Status of the input optics for the O3

Masayuki Nakano on the behalf of KAGRA collaboration
University of Toyama

Objectives of the input optics

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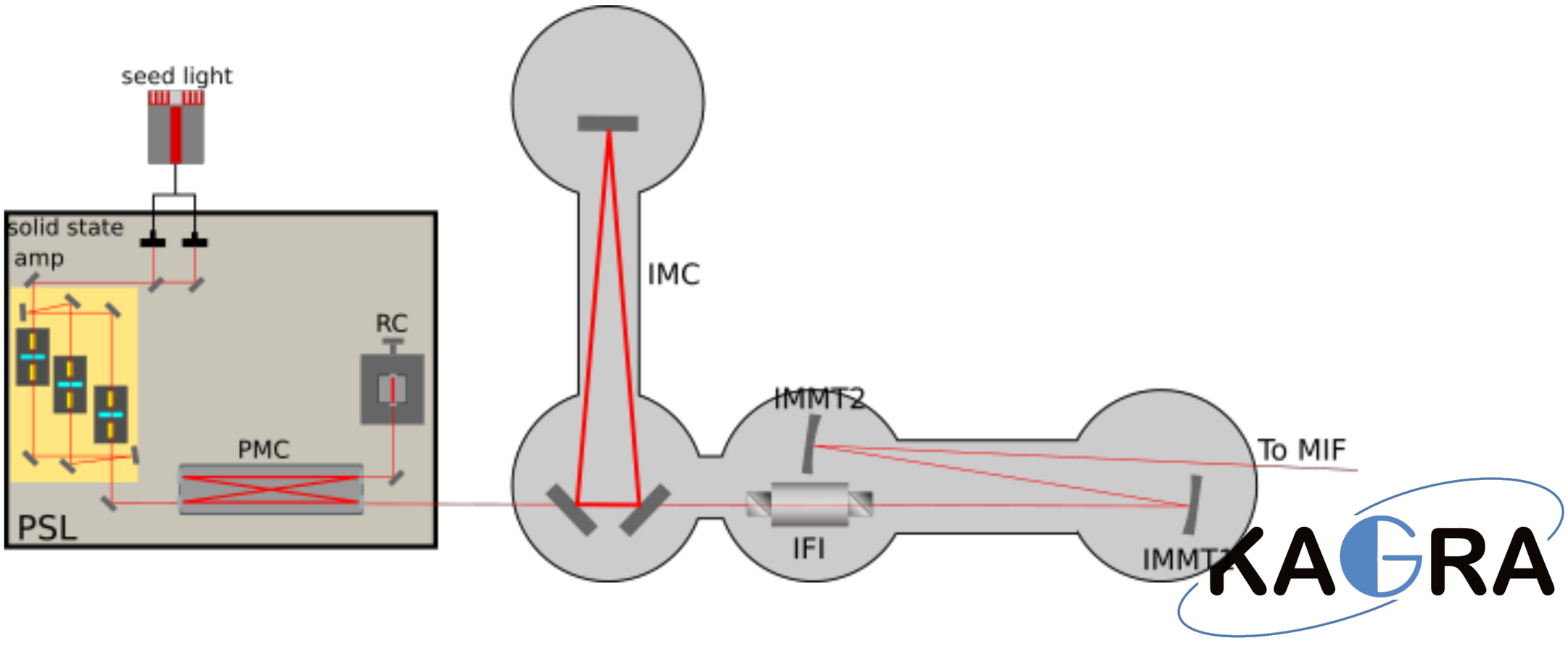
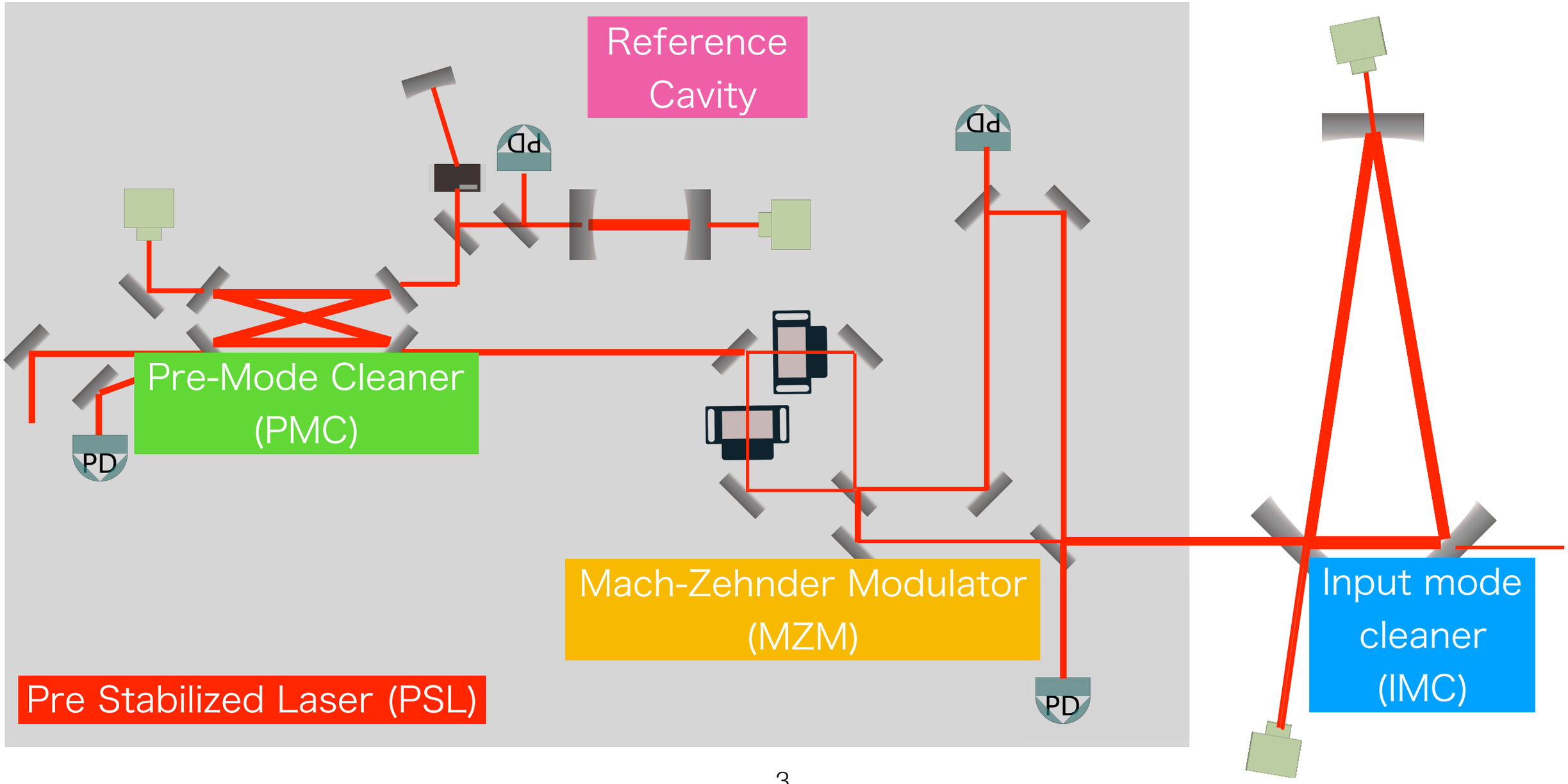
Provide the stable laser to the main interferometer.

- ✓ The frequency stabilization
- ✓ The intensity stabilization
- ✓ The reduction of the beam jitter
- ✓ The cleaning of the spacial mode of the laser



Overview of the input optics



Pre-Stabilized Laser (PSL)

