP ptac093 (2022)

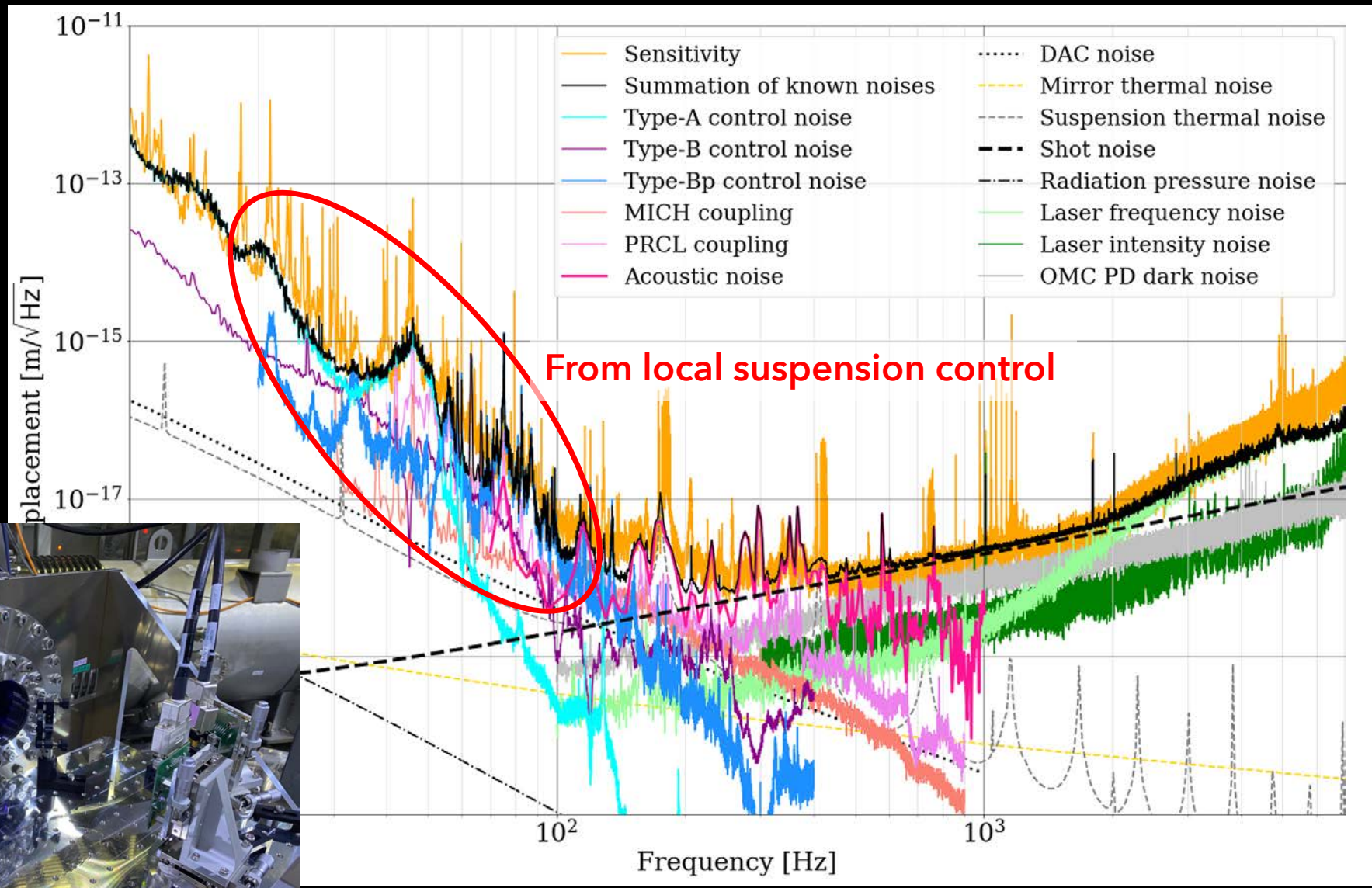


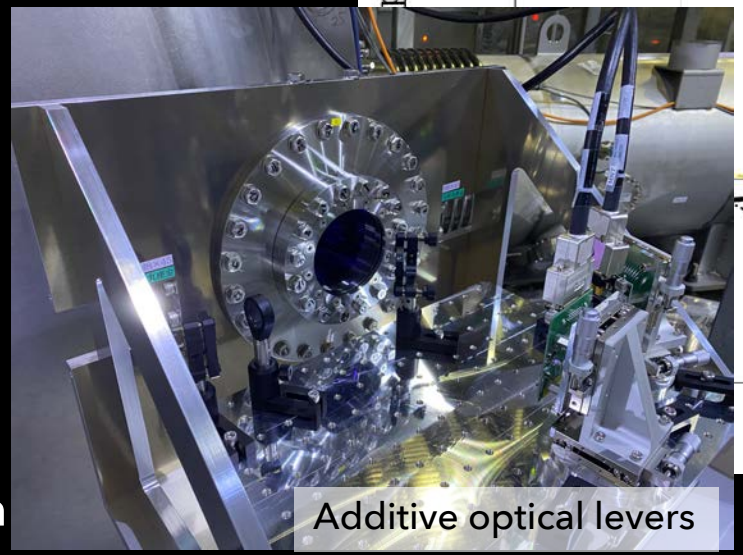
Upgrading vibration-isolation systems

Not to degrade the GW sensitivity

KAGRA collaboration, PTEP ptac093 (2022)

- Inertial damping for main mirror suspensions
- Reduced electronic noise contaminating in the suspension local control
- Damped "overlooked" resonances with improved local sensors/actuators and new optical levers
- Decoupled local DoFs at hardware level as much as possible

