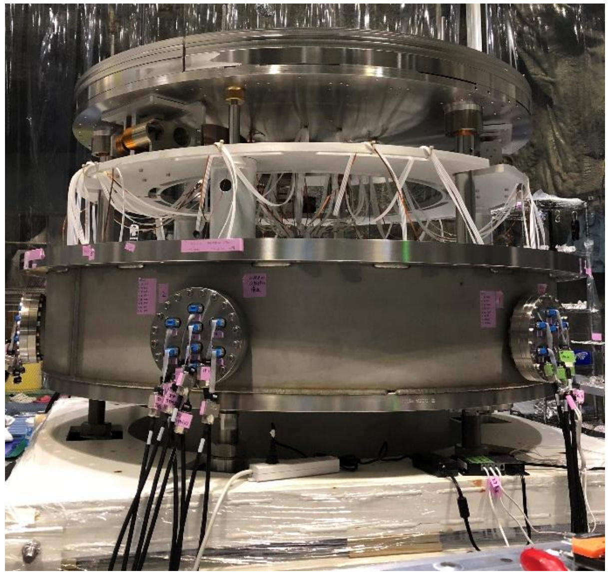
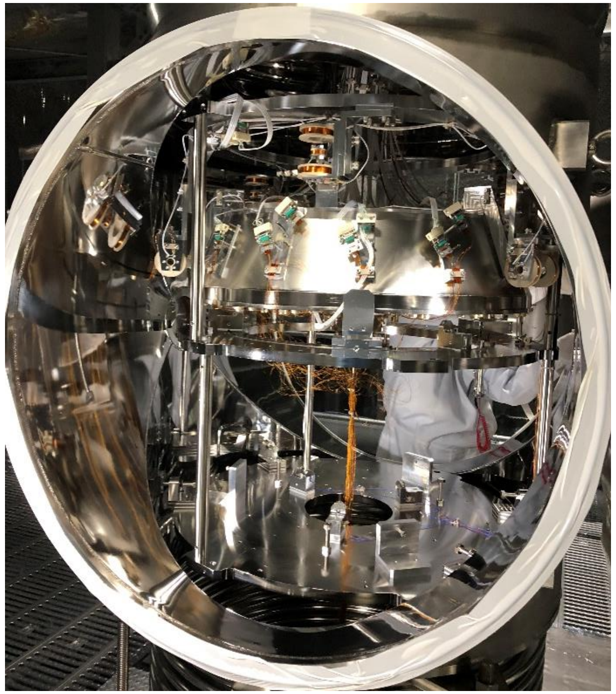
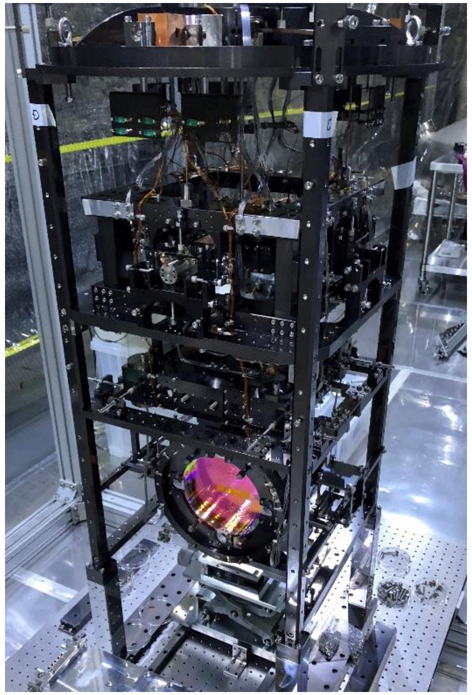
Status of Type-A suspensions for KAGRA







Yoshinori Fujii
for KAGRA collaboration

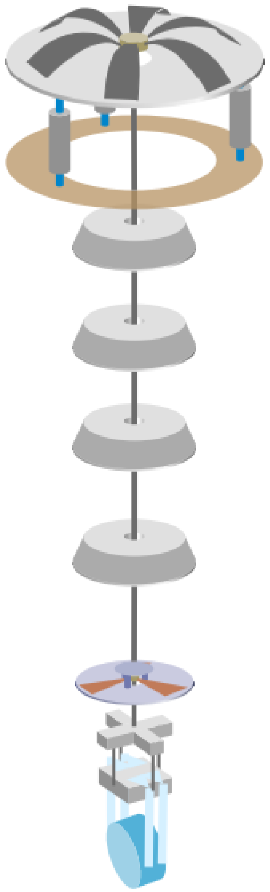
Status of Type-A suspensions for KAGRA

What is going on?

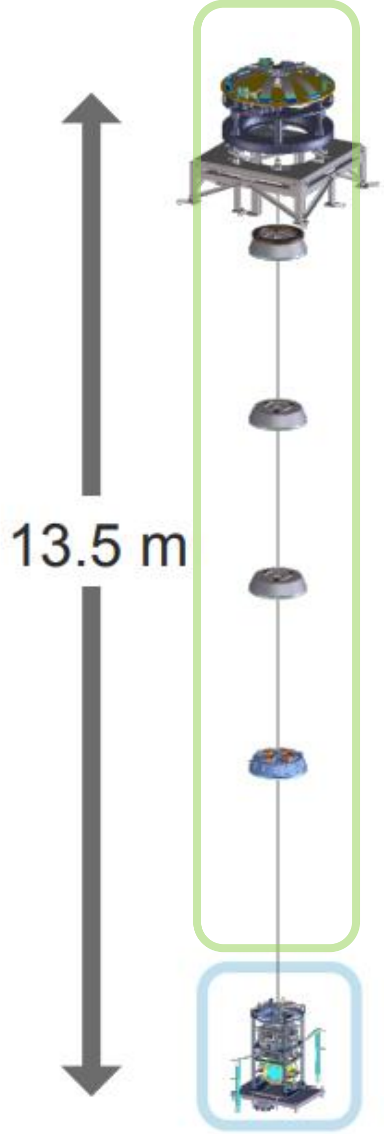
-- Mechanical installation

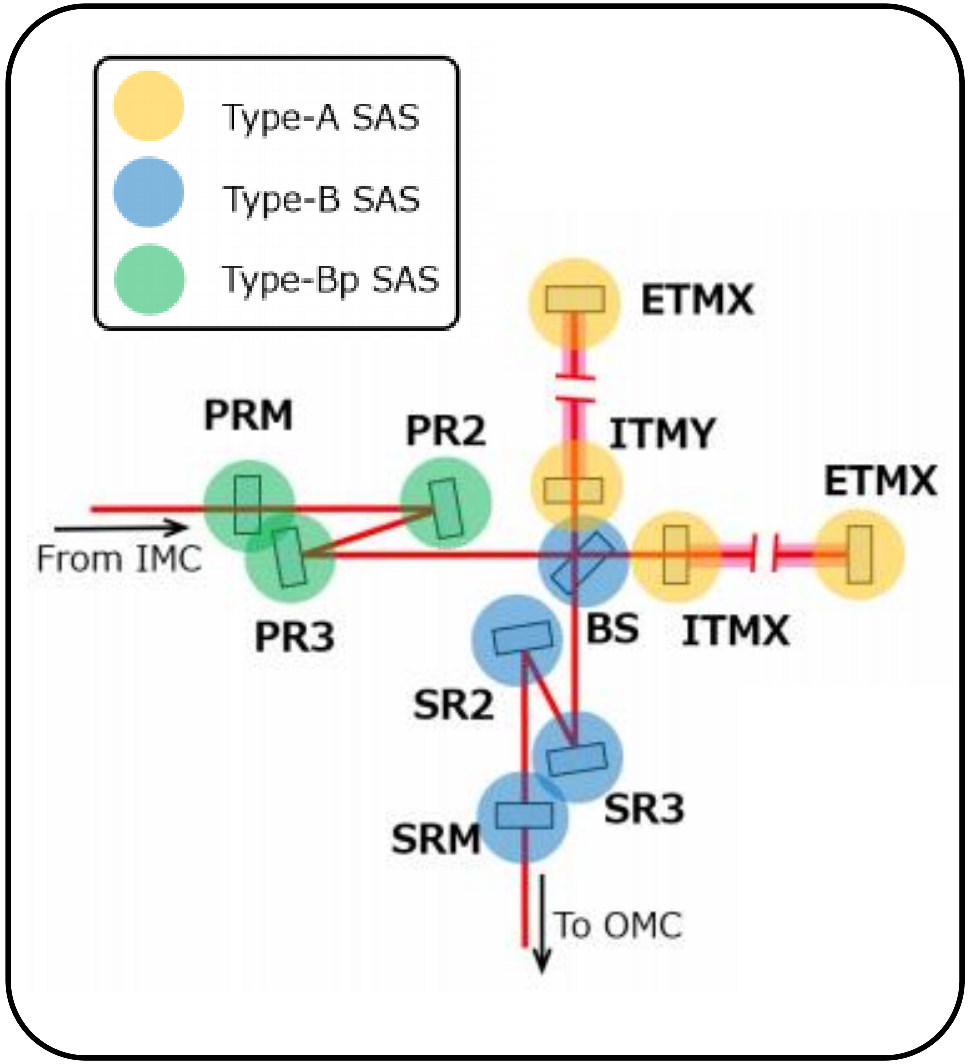
-- Servo filter implementation

-- Verification of suspension performance



Type-A suspensions?



