AndoLab Seminar

2022/11/18

Current Status of DPFP cavity experiment

M2　Masaya Ono

Abstract

- I will give a talk about my experiment “ASC of DPFP cavity”
  - However, now in the middle of commissioning of LSC

- For my experiment, we
  - Developed a suspension
  - Set up LIGO CDS

- I will introduce and share their products such as documents, data

Contents

- Suspension
- LIGO CDS
- Sensors and Actuators
- Current Status
- Future works

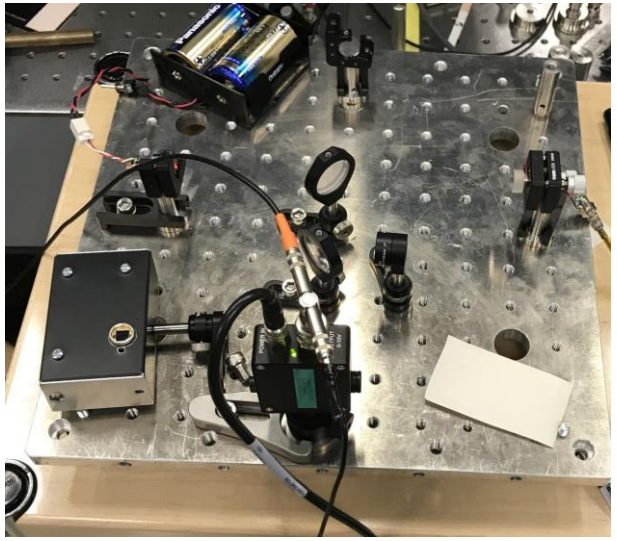
AndoLab Company Suspension

What is AndoLab Company ?

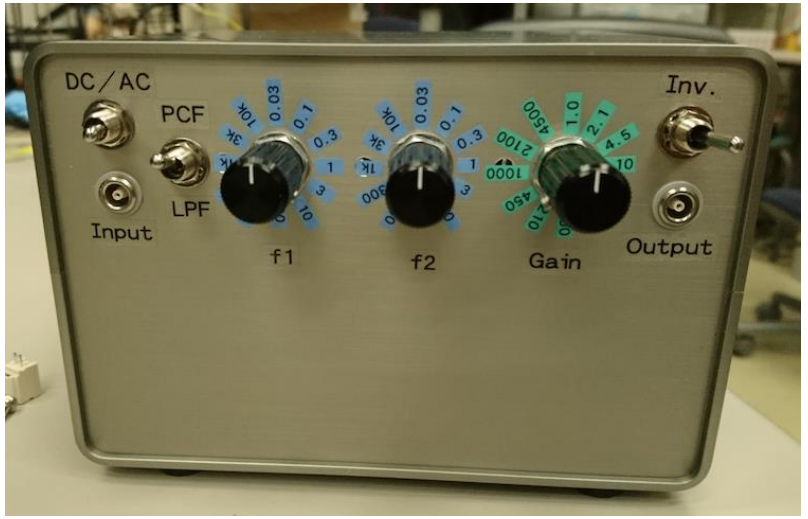
Meetings to develop some products which can be used for a wide range of purposes

So far, ALC is held 3 times

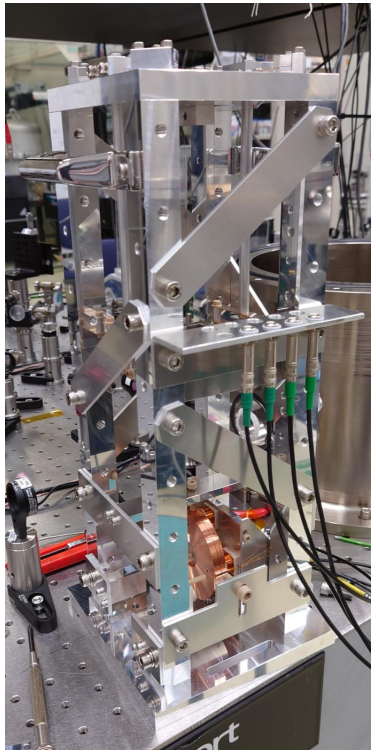
- Simple Michelson Interferometer for Outreach event (2019 / 6 ～ 2019 / 8)
- Switchable filter circuit (ST560) (2019 / 6 ～ 2019 / 7)
- **Suspension** (2022 / 6 ～ 2022 / 8)



Outreach MI



ST560



Suspension

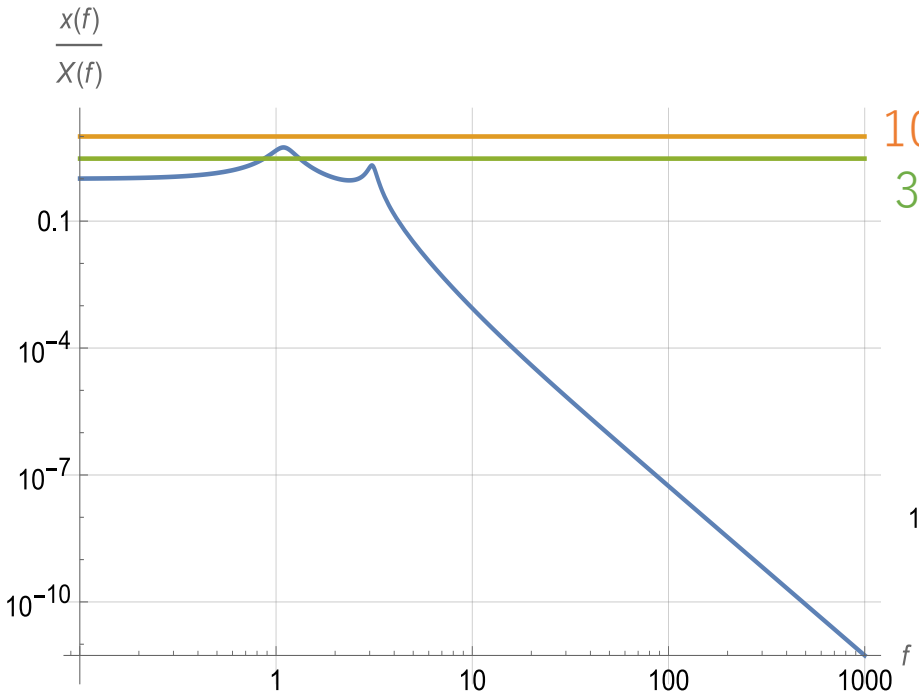
All 10 meetings

1. 6/14 Start-off
2. 6/21 Determine the design concept
3. 6/29 How to build the suspension
4. 7/6 Concrete procedures 1 to suspend masses
5. 7/12 Concrete procedures 2 to suspend masses
6. 7/20 Determine parameters of suspension (Resonant frequency,Weight of masses)
7. 7/27 Discuss CAD design (about the main suspension)
8. 8/3 Discuss CAD design (about Jigs)
9. 8/10 Discuss CAD design (about frames, coil holders, safeties, etc..)
10. 8/24 Final confirmation

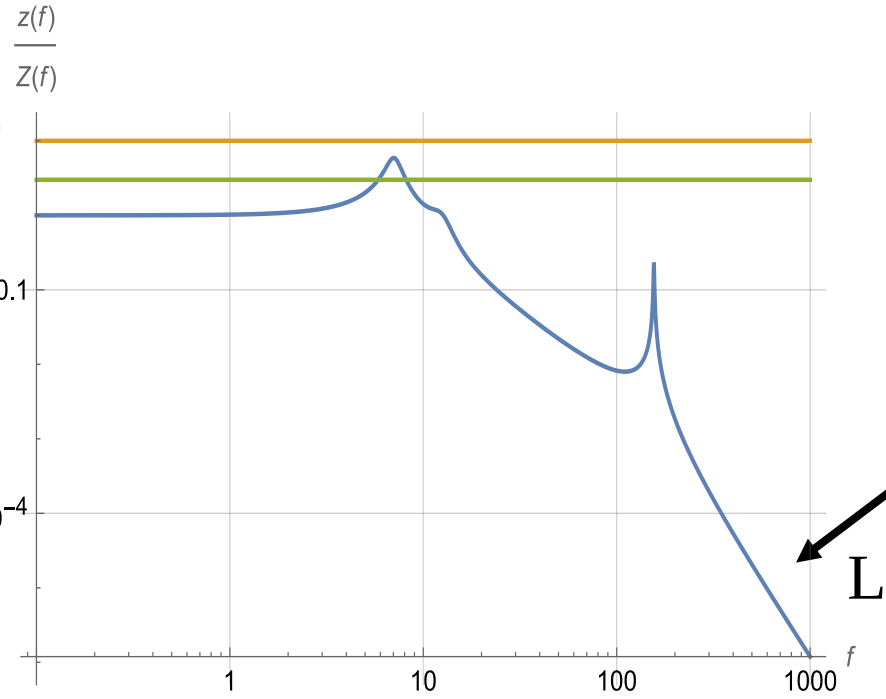
Took 2 months !!

Designed suspension

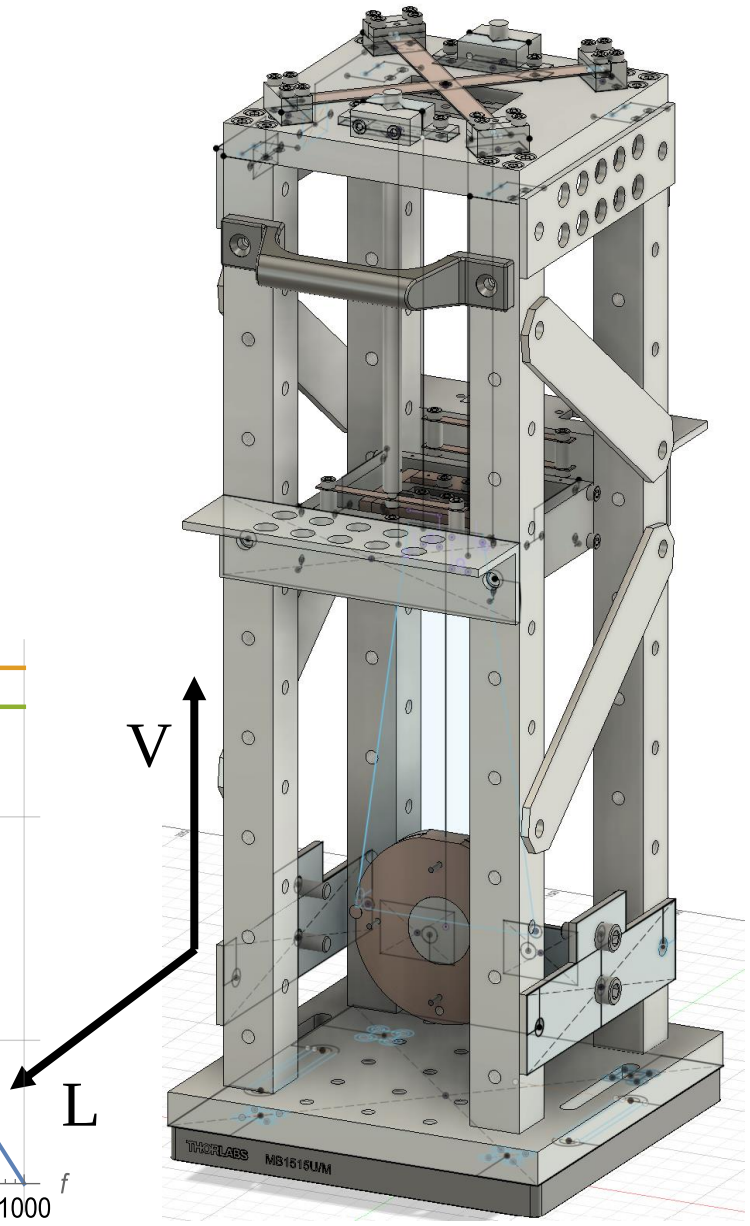
- 3 stages (SUSP, Intermediate Mass, Test Mass)
- Intermediate Mass is damped by eddy current