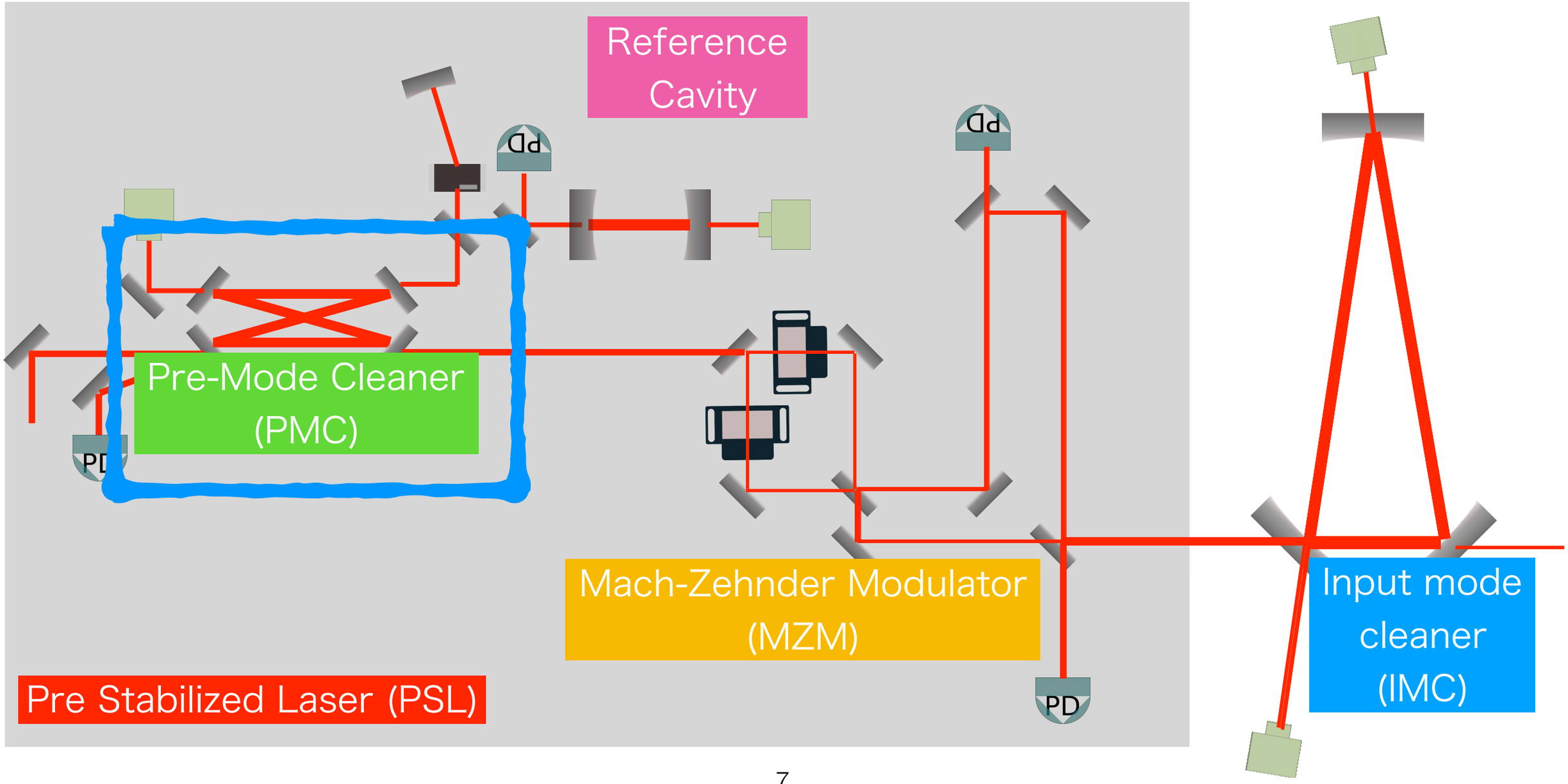
MZM

FSS

PMC

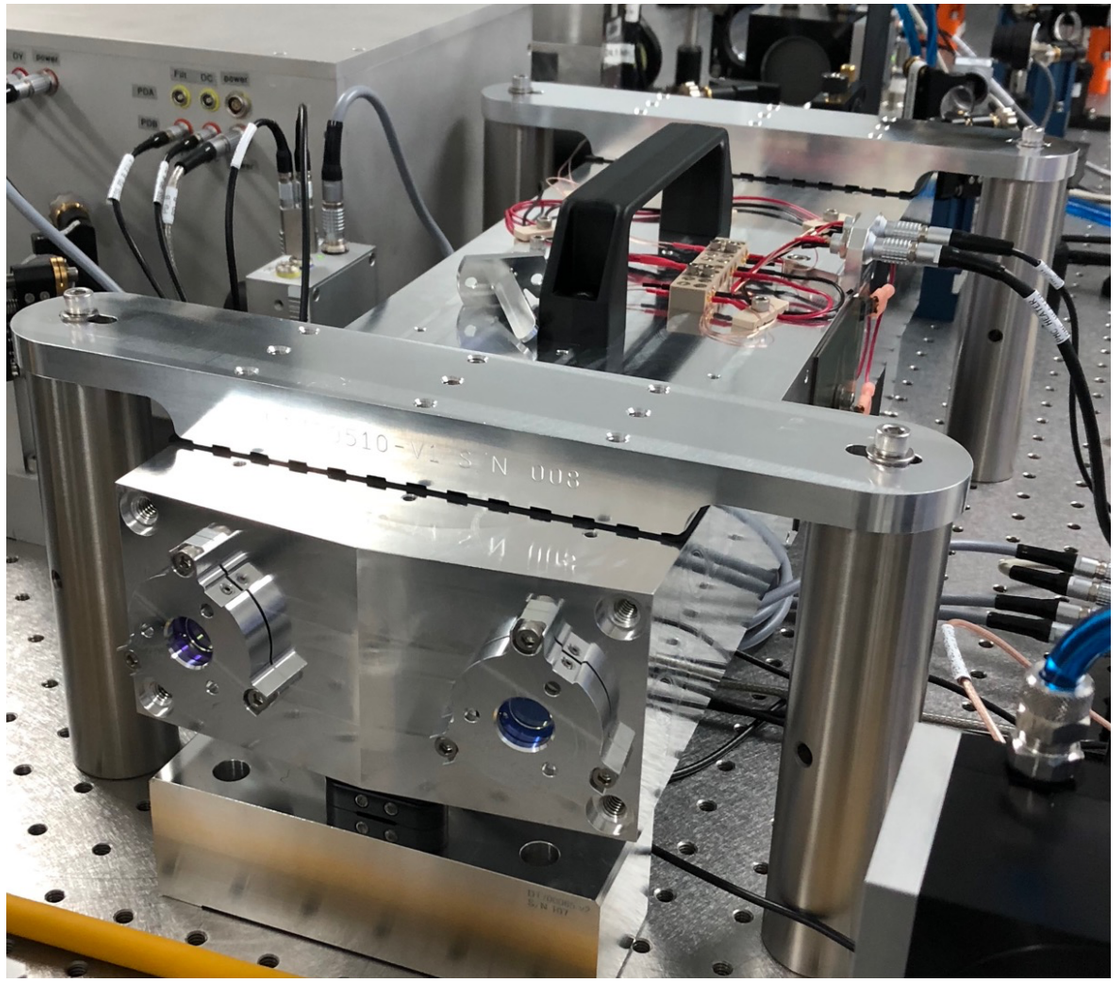
Pre-Mode Cleaner (PMC)

Pre-Mode Cleaner



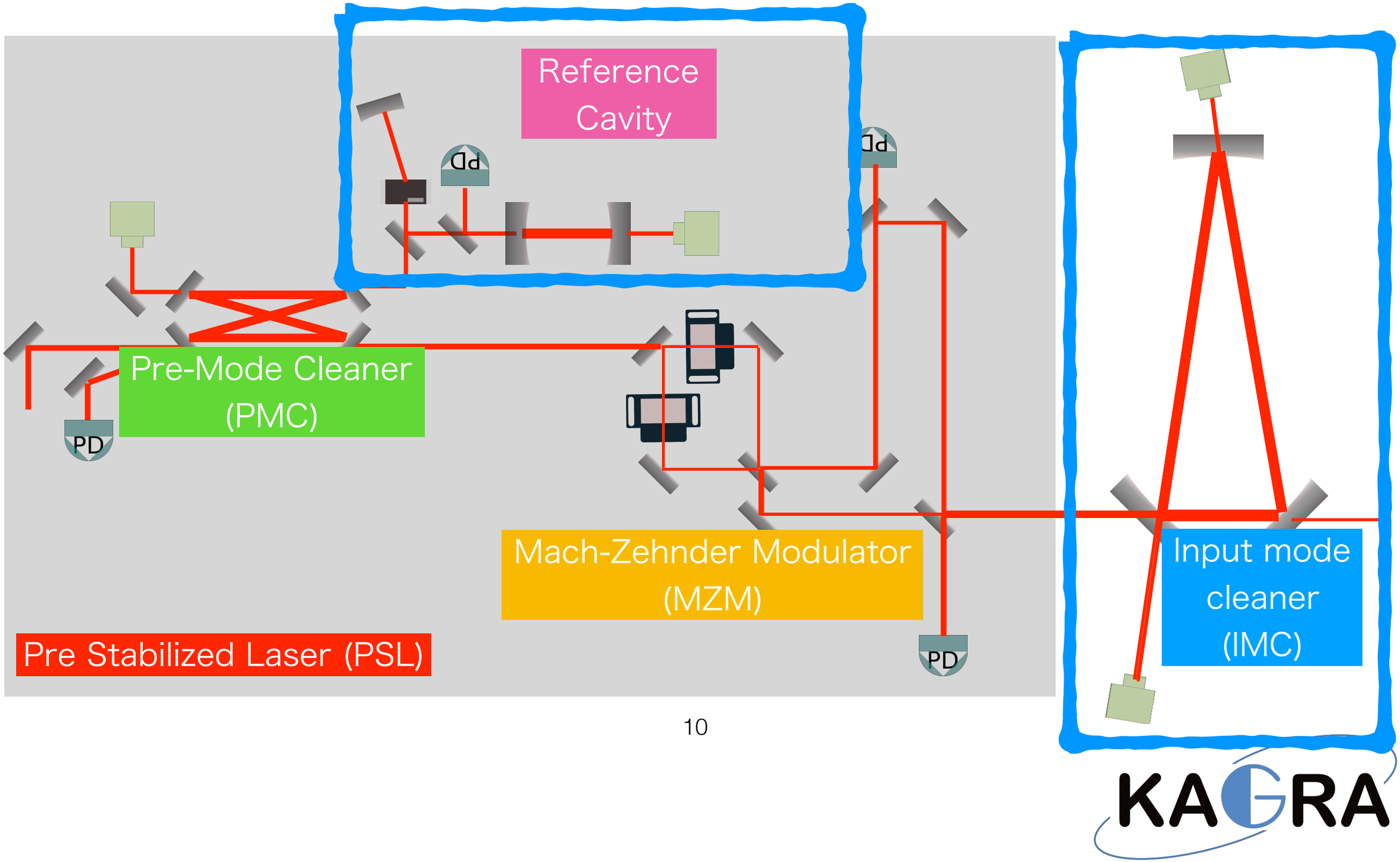
Pre-Mode Cleaner (PMC)

- 2-m long bow-tie shaped cavity.
- Objectives:
  - ✓ Spacial mode cleaning
  - ✓ Beam jitter reduction
  - ✓ RF RAM noise suppression
- Control the Cavity length to follow the laser frequency.
- The control is so stable that once it get locked, it can continue to lock for more than several weeks.



Input Mode Cleaner (IMC) And Reference Cavity(RefCav)

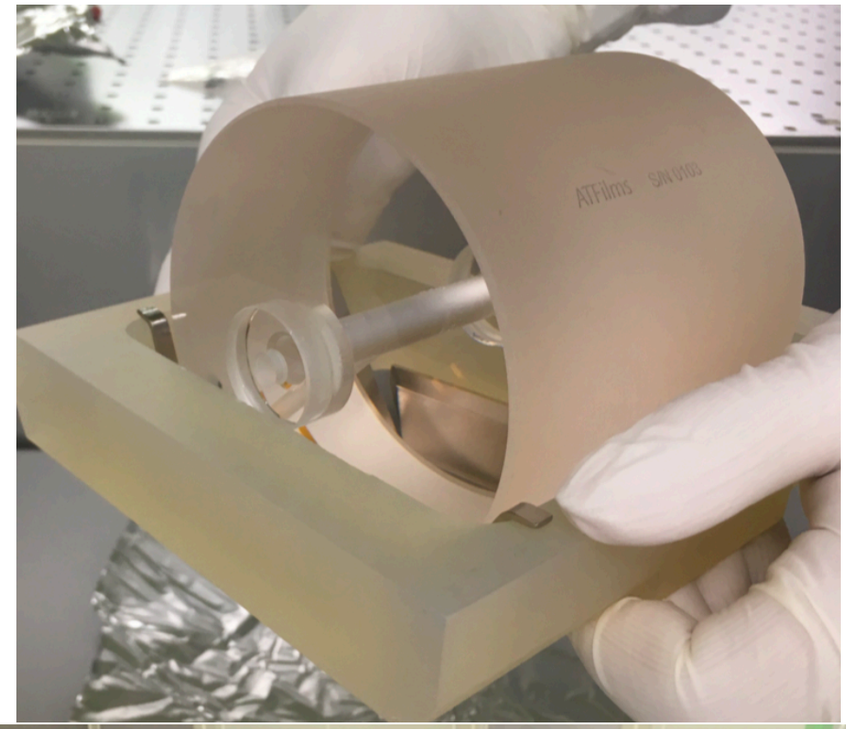
IMC and RefCav

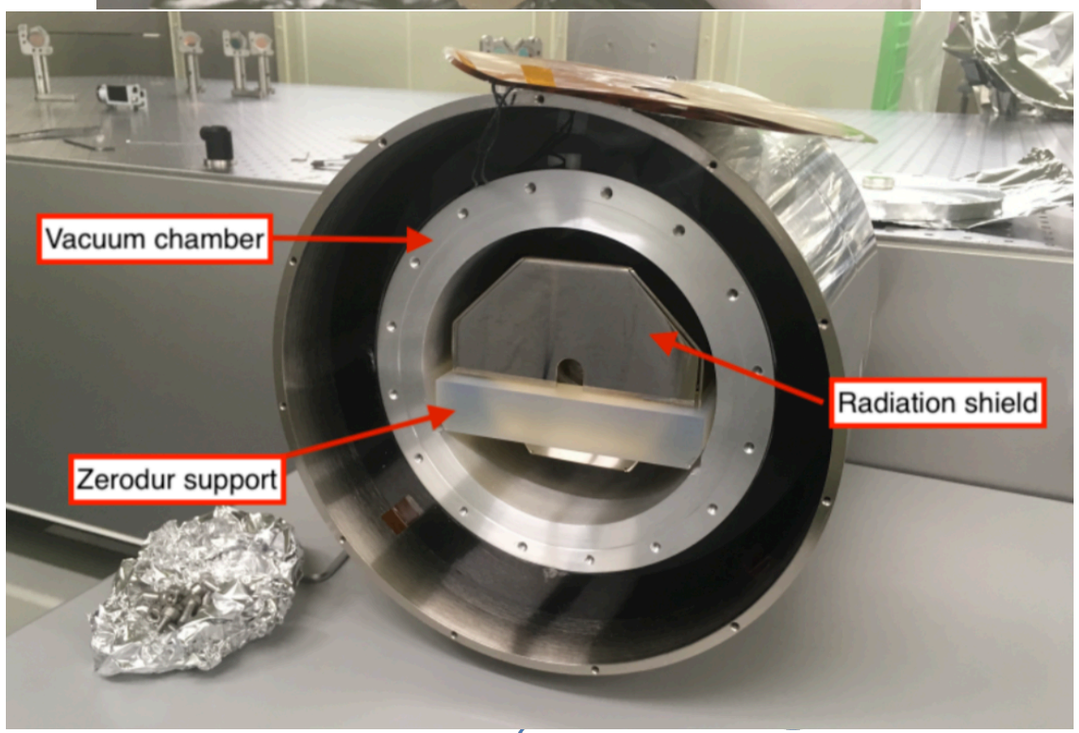


Reference Cavity

- Use the Ultra-Low Expansion (ULE) glass linear cavity as the frequency reference for the frequency stabilization.