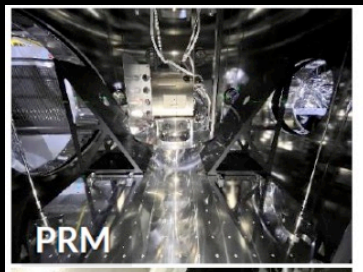


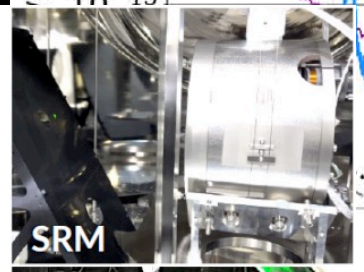


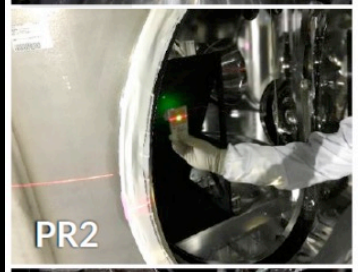
Additive optical levers

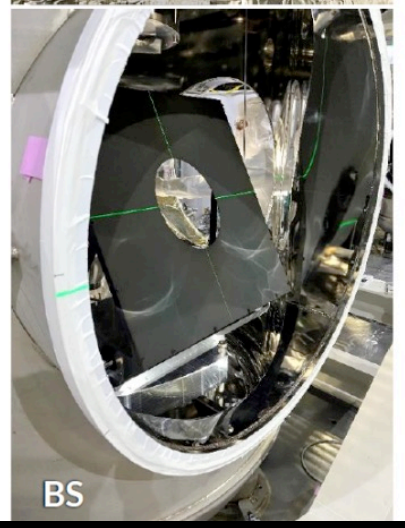
Further stray-light mitigation

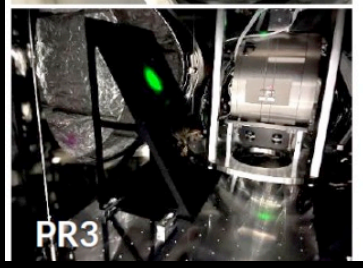
- Installed 14 mid-size baffles around the corner station
- Resolved a crowded optical path (to ISS)
- Additional optical shields
- Additional beam dumps

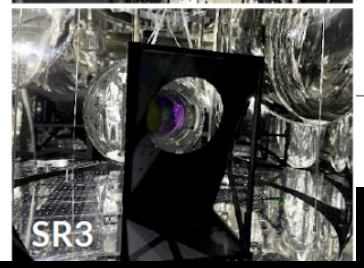










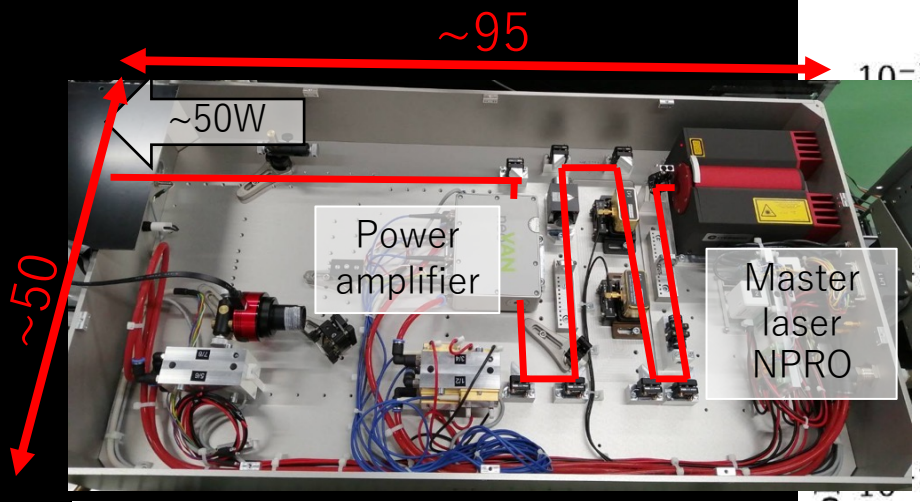


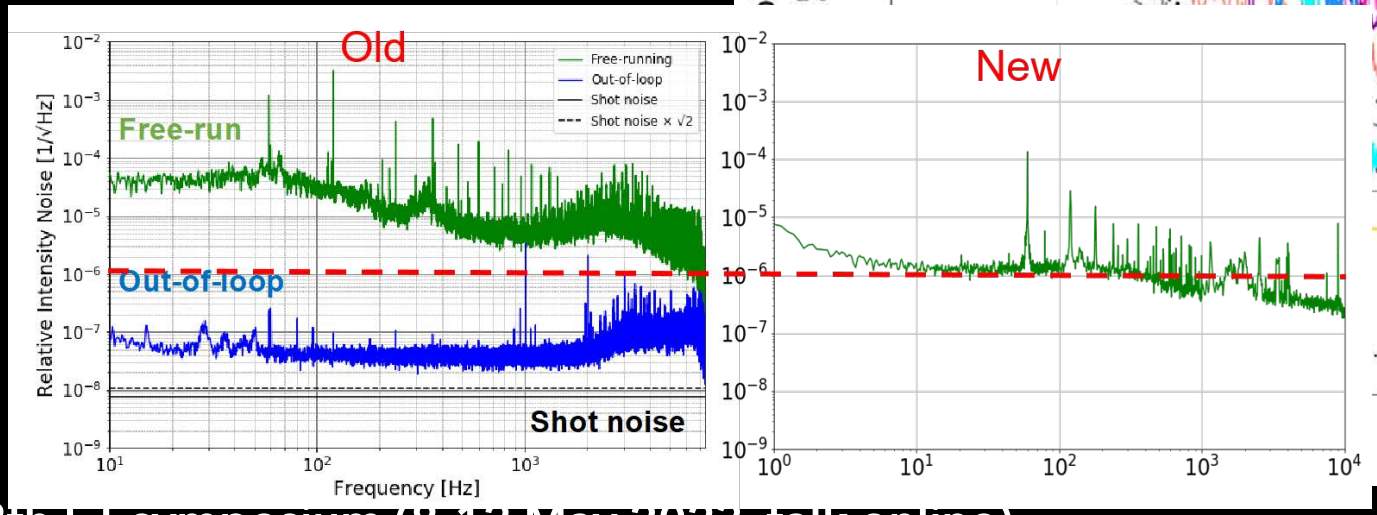
KAGRA collaboration, PTEP ptac093 (2022)

