Status Report of Type-A SAS

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KAGRA VIS Subgroup

KAGRA F2F Meeting @ University of Toyama

Aug. 25, 2016

Type-A Team

Members:

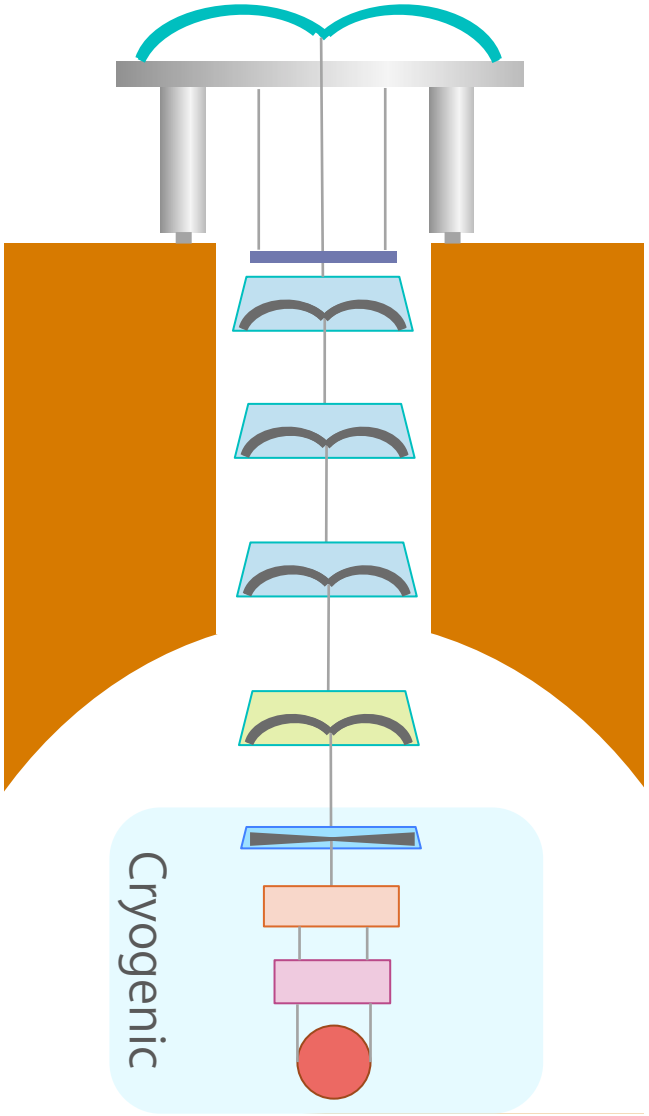
- TAKAHASHI, Ryutaro (Leader)
- ISHIZAKI, Hideharu
- SATO, Naohisa
- OKUTOMI, Koki

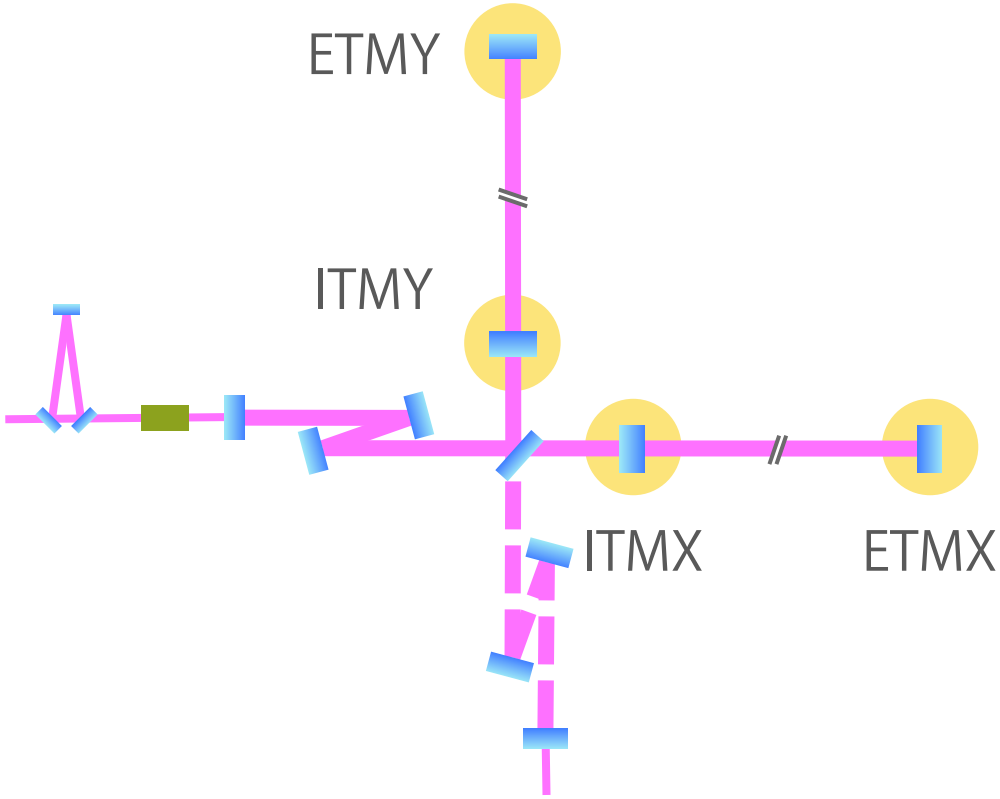
Team Meeting: 13:00- on every Tuesday

Contents

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

Type-A SAS



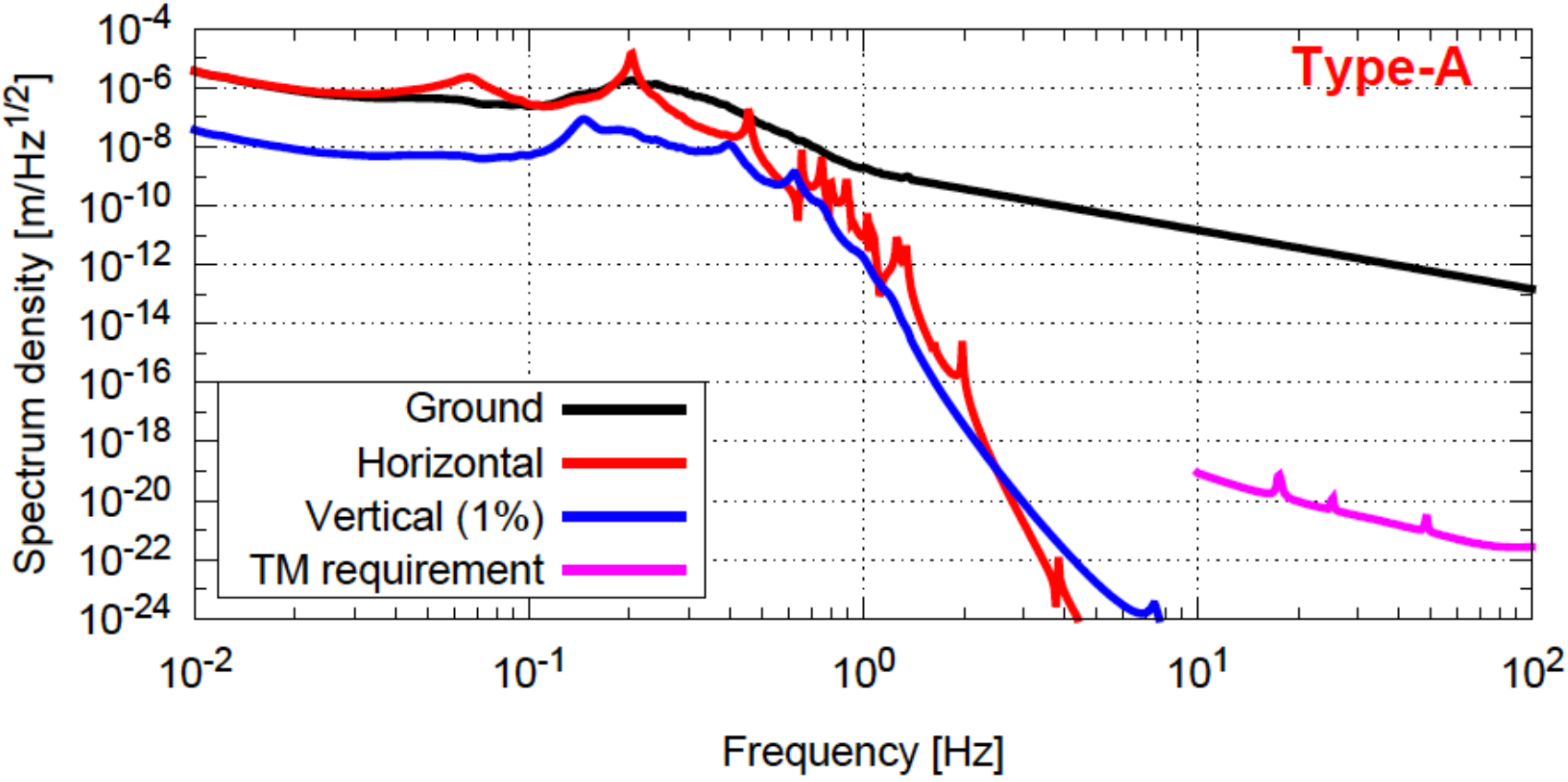


- Largest SAS for test masses
- Cryopayload at the bottom
- Suspended from 2nd floor

Requirements for Type-A

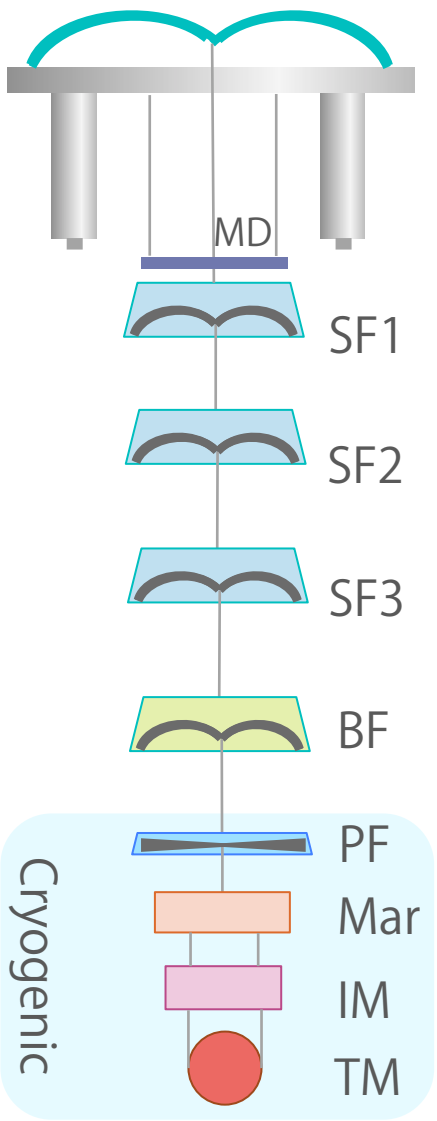
		Value	Unit	Required from
PSD	Longitudinal	1×10^{-19}	$m/Hz^{1/2}$ @ 10 Hz	Sensitivity
	Vertical	1×10^{-17}	$m/Hz^{1/2}$ @ 10 Hz	Sensitivity
RMS	Pitch, Yaw	0.01	urad	
	Velocity	0.1	um/sec	Lock acquisition
	Angular velocity	0.01	rad/sec	Alignment (w/ WFS)
Long term drift	Longitudinal	???	m/hour	Actuator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

