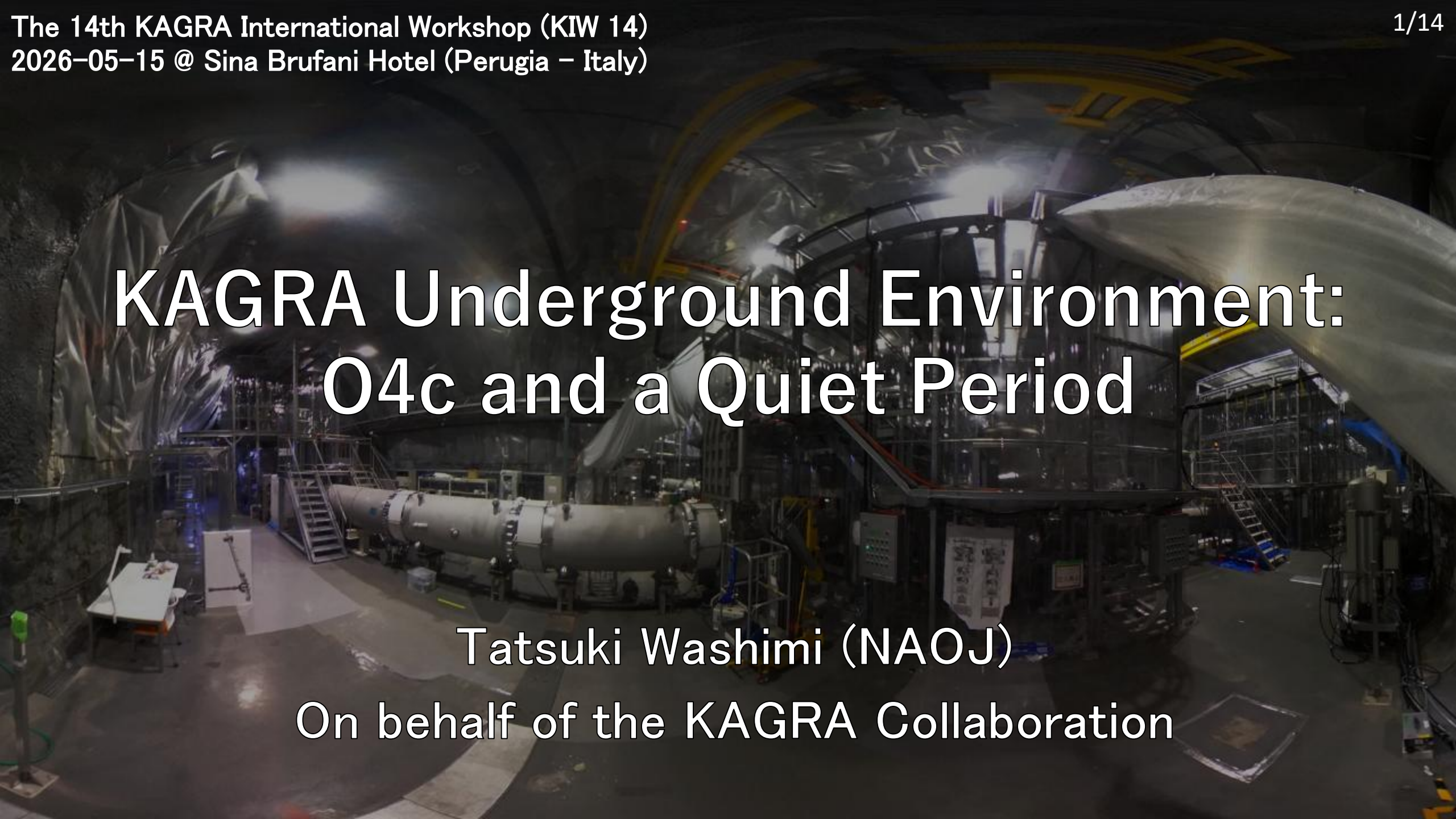
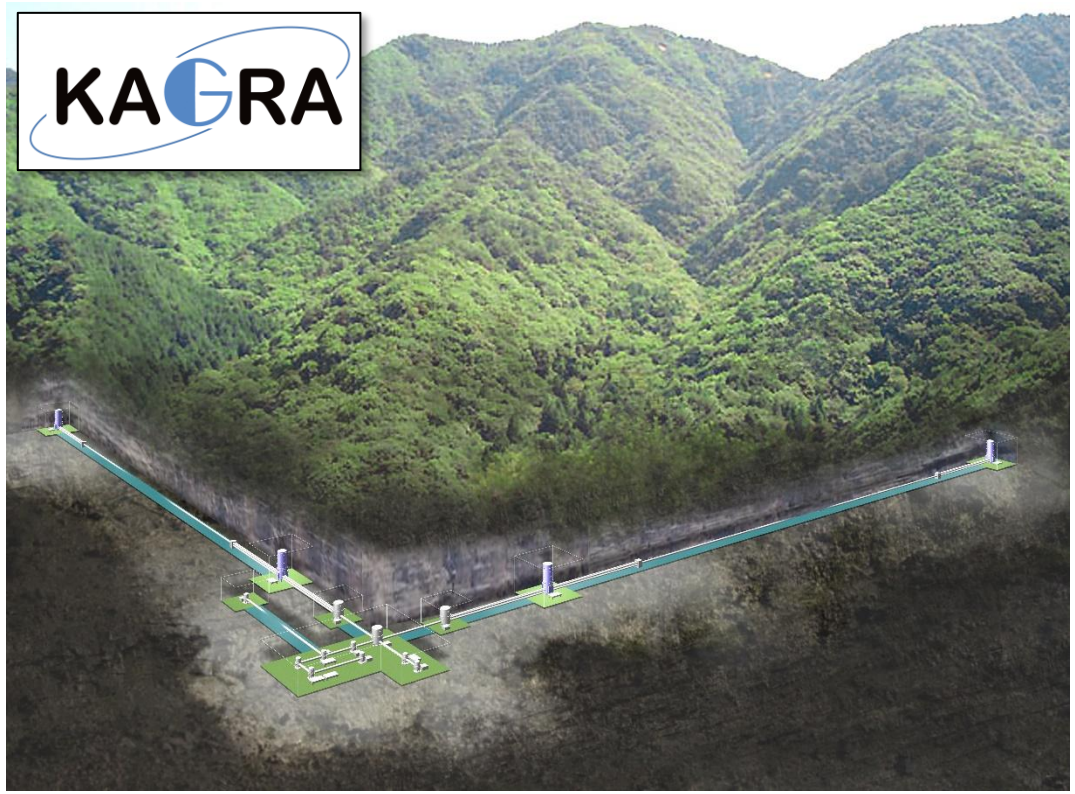
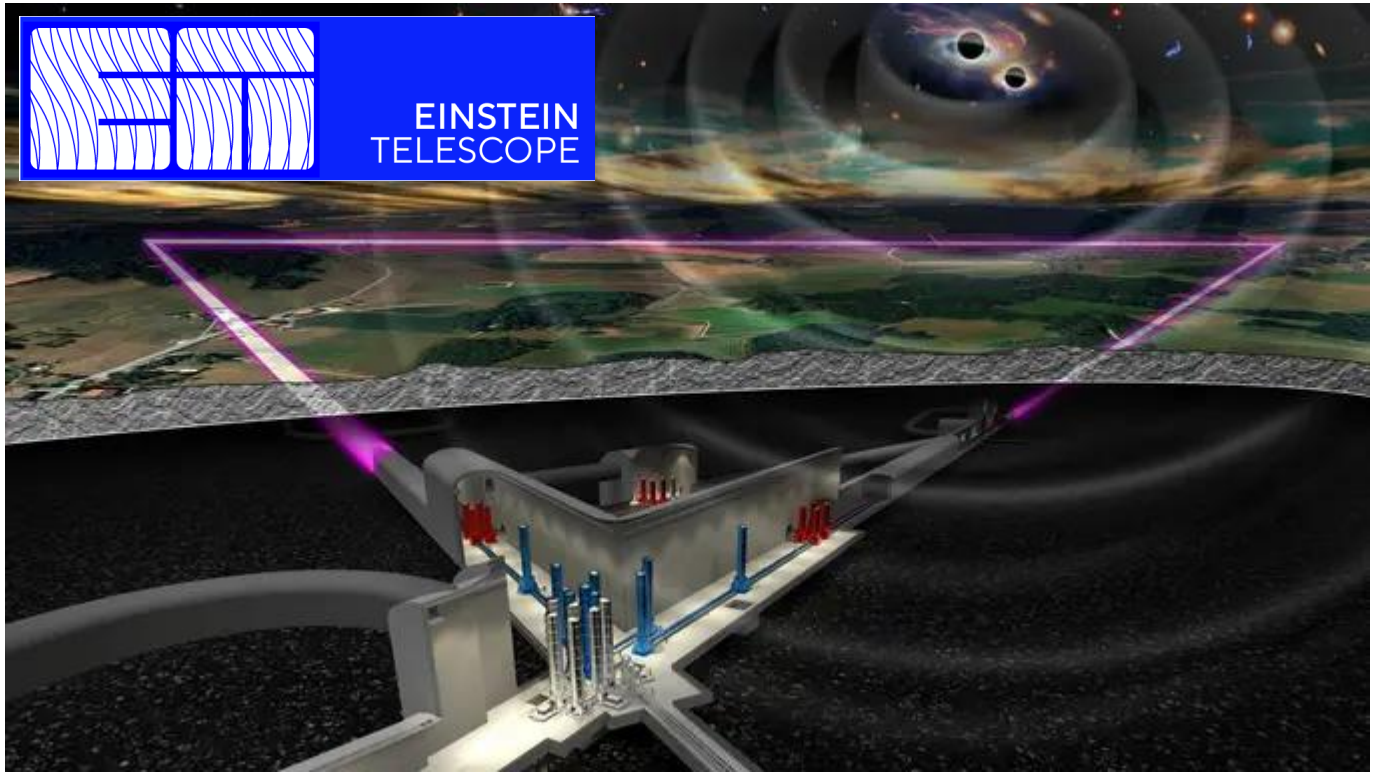


KAGRA Underground Environment: O4c and a Quiet Period

Tatsuki Washimi (NAOJ)
On behalf of the KAGRA Collaboration

Why Underground for GW Detectors?



