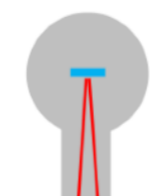
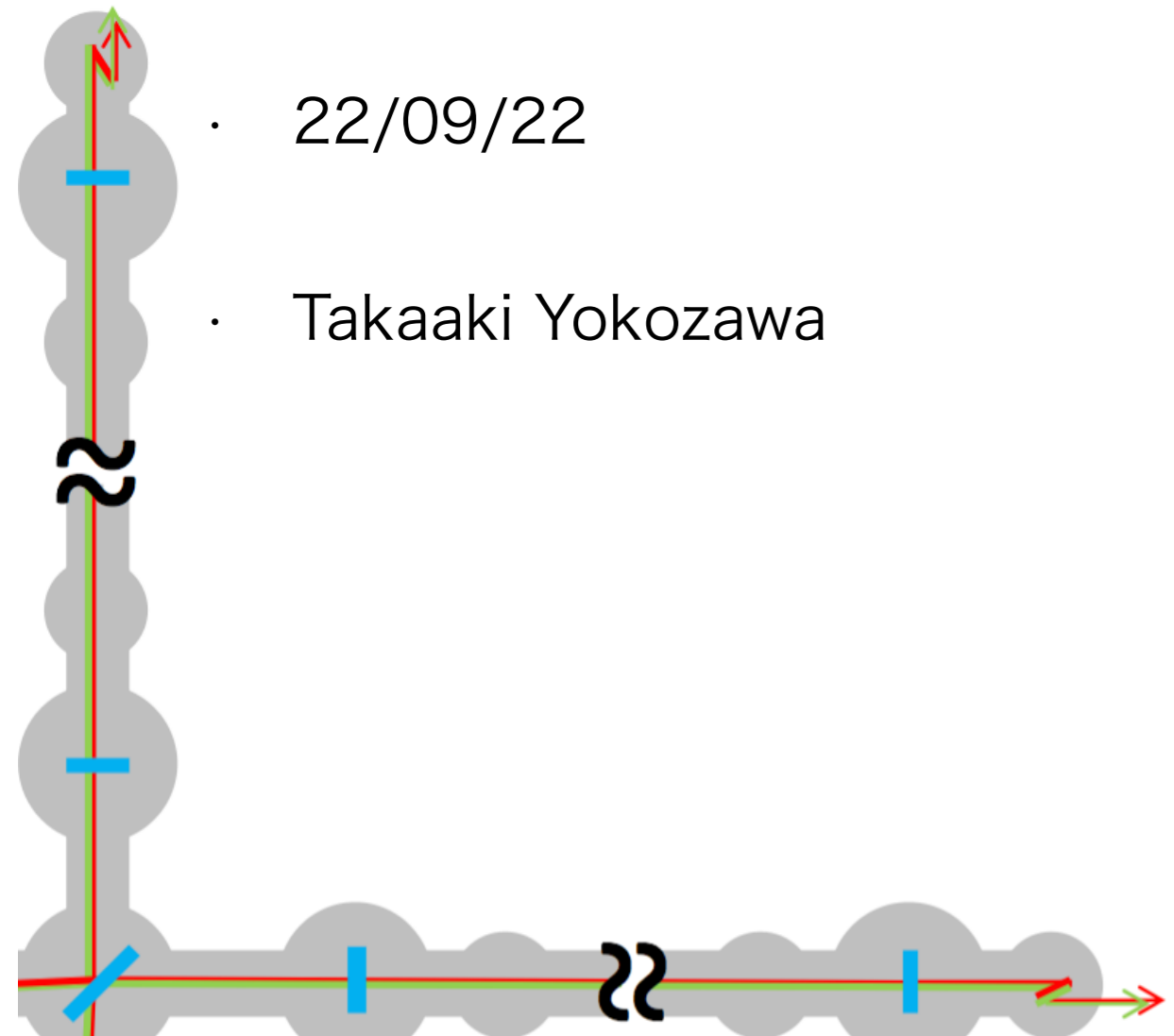
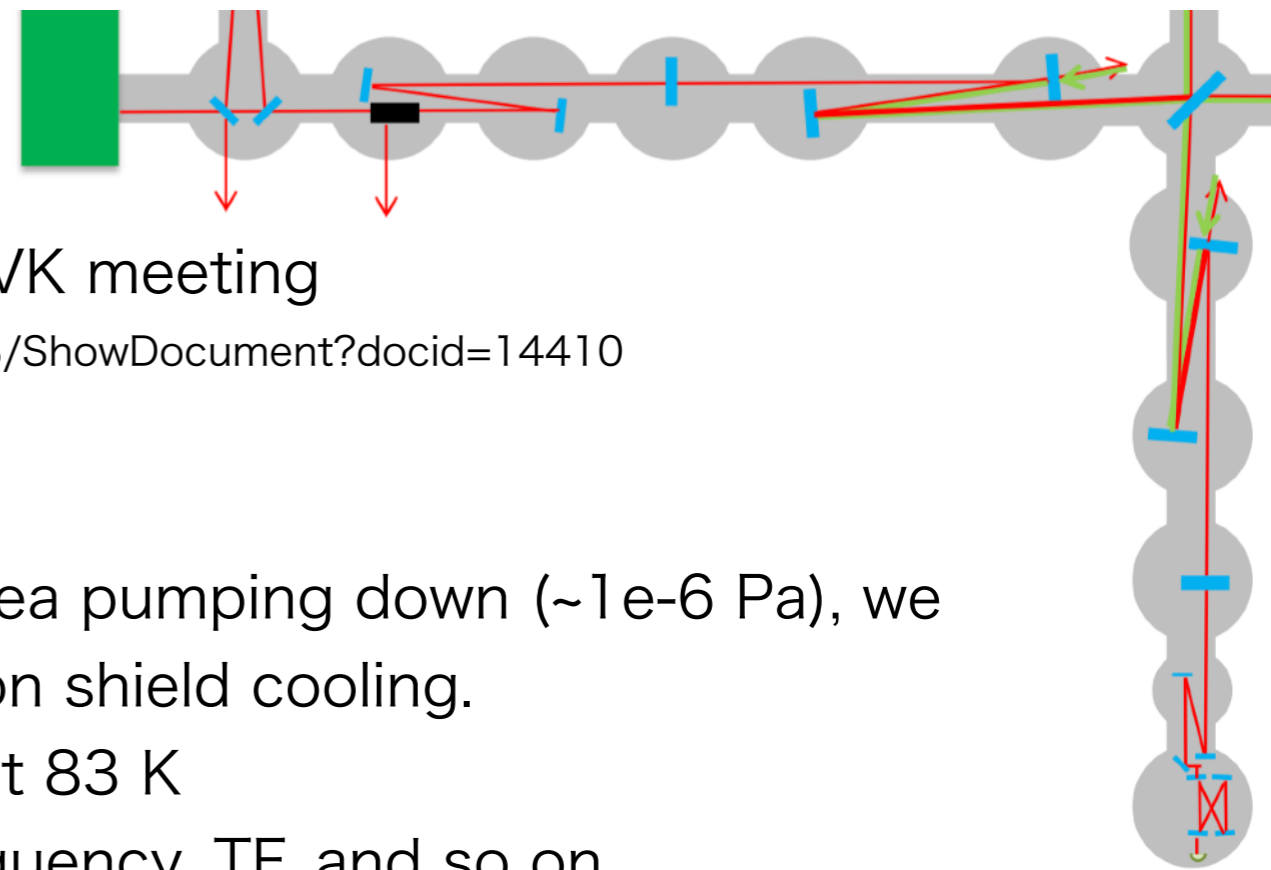


- VK PEM meeting
- 22/09/22
- Takaaki Yokozawa

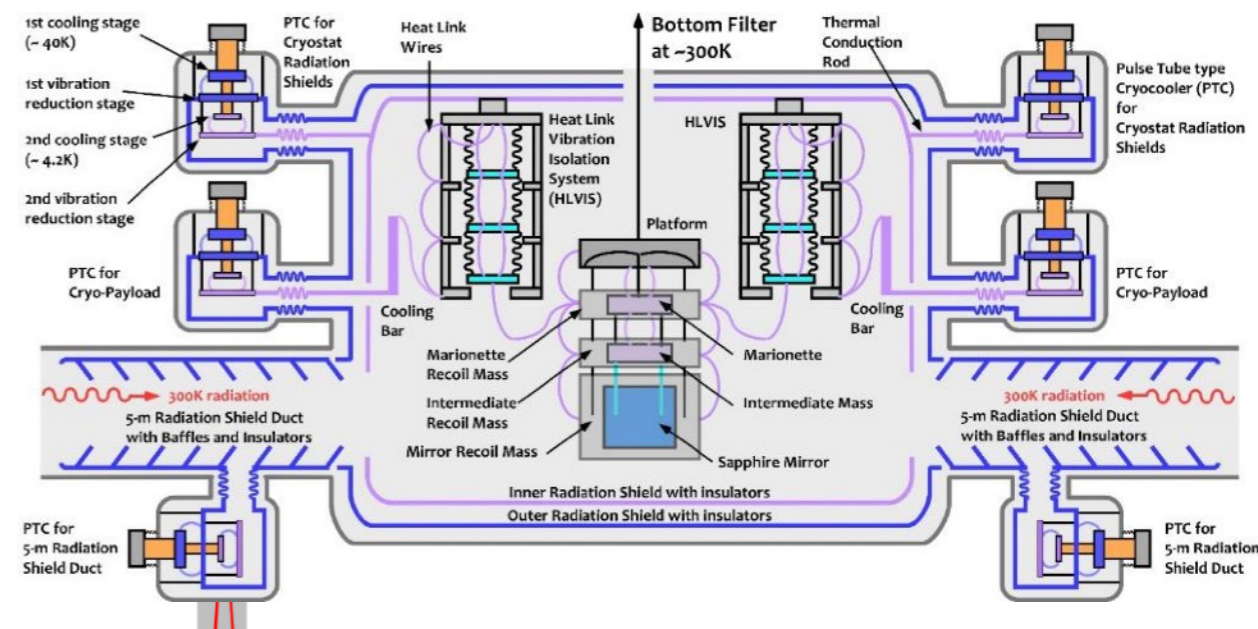
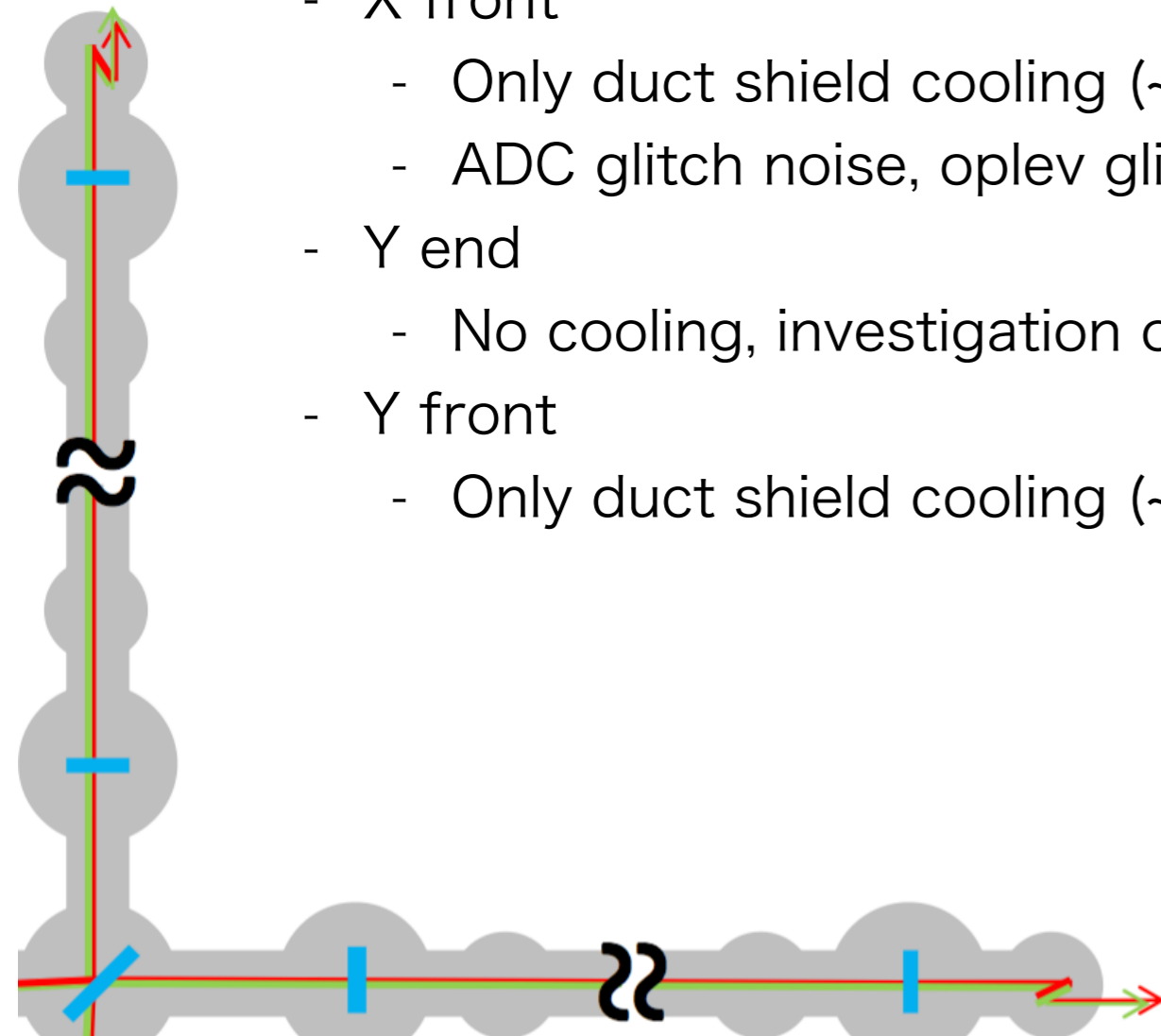




# Status of KAGRA



- See detail in J.Yokoyama-san's slide in LVK meeting
  - <https://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=14410>
- Vacuum and pumping down
  - X end
    - Because both Xarm and TMSX area pumping down ( $\sim 1 \text{e-}6 \text{ Pa}$ ), we started the both duct and radiation shield cooling.
    - Temperature of test mass is about 83 K
      - Characterize the resonant frequency, TF, and so on
  - X front
    - Only duct shield cooling ( $\sim 250 \text{ K}$ )
    - ADC glitch noise, oplev glitch noise investigation
  - Y end
    - No cooling, investigation of the TMSY pumping down
  - Y front
    - Only duct shield cooling ( $\sim 250 \text{ K}$ )





# Status of KAGRA

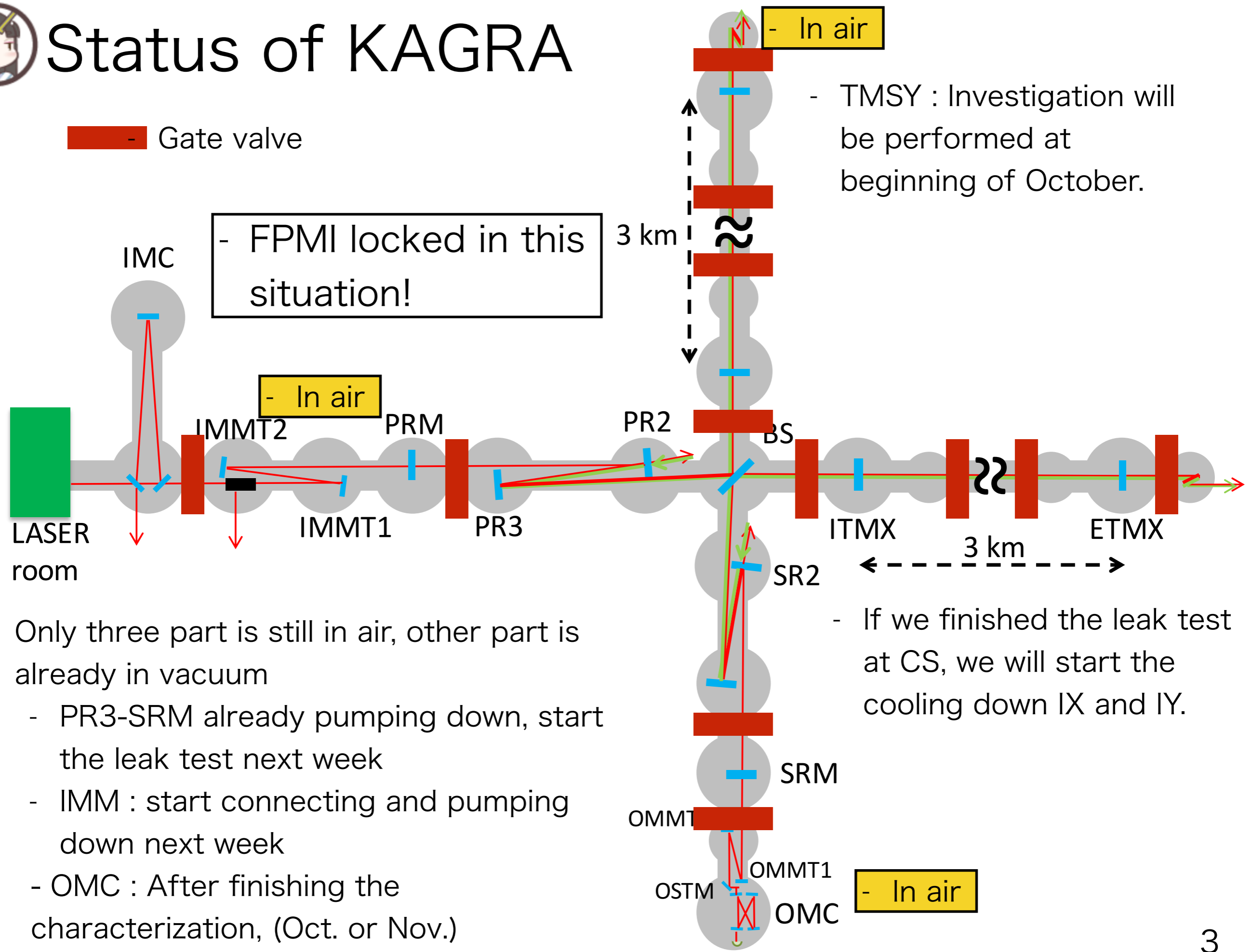
- Gate valve

- FPMT locked in this situation!

- In air

- In air

- TMSY : Investigation will be performed at beginning of October.