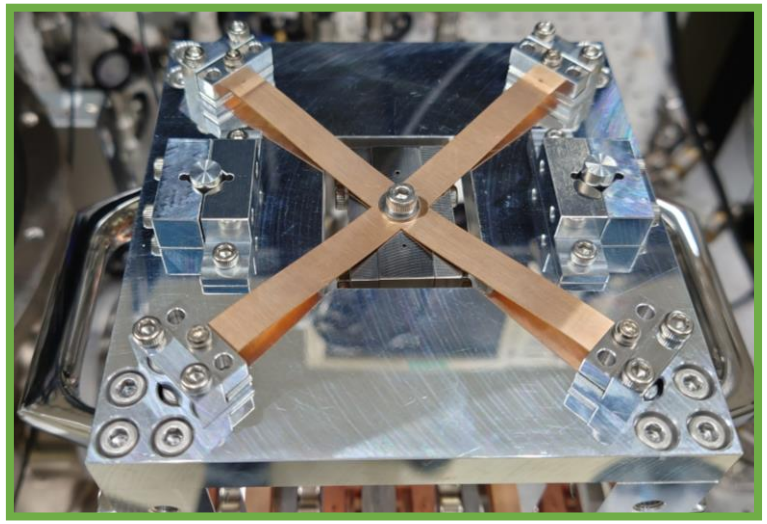
Transfer function “L” direction



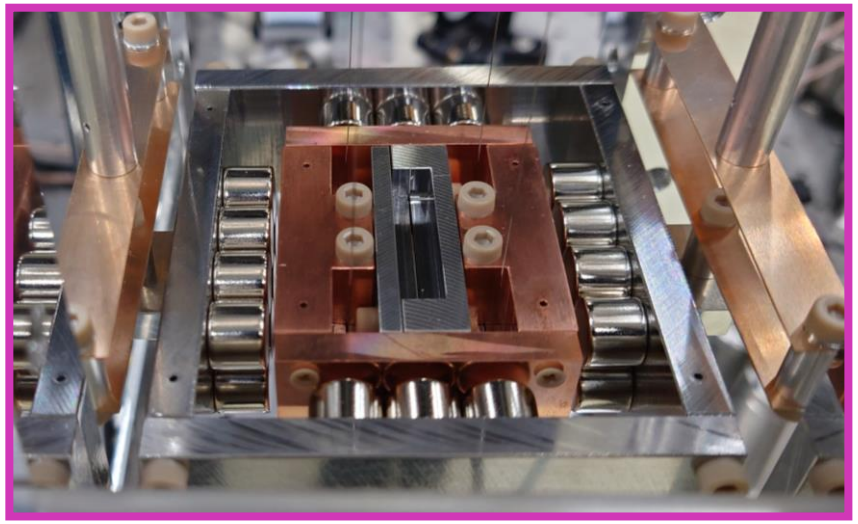
Transfer function “V” direction



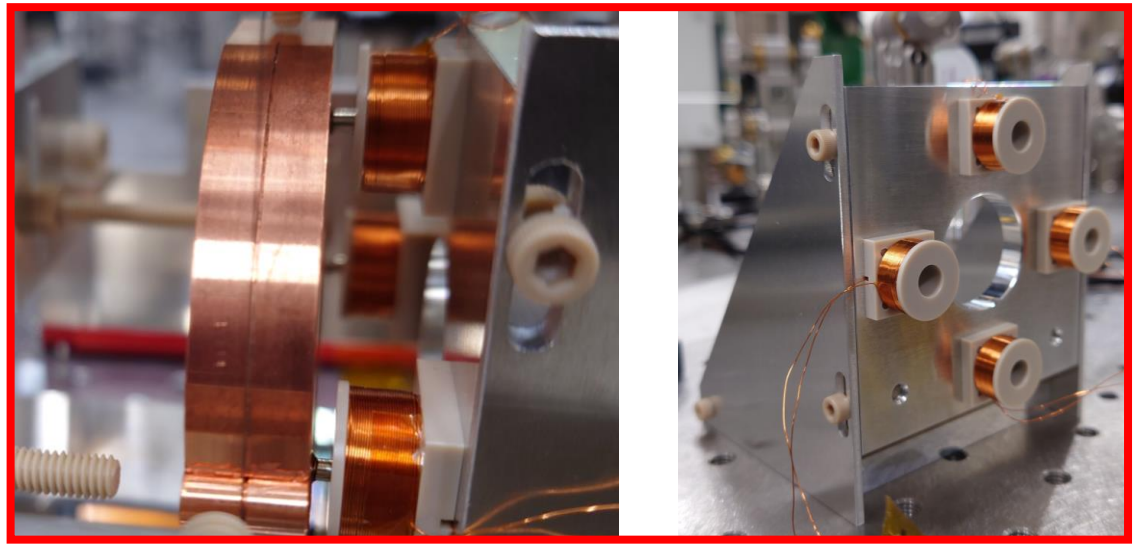
Actual suspension



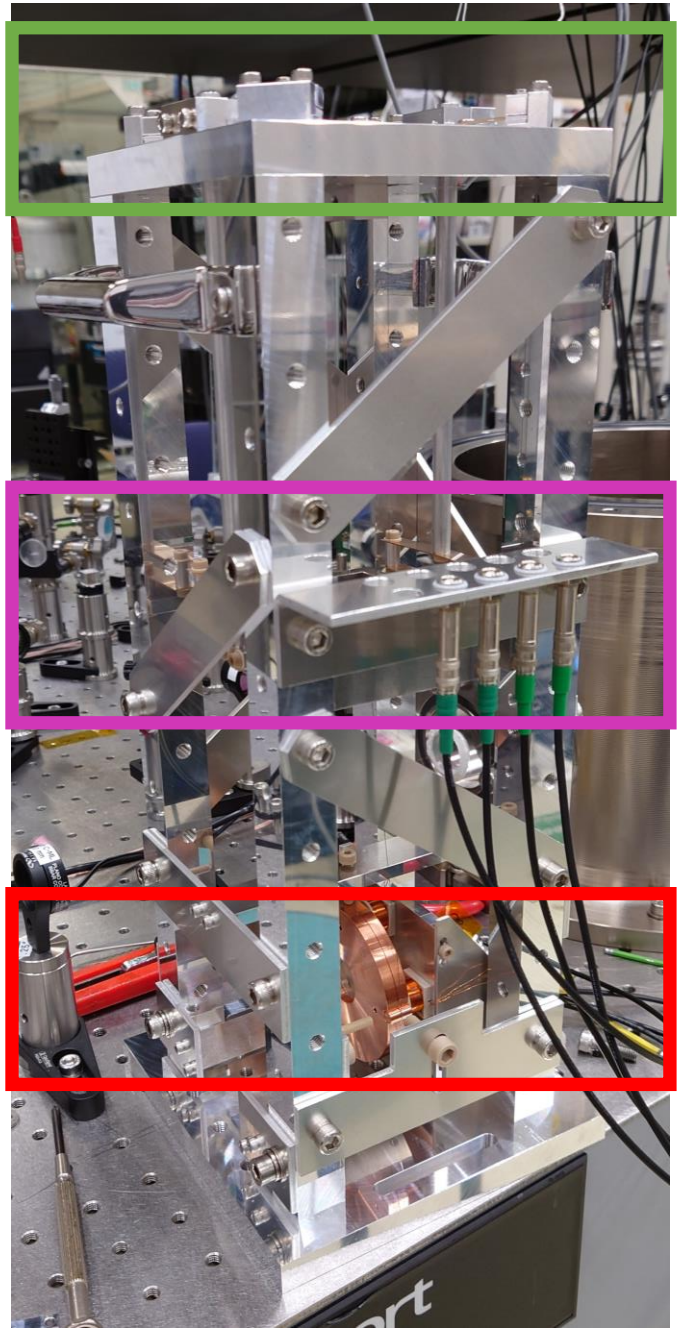
SUSP



Intermediate mass



Test mass and coils



Shared documents

If you are interested in our suspension, please refer to

- Parts list
  - Drawings(pdf), STP files,DXF files are available
- Notes in ALC meetings
  - Oshima-san wrote
  - Japanese

Suspension Parts †

You can download parts data collectively --> Suspension_parts.zip

The overall 3D model file of the suspension is here (Suspension全体 v96.stp)

Testmass Parts †

No.	Name	Material	Drawing	3D	2D	note
1	Testmass2	Copper	pdf	stp	dxf	
2	Testmass2_ear	Copper	pdf	stp	dxf	

Intermediatemass Parts †

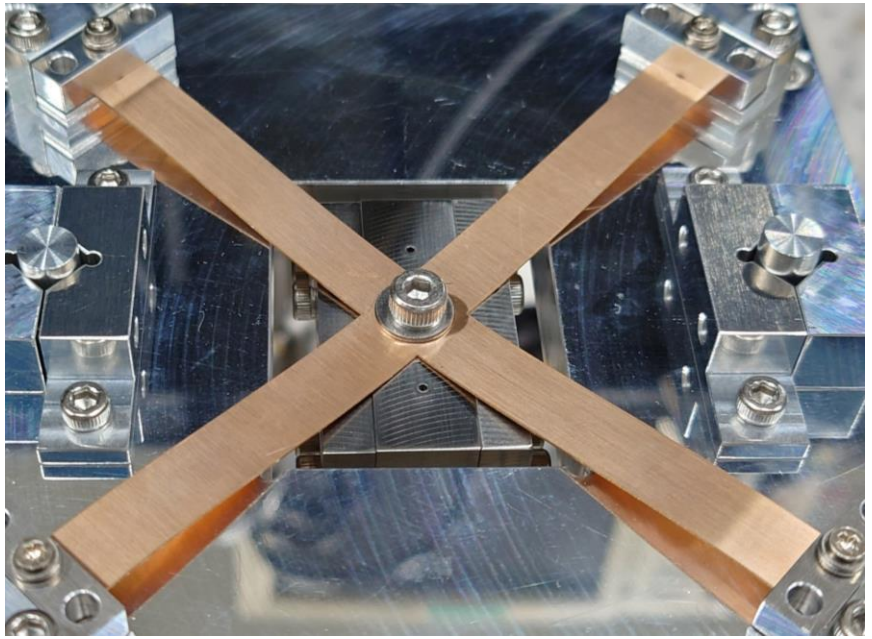
No.	Name	Material	Drawing	3D	2D	note
3	Intermediatemass2_Core	SUS	pdf	stp	dxf	
4	Intermediatemass2_Core_cramp	SUS	pdf	stp	dxf	
5	Intermediatemass2_upper_Cramp	SUS	pdf	stp	dxf	
6	Intermediatemass2_Cramp_plate	SUS	pdf	stp	dxf	
7	Intermediatemass2_Side_Cu1	Copper	pdf	stp	dxf	
8	Intermediatemass2_Side_Cu2	Copper	pdf	stp	dxf	

DampingMagnetSupport Parts †

No.	Name	Material	Drawing	3D	2D	note
9	DampingMagnetSupport_Side1	SUS	pdf	stp	dxf	
10	DampingMagnetSupport_Side2	SUS	pdf	stp	dxf	
11	DampingMagnetSupport_Cramp	Aluminum	pdf	stp	dxf	

Improvements

- Blade springs does not work well?