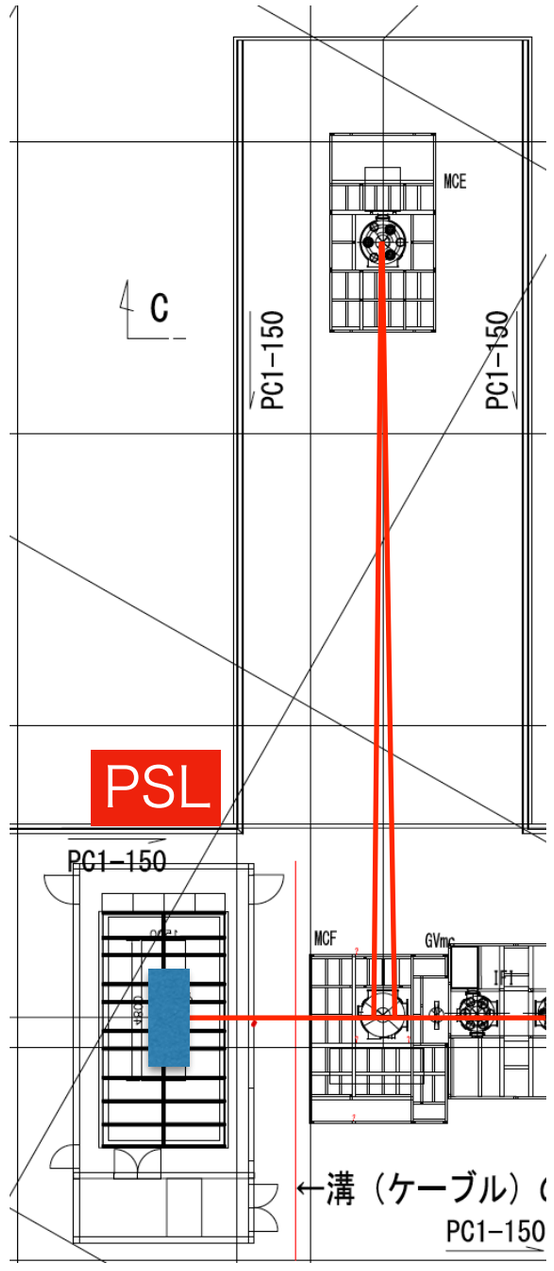
- The Cavity is located inside of the vacuum chamber.
  - ✓ Evacuated down to ~1Pa.

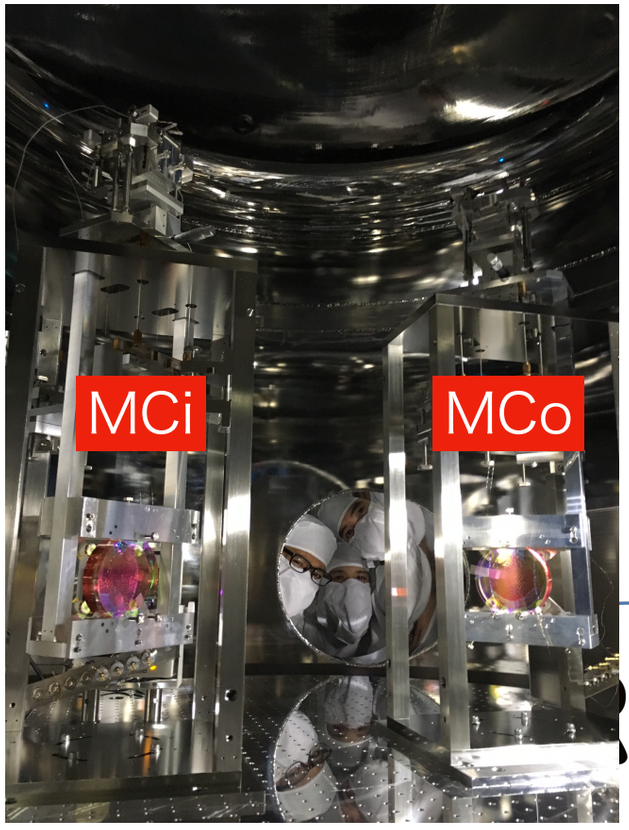




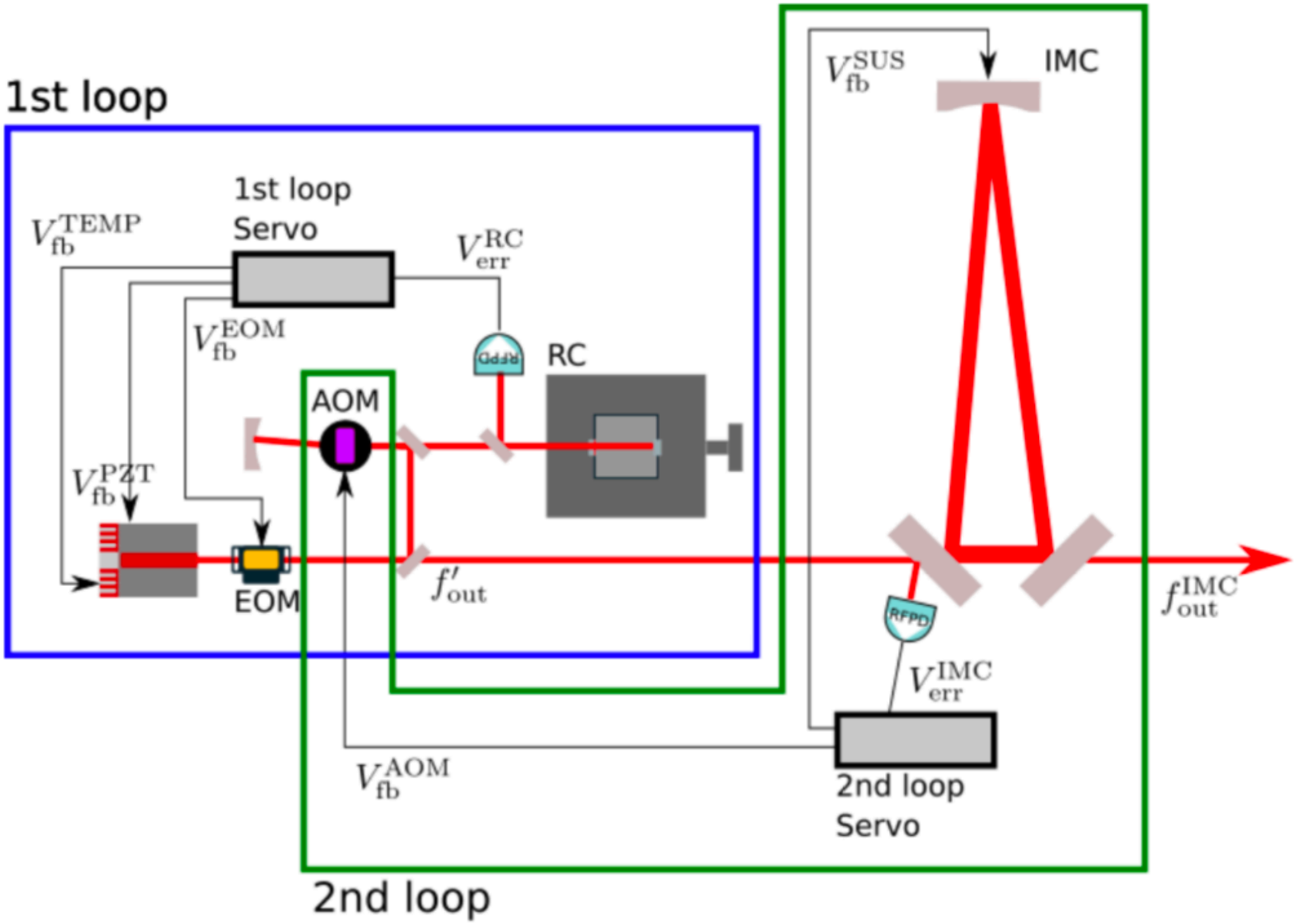
Input Mode Cleaner (IMC)

- Suspended triangular cavity
  - ✓ Cavity length: 25 m
- Located in the vacuum chamber.
- Objectives
  - ✓ The spacial mode cleaning.
  - ✓ The frequency reference for the FSS.
  - ✓ The beam jitter reduction