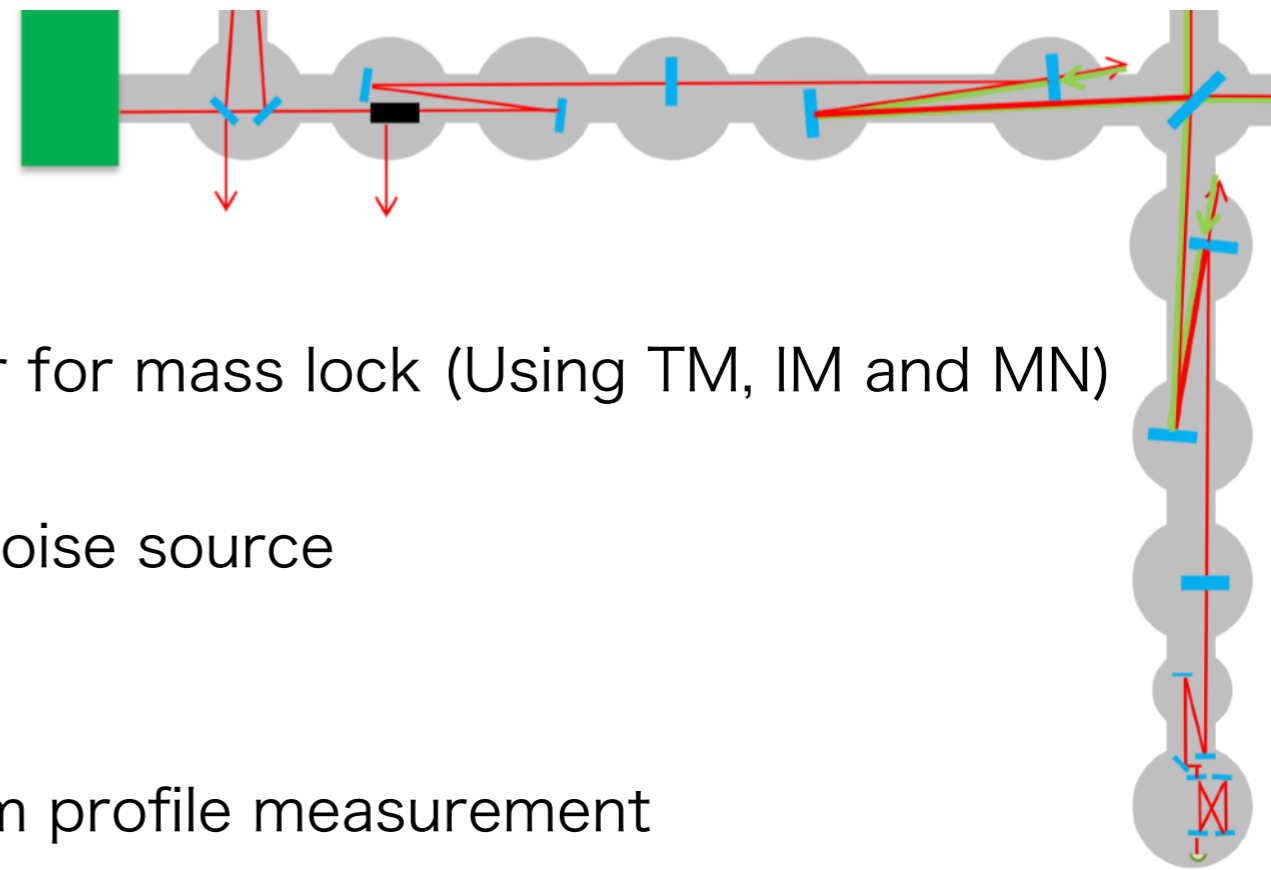


- Only three part is still in air, other part is already in vacuum
  - PR3-SRM already pumping down, start the leak test next week
  - IMM : start connecting and pumping down next week
  - OMC : After finishing the characterization, (Oct. or Nov.)

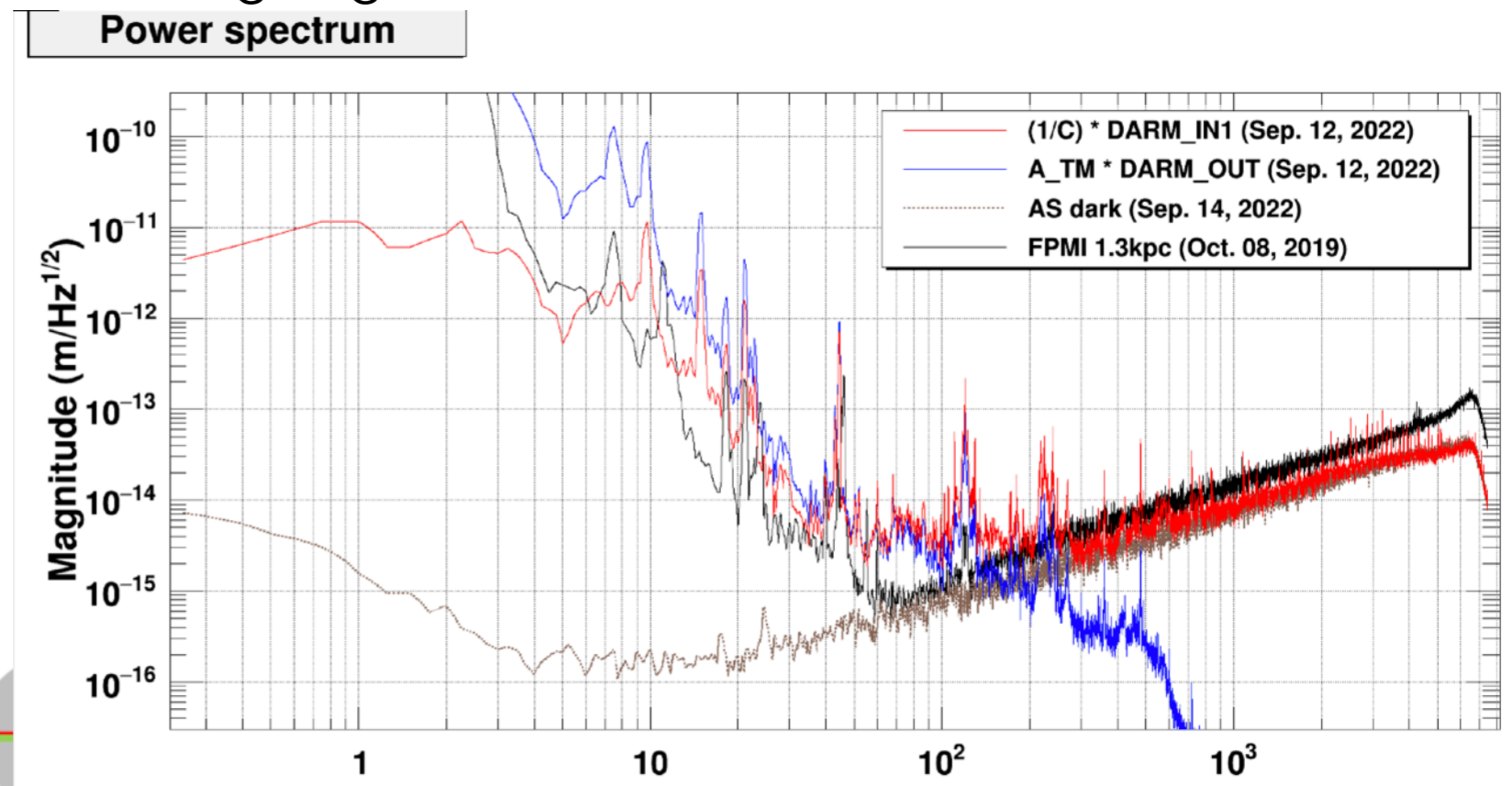
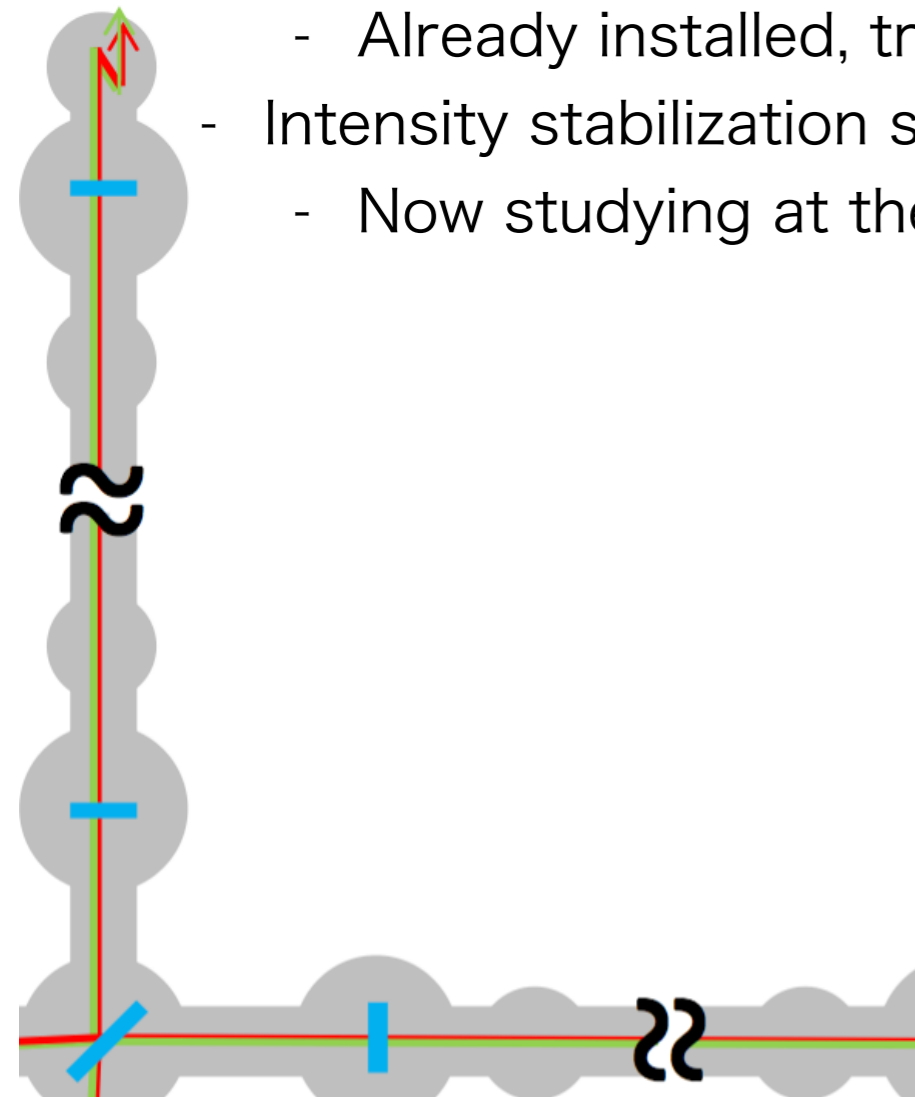
- If we finished the leak test at CS, we will start the cooling down IX and IY.

- In air

# Status of KAGRA



- FPMI lock succeeded
  - ALS DARM lock with appropriate filter for mass lock (Using TM, IM and MN)
  - Hand over from green to IR stable
  - We will start the investigation of the noise source
  - And we will start the PRFPMI lock trial
- OMC
  - Fixing the PD, power budget and beam profile measurement
- New high power laser
  - Already installed, trial to take over from old laser source
- Intensity stabilization system
  - Now studying at the site ongoing

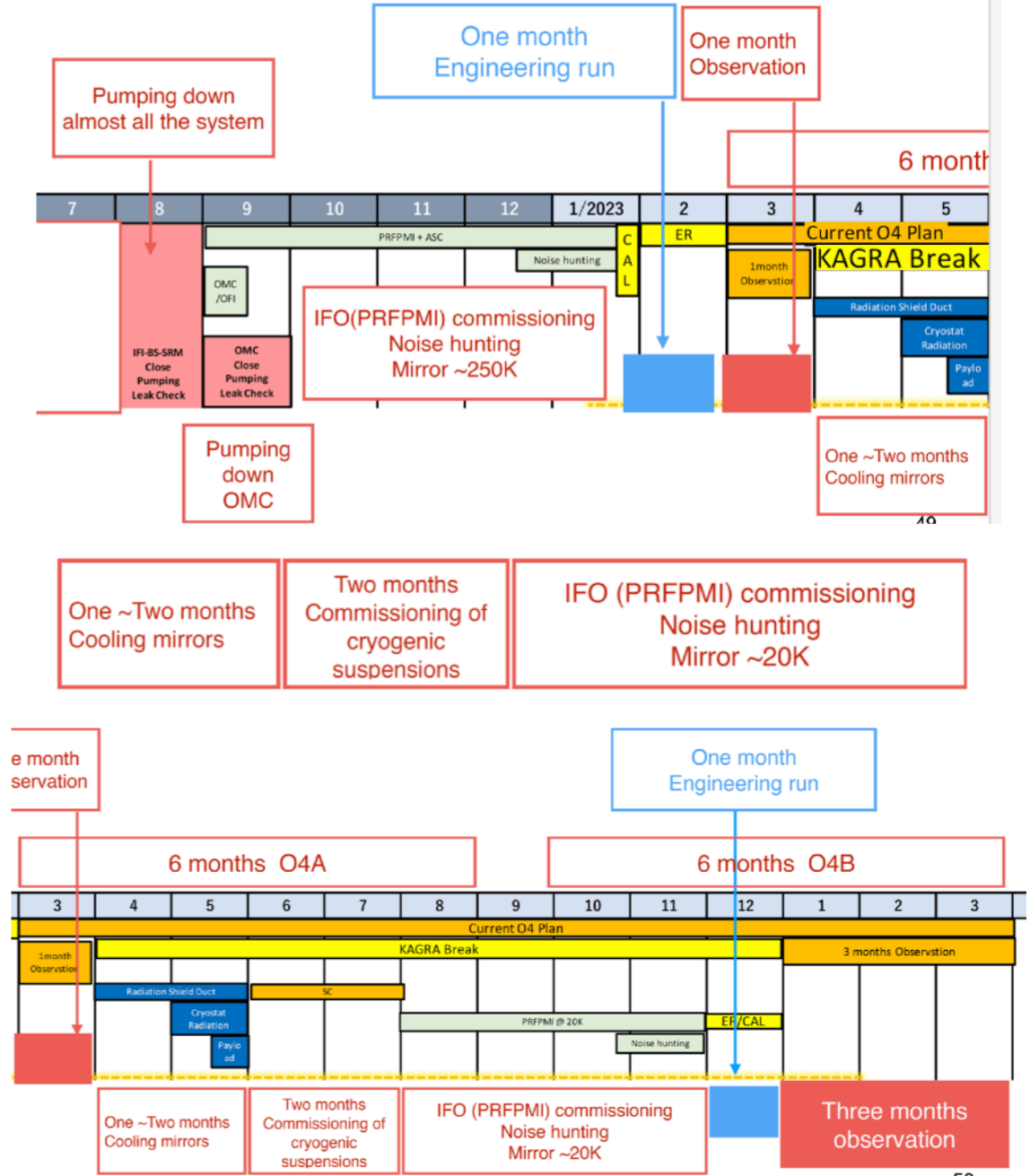
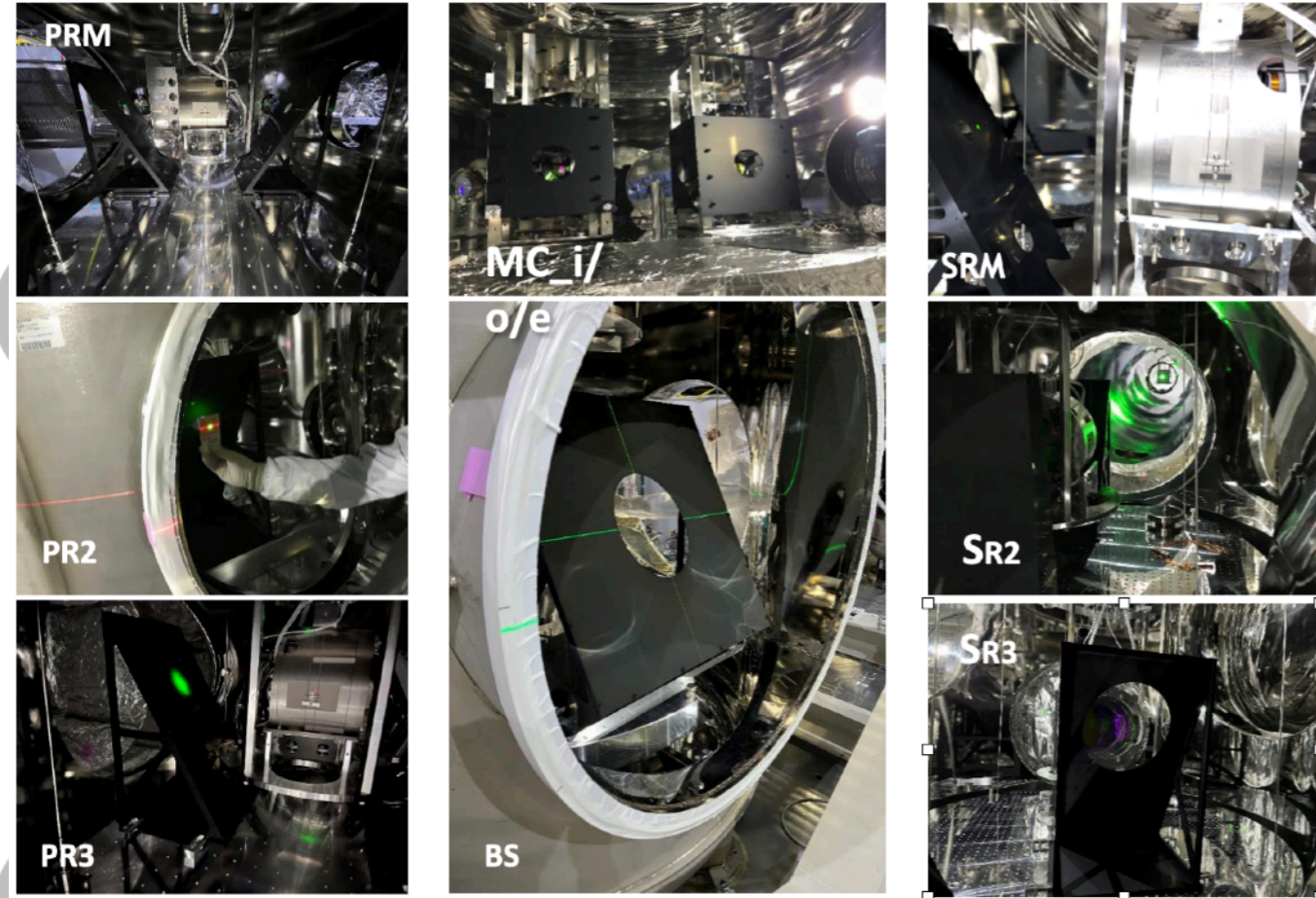
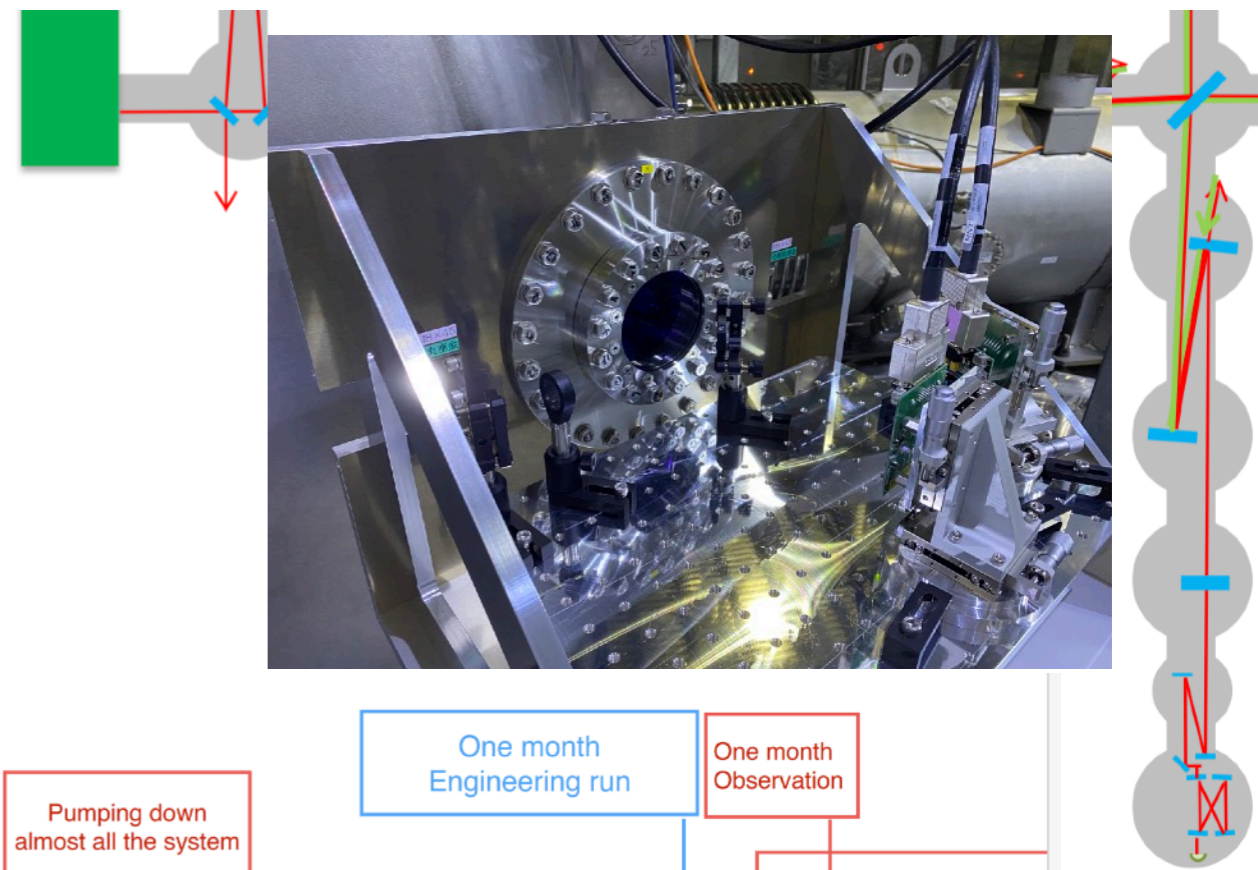