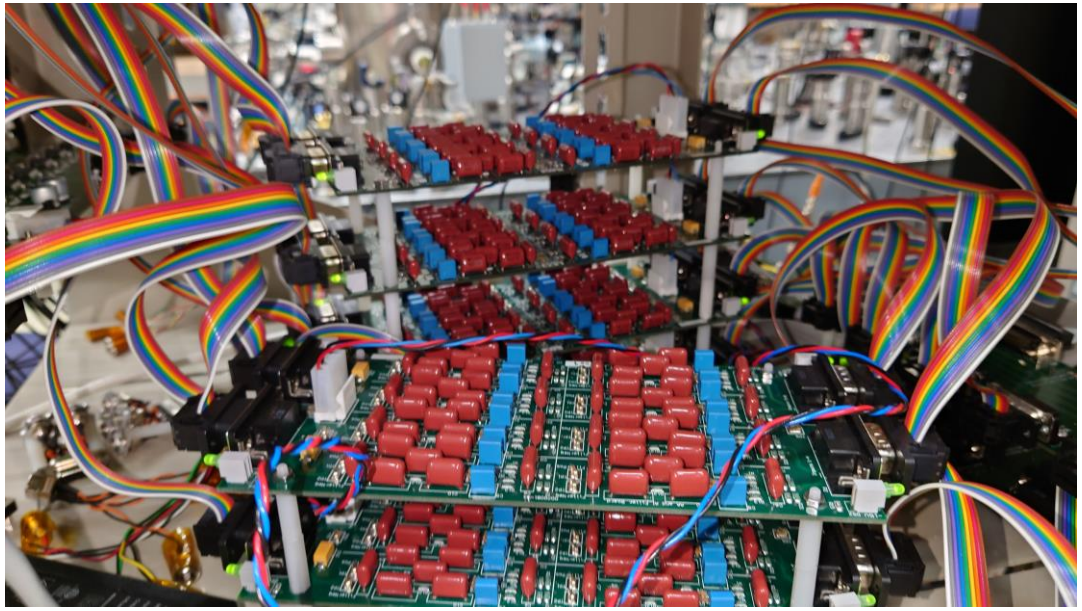
- Pitch resonance is relatively large
  - Using the suspension, I locked a suspended cavity
  - Watching a transmitted beam by a CCD camera, It fluctuate at 2 Hz which is approximately a designed pitch resonant frequency

LIGO CDS

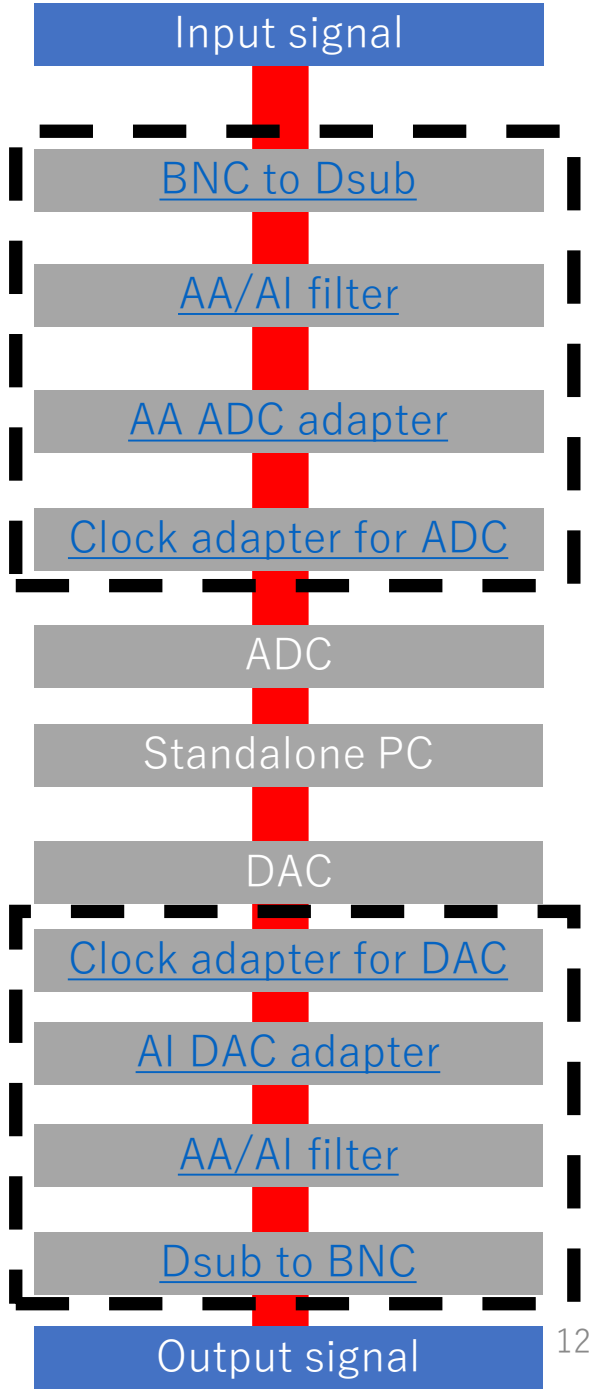
Many analog interfaces are required

denote analog interface circuits

You can access JGWdoc page from these links



AA/AI filters



LIGO CDS Timedelay

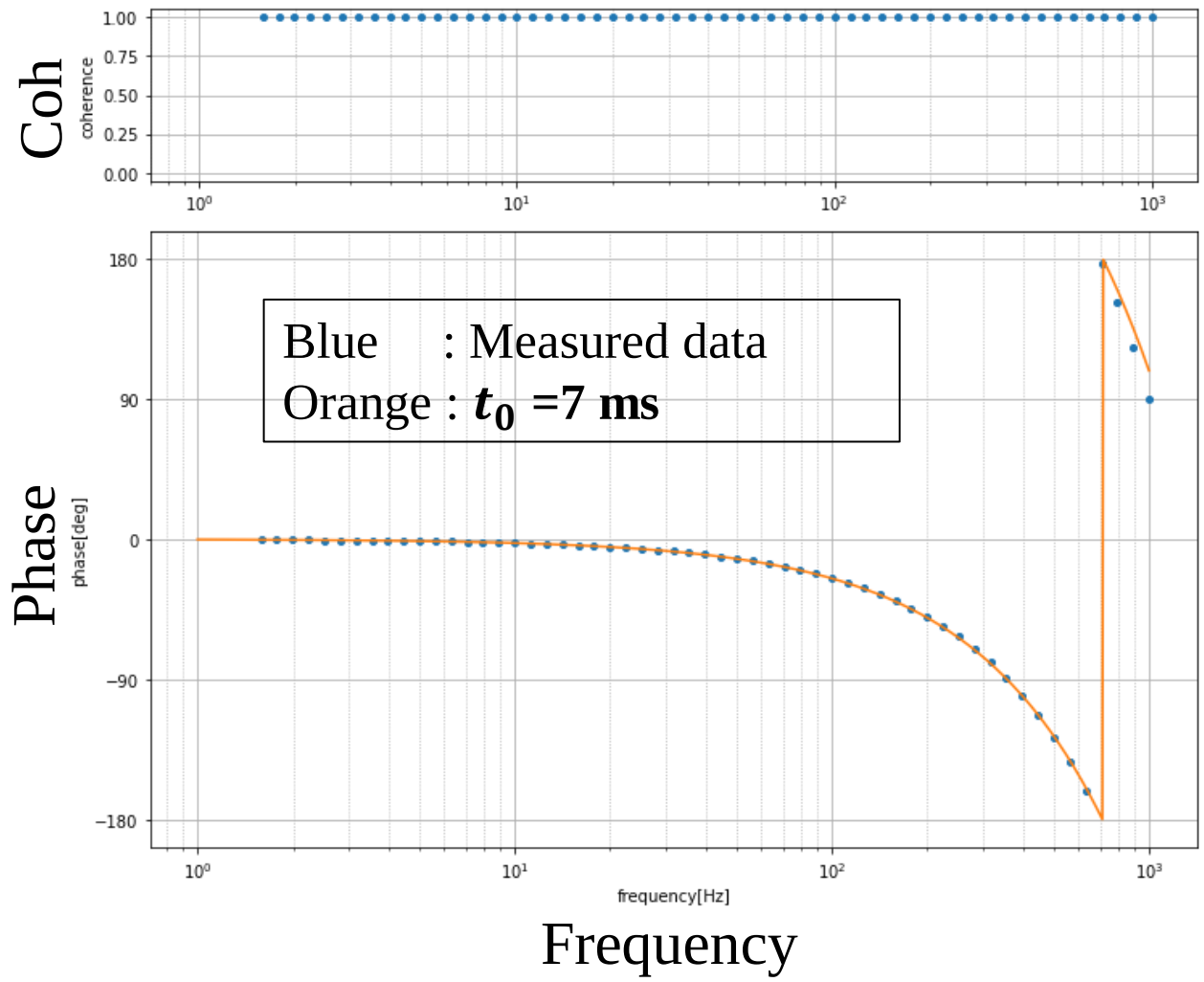
LIGO CDS is very useful but "**slow**"

We measured time delay of LIGO CDS and fitted data by the function $\mathbf{Exp(-2\pi i f t_0)}$