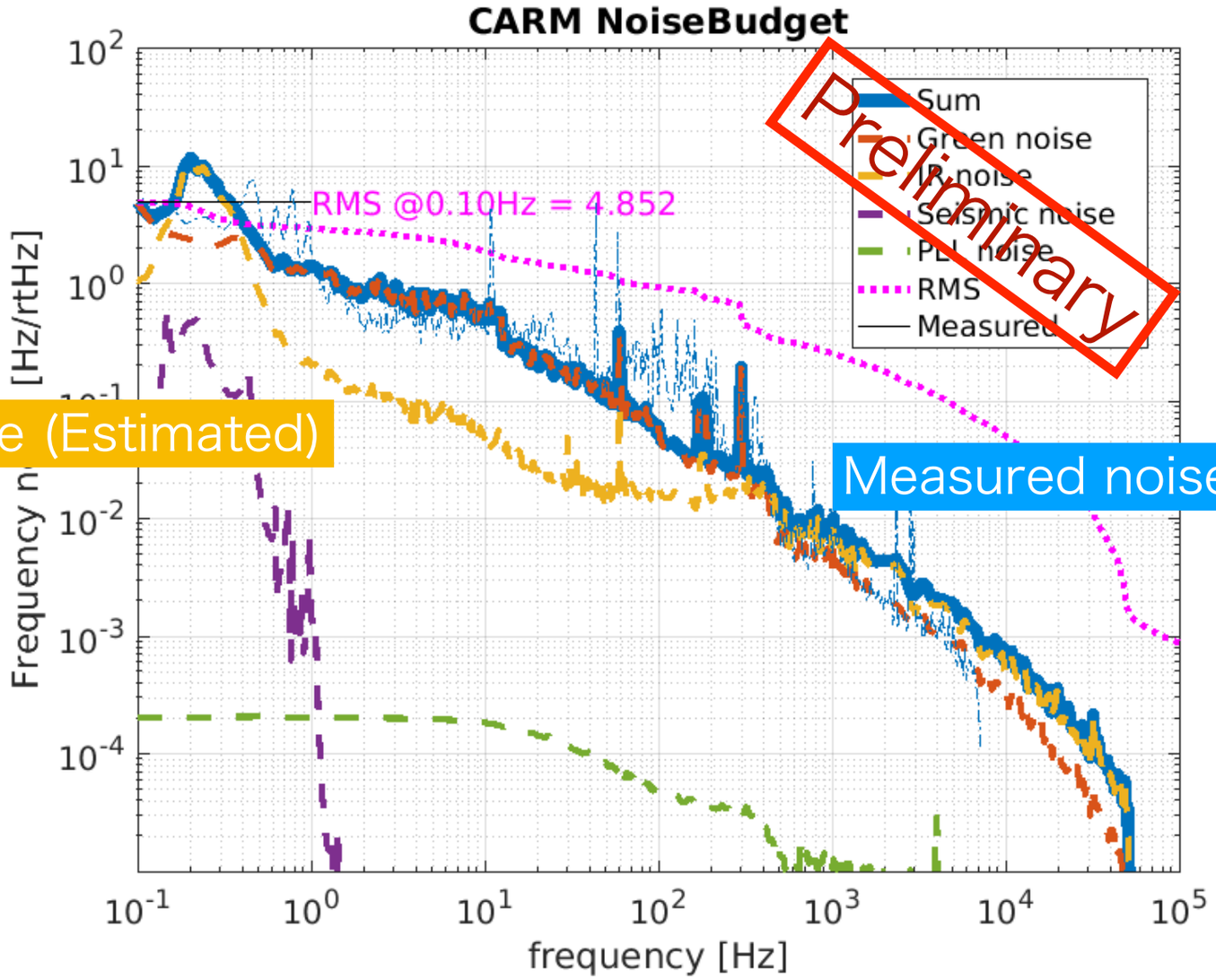


Frequency Stabilization



Frequency Noise

- The frequency noise was measured by using the Xarm
  - ✓ Orange: Estimated frequency noise by using the in-loop signal in the FSS loop.
  - ✓ The estimation seems to be overestimation by factor of 2 or more in high frequencies.



Frequency Noise (Estimated)

Measured noise in Xarm control

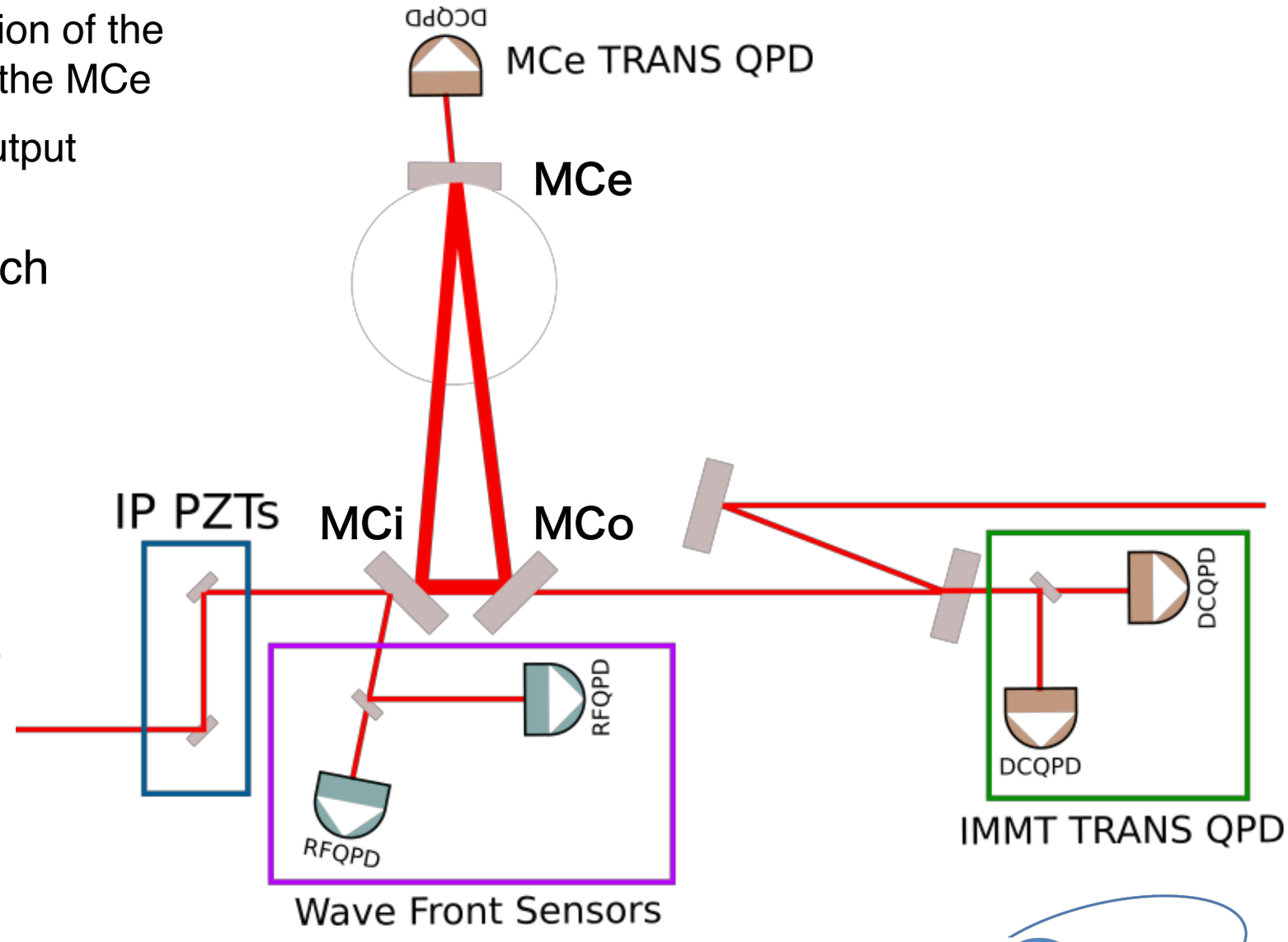
klog 7562

Calculated by Y. Enomoto, K. Yokogawa

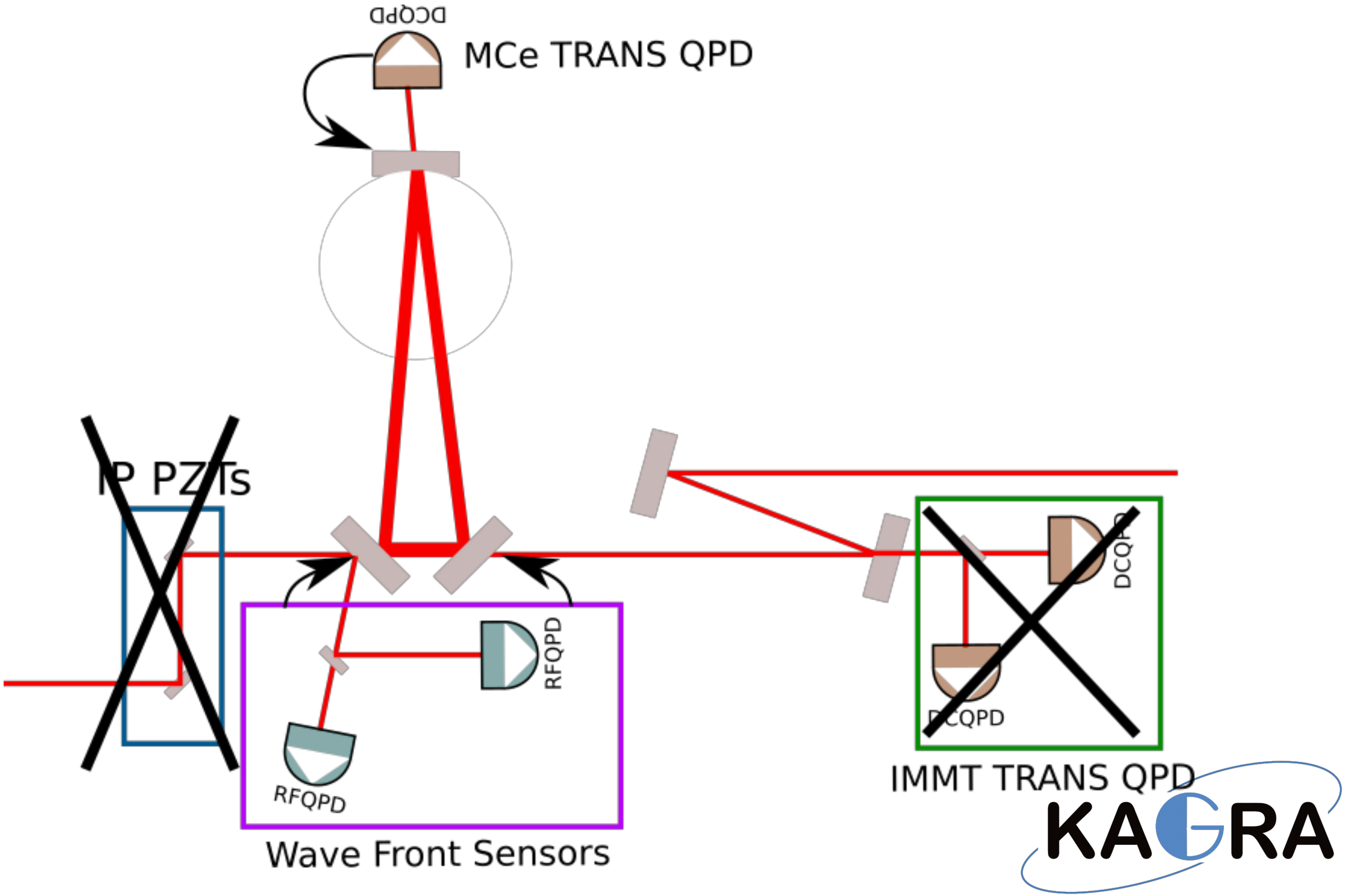
IMC Alignment Sensing and Control (ASC)

IMC alignment sensing & control (ASC)

- 5 DOFs for each direction (pitch and yaw) to be controlled
  - ✓ Cavity axis (3 DOFs for each direction)
    - ➡Bases: Common/Differencial motion of the MCi and MCo, Beam position on the MCe
    - ➡The cavity axis determines the output beam axis.
  - ✓ Injection beam (2 DOFs for each direction)
- 5 sensors
  - ✓ WFS on the IMC REFL table
  - ✓ DC QPD for the MCe TRANS
  - ✓ DC QPD for the IMMT TRANS
- 5 actuators
  - ✓ Input pointing PZTs.
    - ➡In the PSL room.
  - ✓ IMC suspended mirrors.