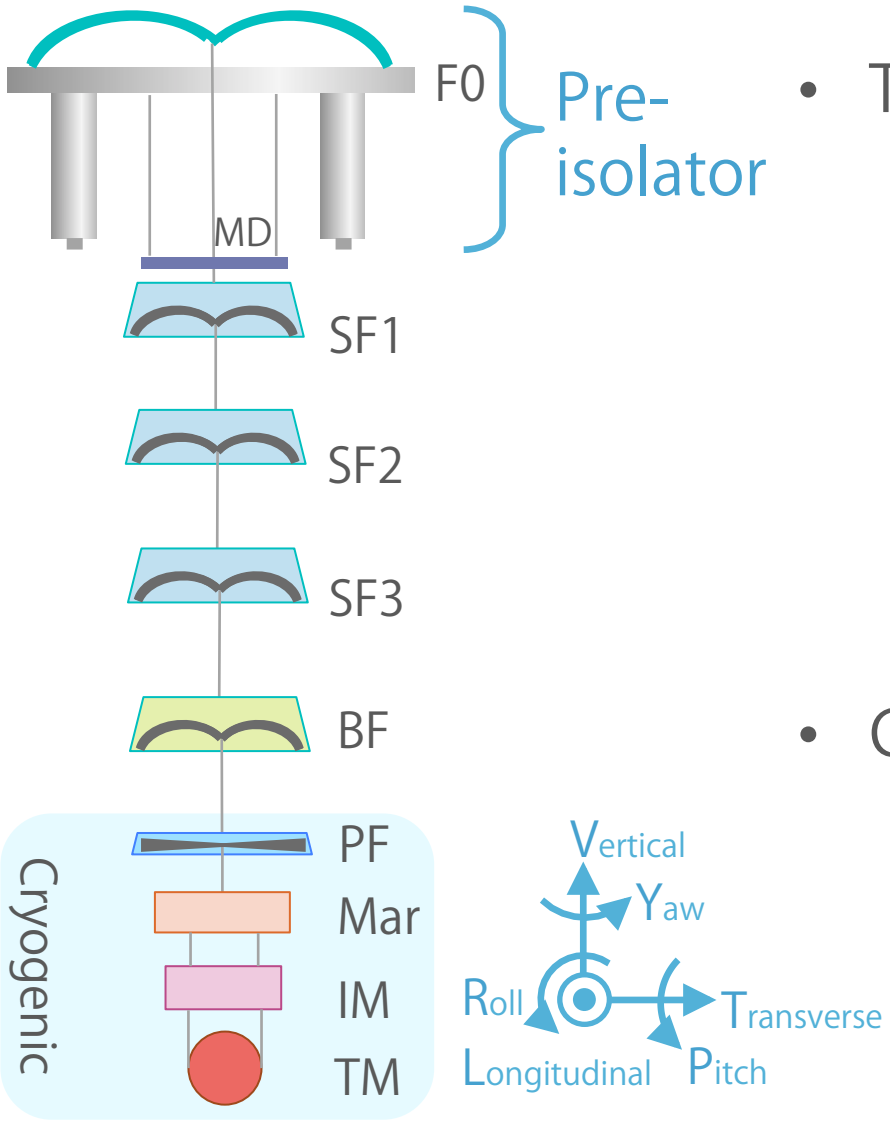


- Top stage (F0)
- Magnetic damper (MD)
- Standard filter (SF) x3
- Bottom filter (BF)

- Platform (PF)
- Marionette (Mar)
- Intermediate mass (IM)
- Test mass (TM)

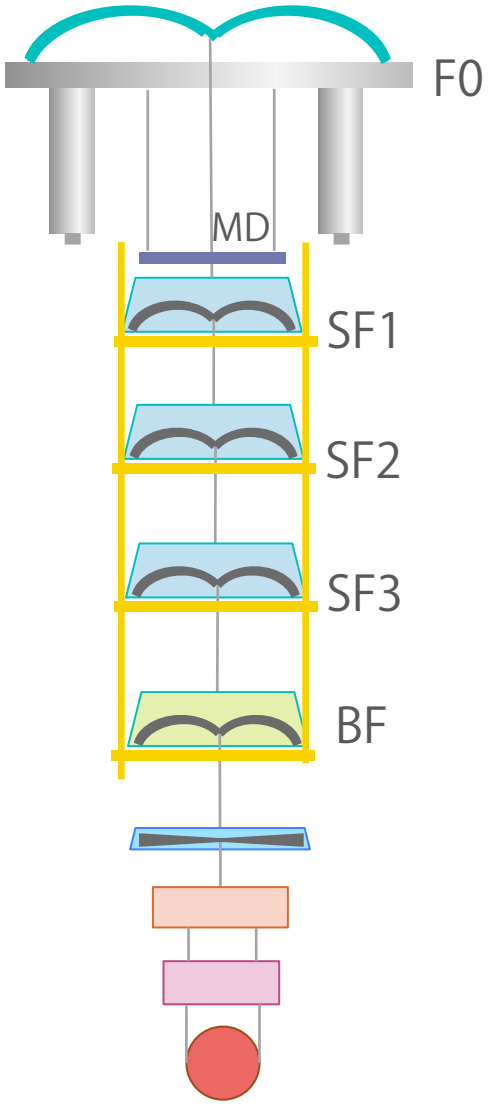
➢ CRY subgroup's talk (Aug. 26)

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)

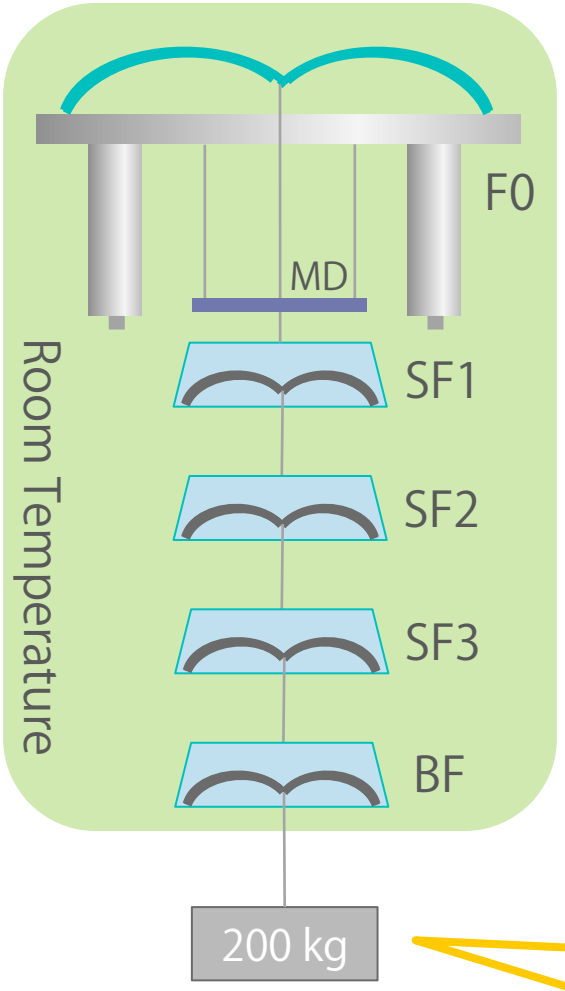
Earthquake Stop – Security Frame



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

Mode Analysis & Control Strategy

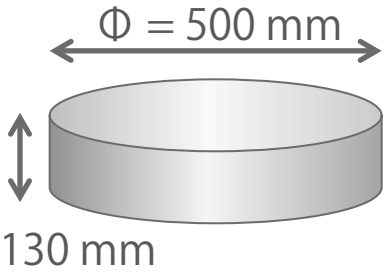
Mode Analysis



- 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/cm^3

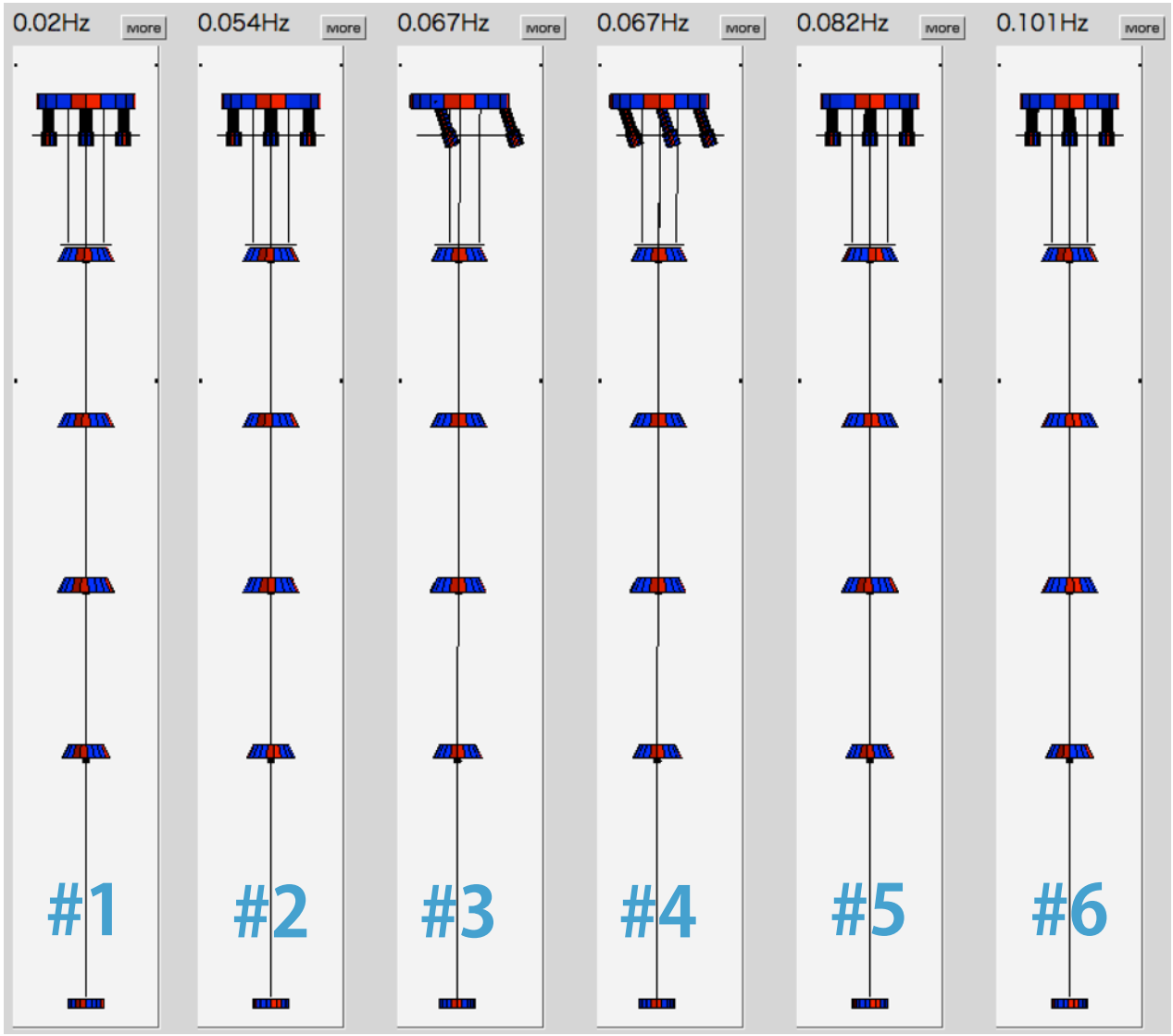


What Is Concerned?