$\boldsymbol{t_0}$ is the time constant and we set it as a fitting parameter

$$\boldsymbol{t_0 = 0.7 \times 10^{-3}[s]}$$

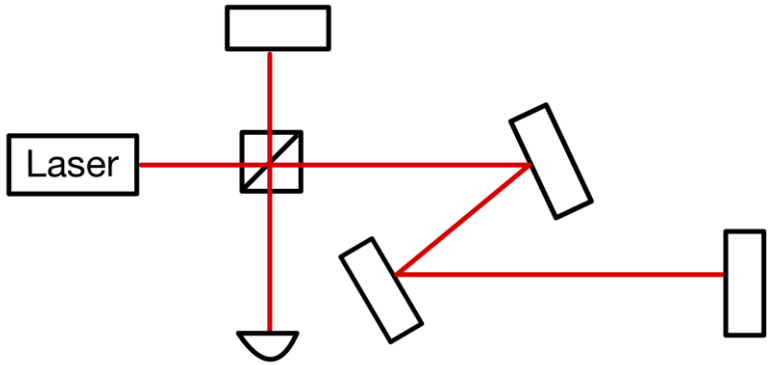
Now LSC is achieved by Moku:Go



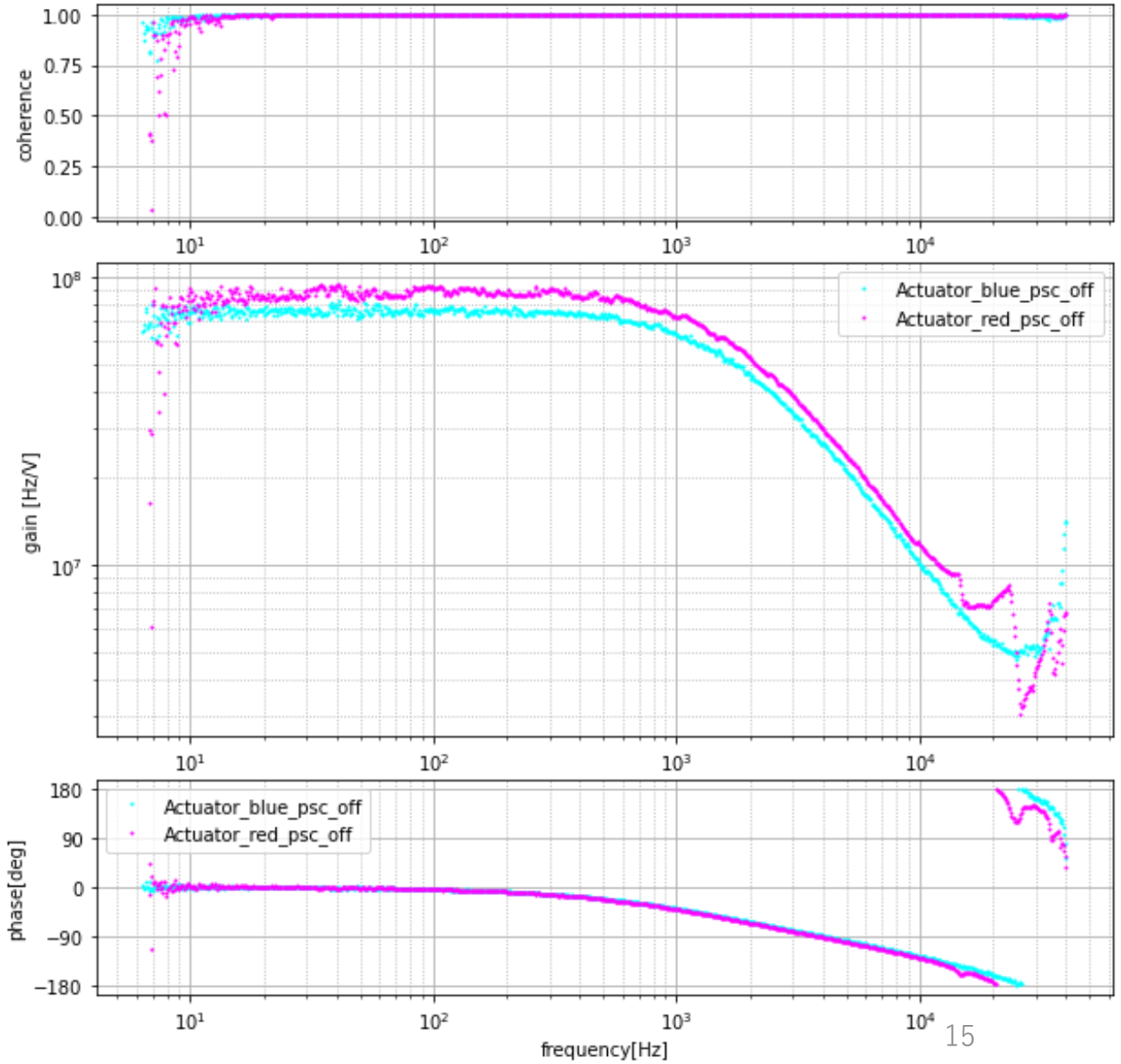
Sensors and Actuators

Laser frequency actuator

Constructed Anti Symmetric Michelson Interferometer and measured laser (Koheras BASIK Y10) “frequency actuator efficiency” and “frequency response”

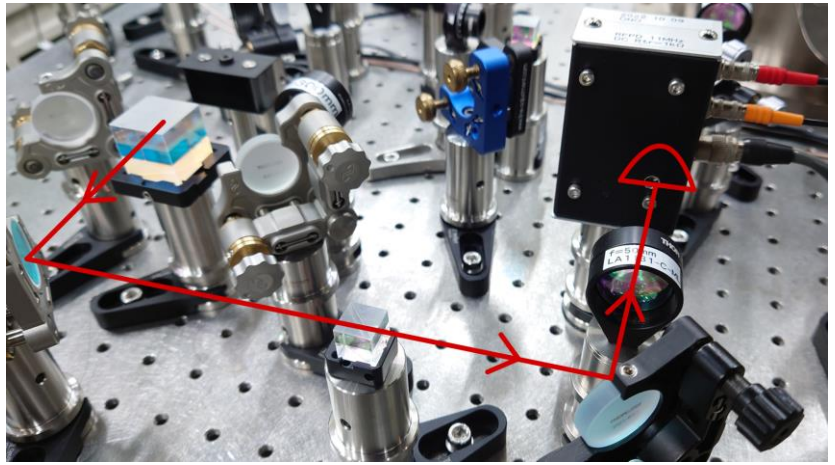


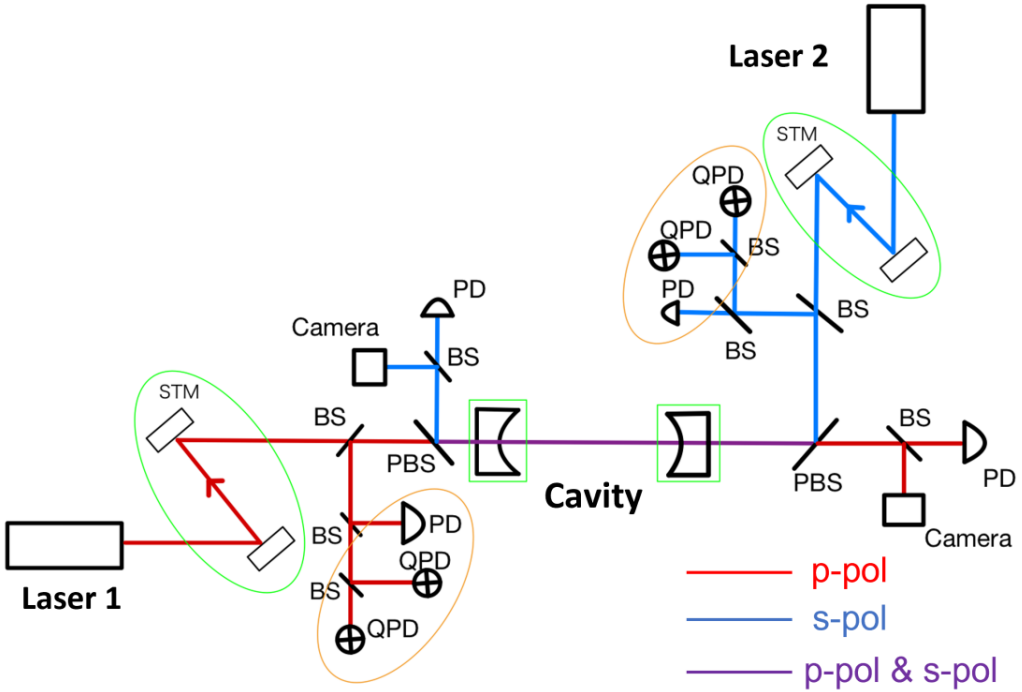
Actuator efficiency ≅ 80 [MHz/V]

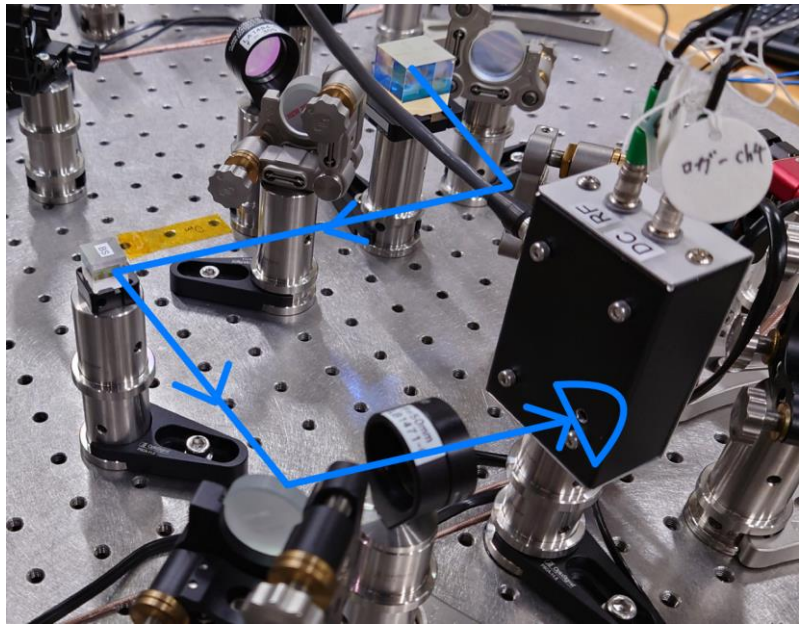


RFPD

To sense the error of the length of the cavity,
I install 2 RFPDs in each reflection port

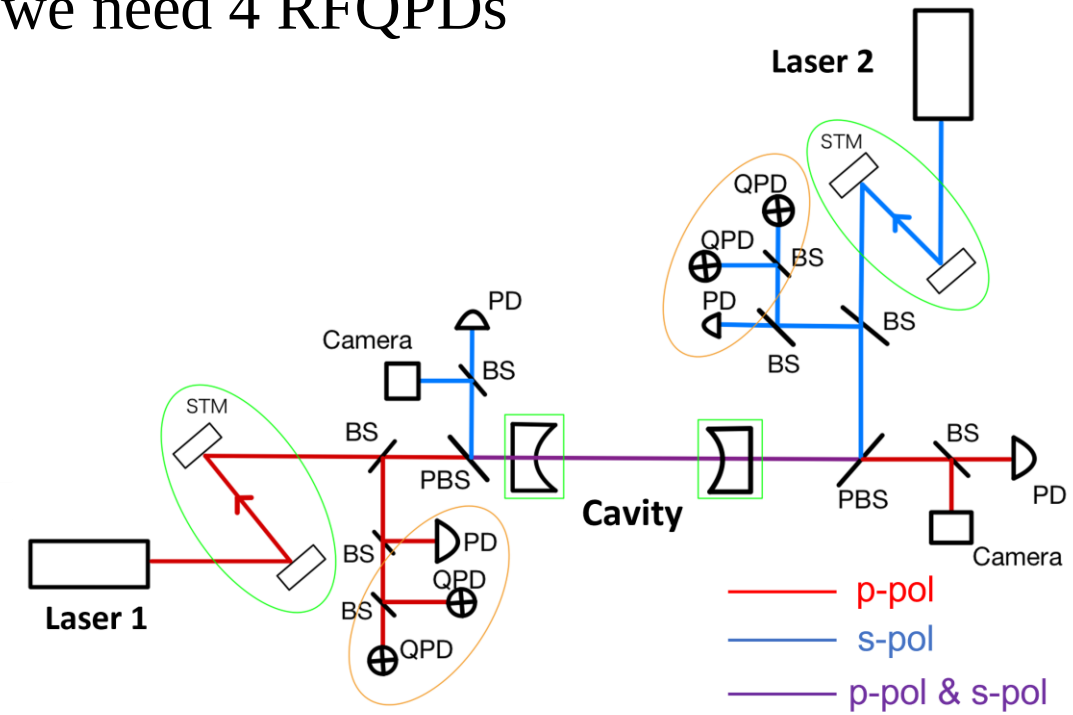


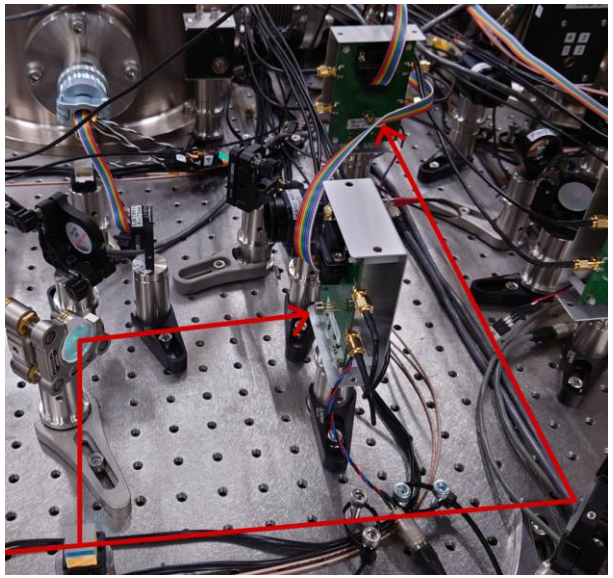




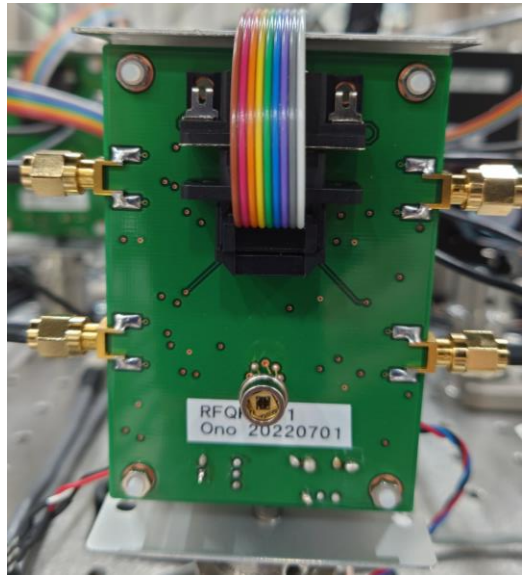
RFQPD for WFS

To sense the error between “the cavity axis” and each “laser axis” by WFS,
we need 4 RFQPDs

