

Status Report of Type-A SAS

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Sokendai D2, NAOJ

KAGRA VIS Subgroup

KAGRA F2F Meeting @ University of Toyama

Aug. 25, 2016

Type-A Team

Members:

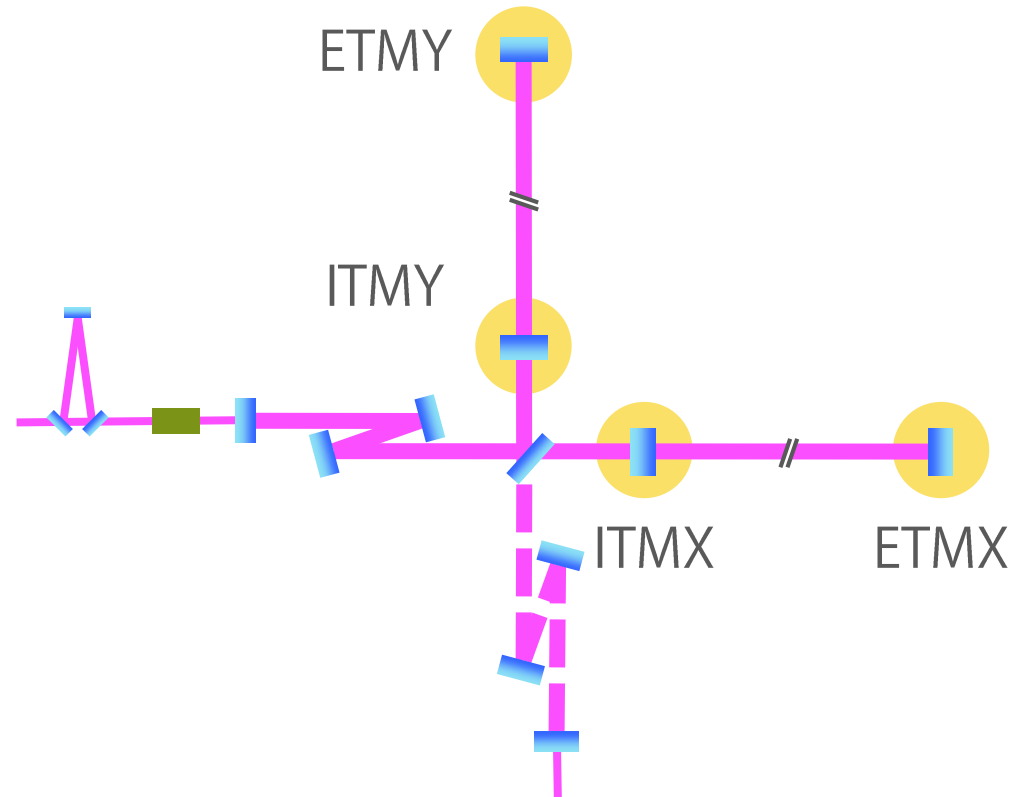
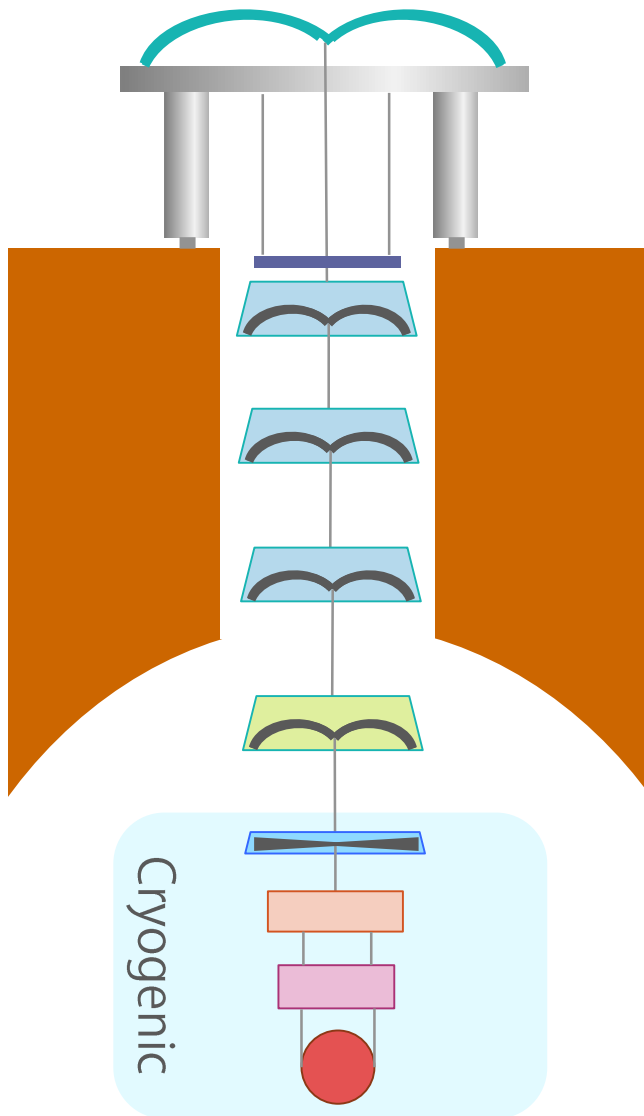
- TAKAHASHI, Ryutaro (Leader)
- ISHIZAKI, Hideharu
- SATO, Naohisa
- OKUTOMI, Koki

Team Meeting: 13:00- on every Tuesday

Contents

- About Type-A SAS
- Mode analysis and control strategy
- Installation

Type-A SAS

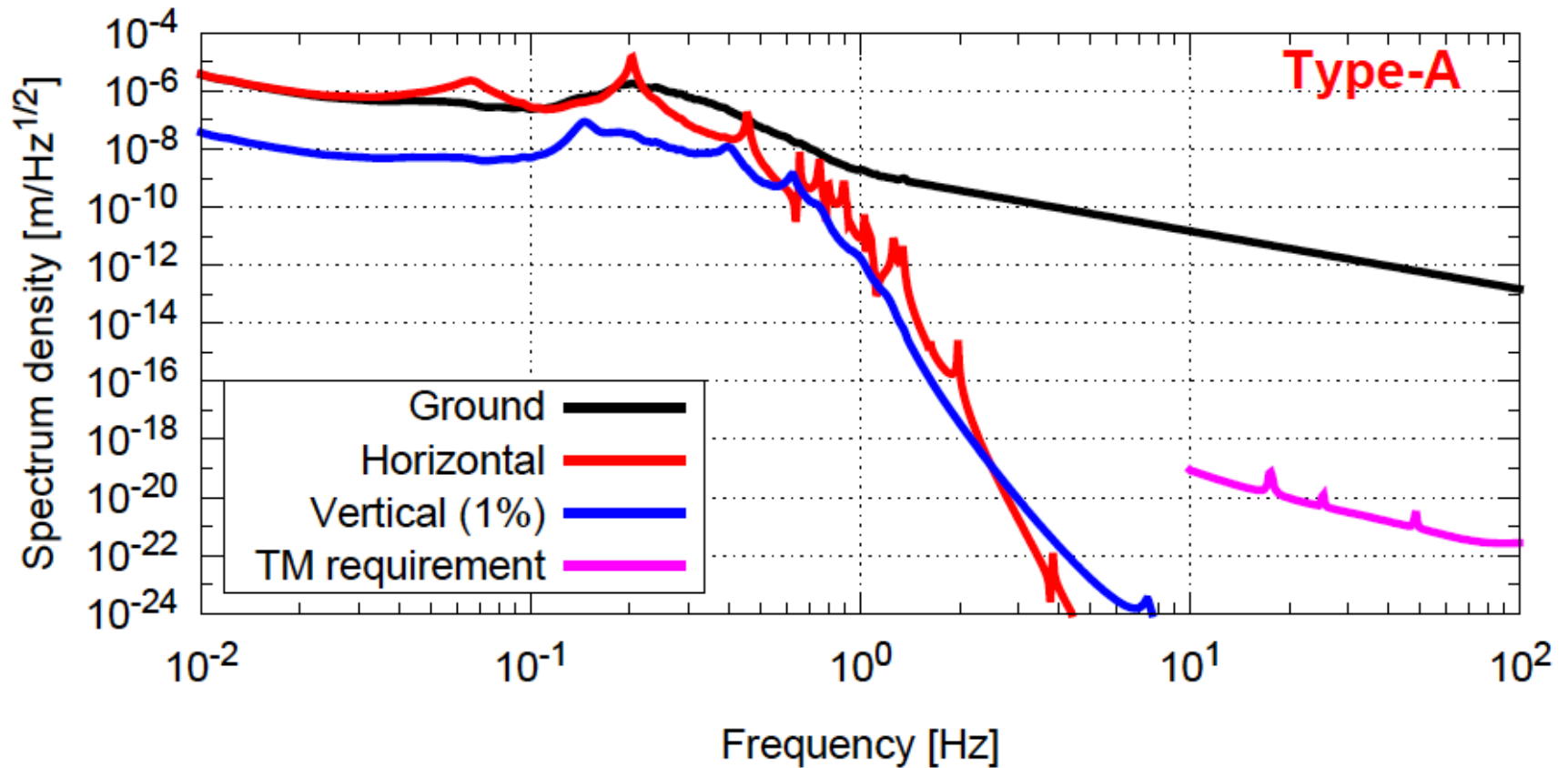


- Largest SAS for test masses
- Cryopayload at the bottom
- Suspended from 2nd floor

Requirements for Type-A

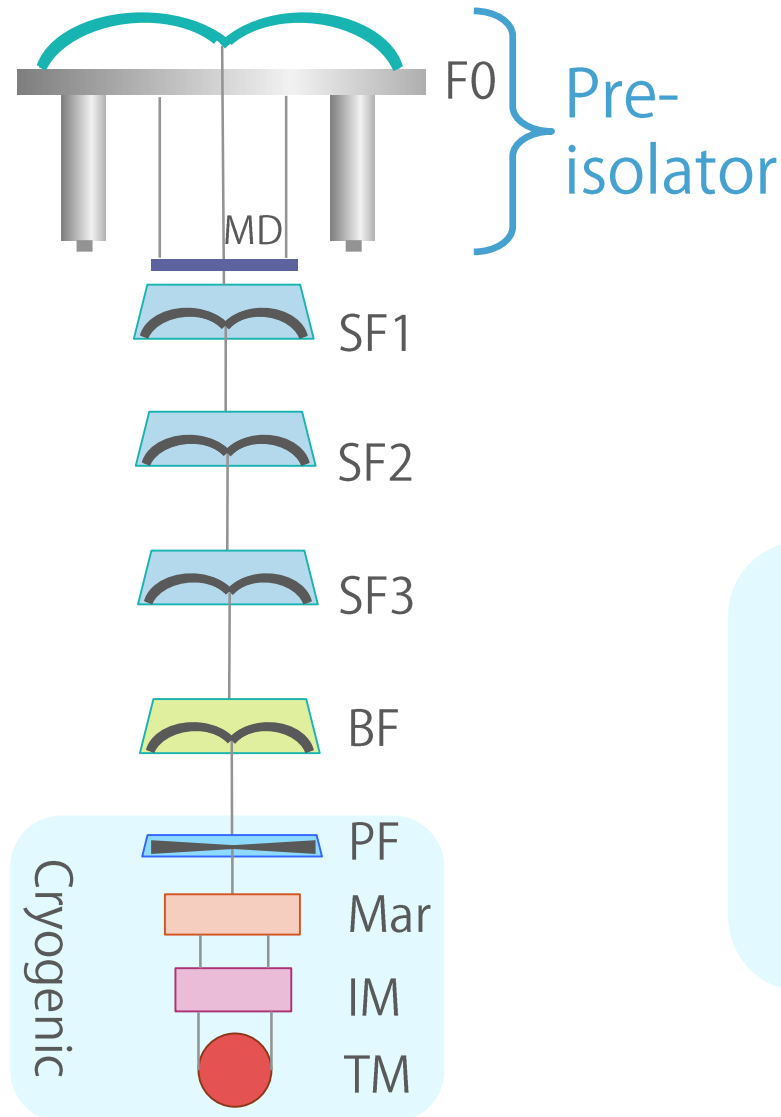
		Value	Unit	Required from
PSD	Longitudinal	1×10^{-19}	$\text{m/Hz}^{1/2}$ @ 10 Hz	Sensitivity
	Vertical	1×10^{-17}	$\text{m/Hz}^{1/2}$ @ 10 Hz	Sensitivity
RMS	Pitch, Yaw	0.01	urad	
	Velocity	0.1	um/sec	Lock acquisition
	Angular velocity	0.01	rad/sec	Alignment (w/ WFS)
Long term drift	Longitudinal	???	m/hour	Actuator range
	Pitch, Yaw	0.4	urad/hour	
Damping time (for all modes)		60	sec	Set typically?

