KAGRA

Installation of the Next High Power Laser for KAGRA

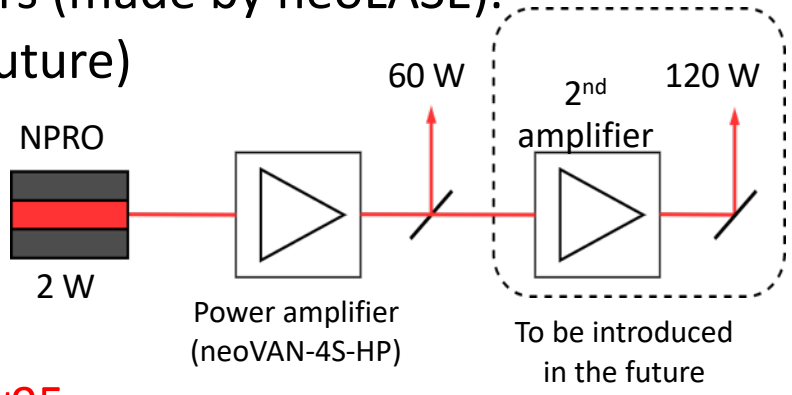
Purpose of this meeting

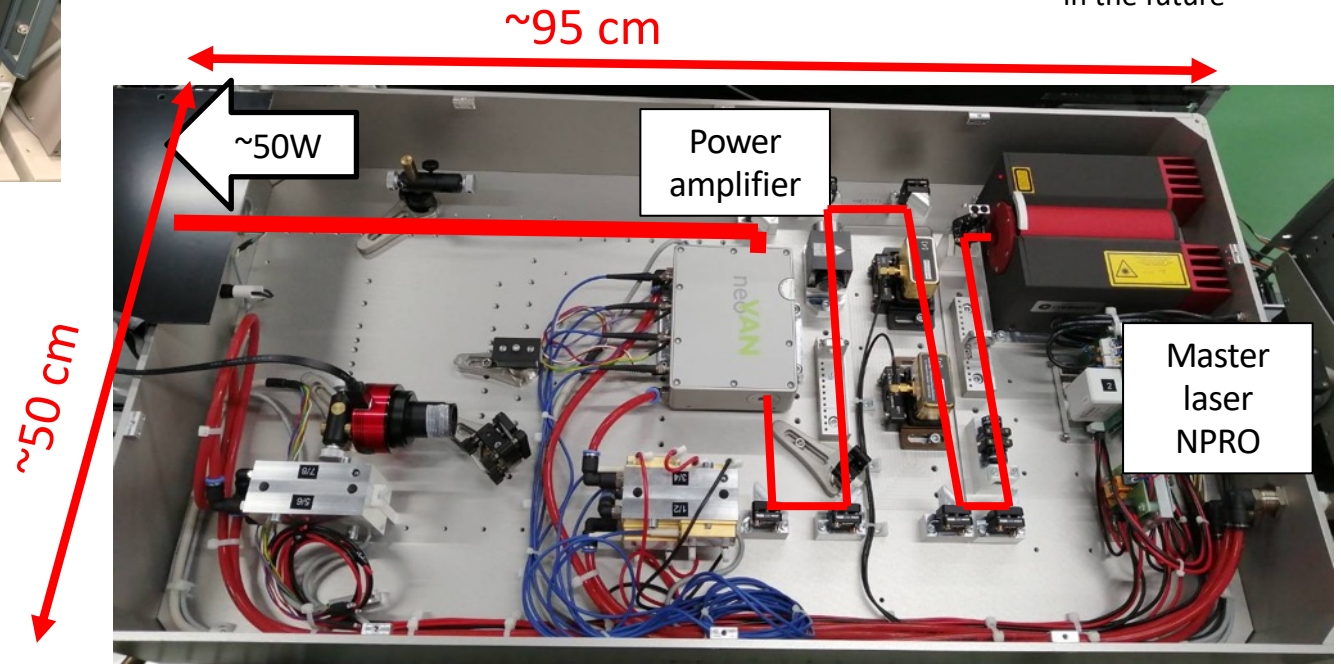
- Estimate the advantages/disadvantages of using the new high power laser(NHPL) from Toyama Univ. to KAGRA.
- Check the readiness of removing NHPL at Toyama Univ.
- Check the readiness of accepting NHPL at KAGRA.
- Estimate schedule of moving NHPL from Toyama Univ. to KAGRA.
- See the concept of switching the current high power laser(CHPL) to NHPL

New high power laser @Toyama Univ.

- A high power laser of the same design as LIGO and Virgo has already been installed at Toyama University.
- It consists of an NPRO and two amplifiers (made by neoLASE).
- Maximum power: 60 W (120 W in the future)

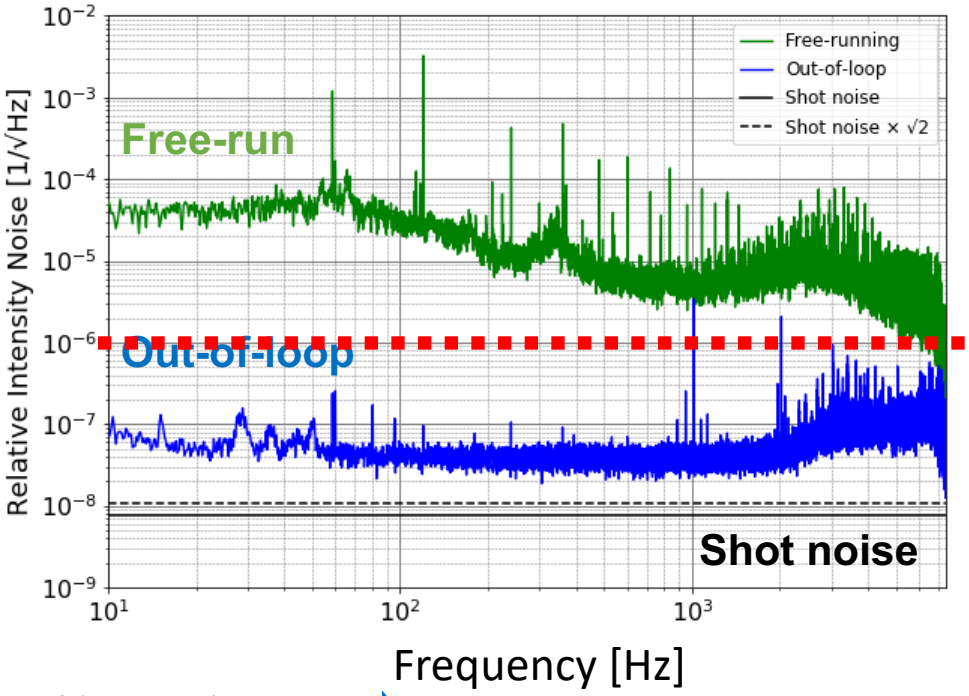
Laser controller (upper) and power supply (lower)