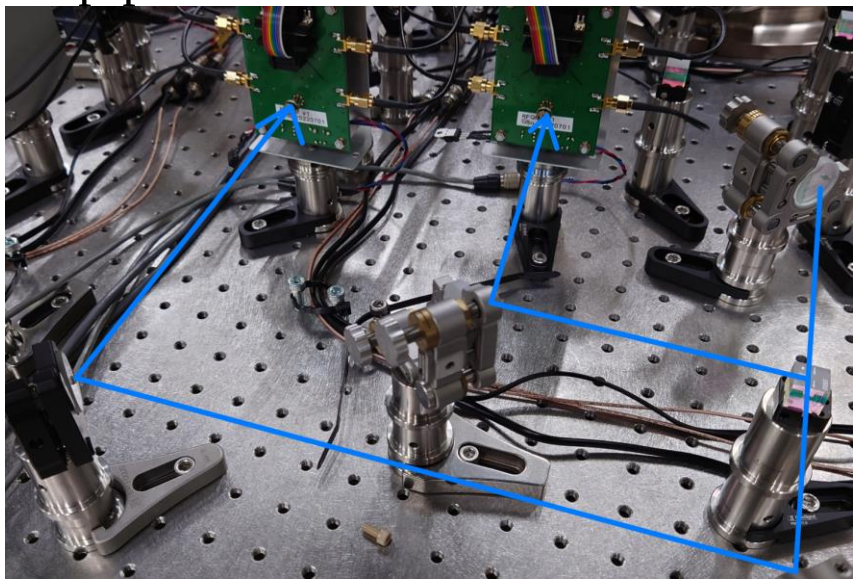




p-pol



RFQPD

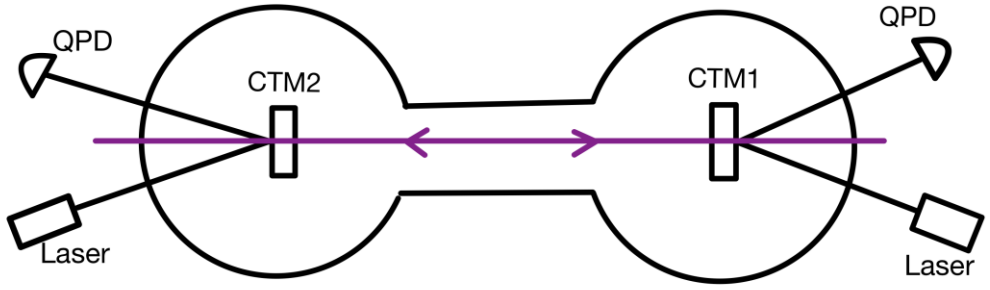


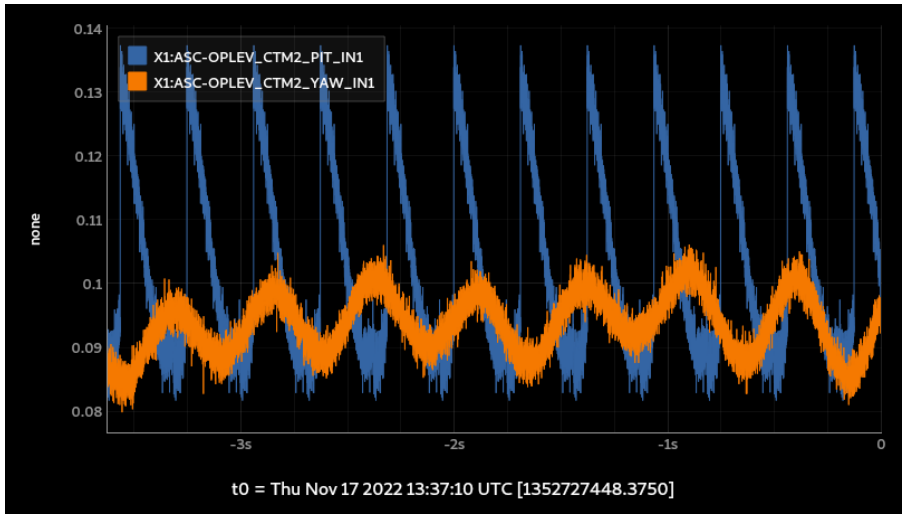
s-pol

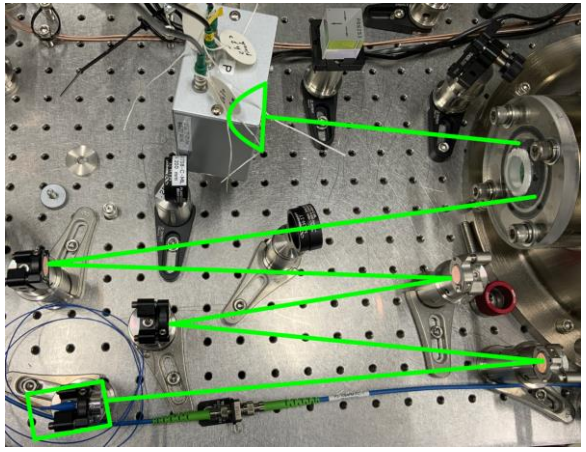
Already confirmed all 16 segments works well

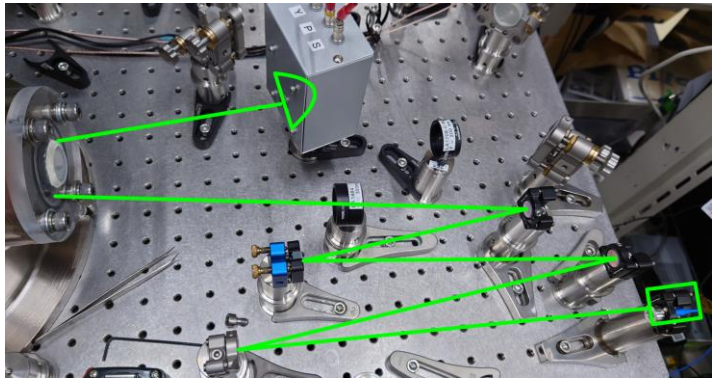
OPLEV

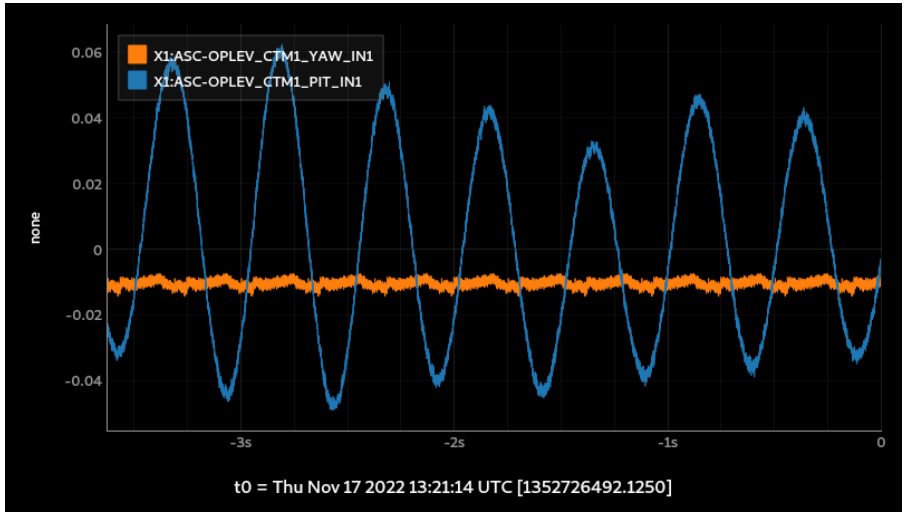
To monitor the fluctuations of CTMs,
I installed 2 OPLEVs