Performance in Design



T. Sekiguchi Ph.D. Thesis, p.72: [JGW-P1504155-v15](#)

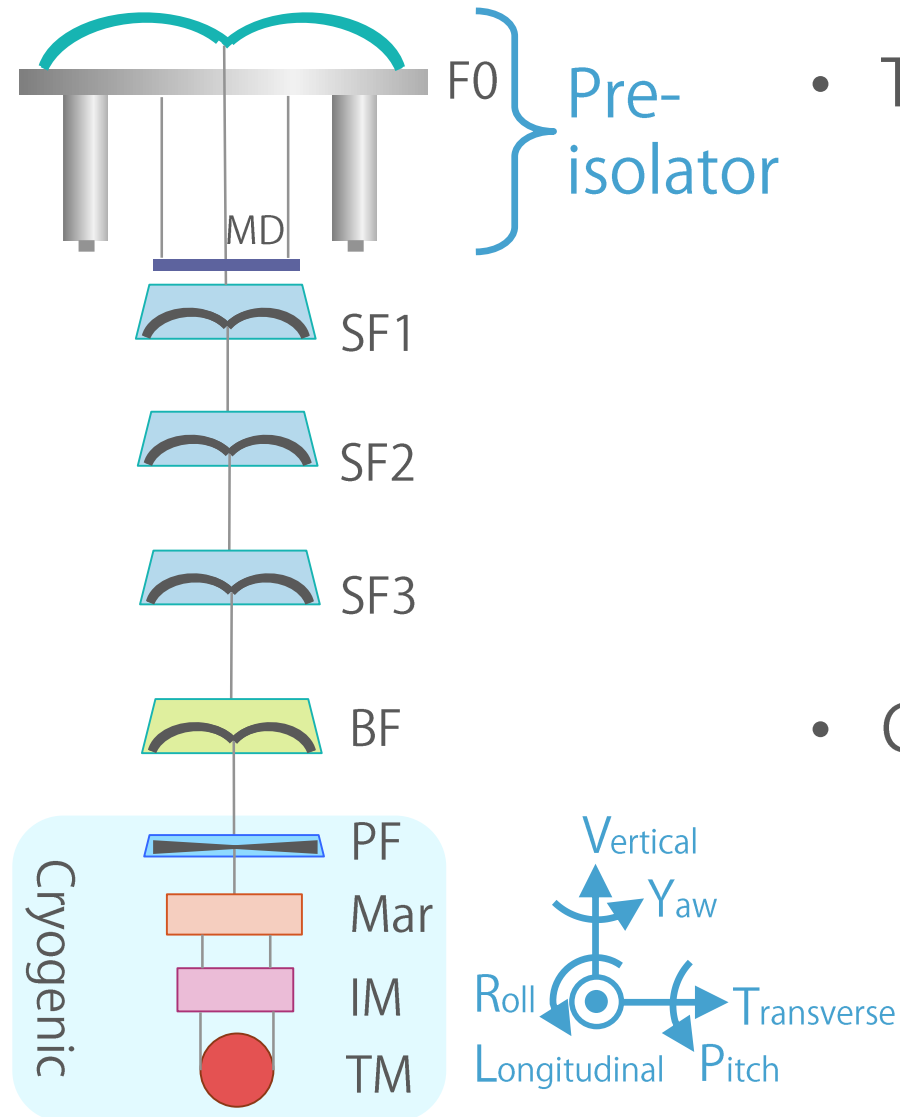
Components of Type-A



- Top stage (F0)
 - Magnetic damper (MD)
 - Standard filter (SF) x3
 - Bottom filter (BF)
- Platform (PF)
 - Marionette (Mar)
 - Intermediate mass (IM)
 - Test mass (TM)

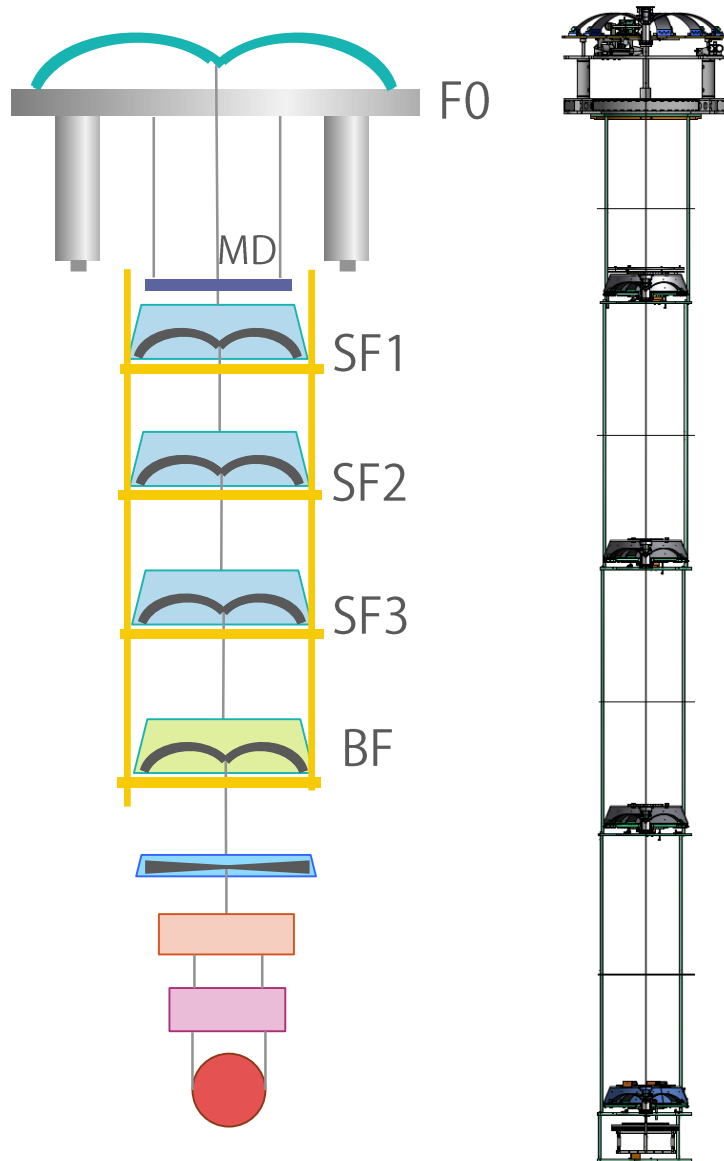
➤ CRY subgroup's talk (Aug. 26)

Sensors, Actuators and Motors



- Top stage (F0)
 - LVDT (L, T, Y)
 - Accelerometer (L, T, Y)
 - Stepper motor (L, T, Y)
 - Picomotor (Y)
 - Fishing rod (V)
- GAS filter (F0, SF1-3, BF)
 - LVDT (V)
 - Fishing rod (V)

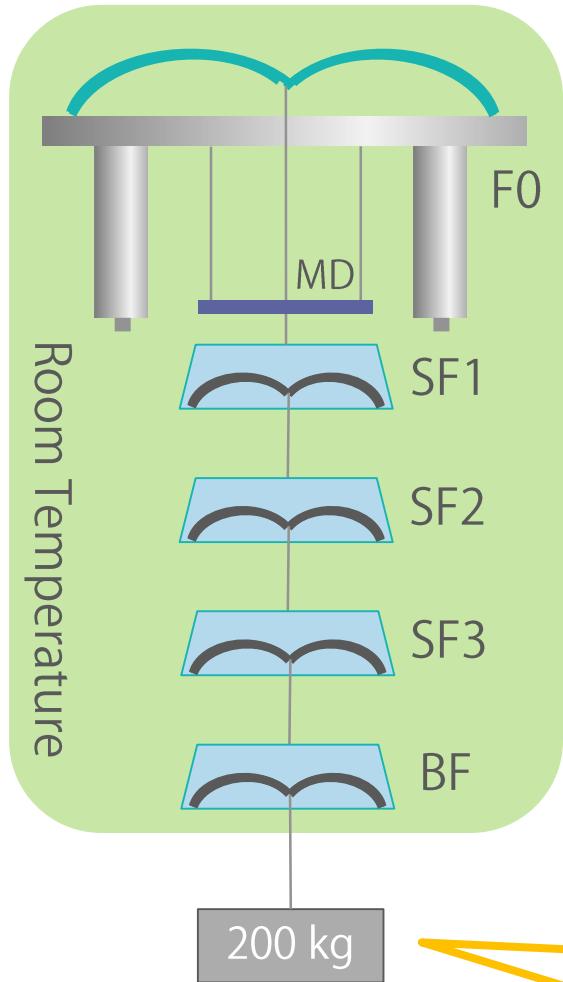
Earthquake Stop – Security Frame



- Structure for safety
- Fixed to the wall of vacuum chambers

Mode Analysis & Control Strategy

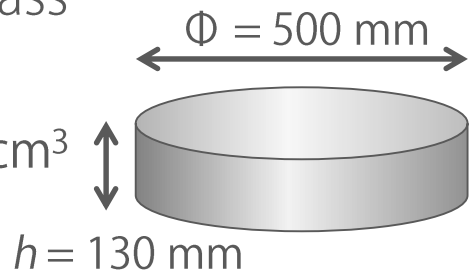
Mode Analysis



- To make damping control strategy of the modes in room temperature parts of Type-A
- Calculation based on
 - SUMCON
 - MATLAB