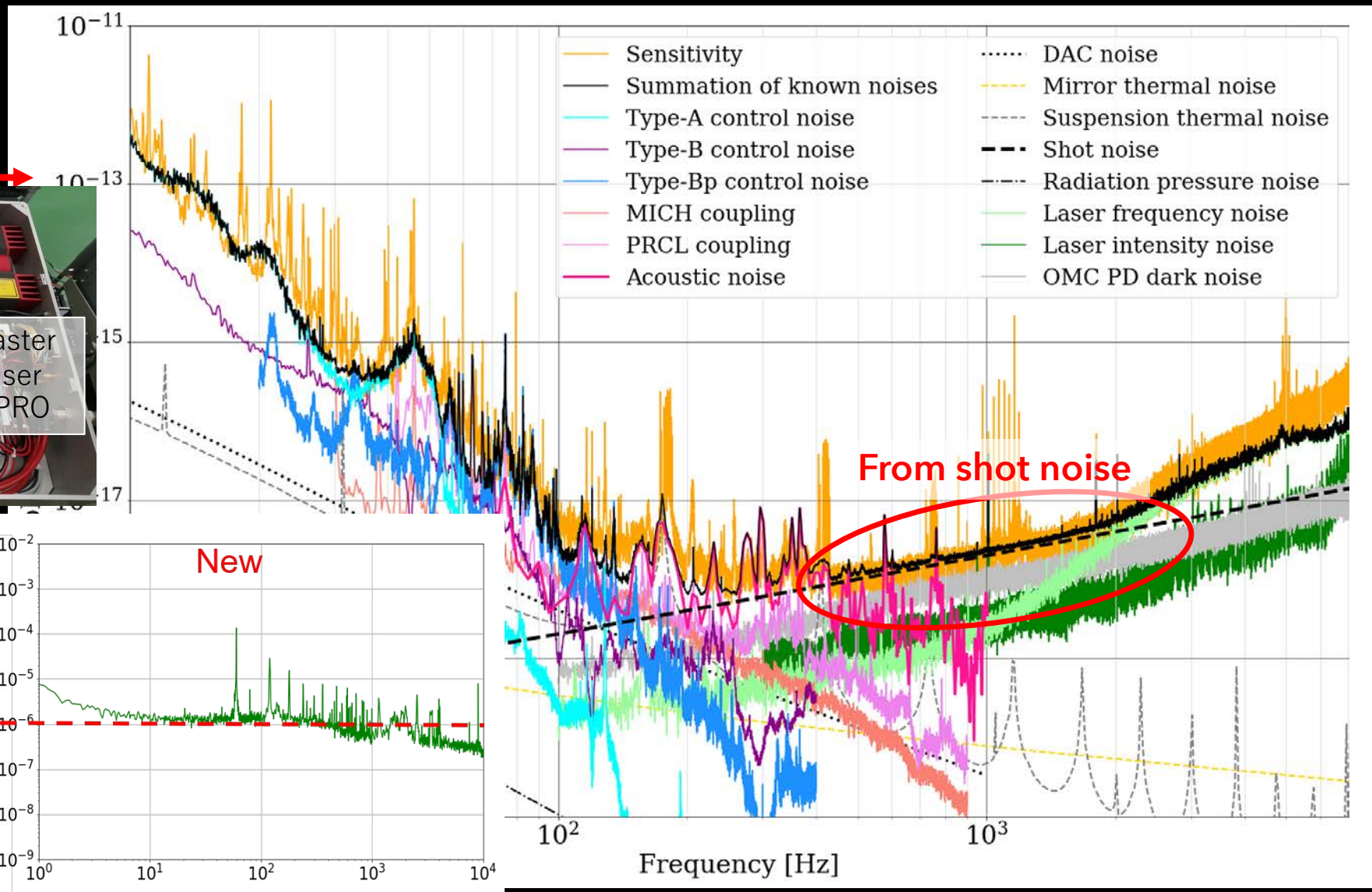
Preparation for higher power input

KAGRA collaboration, PTEP ptac093 (2022)

- Higher power laser source is now ready (not yet replaced)