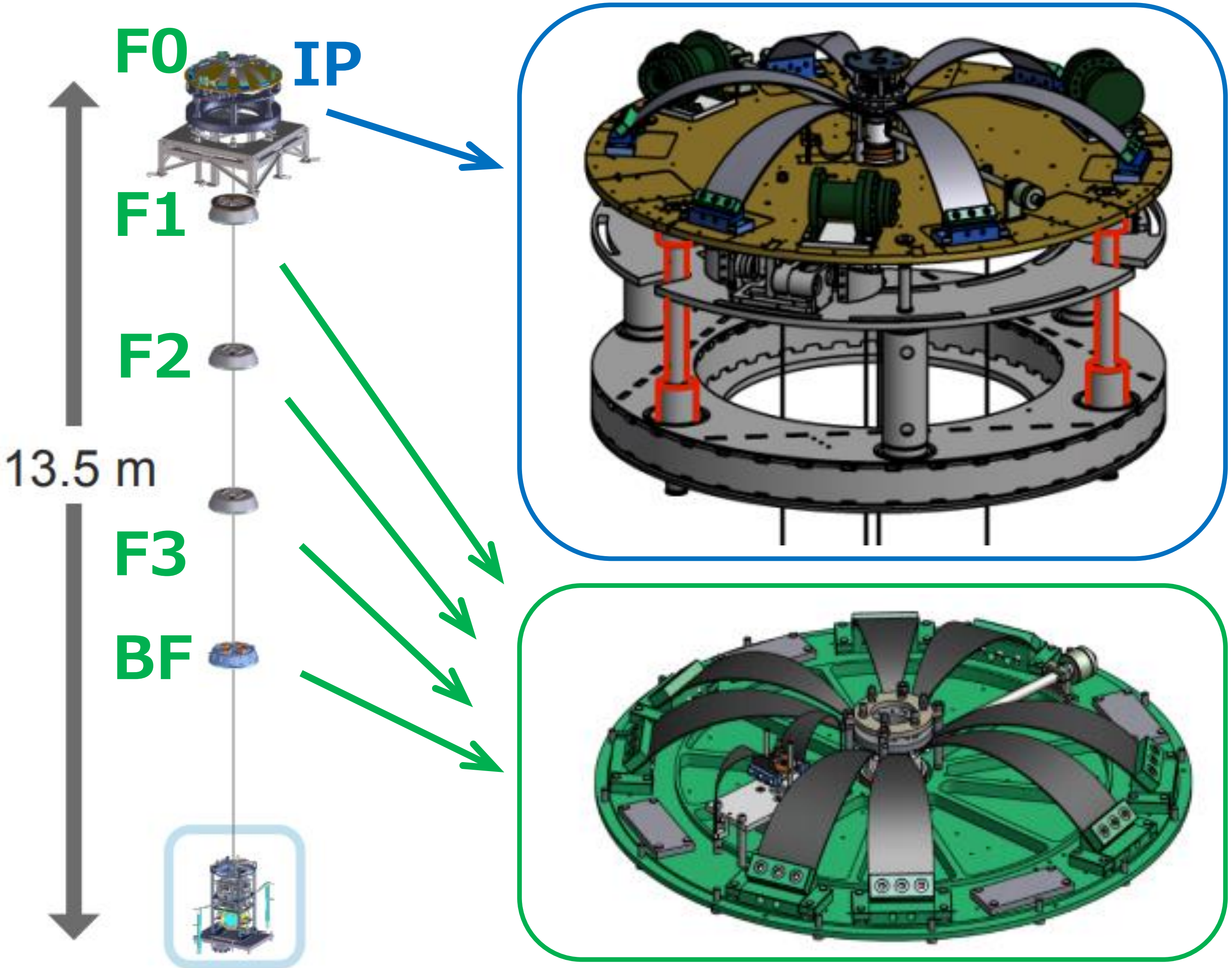


For the test masses,

- Upper 5 stages:
  room-temperature

- Lower 4 stages:
  cryogenic-temperature

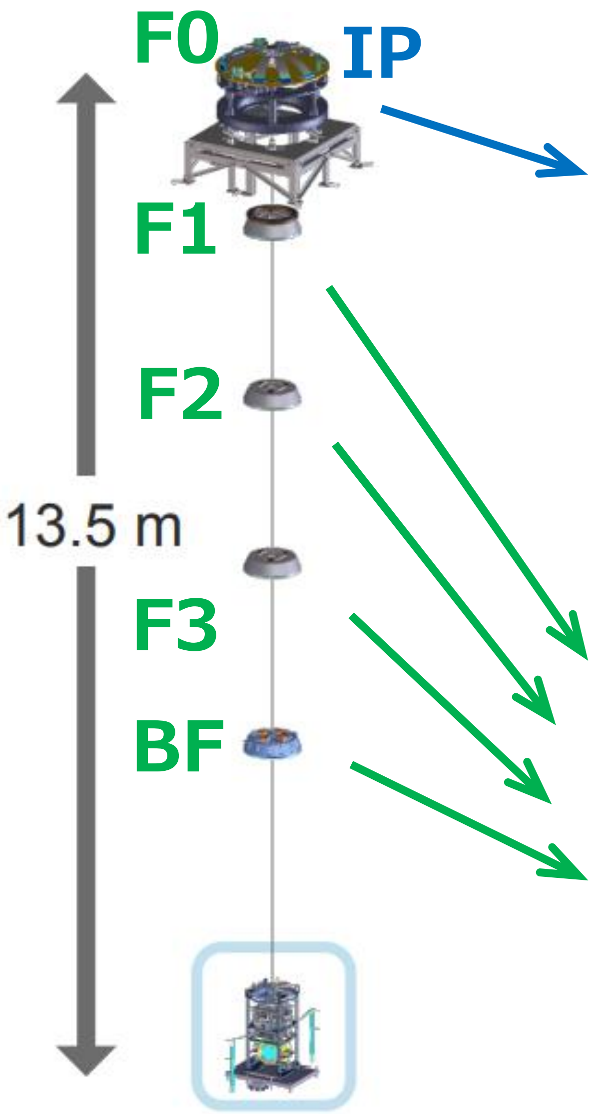
Type-A suspensions?

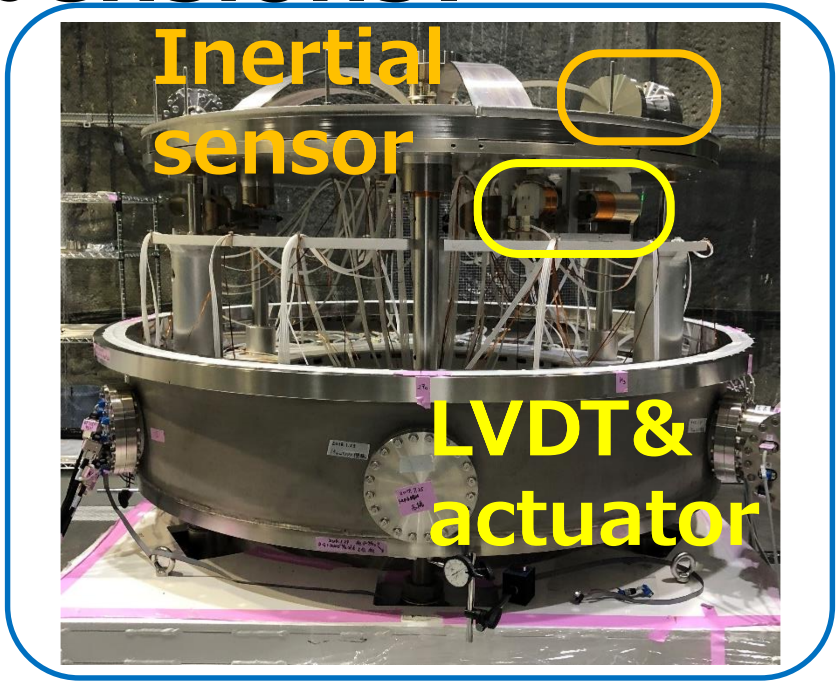


INVERTED PENDULUM
(~ 70 mHz)

GEOMETRIC-ANTI SPRING
(~ 0.4 Hz)

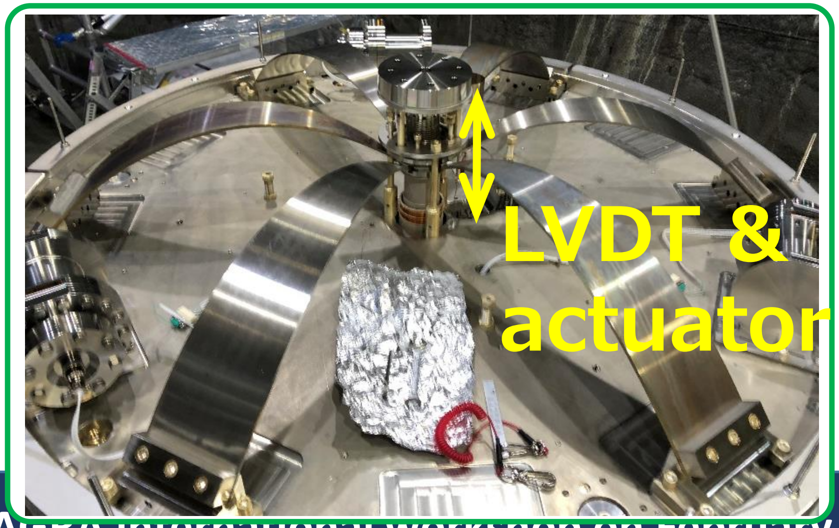
Type-A suspensions?





Inverted Pendulum

with 3 horizontal
-- LVDT & actuator units
-- inertial sensors

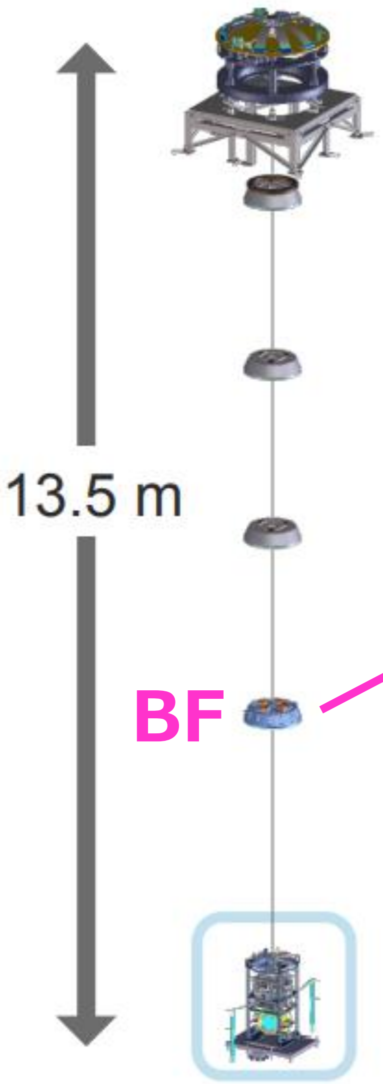


Geometric-Anti Spring

with 1 vertical
LVDT & actuator unit

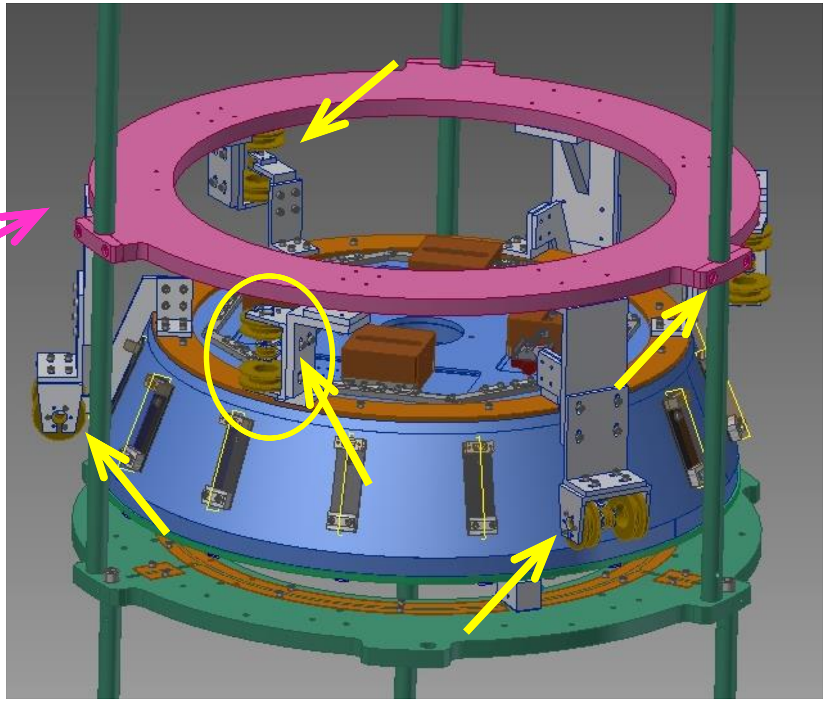
Type-A suspensions?

