2019/6/21

6th KAGRA International workshop: in Wuhan, China

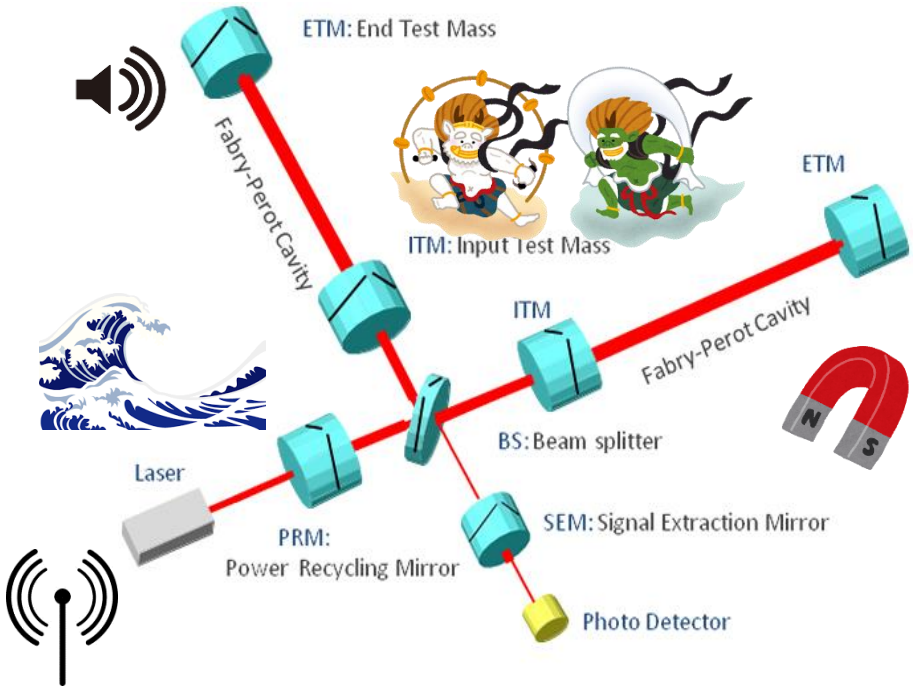
Status of KAGRA Physical Environmental Monitors toward the O3

Tatsuki Washimi (NAOJ), On behalf of KAGRA PEM

Contents

Examples of Environmental Noise

- Vibration & Sound from machines, Seism, …
  - Vibration of optics (laser, mirror,...), vacuum apparatus (chamber, view port, ...)
- Sound (Density fluctuation of air)
  - Fluctuation of refractive index
  - Newtonian noise
- Magnetic field
  - coupling to the actuator magnets
- Radio frequency waves (MHz)
  - beat noise
  - coupling to the laser modulations
- Electrical noise
  - all readout and control electronics
- gravity gradient
- cosmic ray
- etc …

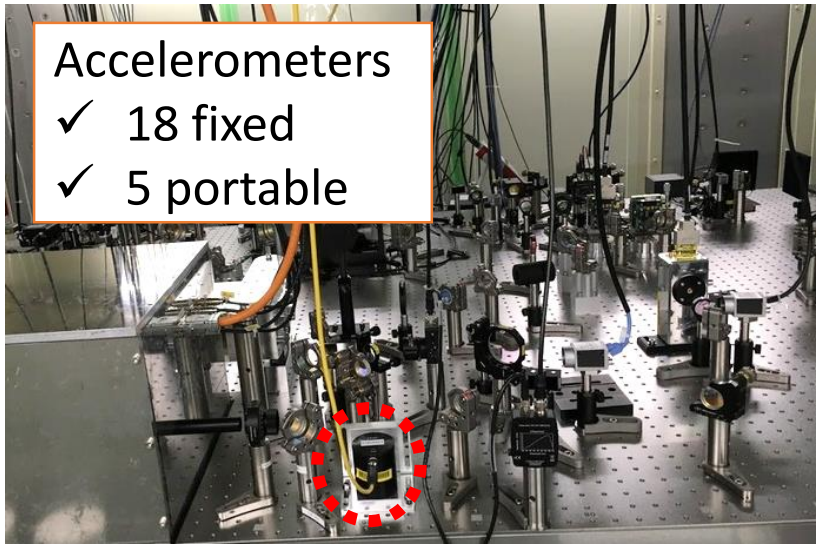


➡ Targets of Physical Environmental Monitors (PEM)

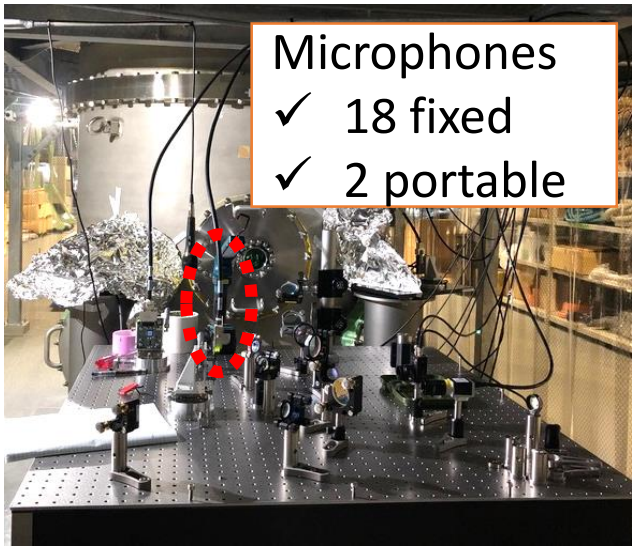
c.f. Non-physical Environment (slow monitor)