# Status of KAGRA

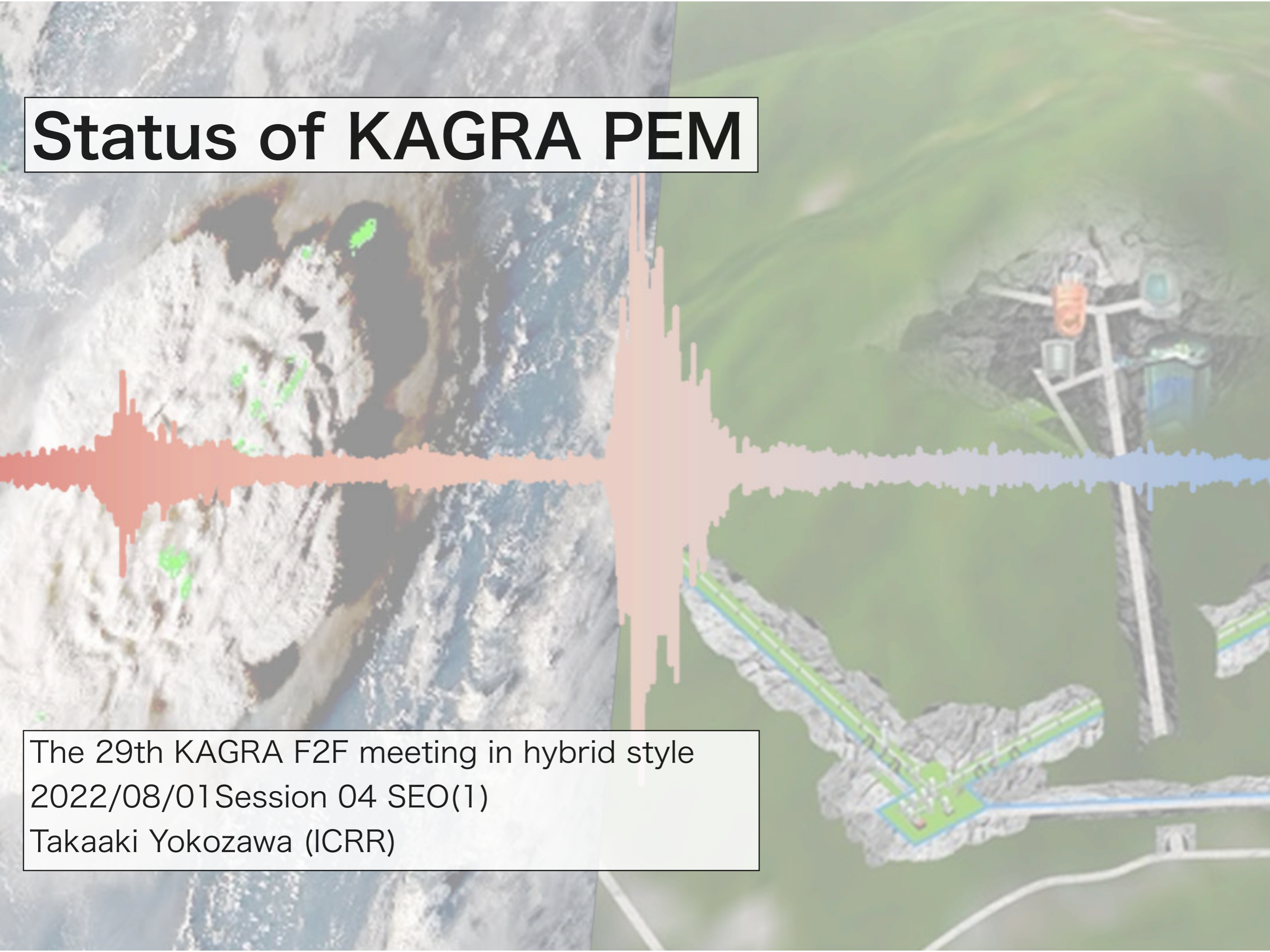
- All planned mid-size baffles were installed
- All planned new optical lever were installed
- SRM mirror replaced to 0% reflection one
  - No RSE but improved the shot noise





# Status of KAGRA PEM

The 29th KAGRA F2F meeting in hybrid style  
2022/08/01 Session 04 SEO(1)  
Takaaki Yokozawa (ICRR)







# Install the PEM toward O4

- Toward the O4, several PEMs are re-installed (including re-cabling)
  - AMP Boxes for portable PEM
  - New medm screen
  - PEM Map for O4 (preparing)
- Need the help to evaluate the sensor ex. for Rapid Response Team



ID	Component	Value	Unit	Filter	Bank	ADCP
01	K1:PEH-ACC_PSL_TABLE_PSL1_Y	S180920 ; TEAC710 + TEAC AMP	2.25e-04	QFilterBank	Q01SP	
02	K1:PEH-ACC_PSL_TABLE_PSL2_X	S180920 ; TEAC710 + TEAC AMP	4.52e-05	QFilterBank	Q01SP	
03	K1:PEH-ACC_PSL_TABLE_PSL3_Z	S180920 ; TEAC710 + TEAC AMP	2.56e-04	QFilterBank	Q01SP	
04	K1:PEH-PORTABLE_PSL_BOOTH_PSL_BNC4		0.00e+00	QFilterBank	Q01SP	
05	K1:PEH-ACC_PSL_PERI_PSL1_Y	S170722 ; K1ST1AR 86496 (Not Located)	0.00e+00	QFilterBank	Q01SP	
06	K1:PEH-ACC_PSL_PERI_PSL2_X	S170722 ; K1ST1AR 86496	4.25e-05	QFilterBank	Q01SP	
07	K1:PEH-ACC_PSL_PORTABLE_1	S170722 ; K1ST1AR 86496	0.00e+00	QFilterBank	Q01SP	
08	K1:PEH-ACC_PSL_PORTABLE_2	S170722 ; K1ST1AR 86496	0.00e+00	QFilterBank	Q01SP	
09	K1:PEH-MIC_PSL_TABLE_PSL1_Z	SRK Microphone S308012	1.37e-04	QFilterBank	Q01SP	
10	K1:PEH-MIC_PSL_TABLE_PSL2_Z	SRK Microphone S308014	9.05e-04	QFilterBank	Q01SP	
11	K1:PEH-MIC_PSL_TABLE_PSL3_Z	SRK Microphone S308876	4.76e-04	QFilterBank	Q01SP	
12	K1:PEH-PORTABLE_PSL_BOOTH_PSL_BNC12		0.00e+00	QFilterBank	Q01SP	
13	K1:PEH-ACC_MCF_TABLE_1MCFREFL_Z	S100136 ; TEAC710	6.26e-04	QFilterBank	Q01SP	
14	K1:PEH-MIC_MCF_TABLE_1MCFREFL_Z	S201195 ; AC0 4150N	6.03e-01	QFilterBank	Q01SP	
15	K1:PEH-MIC_MCF_BOOTH_1MCFREFL_Z	S211320 ; AC0 4150N	8.11e-01	QFilterBank	Q01SP	
16	K1:PEH-PORTABLE_MCF_BOOTH_1MCFREFL_BNC4		0.00e+00	QFilterBank	Q01SP	
17	K1:PEH-ACC_MCE_TABLE_1MCTRANS_Z	S180920 ; TEAC710	0.077e-04	QFilterBank	Q01SP	
18	K1:PEH-MIC_MCE_TABLE_1MCTRANS_Z	S201197 ; AC0 4150N	5.76e-02	QFilterBank	Q01SP	
19	K1:PEH-PORTABLE_MCE_BOOTH_1MCTRANS_BNC3		0.00e+00	QFilterBank	Q01SP	
20	K1:PEH-PORTABLE_MCE_BOOTH_1MCTRANS_BNC4		0.00e+00	QFilterBank	Q01SP	
21	K1:PEH-ACC_FR_TABLE_REFL_Z	S180920 ; TEAC710	9.78e-04	QFilterBank	Q01SP	
22	K1:PEH-MIC_FR_TABLE_REFL_Z	S180926 ; AC07146/4150	9.46e-03	QFilterBank	Q01SP	
23	K1:PEH-MIC_FR_BOOTH_REFL_Z	S201195 ; AC0 4150N	1.57e-01	QFilterBank	Q01SP	
24	K1:PEH-PORTABLE_FR_BOOTH_REFL_BNC4	S211347 ; TEAC710	1.04e-01	QFilterBank	Q01SP	
25	K1:PEH-ACC_FR_TABLE_ISS_Z	ISS AMP	0.00e+00	QFilterBank	Q01SP	
26	K1:PEH-MIC_FR_TABLE_ISS_Z	ISS AMP	0.00e+00	QFilterBank	Q01SP	
27	K1:PEH-PORTABLE_FR_BOOTH_FRM_BNC3	TEAC710 S211344	0.00e+00	QFilterBank	Q01SP	
28	K1:PEH-PORTABLE_FR_BOOTH_FRM_BNC4	TEAC710 S211343	0.00e+00	QFilterBank	Q01SP	
29	K1:PEH-SEIS_MCF_DND_X	QController				
30	K1:PEH-SEIS_MCF_DND_Y	QController				
31	K1:PEH-SEIS_MCF_DND_Z	QController				

MCFO ADC0

ID	Component	Value	Unit	Filter	Bank	ADCP
01	K1:PEH-PORTABLE_IYC_RACK_IYO_ABC0_DS01		0.00e+00	QFilterBank	Q01SP	
02	K1:PEH-PORTABLE_IYC_RACK_IYO_ABC0_DS02		0.00e+00	QFilterBank	Q01SP	
03	K1:PEH-PORTABLE_IYC_RACK_IYO_ABC0_DS03		0.00e+00	QFilterBank	Q01SP	
04	K1:PEH-PORTABLE_IYC_RACK_IYO_ABC0_DS04		0.00e+00	QFilterBank	Q01SP	
05	K1:PEH-PORTABLE_IYC_RACK_IYO_ABC0_DS05		0.00e+00	QFilterBank	Q01SP	
06	K1:PEH-PORTABLE_IYC_RACK_IYO_ABC0_DS06		0.00e+00	QFilterBank	Q01SP	
07	K1:PEH-PORTABLE_IYC_RACK_IYO_ABC0_DS07		0.00e+00	QFilterBank	Q01SP	
08	K1:PEH-PORTABLE_IYC_RACK_IYO_ABC0_DS08		0.00e+00	QFilterBank	Q01SP	
09	K1:PEH-ACC_BS_TABLE_POP_Z	S211346 ; TEAC710	1.70e-01	QFilterBank	Q01SP	
10	K1:PEH-MIC_BS_TABLE_POP_Z	S200917 ; AC04150N	1.97e-01	QFilterBank	Q01SP	
11	K1:PEH-PORTABLE_BS_BOOTH_POP_BNC3	Being by RFP group	2.90e+00	QFilterBank	Q01SP	
12	K1:PEH-PORTABLE_BS_BOOTH_POP_BNC4	Being by RFP group	2.97e+00	QFilterBank	Q01SP	
13	K1:PEH-ACC_BS_TABLE_POS_Z	S211347 ; TEAC710	3.48e-01	QFilterBank	Q01SP	
14	K1:PEH-MIC_BS_TABLE_POS_Z	S200916 ; AC07146/4150	2.72e-01	QFilterBank	Q01SP	
15	K1:PEH-PORTABLE_BS_BOOTH_POS_BNC3		5.01e-01	QFilterBank	Q01SP	
16	K1:PEH-PORTABLE_BS_BOOTH_POS_BNC4		5.94e-01	QFilterBank	Q01SP	
17	K1:PEH-MIC_BS_FIELD_BS_Z	S131028 ; AC0 4150N	6.067e-01	QFilterBank	Q01SP	
18	K1:PEH-MIC_BS_BOOTH_BS_Z	S200029 ; AC04150N	2.935e-01	QFilterBank	Q01SP	
19	K1:PEH-PORTABLE_BS_BOOTH_BS_BNC3		0.00e+00	QFilterBank	Q01SP	
20	K1:PEH-PORTABLE_BS_BOOTH_BS_BNC4		0.00e+00	QFilterBank	Q01SP	
21	K1:PEH-MIC_SR_BOOTH_SR_Z	S211348 ; TEAC710	2.589e-01	QFilterBank	Q01SP	
22	K1:PEH-PORTABLE_SR_BOOTH_SR_BNC2		0.00e+00	QFilterBank	Q01SP	
23	K1:PEH-PORTABLE_SR_BOOTH_SR_BNC3		0.00e+00	QFilterBank	Q01SP	
24	K1:PEH-PORTABLE_SR_BOOTH_SR_BNC4		0.00e+00	QFilterBank	Q01SP	
25	K1:PEH-ACC_OHC_TABLE_AG_Z	S211349 ; TEAC710	4.07e-01	QFilterBank	Q01SP	
26	K1:PEH-MIC_OHC_TABLE_AG_Z	S201198 ; AC04150N	6.784e-01	QFilterBank	Q01SP	
27	K1:PEH-MIC_OHC_BOOTH_OHC_Z	S211398 ; AC04150N	7.905e-01	QFilterBank	Q01SP	
28	K1:PEH-PORTABLE_OHC_BOOTH_OHC_BNC4		0.00e+00	QFilterBank	Q01SP	
29	K1:PEH-MHG_IYO_PORTABLE_X		0.00e+00	QFilterBank	Q01SP	
30	K1:PEH-MHG_IYO_PORTABLE_Y		0.00e+00	QFilterBank	Q01SP	
31	K1:PEH-MHG_IYO_PORTABLE_Z		0.00e+00	QFilterBank	Q01SP	