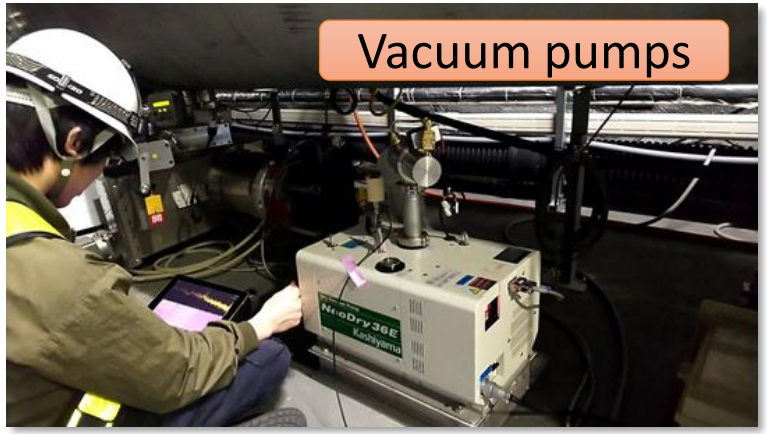


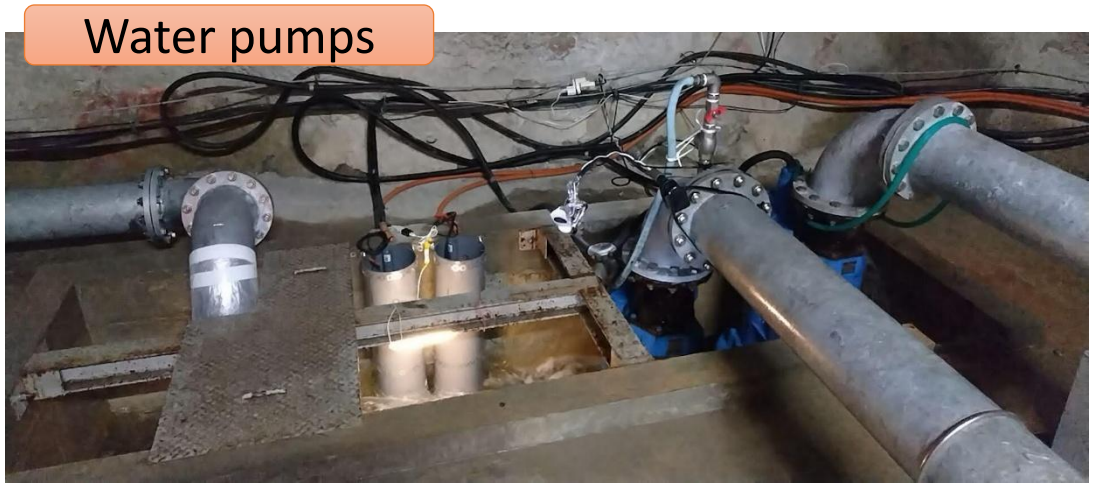
Underground sites provide a naturally quiet environment for low-frequency GW detection.

➢ This is also a key issue for future underground detectors such as ET.

➢ Next challenge: infrastructure noise generated inside the experimental area.

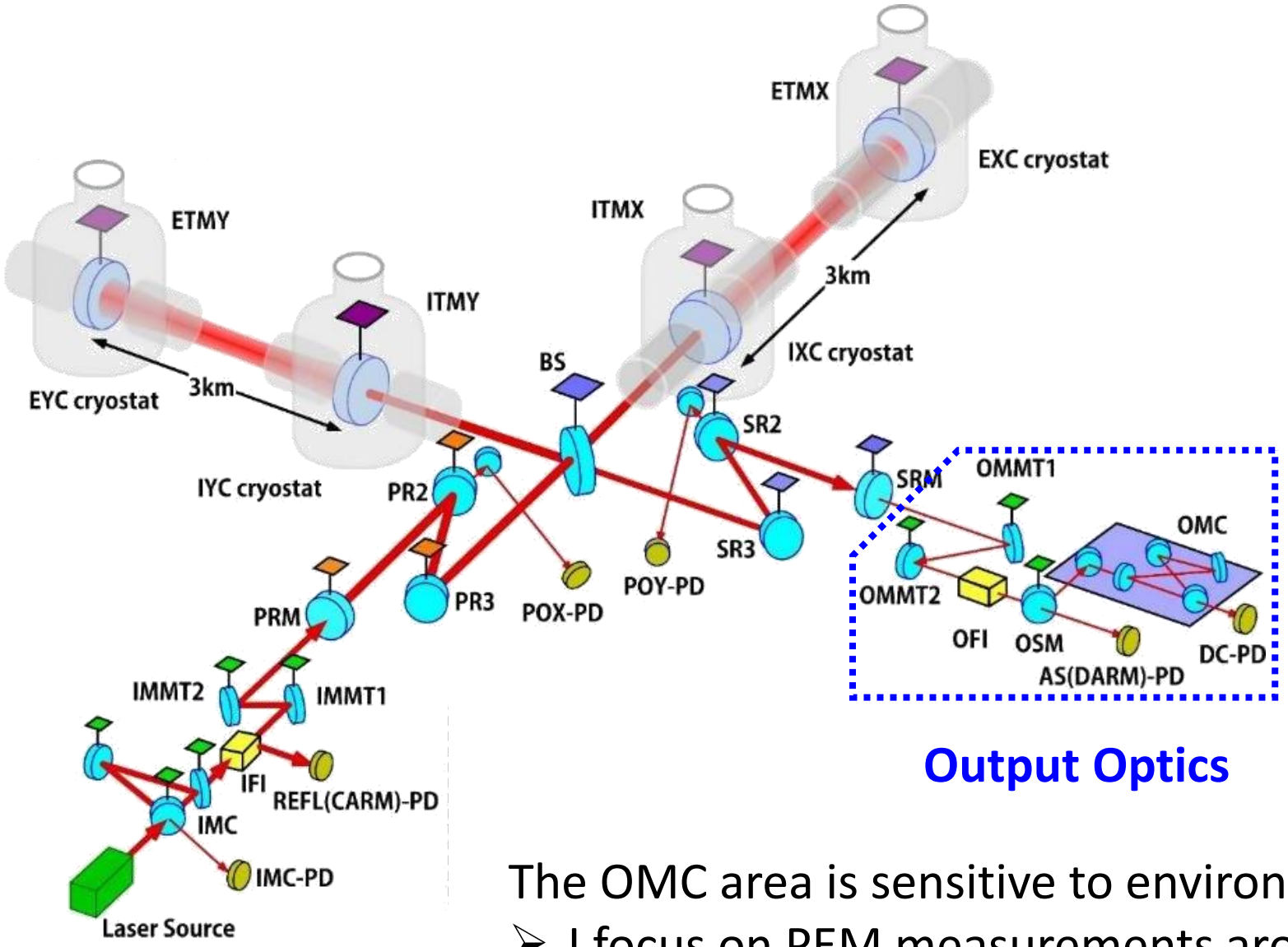
Local Noise Sources in KAGRA





Some systems can be turned off during observation, while others must keep running.