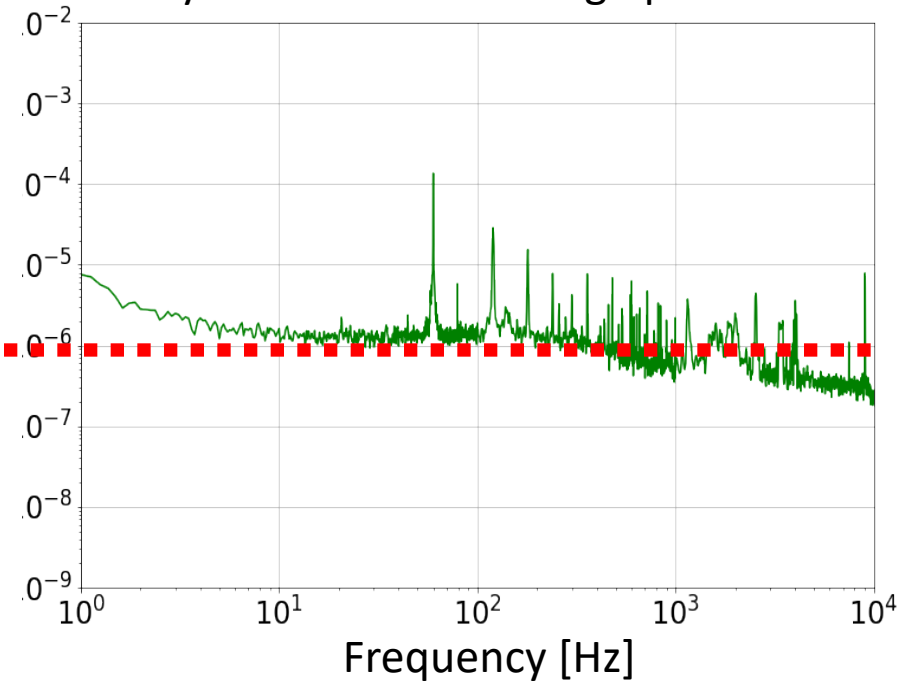


Advantage 1: Intensity noise

Intensity noise of current KAGRA laser



Intensity noise of the new high power laser

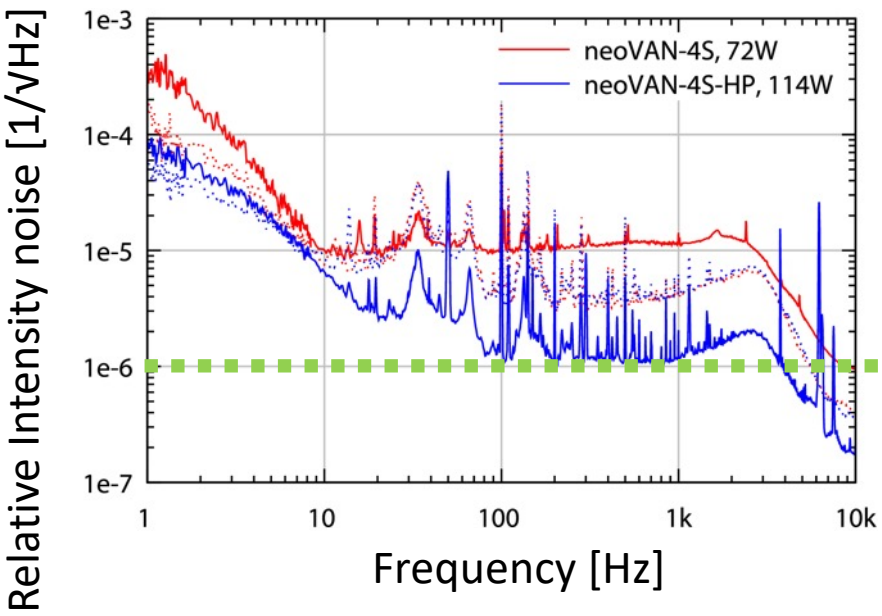


黒宮さんのスライドより引用
(JGW-G2012322)

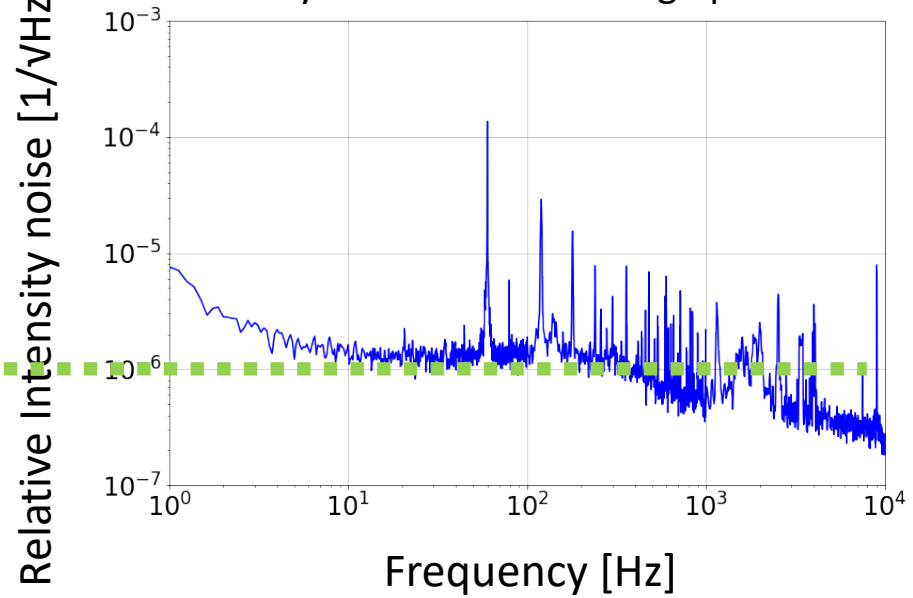
New laser is better for 1-1.5 order of magnitude in all the frequency.