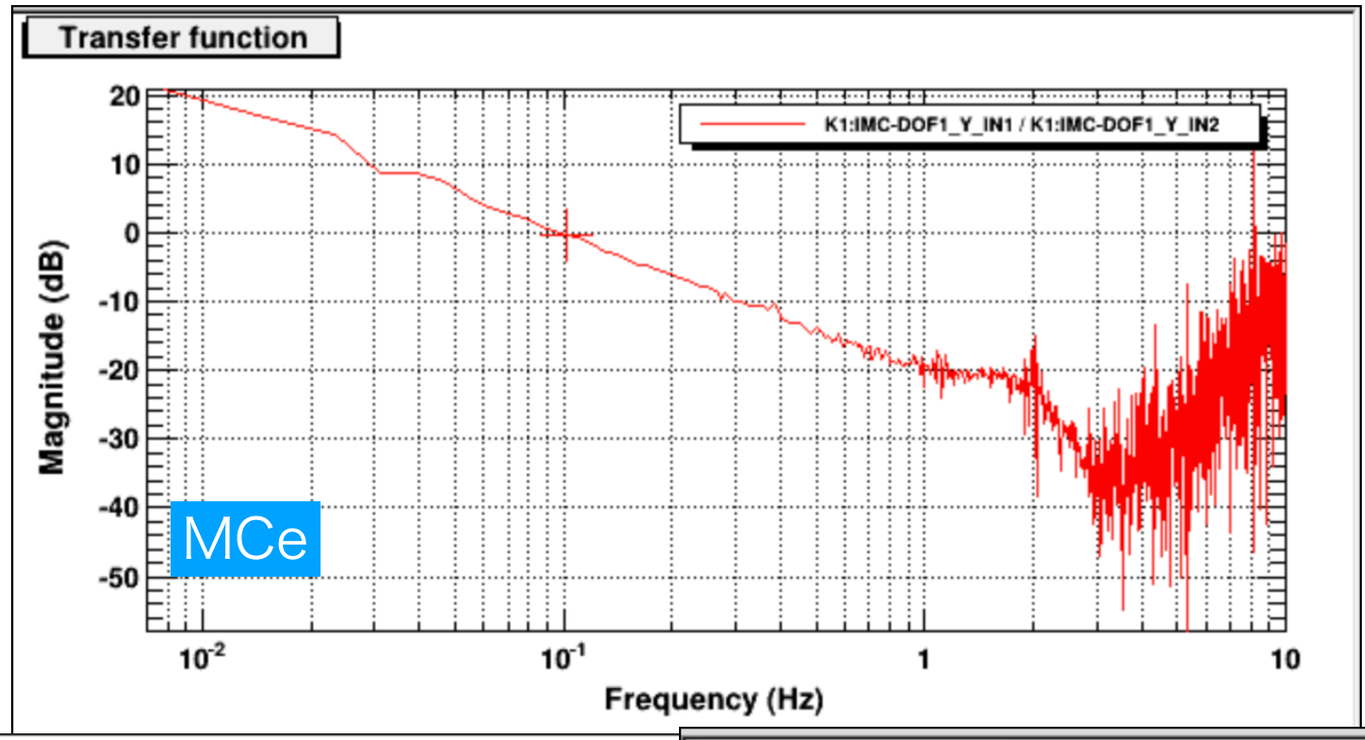


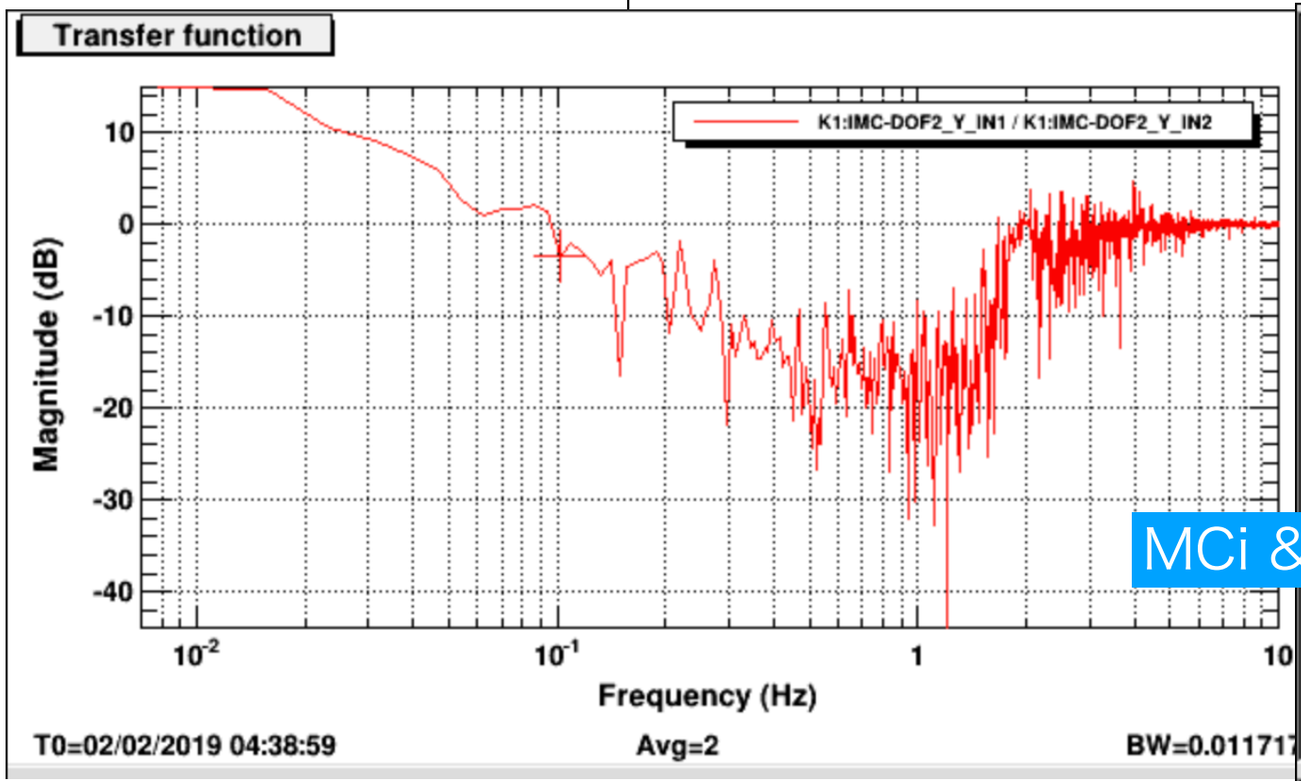
IMC ASC (current configuration)