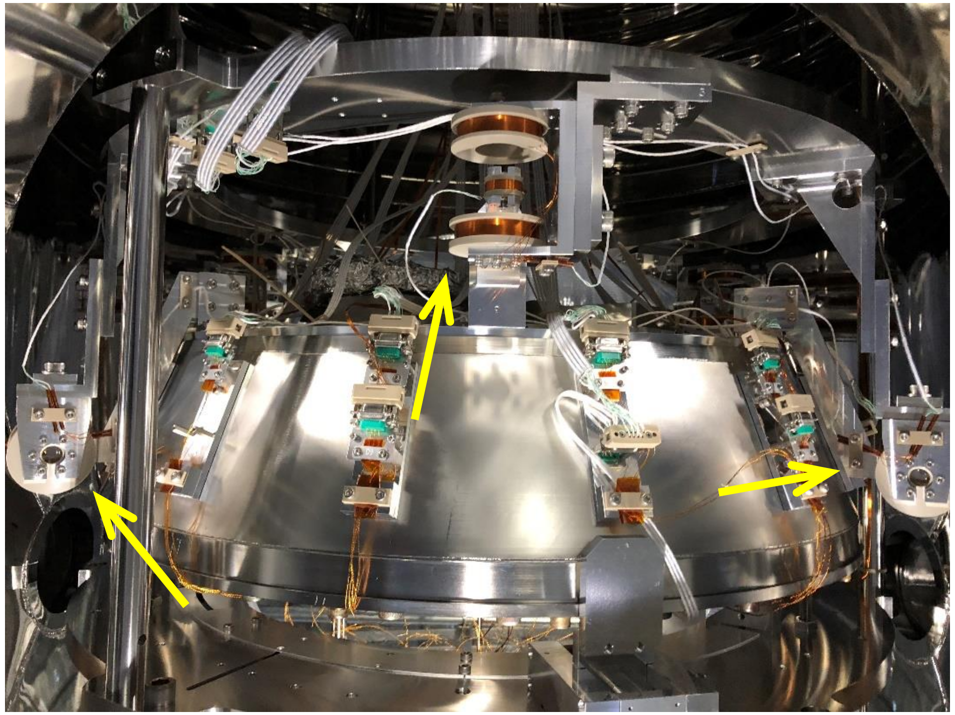
(With collaboration of group in Pisa)



Bottom-Filter DAMPER

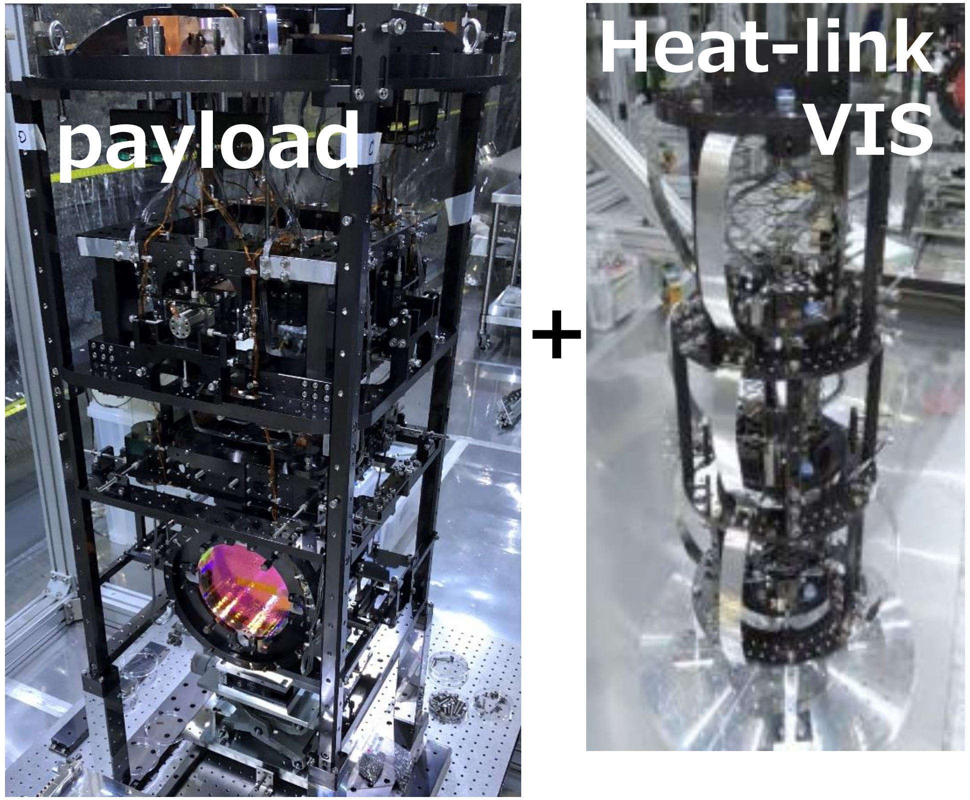
with 3 horizontal & 3 vertical LVDT & actuator units





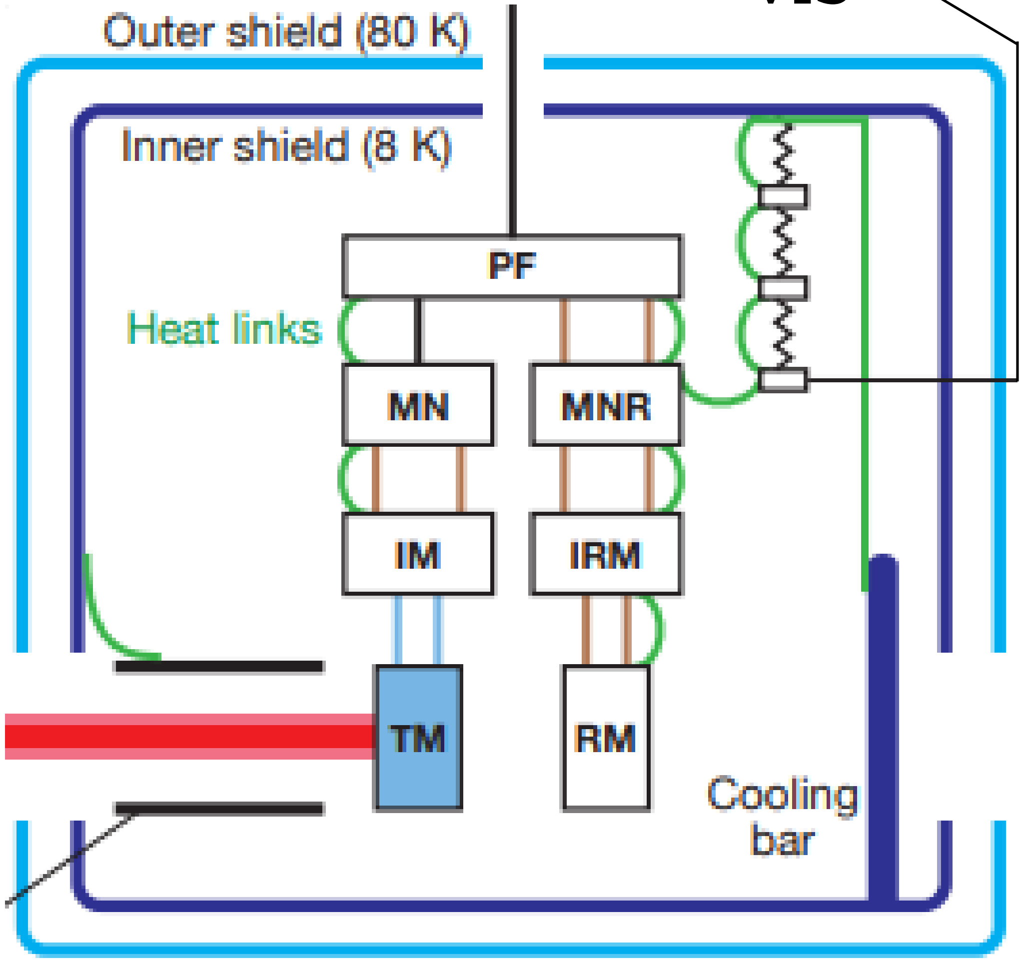
Type-A suspensions?

Inside cryostat



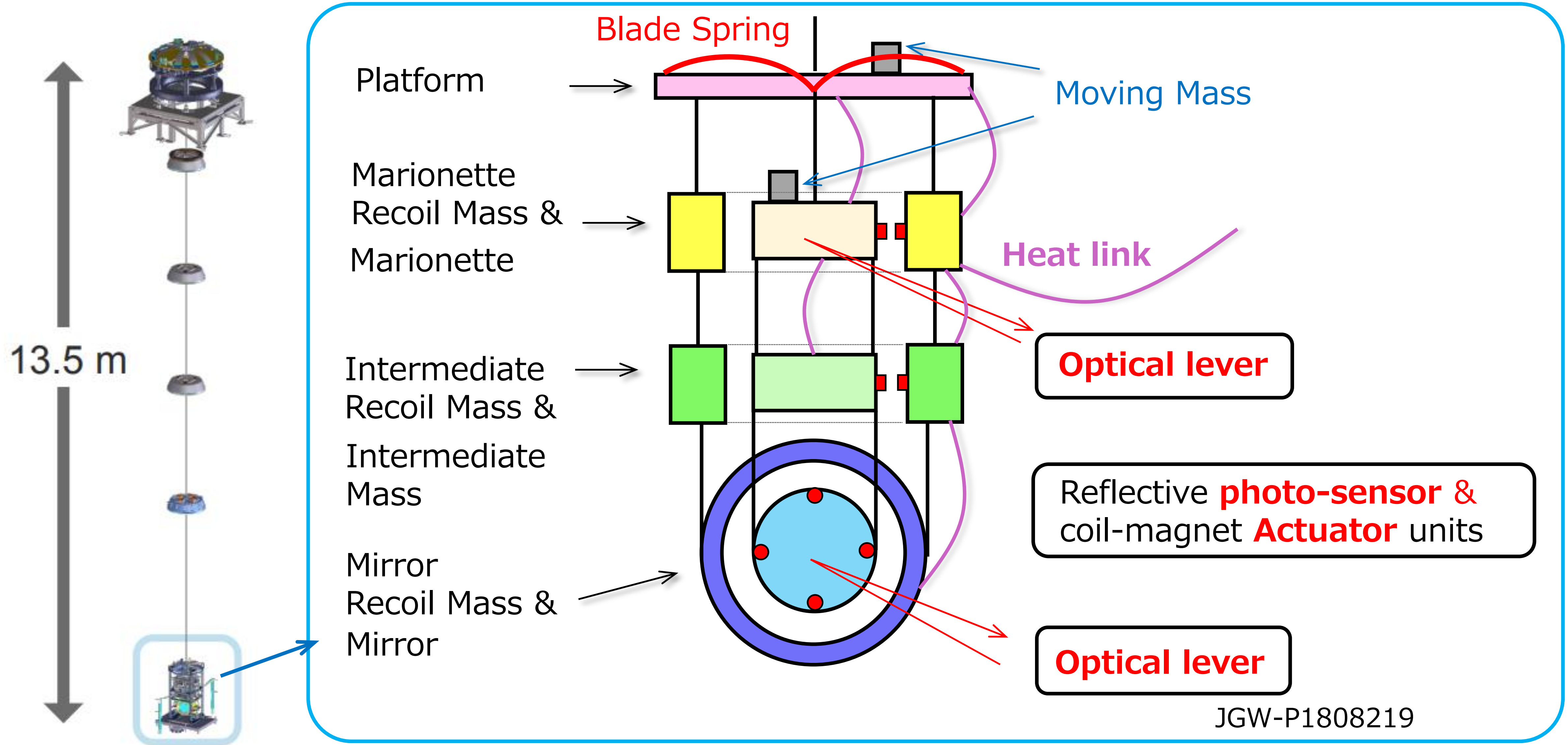
(+ Wide-angle baffle)

Heat-link VIS



JGW-P1809347

Type-A suspensions?



Then, mechanical installation status

for O3-observation

Mechanical installation has done! For all 4 of them!

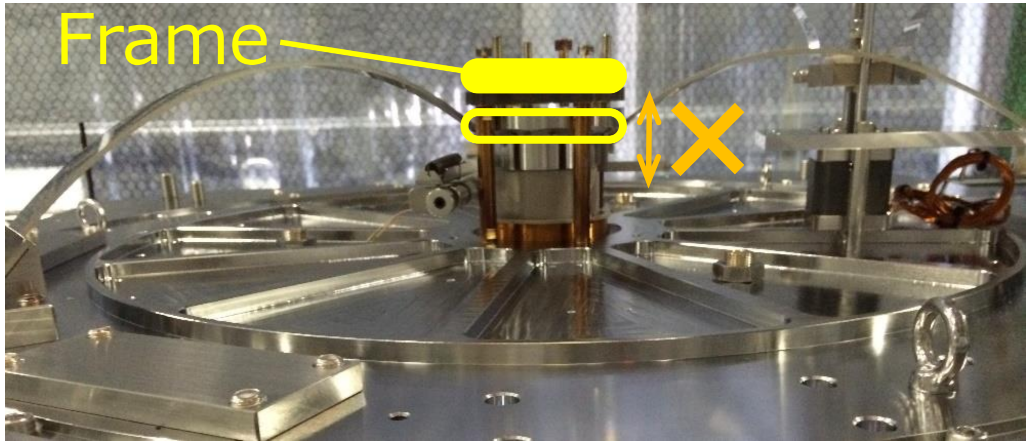
(Still mechanical-wise repairing work remains though..)