Better stability

Local damping improvement

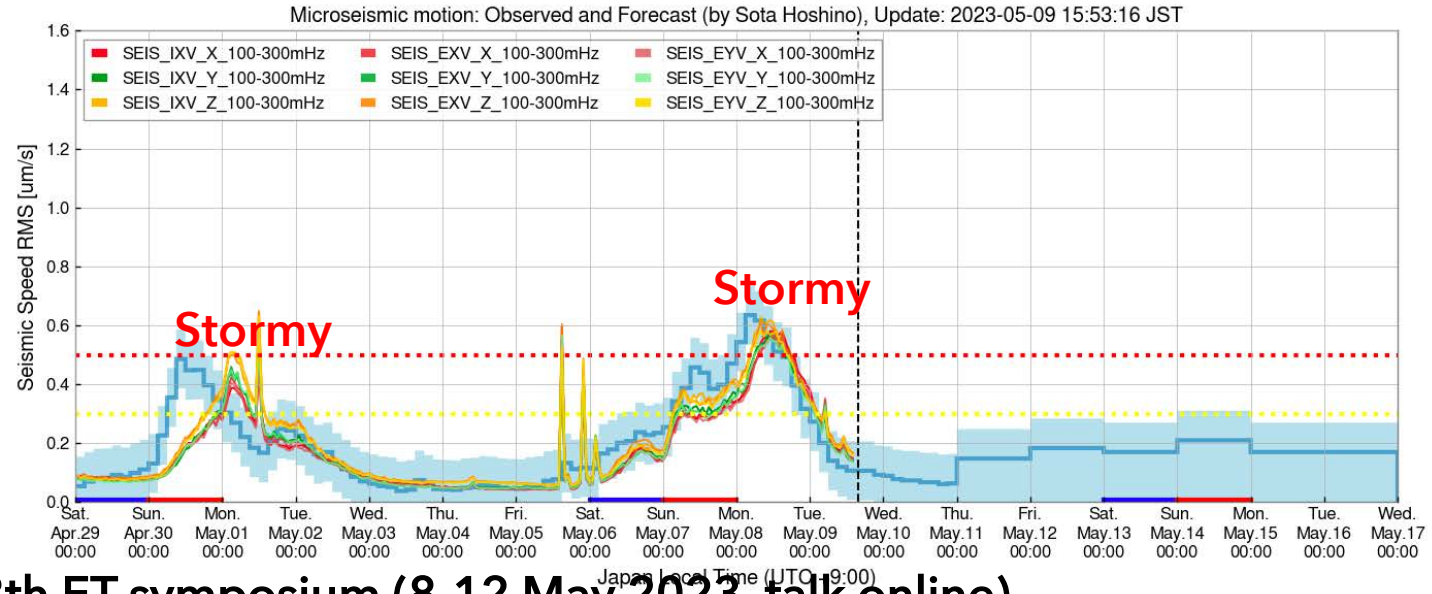
- Now PRFPMI can be maintained even in somewhat stormy days.

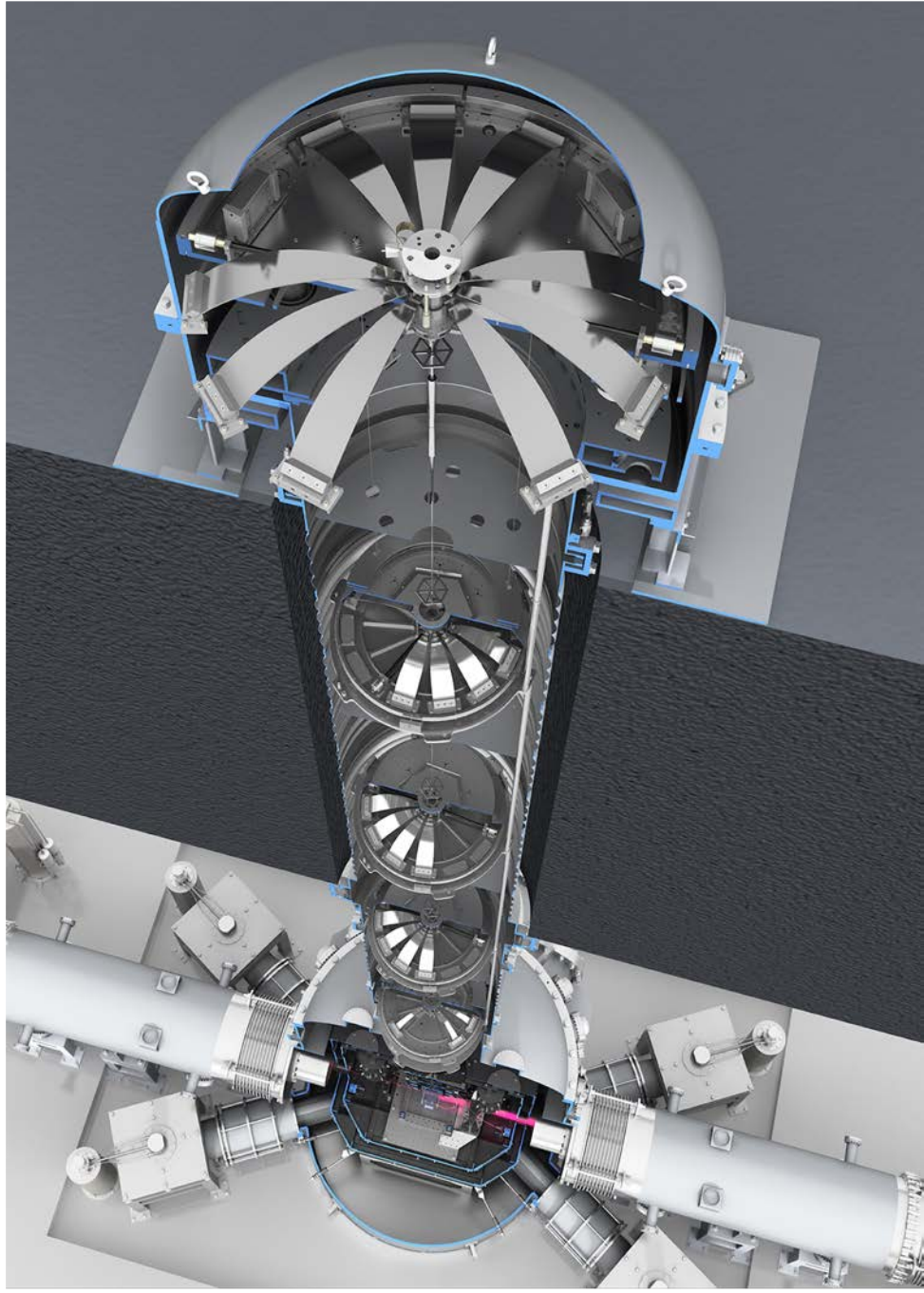
Angular-sensing control (ASC)

- Took time for wave-front sensing (WFS) in a strategic way; now WFS can be implemented for some global DoFs; drastically improved the contrast fluctuation.
- In addition, some noise structures and noise floor got better in the sensitivity curve.