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

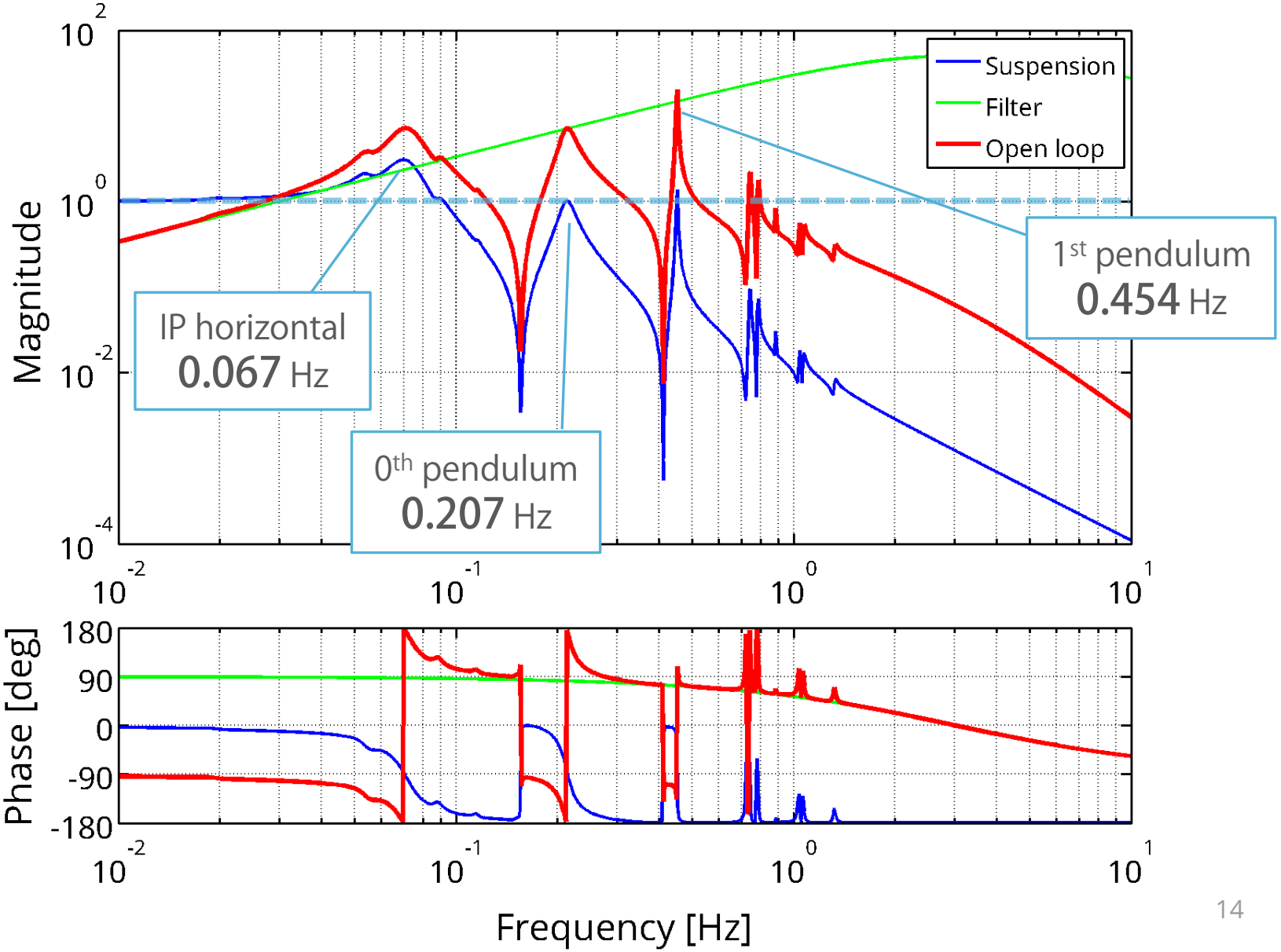
#5: 0.082 Hz

Yaw whole chain 2nd

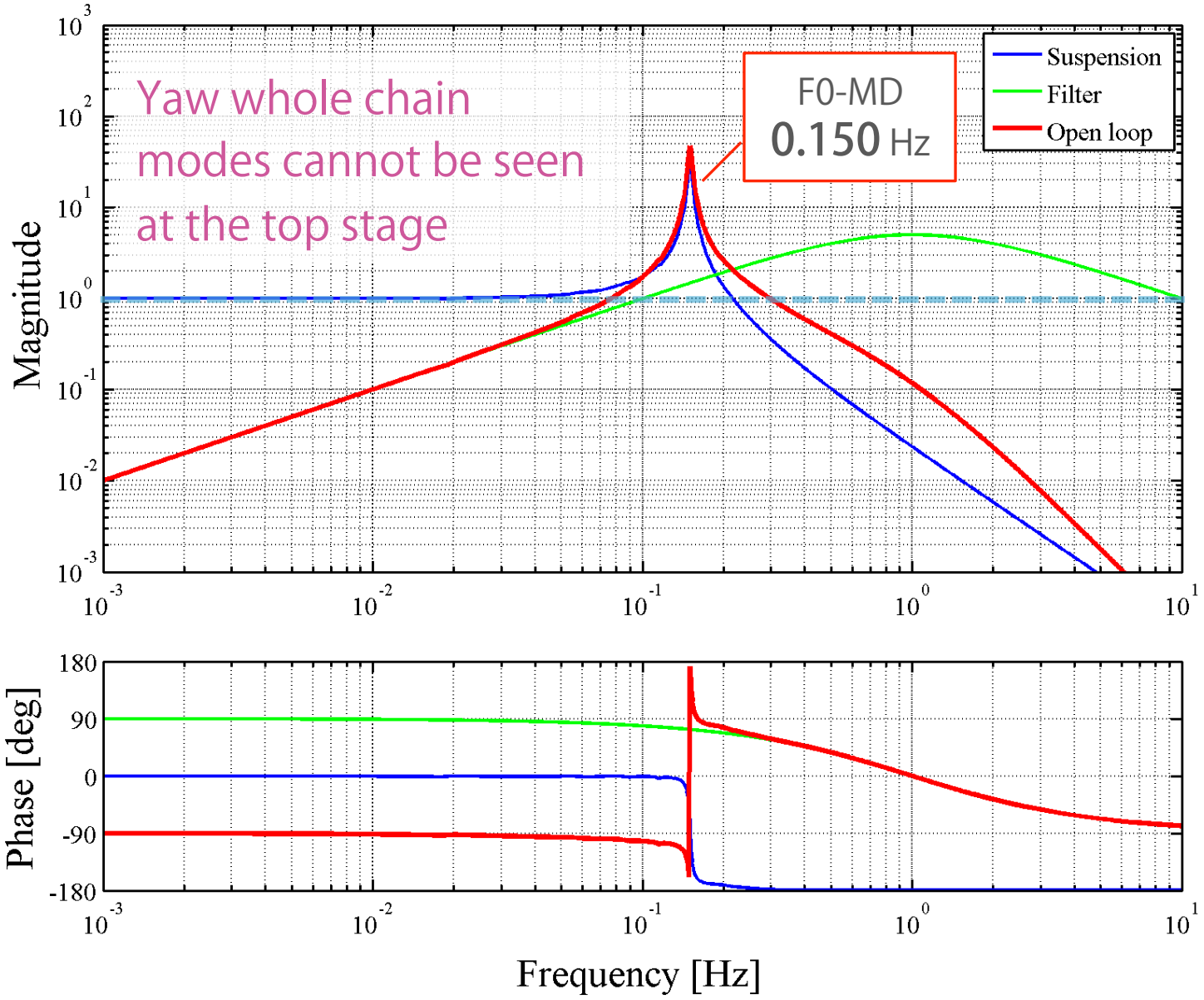
#6: 0.101 Hz

Yaw whole chain 3rd

Open-loop Transfer Function (LF0)



Open-loop Transfer Function (YF0)