Comparison with LIGO's new laser

Intensity noise of LIGO's new laser



Intensity noise of the new high power laser

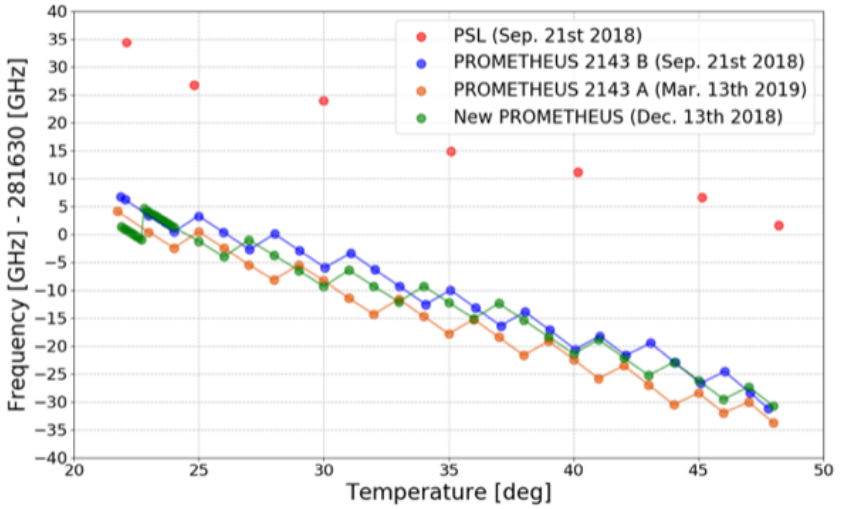


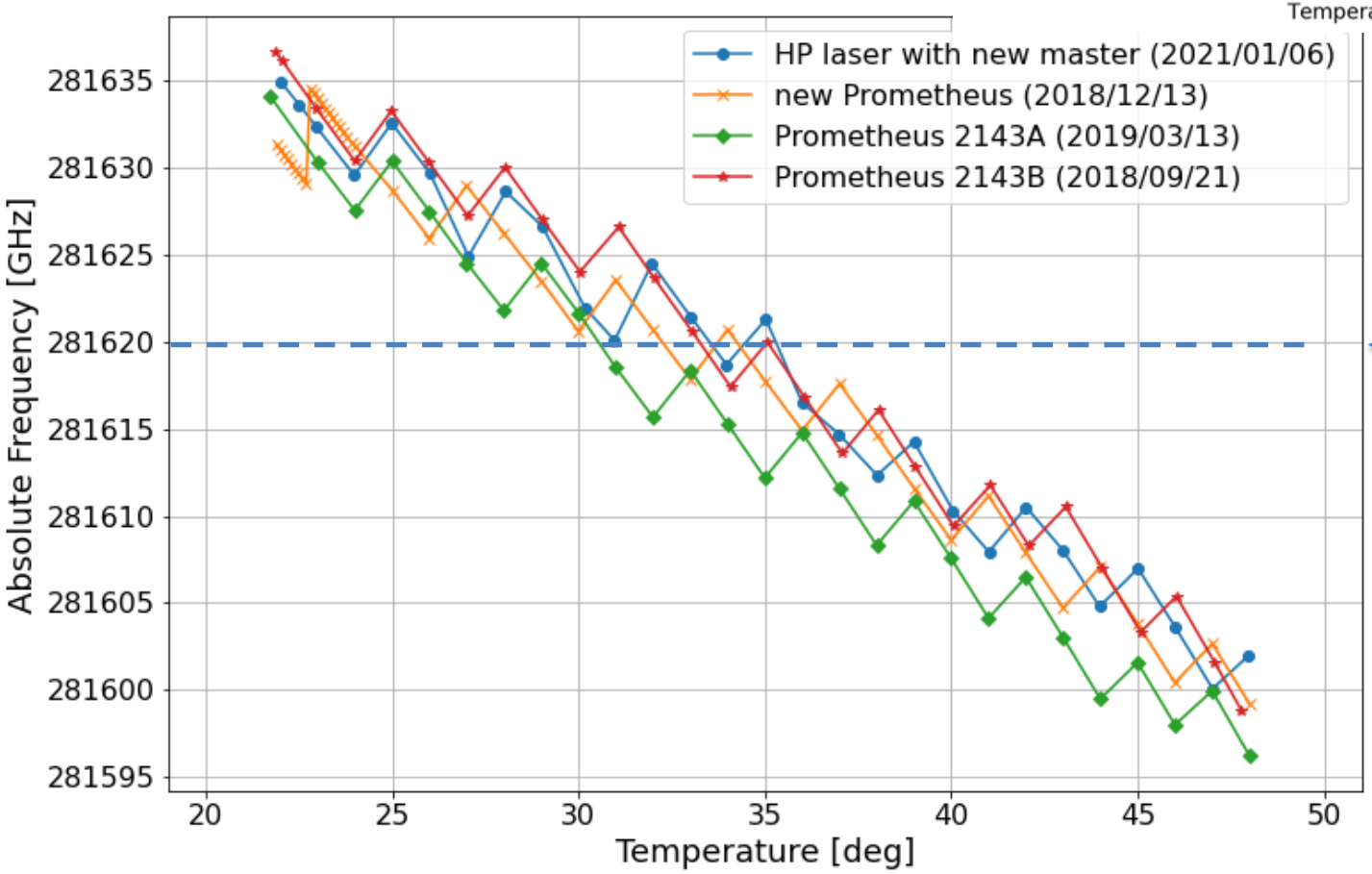
Opt. Lett. **44,** 719-722 (2019)より引用

Comparable or better noise level than LIGO's new laser

Advantege2: Absolute wave length

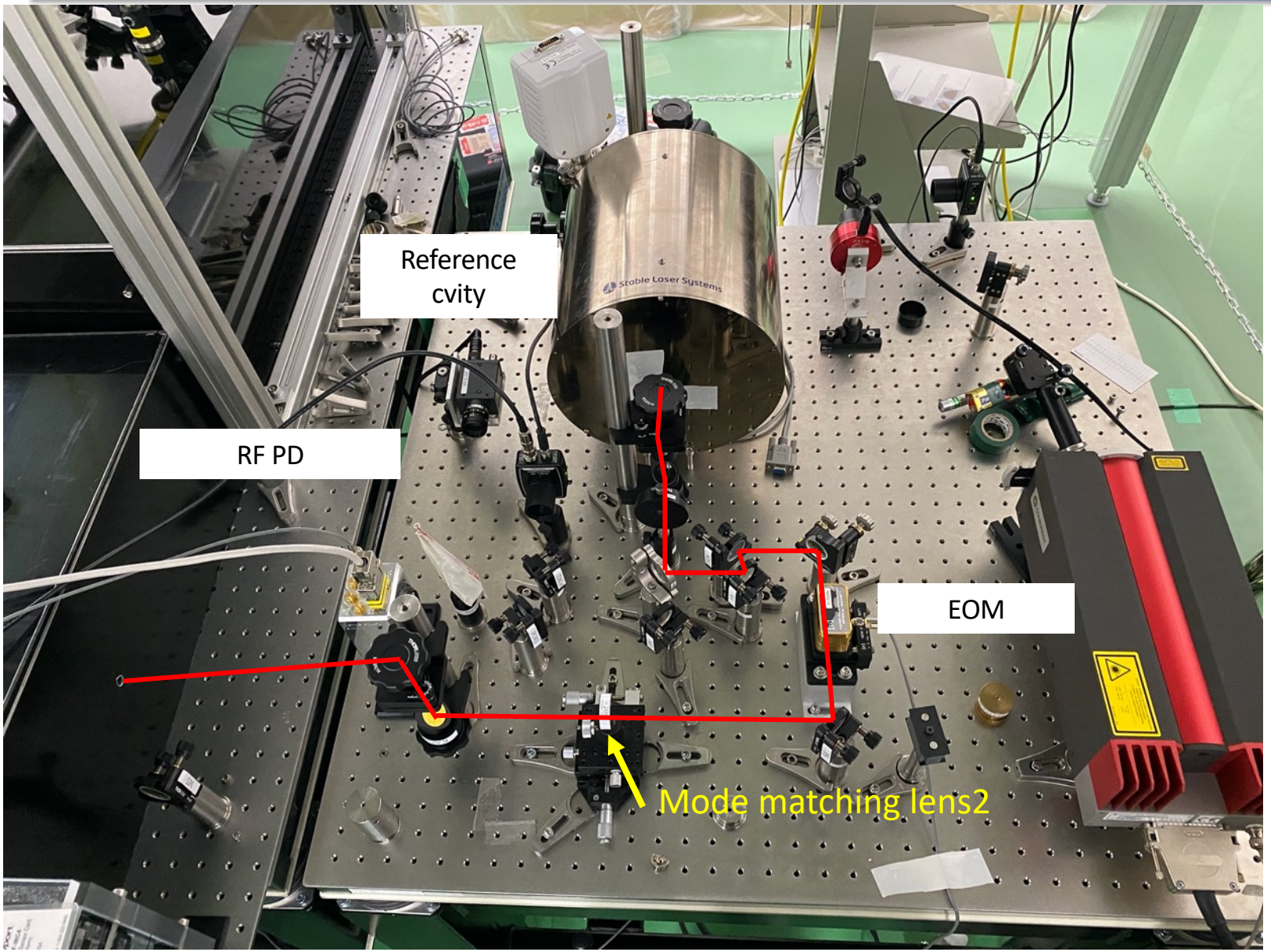
Current very separated frequency between IR and green becomes much relaxed.