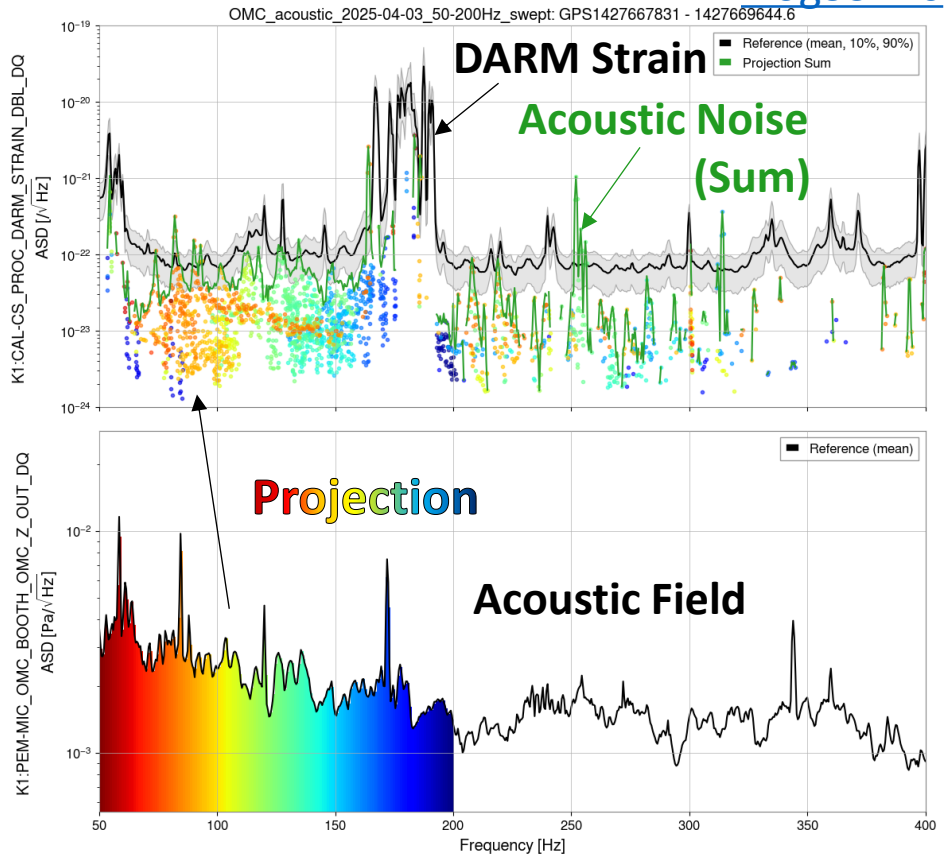
A Noise-Sensitive Region of KAGRA: OMC Area



Output Optics

Acoustic Injection Test (2025-04-03)

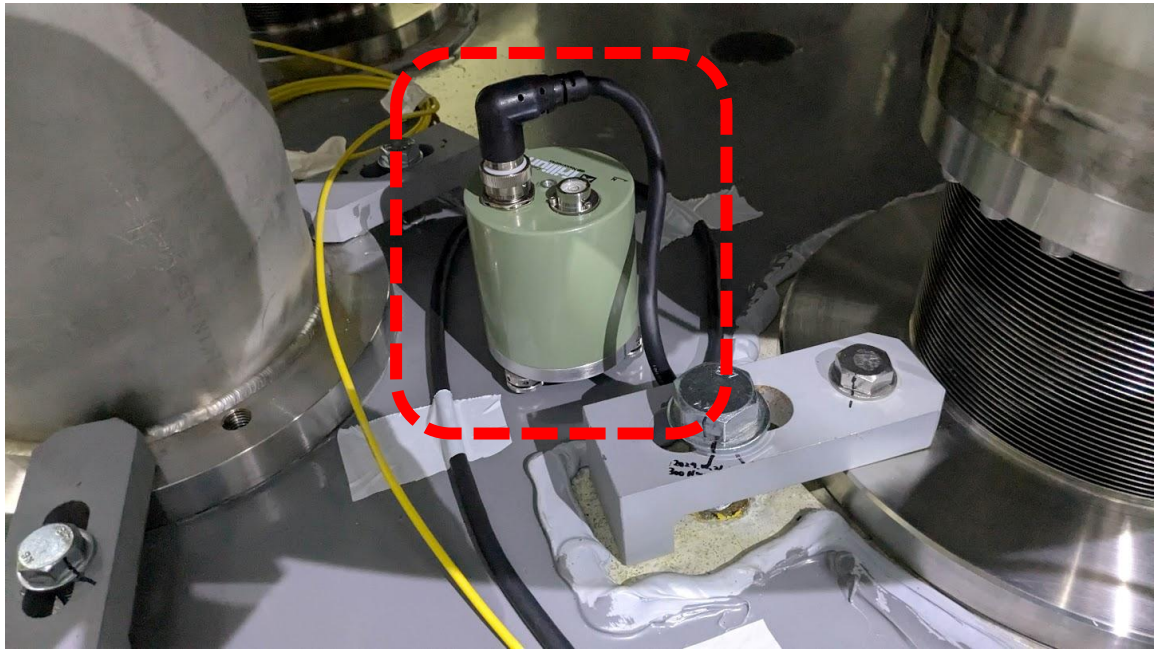
klog33220

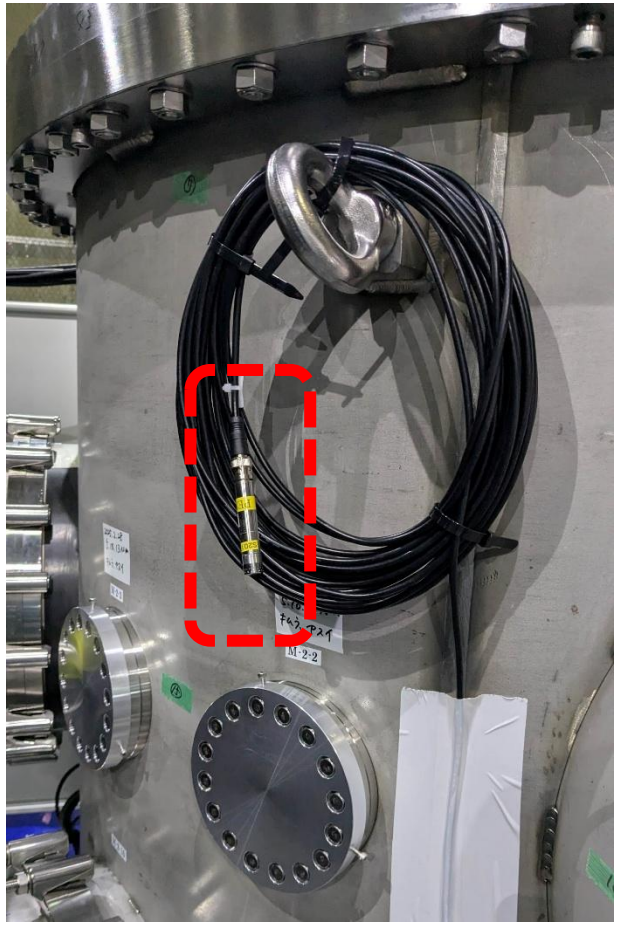


The OMC area is sensitive to environmental noise coupling to the DARM.

- I focus on PEM measurements around the OMC in this talk.

PEM Sensors Around the OMC





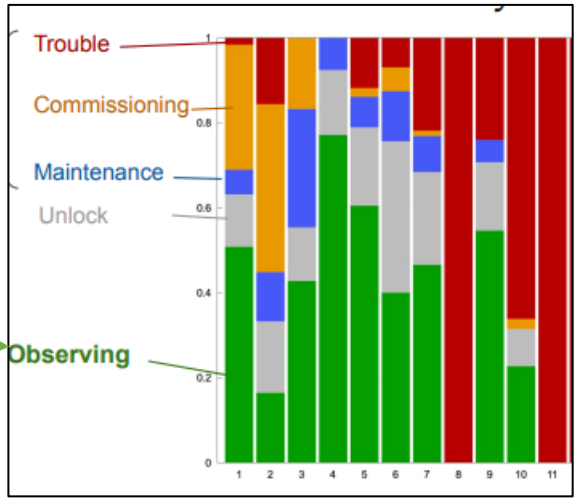
- Seismometer: Trillium Compact 120
- Microphone: ACO 4152N (+ ACO LF amplifier)
- Ground-voltage monitor: OMC chamber – OMC electronics rack (w/ ADC)