Damping Strategy

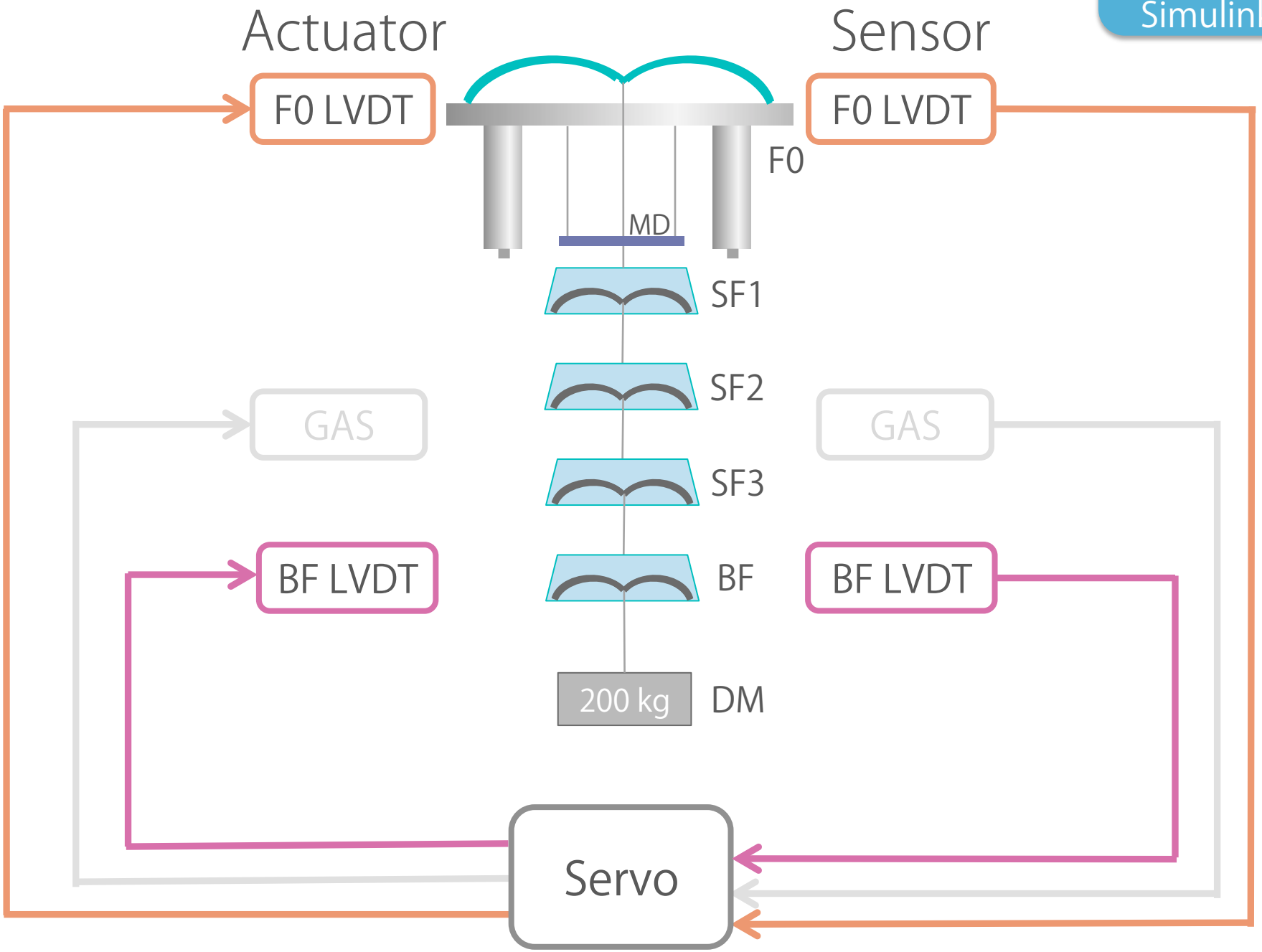
Translational modes

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

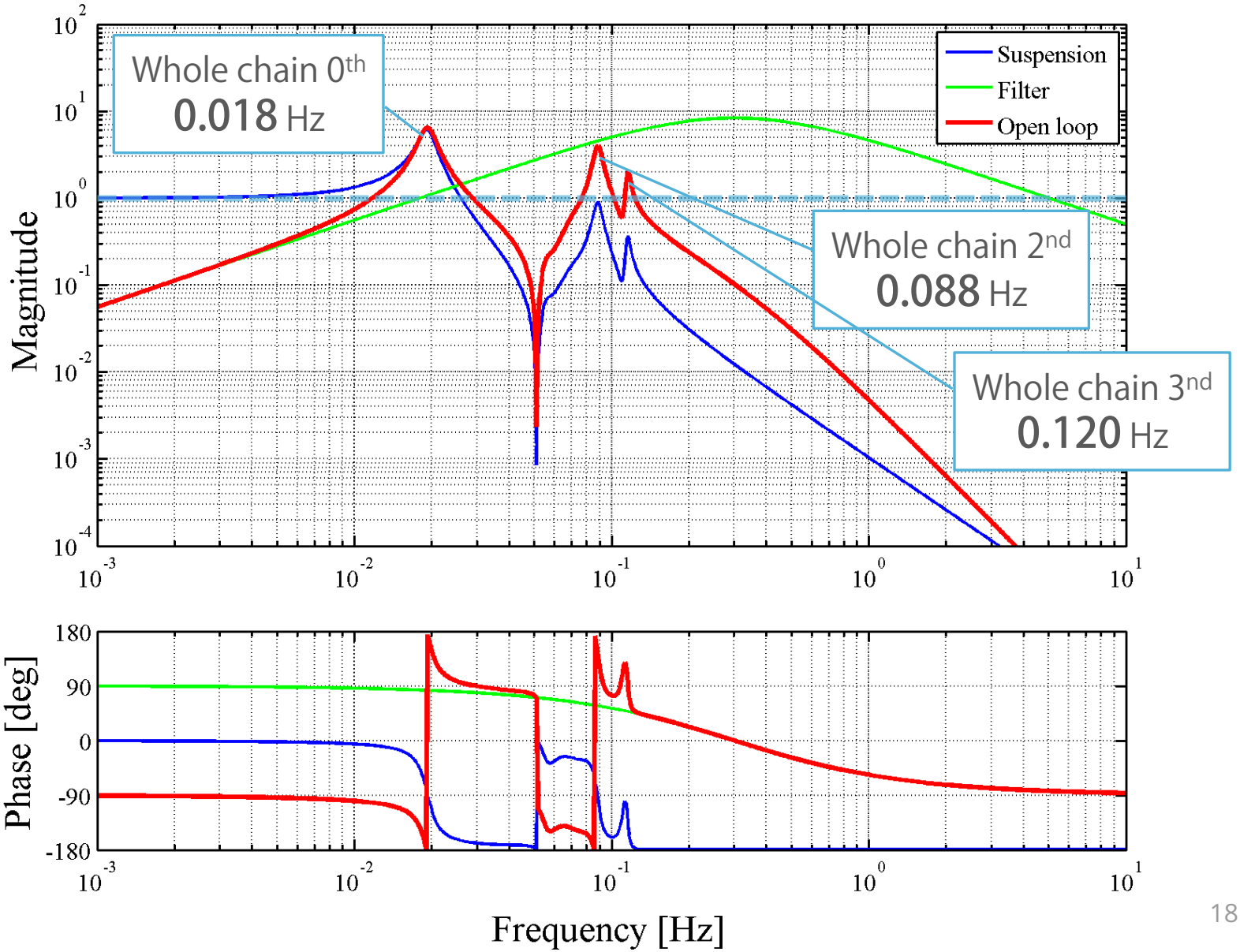
Yaw modes

- The lowest resonance in yaw (whole chain 0^{th}) is difficult to be damped with F0 control

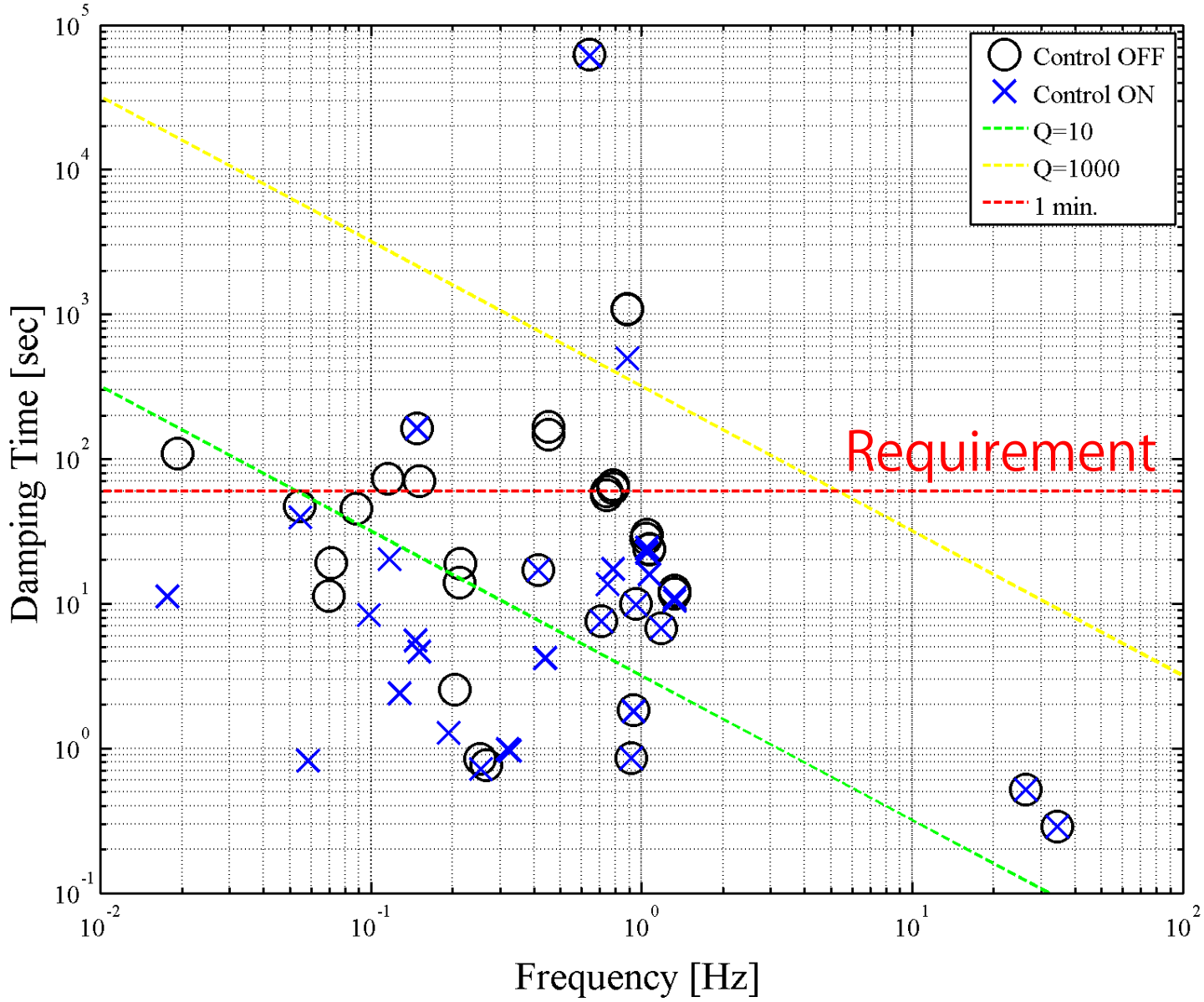
➢ Add controls on the Bottom Filter (BF) and check possibility to damp the lowest modes


Actuator
Sensor
F0 LVDT
F0 LVDT
F0
MD
SF1
SF2
GAS
GAS
SF3
BF LVDT
BF
BF LVDT
200 kg
DM
Servo

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

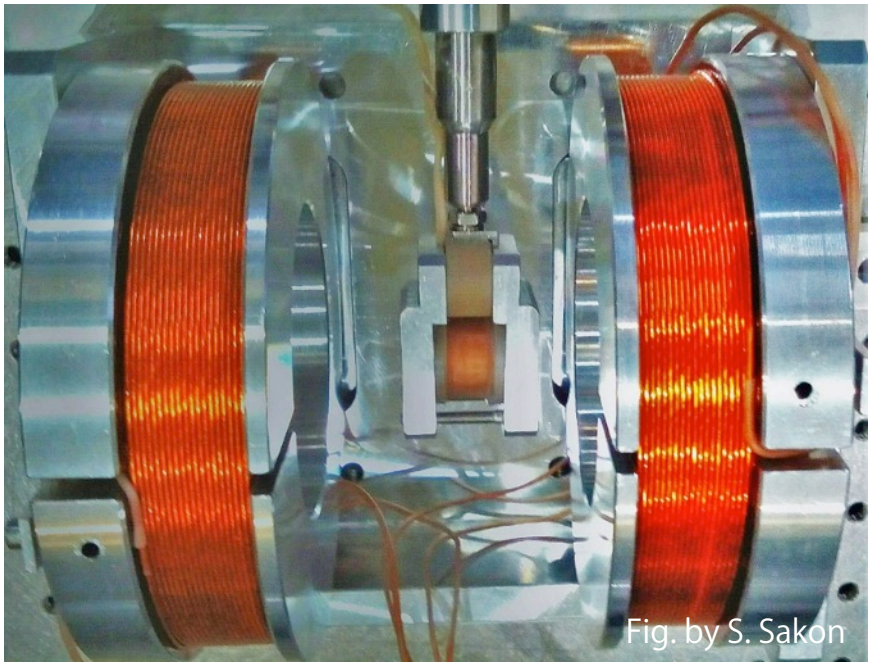
Yaw modes

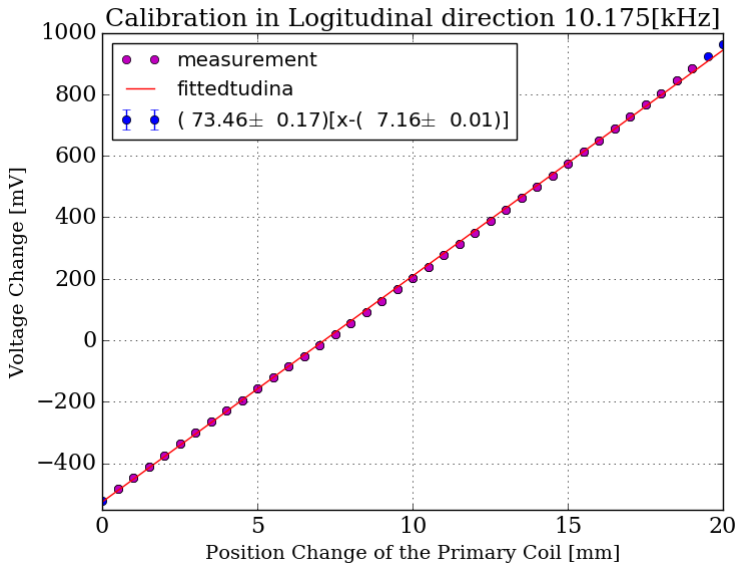
- The lowest whole-chain mode can be damped with BF control
- 1st whole-chain mode becomes raised
  - might be a problem? => under investigation