- temperature, humidity, atmospheric pressure, … : facility and apparatus
- oxygen concentration, vacuum pressure, fire alarm,… : safety

Current status of PEM installation



Accelerometers
- ✓ 18 fixed
- ✓ 5 portable



Microphones
- ✓ 18 fixed
- ✓ 2 portable

Magnetometers
- ✓ 2 fixed
- ✓ 3 portable

Seismometers
- ✓ 5 fixed
- ✓ 1 portable

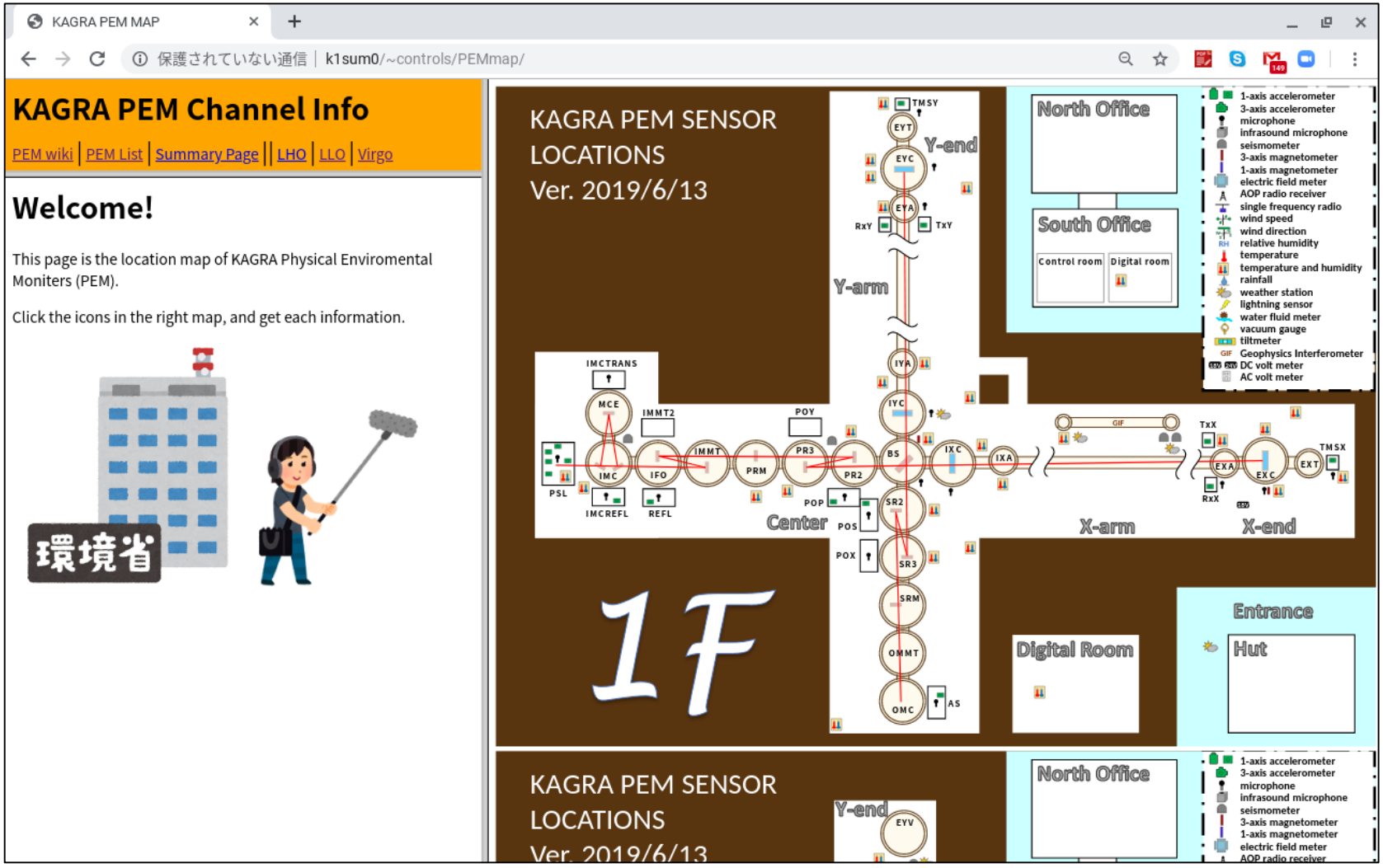
Weather station
- ✓ 1 fixed

Other sensors :
- ◆ Radio frequency recover (1)
- ◆ DC power monitor (1)
- ◆ Temperature & humidity sensors (69)
- ◆ Vacuum gauges (11)

The PEM sensor information is in
http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/KAGRA/Subgroups/PEM/List

Baseline PEM installation for O3 has done!

Current status of PEM installation



You can see the KAGRA PEM sensor location map

- https://www.icrr.u-tokyo.ac.jp/~washimi/KAGRA/PEM/PEMmap/
- Icons are common with LIGO (http://pem.ligo.org/channelinfo/index.php)