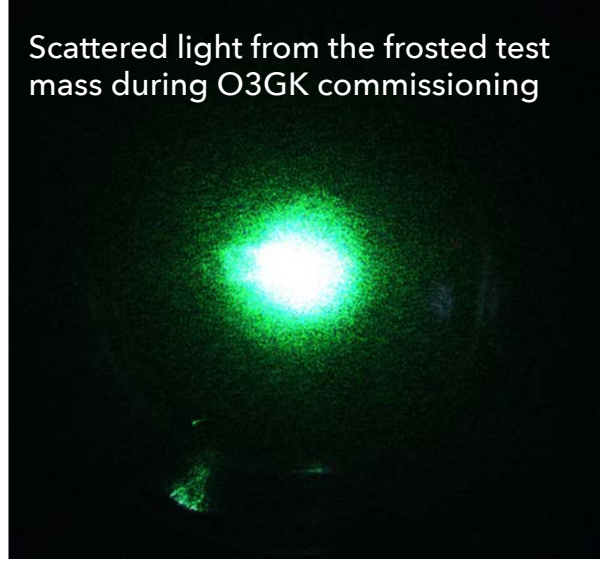
Doppler phase noise cancellation

- For auxiliary green laser paths; now stable lock acquisition is possible even in somewhat stormy days.





Better reliability


Scattered light from the frosted test mass during O3GK commissioning

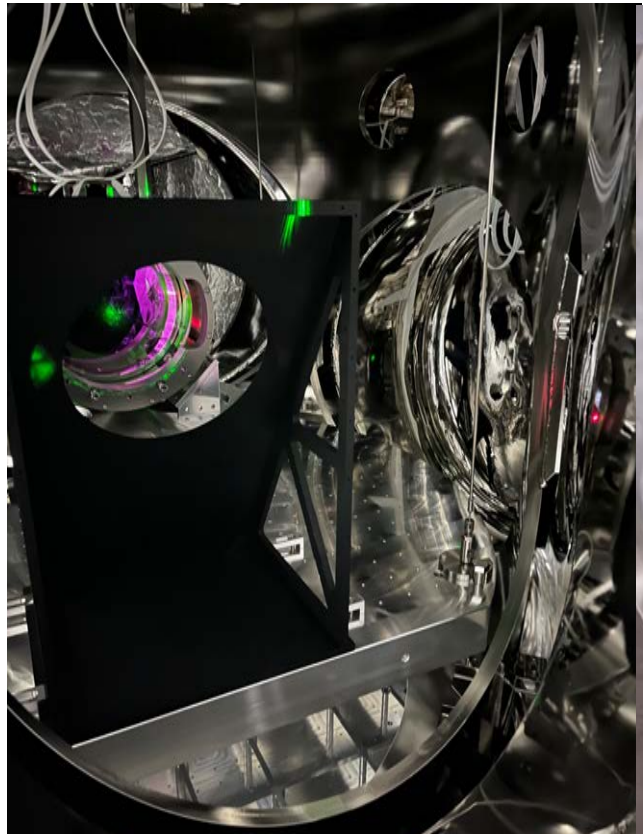
To overcome frosting

- Better vacuum pressure with additional pumps
- Leak check allover the vac chambers thoroughly; took long time to complete.
- Monitors for partial pressures of remnant components
- Defrost heaters
- Re-consider the cooling procedure

1 of 4 main mirrors has been at ~80 K without frosting for ~1 yr.

To avoid beam clipping/mis-centering

- Adjusted heights of suspended mirrors basing on measurement for global balancing
- Reliable beam spot target plates
- Additional beam-position monitors/references
- Expanded adjustable height range for the main mirrors when cooled down.
- Implemented beam position control



Unlike O3GK, we are not facing:
- Unwanted beam clipping, and
- Superius *severe* birefringence(?) effects that degrade WFS reliability.