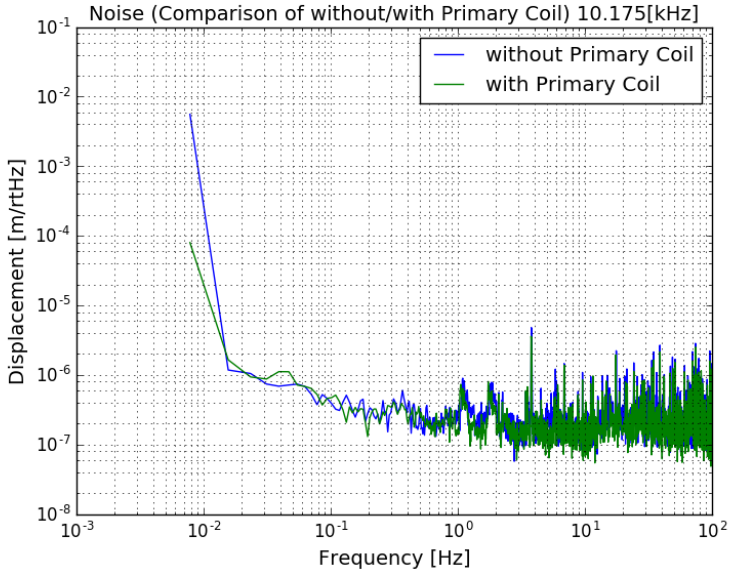
Next step

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

BF LVDT

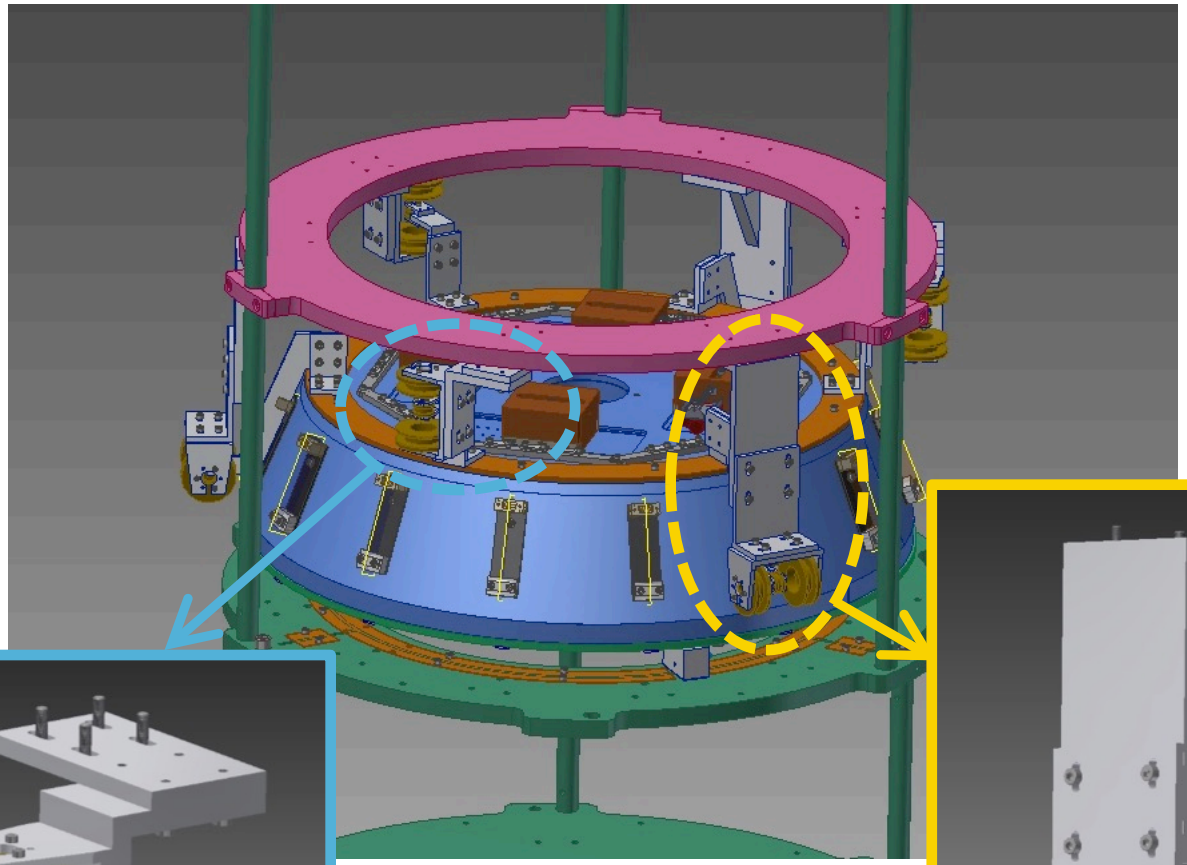


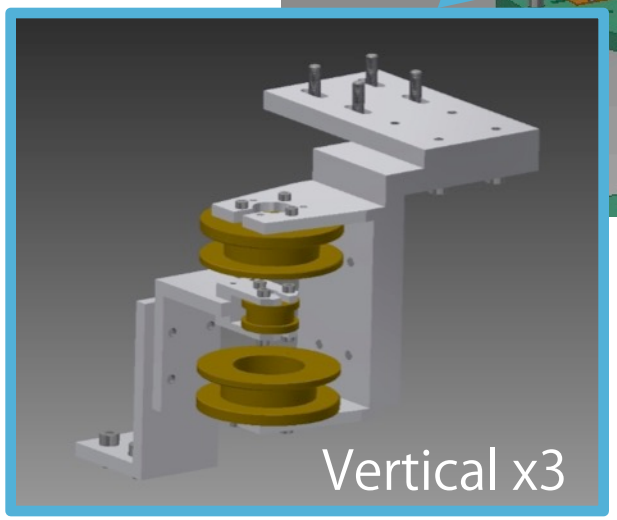


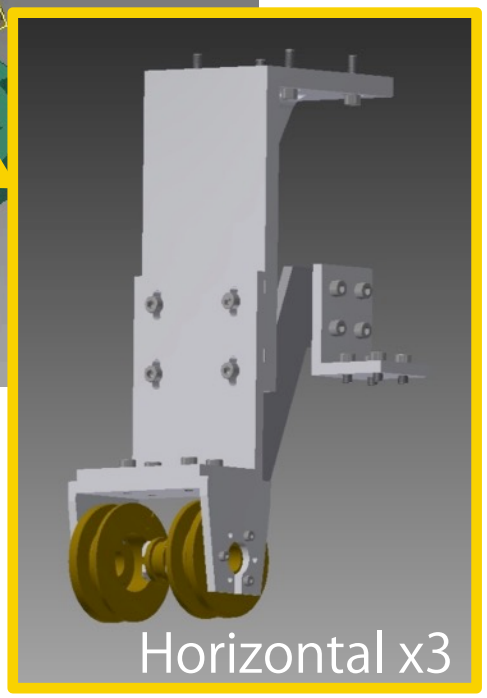


- Under design work, based on Adv. Virgo F7 LVDT
- Tested with our driver circuit