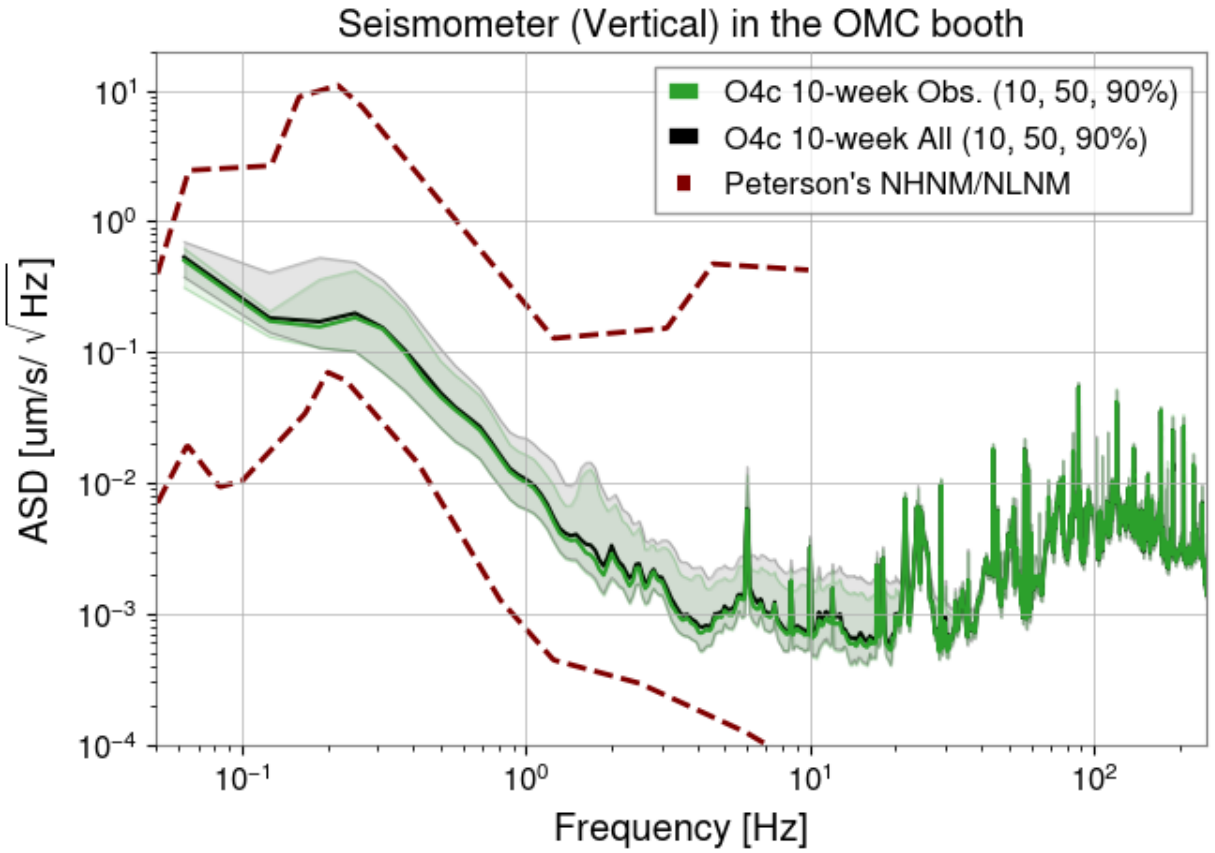
OMC Environment Spectra for O4c

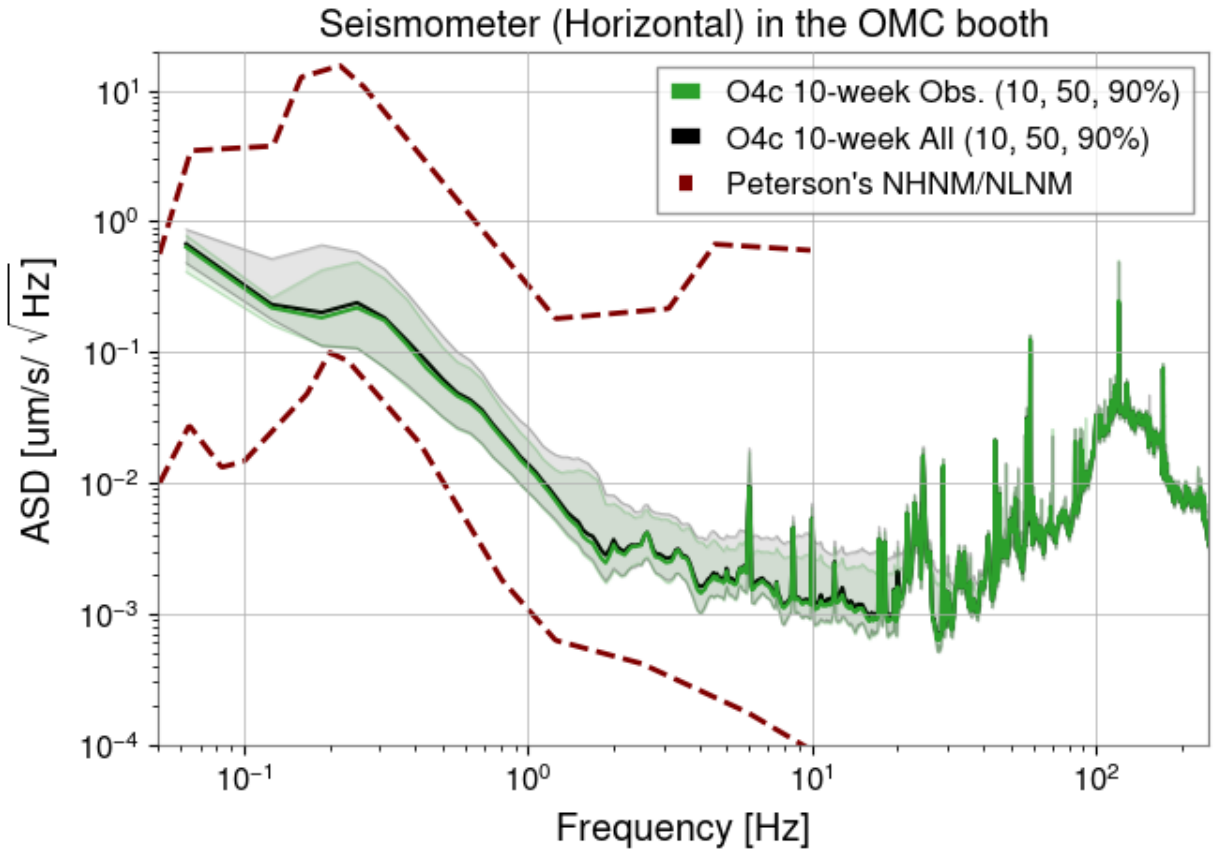
Reference spectra were evaluated from the first 10 weeks of O4c.

- From Jun. 5th to Aug. 15th in 2025
- **Black: all data; green: observation mode**
- ASDs were computed every 10 minutes using Welch averaging.
- Sensor frequency responses were corrected.

See Ushiba-san's talk for details







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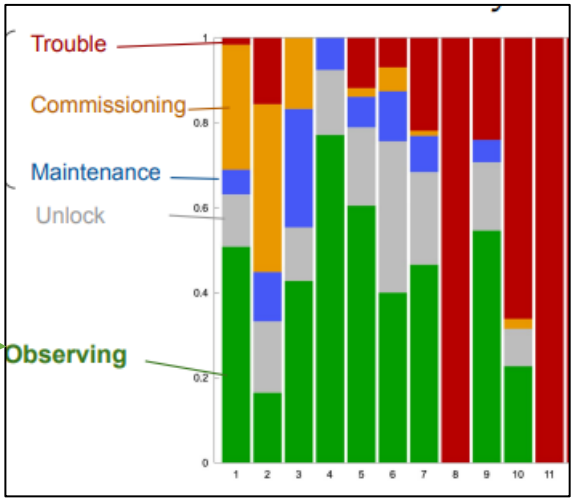
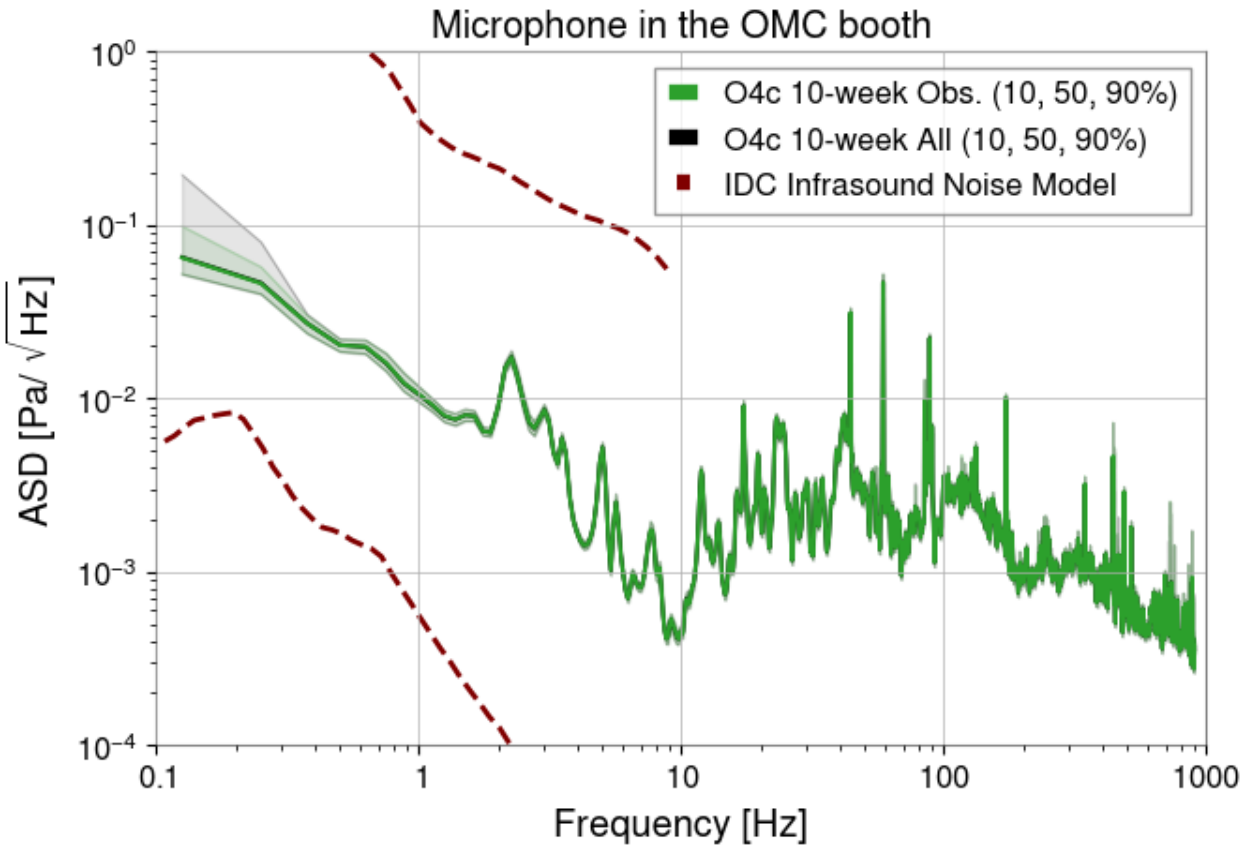
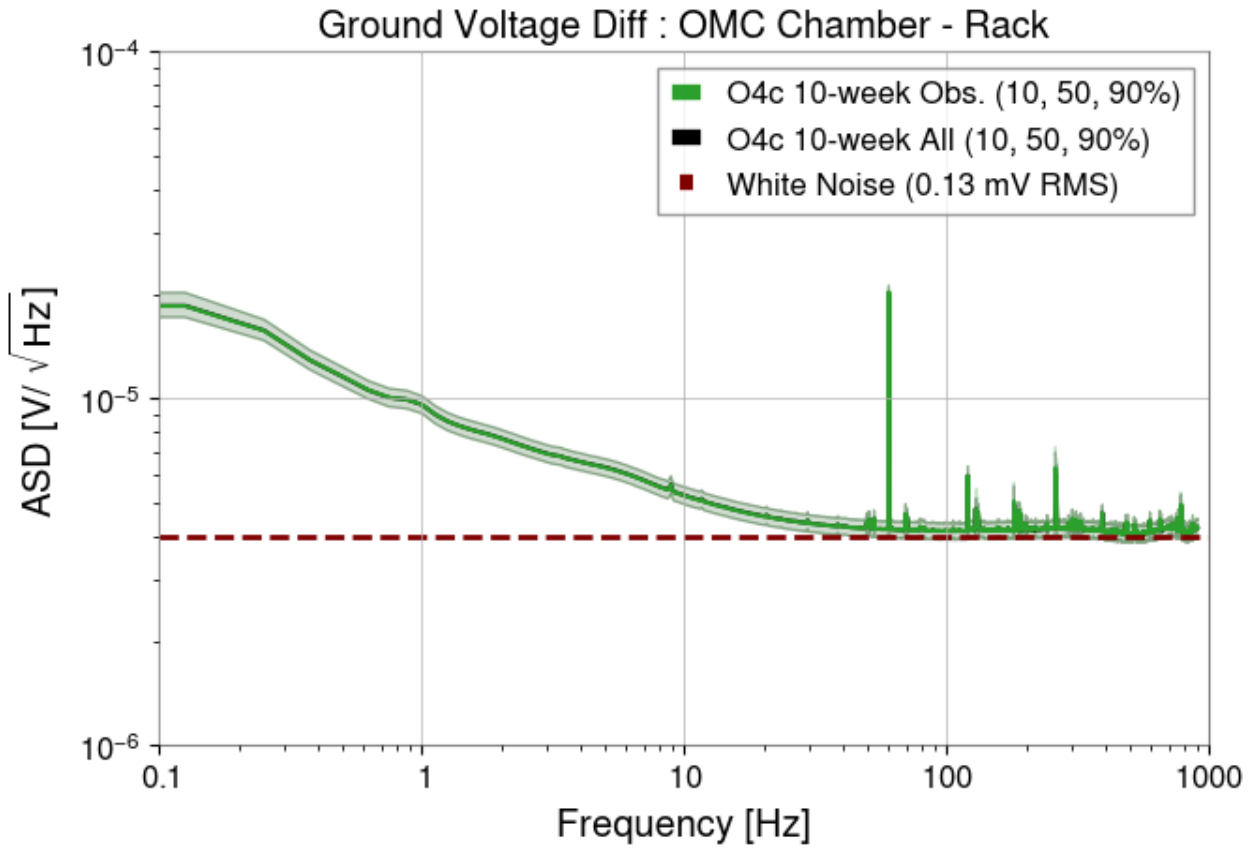