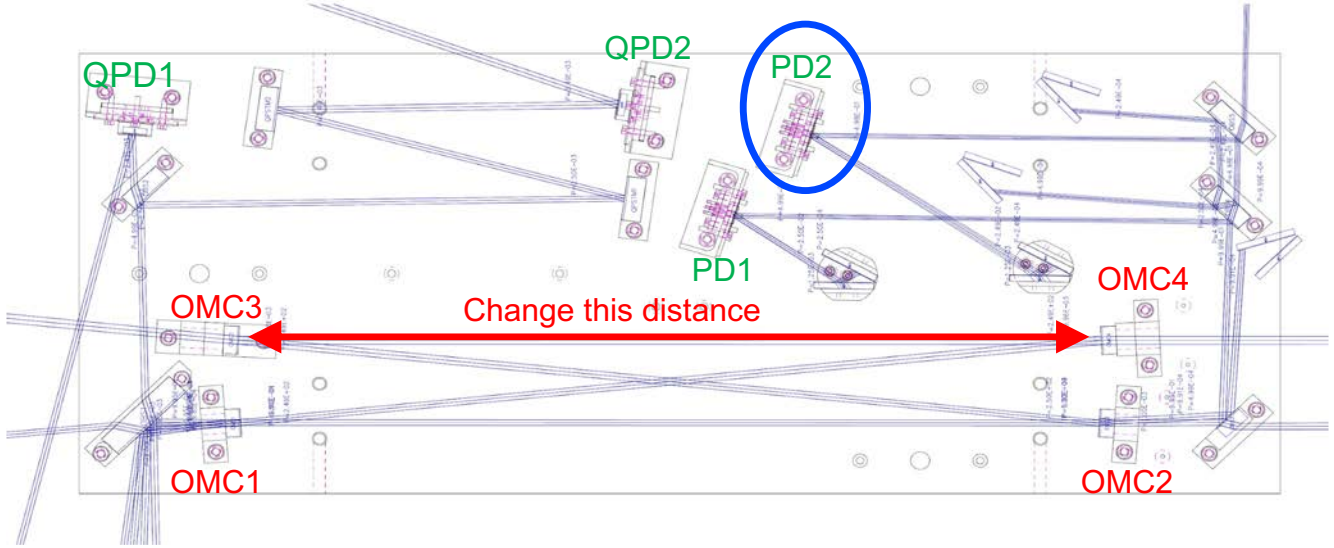
Avoid unnecessary power loss

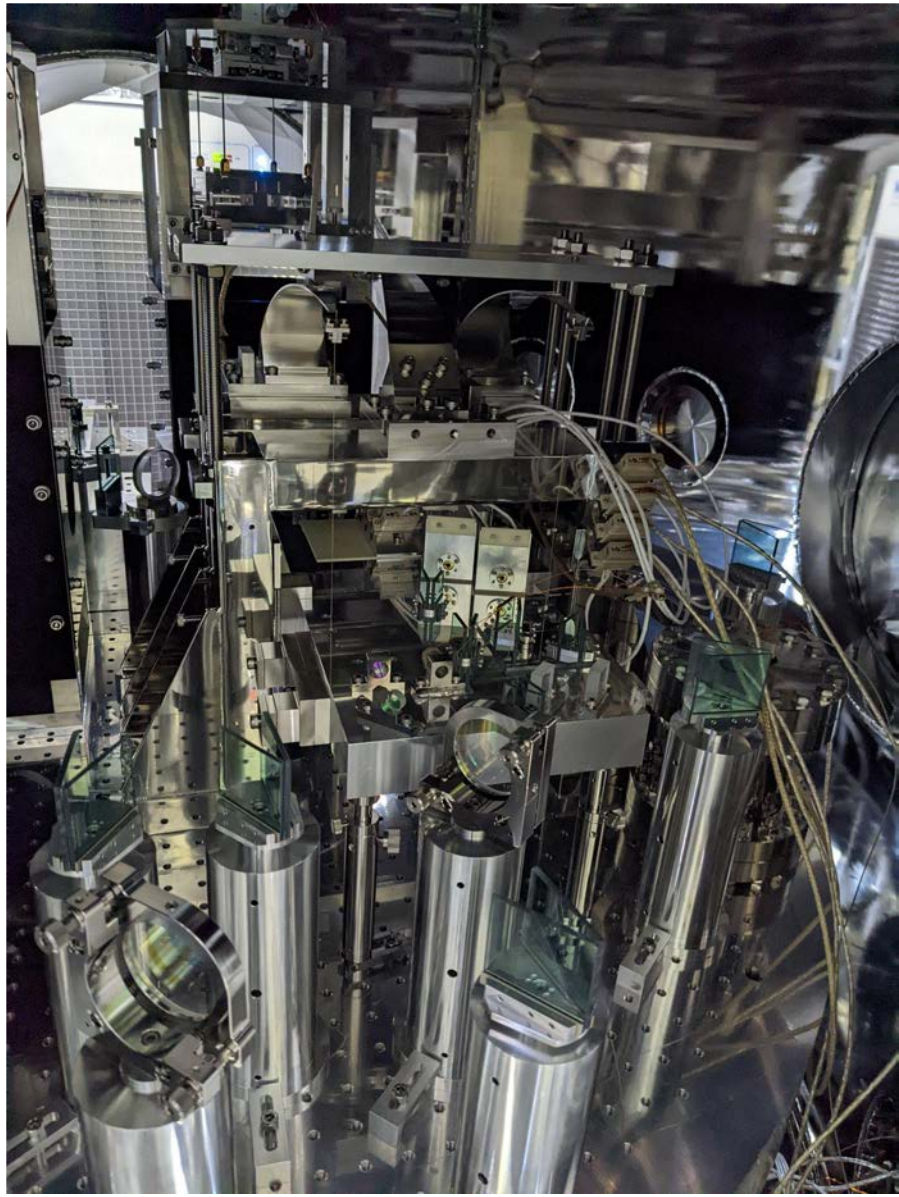
Transparent SRM

- During O3GK, 30% trans SRM was used, but not doing RSE.
- It has been replaced with a transparent mirror, as we may give up to do RSE during O4(?).