Dummy Mass

- Cylinder
- SUS: 7.8 g/cm³

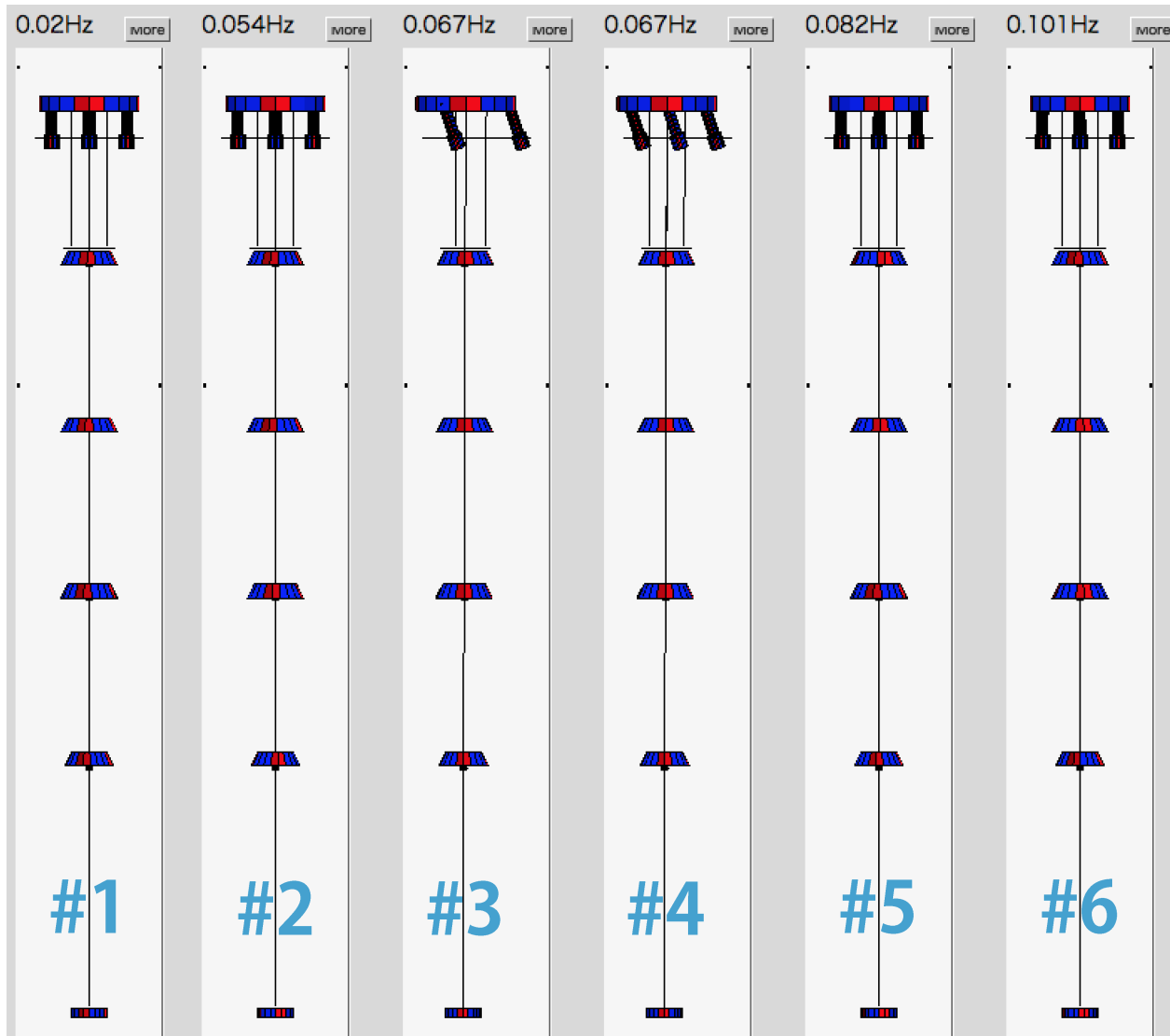


What Is Concerned?

SAT team in Adv. Virgo suggested that...

- Lowest-frequency modes come from whole chain of the suspension is difficult to be damped with top-stage controls in Virgo Superattenuator
- Same problem could rise in KAGRA, especially Type-A which has as long suspended chain as the Superattenuator
- If so, we should implement another controllers at some lower stages
- We need to make a damping strategy

Lowest Eigenmodes in Type-A



#1: 0.02 Hz

Yaw whole chain 0th

#2: 0.054 Hz

Yaw whole chain 1st

#3: 0.067 Hz

IP horizontal

#4: 0.067 Hz

IP horizontal

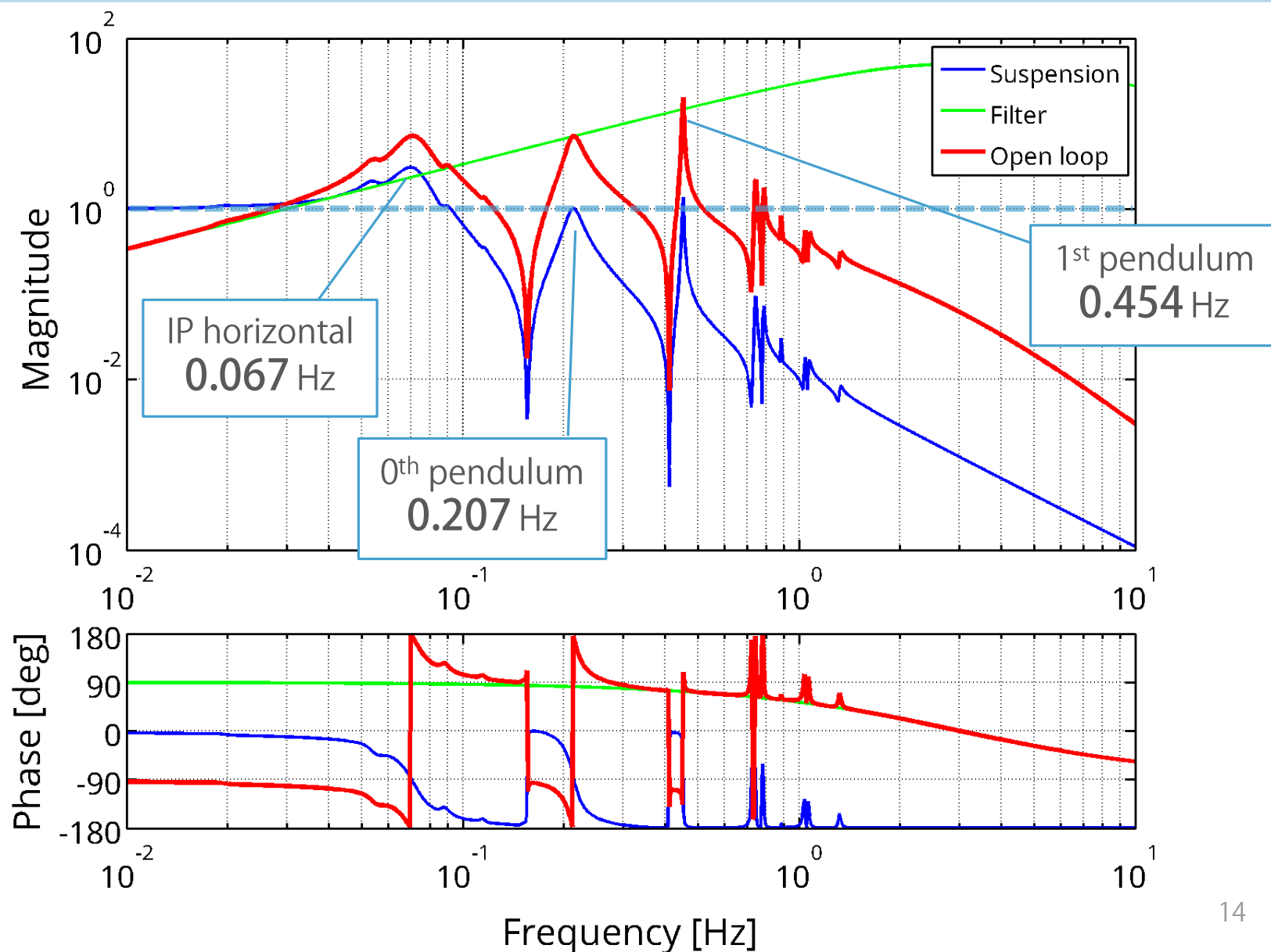
#5: 0.082 Hz

Yaw whole chain 2nd

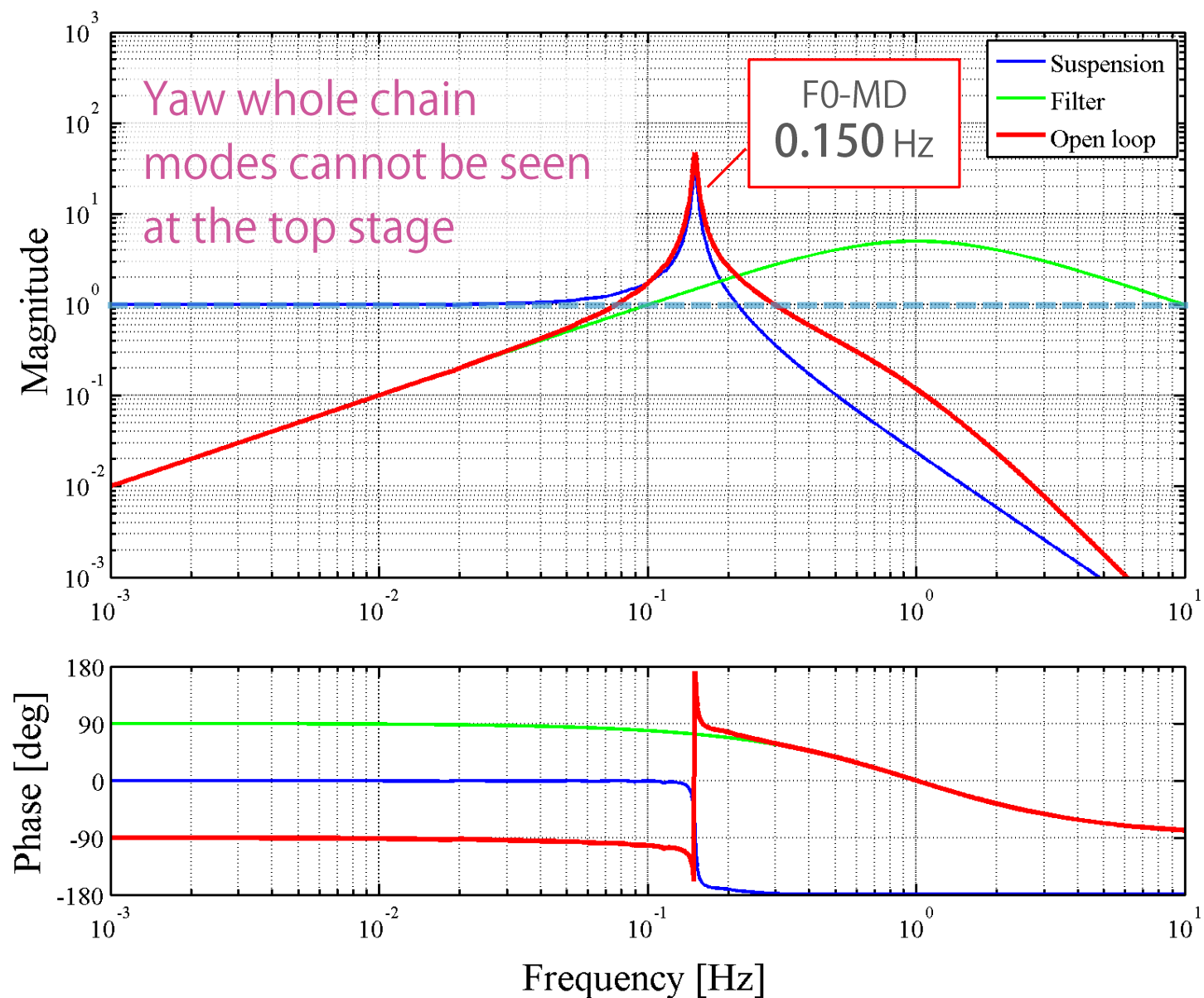
#6: 0.101 Hz

Yaw whole chain 3rd

Open-loop Transfer Function (LF0)



Open-loop Transfer Function (YF0)