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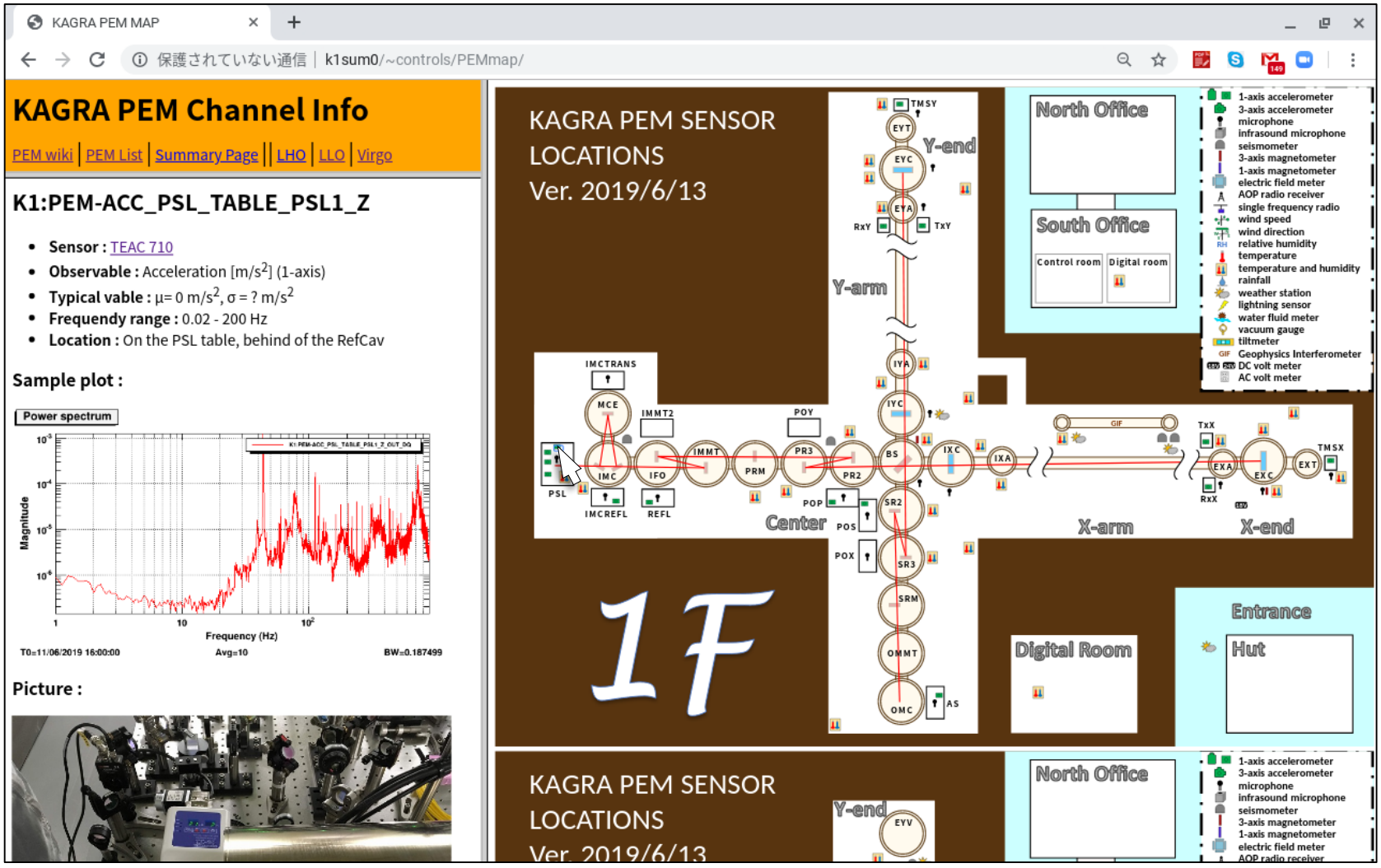

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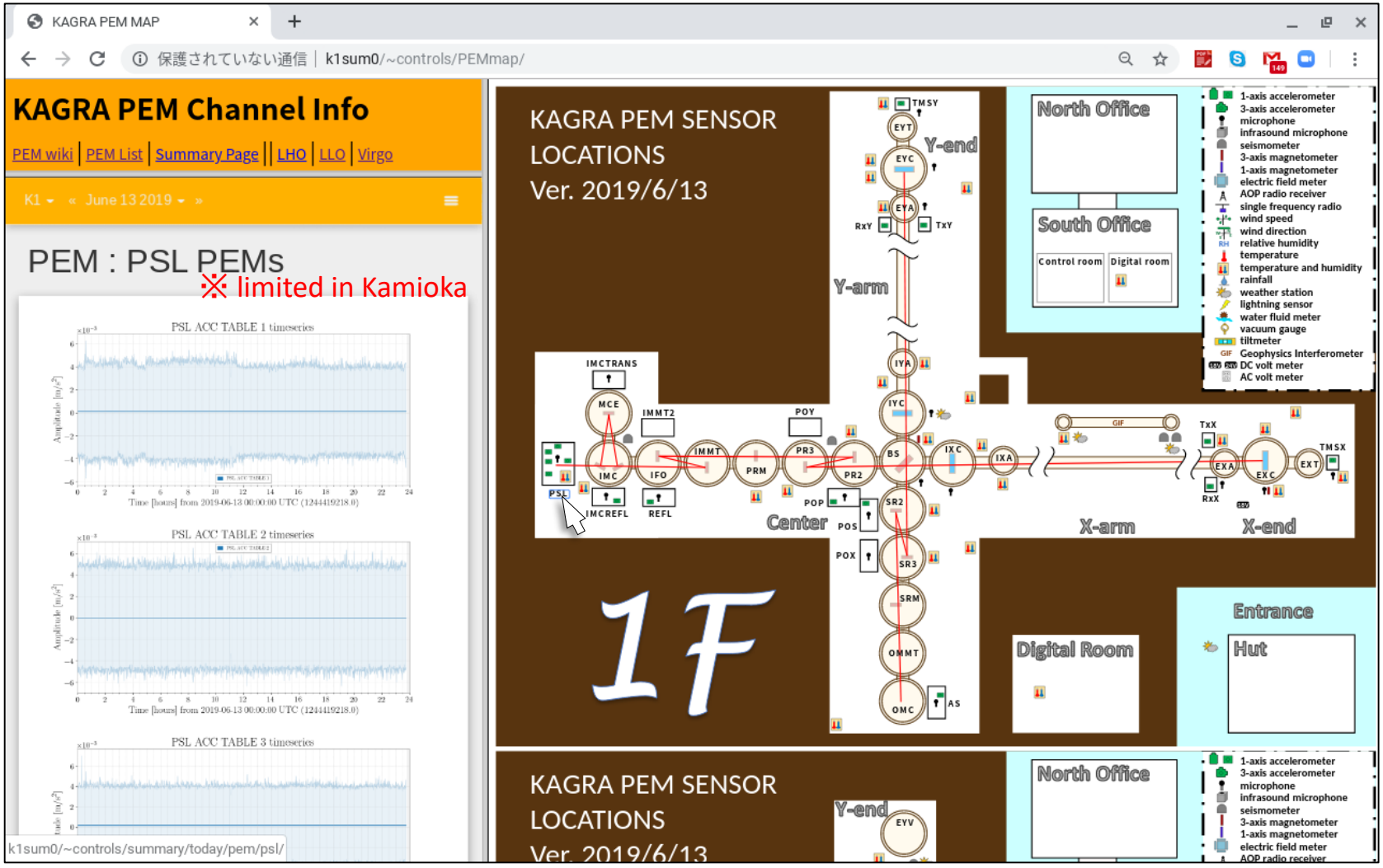