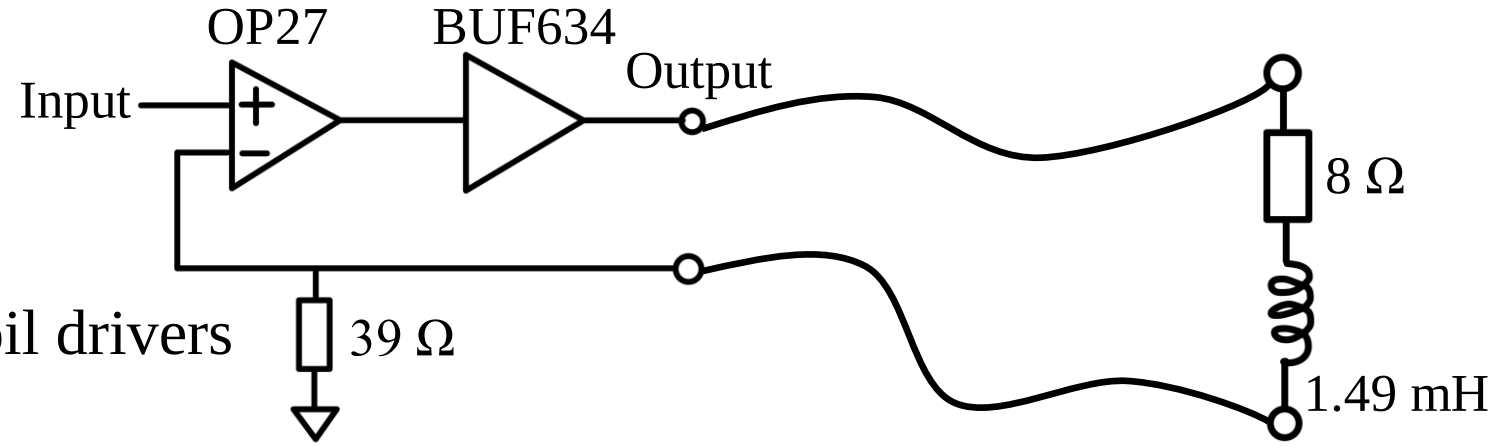


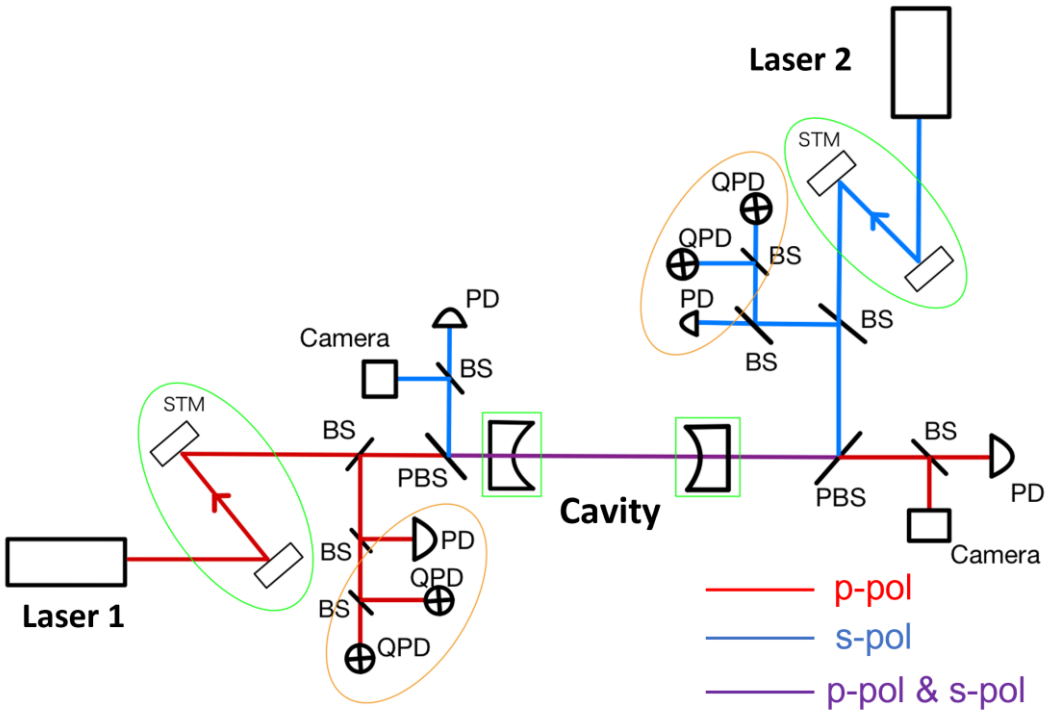


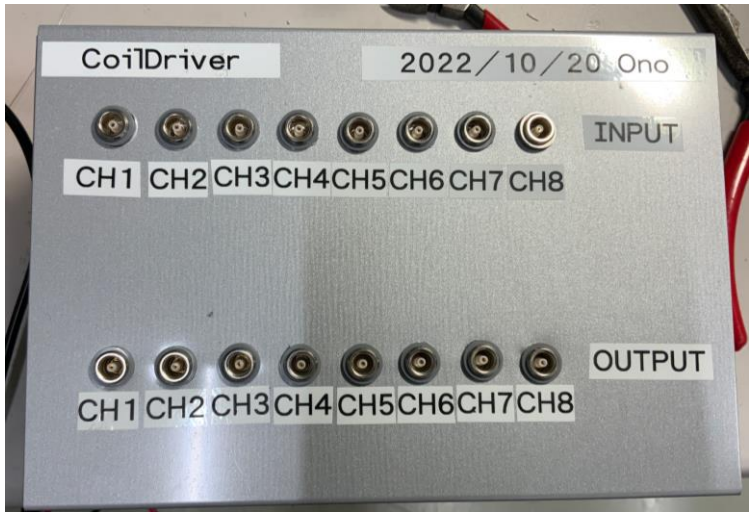


Coil and coil driver circuit

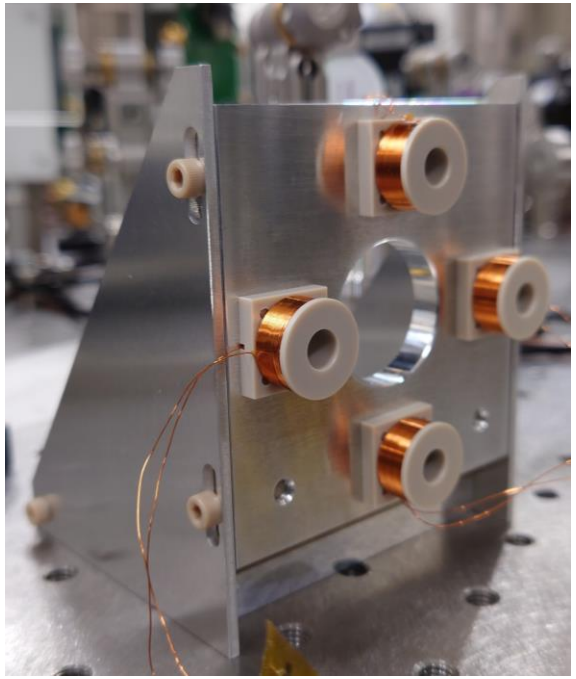
To actuate the cavity axis,
we need 8 Coils and 8 channels of coil drivers