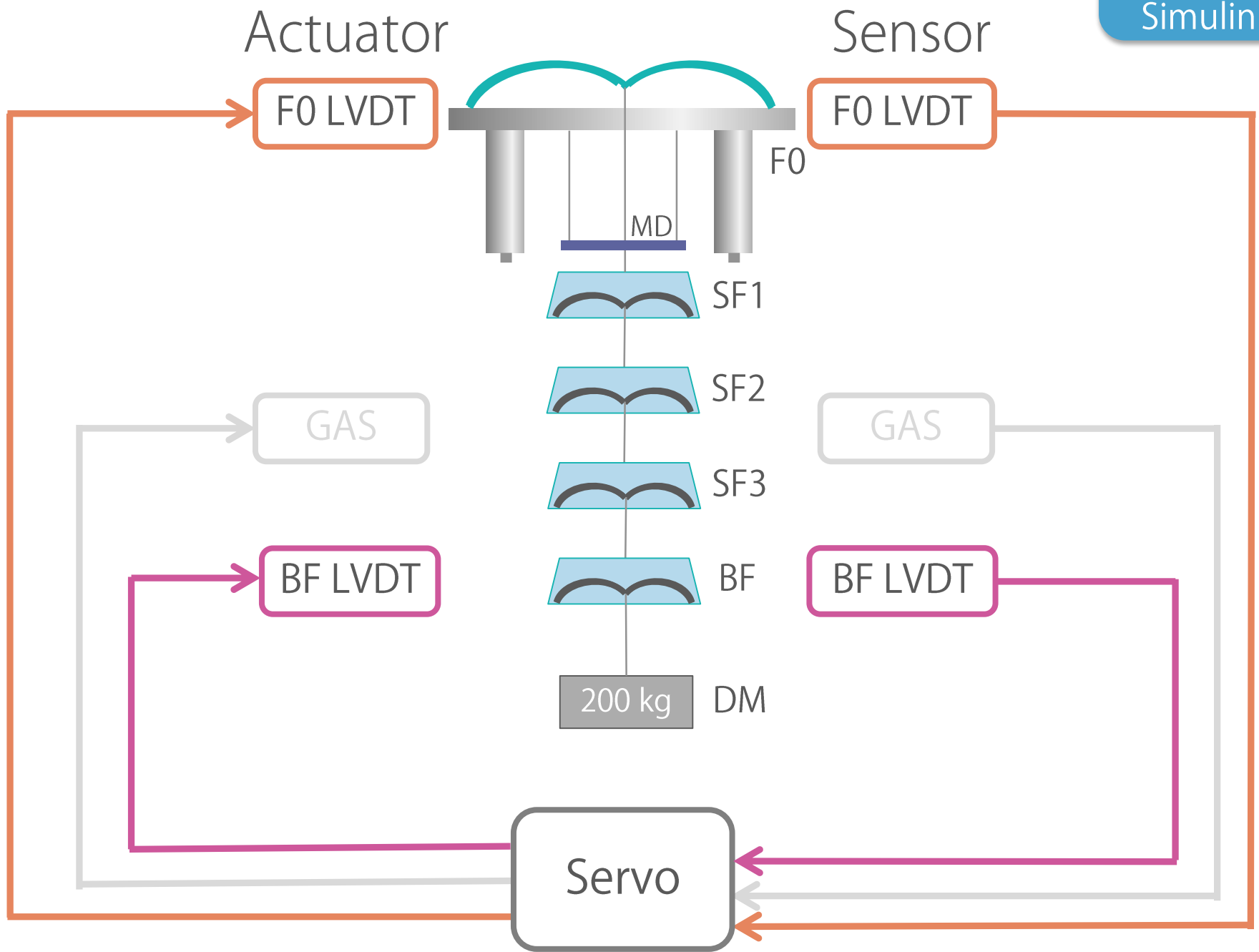
Damping Strategy

Translational modes

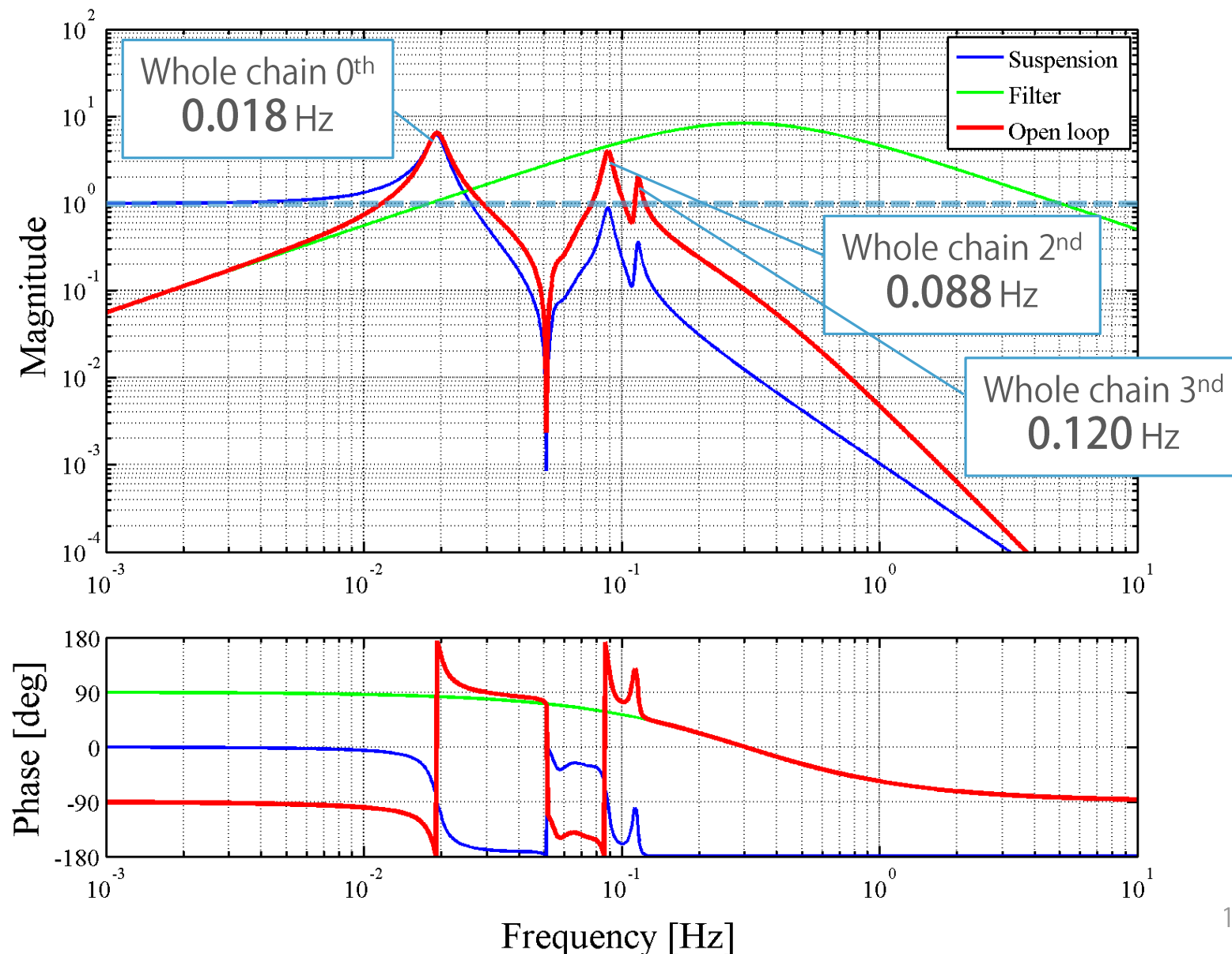
- It seems that the lower frequency modes could be damped only with F0 control

Yaw modes

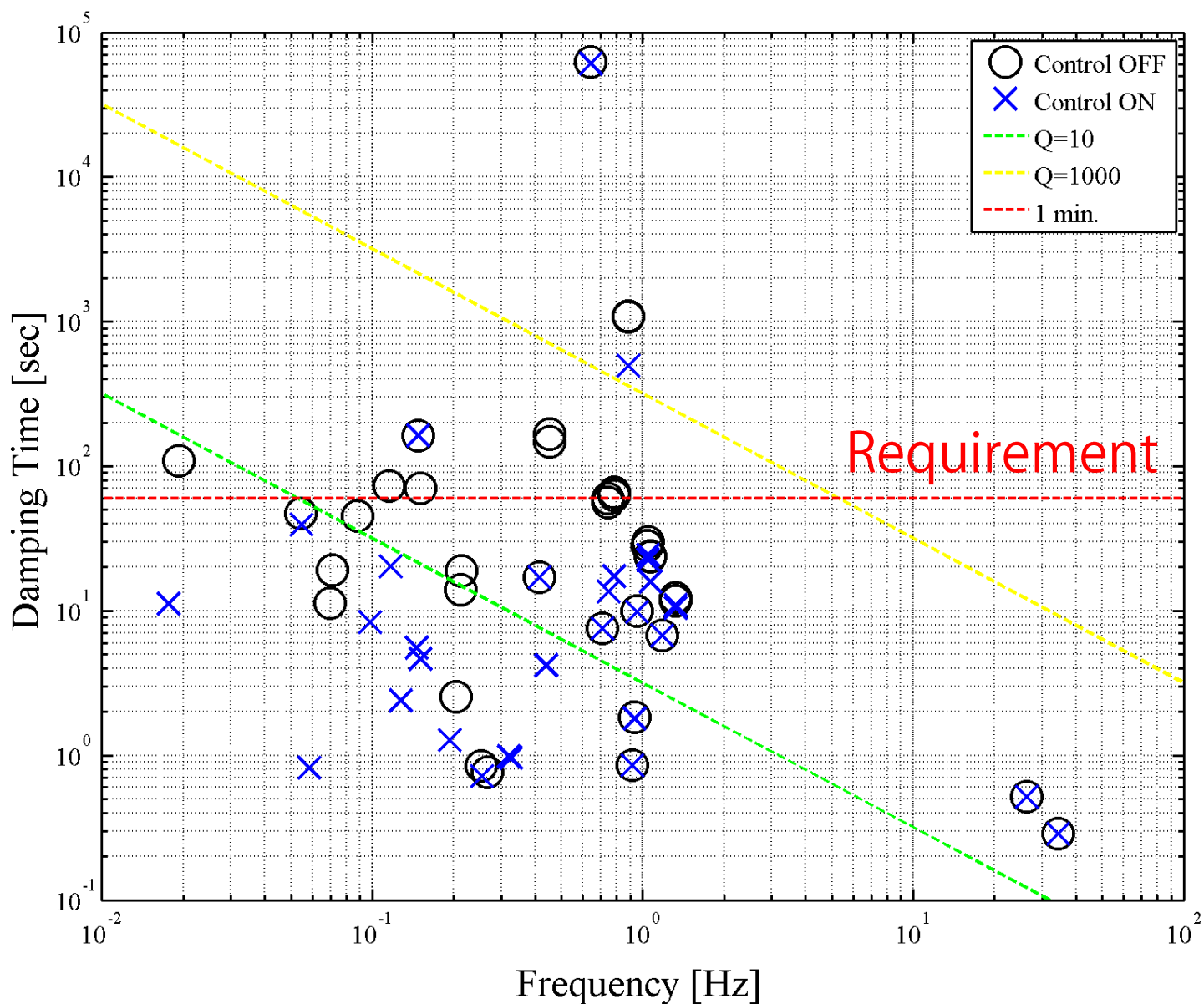
- The lowest resonance in yaw (whole chain 0th) is difficult to be damped with F0 control
- Add controls on the Bottom Filter (BF) and check possibility to damp the lowest modes



Open-loop Transfer Function (YBF)



Damping Time (F0 + BF Control)



Section Summary: Mode Analysis

Translational modes

- Closed loop system with F0 + BF control is stable

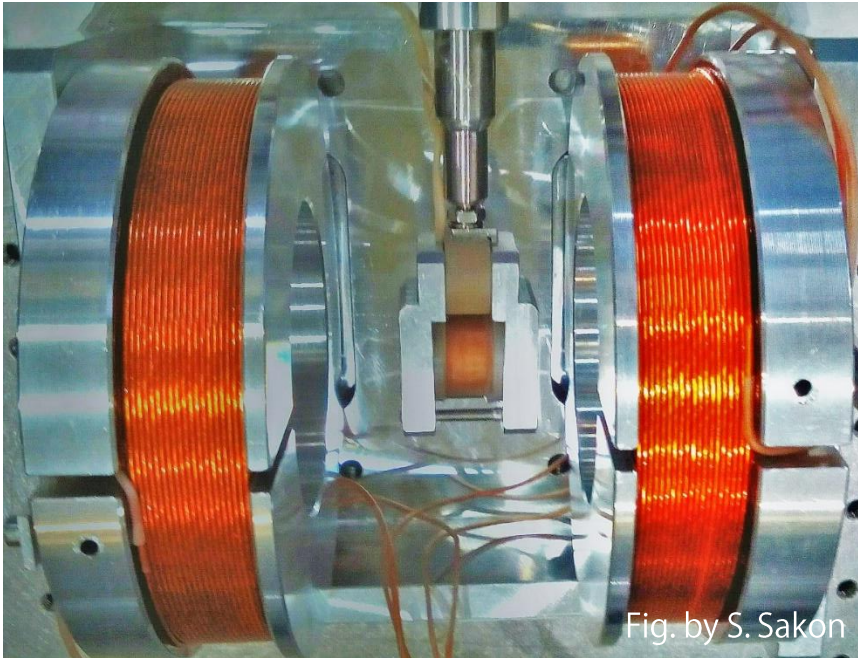
Yaw modes

- The lowest whole-chain mode can be damped with BF control
- 1st whole-chain mode becomes raised
 - might be a problem? => under investigation