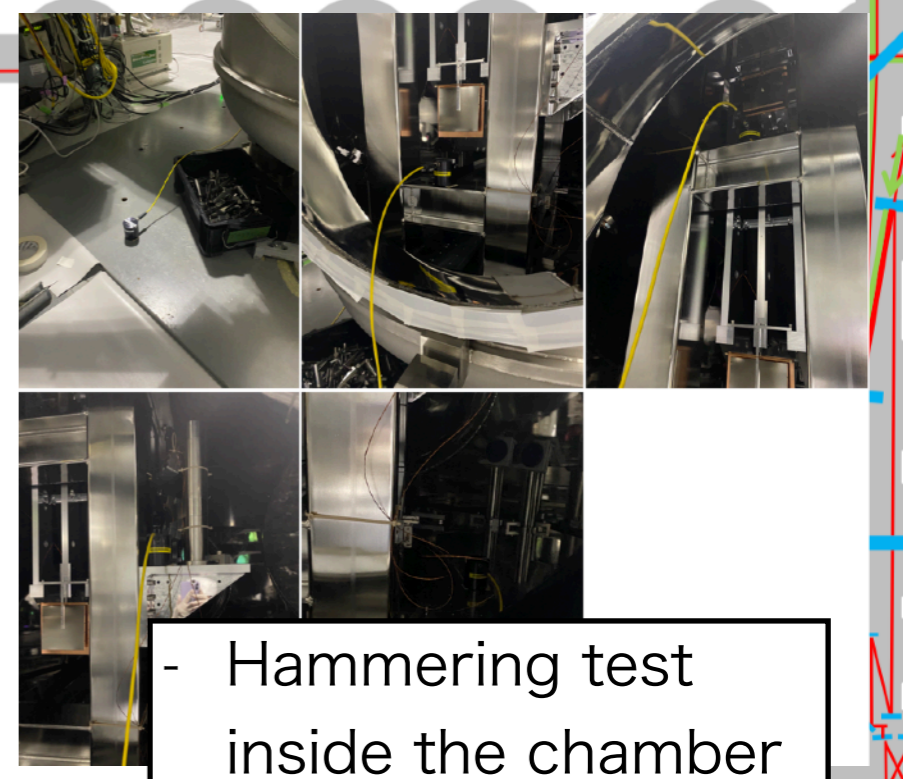
IYO ADC0



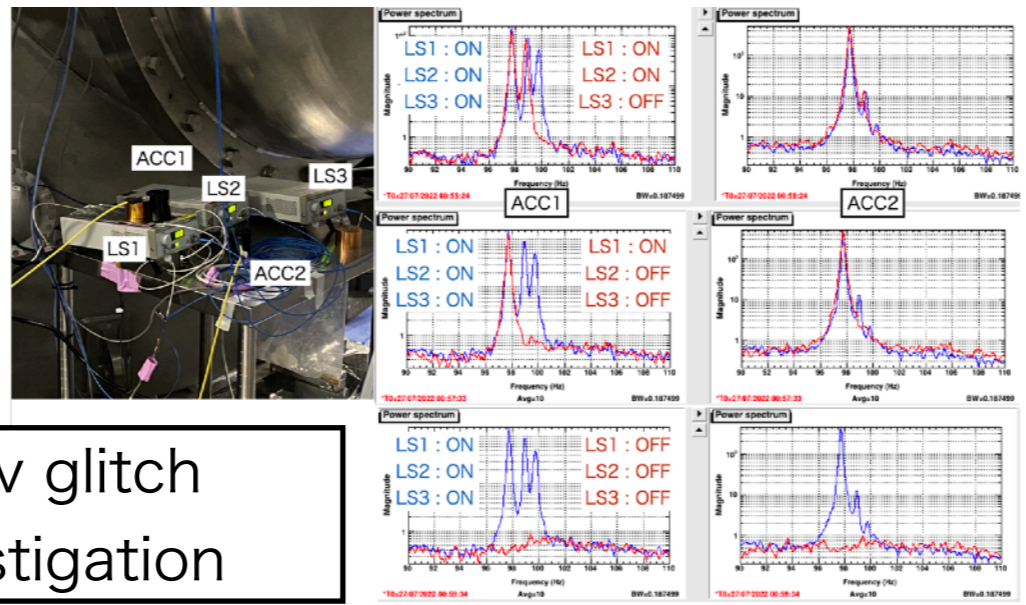


# Portable PEM work

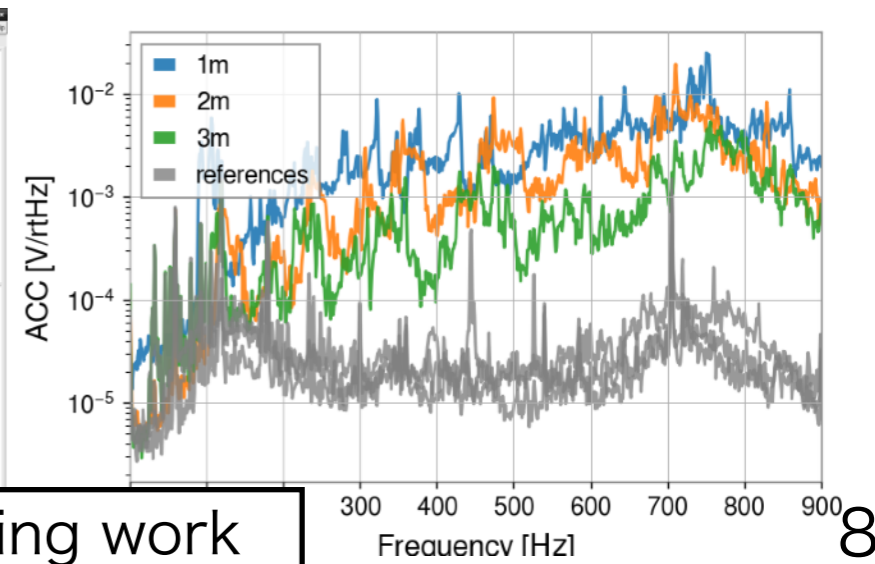
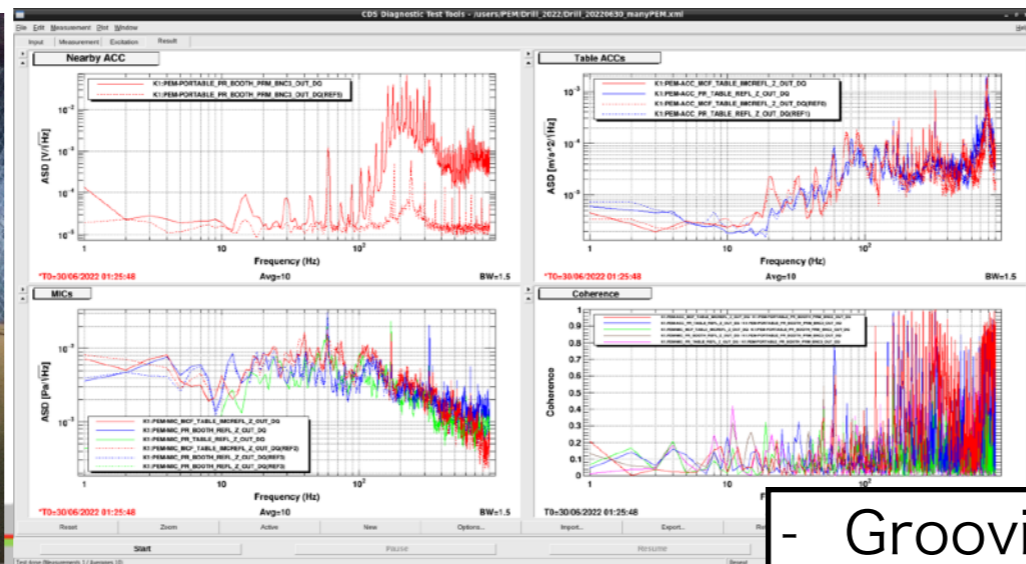
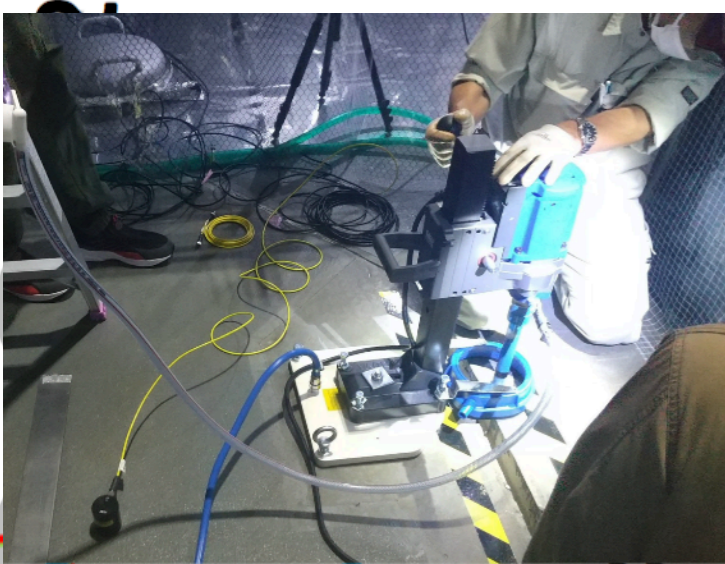
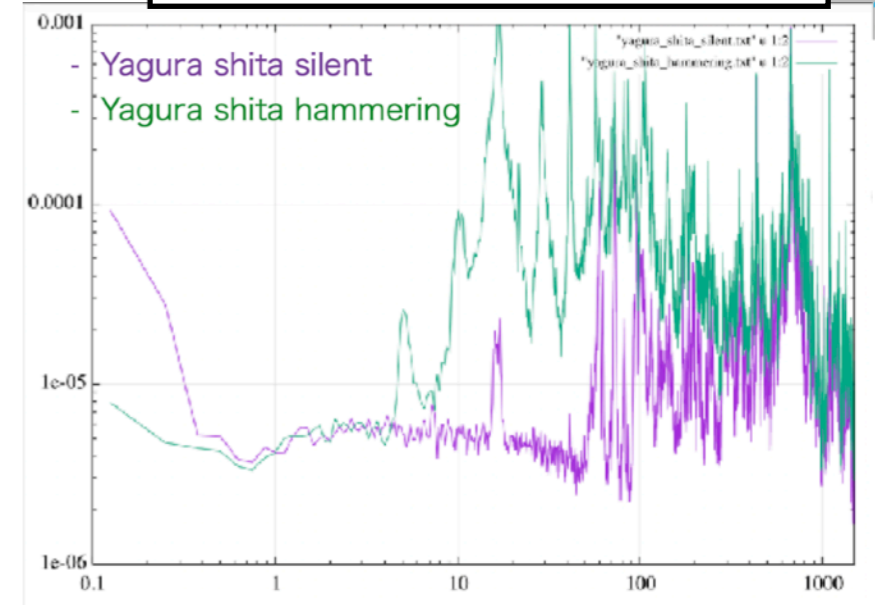
- Many environmental evaluation work were done
  - **Easy setting** the portable PEMs (ACC, MIC, ...)
  - Checking the vibration from the **grooving work**
    - Judge this work is safe to interferometer or not
  - **Eigen frequency** check before closing the chamber
    - Photon calibration, Yagura, optical table, ...



- Hammering test inside the chamber



- Oplev glitch investigation



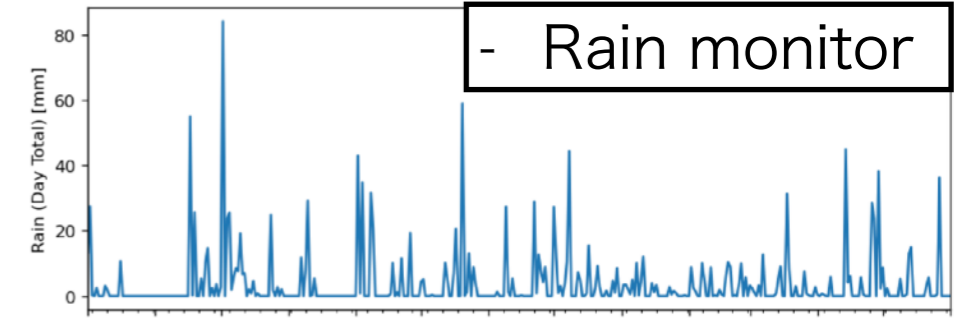
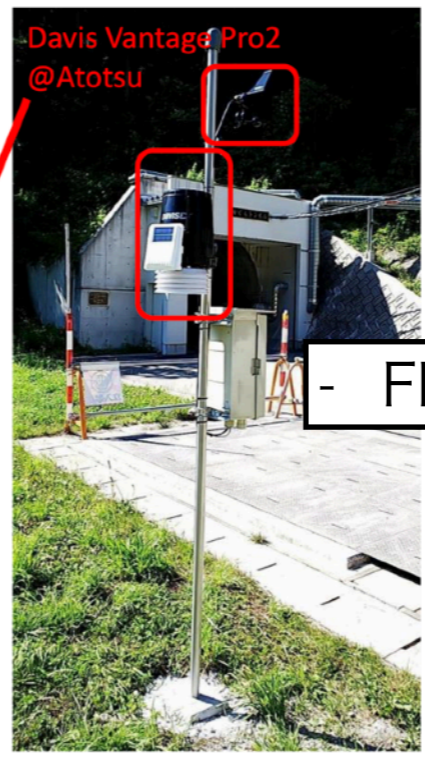
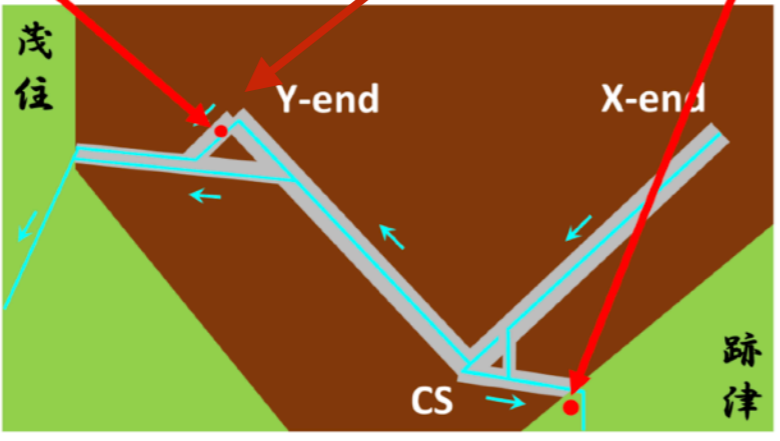
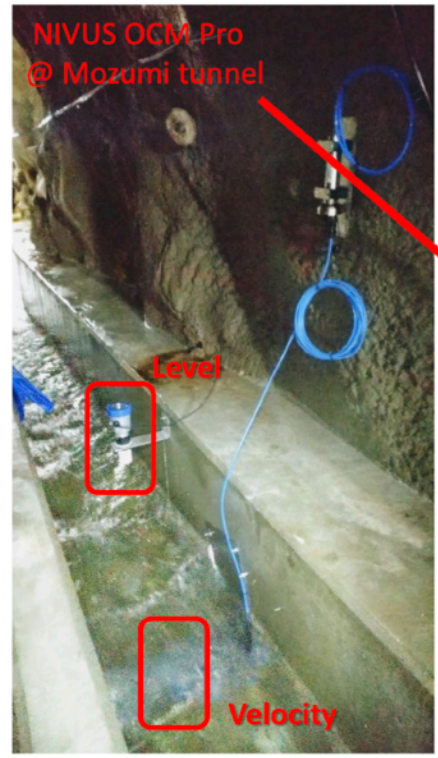
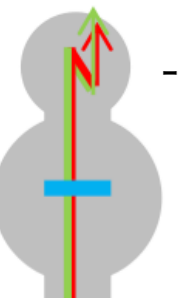
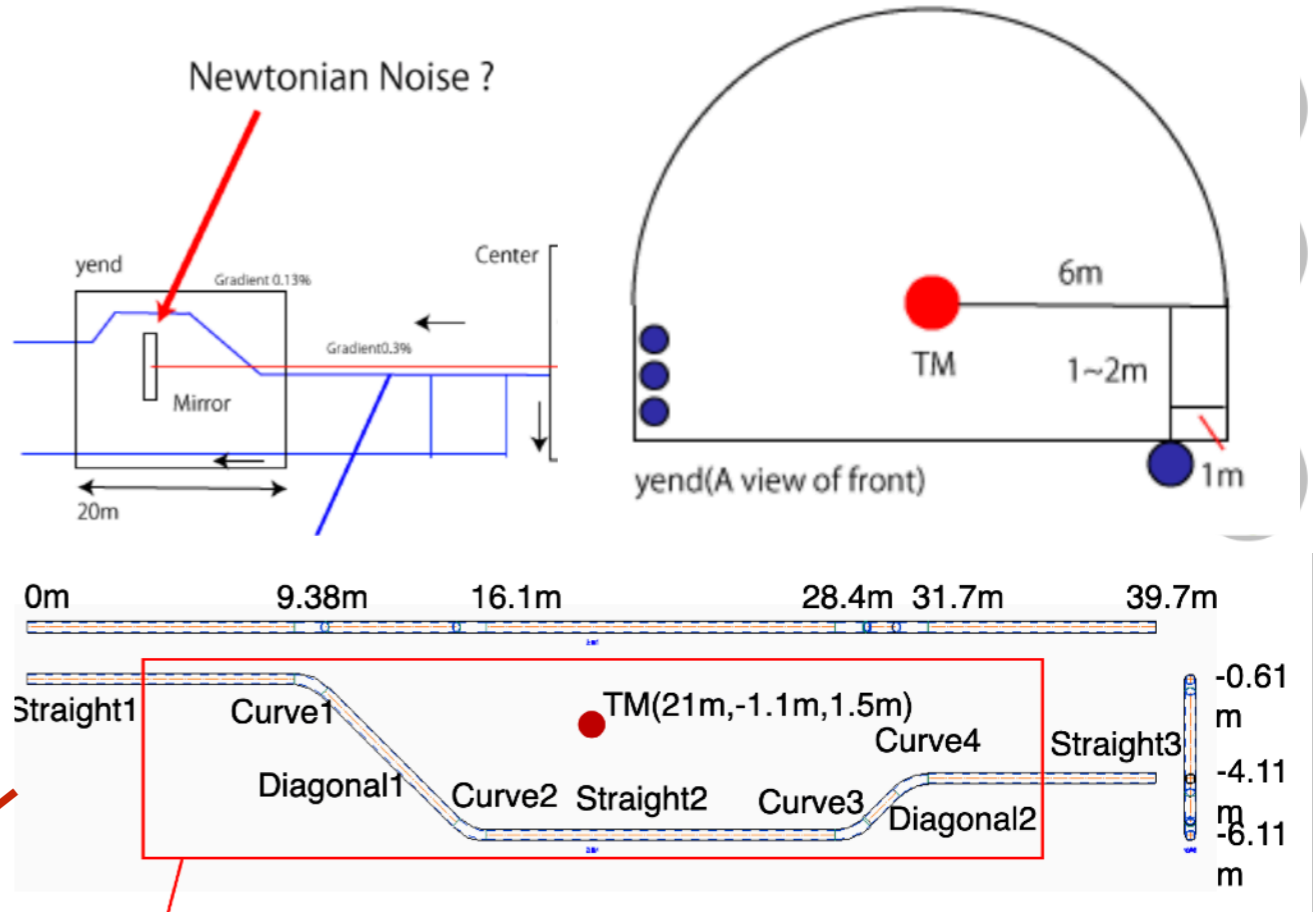
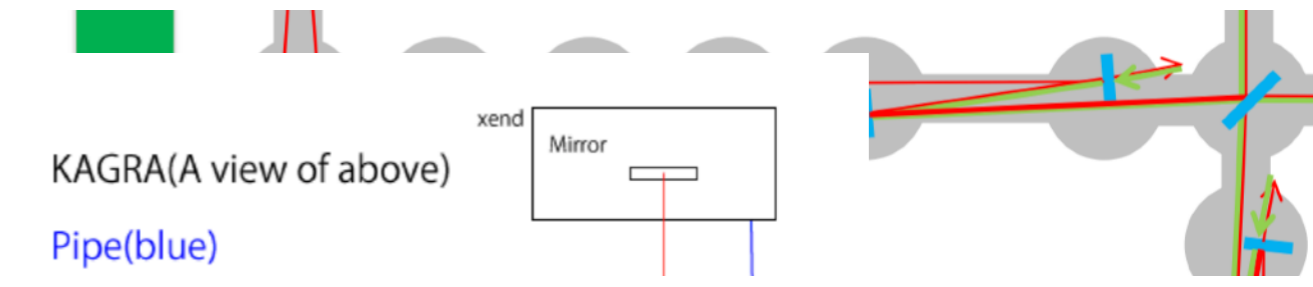
- Grooving work