Mechanical installation has done! HOWEVER ..

ETMX & ETMY:

for ETMX - F2 GAS
for ETMY - F1 & F2 GAS

Hitting,, ~No oscillation

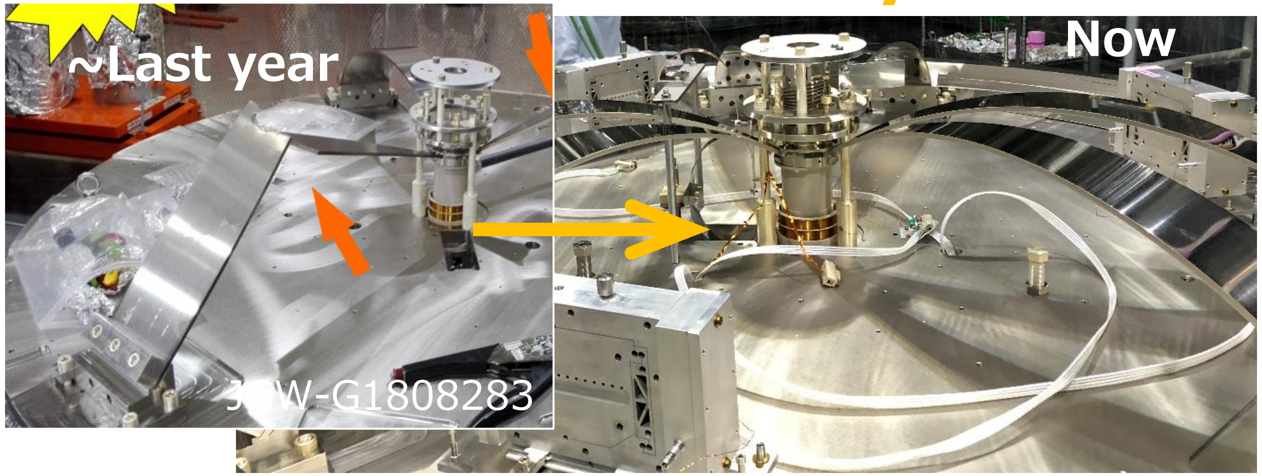


Mass tuning, necessary
but no accessibility.

ITMX & ITMY:

for ITMX / ITMY – F0 GAS

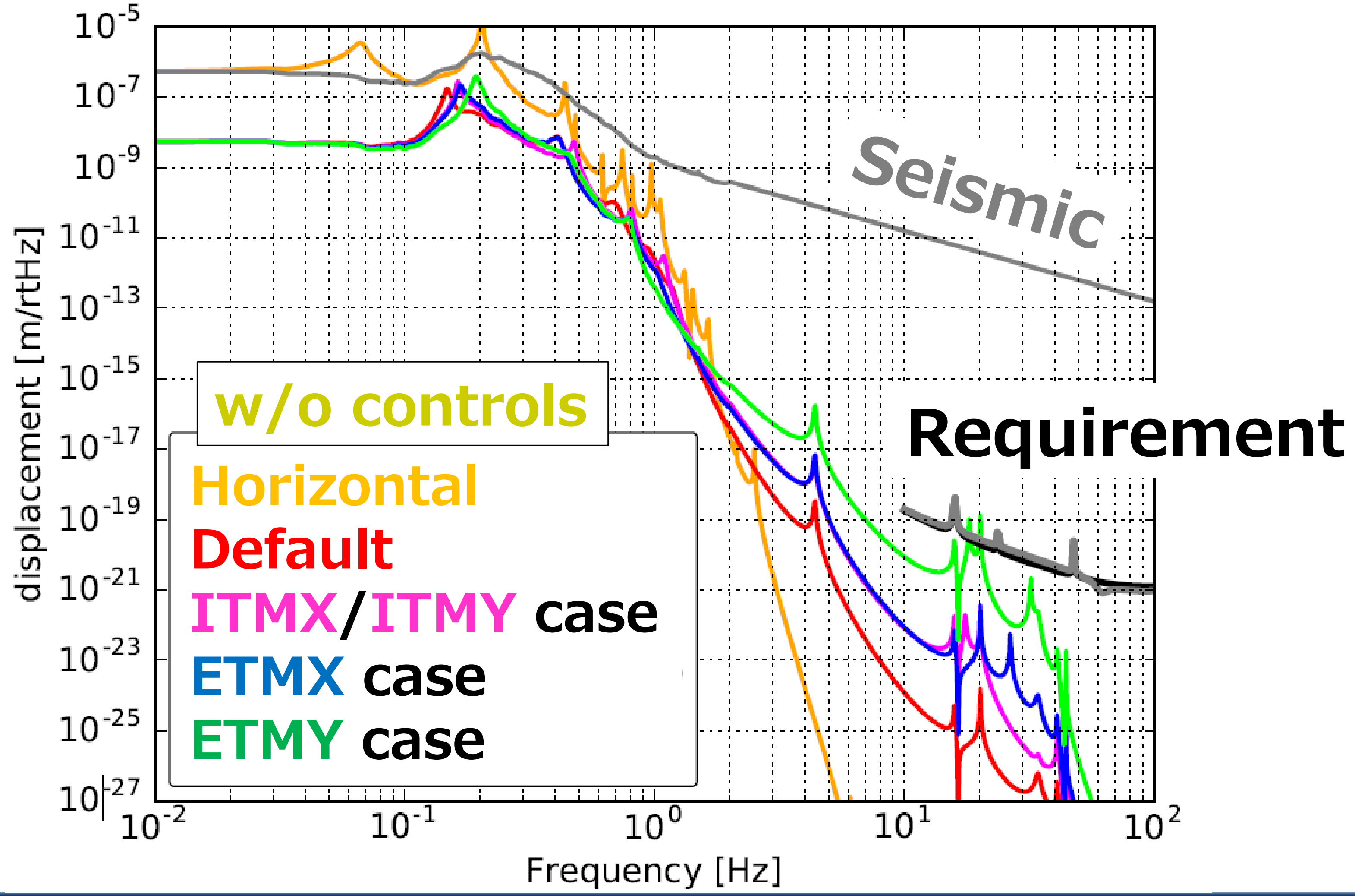
Newly made blades could not hold the system..



Blade replacement, necessary
but time consuming (etc).

Mechanical installation has done! HOWEVER ..

According to a simulation, assuming 1% coupling,



"acceptable
for the O3-run"

(should be)

Note:
-- Modeled w/o Heat-links
-- params are not tuned.

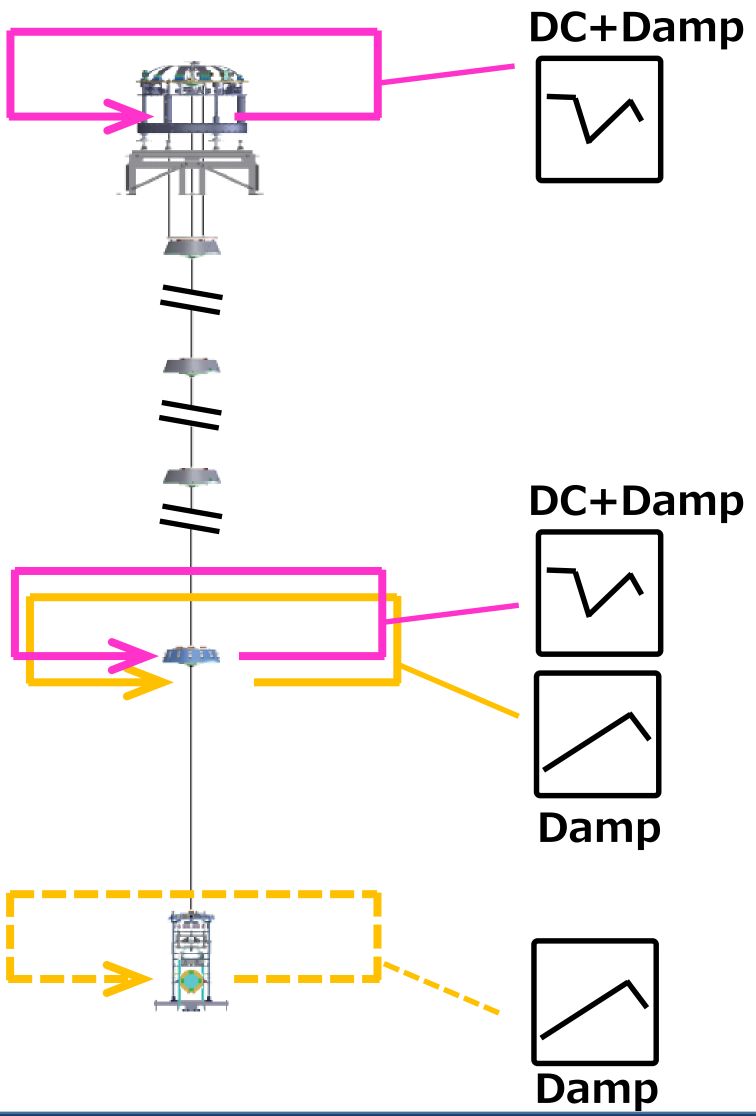
Servo filter implementation status

With displacement sensors, [for damping]

IP

BF-damper

(TMoplev)