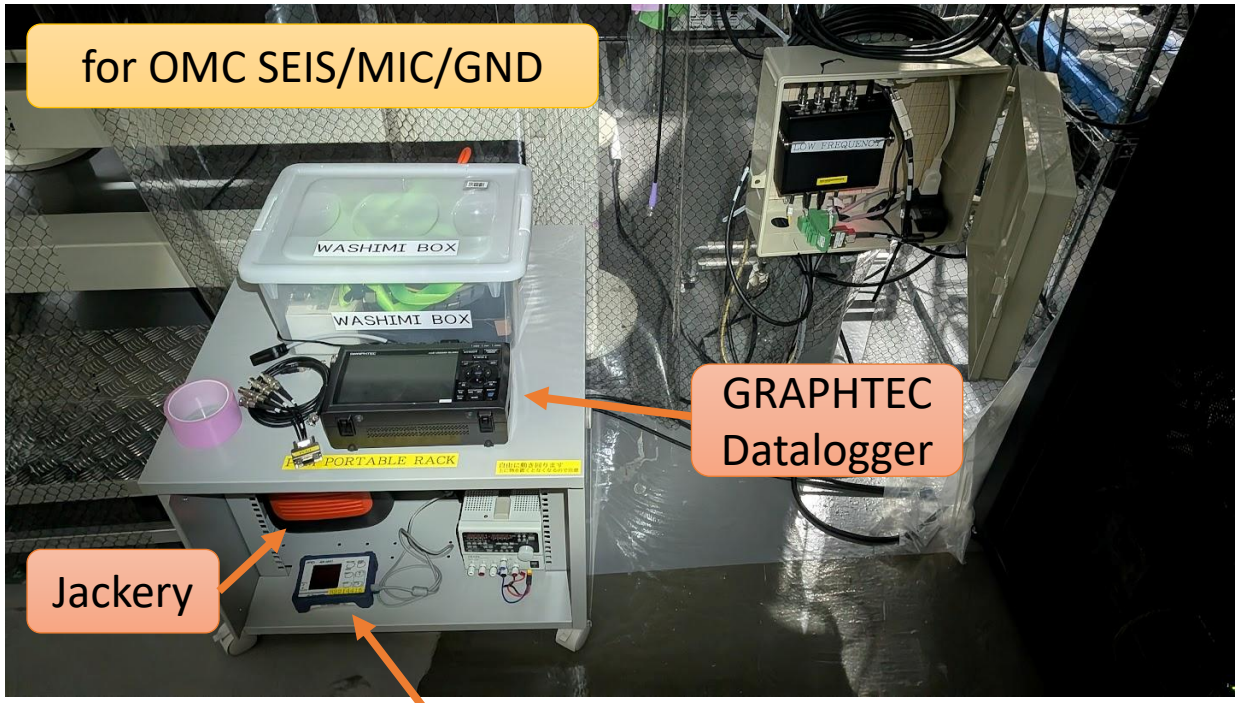




Planned Site-Wide Power Outage

A planned power outage provided a rare site-wide “switch-off” reference.

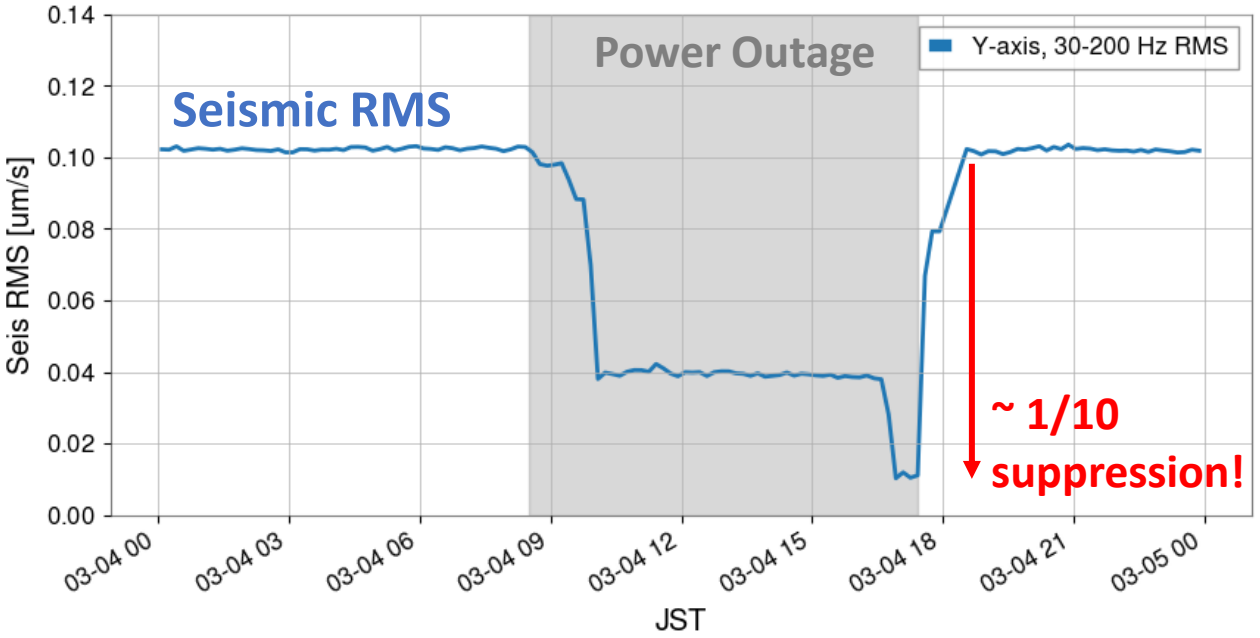
- Date: 4 March 2026
- Most facility equipment was stopped.
- Measurements continued using portable power stations and independent loggers.