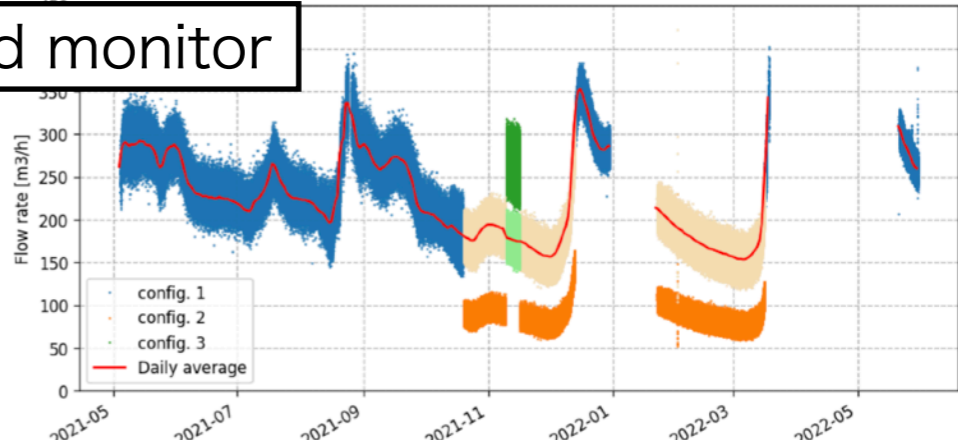


# Water fluid and NN noise

- **Water fluid monitor** at the Yend
  - Checked the relationship between weather station and water fluid
  - One of the important topic to understand the underground waters
- **Newtonian noise** evaluation from water
  - Now simulation is ongoing
    - More realistic water path
  - T. Suzuki(TITECH) future



- Fluid monitor

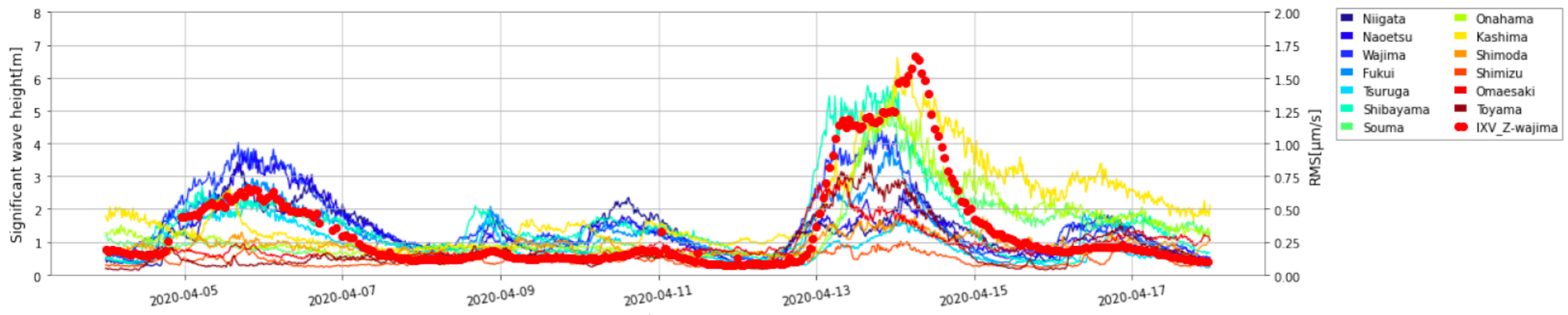
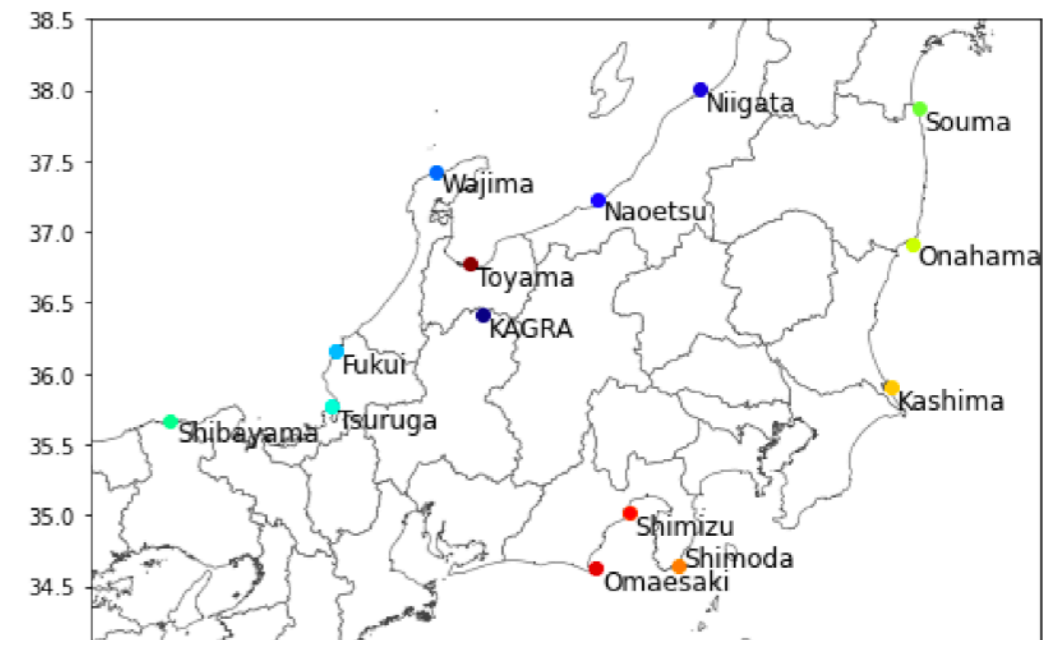
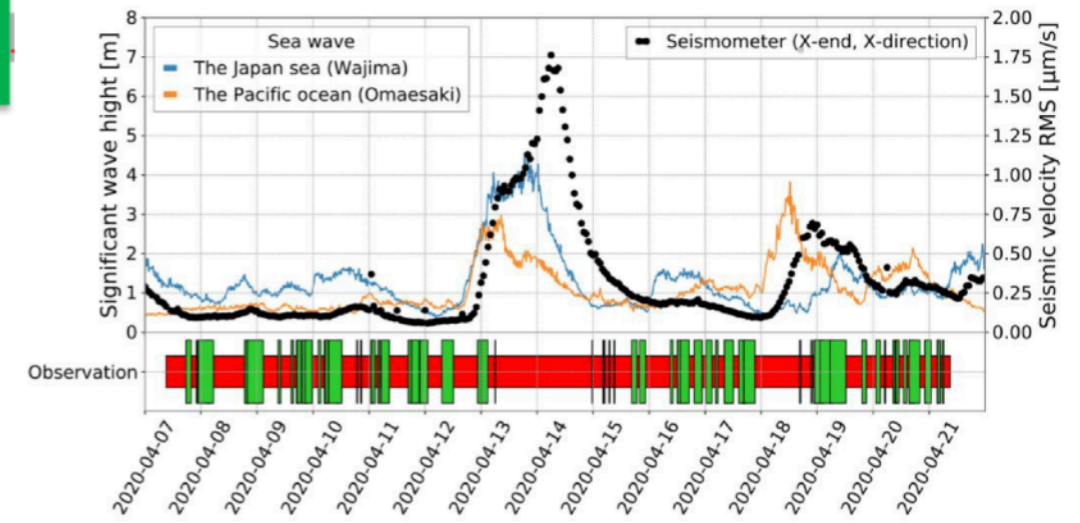






# Microseismic analysis

- Microseismic from ocean wave affect to the interferometer
  - Dead time to bKAGRA phase1, O3GK
- Investigate the relationship between KAGRA seismometers and ocean wave
- Ocean wave data is obtained from NOWPHAS for each bays
- See detail in S.Hoshino poster (m05)
  - Seasonal ocean wave change
  - Correlation coefficient
  - Principal component analysis
  - Multiple regression analysis

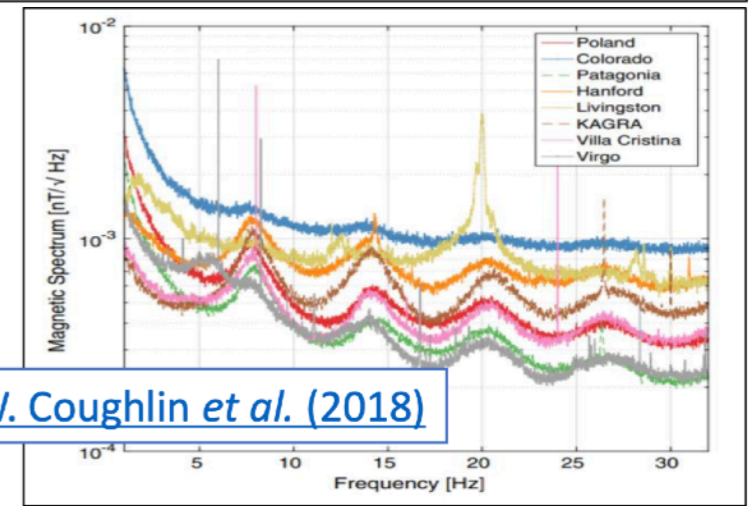
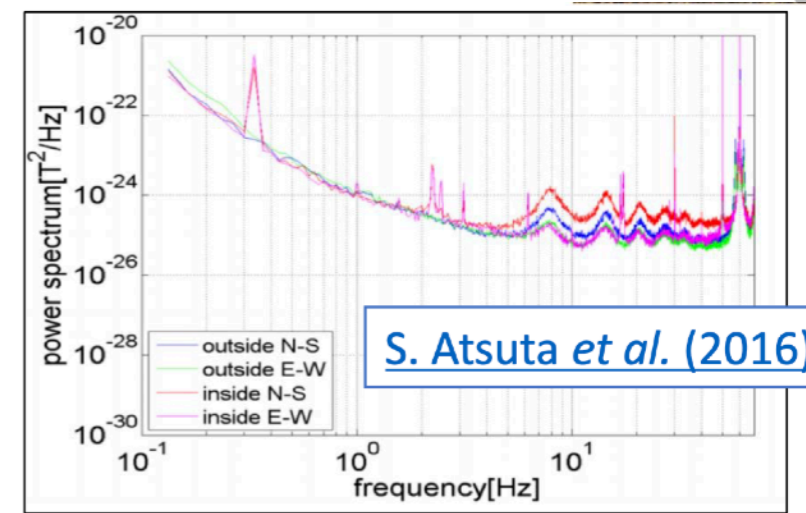
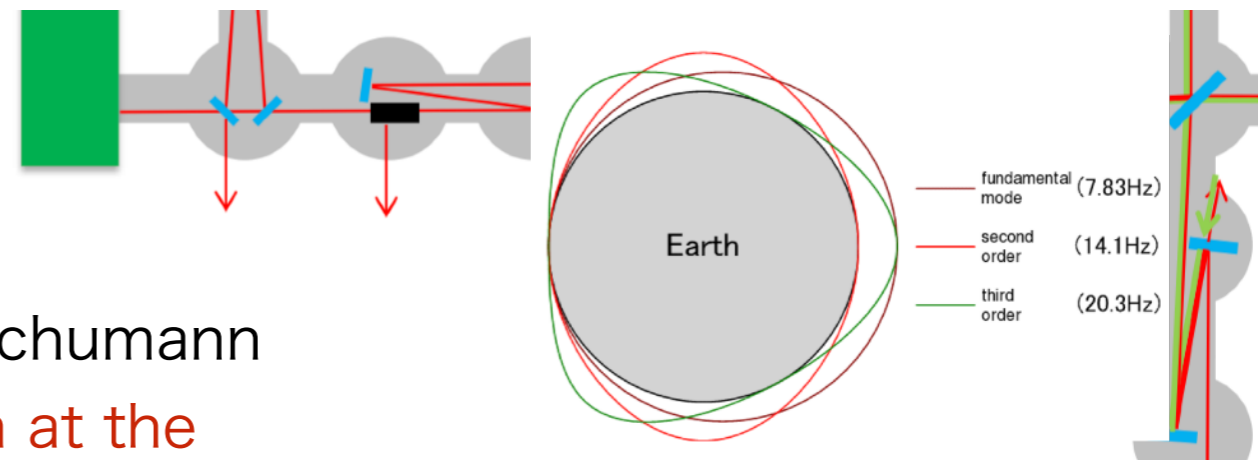


- Time series of the KAGRA seismometer(red) and ocean wave data(Color)

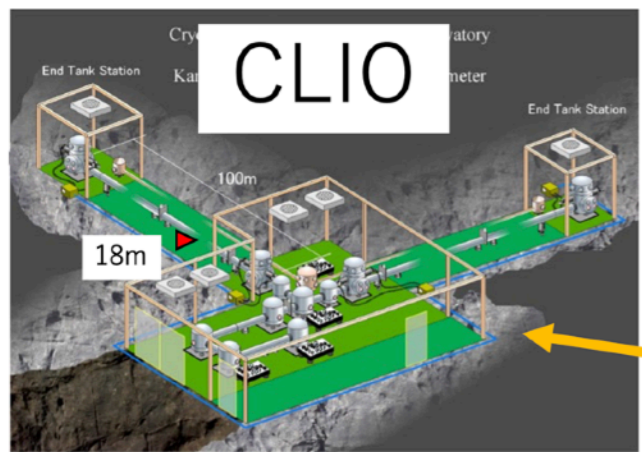


# KAGRA Schumann resonance

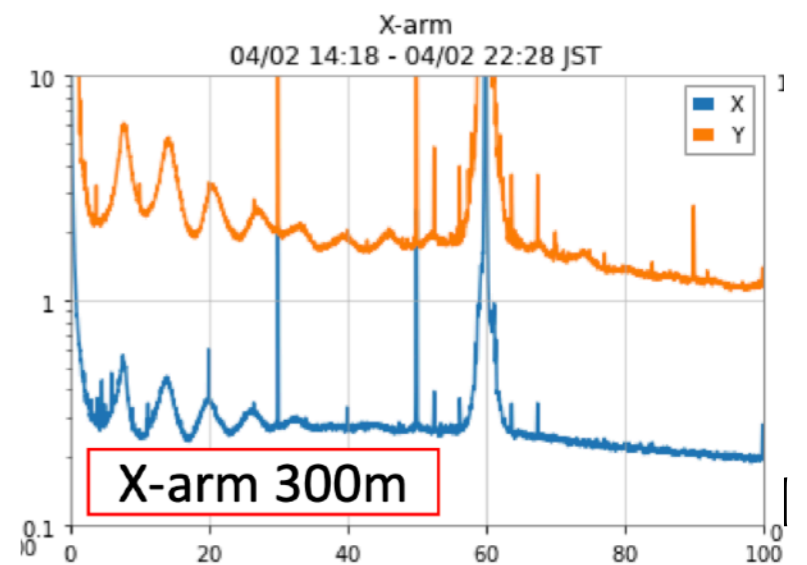
- From the previous study, the amplitude of Schumann resonance at the underground is **larger than at the surface** (Typically, 1 pT)
- Beginning of July (7/3-7/9), we measured the magnetic field, focusing near the **beam duct**
  - Y-30m, X-1500m, X-2440m, CLIO Yarm, ...
- See detail in I.Fukunaga poster (m03)
  - New portable magnetometer system
  - Distance from beam duct
  - Direction of magnetic field



## Measurement Location



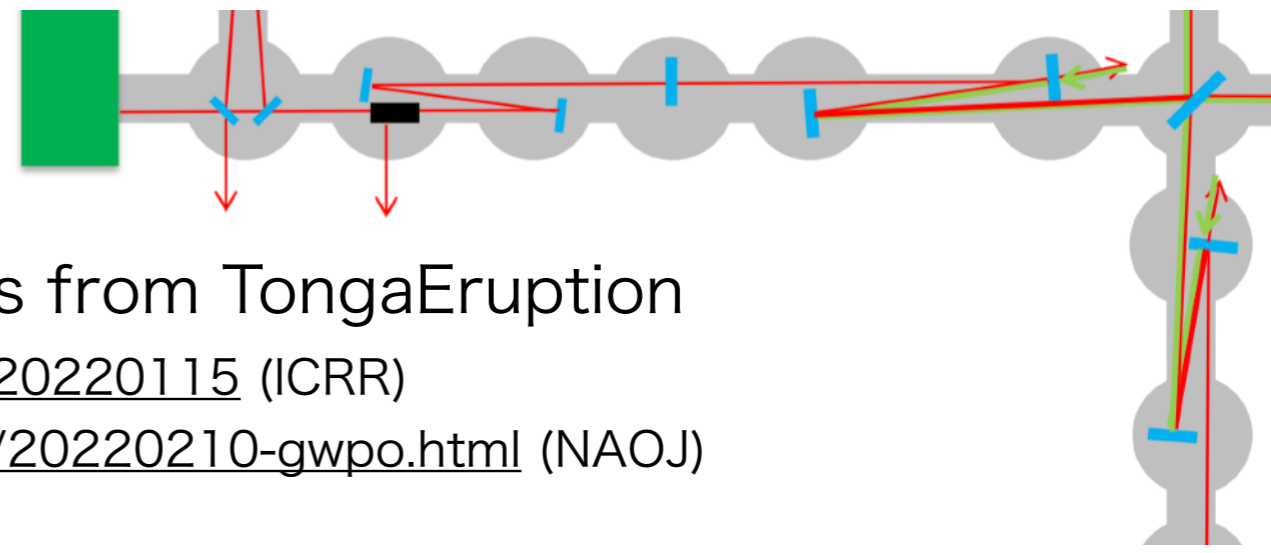
Location
PEM area
Yarm(30m)
CLIO Yarm (18 m)
KAGRA Front room
Xarm(1500 m)
Xarm(2440 m)







# Signals from Tonga Eruption



- KAGRA PEM detected several signals from TongaEruption
  - <https://gwcenter.icrr.u-tokyo.ac.jp/en/tonga-20220115> (ICRR)
  - <https://www.nao.ac.jp/en/news/topics/2022/20220210-gwpo.html> (NAOJ)