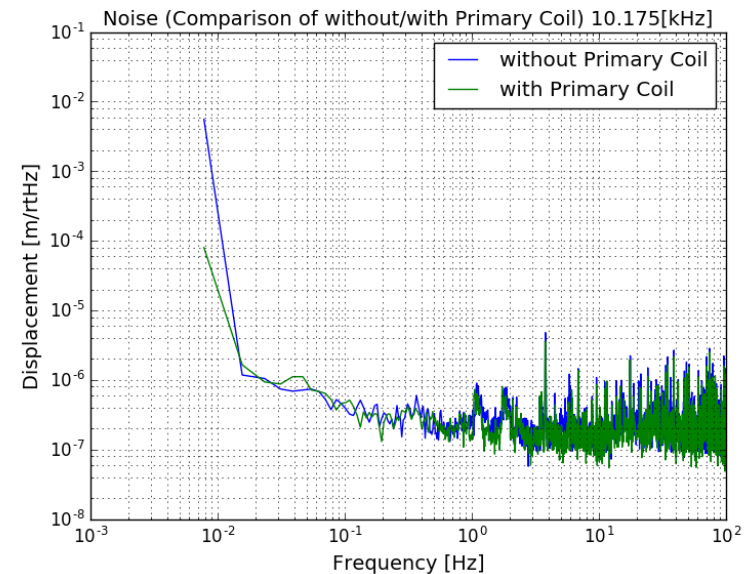
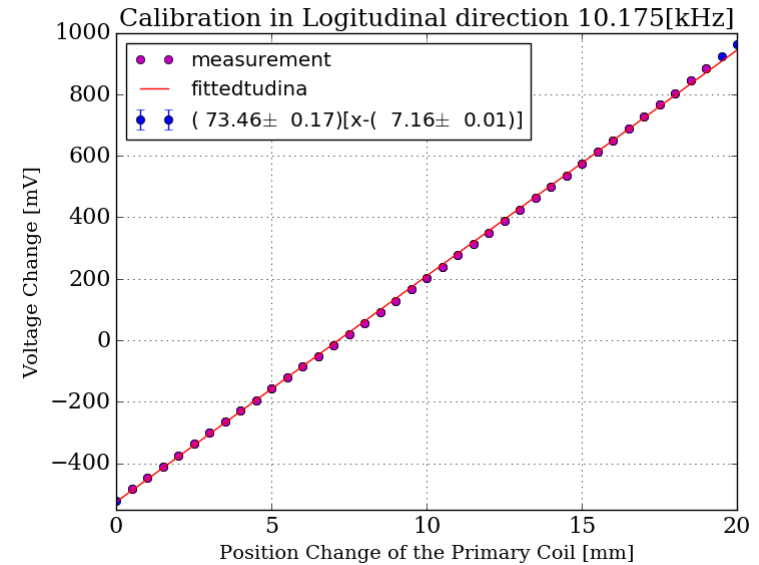
Next step

- Estimation of required sensor/actuator's performance
- Analysis of the suspension model including CRYp

BF LVDT



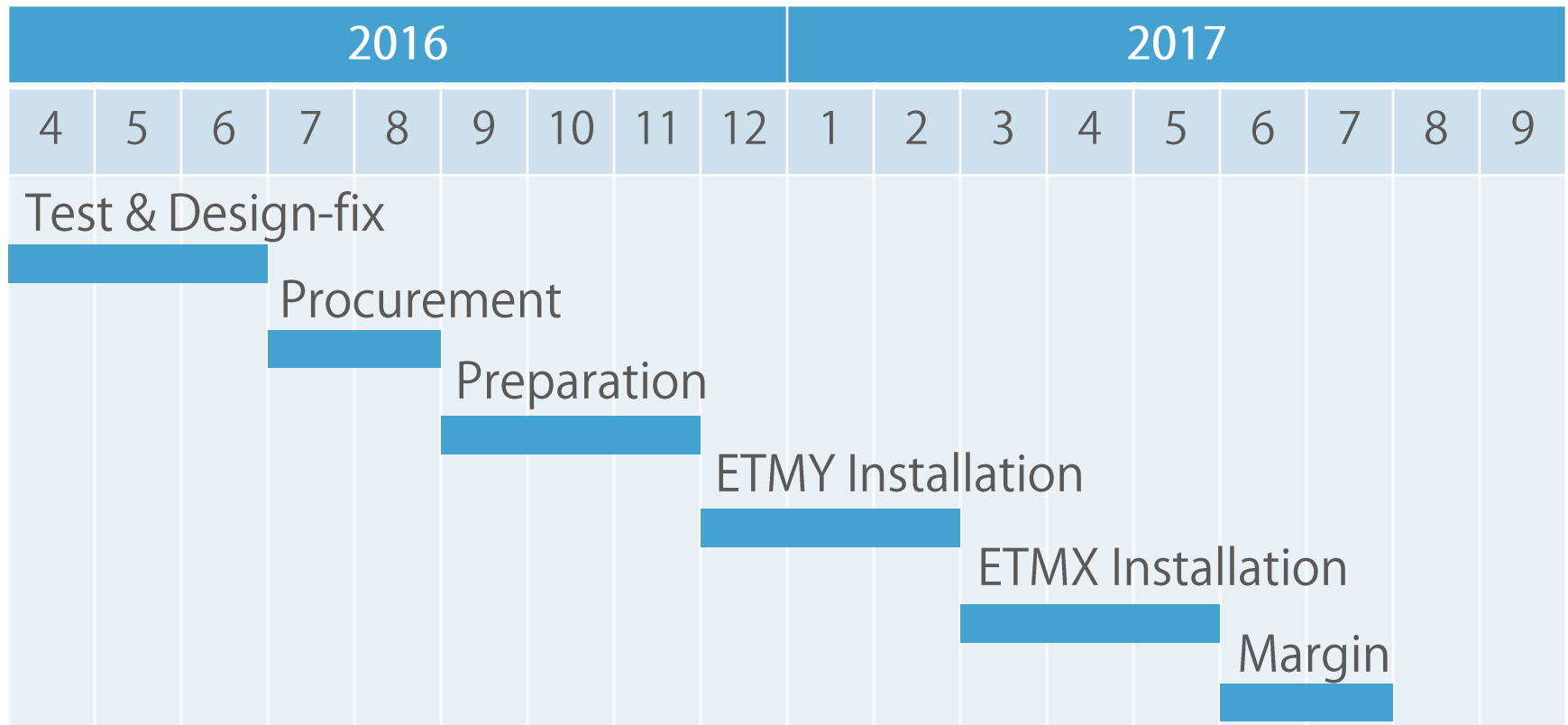
- Under design work, based on Adv. Virgo F7 LVDT
- Tested with our driver circuit



Configuration of BF LVDT

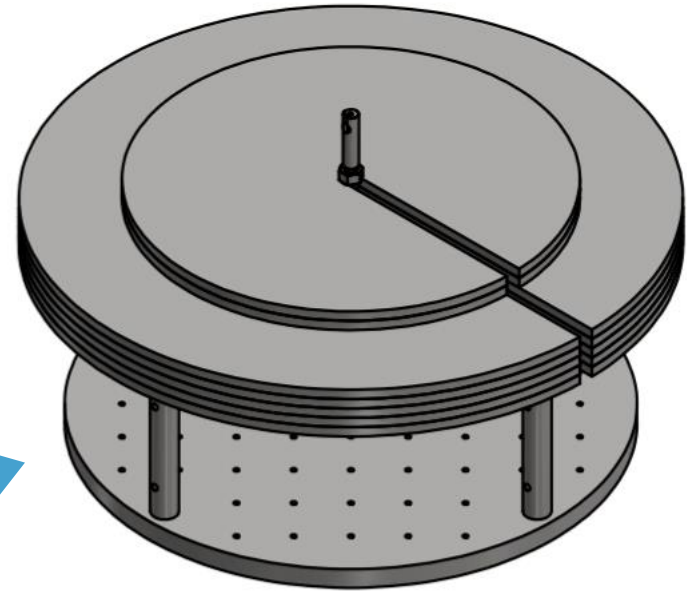
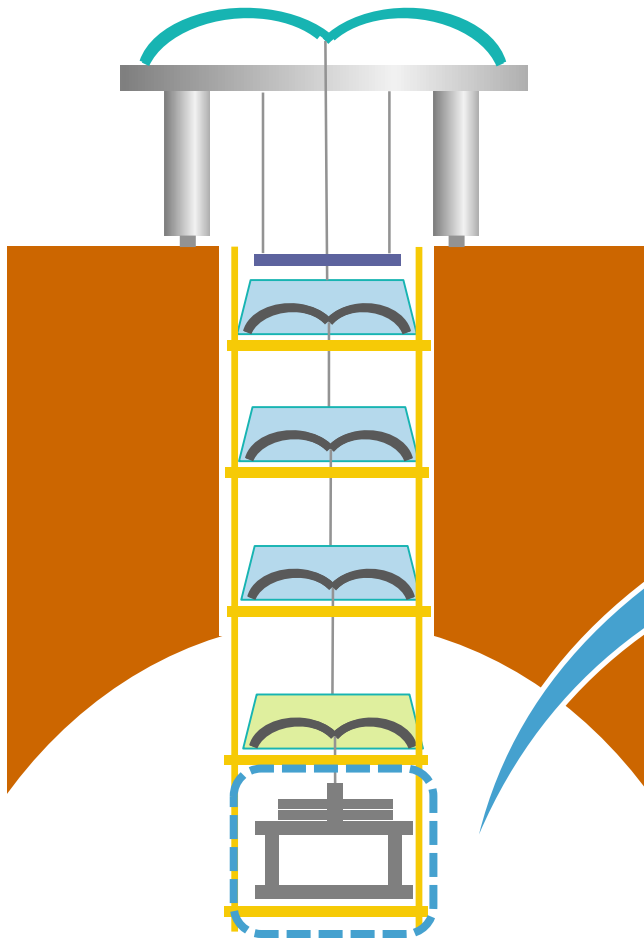
Installation