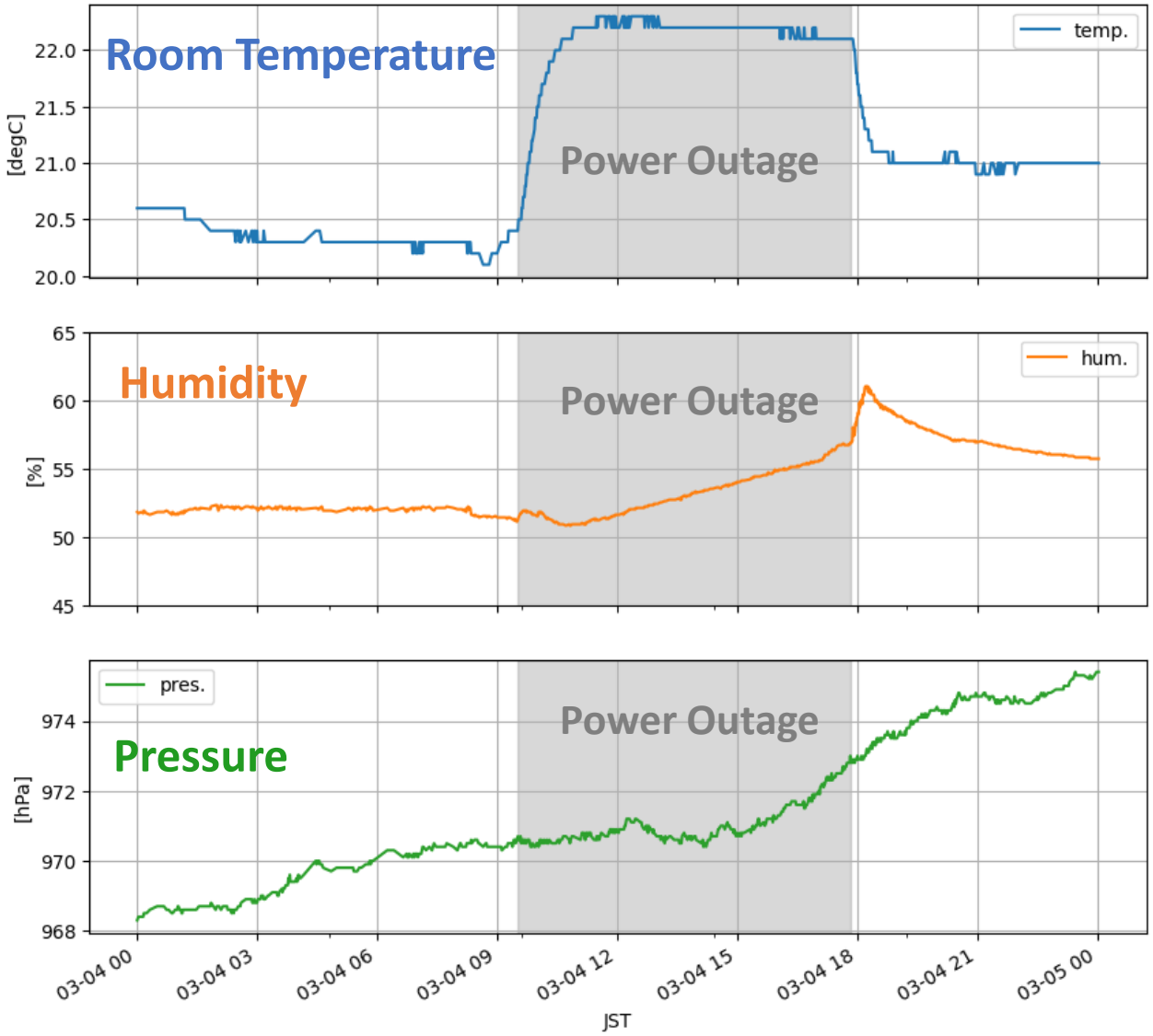


This study was supported by ERI JURP 2025-F2-04 in ERI, UTokyo.

Timeline of the Power Outage Measurement

- Maintenance work started around 8:30 JST.
- The air-conditioning system was switched off.
  - ➢ Temperature and humidity increased.
- Fresh-air circulation, powered by a temporary generator, stopped at 16:51 JST.
  - ➢ **Quietest interval**
- Power was restored at 17:38 JST.