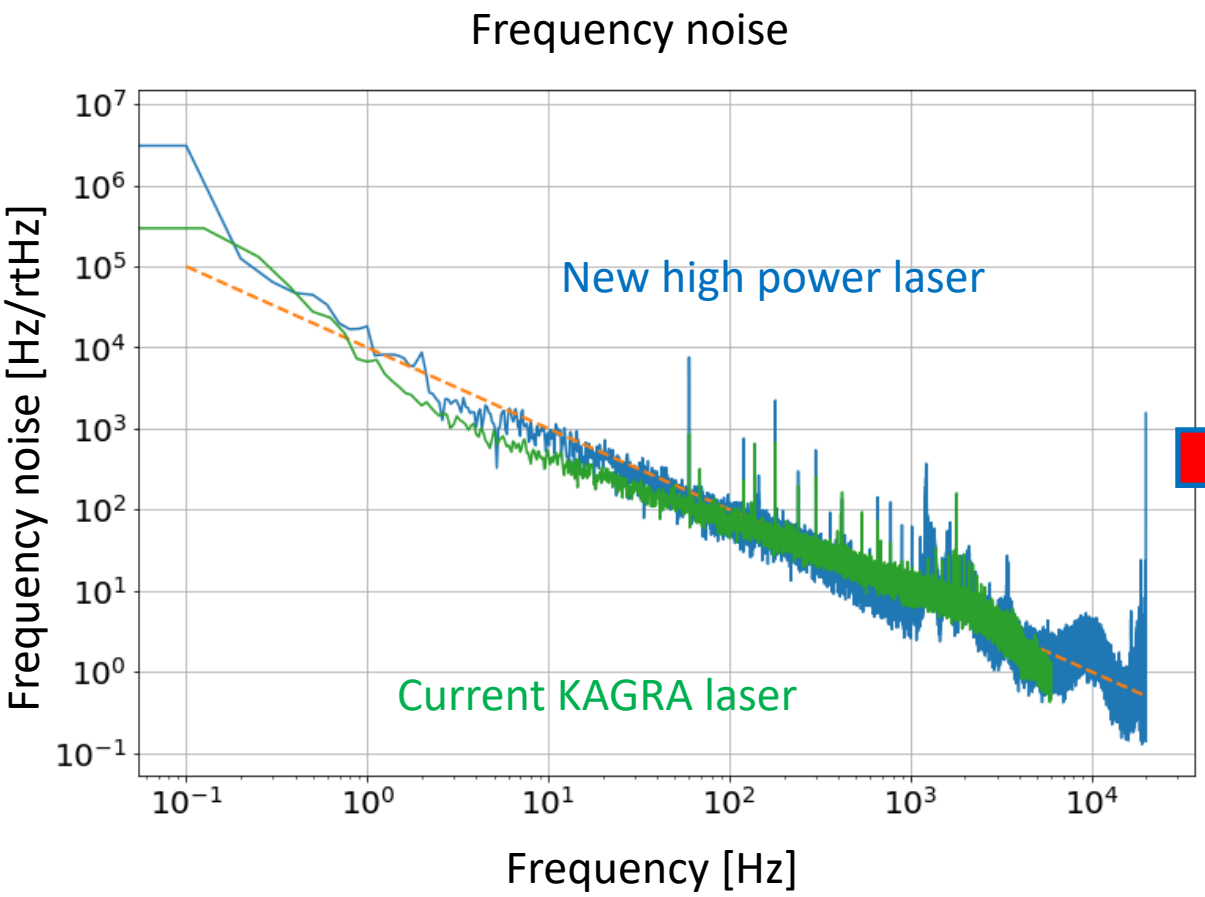


281620GHz

Reference cavity



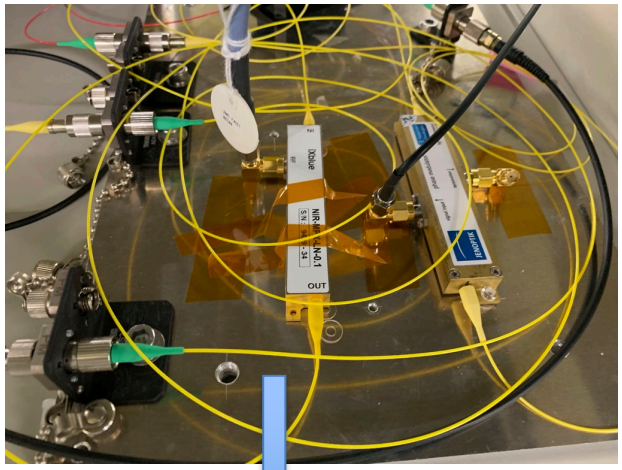
Frequency noise

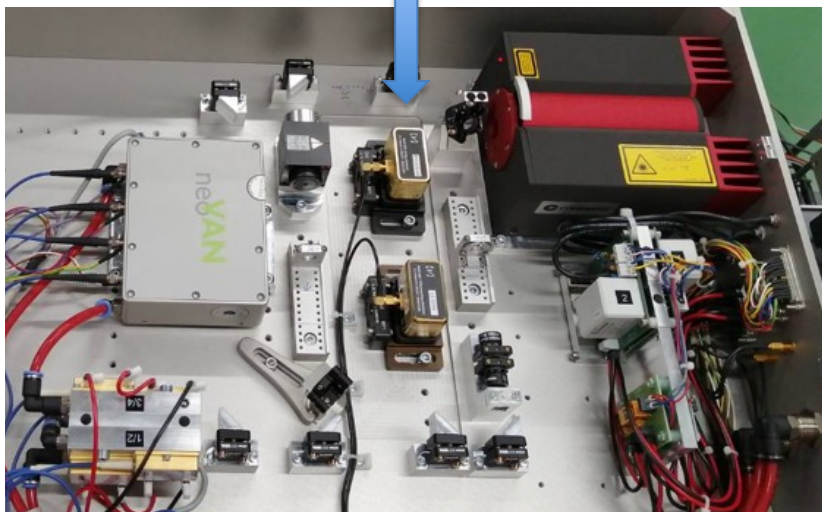


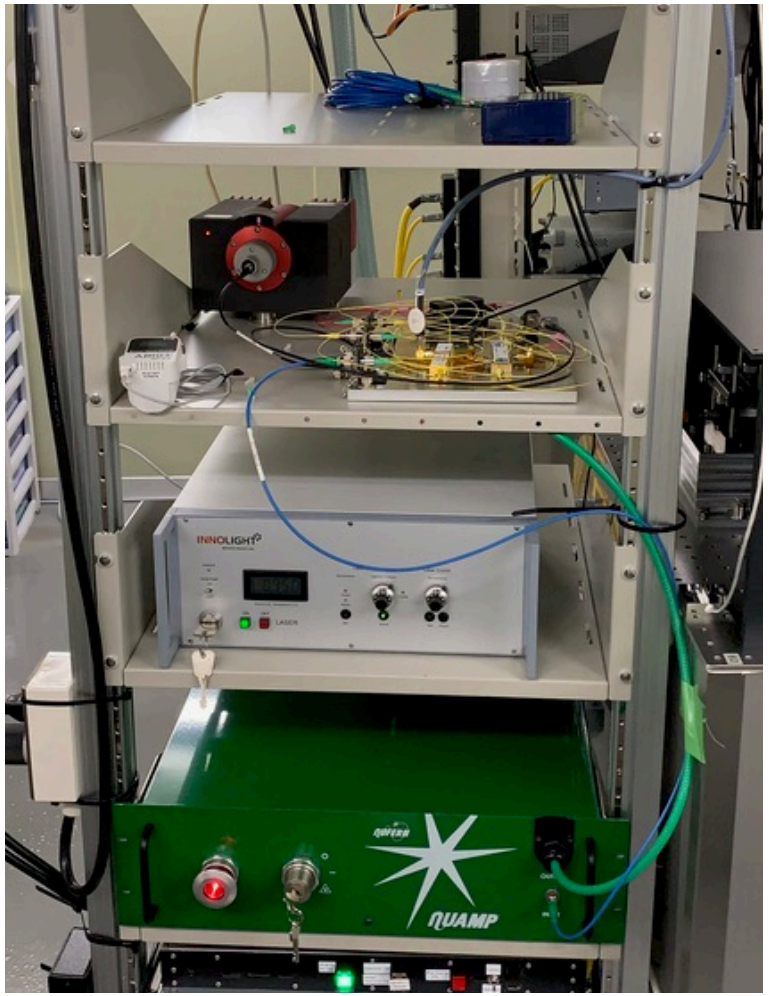
Same noise level

Advantage 3: location of wideband EOM

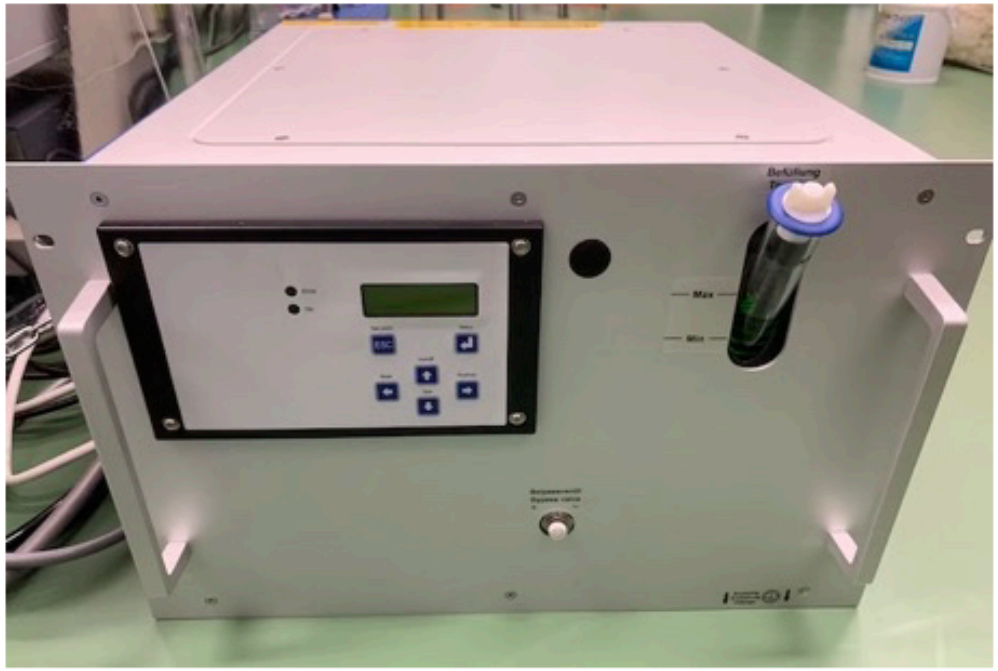
- We can avoid exposing EOM on rack that is very weak for environmental noise.







Advantage 4: Chiller



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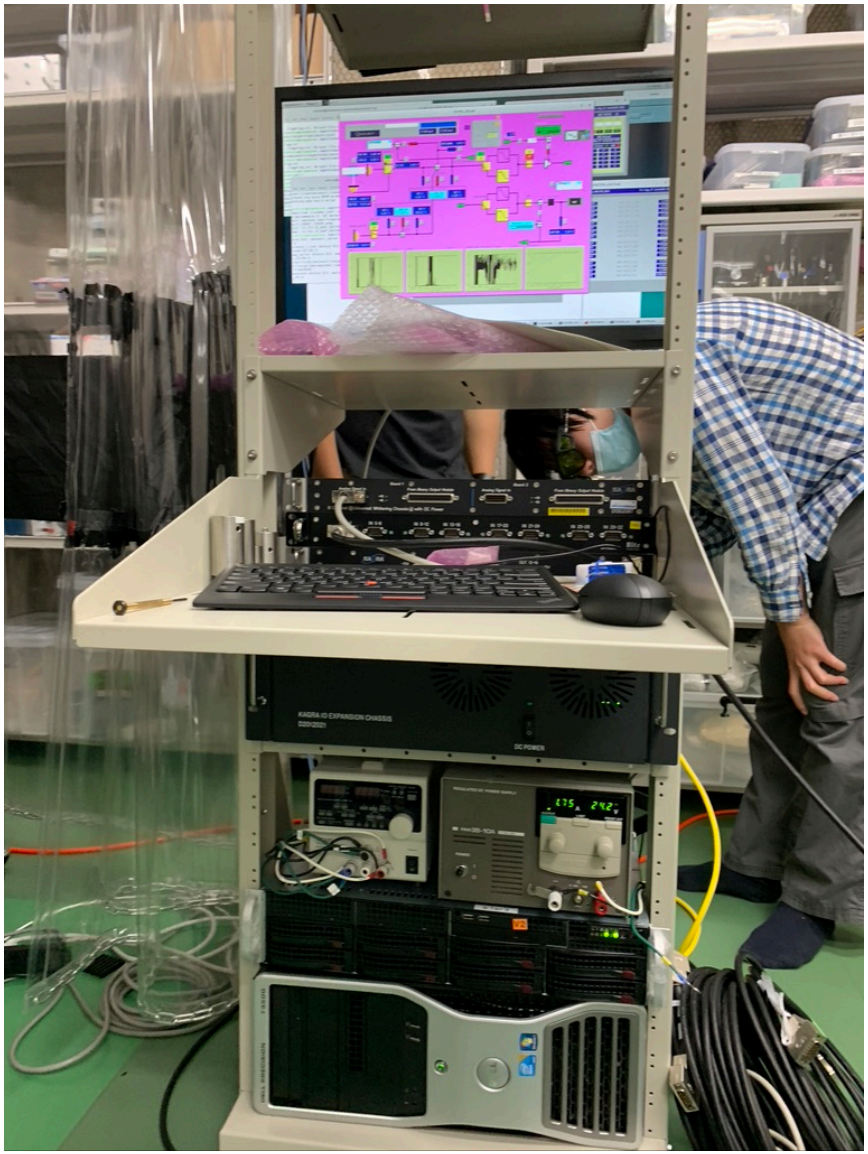
- New chiller has about 100cc evaporated in half a year.
  - ➢ 10% OptiShield+ is better for
- Current KAGRA's chiller has several 100cc evaporated in a month (roughly 10 times more).