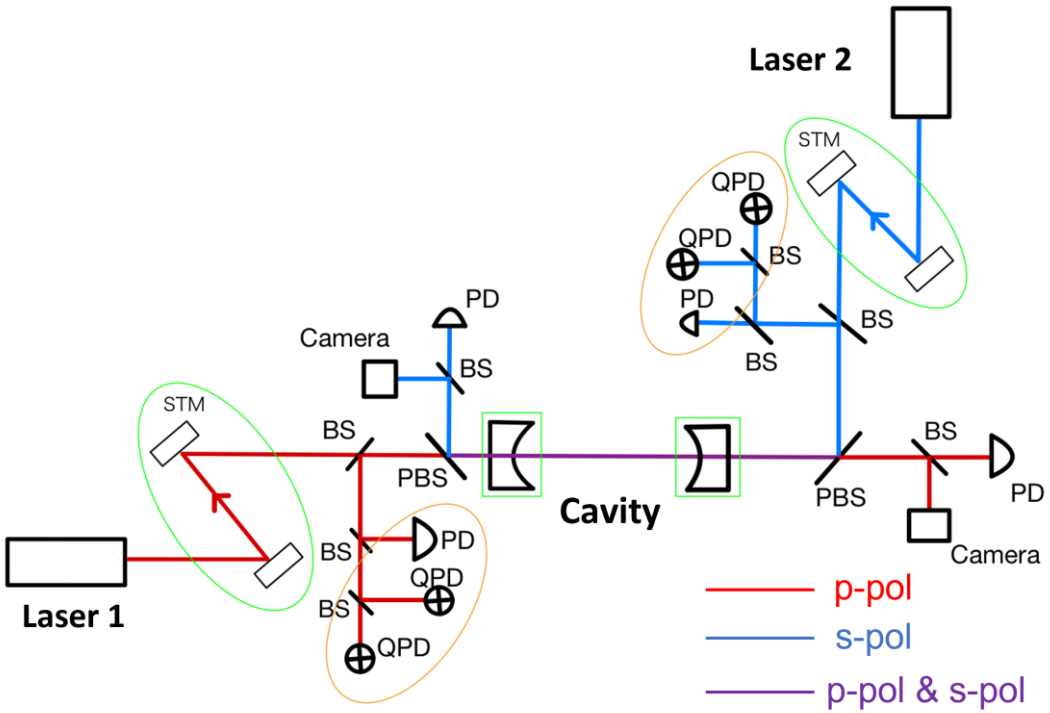
Coil Driver



Coils

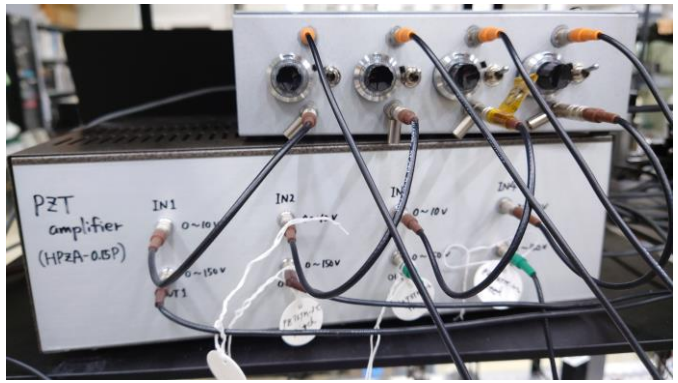
PZT STM and PZT amp

To actuate 2 beam axes, we need 4 STeering Mirrors and
8 channels of PZTamp

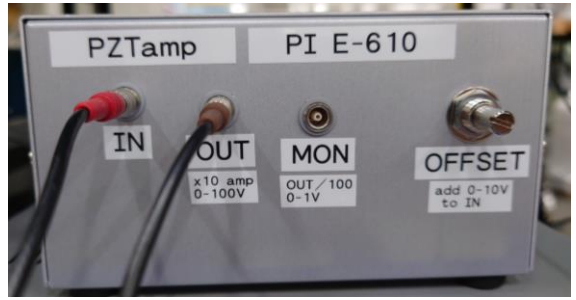


PORALIS K05P2

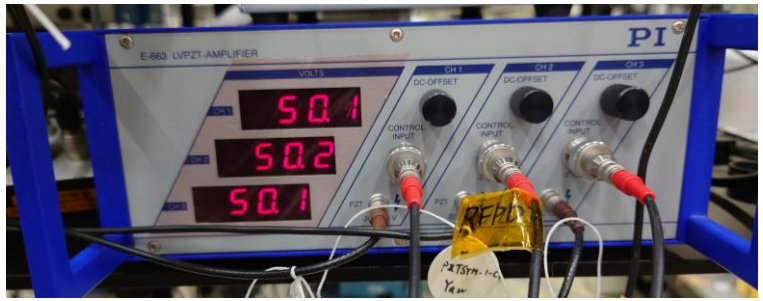
マツサダプレシジョン HPZA-0.15P



PI E-610



PI E-663



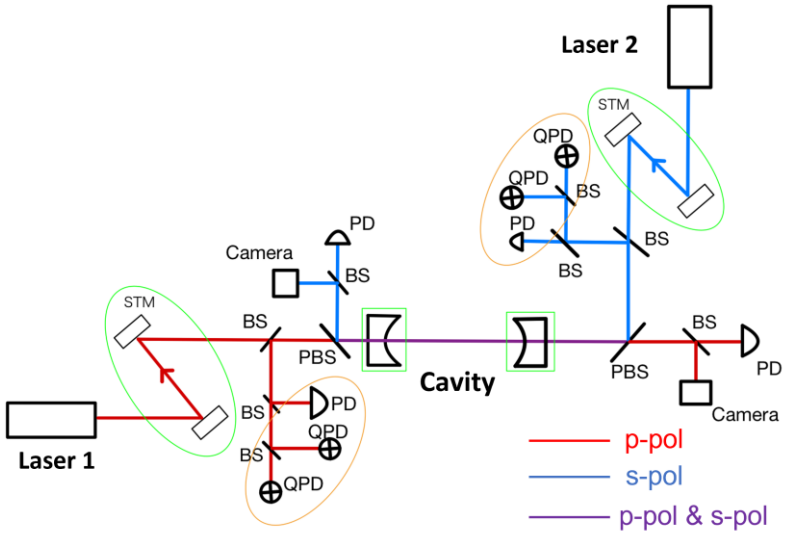
Current Status

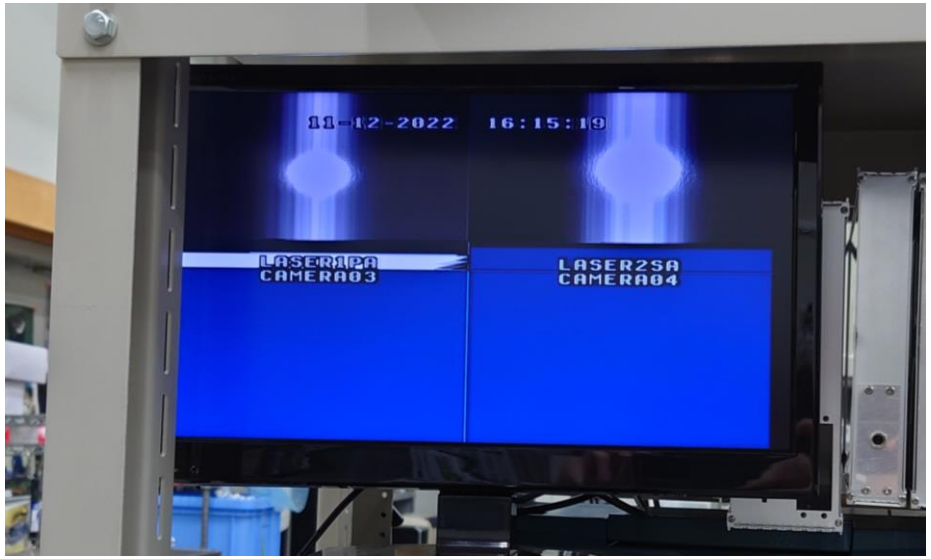
2 lasers resonance

This week, I achieved the simultaneous resonance of DPFP cavity

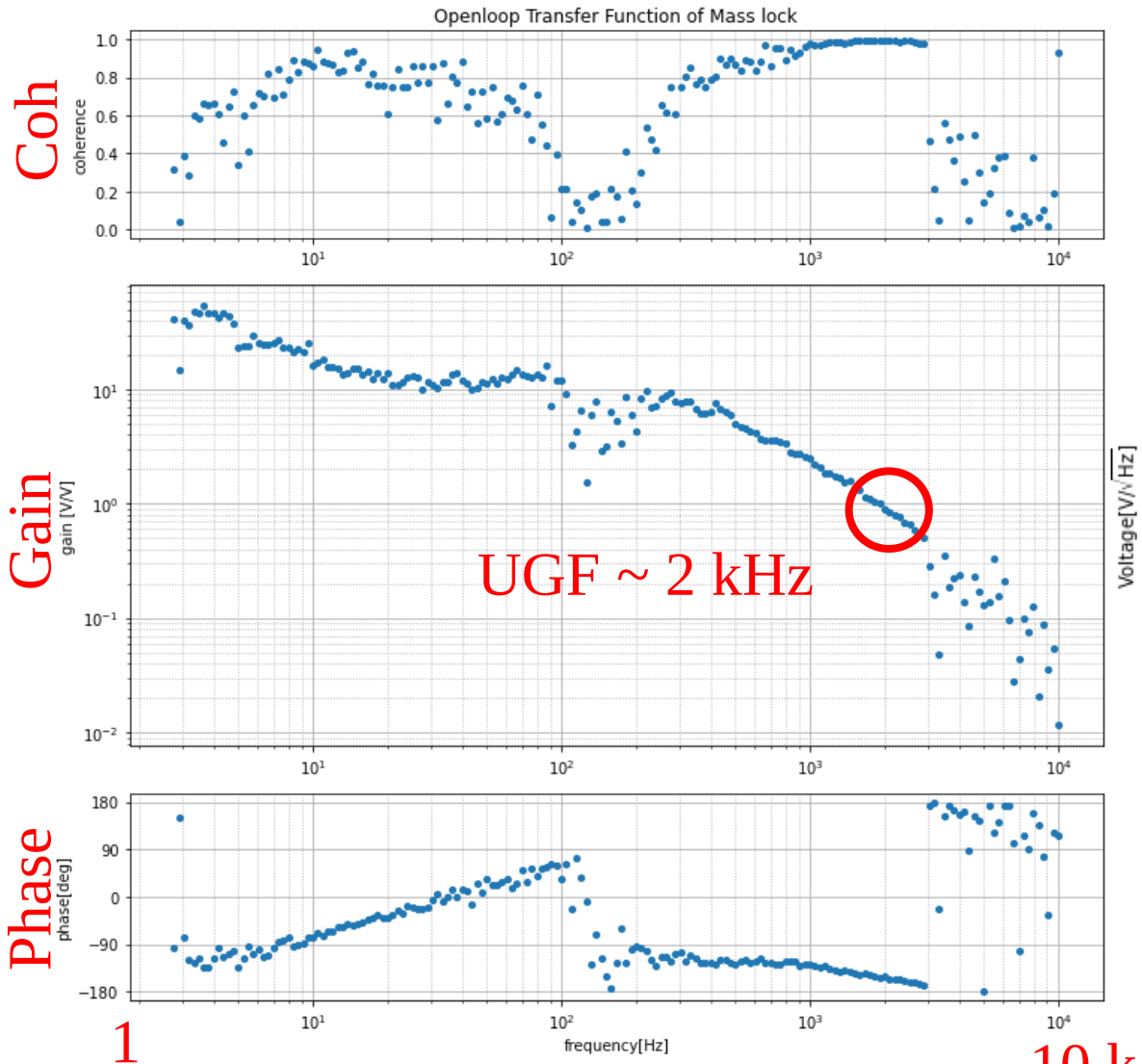
Laser1 is “Mass Lock” (The actuator is Cavity Test Mass)
Laser2 is “Freq Lock” (The actuator is Laser Frequecy)

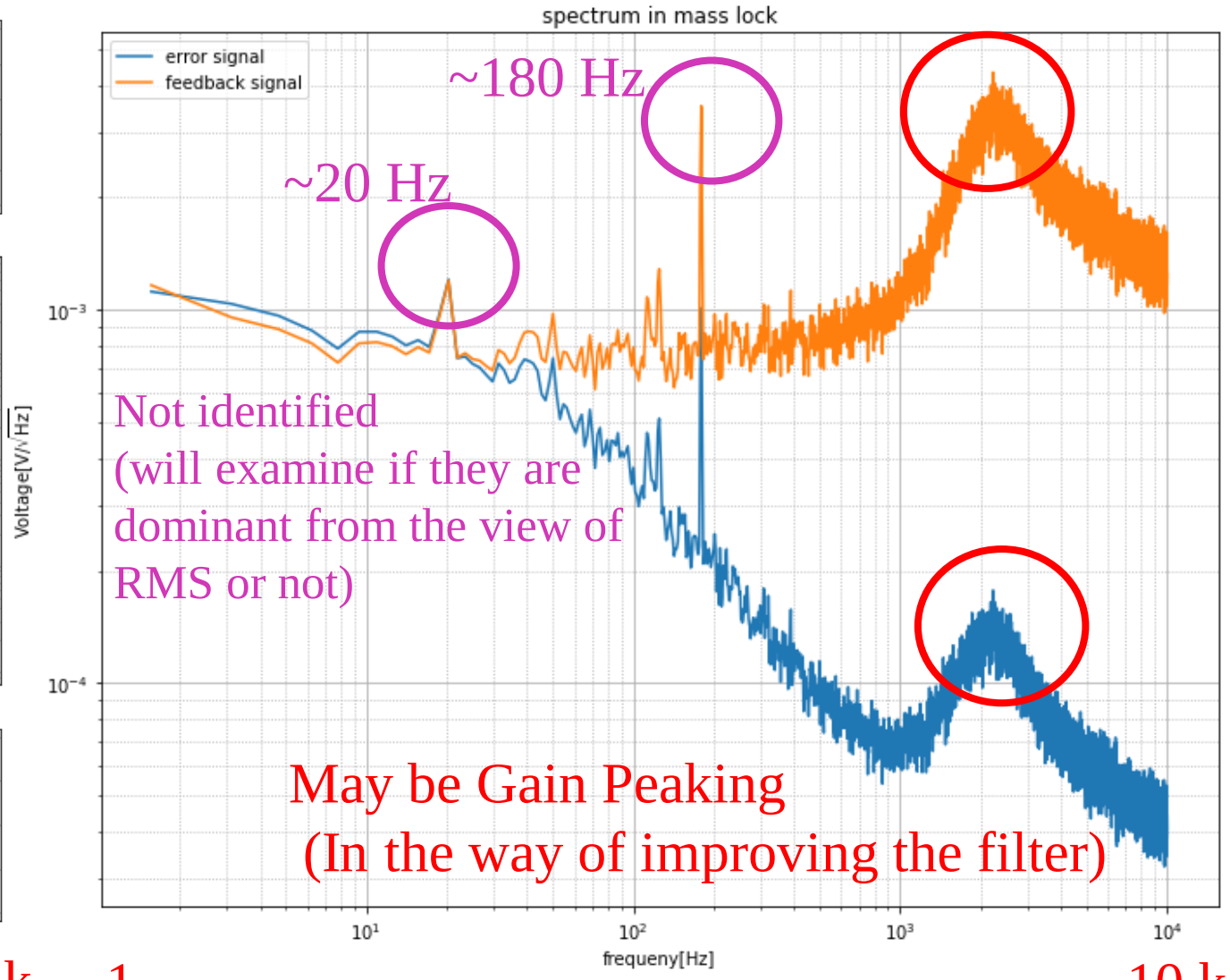
However, the feedback-loop controls are not stable (especially Freq lock)