Configuration of BF LVDT

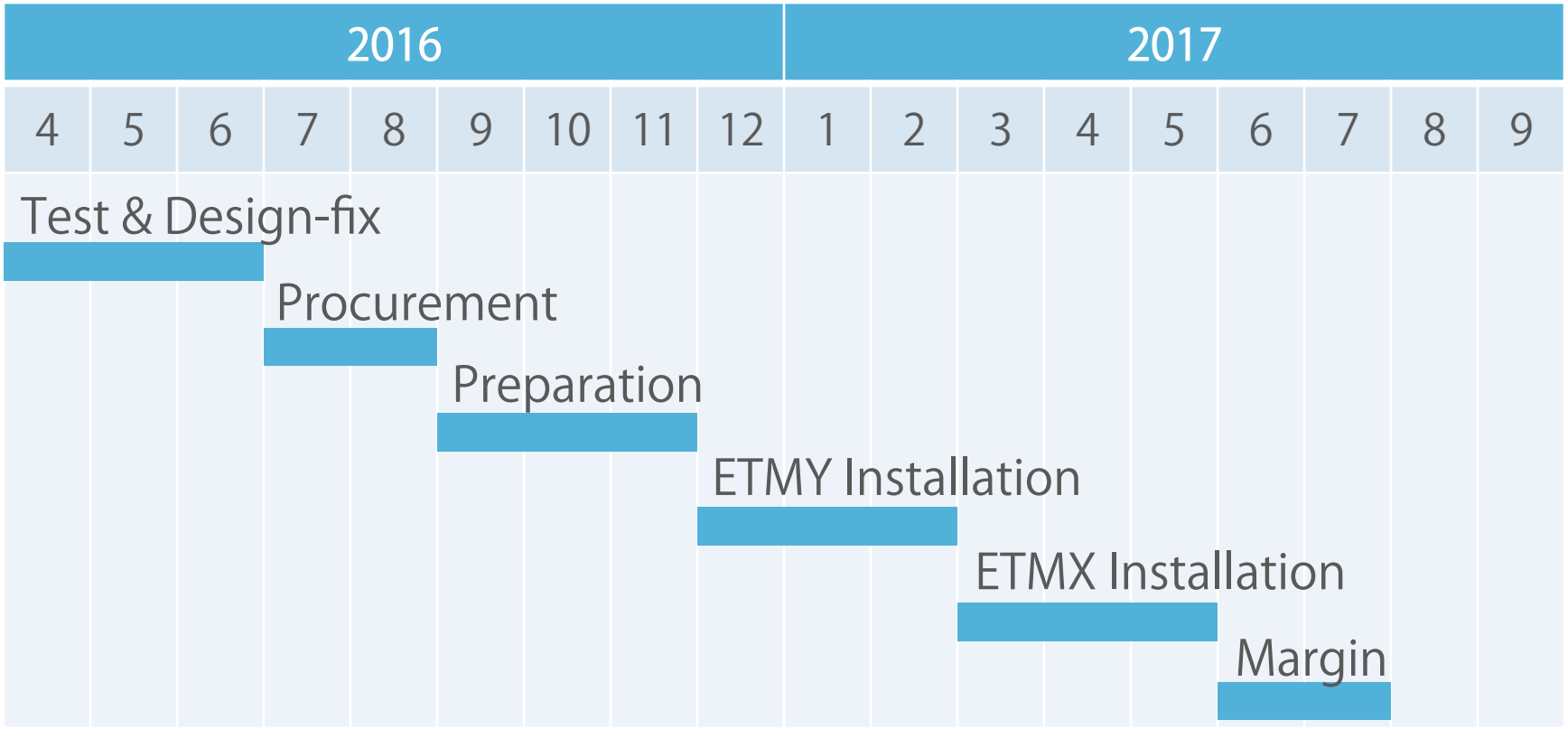






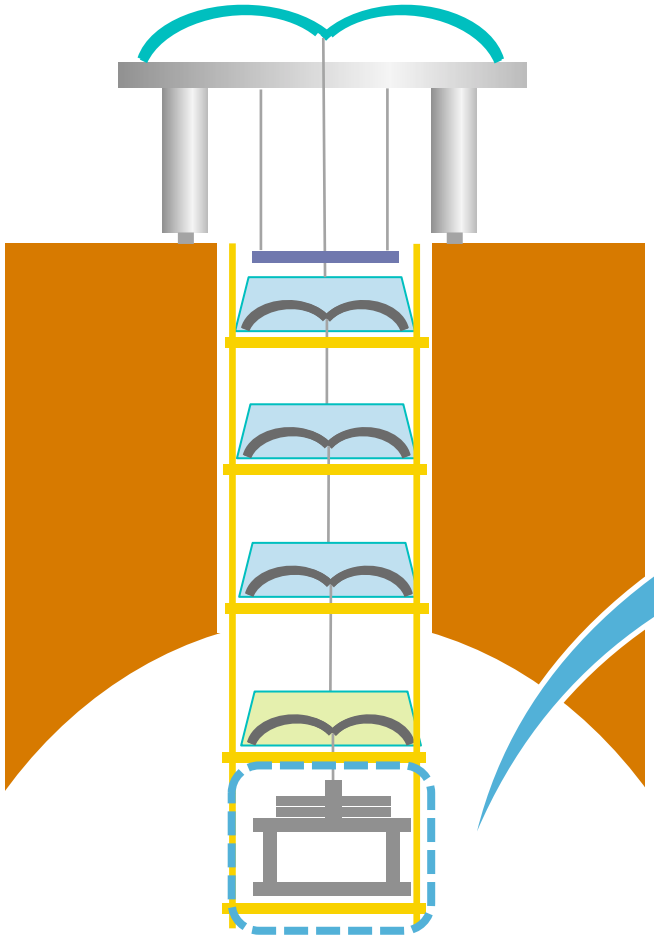
Installation

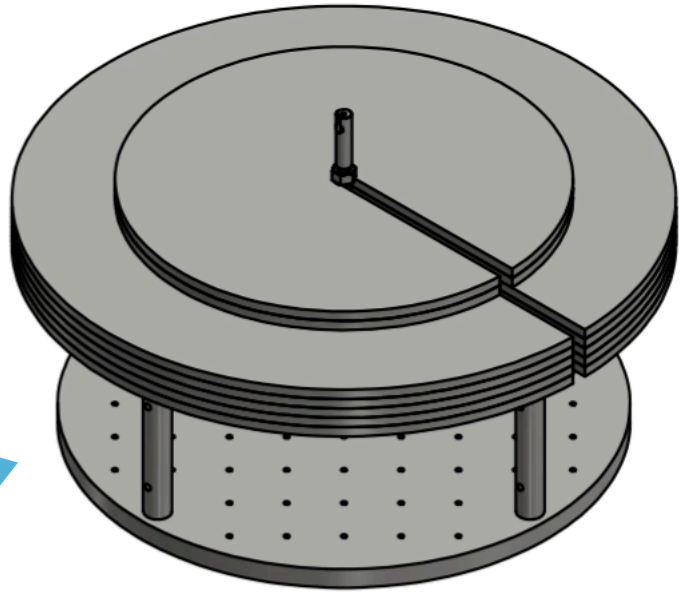
Installation Schedule



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

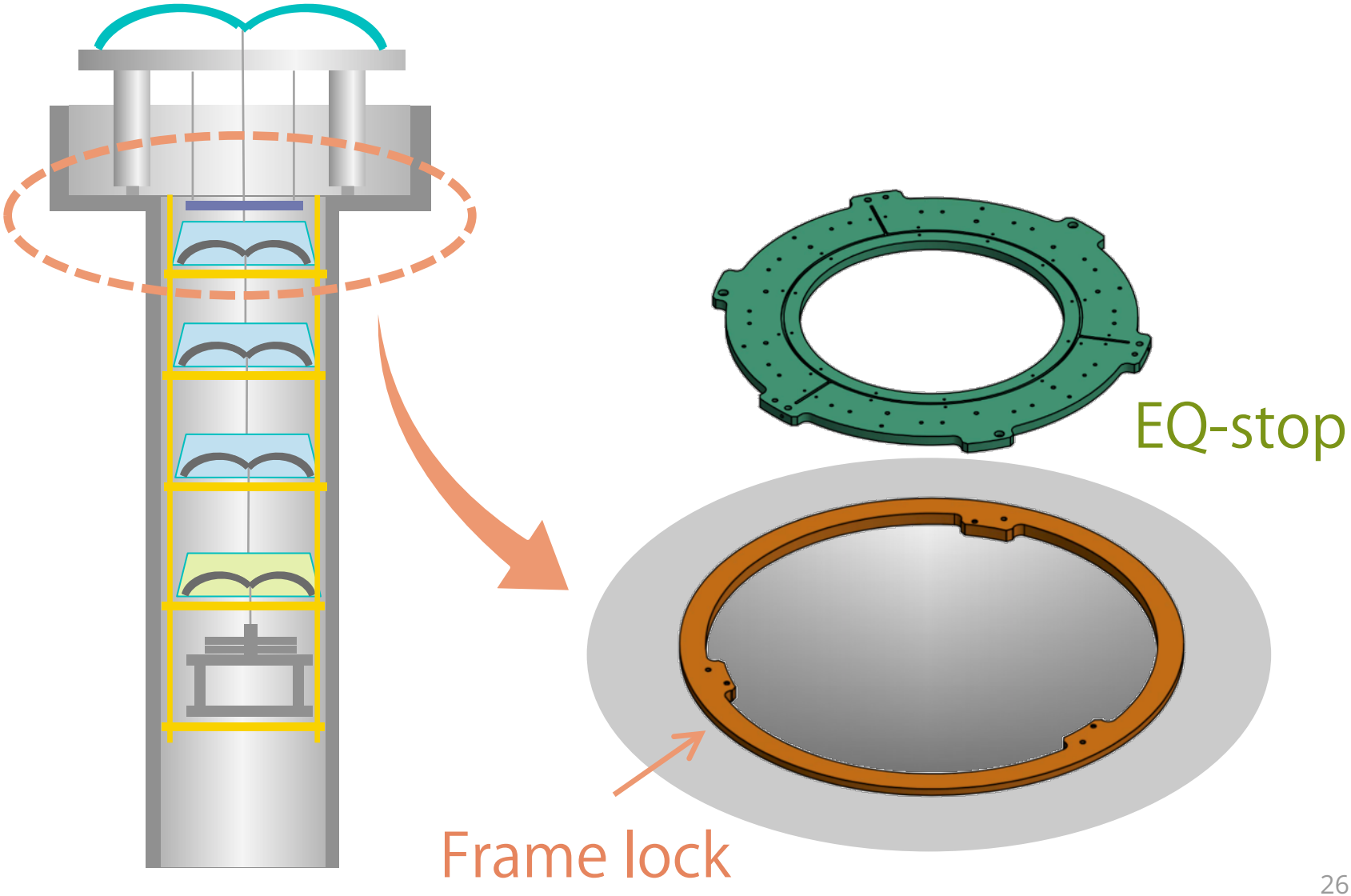
Dummy Payload





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

Installation Plan



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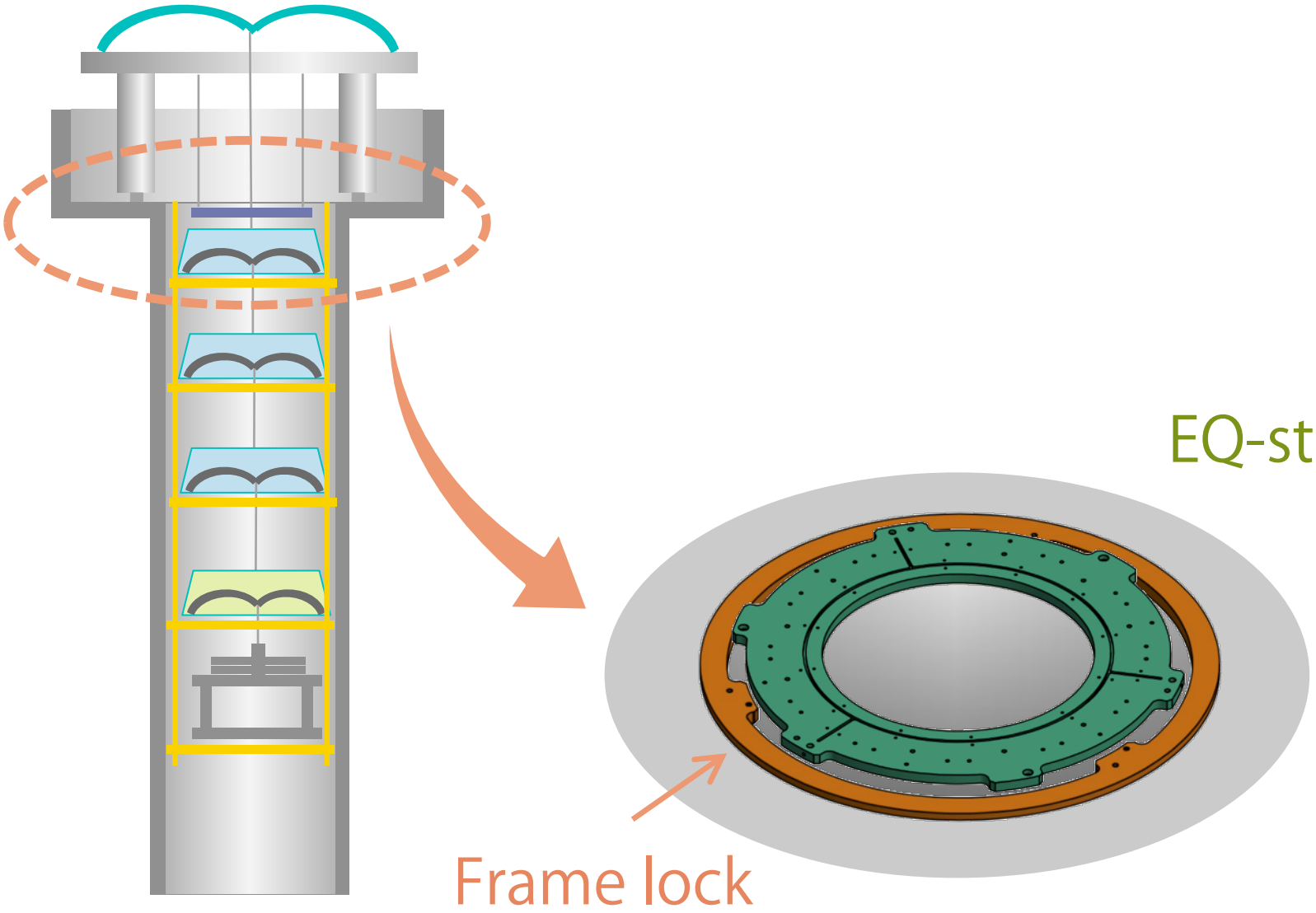

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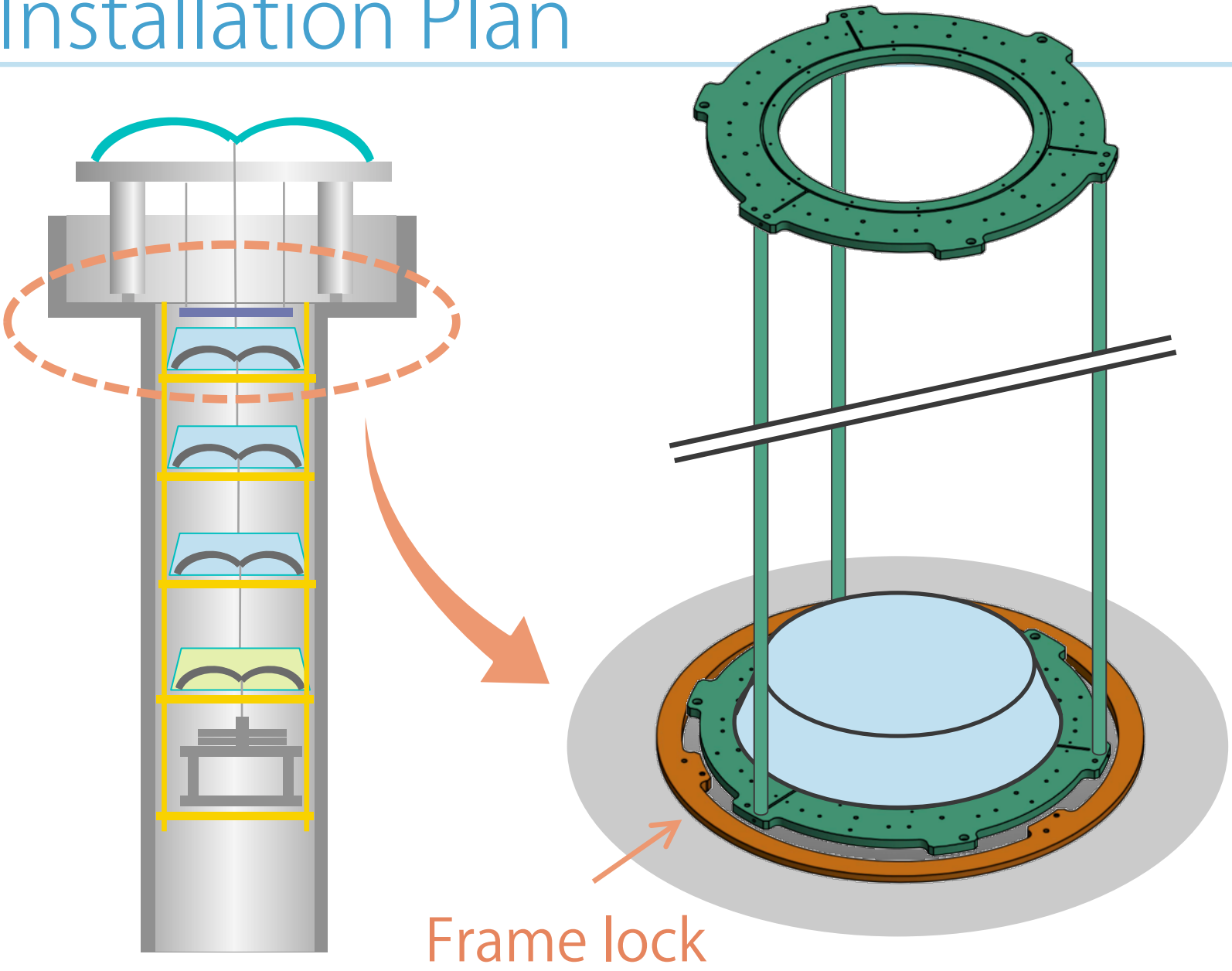