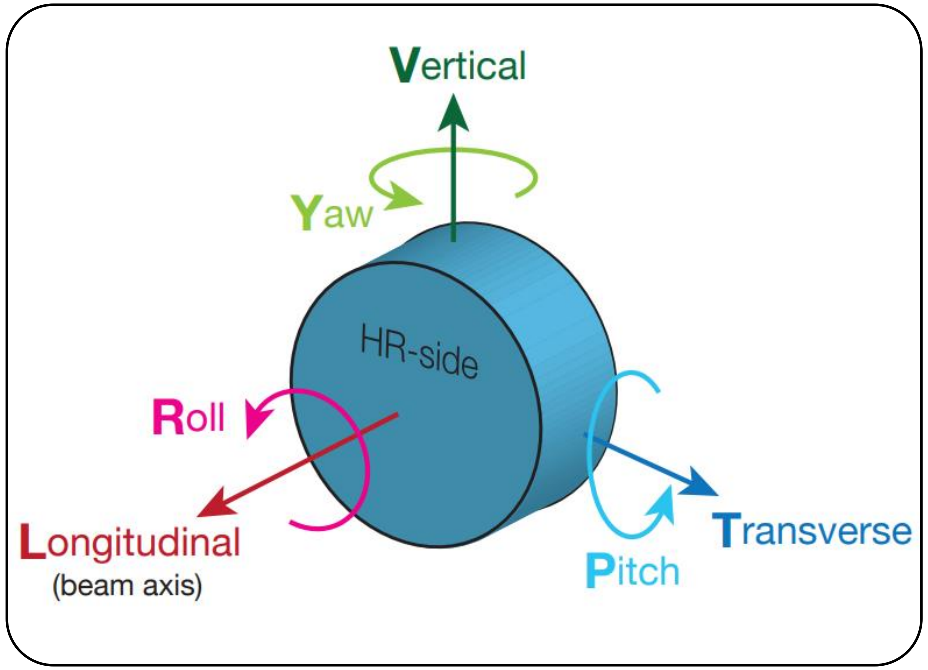


For L / T / Yaw

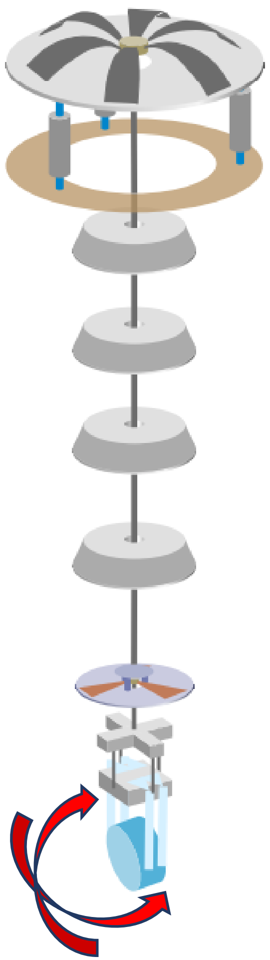
For Yaw

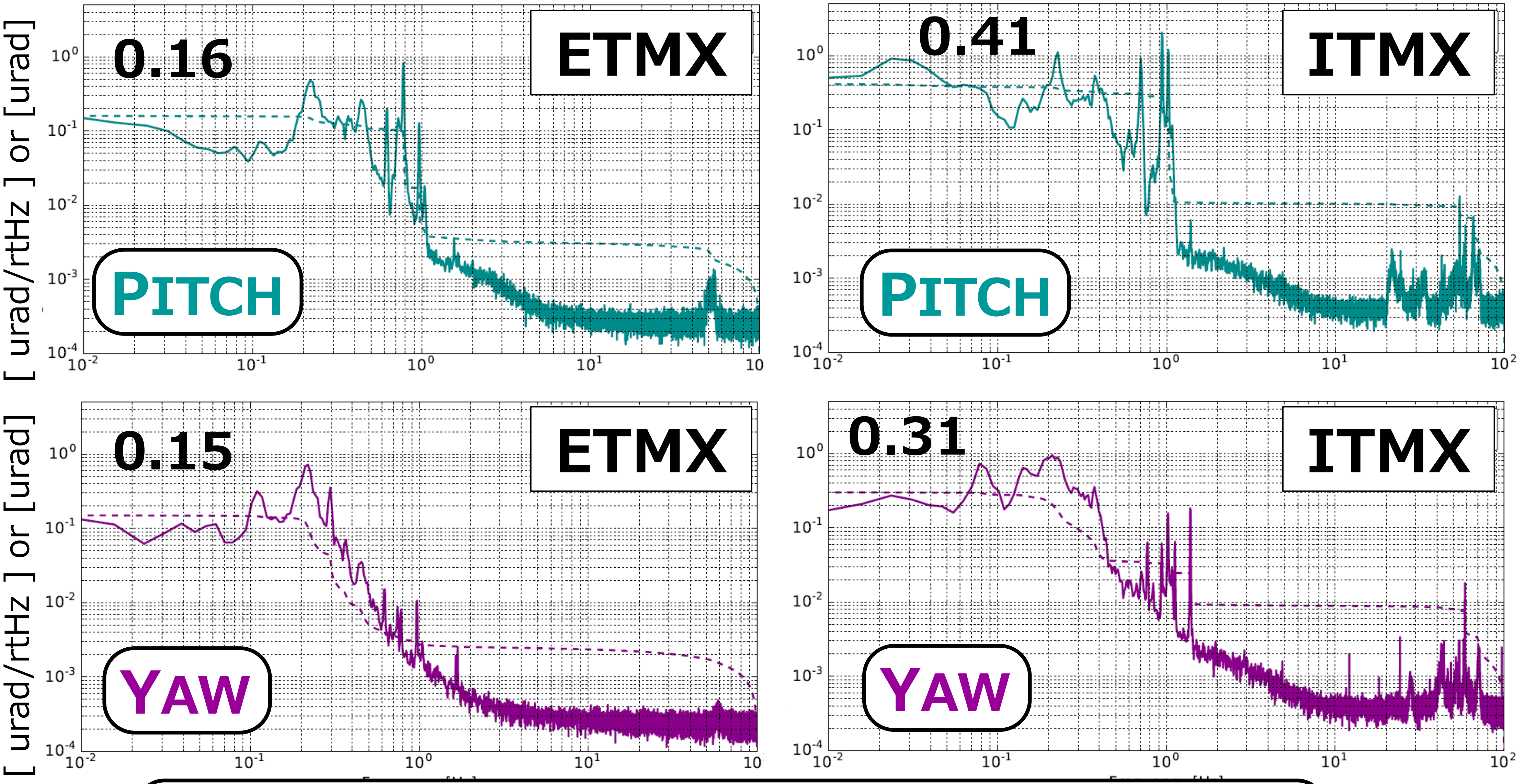
For L / T

For P / Y



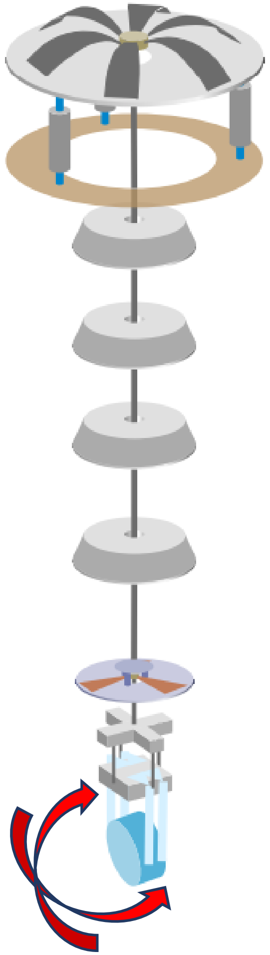
With displacement sensors, [residuals]

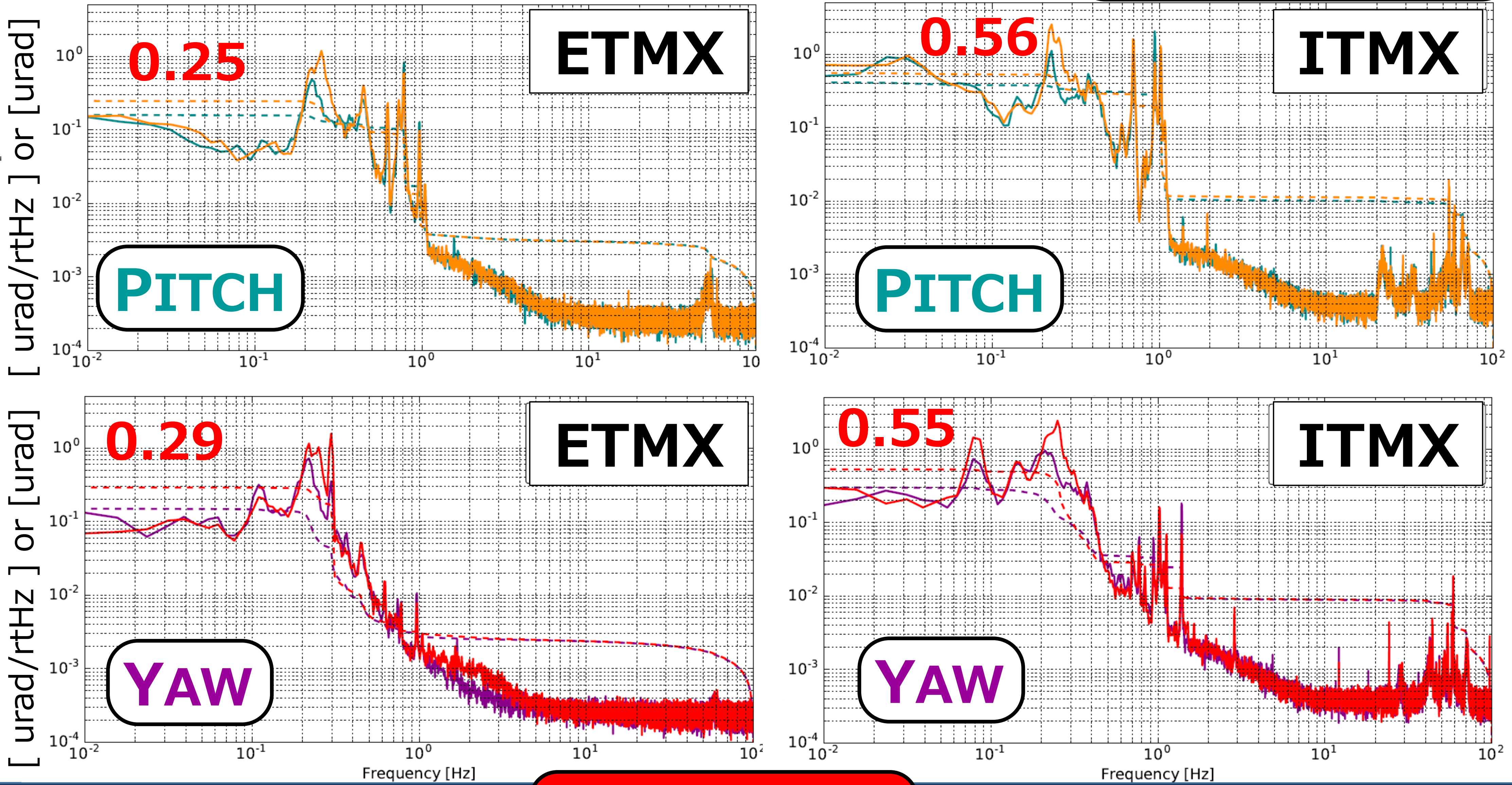




Locked! Thanks to Kamioka environment.