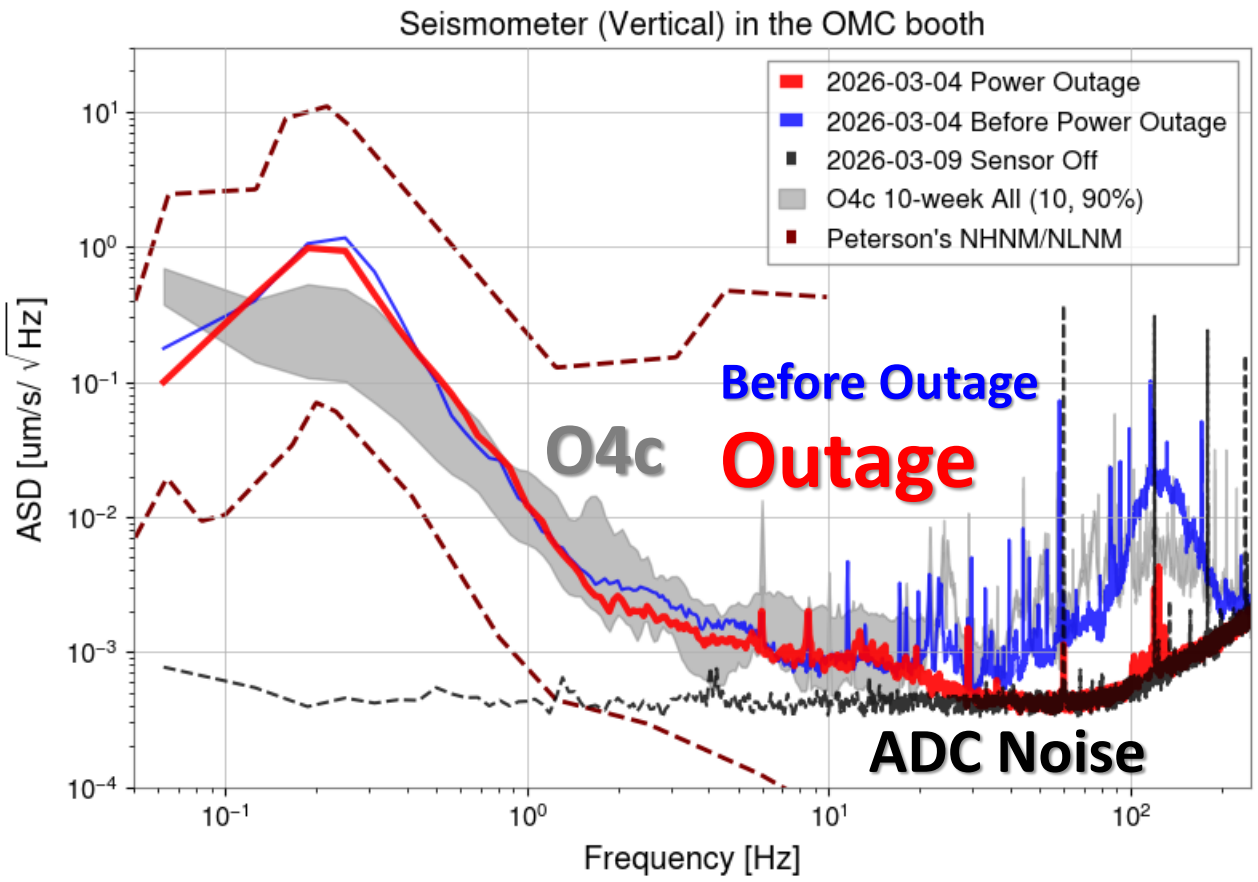


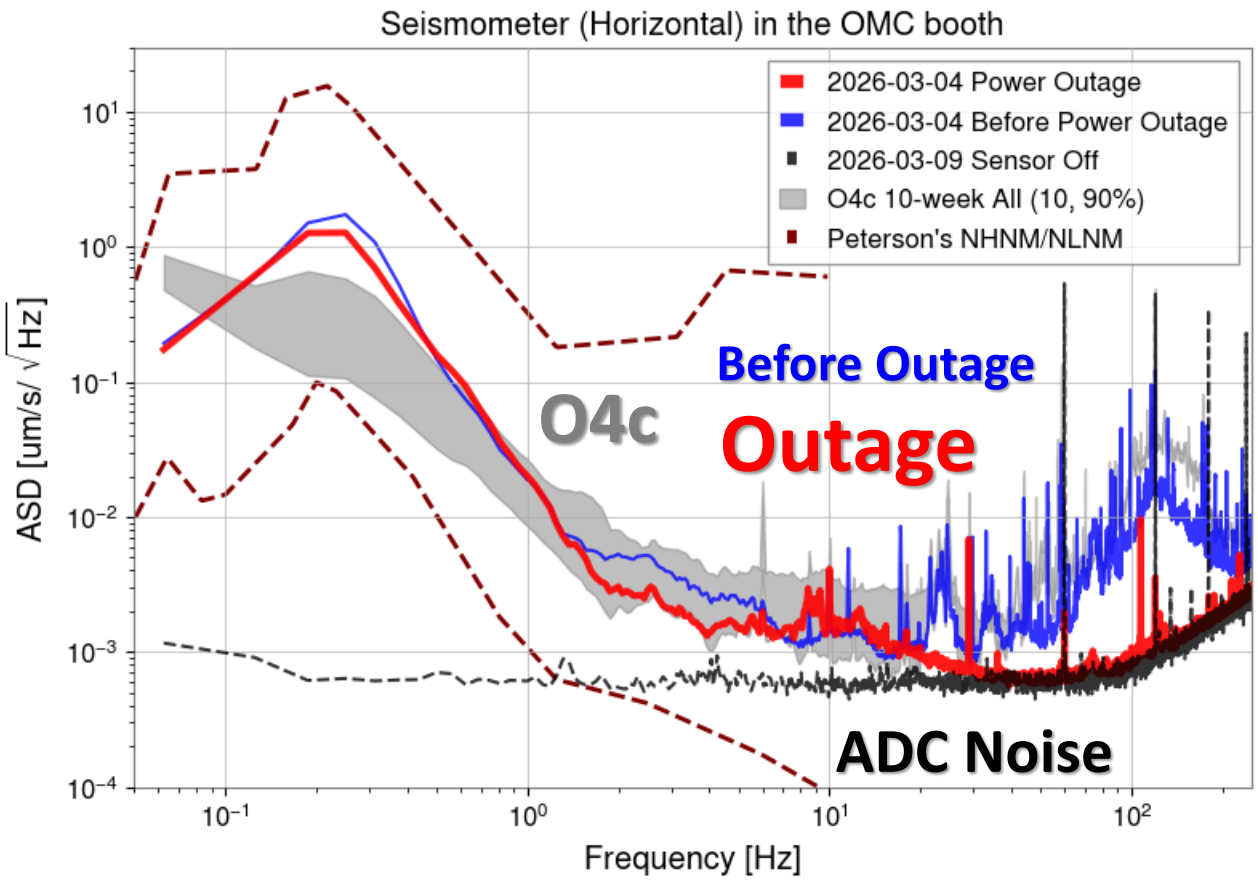


Seismic–Velocity Spectra During the Outage

Facility-related vibration was suppressed during the power outage.

- Below ~1 Hz: mainly natural microseismic motion.
- Above 20 Hz: the quiet spectrum approaches the lower tail of the O4c distribution.

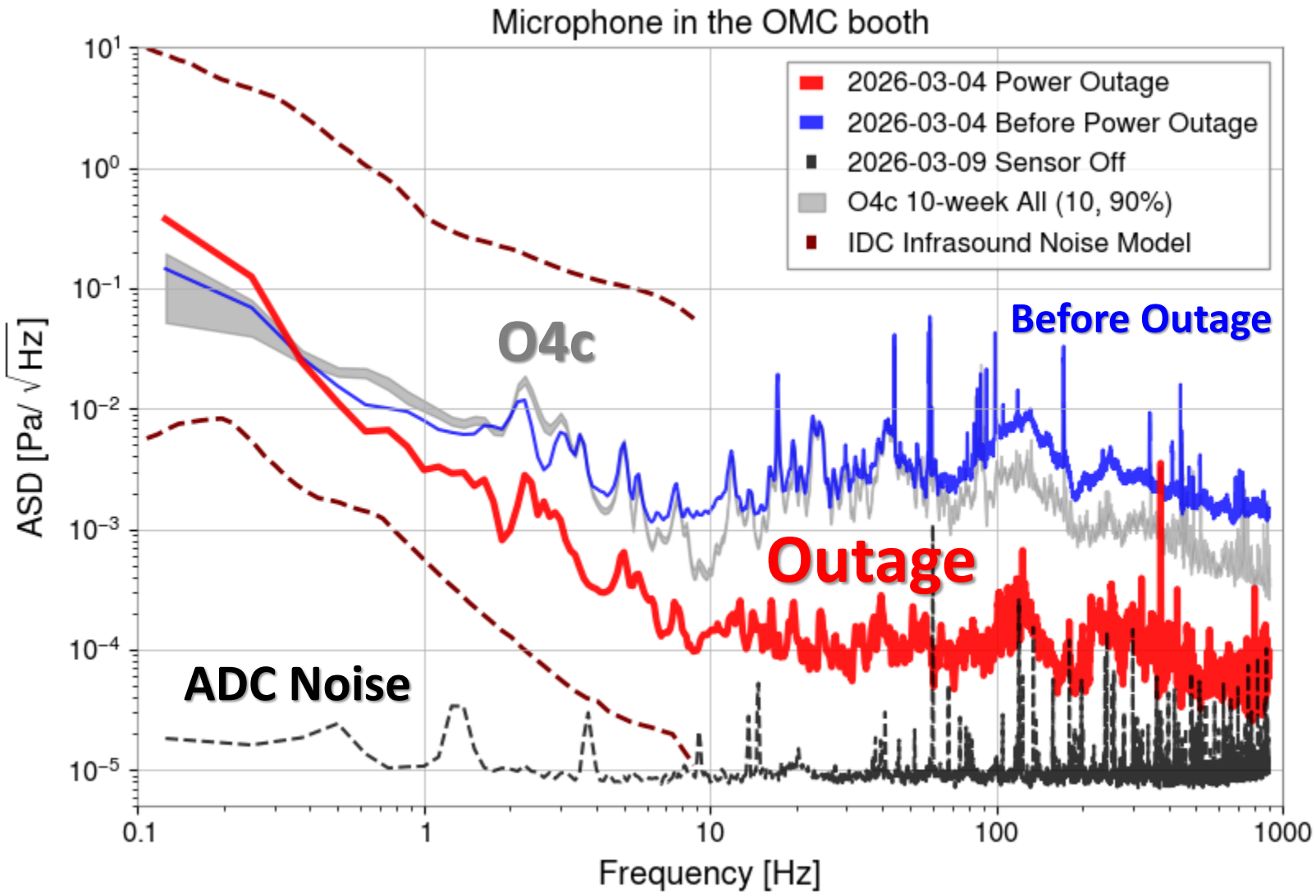




Acoustic Spectra During the Outage

Broadband acoustic noise was greatly reduced when facility equipment was stopped.

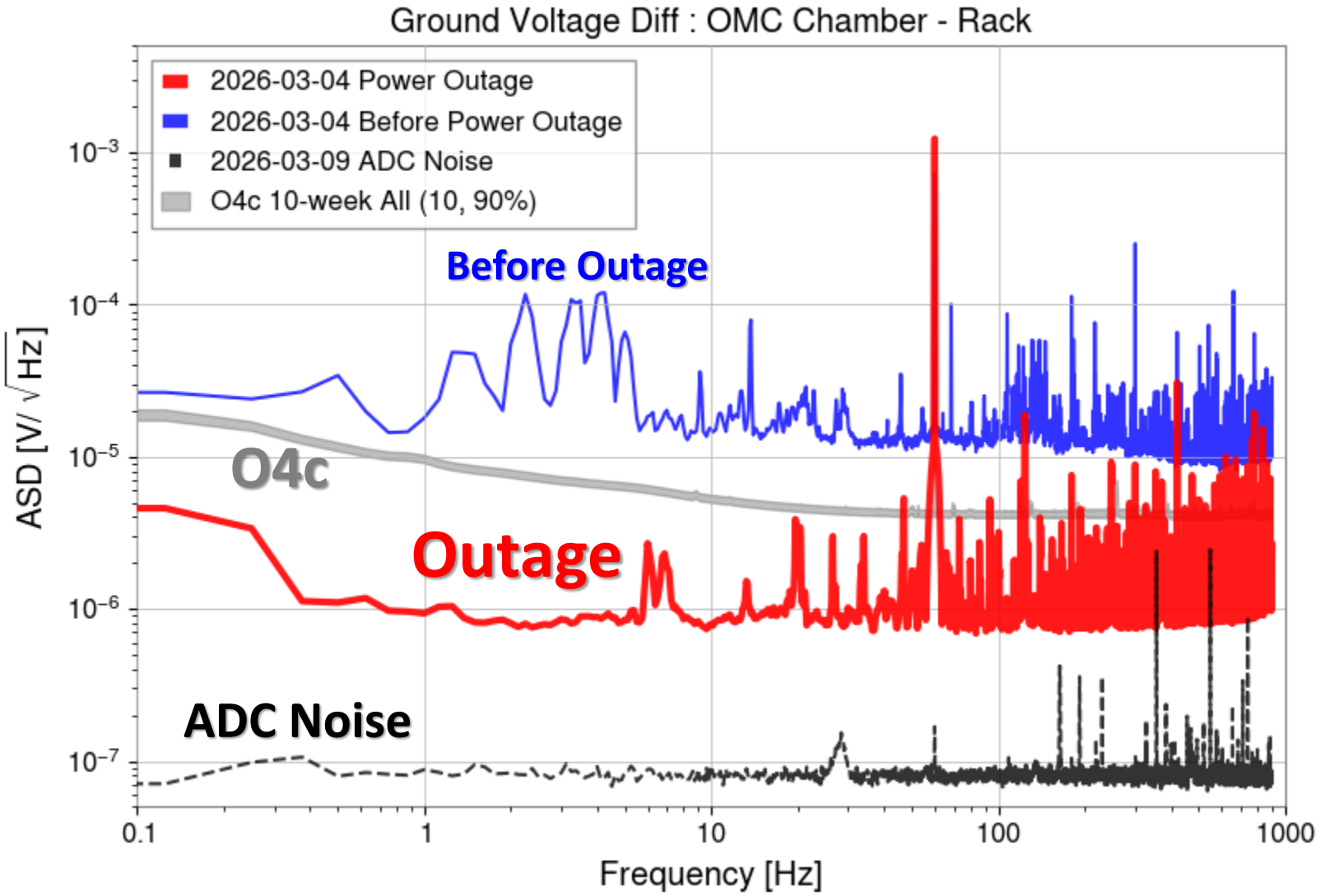
- The reduction is clear above ~1 Hz.
- The power-outage spectrum is below the O4c reference band over much of the audio band.
- Residual narrow features remain.