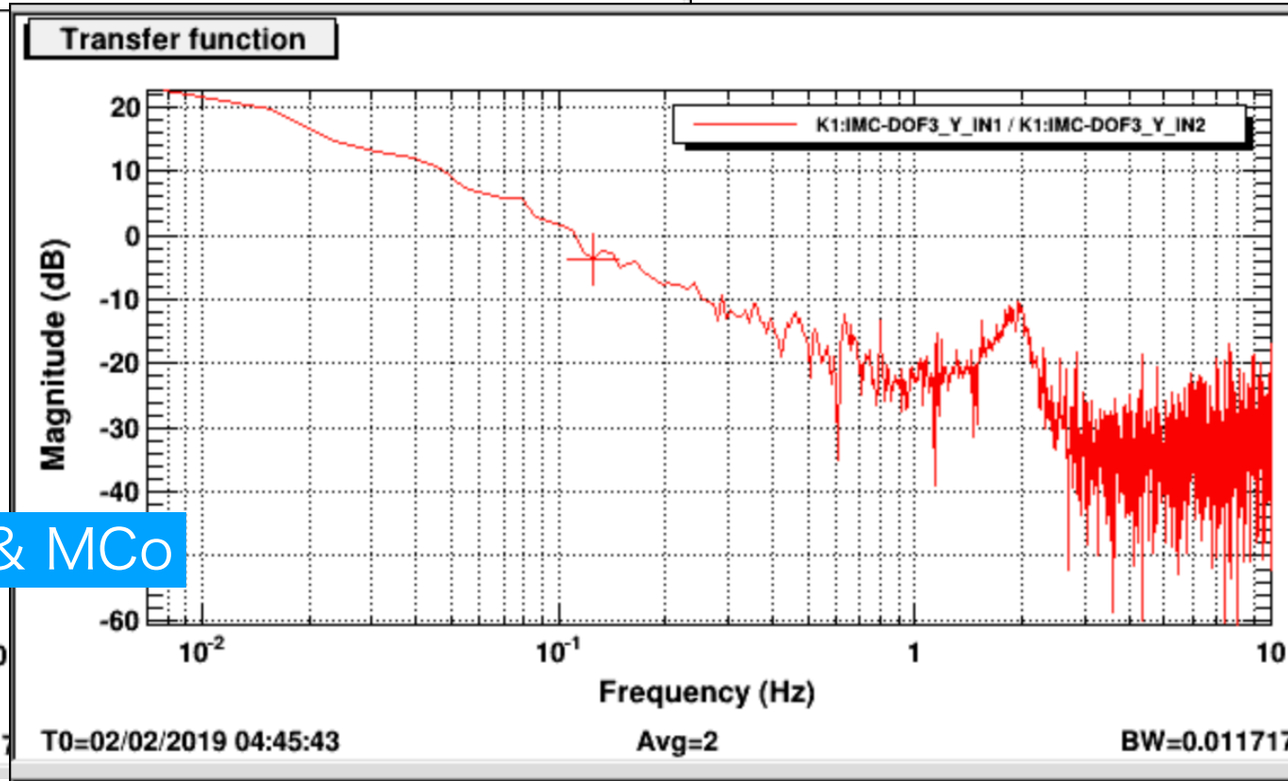


Control bandwidth

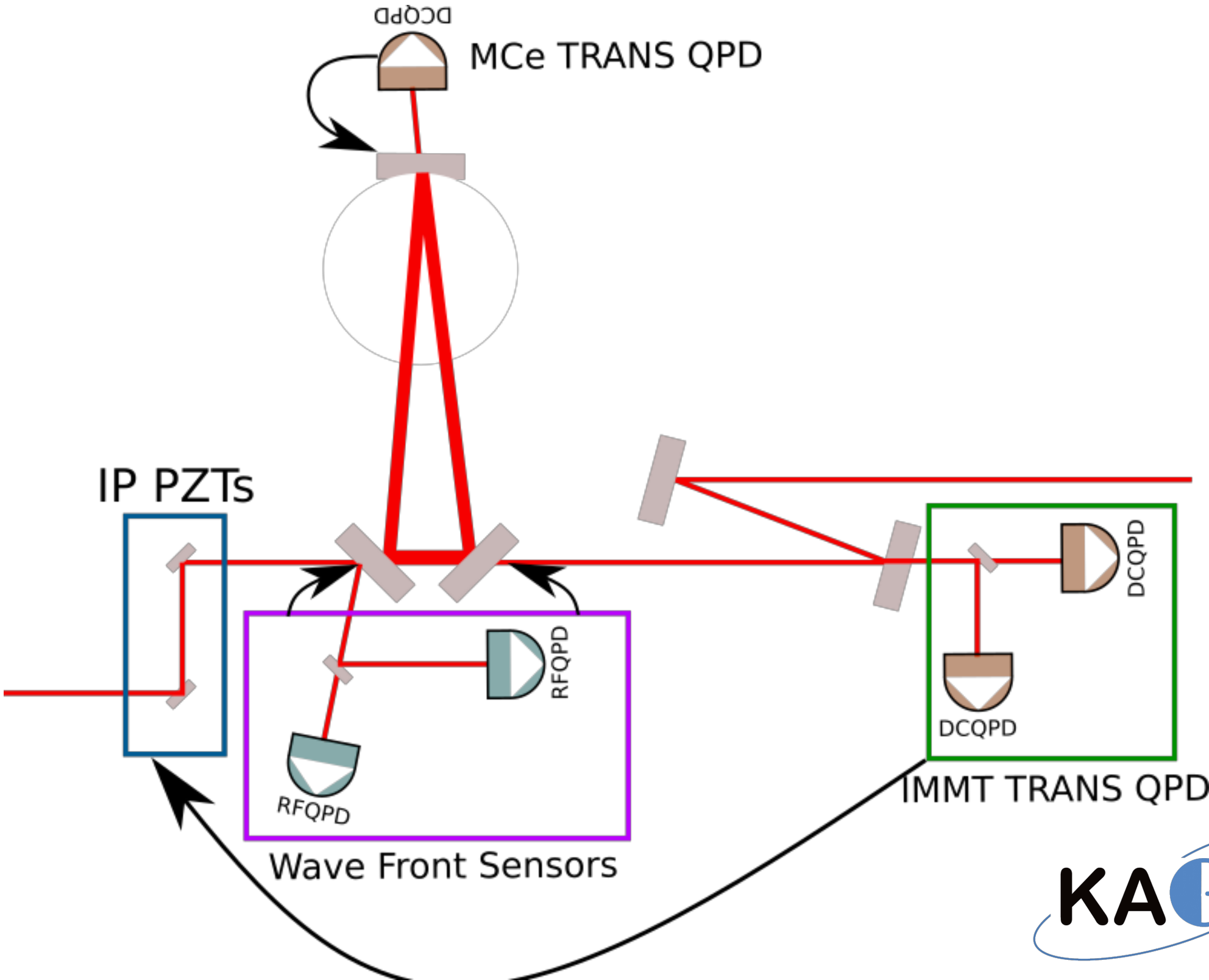
- For all DOF, the UGF is 0.1 Hz



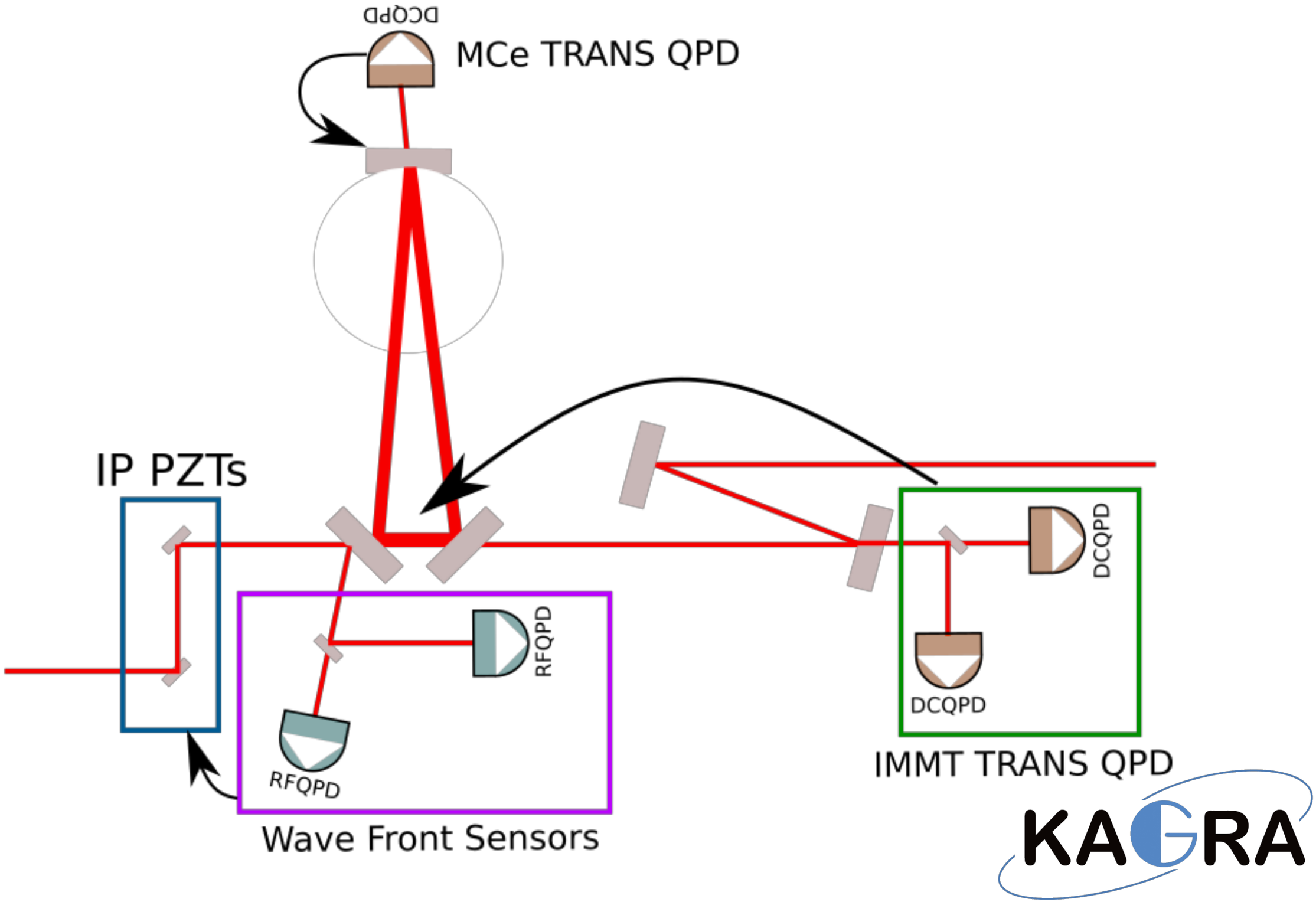




IMC ASC (final configuraion 1)

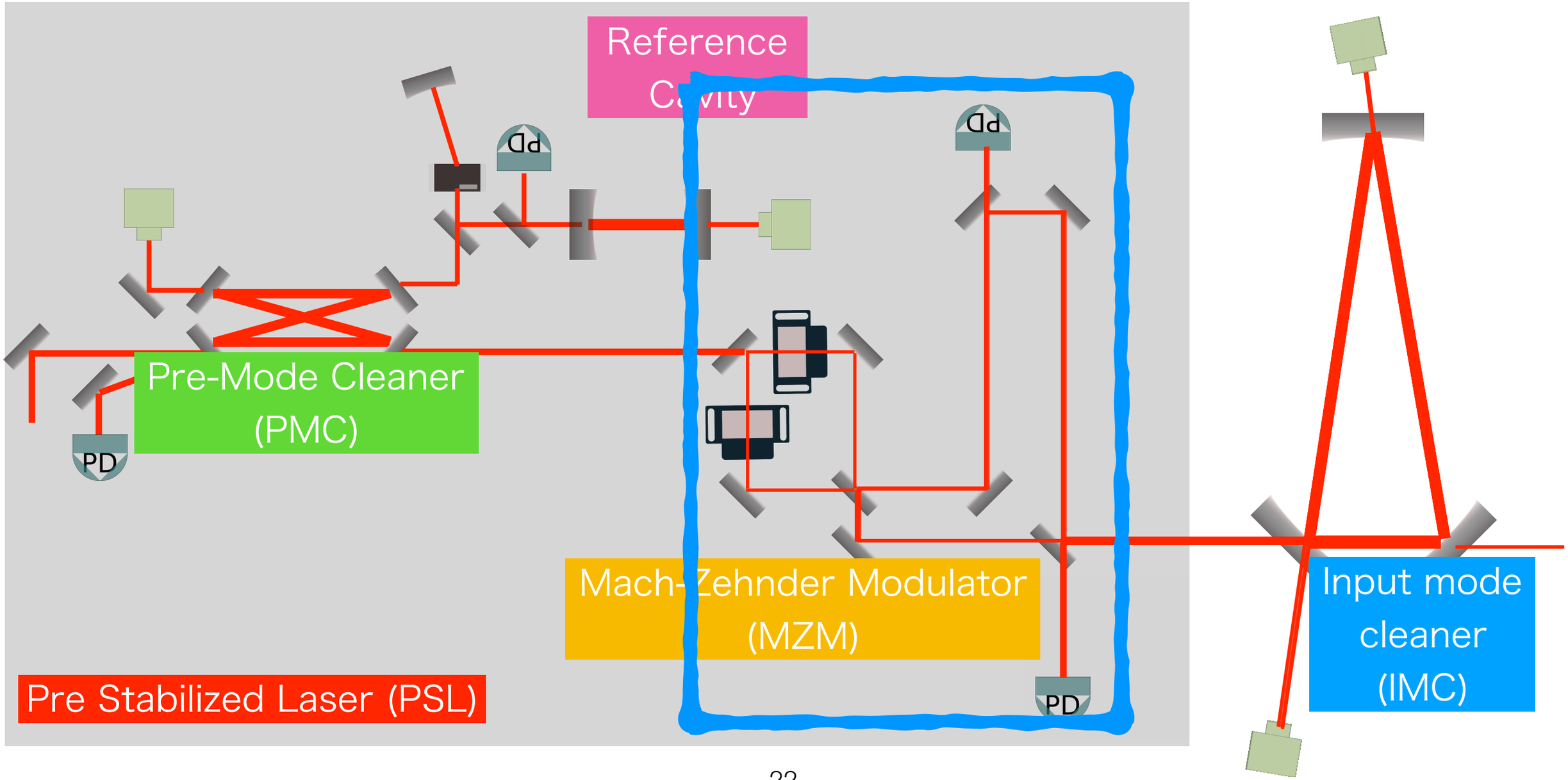


IMC ASC (final configuration 2)



Mach-Zehnder Modulator (MZM)