With displacement sensors, [residuals] In bad weather

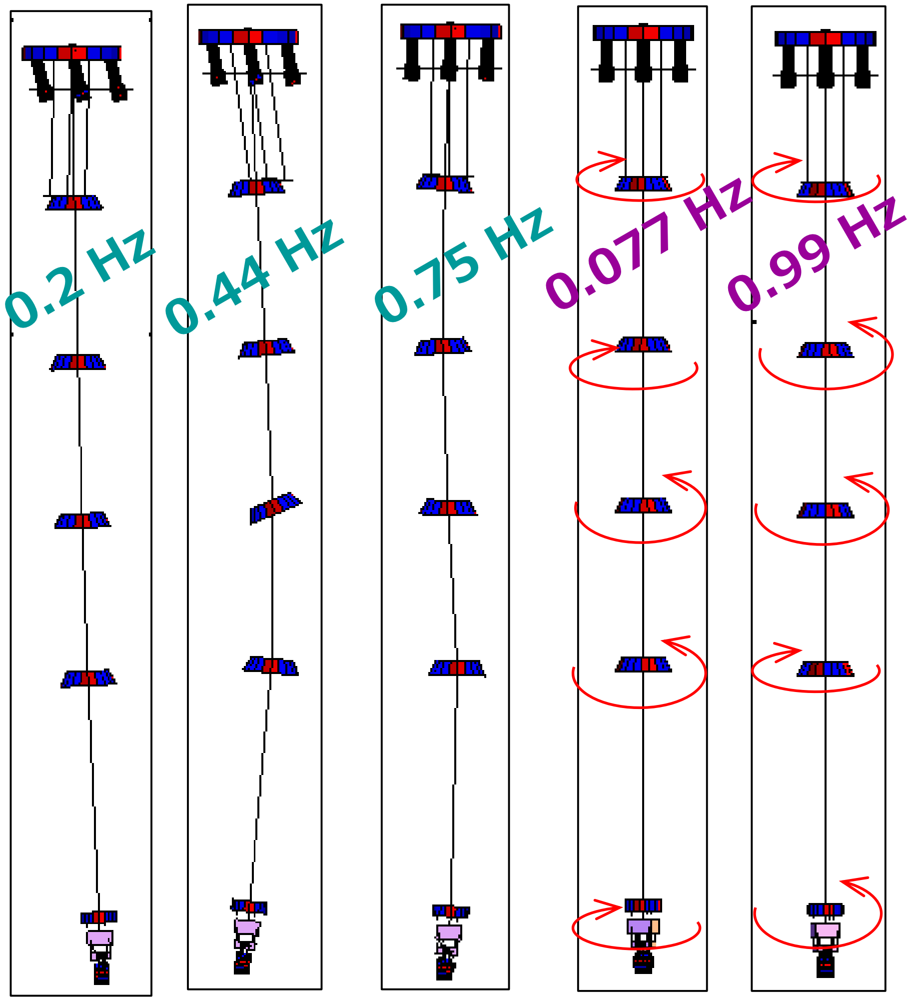




***NOT* locked..**

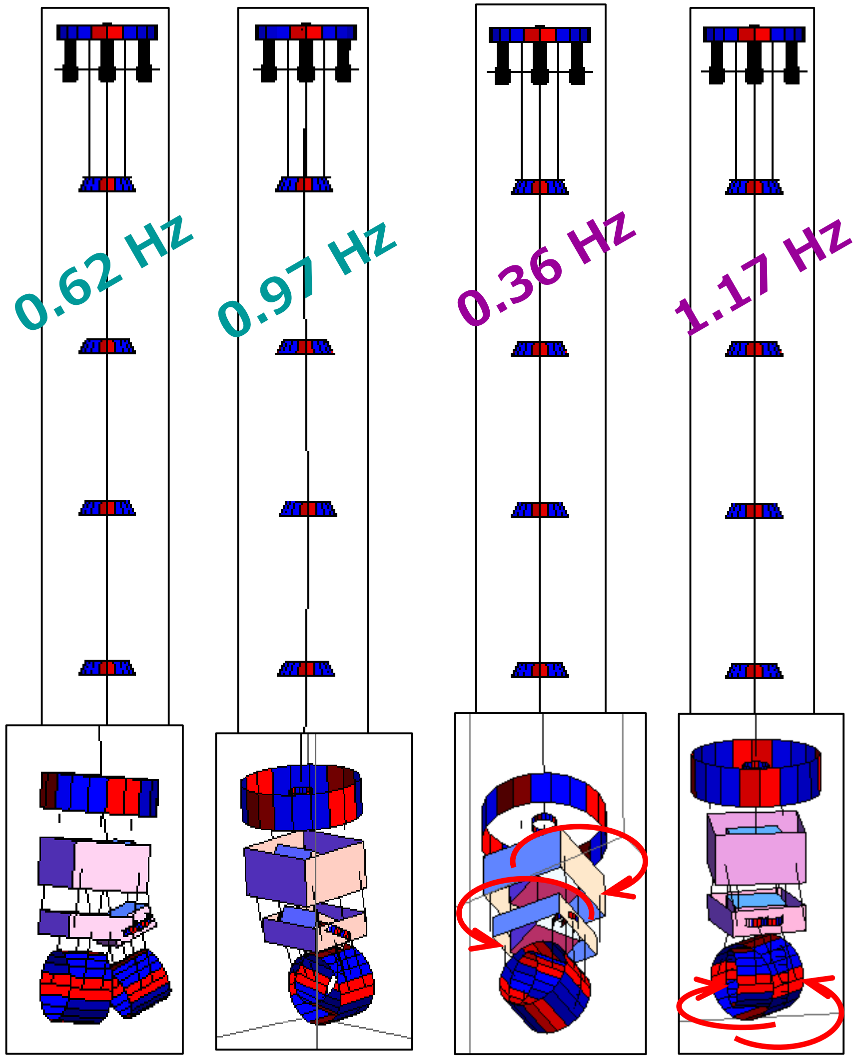
Candidate (main) resonant modes?

Preliminary



→ damping at tower-part

+ decoupling / inertial damping

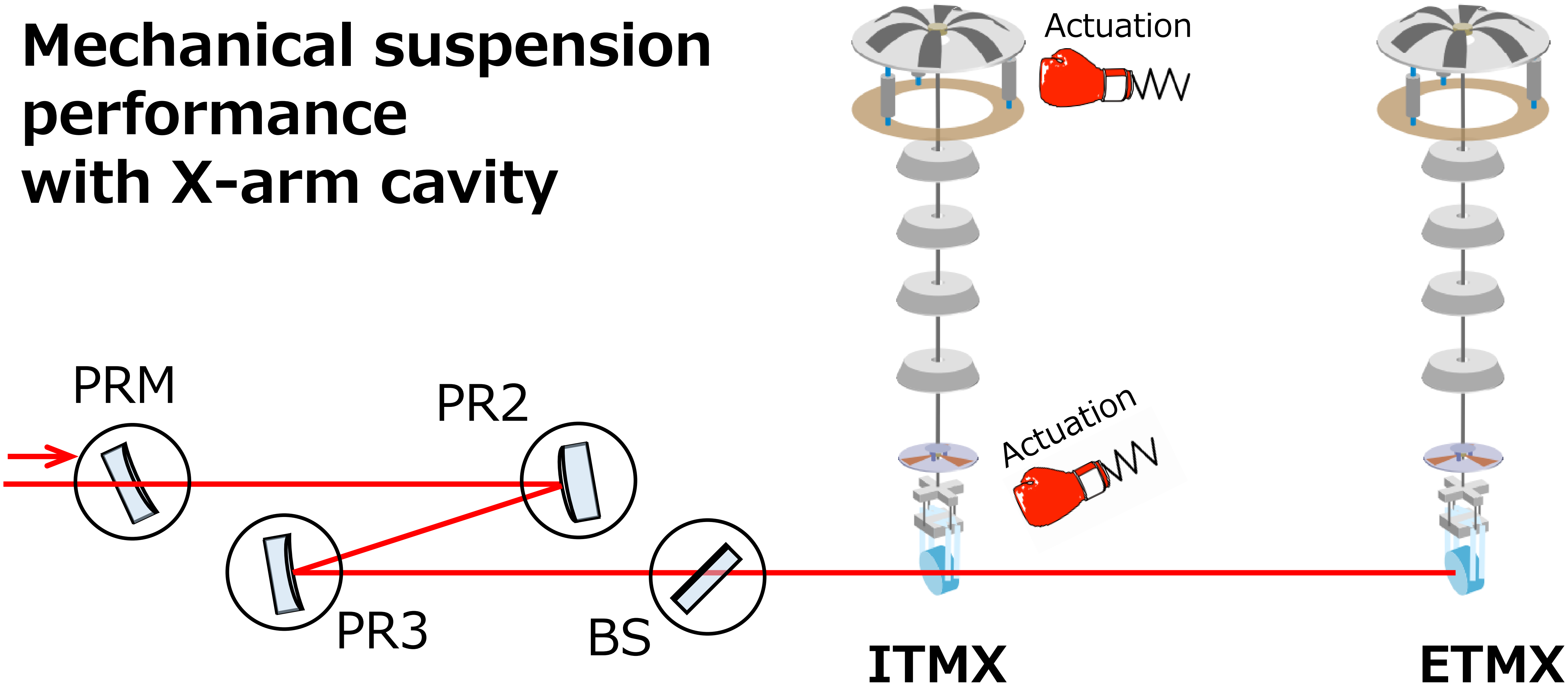


→ damping at payload

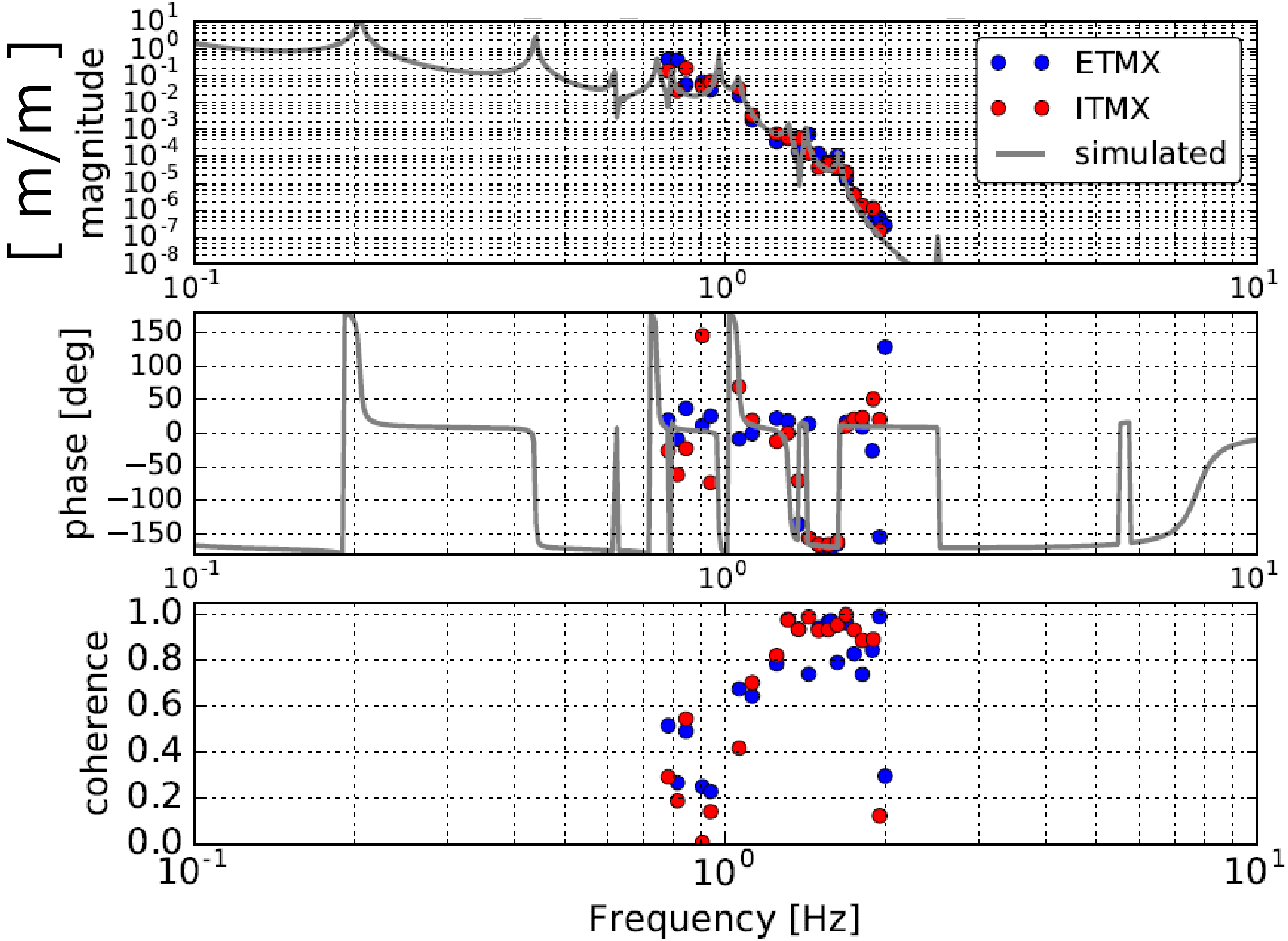
Verification of suspension performance

Measurement:

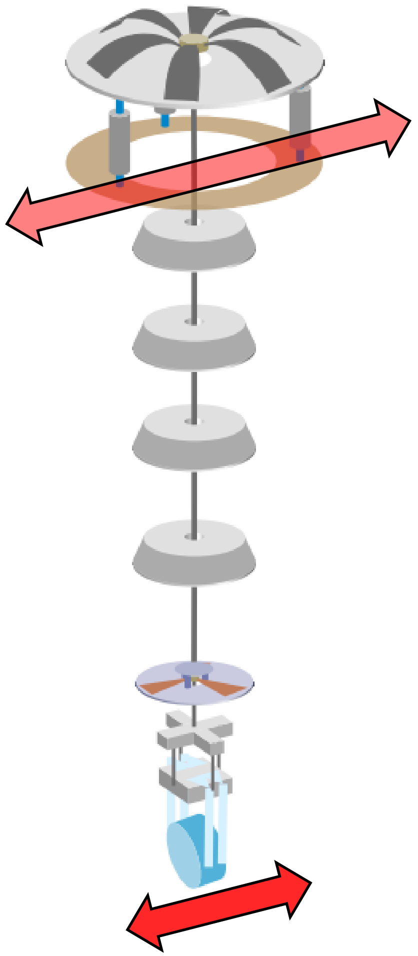
Mechanical suspension performance with X-arm cavity



Vibration isolation ratio, [Good news!]