- Submitted to PTEP
  - <https://arxiv.org/abs/2206.14396>

## - Seismometers

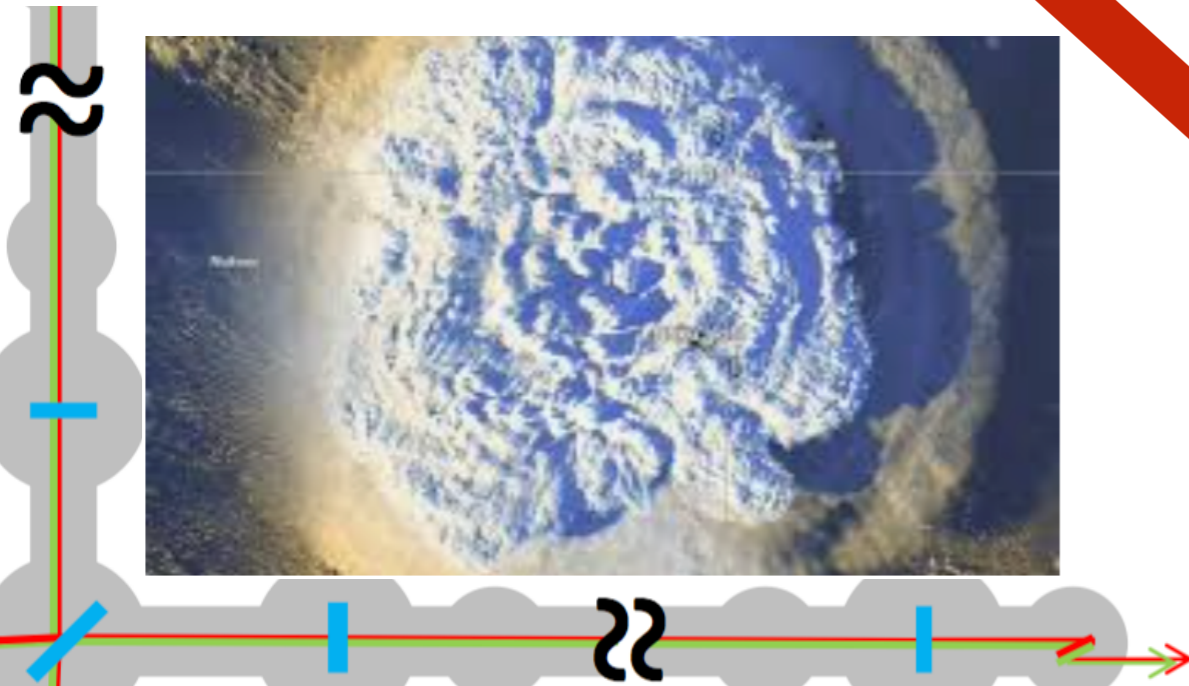
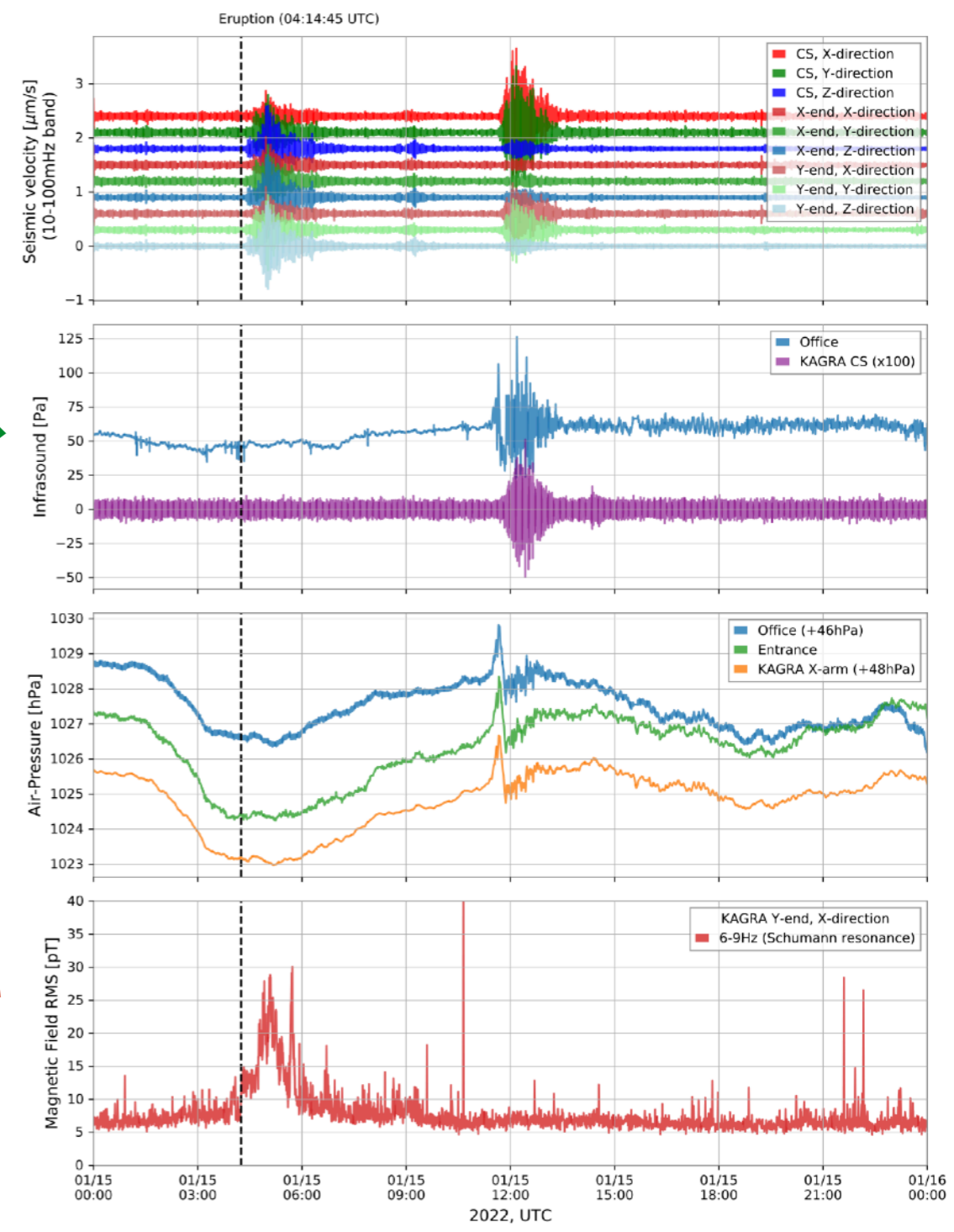
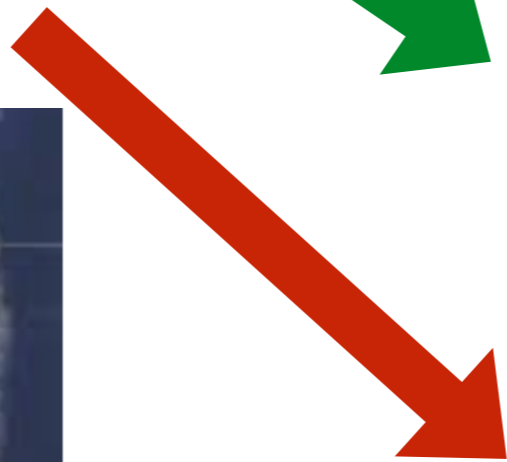
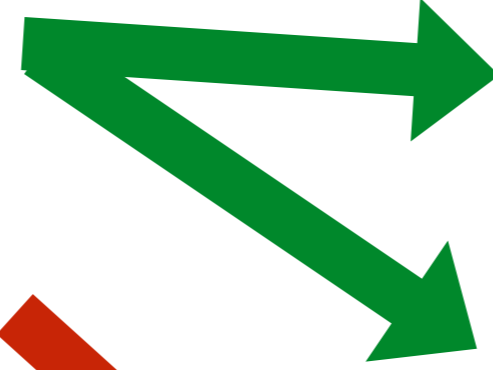
- Ground motion (p,s)
- Air pressure wave

## - Infrasond sensors, barometers

- Air pressure wave

## - Magnetometer

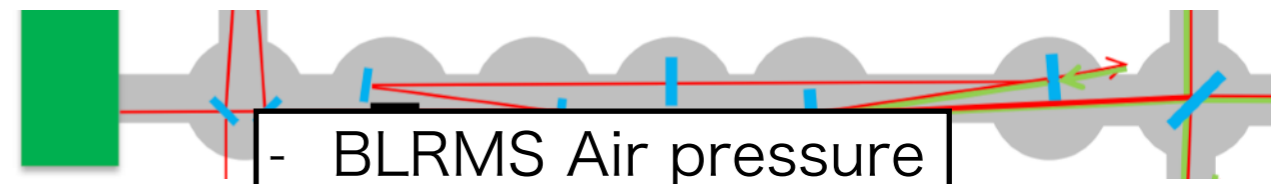
- Increasing the amplitude from Schumann resonance



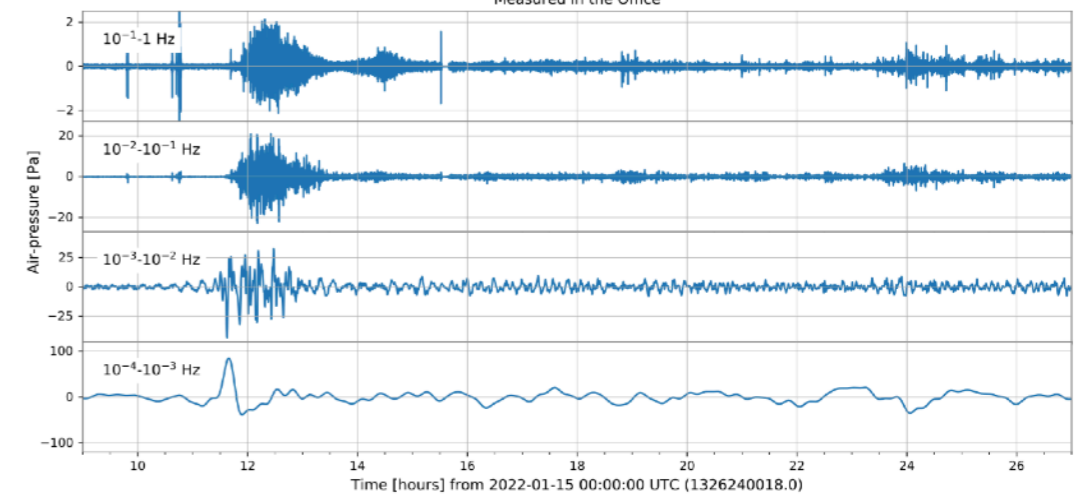


# Signals from Tonga Eruption

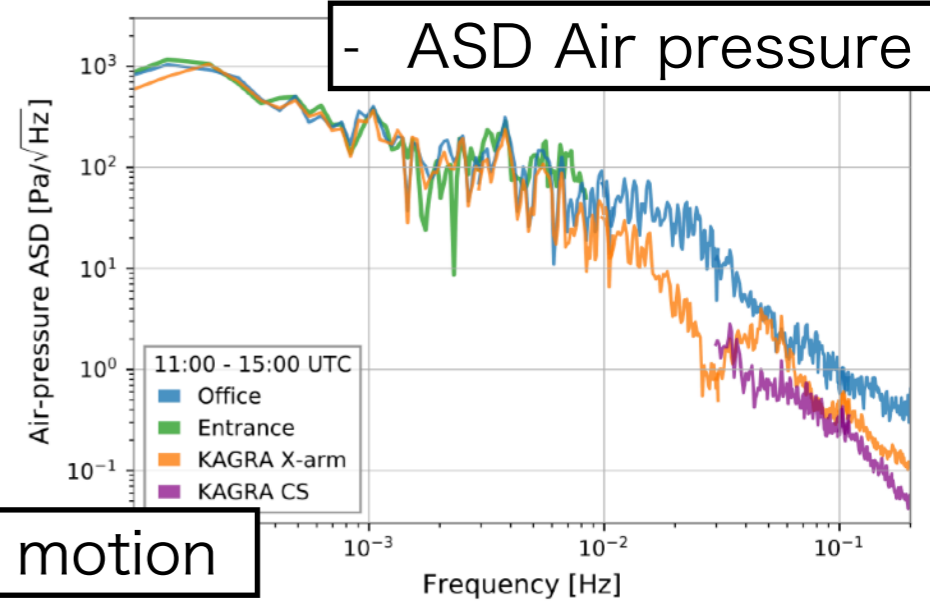
- The detail in JGW14072
  - KAGRA Internal seminar
- **Band limited RMS** (seismic motion, magnetic field)
- **Spectrum analysis**
  - With evaluating the sensor noise, calibration
- **Transfer function measurement**
  - Outside(surface) to underground
  - Velocity of the air pressure wave
  - Center area to X arm
- From this event, we started the rich environment for the infrasound and the air pressure
- See also Takamori-san talk (next talk)



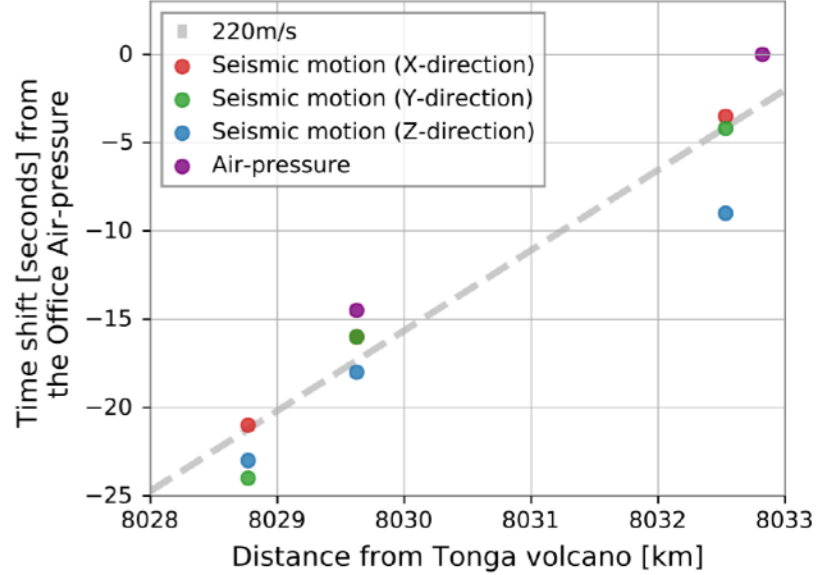
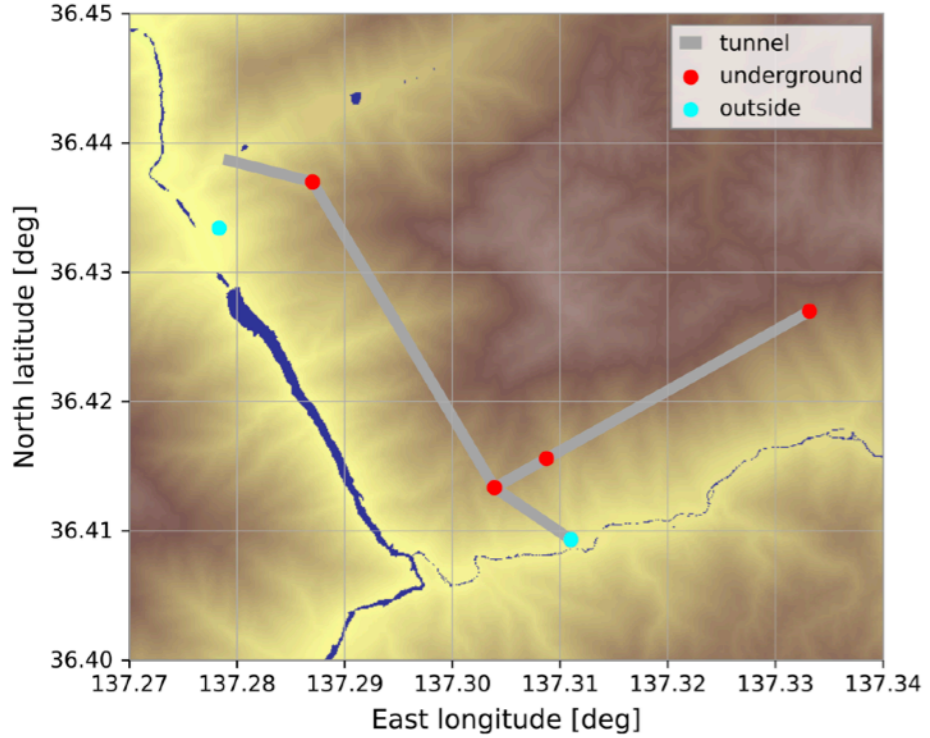
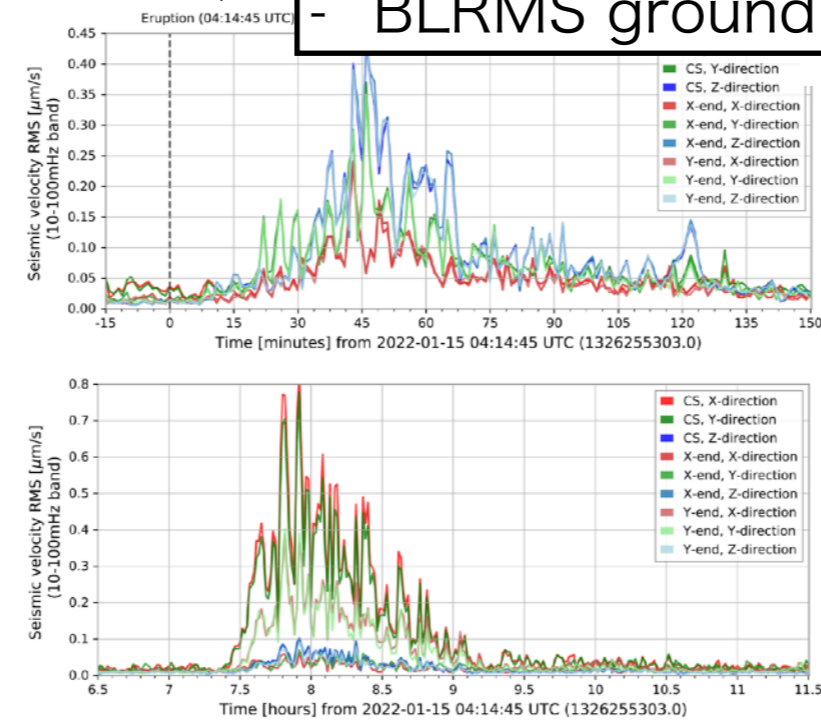
- BLRMS Air pressure