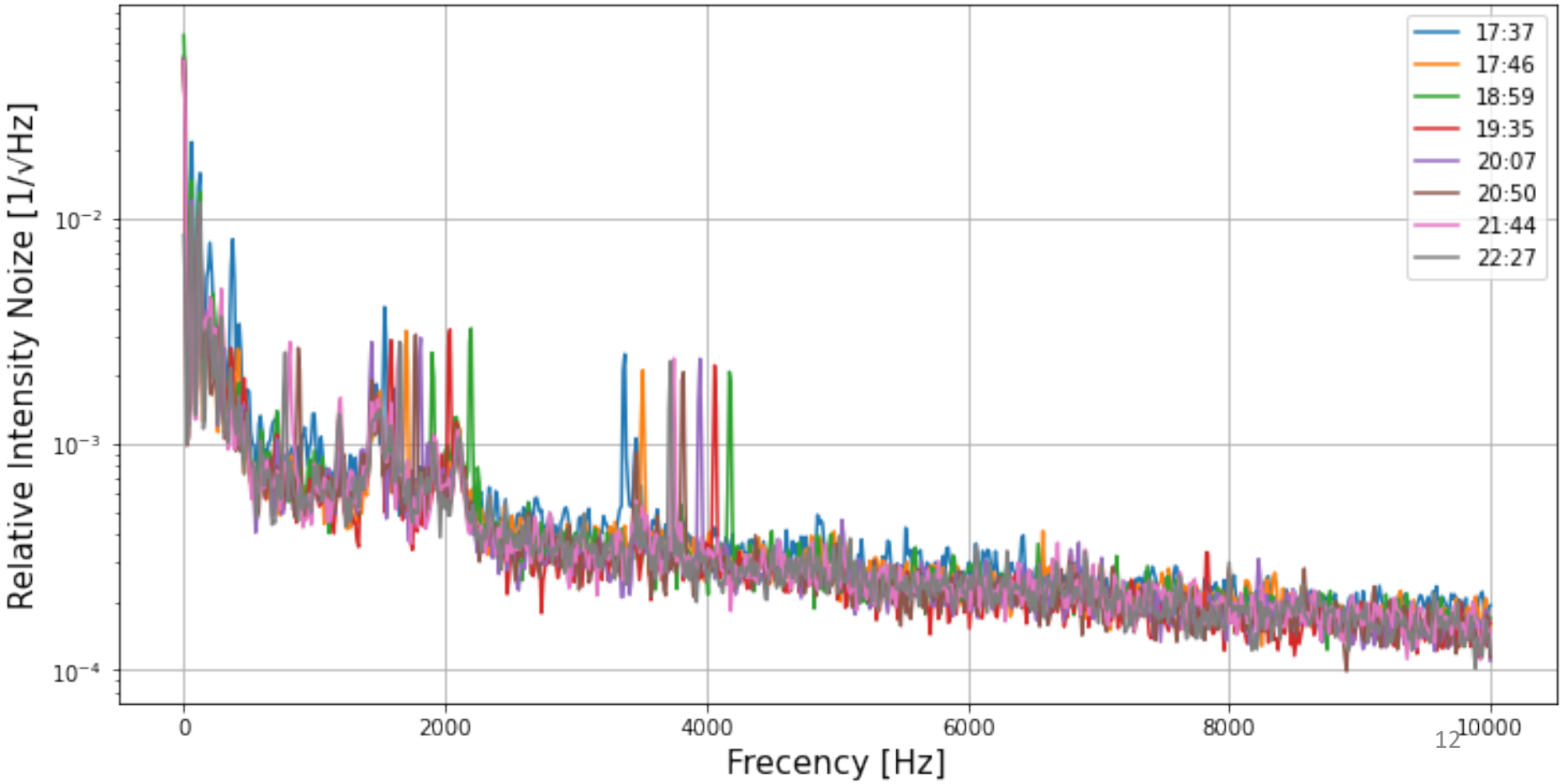
Advantage 5: Running EPICS IOC on HPL system

- Independent EPICS IOC is running on new laser system.
  - EPICS channels can be read already in the DGS.
- Making a new ISS control model.



Disadvantage 1: moving intensity noise

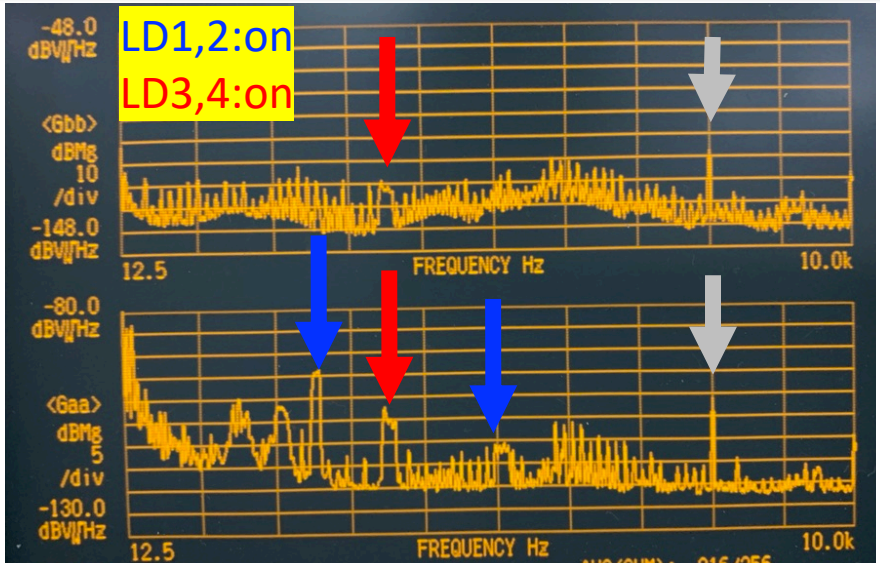
- 5 hours measurement after temperature became stable.
- Still motions exist, but not so fast.



Noise source investigation.

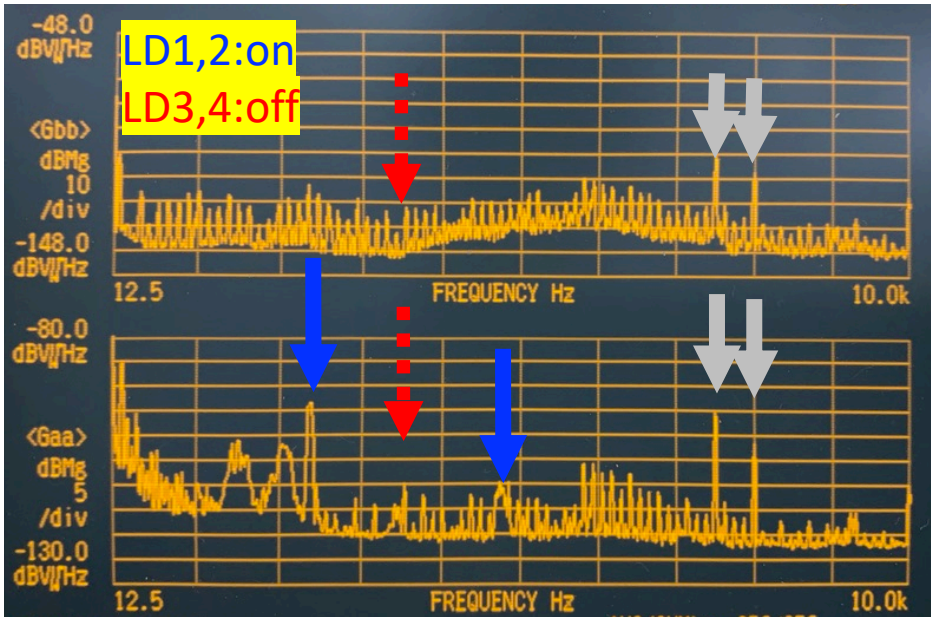
- Probes were attached directly at +/- terminal of LD voltage input.
- Compared the voltage with intensity noise.
- Conclusion is that moving noises come from the power supply for LD.

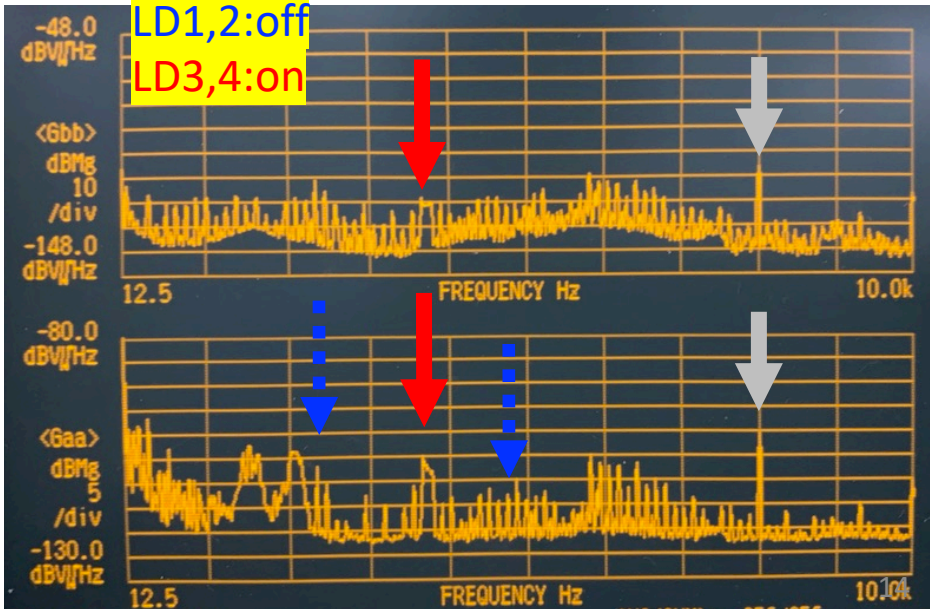
Noise source of RIN: power supply for LD