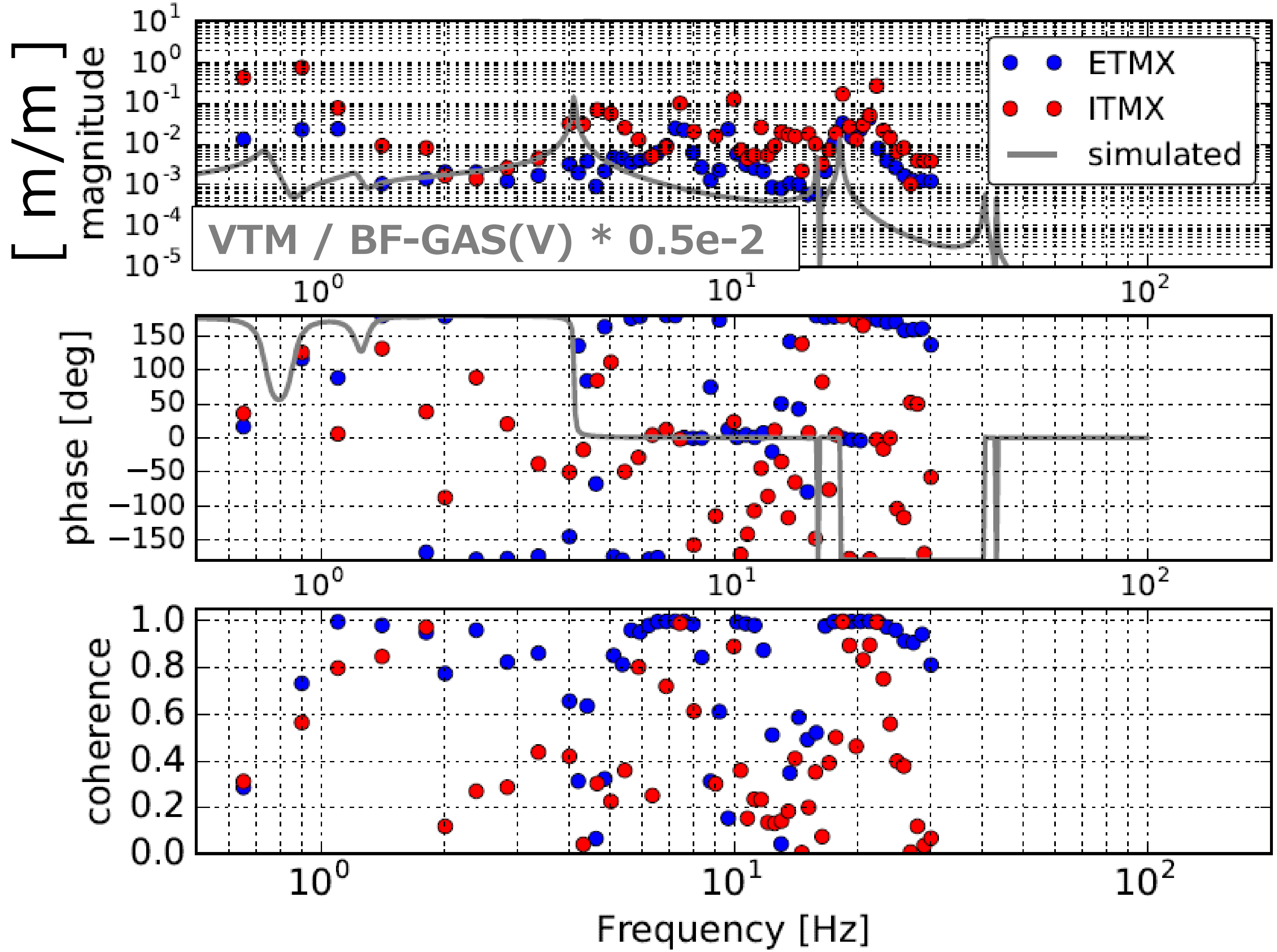


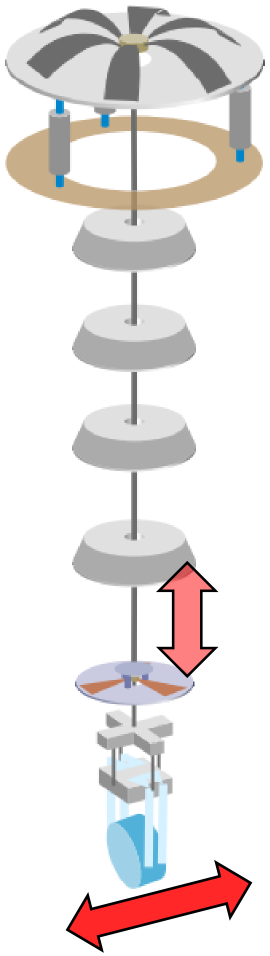
From ground to TM



V to L coupling, [System is not yet identified..]

From BF-GAS to TM





Real was not so simple..

Summary:

-- All the Type-A suspensions have been installed.
-- Damping controls are working properly, however,
some resonances are not yet damped efficiently.

- [ ] Implement damping controls at payload stages

-- Reducing RMS is necessary when the seismic noise is high.

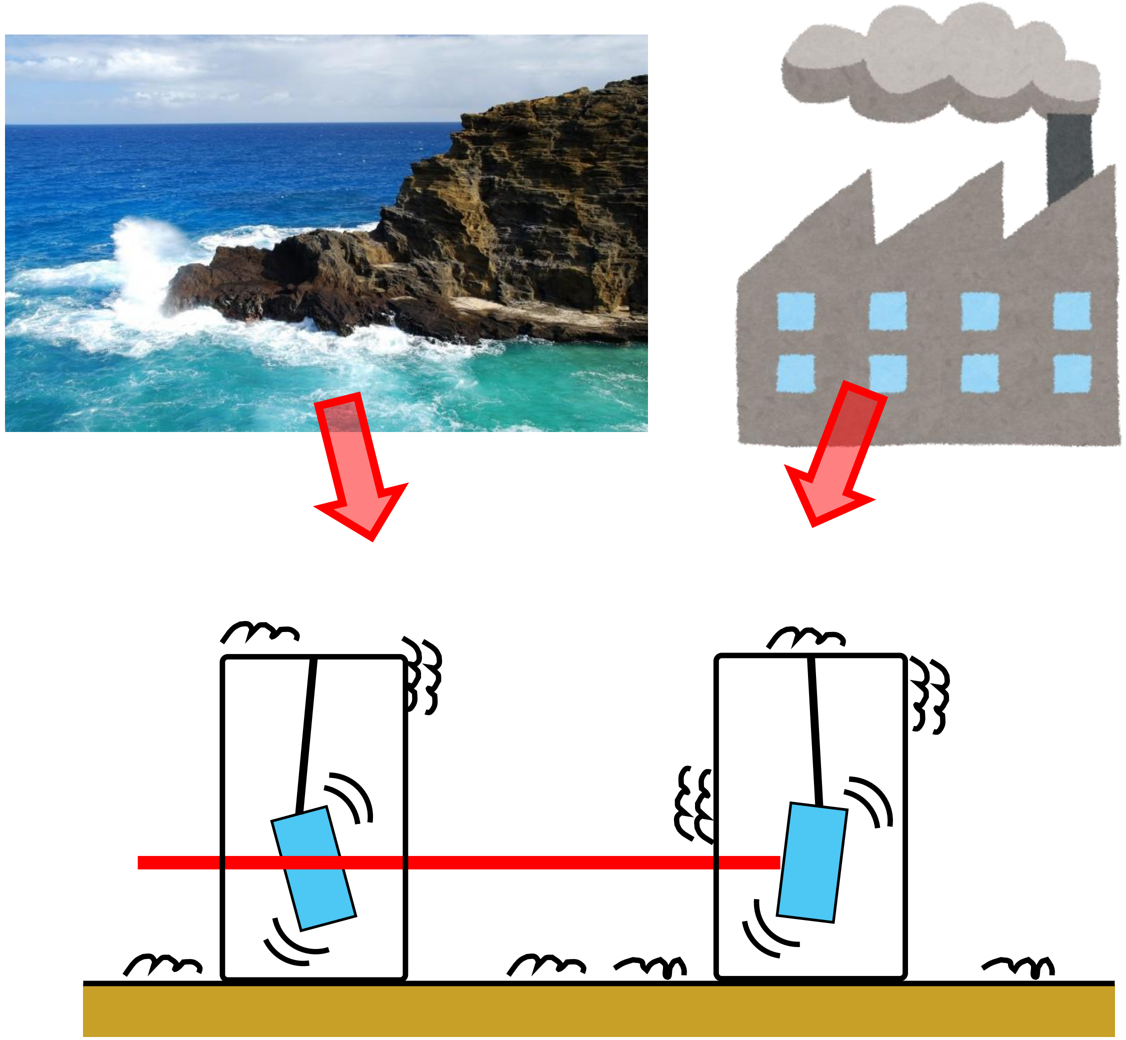
- [ ] Implement inertial damping at IP stage

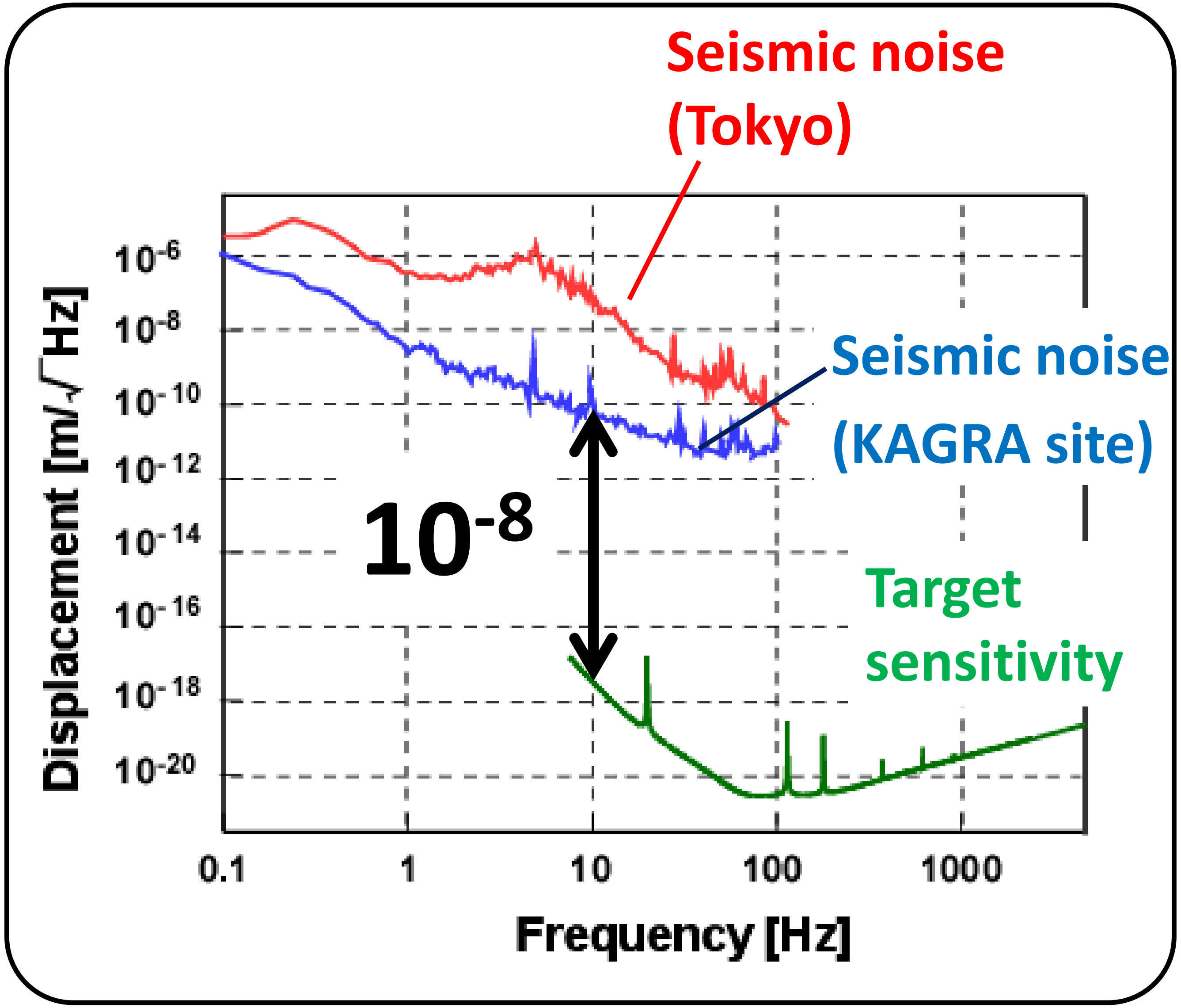
For soon next:

- [ ] Do mode identification including the heat-link peaks
- [ ] Design the filters in the observation phase.