- ASD Air pressure



- BLRMS ground motion

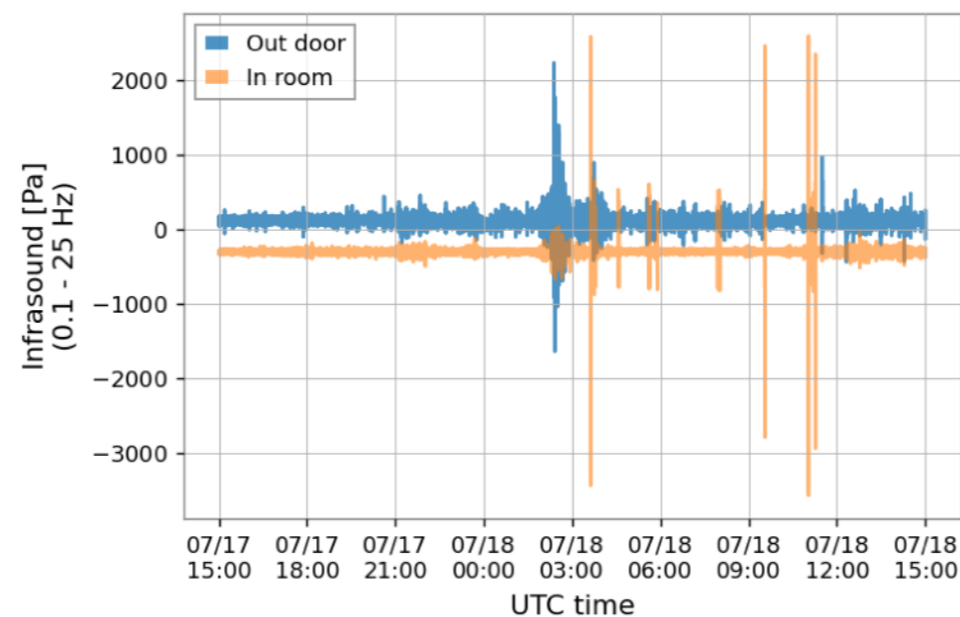
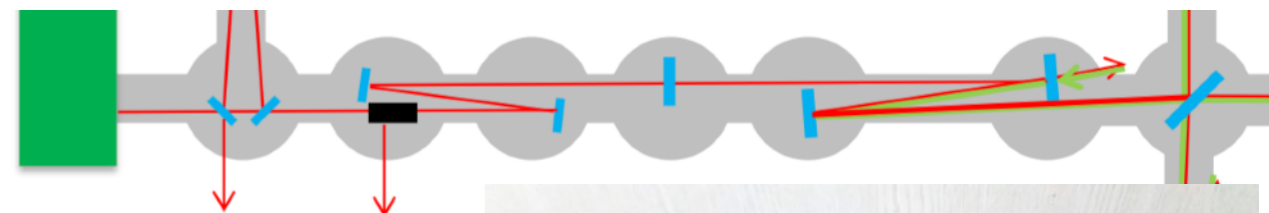


- Time shift Air pressure



# Infrasound analysis

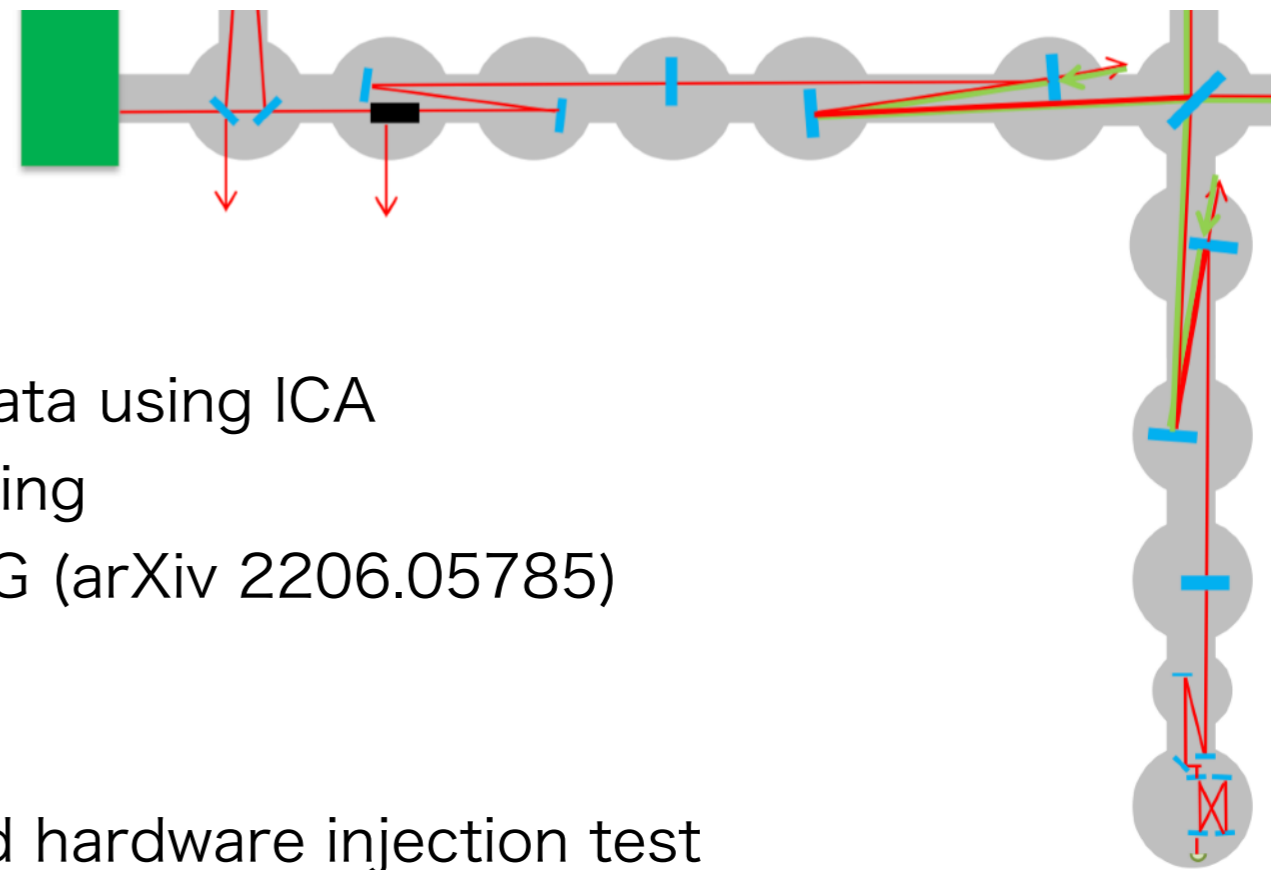
- Set the **storeroom** outside of the analysis building
  - Reducing the effect of the **human activity**
    - Talk, door open/close
    - We can detect the sound from **dam**
- Combination of the **barometer and infrasound** at the underground
  - We can cover wide frequency range for each area
- Discussion topic
  - Set the infrasound at Atotsu entrance, near the XYend
  - Data logging
  - With weather station and/or temperature monitor
  - Network KAGRA/Niigata/Toyama







# Offline noise subtraction

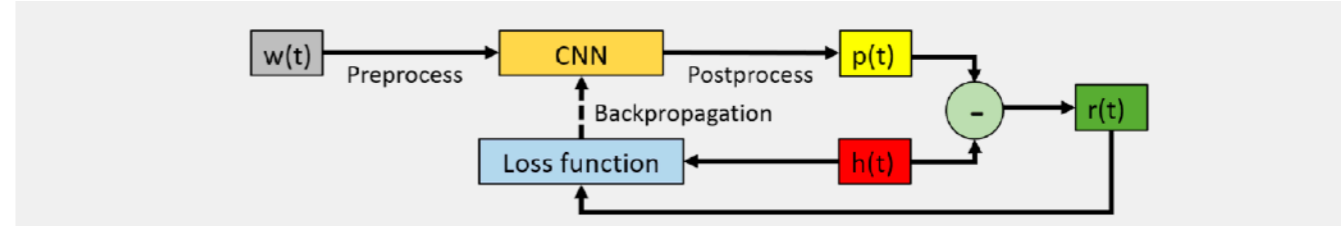
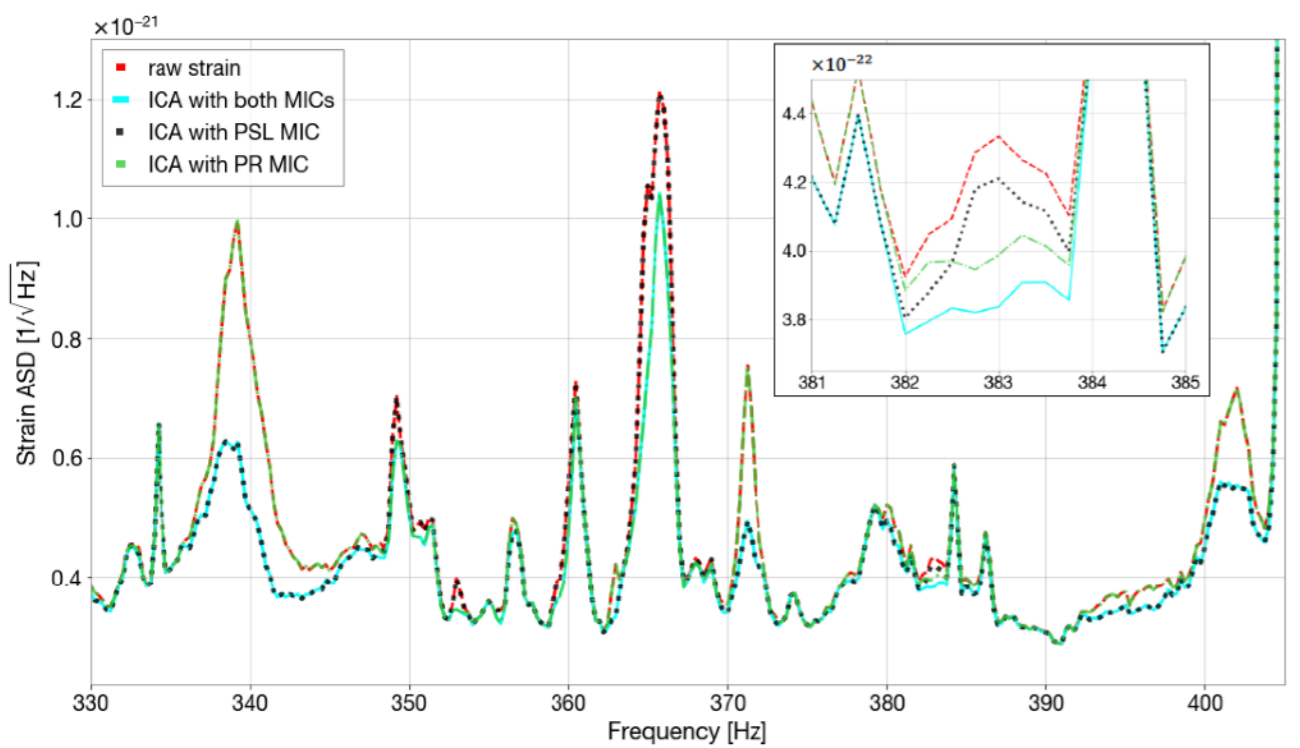
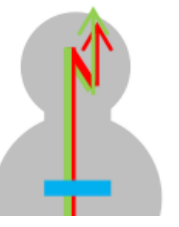


## - Independent Component Analysis (ICA)

- Noise subtraction from KAGRA O3GK data using ICA
- Already presented in previous F2F meeting
- English correction and submitted to CQG (arXiv 2206.05785)
- Non-linear noise subtraction study

## - Denoising by DeepClean

- Check the performance by software and hardware injection test
- 60 Hz noise subtraction using O3GK data
- See detail in Chia-Jui Chou in oral (Session 08 DAC)
- See detail in Yi Yang in poster (Poster s05)



- $w(t)$ : witness channels
- $p(t)$ : predicted noise
- $h(t)$ : raw strain
- $r(t)$ : cleaned strain
- Loss function:  
 $J = \omega J_{asd} + (1 - \omega) J_{mse}$

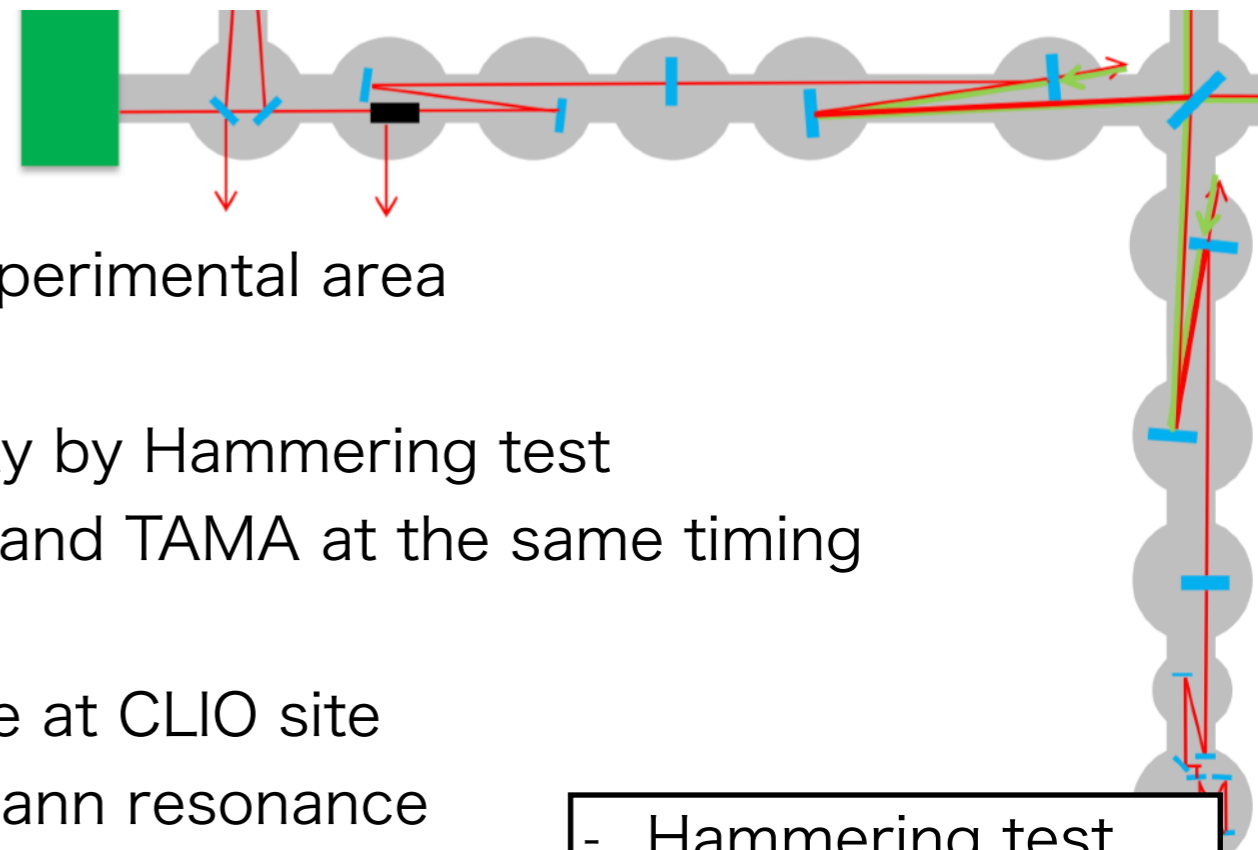
$$J_{asd} = \frac{1}{M} \sum_{i=0}^{M-1} \sqrt{\frac{S[r, r][i]}{S[h, h][i]}}$$

$$J_{mse} = \frac{1}{N} \sum_{i=0}^{N-1} r[i]^2$$



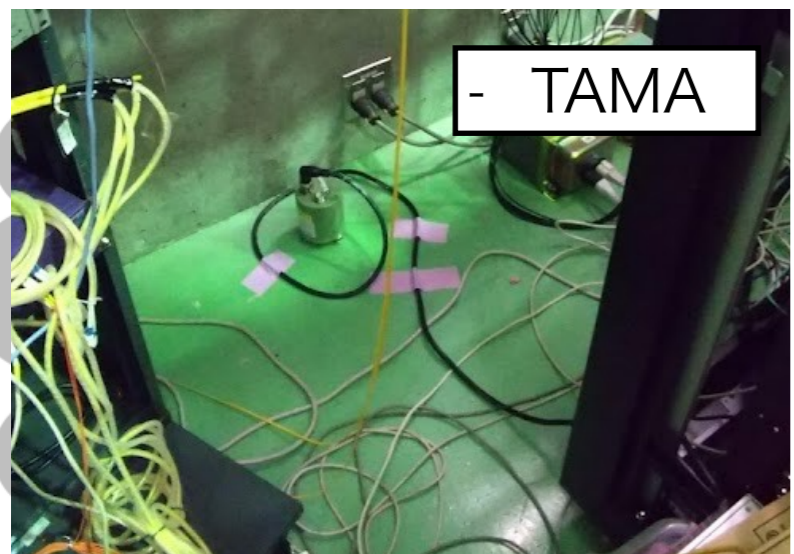


# PEM work at TAMA and CLIO

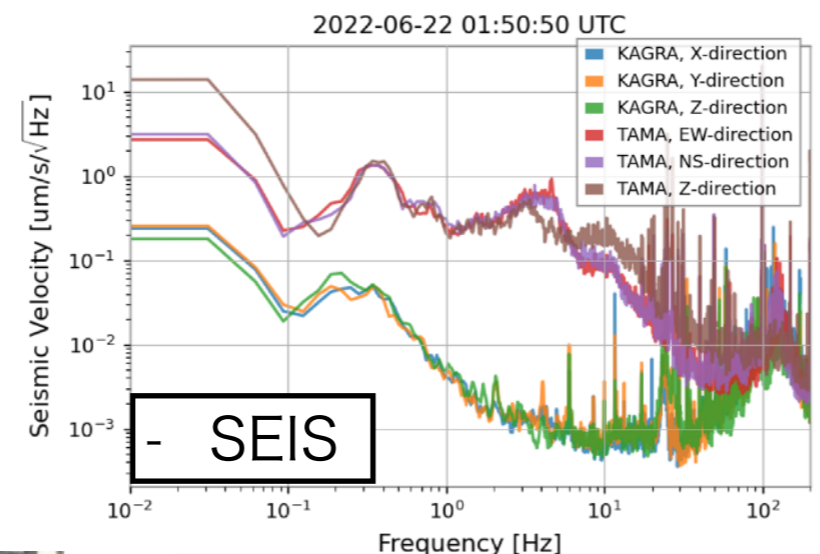


- PEM measurement outside of the KAGRA experimental area
  - TAMA
    - Search the 170 Hz noise in Filter Cavity by Hammering test
    - Seismic motion measurement KAGRA and TAMA at the same timing
  - CLIO
    - Set the accelerometer and microphone at CLIO site
      - During the measurement of Schumann resonance