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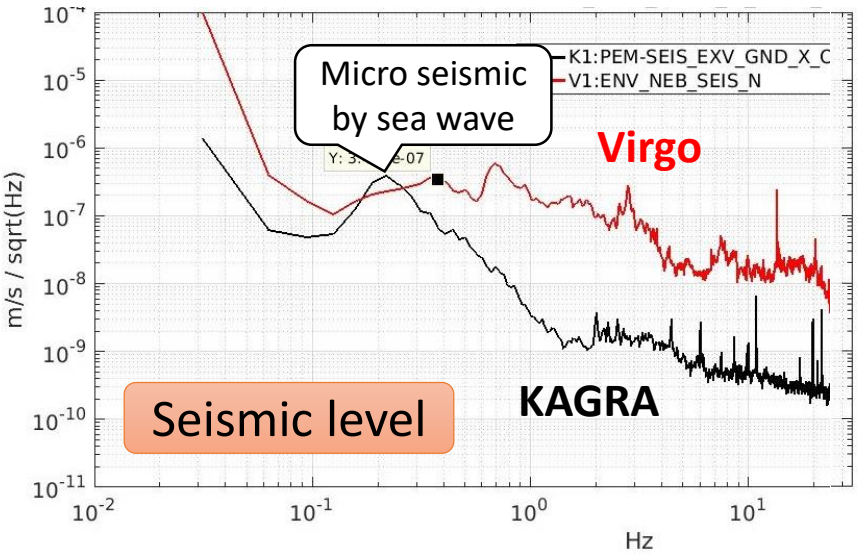
Characterization : Underground

As well known, seismic noise in underground is smaller than on surface.

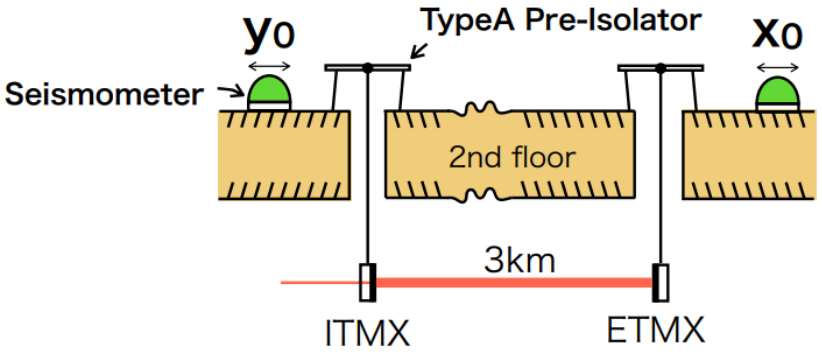
The differential mode of 2 seismometers, 3km distant, is smaller than the common mode.

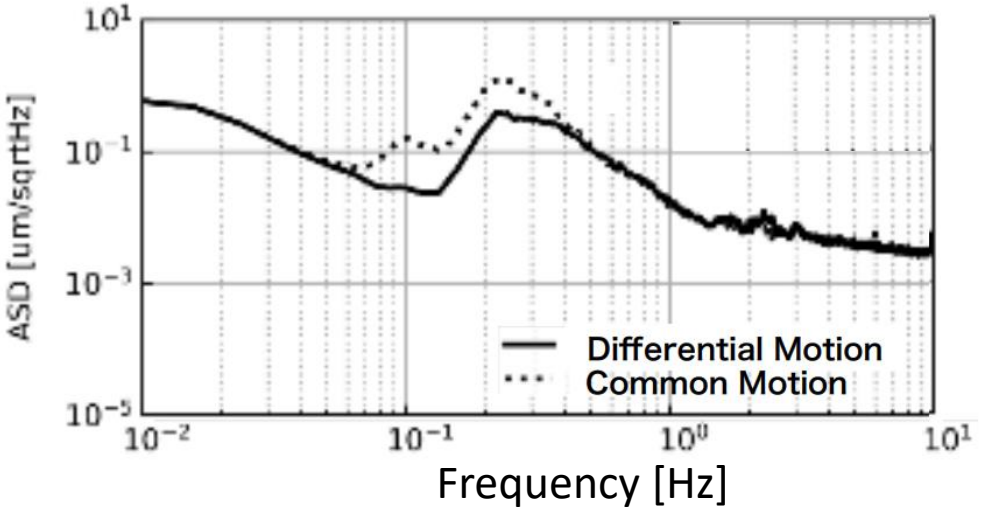
➢ The rock hard, but not perfect.