Installation Schedule



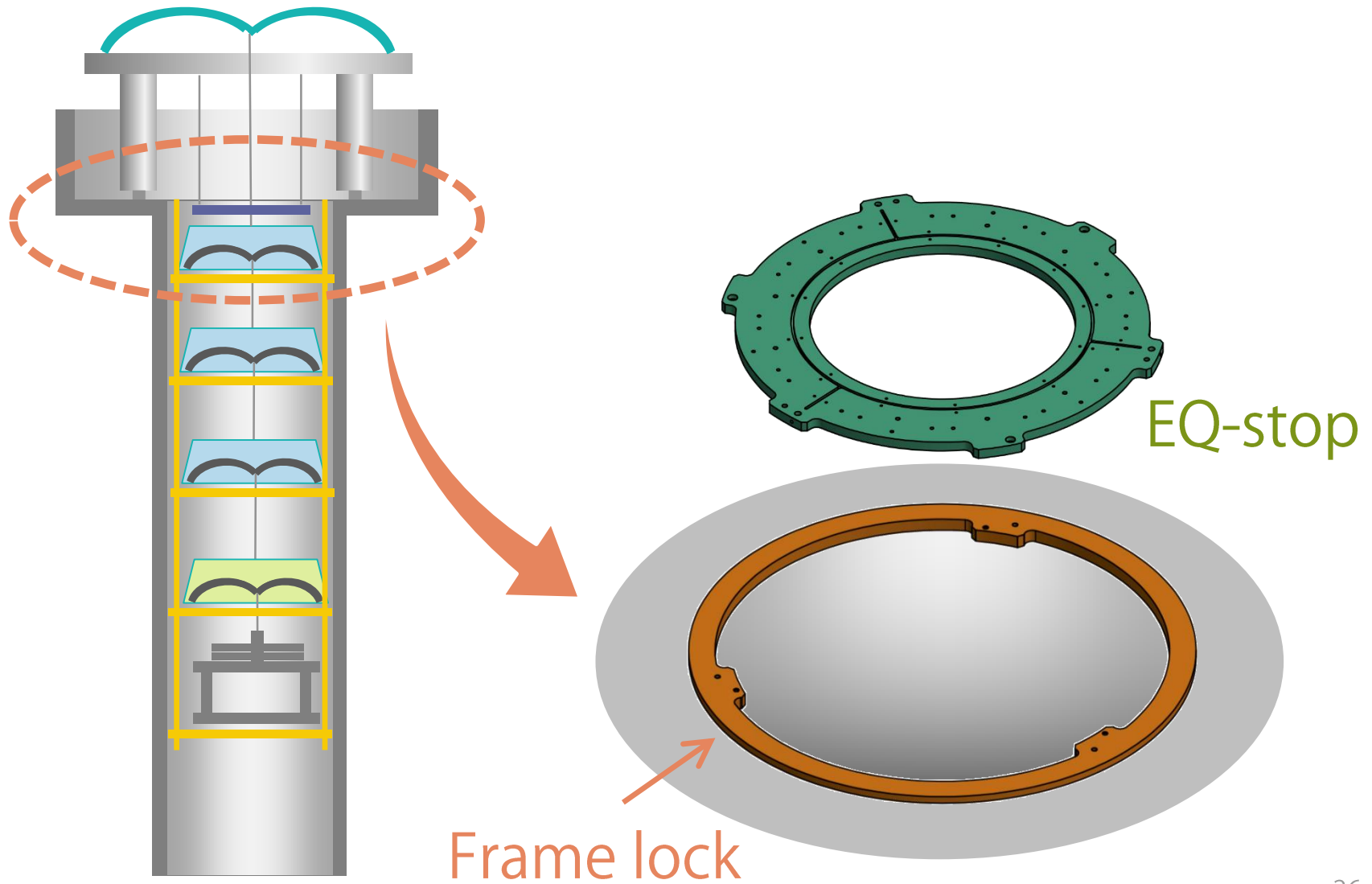
After installations of Type-A room-temperature parts,
Cryopayloads are integrated