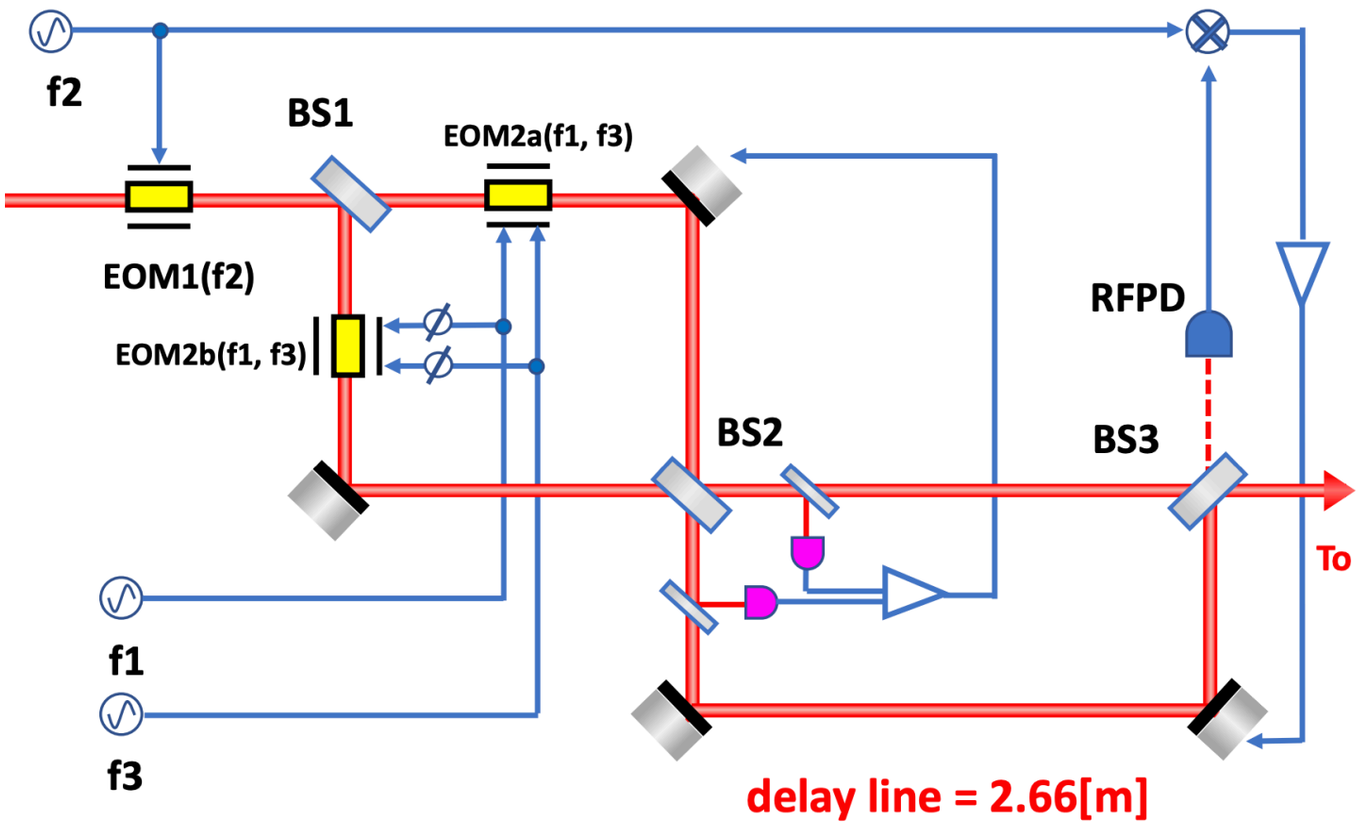
Overview of the input optics

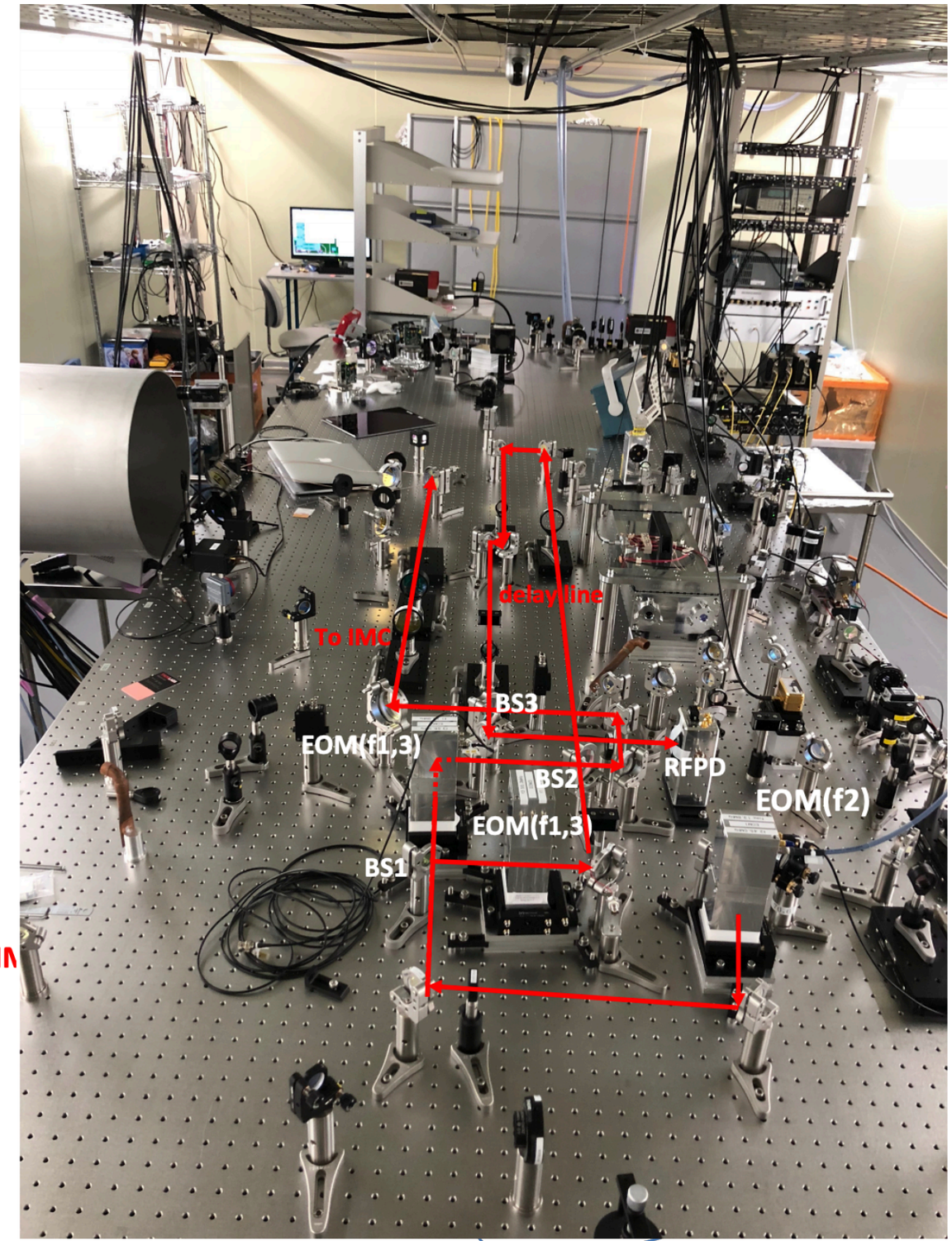


Mach-Zehnder Modulator (MZM)

Kohei Yamamoto, JGW-G1909583

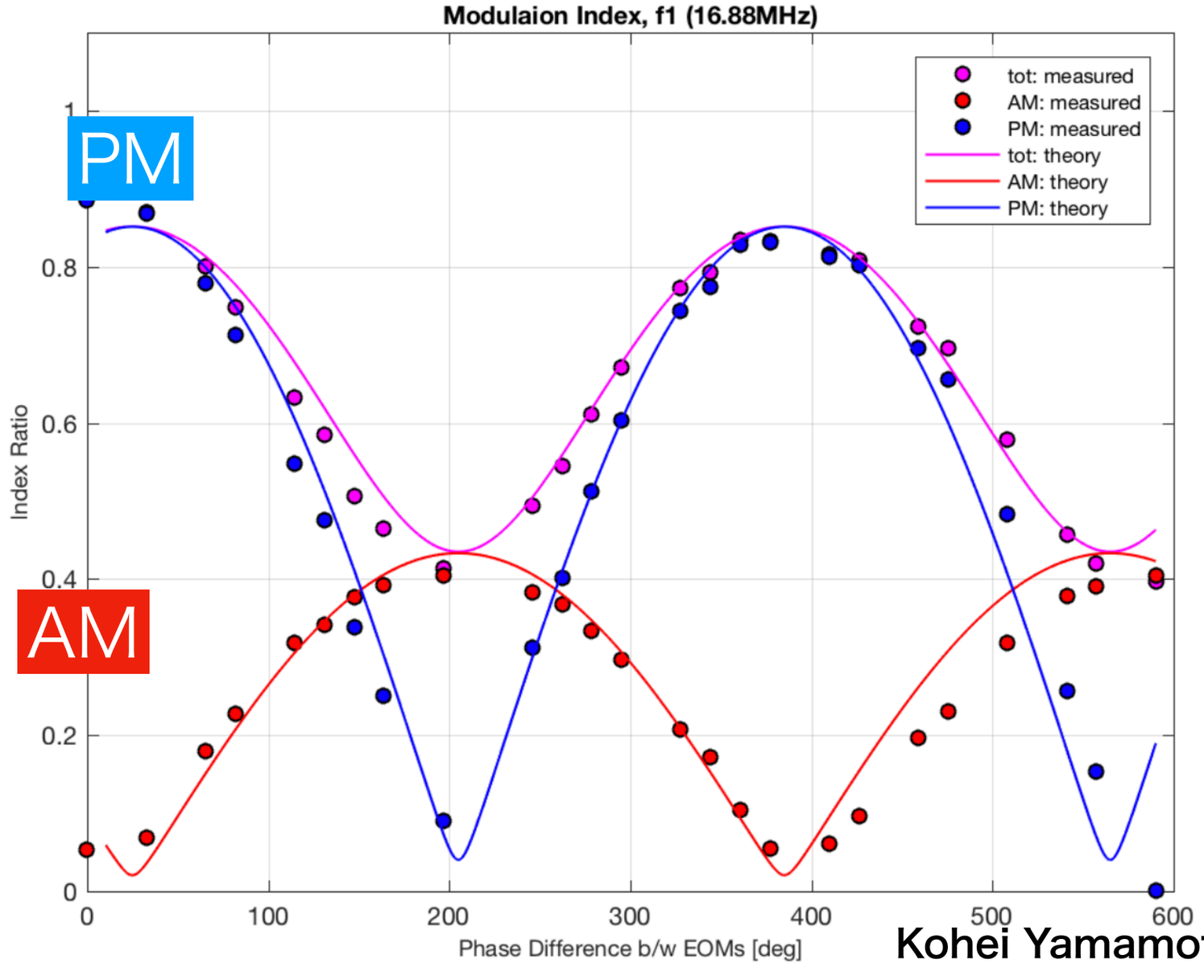
- MZM can generate the tunable AM
  - ✓ To cancel the AM generated by the detuning of the RSE interferometer
  - ✓ To generate the AM for the lock acquisition
- MZM has been installed on the PSL.