Residual ground motion in the X arm

JGW-G1910078





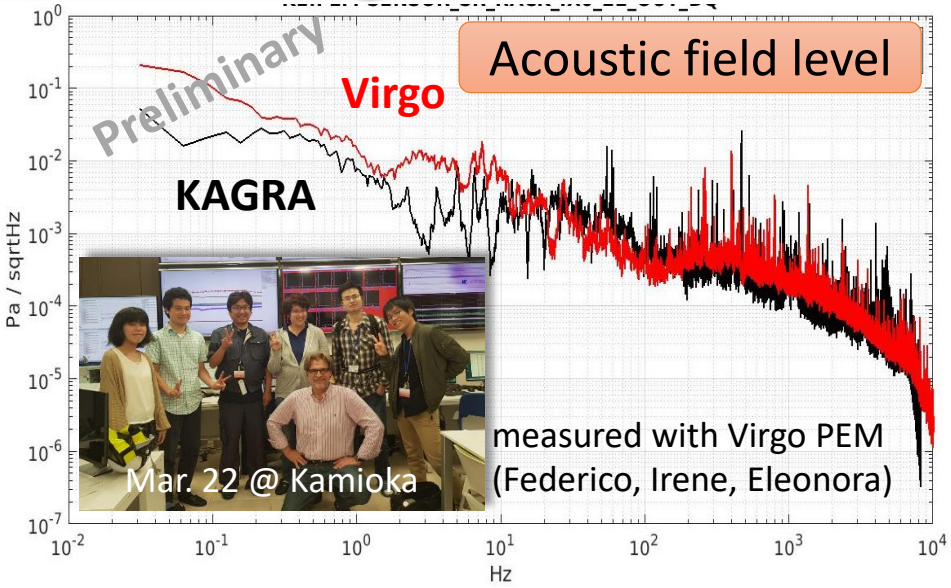
Characterization : Underground

The acoustic noise level is similar between KAGRA and Virgo (O3 science mode)

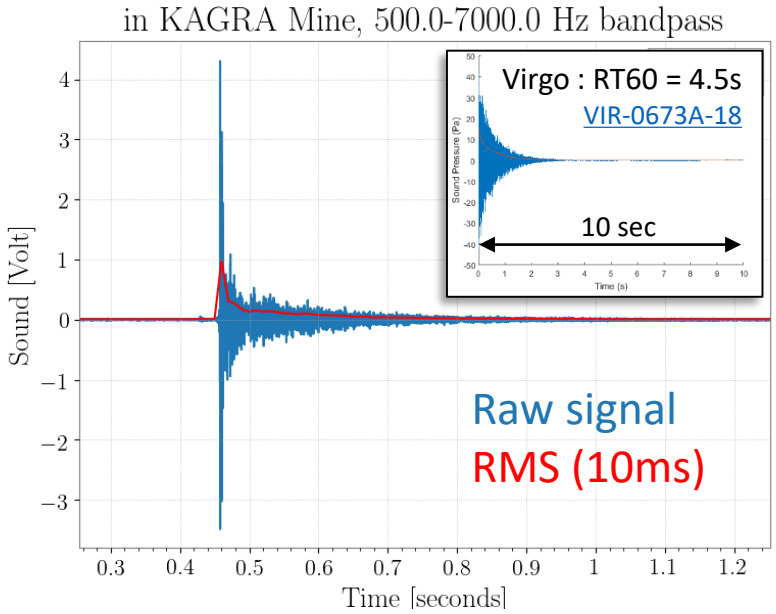
✓ we used the Virgo infrasound microphone

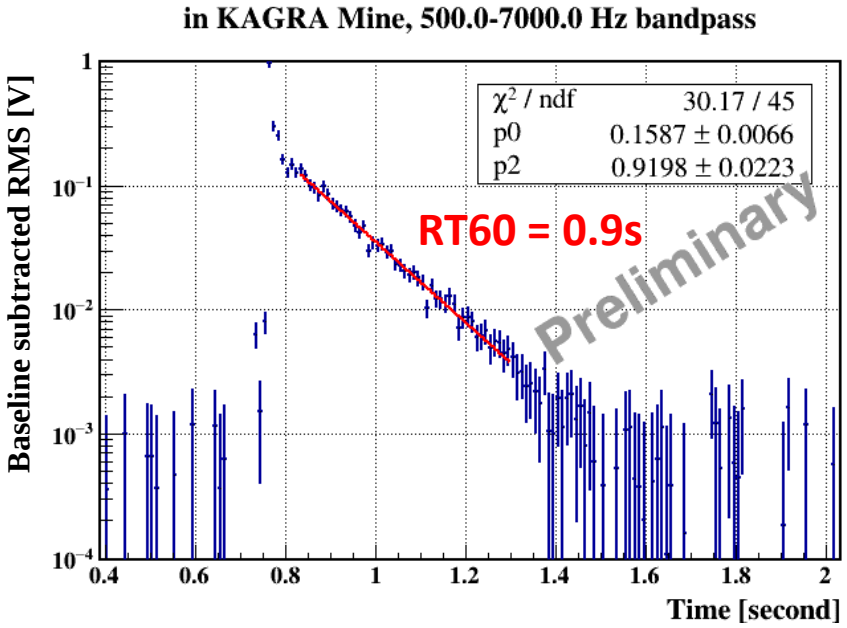
The Reverberation time in KAGRA mine is much shorter than in Virgo site.