Dummy Payload

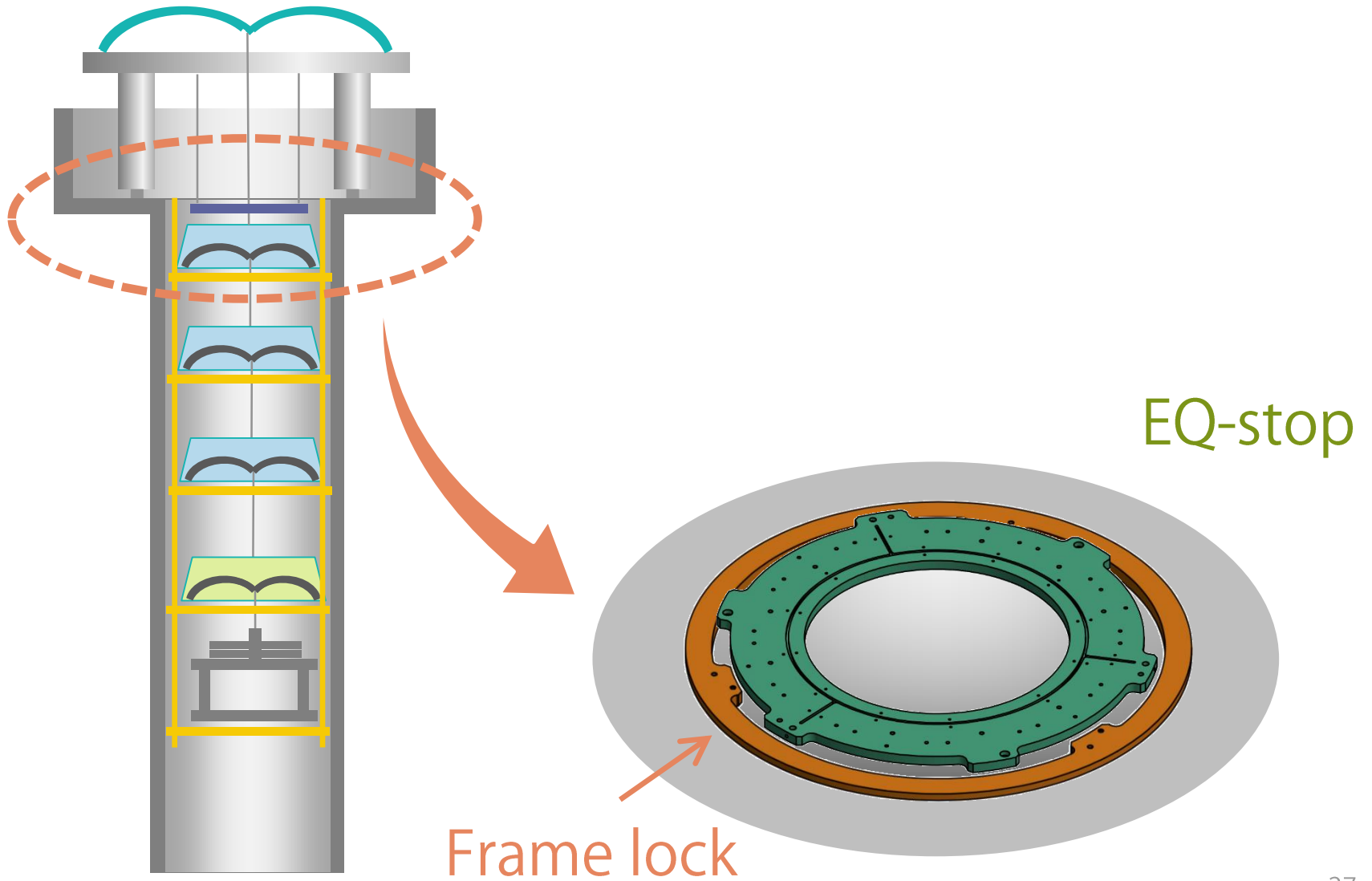


- Alternative load, instead of the CRYp
- Used during the installation work

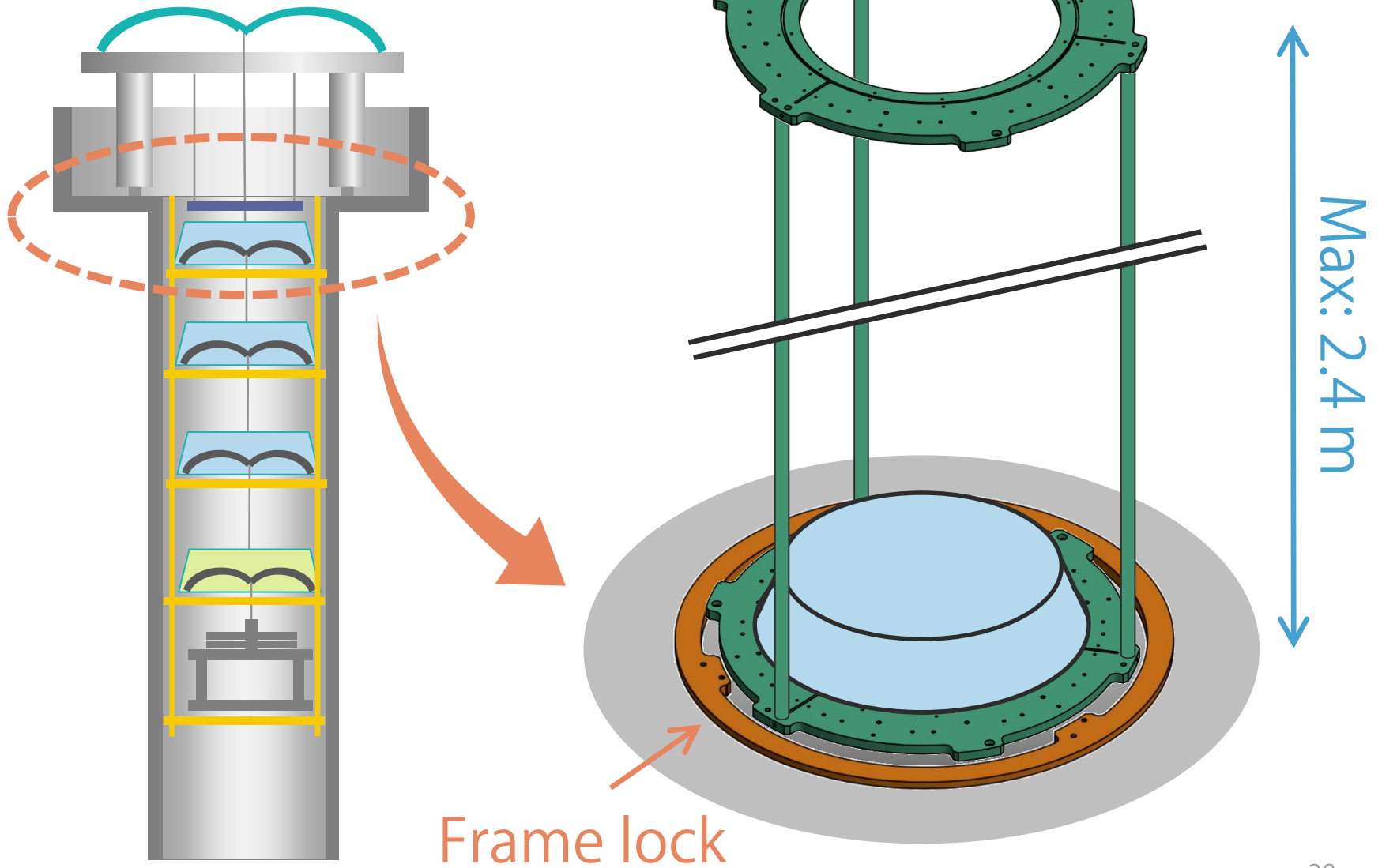
Installation Plan



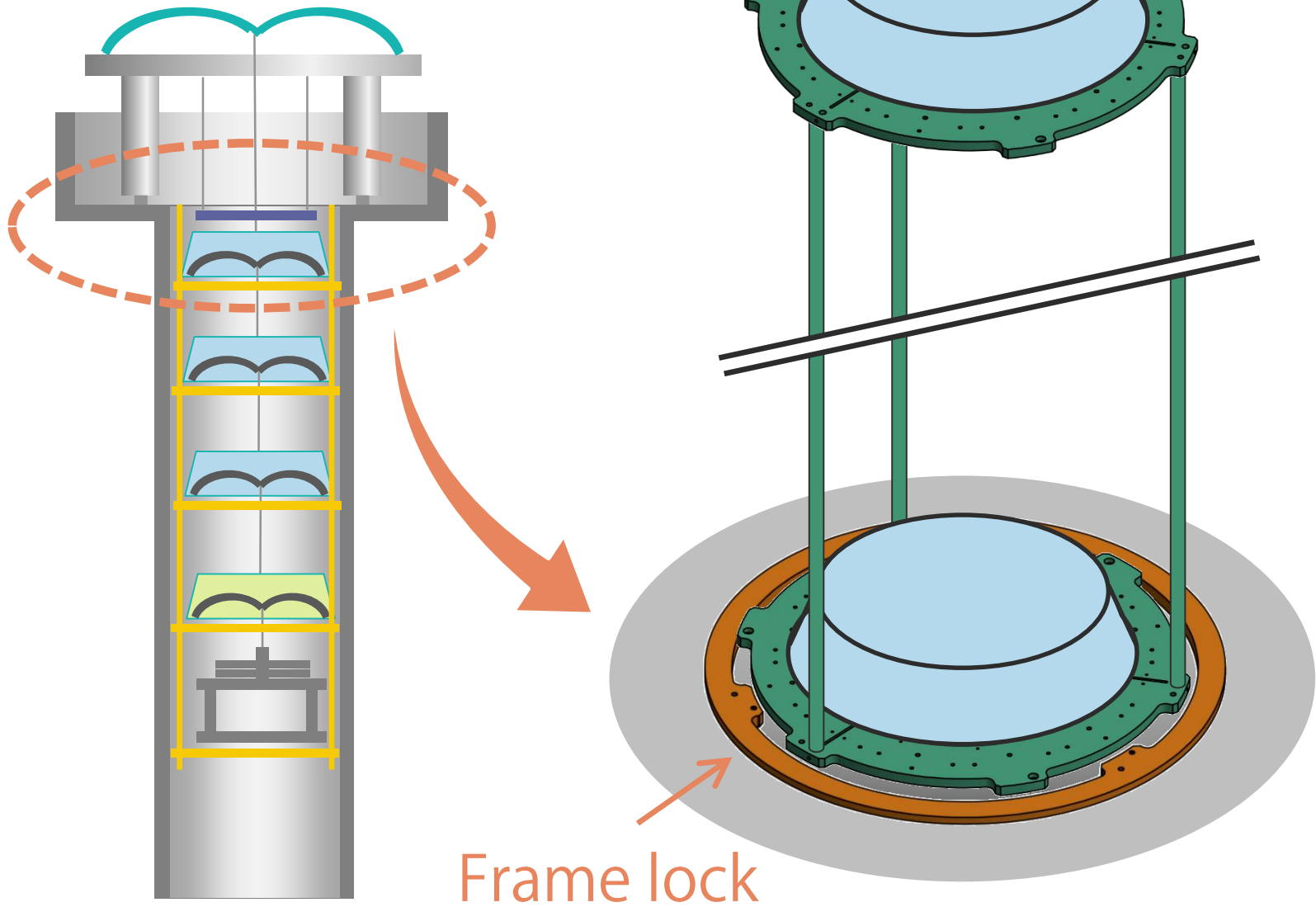
Installation Plan



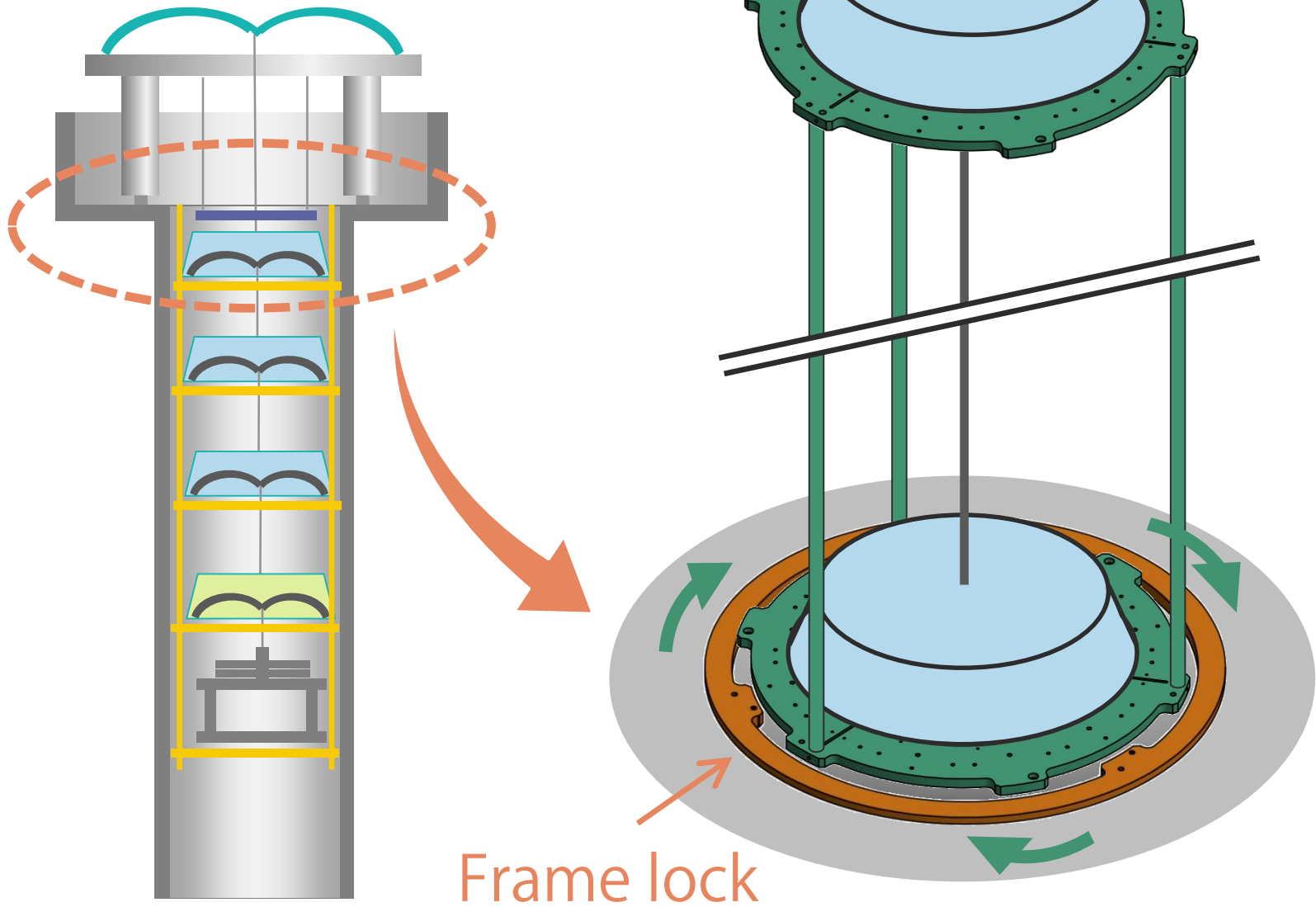
Installation Plan



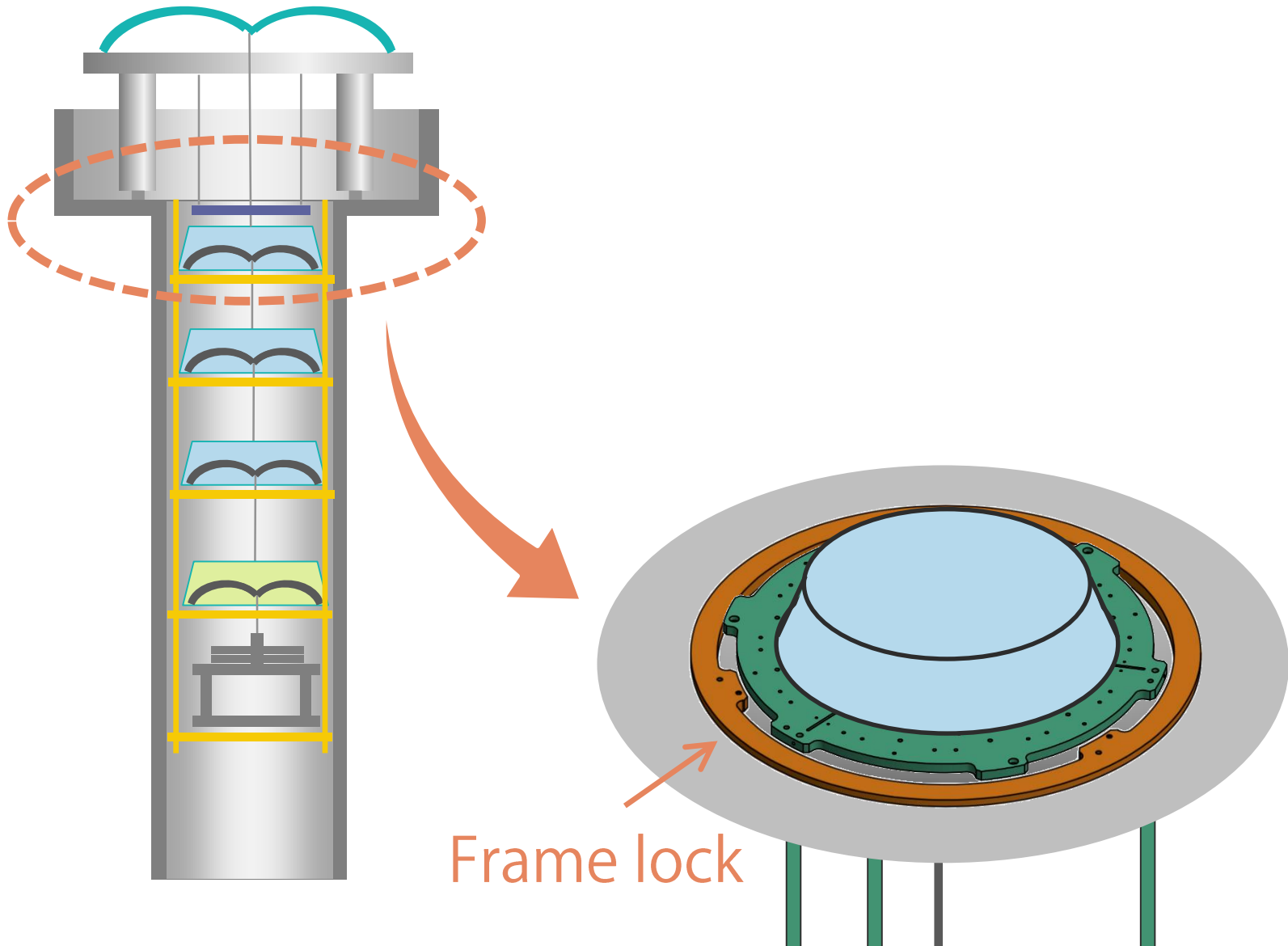
Installation Plan



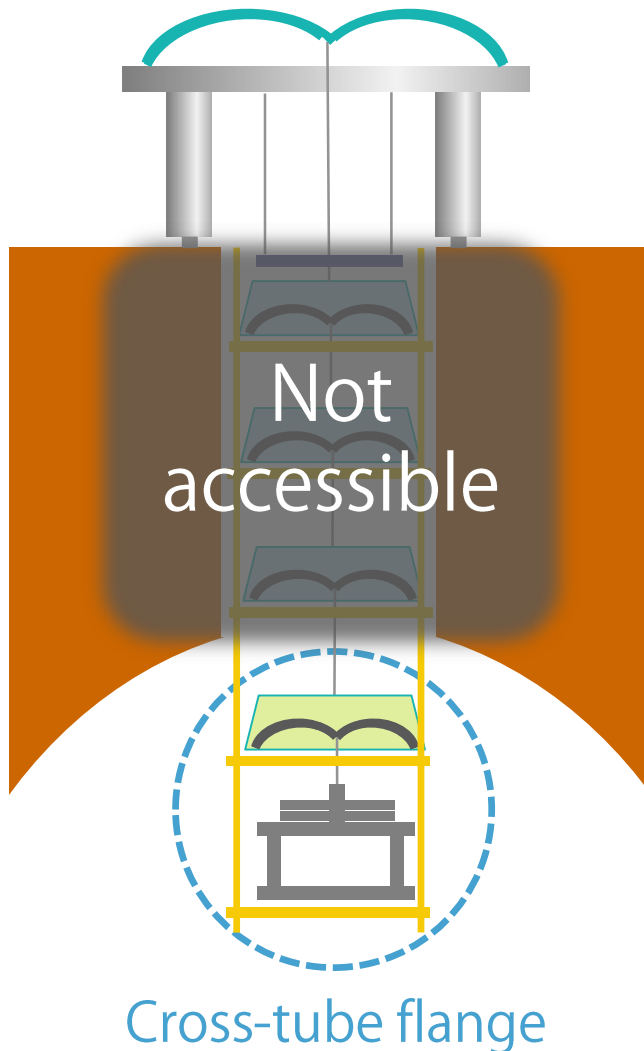
Installation Plan



Installation Plan

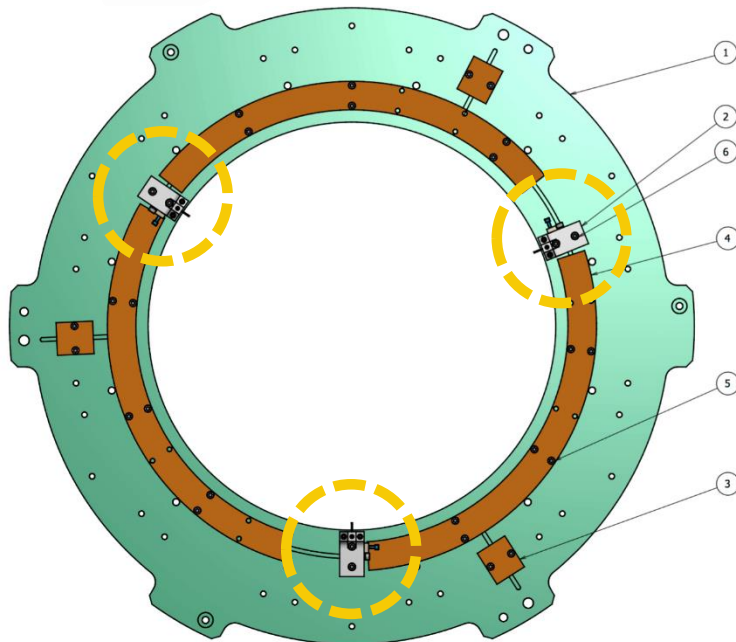
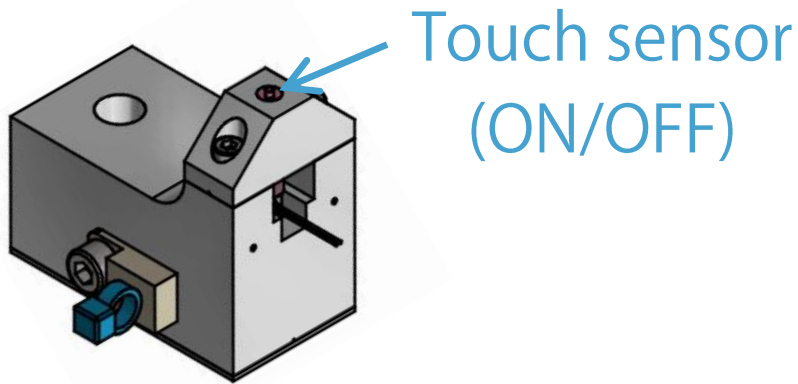


Problems in Installation



- We have to install stages one by one
- Optimal load adjustment required in each stage
 - All masses below the stage have to be released
- Parts in the vertical corrugated tube are not accessible
 - We have to know the stages sitting?/freely-suspended?

Release Sensor



- To confirm the stages are released from EQ-stops and freely-suspended
- 3 units / stage
- LED indications during the installation work