Ground-Voltage Spectra During the Outage

Ground-voltage noise decreased by more than an order of magnitude.

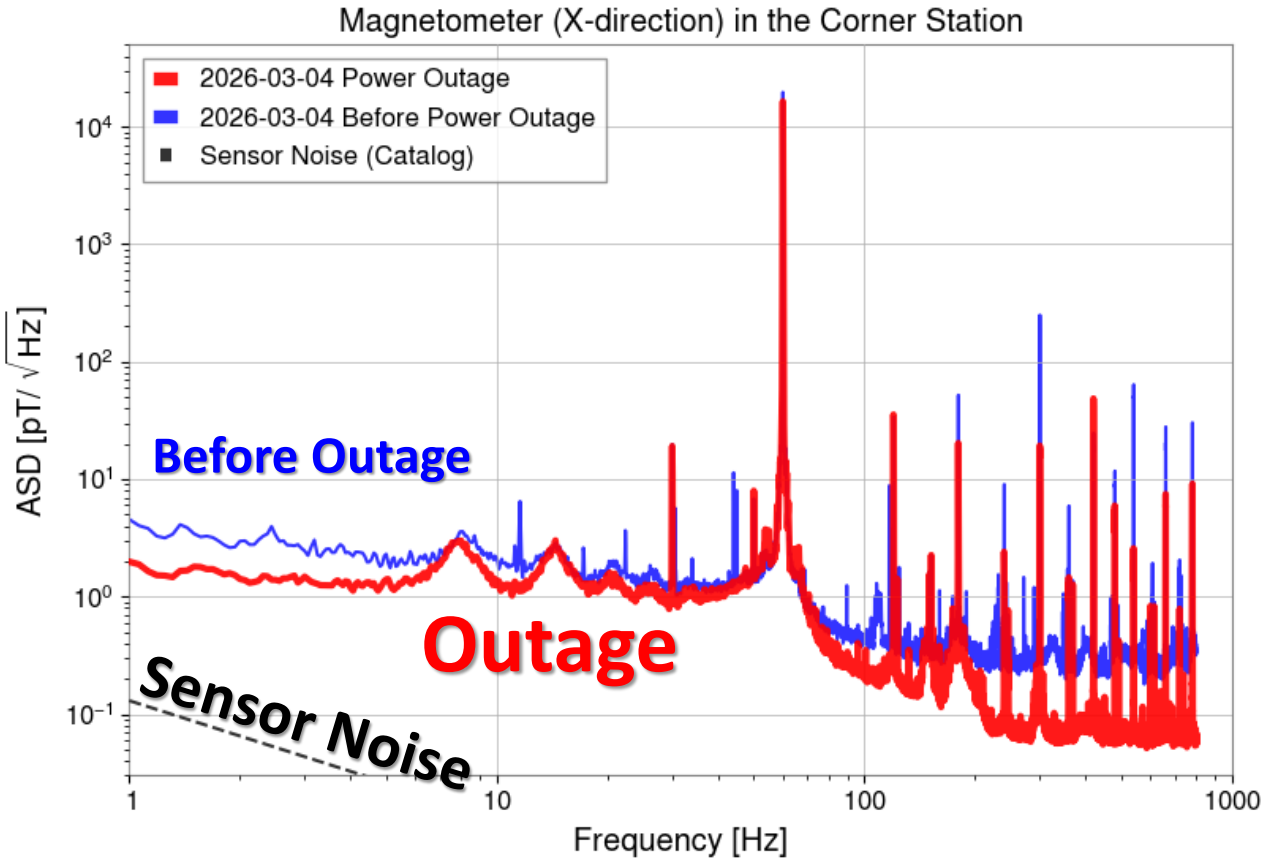
- The quiet-period spectrum is well above the ADC-noise floor.
- Broadband electrical noise is strongly affected by facility operation.
- Residual line features remain at higher frequencies.

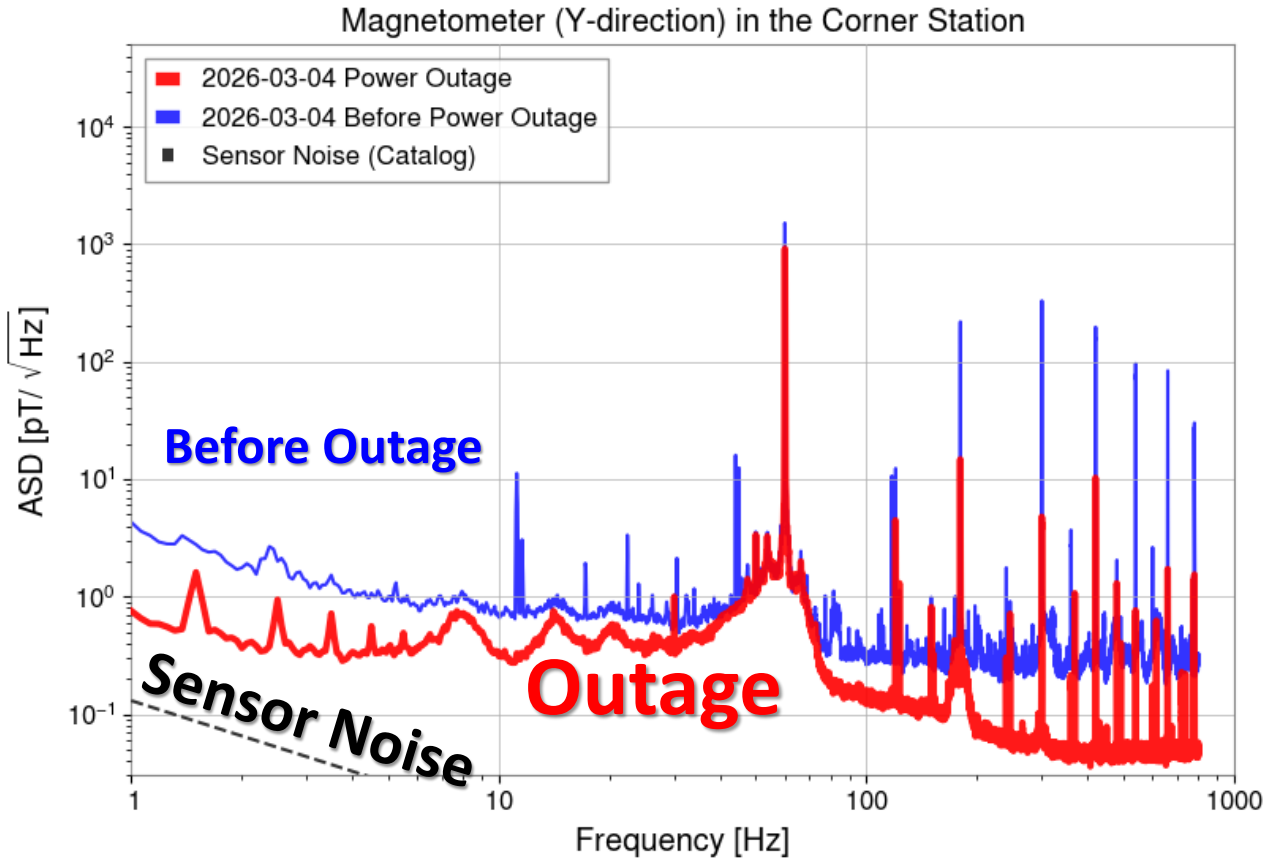


Magnetic Spectra During the Outage

Broadband magnetic noise was reduced, but persistent line features remained.

- The power-outage spectrum is generally lower at high frequencies.
- Strong narrow lines remain above the catalog sensor-noise level.
- The Schumann resonances (8, 14, 20, 26, 33 Hz) did not change significantly.





Summary

- O4c environmental monitoring
  - Established normal-operation reference spectra around the OMC.
  - PEM sensors probe seismic, acoustic, magnetic, and electrical environmental fields.
- Site-wide quiet reference
  - The planned power outage provided a rare facility-off reference.
  - Facility operation contributes significantly to seismic, acoustic, and ground-voltage noise.
  - Magnetic broadband noise was reduced, while persistent line features remained.
- Implications
  - KAGRA provides an operational underground test case for infrastructure-noise studies.
  - This is relevant for future underground detectors such as ET.