➢ Useful information for ET.



Reverberation time





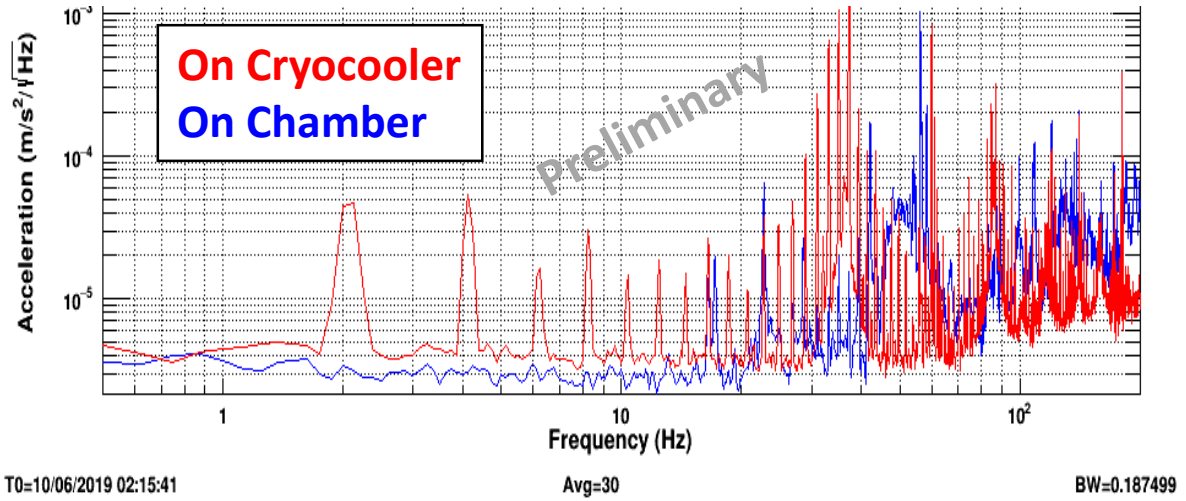
Characterization : Cryogenic System

Vibration

The cryocoolers for a mirror drive at 2Hz.

- 2Hz and its harmonic peaks observed on a cryocooler.
- They are not seen on the chamber.

Cryogenic accelerometer is under development in KEK.

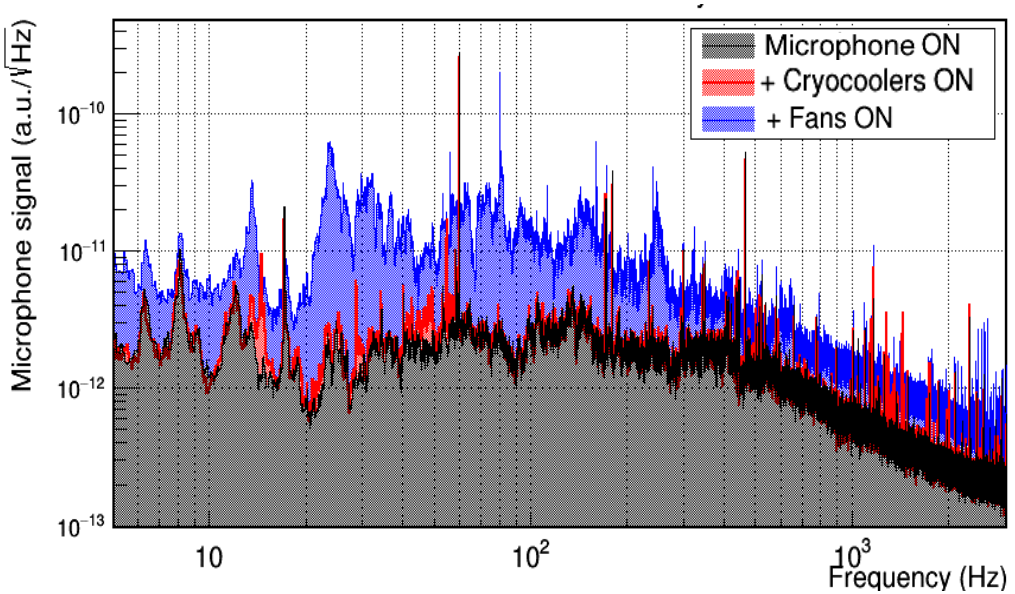


Sound

The components from the cryogenic system are seen in 13-59 Hz and 1135-2015 Hz.

- the main sound we can hear from cryocooler is ~10kHz.