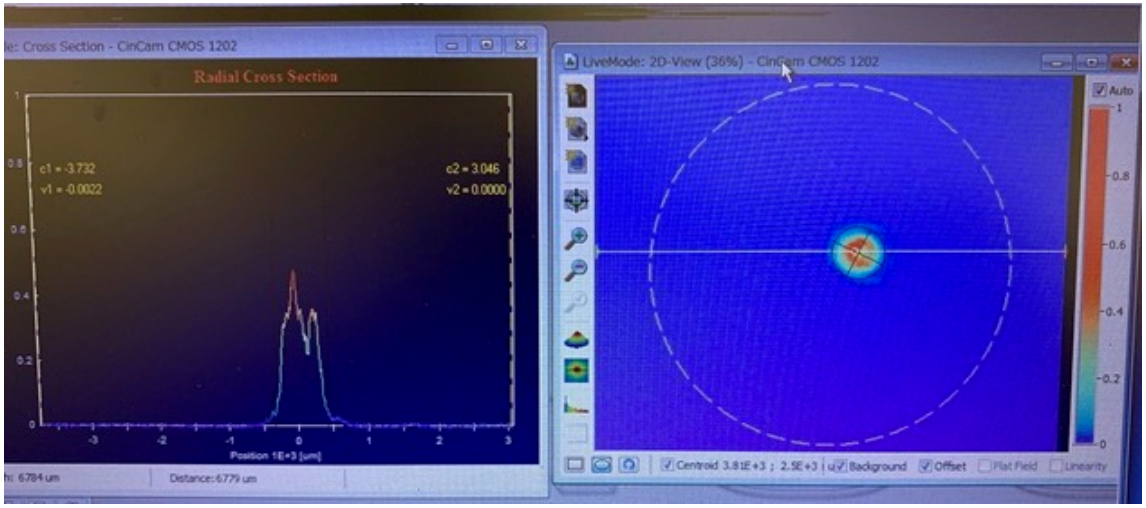
Voltage on LD3,4

Intensity noise



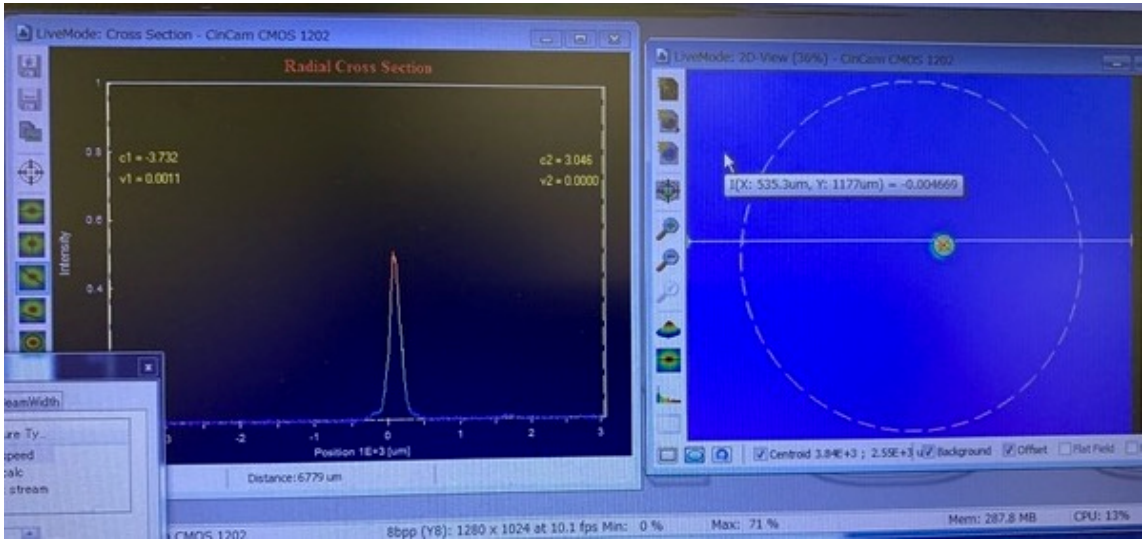


Diaadvantage2: bad beam shape with high power



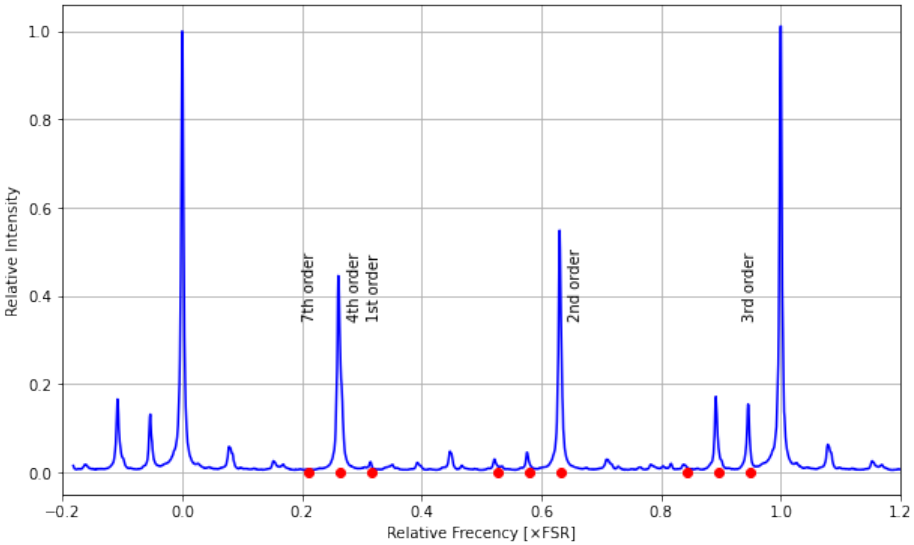
Found bad beam shape around waist.

Lower power (9A->7A) improves the shape.