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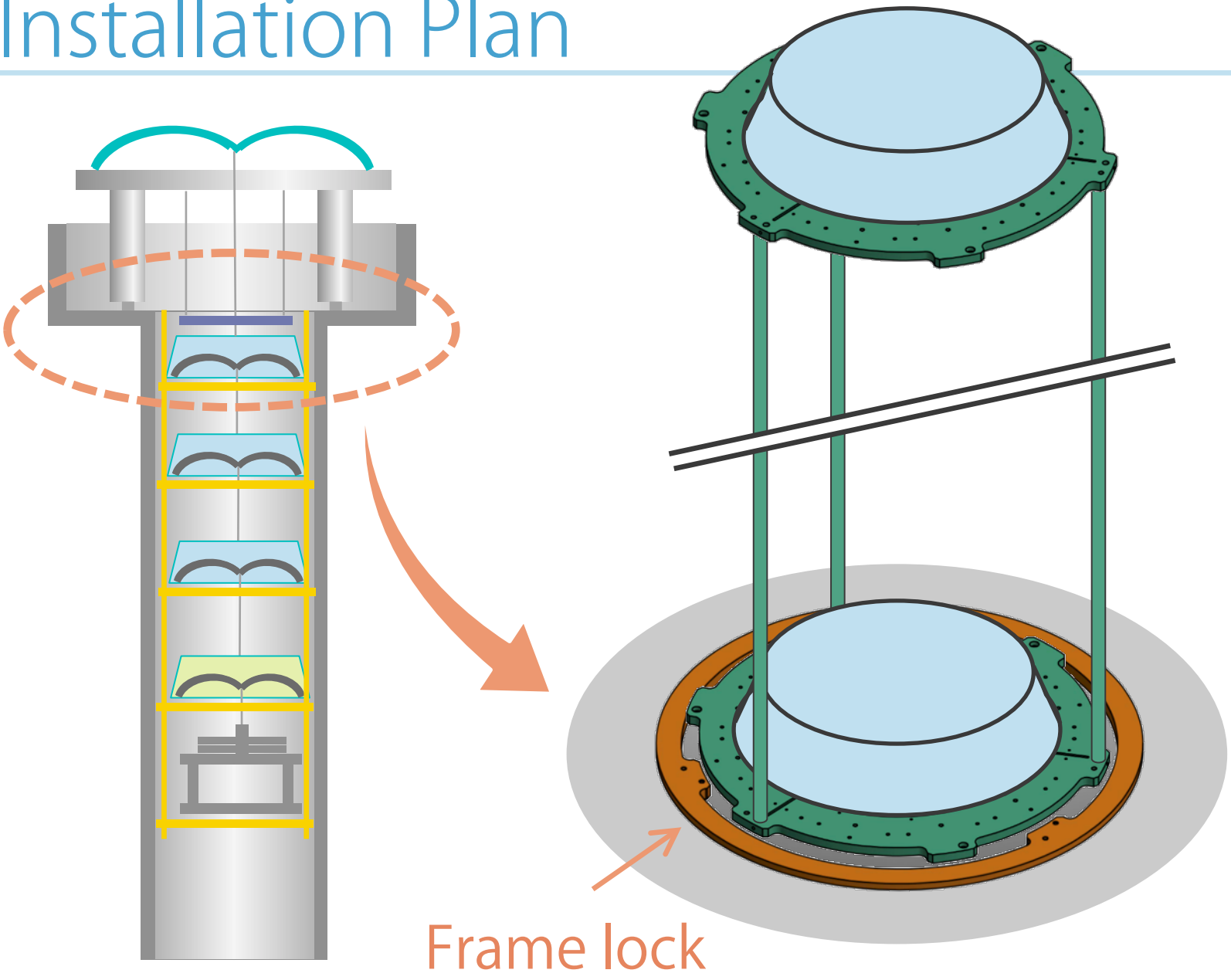

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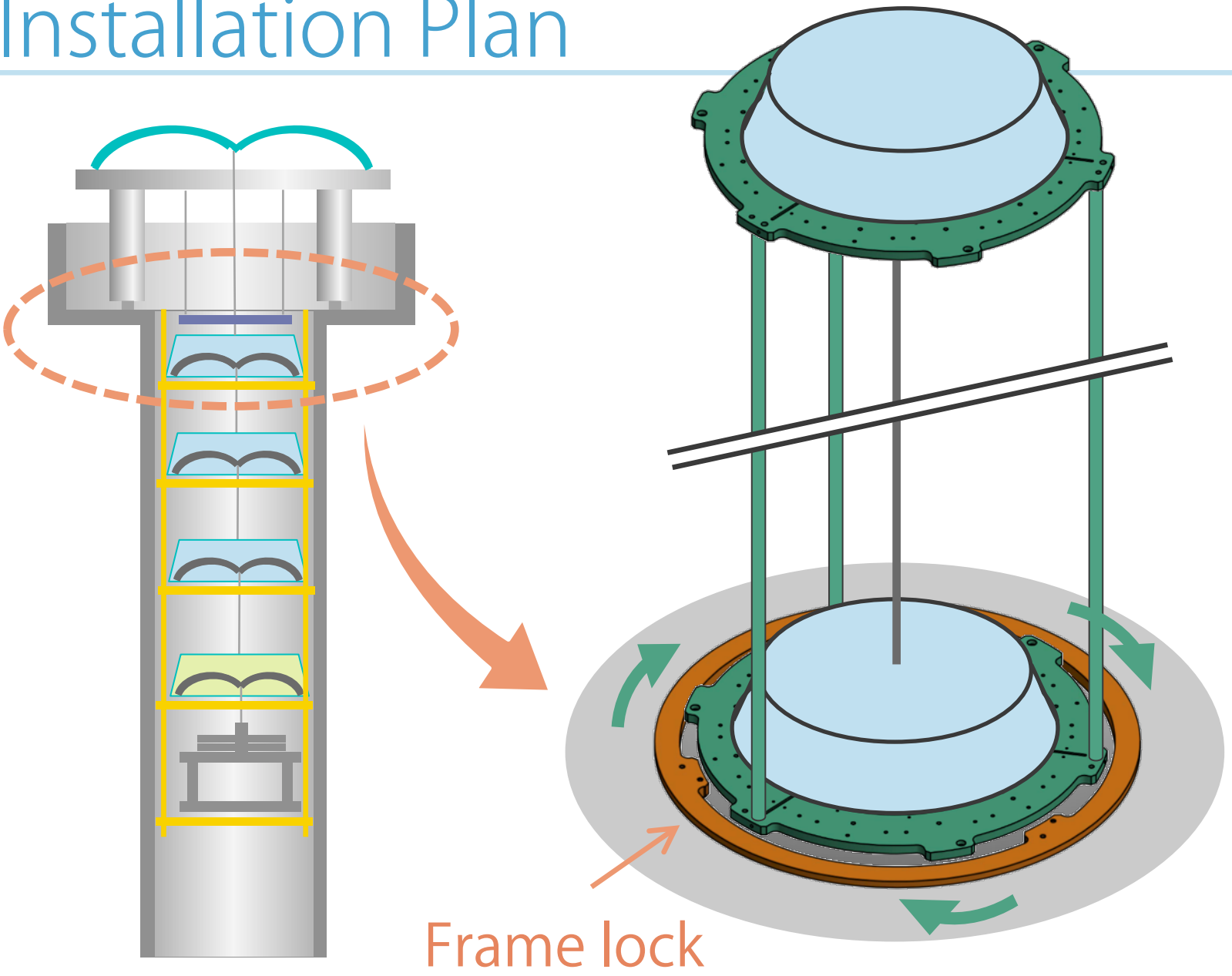
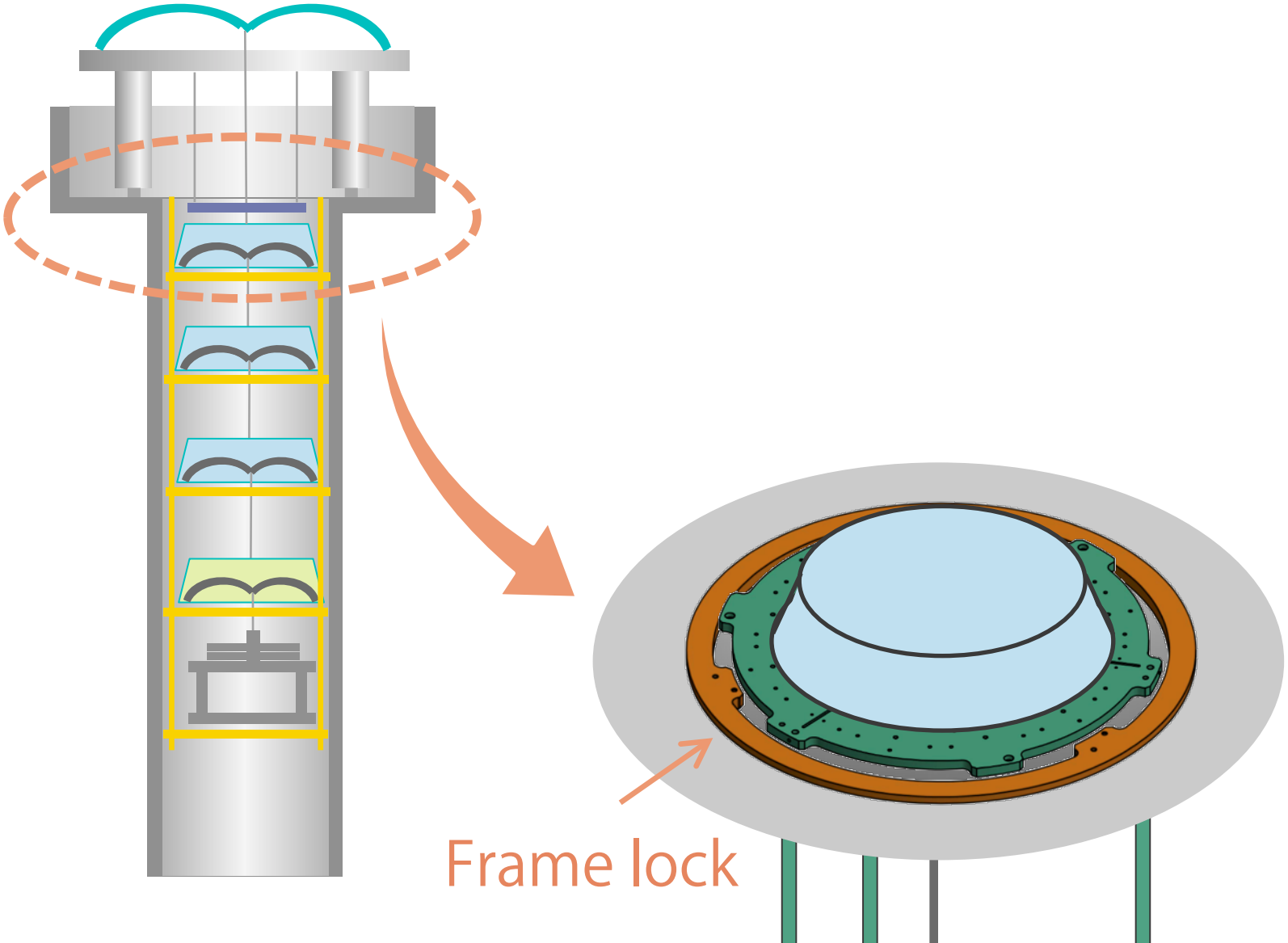
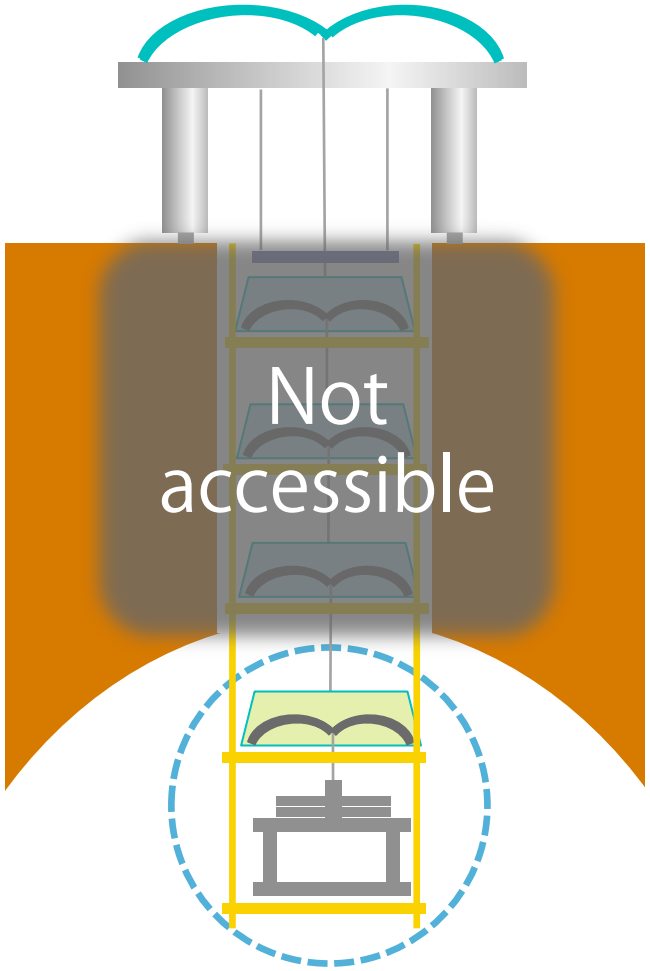