※Fans are working only construction phase



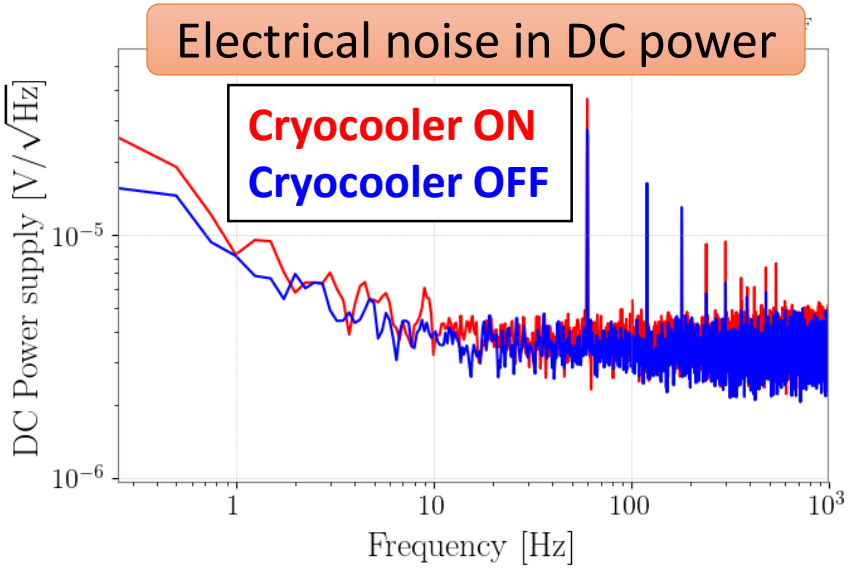
Characterization : Cryogenic System

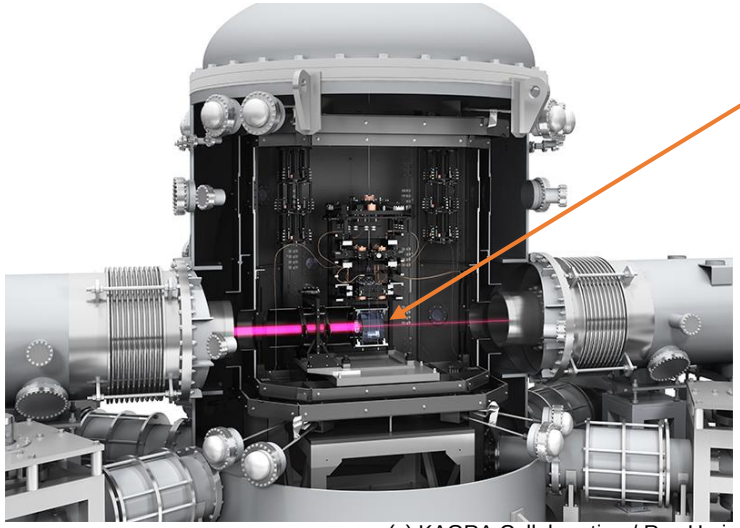
A compressor of a cryocooler uses much electric-power (4kW/unit).

- DC power line is not spoiled.

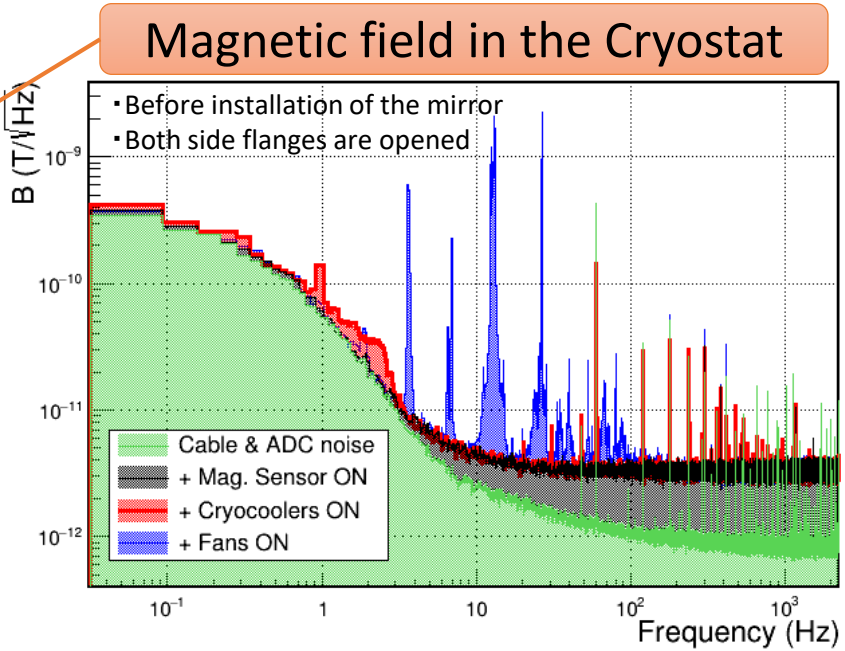
The magnetic field in the cryostat coming from cryocoolers : mainly in 1-3 Hz.

- Magnetic field is less than KAGRA requirement (~10^{-9} T).