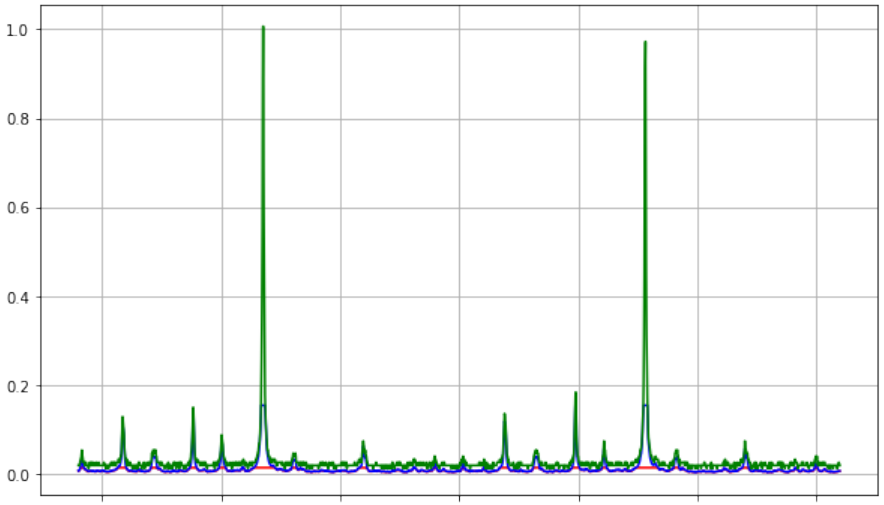


Mode scan for 9A and 7A

New master laser
Current: 9A



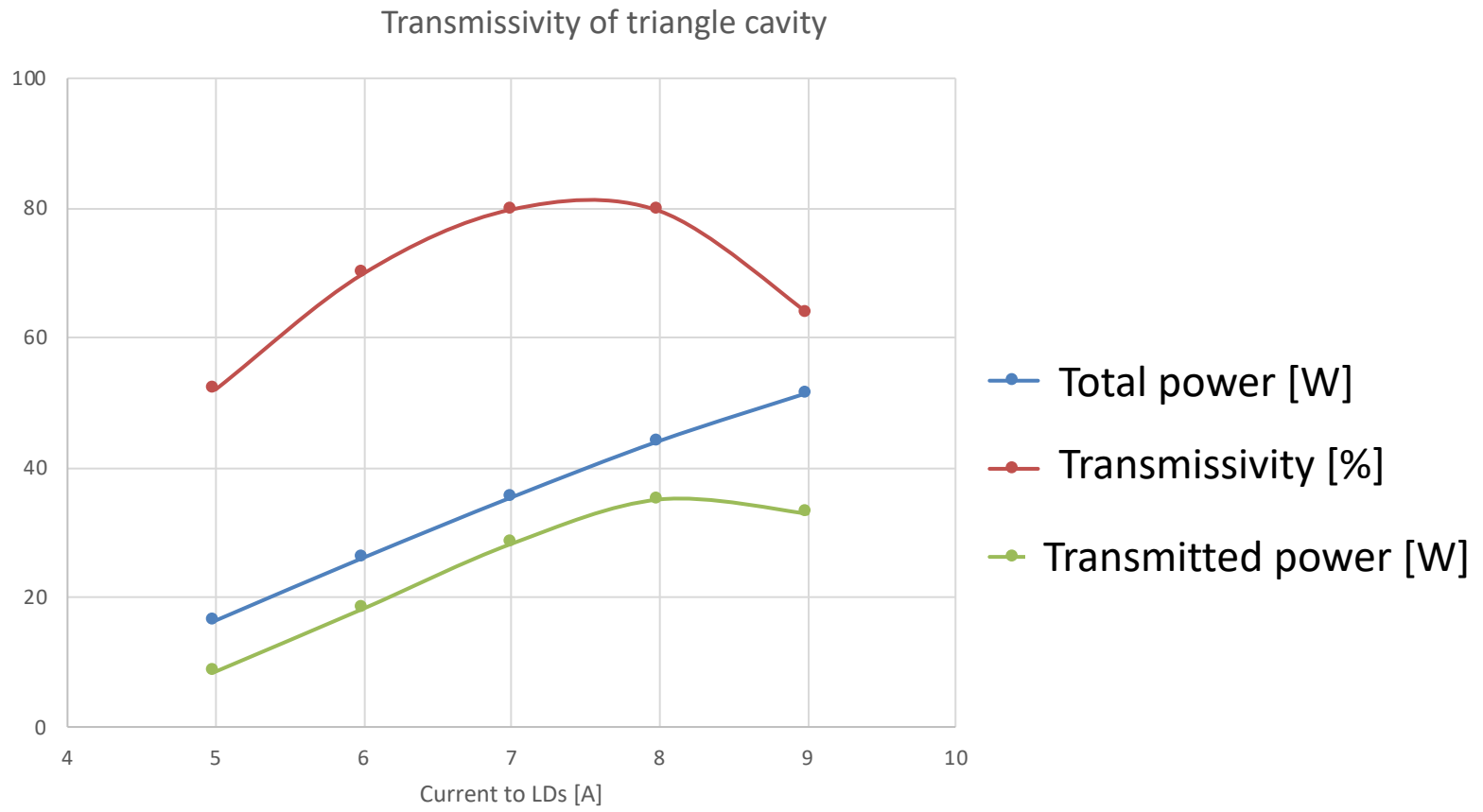
New master laser
Current: 7A



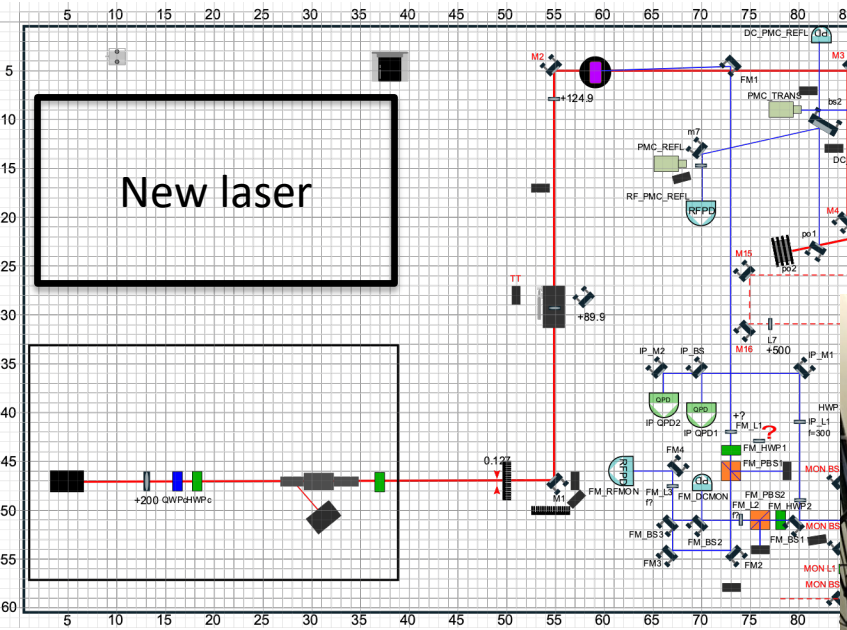
- Excess modes are much lower with 7A.
- Cavity transmissivity reached 80% at least with a simple triangle cavity.
- Bad shape will be converted to just loss at the PMC and won't show up at the transmitted light of PMC.