- Filters sit on these sensors when we lower by one stage

* Filters not locked either horizontal nor vertical direction

Points to Be Considered

- Footholds
- Perpendicularity of EQ-stop rods
- Required accuracy of assembling
- Position adjustment of magnetic damper
- Uninstallation procedure for emergency
- Longest maraging wire keeping
- Vacuum leakage test

Summary

About Type-A SAS

- In bKAGRA operation by the end of 2018, 2 Type-A SAS will be installed

Mode analysis and control strategy

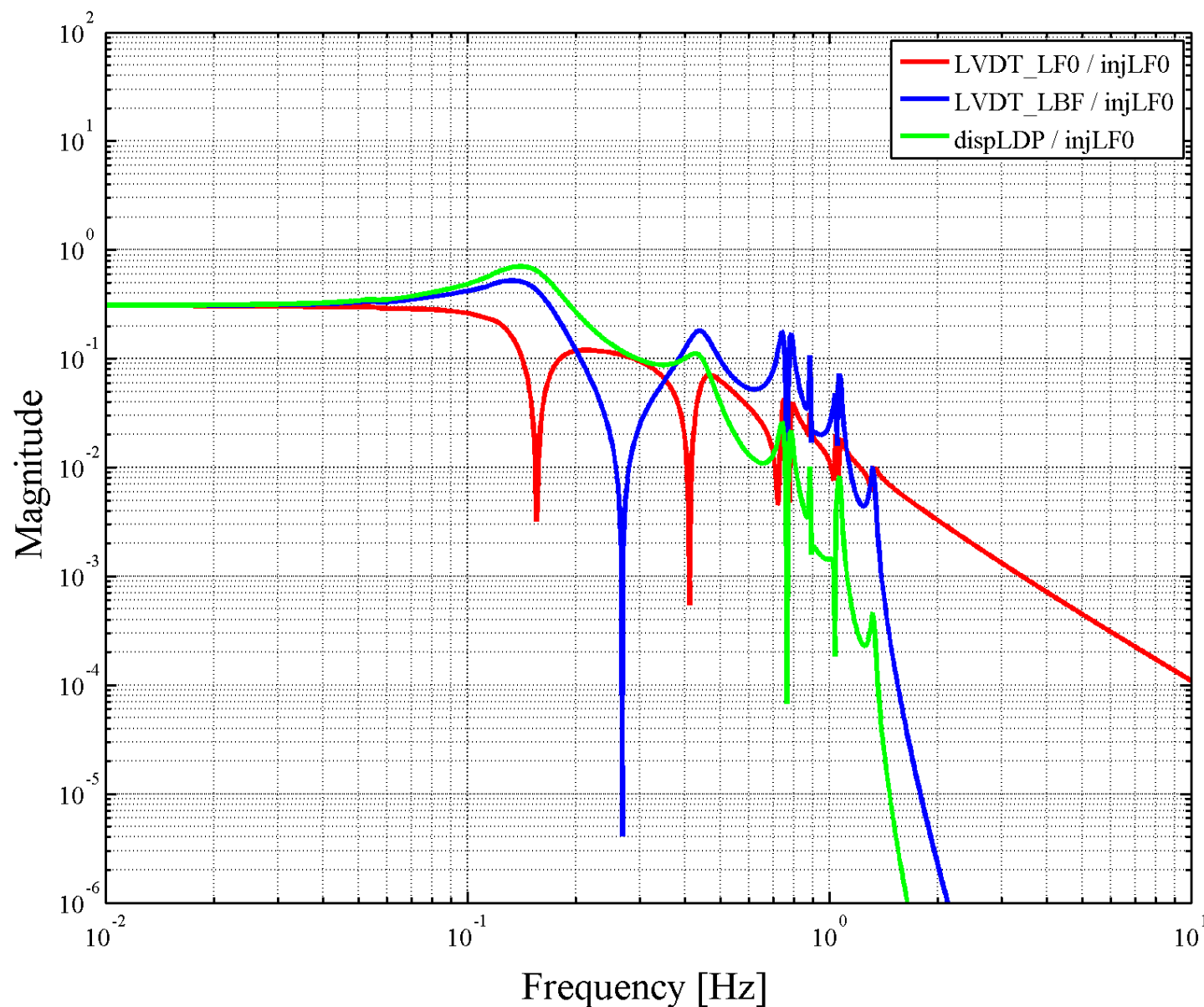
- We need BF controls to damp lowest yaw modes
- BF LVDT design and test is ongoing
- Next step => Analysis of suspension models including CRYp

Installation

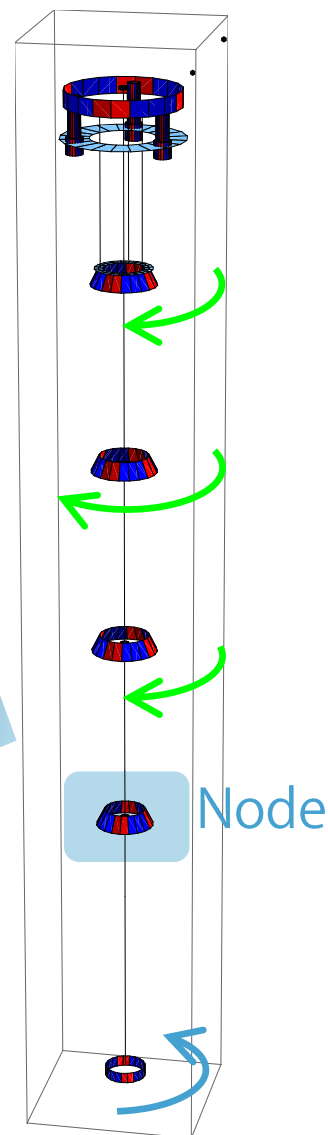
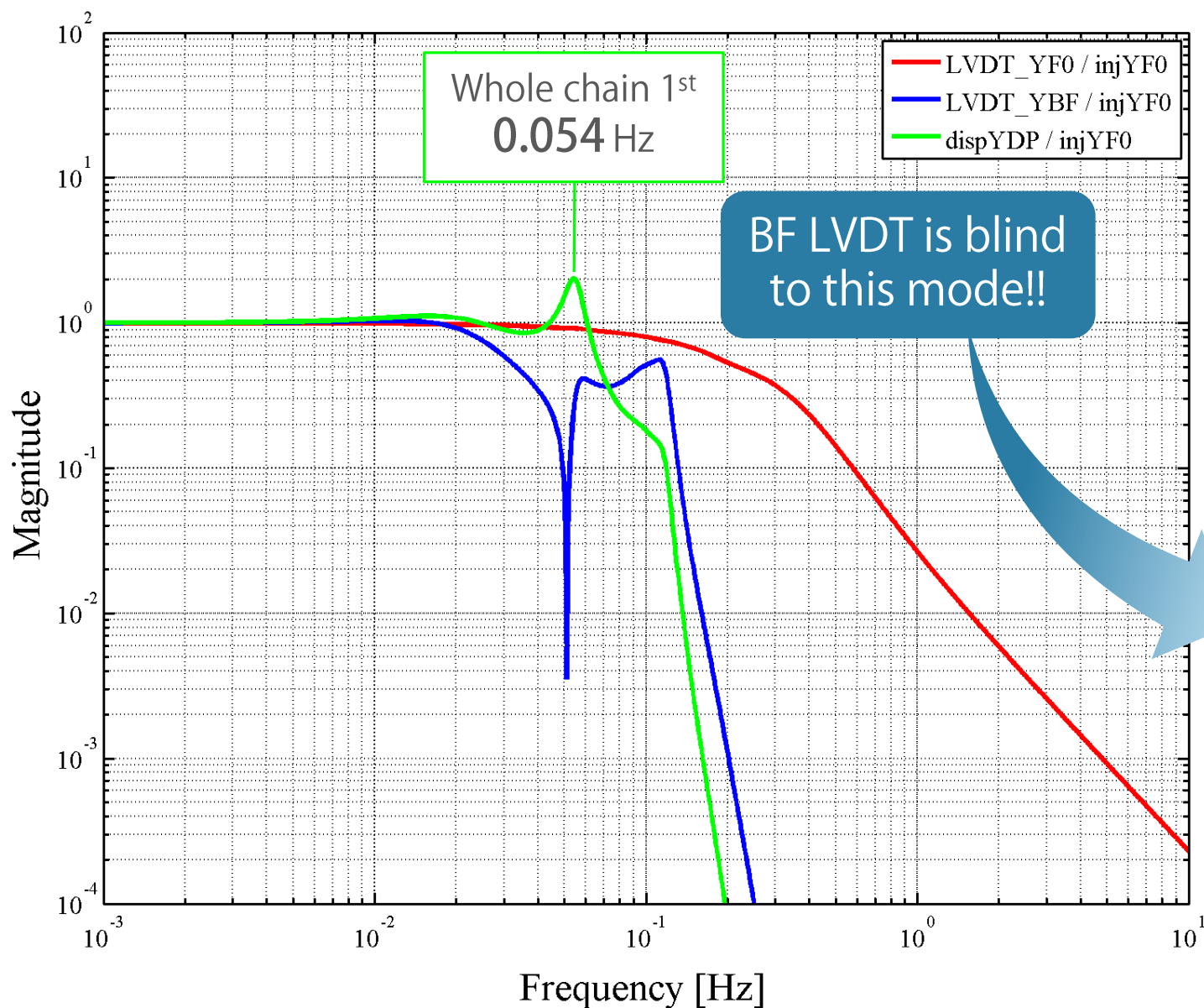
- Installation procedure is under updating
- Unaccessibility of the vertical corrugated tube makes the installation work more challenging

Backup Slides

Closed-loop Gain (LF0 act.)



Closed-loop Gain (YF0 act.)



Closed-loop Gain (YBF act.)