(c) KAGRA Collaboration / Ray.Hori

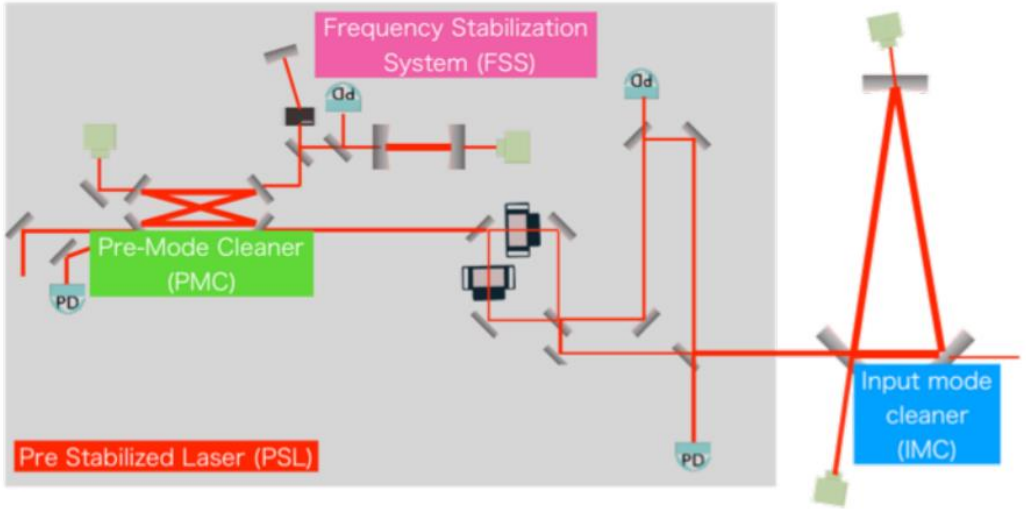


Current status of PEM injection

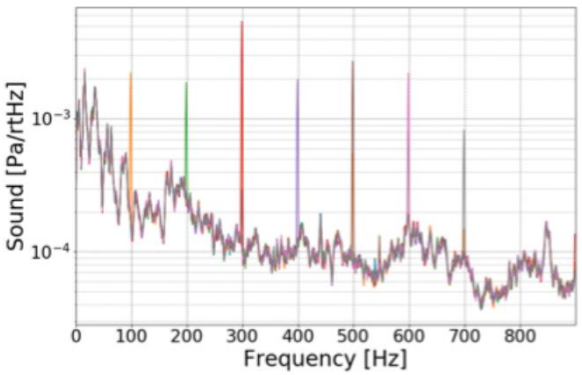
JGW-G1910071

We just started the acoustic injections in PSL room
to evaluate the acoustic couplings for the each channel of the PSL and IMC.

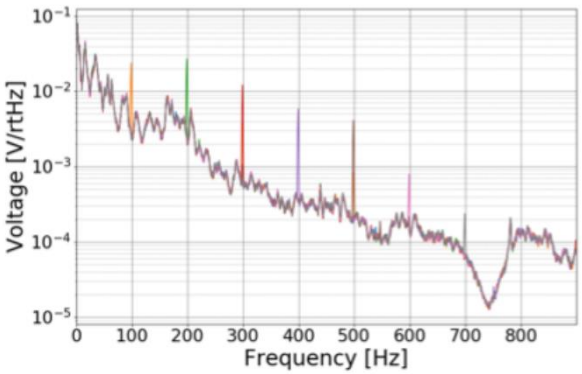
100, 200, 300, …,
700 Hz



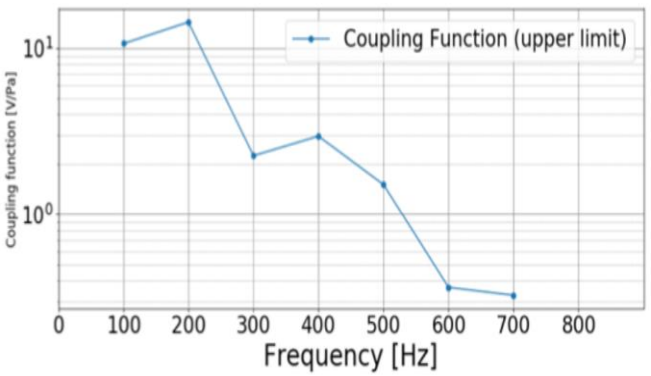
Microphone signal



PMC control signal



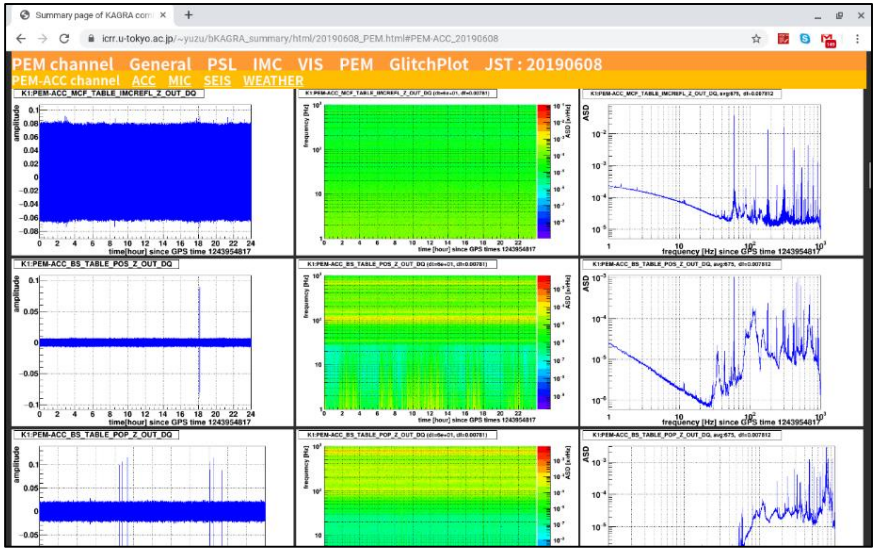
Coupling function



Plans for the O3 joining

- More PEM installation
  - ACC on chamber, duct, view port
  - DC/AC power monitor
  - RF monitor, lightning sensor,…
- Noise hunting
  - See the next talk (by Kaihotsu)

- Development of online/offline monitoring tool
- Preparation of PEM injection devices /softweare
- Evaluation of coupling between interferometer and PEM



Summary

- Baseline PEM installation for O3 has done!
- PEM characterization in KAGRA experimental site
  - Underground : Very good
  - Cryogenic system : Not bad
  - (Environment noise mapping & hunting : Next talk)
- PEM injection in KAGRA
  - Just beginning
- Toward the O3 joining of KAGRA
  - More PEM installation
  - Noise hunting
  - Development of monitoring tool
  - Preparation of PEM injection
  - Evaluation of coupling between interferometer and PEM

backup

Abstract :
Physical Environmental Monitors (PEM) play an important role of the noise identification/hunting for GW detectors. Especially, the environmental information of KAGRA will be important for the future GW detectors, because KAGRA is a underground and cryogenic experiment.
We have installed the seismometers, accelerometers, microphones and magnetometers to KAGRA site and are monitoring their behaver during the commissioning term. In this talk, we will report the current progress and future prospect of the PEM in KAGRA toward our joining the O3.