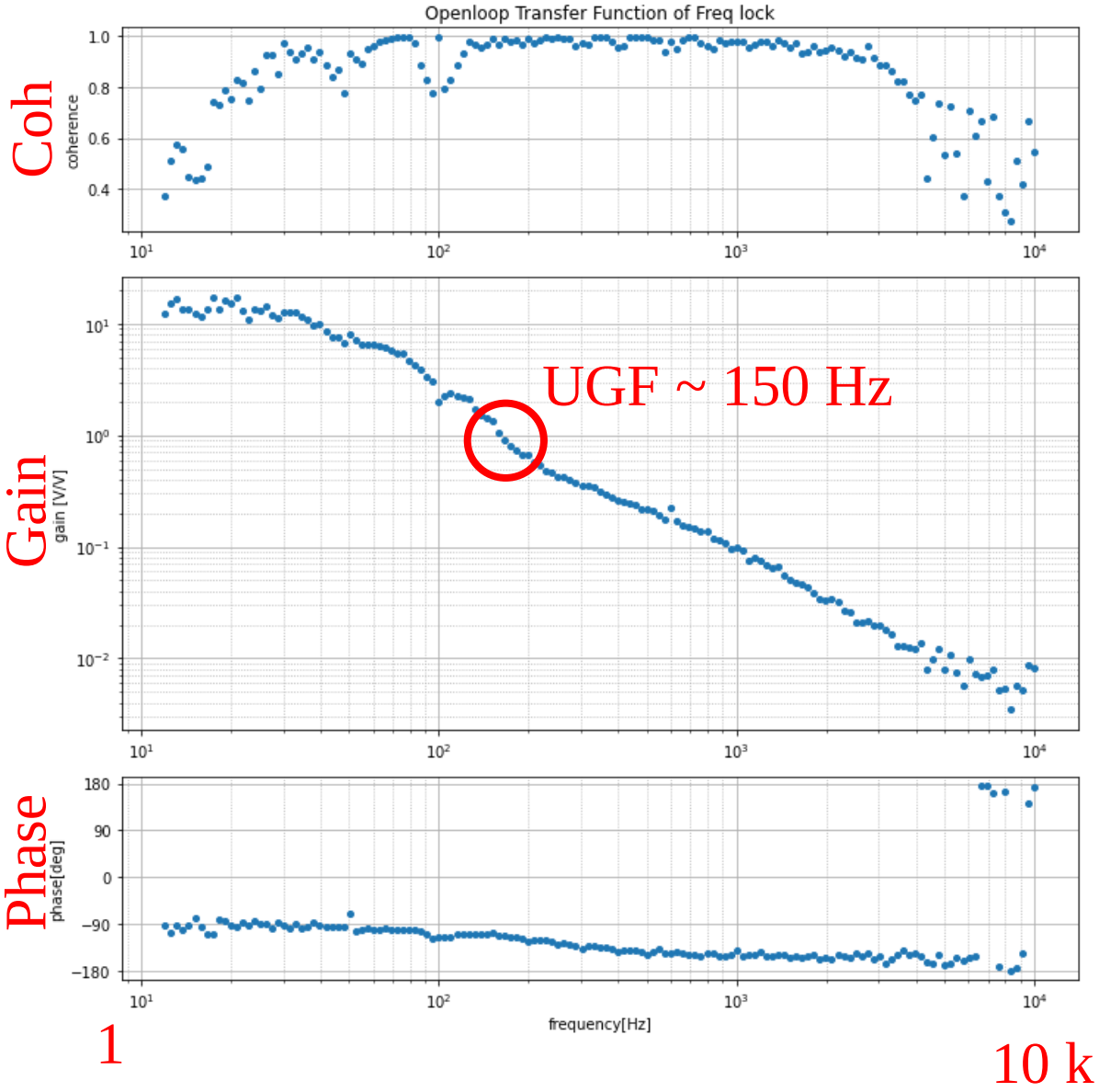


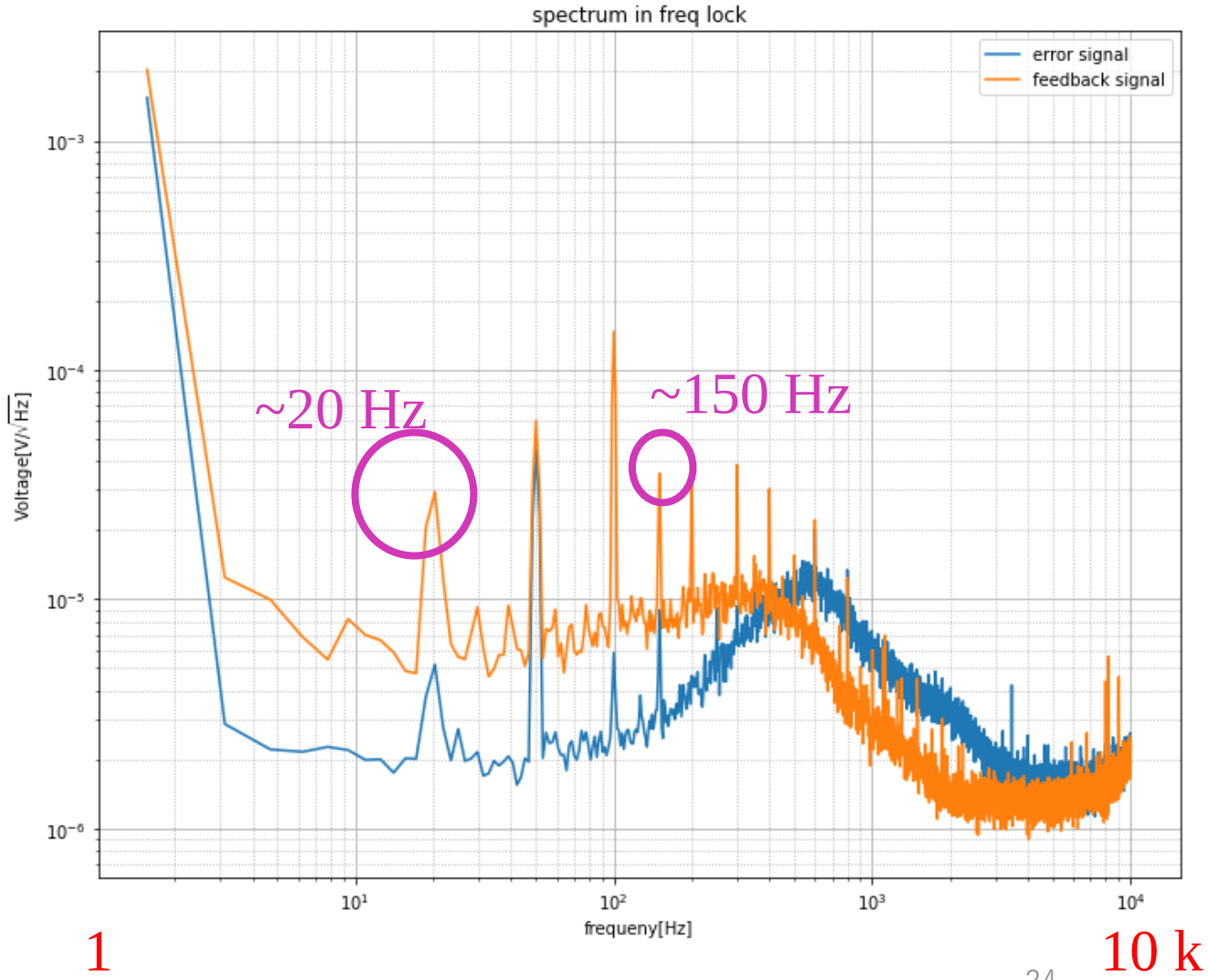
Openloop and Spectum of Masslock





Openloop and Spectum of Freqlock

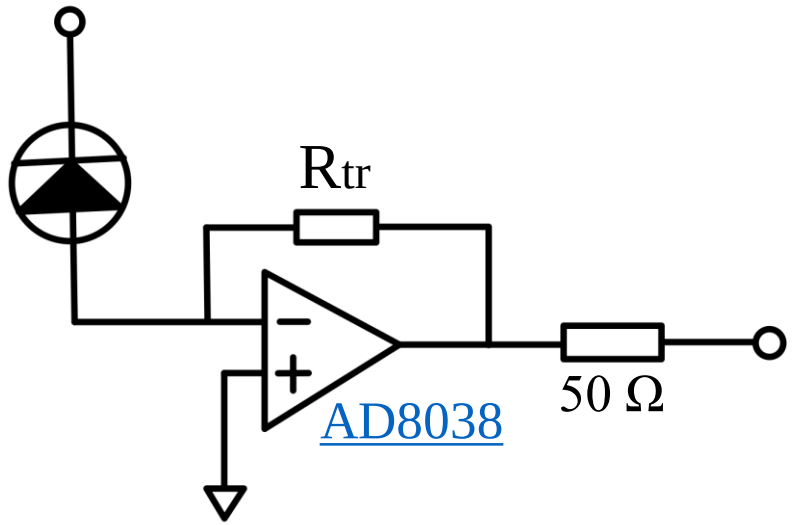


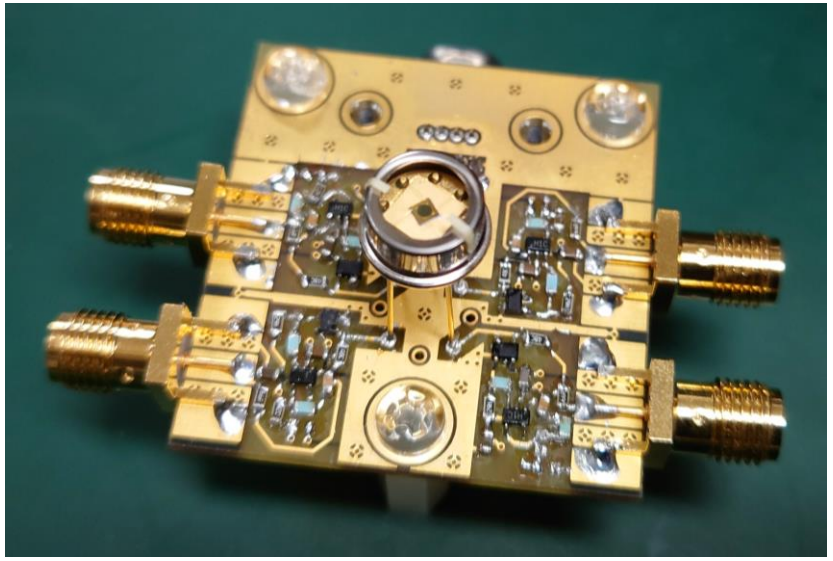


Future future plans

Broadband RFPD, RFQPD

- Komori-san recommends a OPAMP “AD8038”
- It is fast and low current noise
- I hope to develop Broadband RFPD and RFQPD





Komori-san’s LISA QPD

Modify our suspension for B-L DM search

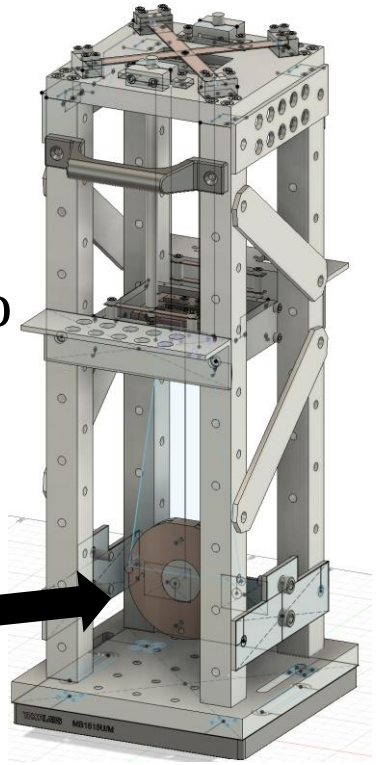
- According to Komori-san's calculation,

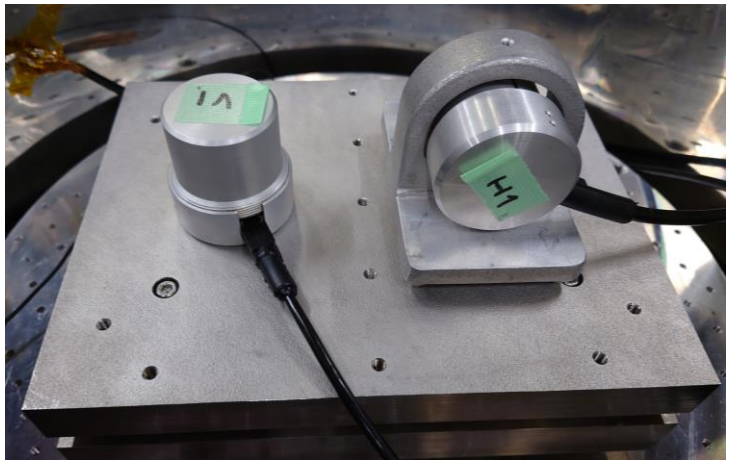
We need $10^{-17}\left[\mathrm{m}/\sqrt{\mathrm{Hz}}\right]$@100 [Hz] in order to search B-L DarkMatter (@100 Hz)

- For more isolation, Komori-san and B4 students is going to lock the suspended cavity on a stack

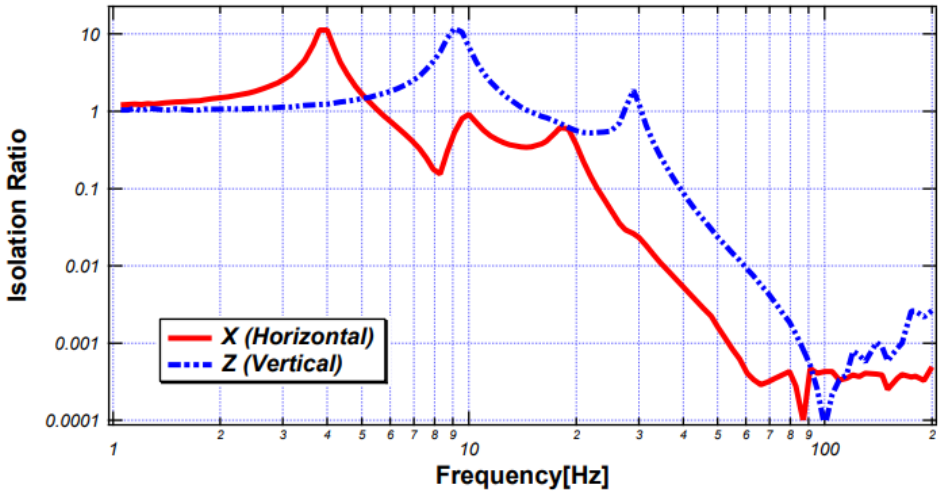
- If searching B-L DM, we need to make different the material of the 2 test masses.

W?, Si? , Cu?, Zn?, Pb?





Appearance of the Stack
(B4 students measure seismic noise using Geophones)

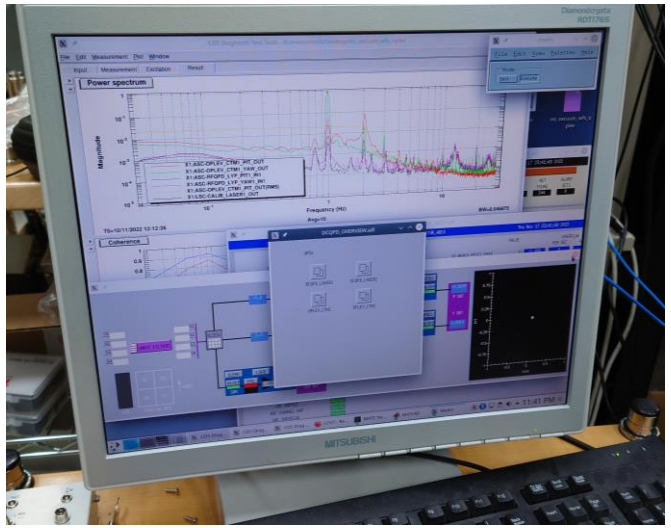


Isolation Ratio (© P.54 of Numata-san's Doctor thesis)

Our LIGO CDS update

- More AA/AI filters are required
  - This summer, we ordered a repair of 2 ADC boards
  - However, 1 board is not used because AA/AI filters are in short

- Replace PC higher spec
  - Due to the spec of PC which is used for LIGO CDS, “NDSCOPE”(oscilloscope) cannot display more than 2 channels



Summary

- LSC of 2 lasers are already achieved
  - However, now in commissioning
- After that, I will move on to ASC DPFP cavity
  - Already confirmed PDH signals from all 16 segments of 4 RFQPDs when it is in no-control (off resonance)
- The suspension will be applied to B-L DM search experiment
- Hope to do
  - Make broadband RFPD,RFQPD
  - Update our LIGO CDS

Thank you for listening