Transmissivity of triangle cavity

- Good around 7~8A
- Max transmitted power at 8A



Space for new HPL on PSL table



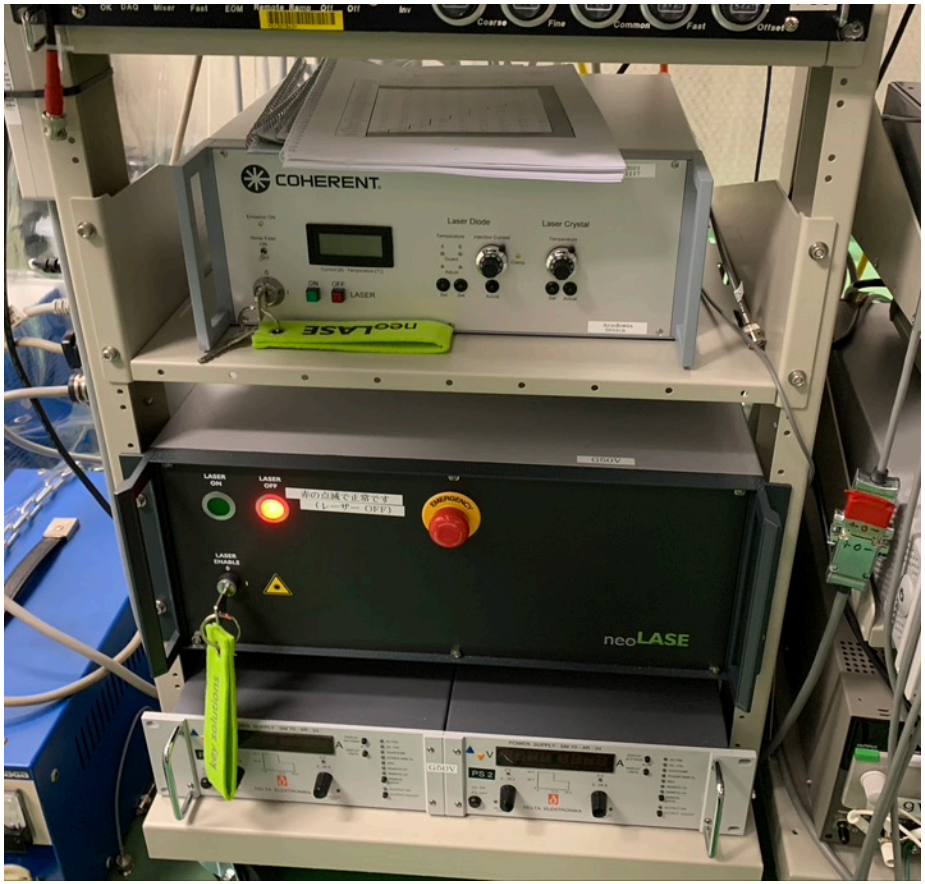
Space for the new laser in 19 inch rack

- Needs 10U on rack

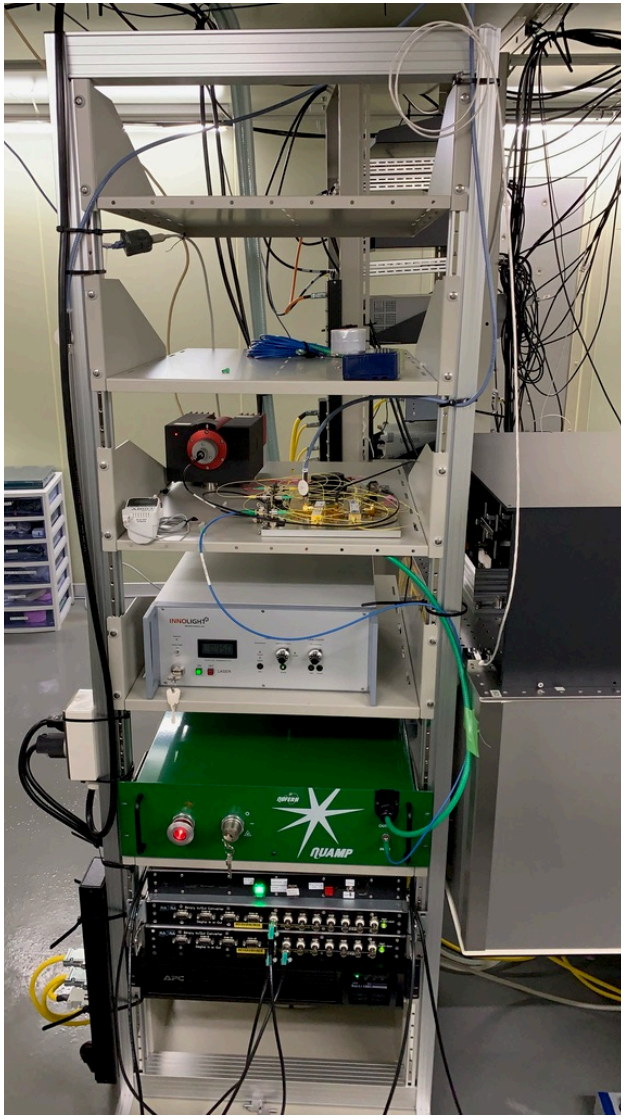
Master laser controoler ->

Power amp controller ->

Power supply for LD ->

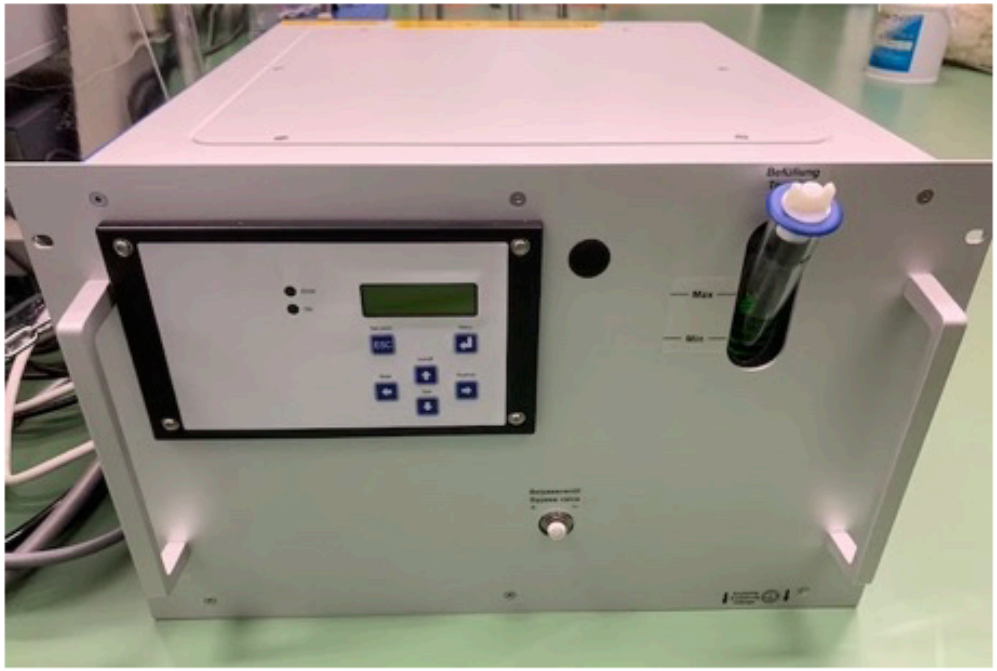


Space for the new laser in 19 inch rack



- We have enough space in current rack, but EOM is weak for vibration -> introducing down time.
- Probably it is better to buy another rack.

Water tube for chiller



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- New chiller has about 100cc evaporated in half a year.
  - ➢ 10% OptiShield+ is better for
- Current KAGRA's chiller has several 100cc evaporated in a month (10 times more).

Water tubes for chiller

Space for chiller

- Needs more power distribution? One of the switch is available.

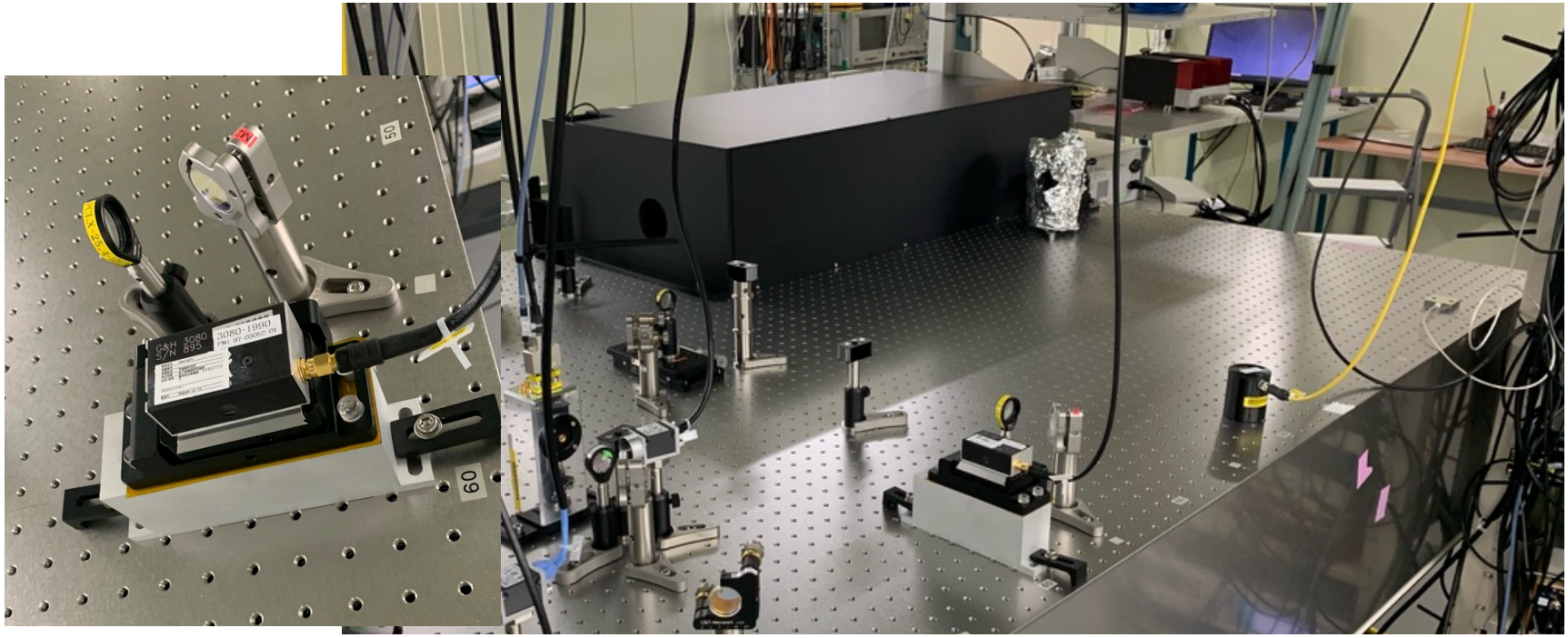
Schedule of moving of HPL to KAGRA site

- Third week of June (week of 6/20) is the first candidate.
- The next chance is week of 7/4.

- We will move HPL into KAGRA mine, and check its operation.
  - Needs characterization.
  - Needs long term stable operation.
- Date of switching from current laser to new HPL is not decided yet.

Switching laser

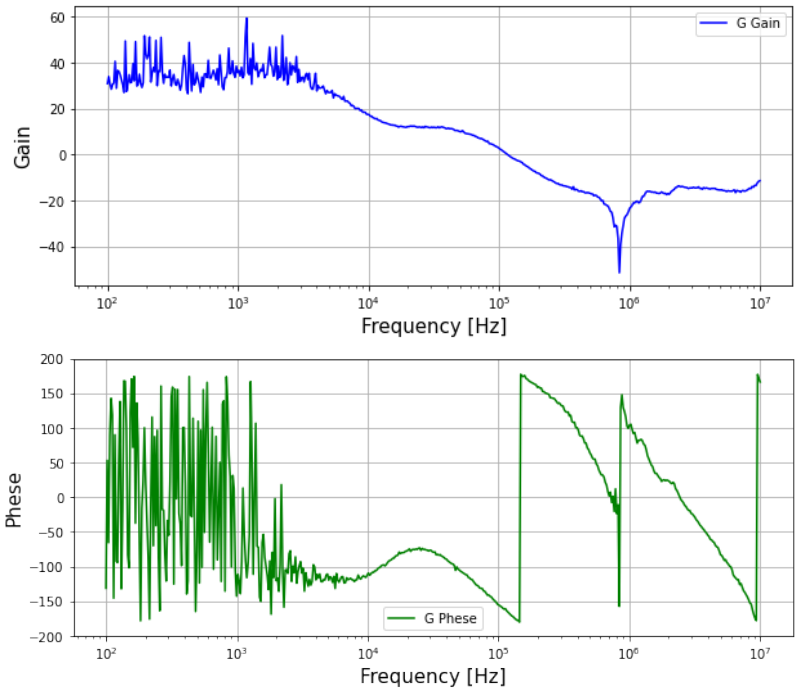
- Most difficult thing is a mode matching.
  - We have enough space to make a new mode matching path between output of NHPL and the first steering mirror.
  - Replacing the steering mirror to a flip mirror?
  - Removing the mount of the steering mirror to recode the current mirror position?
  - Some more ideas...



Another difficulty: EOM

- Efficiency of wideband EOM will be much smaller.
- We checked the servo loop with for EOM path with 150V output, x20 amplifier.

- UGF reached ~150kHz, comparable with KAGRA's UGF~<200kHz
- Resonant frequency of wideband EOM is ~800kHz.
- Phase margin is limited by a big phase delay around 1MHz of SR560. It can be improved with the common mode circuit used in KAGRA.



After switching laser.

- After switching lasers, the current laser will be a spare.

- We are ordering another new HPL.
  - This new laser will be a main laser for KAGRA.
  - The current HPL at Toyama Univ. will be a spare laser.