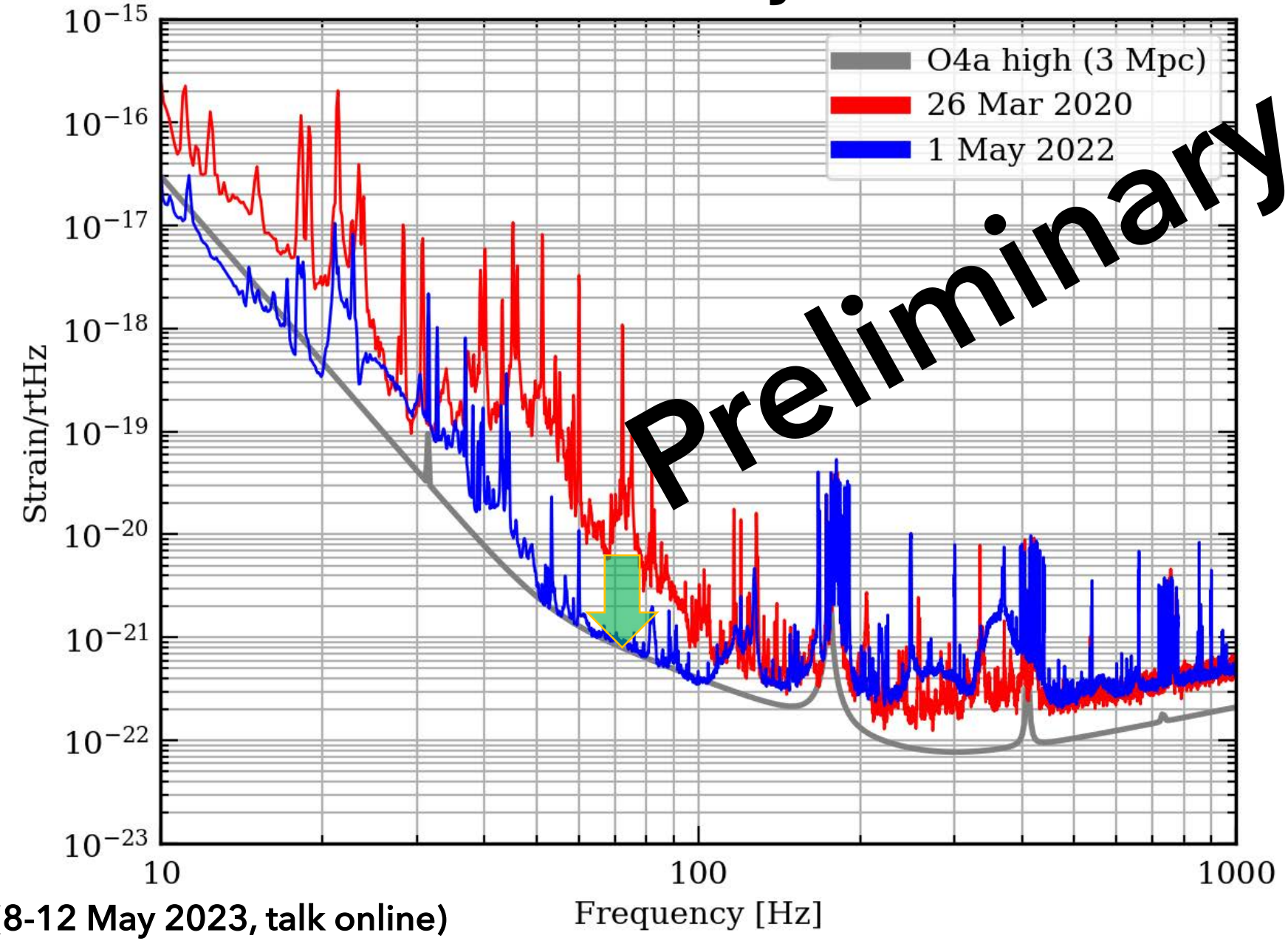
Output mode cleaner (OMC) upgrade

- Higher transmissivity: 80% -> 95%
- Fix the broken DCPD -> Double the GW signal
- Revise absolute length





The latest stable sensitivity



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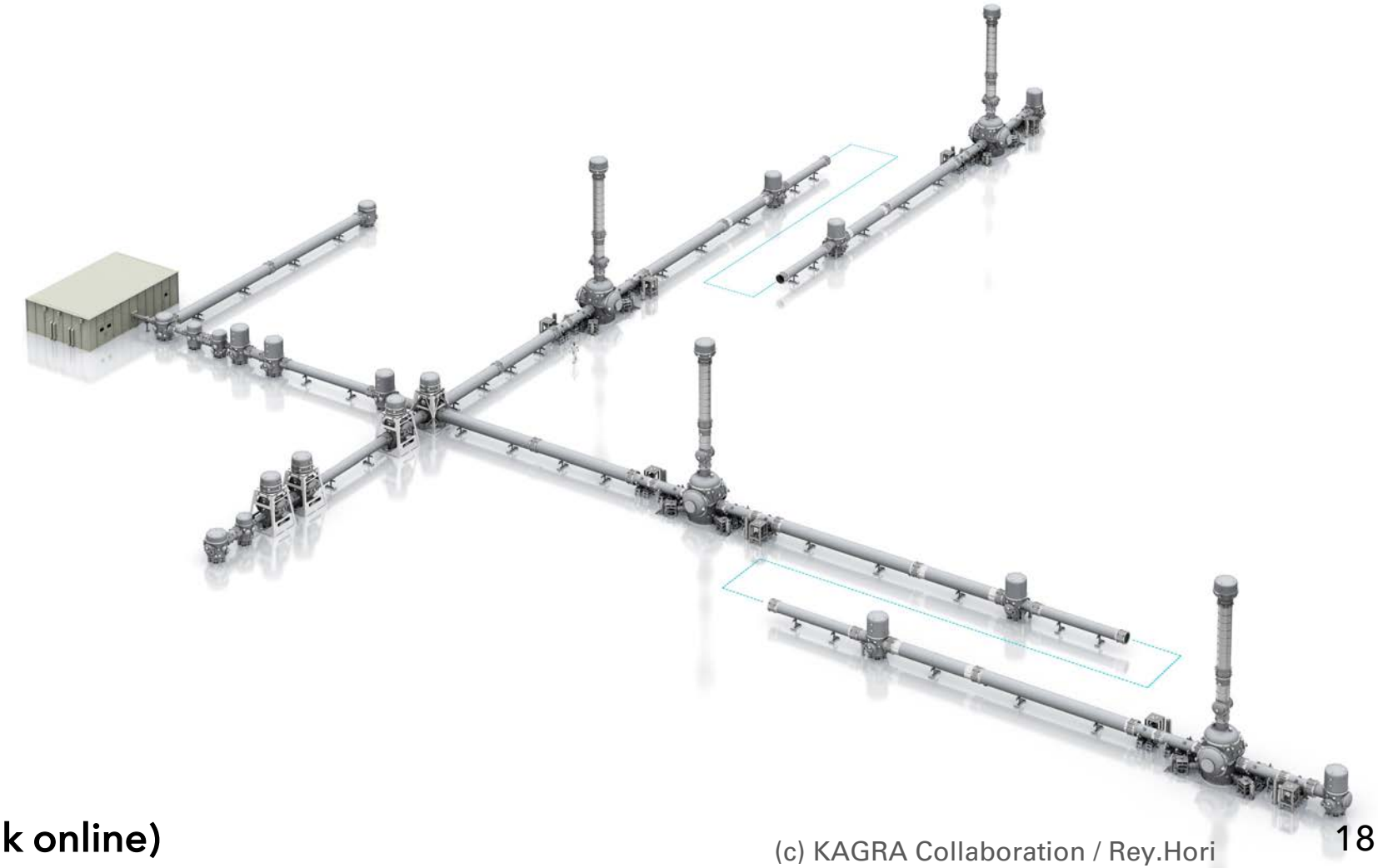