Installation Plan



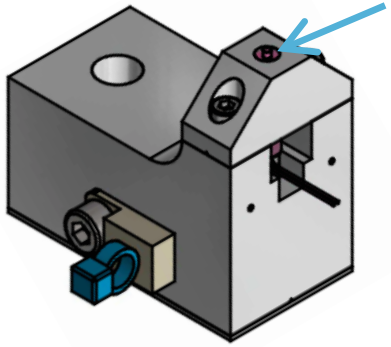
Problems in Installation

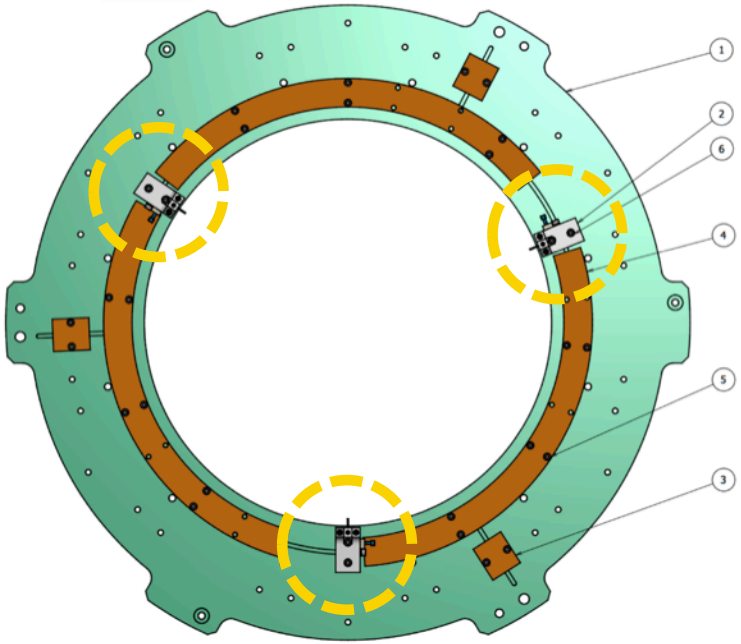


Cross-tube flange

- 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





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- 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

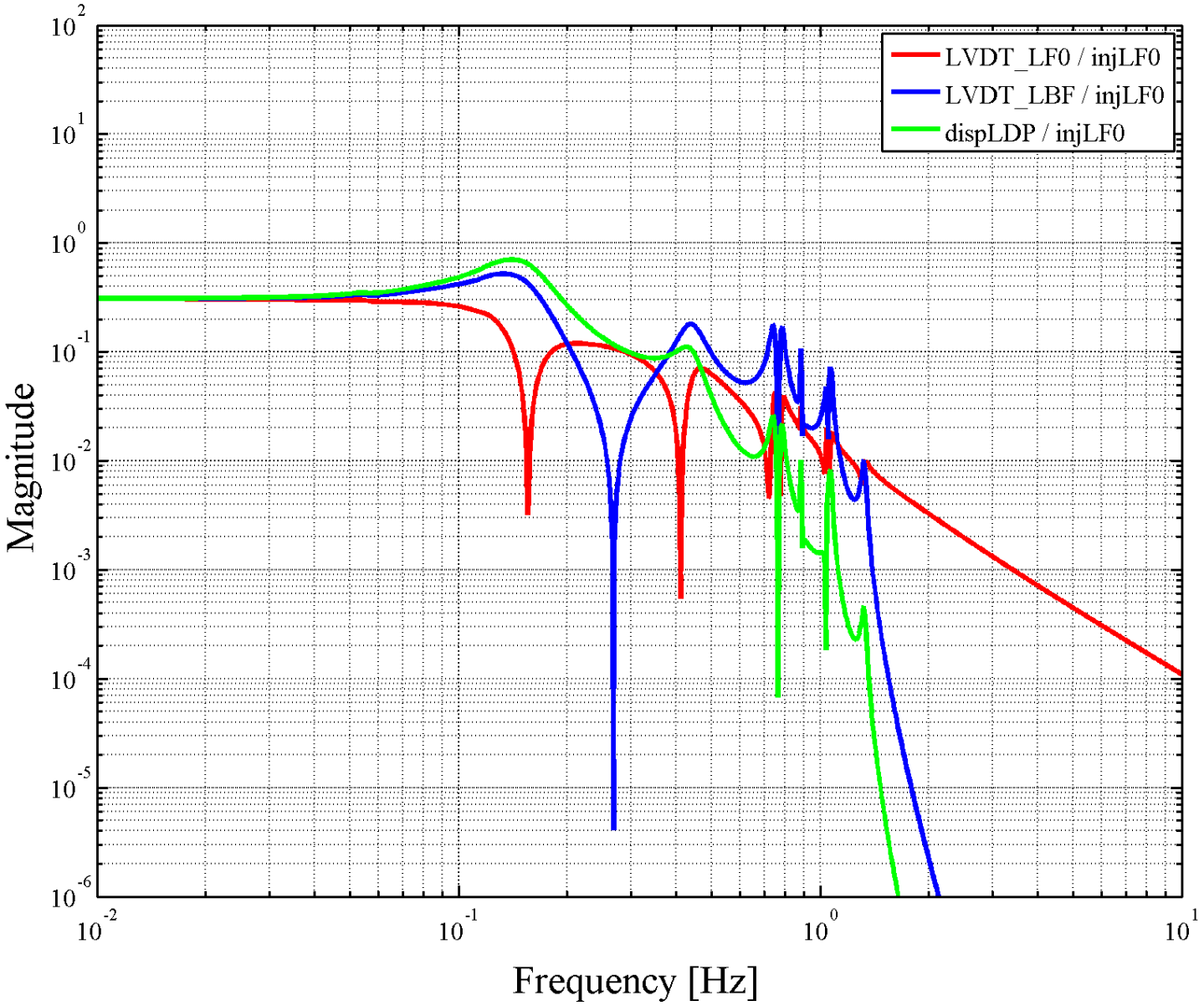
- We need BF controls to damp lowest yaw modes
- BF LVDT design and test is ongoing
- Next step => Analysis of suspension models including CRYp

Installation

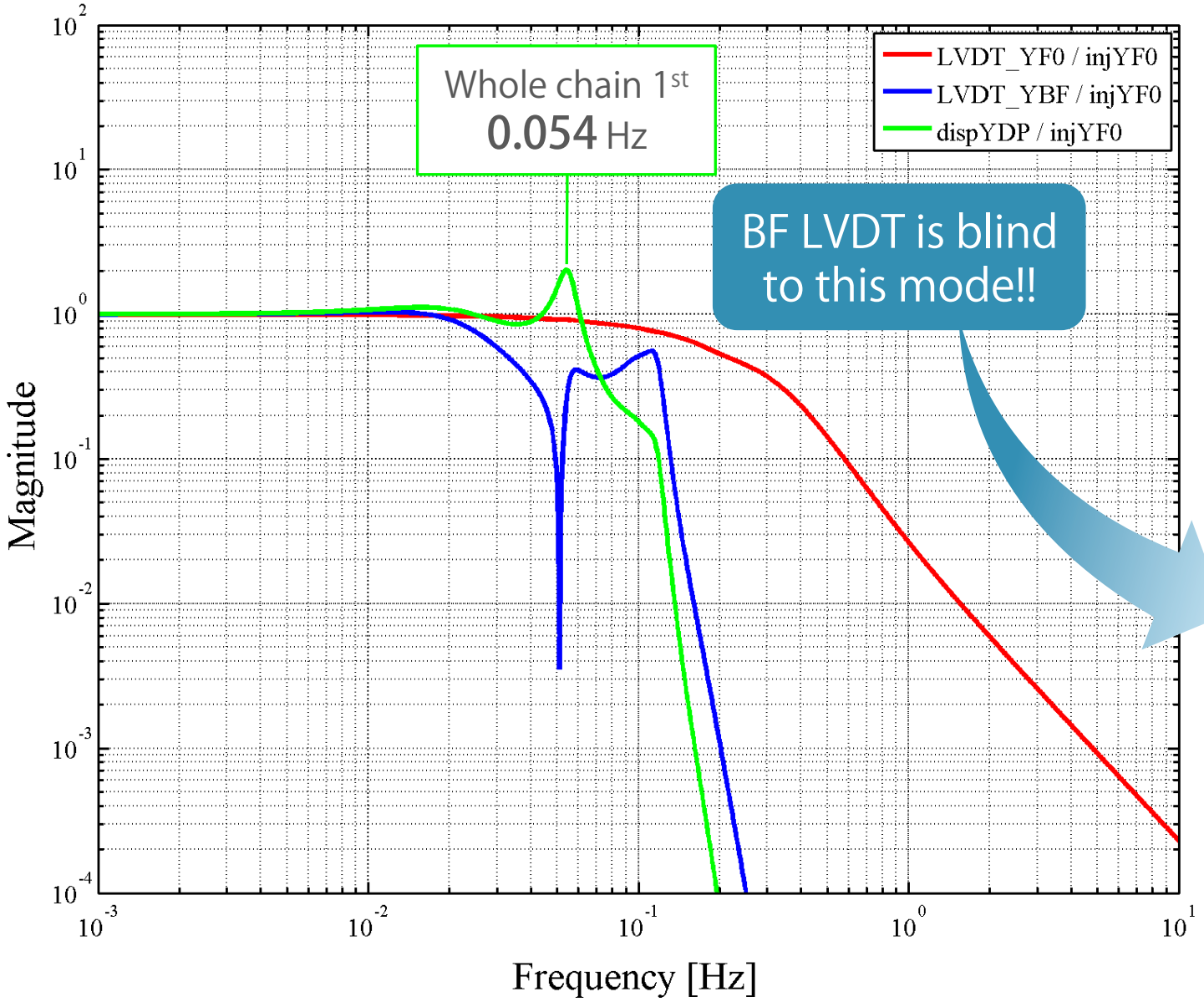
- Installation procedure is under updating
- Unaccessibility of the vertical corrugated tube makes the installation work more challenging

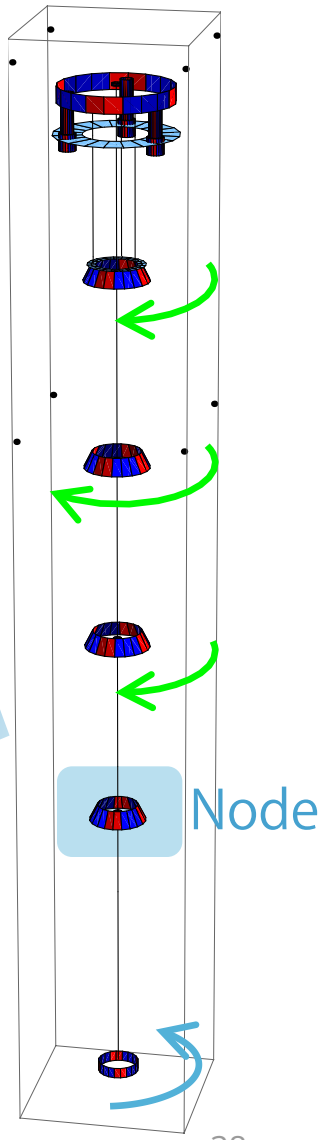
Backup Slides

Closed-loop Gain (LF0 act.)



Closed-loop Gain (YF0 act.)





Closed-loop Gain (YBF act.)