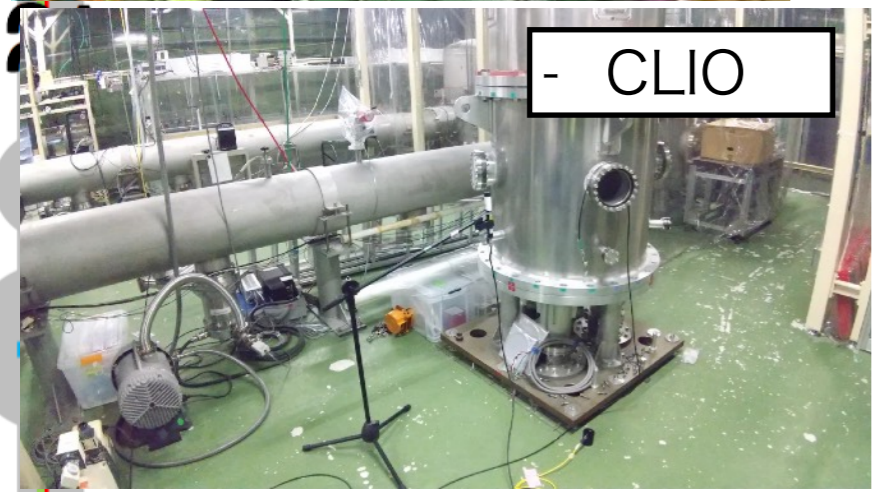
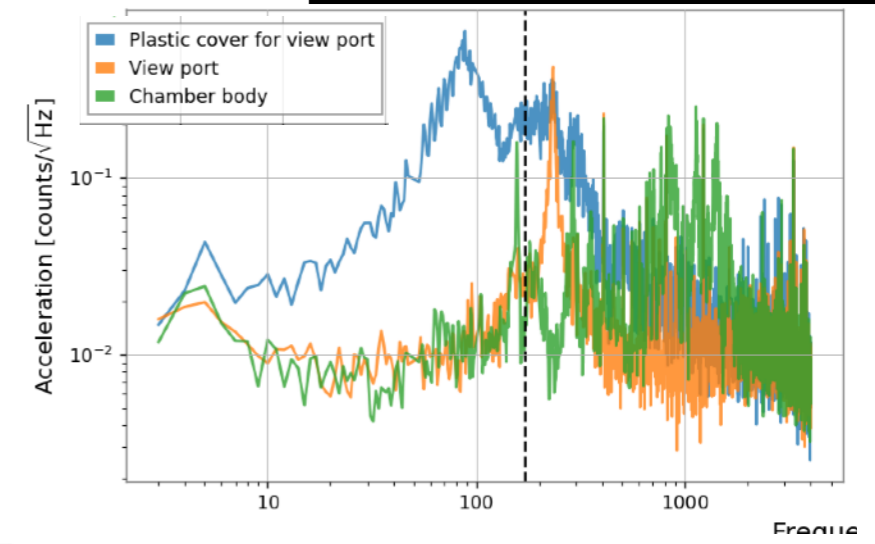
- Hammering test



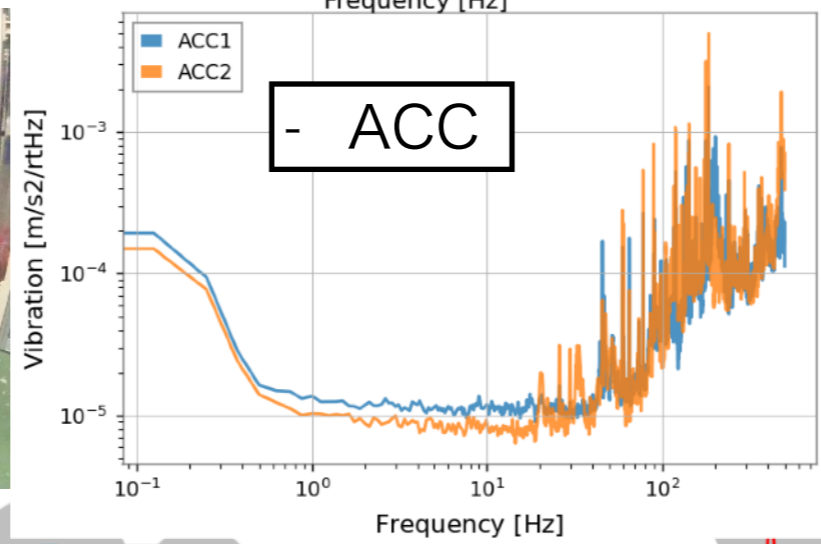
- TAMA



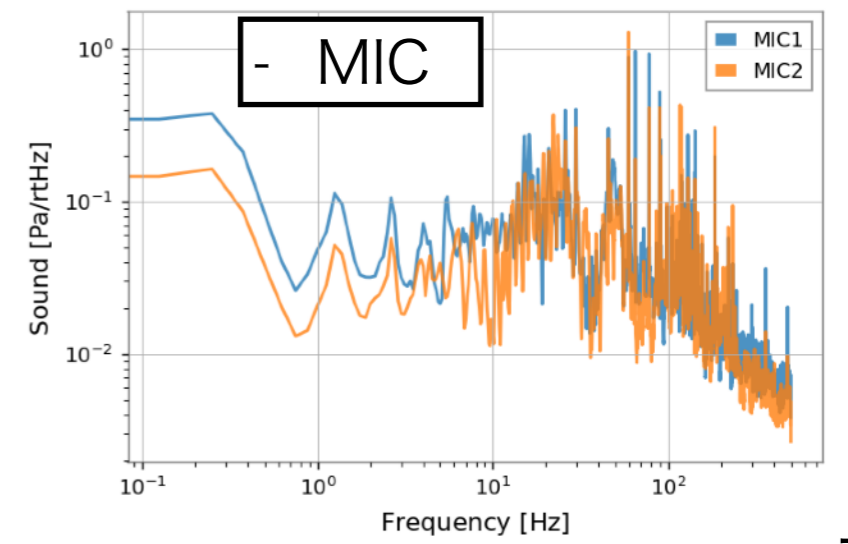
- SEIS



- CLIO



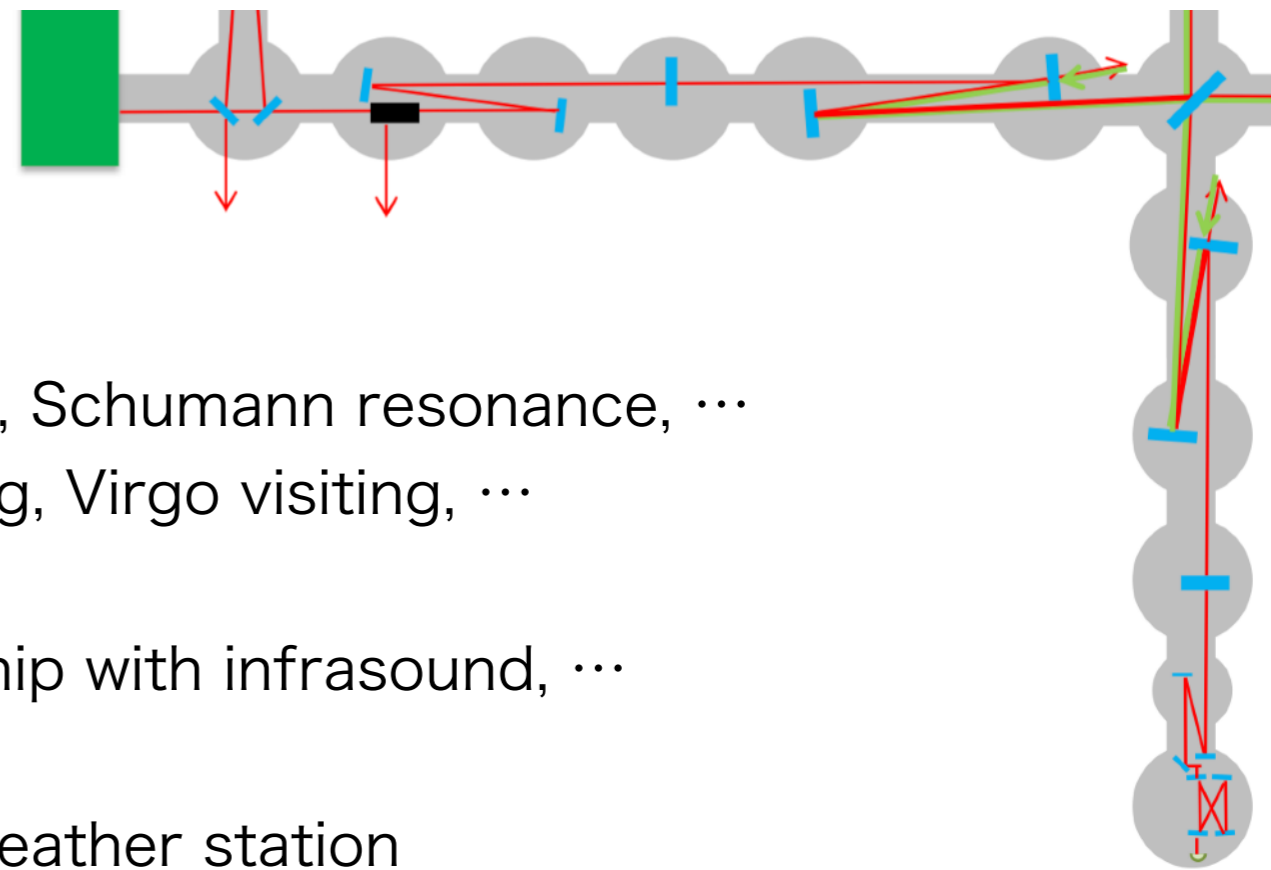
- ACC



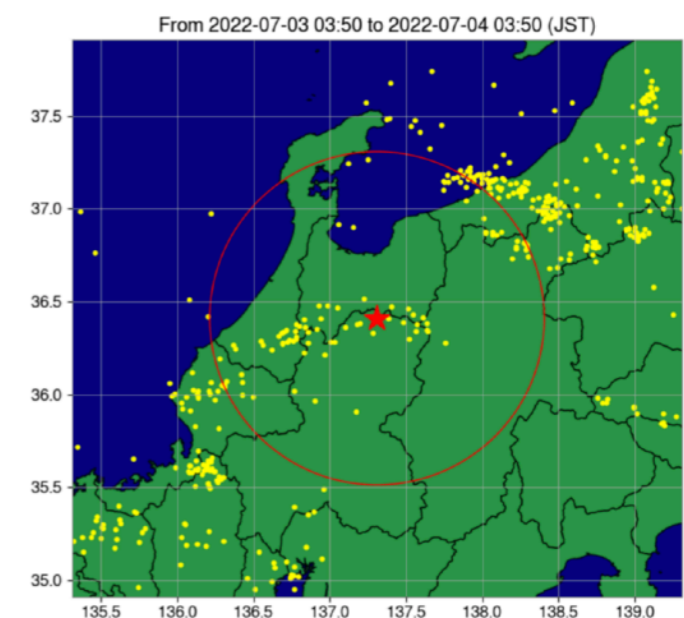
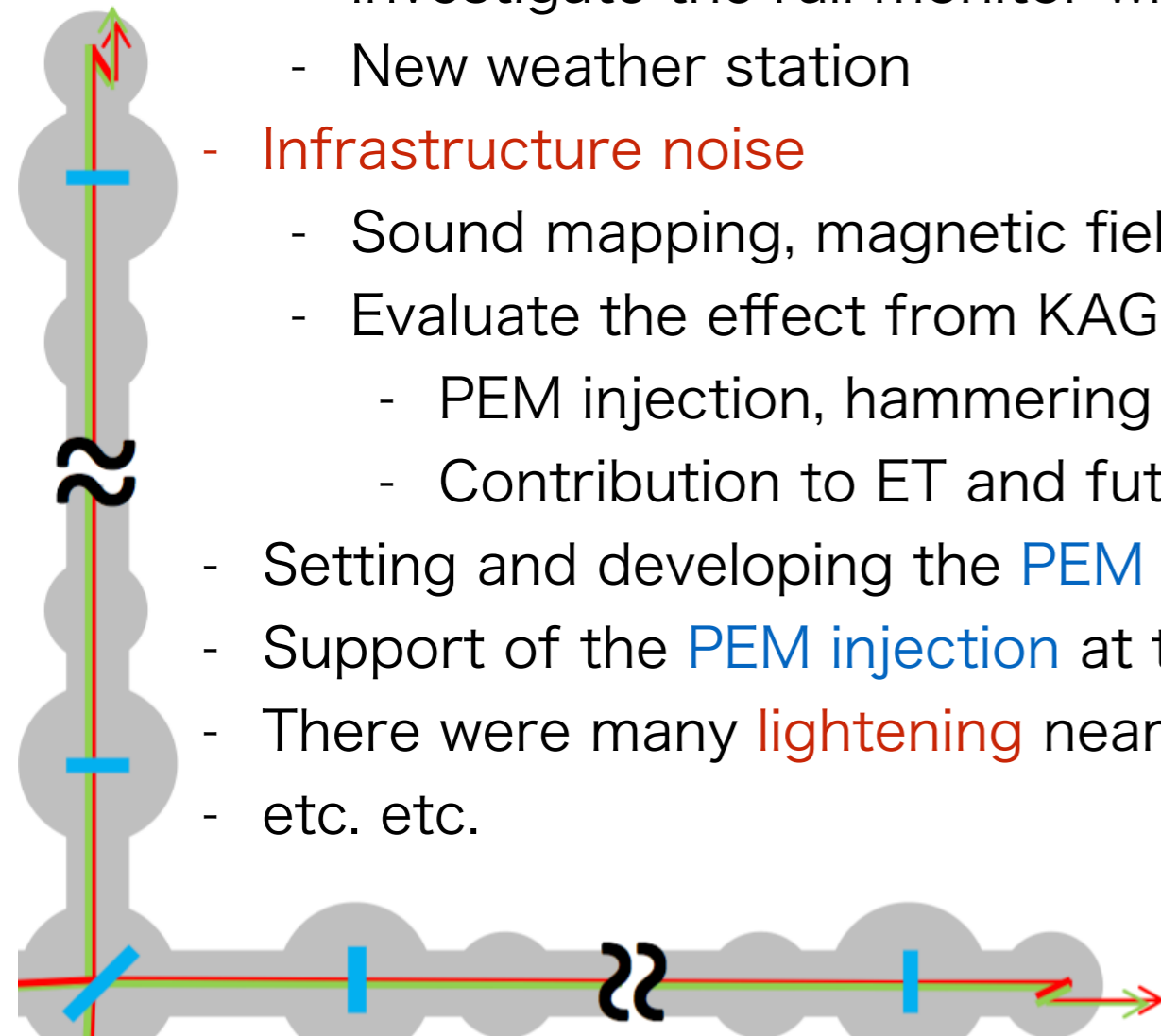
- MIC



# Future tasks



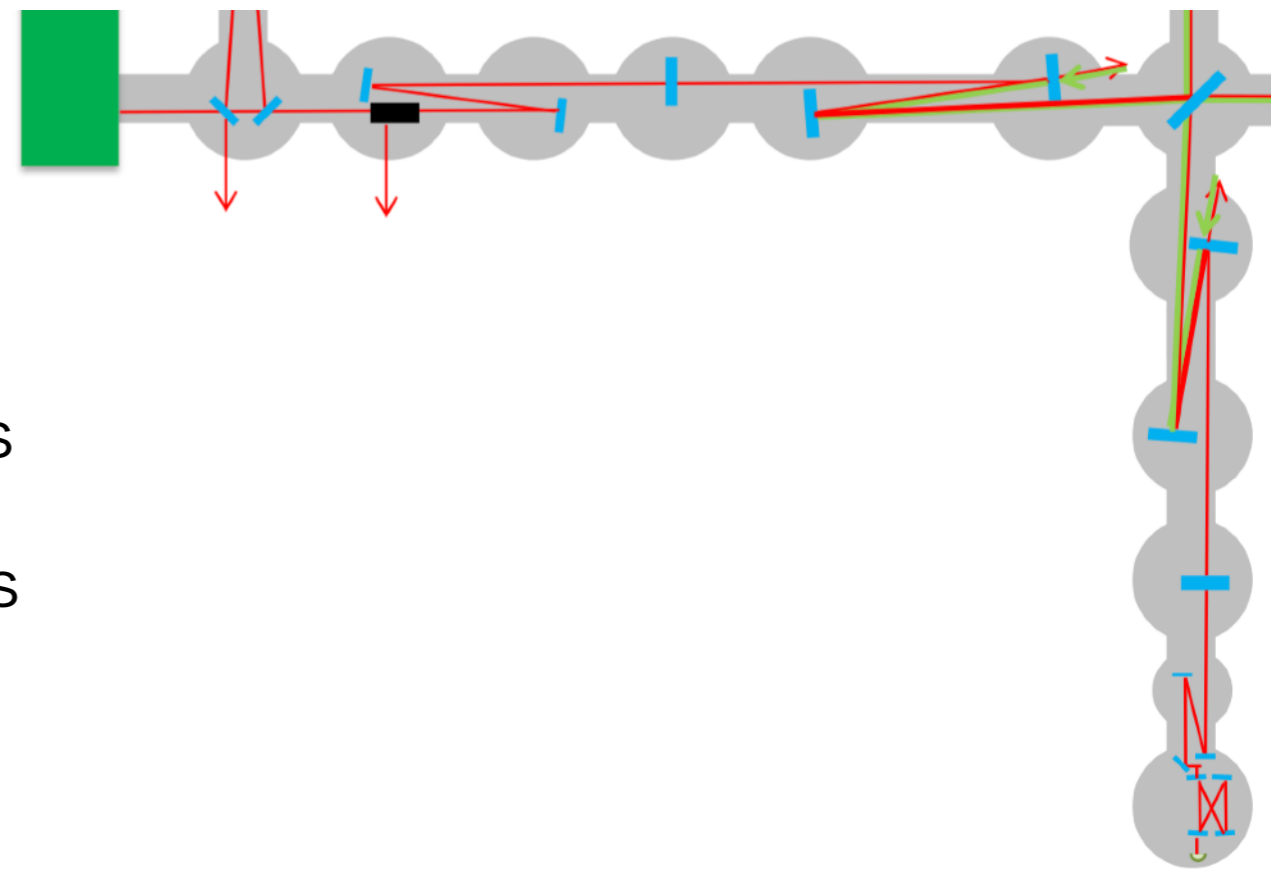
- Discussion with **ET collaborators**
  - Newtonian noise, infrastructure noise, Schumann resonance, ...
  - ILANCE workshop, Bi-monthly meeting, Virgo visiting, ...
- **Seismic motion** analysis
  - Earthquake, human activity, relationship with infrasound, ...
- Increasing the **weather information**
  - Characterize the weather using the weather station
  - Investigate the rail monitor with heavy snow
  - New weather station
- **Infrastructure noise**
  - Sound mapping, magnetic field mapping, vibration mapping, ...
  - Evaluate the effect from KAGRA environment
    - PEM injection, hammering test, global magnetic injection test
    - Contribution to ET and future detectors
- Setting and developing the **PEM injection**
- Support of the **PEM injection** at the site
- There were many **lightening** near the KAGRA site
- etc. etc.







# Summary



- Presented the current PEM activities
  - See also the related talks, posters
    - Poster : S. Hoshino (m05)
    - Poster : I. Fukunaga (m03)
    - Oral : A.Takamori (Session 04)
    - Oral : C.J. Chou (Session 08)
    - Poster : Y.Yang (s05)
- There are many activities related with PEM, so if you have interested in our activity, please contact us
- There are also many activities in the commissioning toward O4