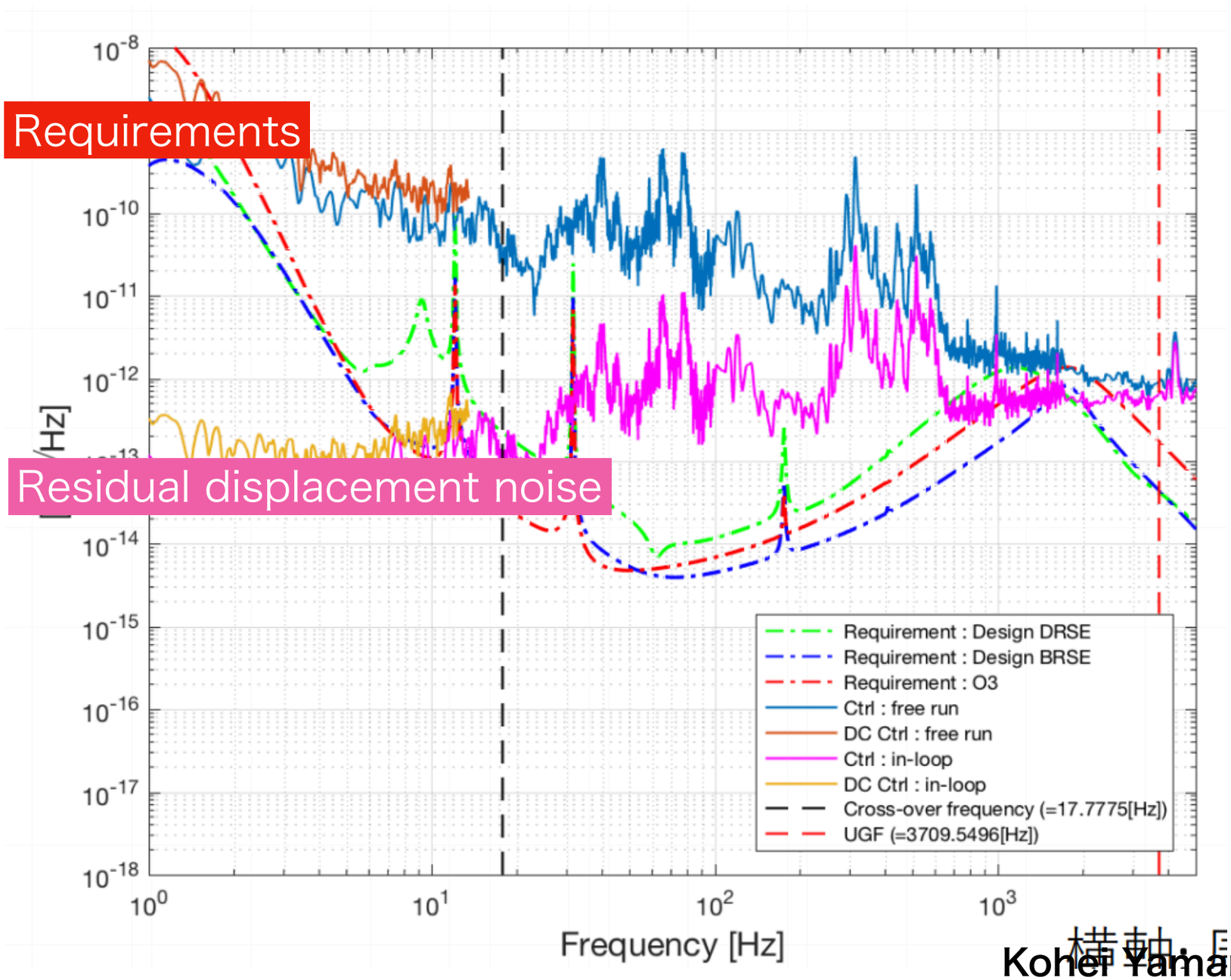
Mach-Zehnder Modulator (MZM)

- The AM can be tuned by tuning the phase difference between the EOMs
  - ✓ Demonstrated by the experiment



Displacement noise of the MZM

- The displacement noise couples with the GW signals via the modulations.
- The displacement noise has not met the requirement
  - ✓ We decided not to use the MZM for the O3.



Summary

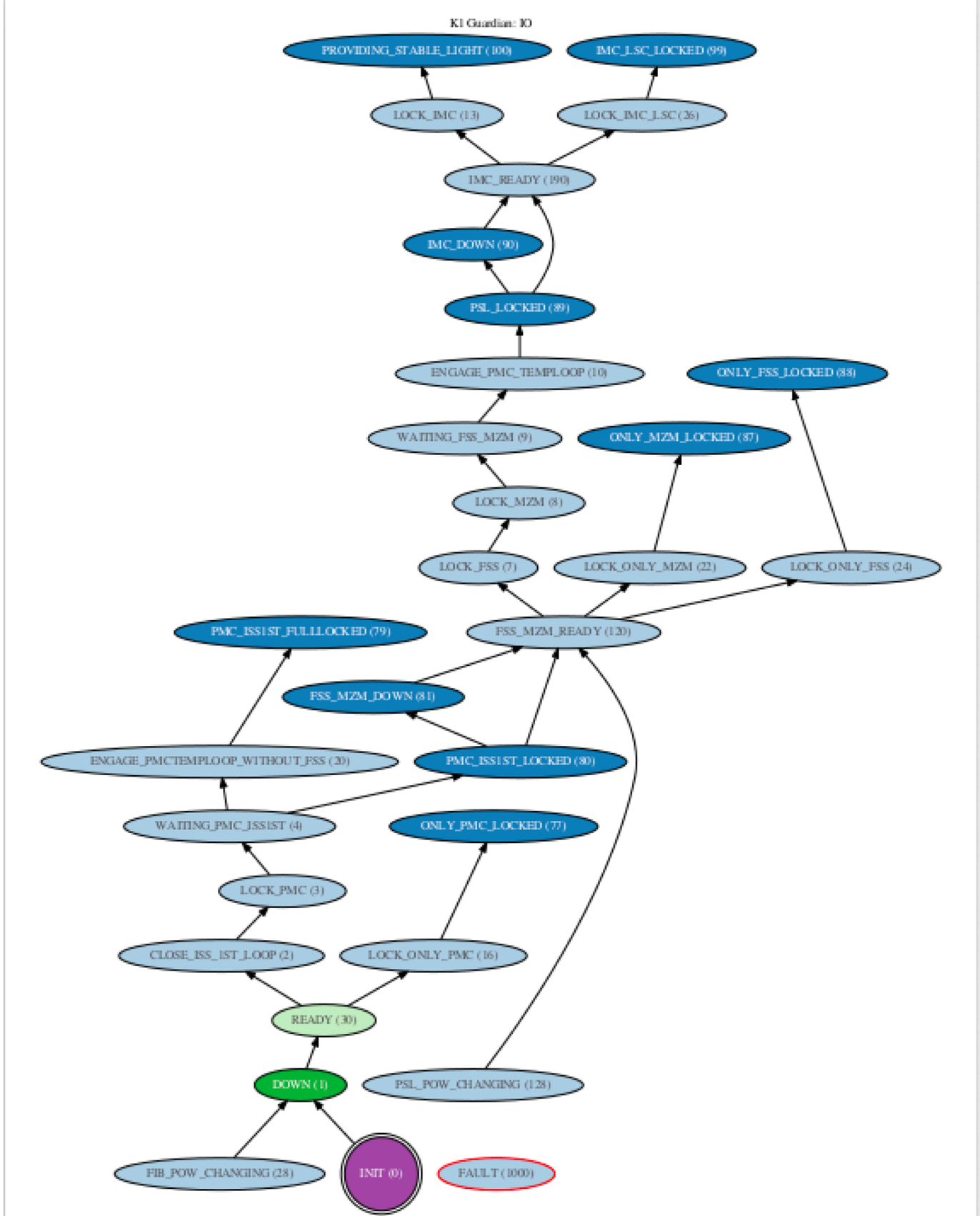
Summary

- Almost all system has been installed.
- All system are operated automatically with the guardian.
- The frequency noise has been estimated by using the Xarm control signal
- IMC ASC is using limited sensors so far.
  - ✓ It will be finalized in a couple of weeks.
- MZM has been installed and demonstrated to generate the tunable AM.
  - ✓ The displacement noise has not met the requirement.
    - Use the monolithic MZI?
    - Use the rigid mirror mounts?
- High power test is on going.
  - ✓ Up to now, the maximum power from the IMC is 4 W

Appendix

Guardian

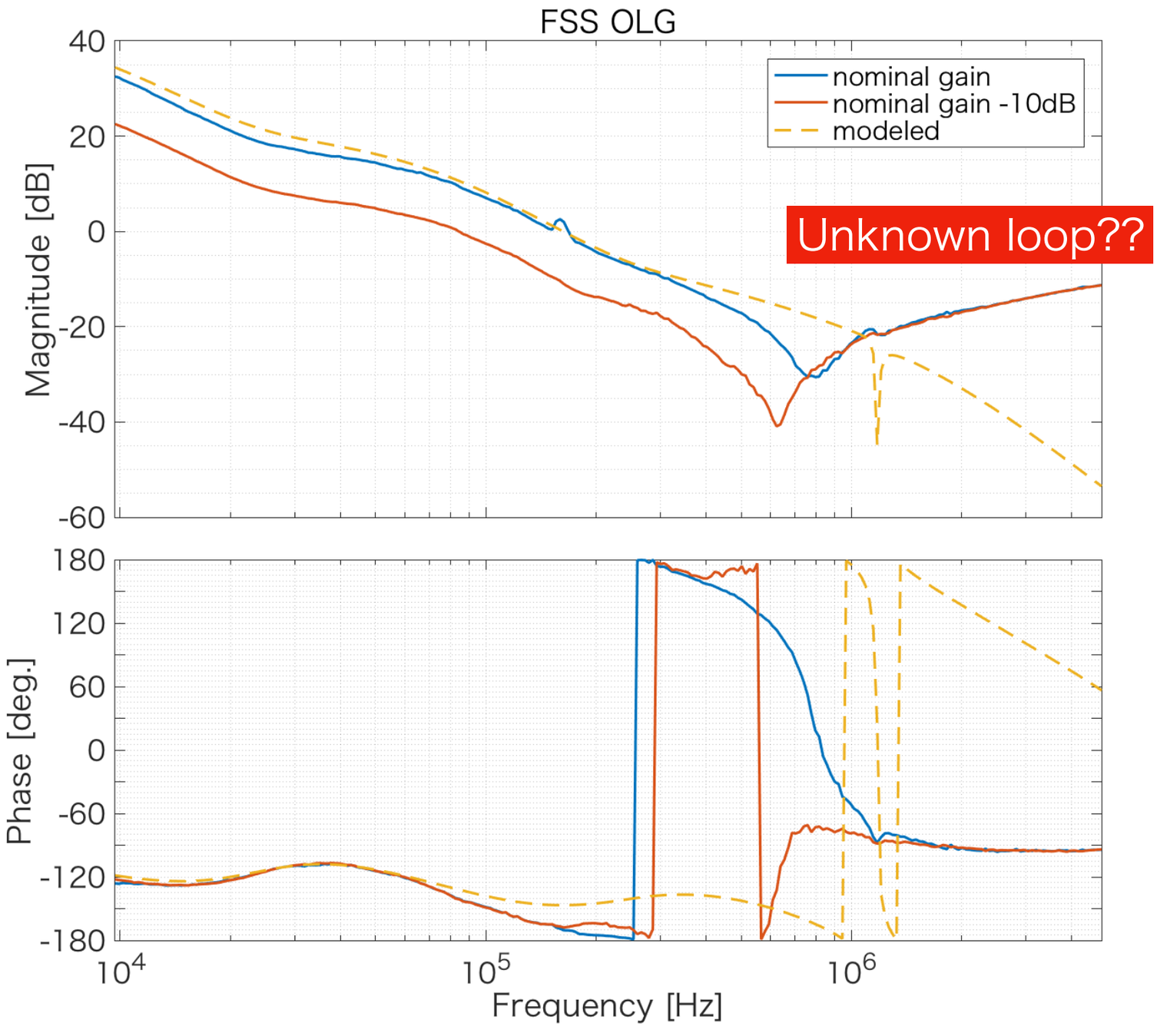
- All system has been operated automatically by using the guardian.



Status of the input optics

- Almost all system has installed.
- The maximum power from the IMC is 4 W so far.
- The alignment control for the input mode cleaner is not finalized yet.
- Although the modulation system using the Mach-Zehnder interferometer has been installed, the displacement noise does not meet the requirement for the O3.
  - ✓ We decided not to use the MZM in the O3.

Unknown loop in the FSS



- The plot shows the OLGs with two different servo gain.
  - ✓ At high frequencies no change, even the gain is different
  - ✓ There might be an unknown loop independent from the FSS loop

Control Bandwidth of the PMC

- UGF: ~6 kHz -> Is enough?