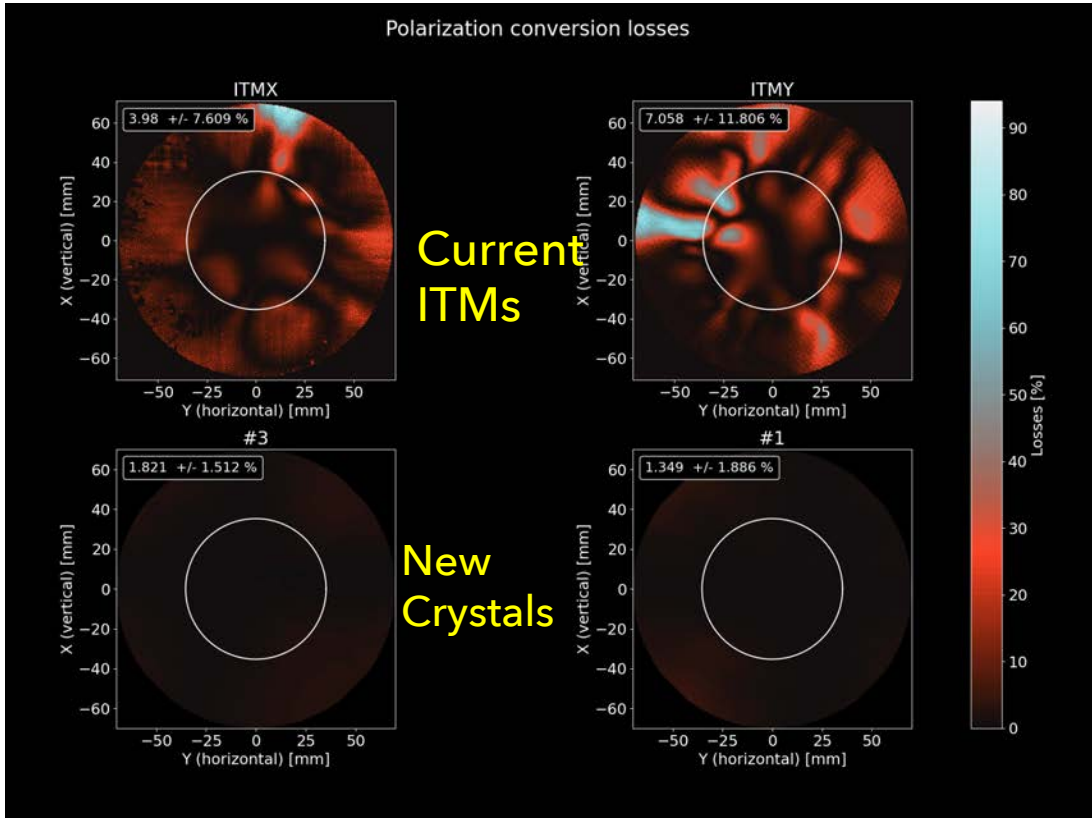
Towards re-joining O4...

The strategy is under discussion

- Open some chambers to do additional in-vac works?
- Turn on all the coolers for all the main mirrors?
- Replace with the new higher power laser source and input ~50W?
- Implement better ASC?
- Optimize more the local control?
- (RSE?)

For O5

- Birefringence in the sapphire crystals will be a problem in the current KAGRA mirrors.
- Search for better crystals was carried out.
- Found that crystals from a Korean company have better birefringence homogeneity compared to the currently installed TMs and comparable absorption.
- We are in a process of making new ITMs with crystals from this company.
- Hopefully, we can install a new set of ITMs before O5.



Summary

- KAGRA will join O4a from 24 May to 21 June 2023, and come back to O4 in the spring of 2024 with the better sensitivity.
- Now better sensitivity than that of O3GK is achieved.
- 1 of 4 main mirrors has been at ~80 K for ~1 yr without frosting.
- Despite using the same mirrors as of O3GK, ASC works mostly well; no *severe* birefringence effects.
- Upgrade plan is under discussion. New ITM preparation is in progress for O5.