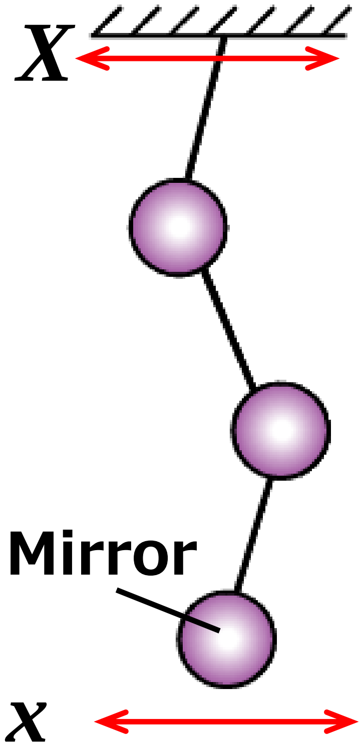
Backup

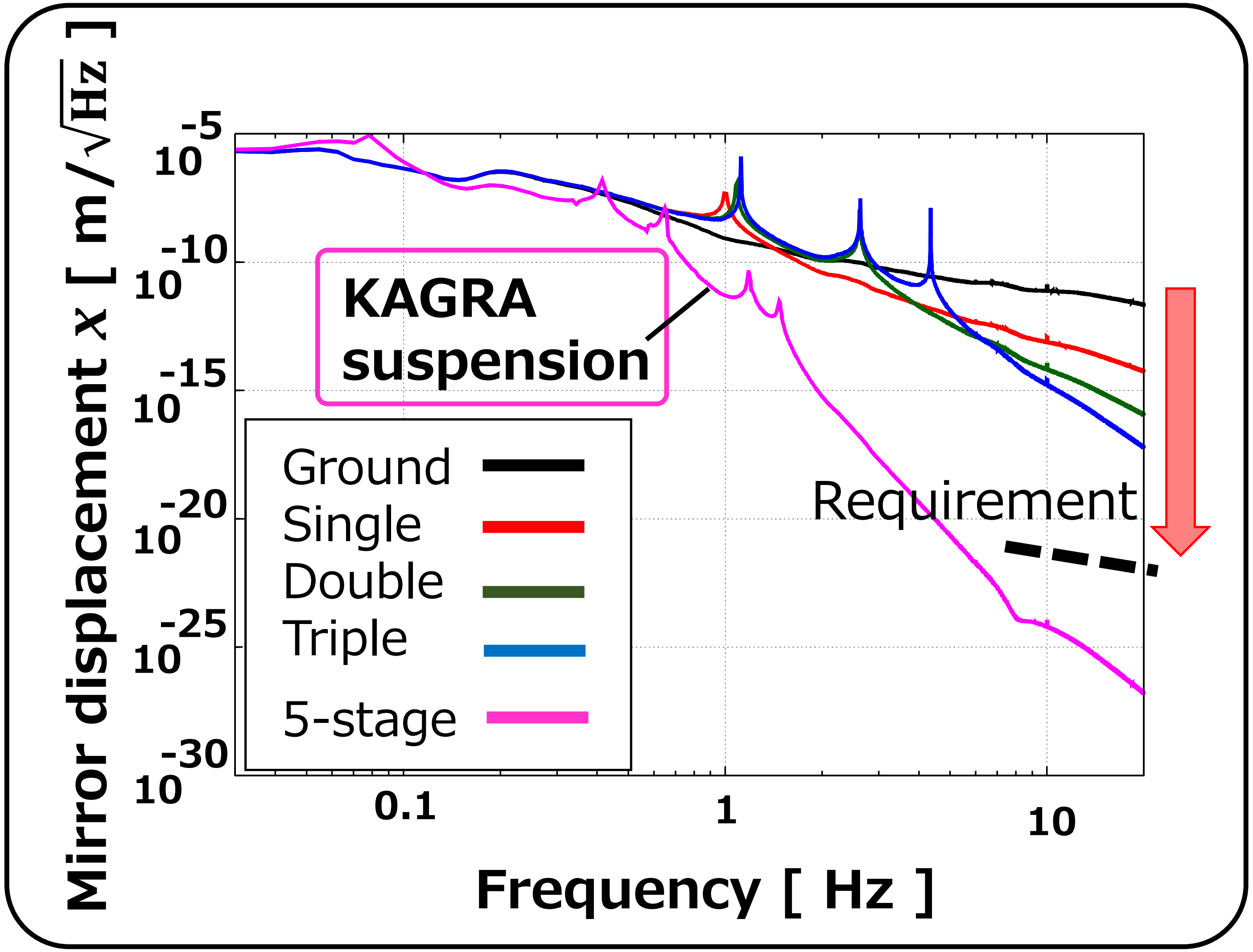
Seismic noise



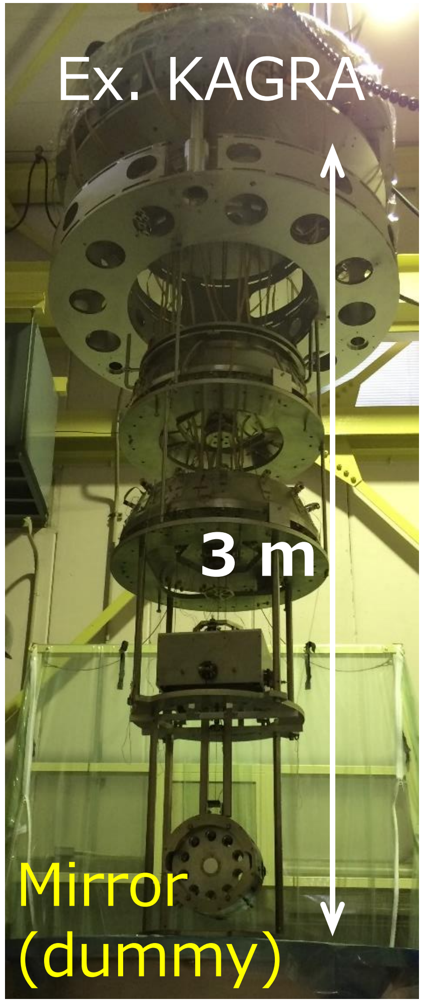


Seismic attenuation



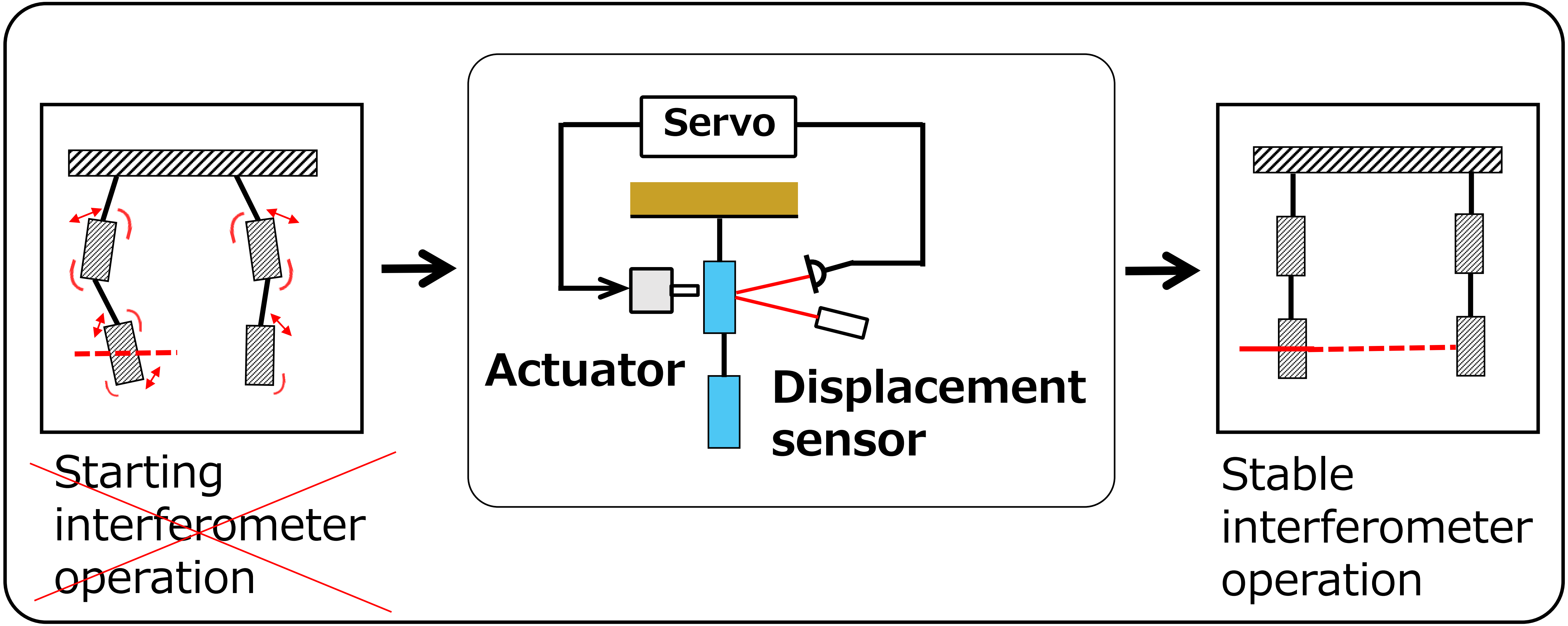


(Type-B suspension case)



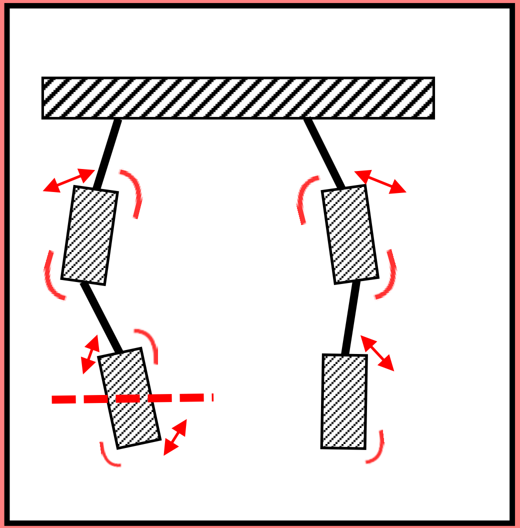
Resonance damping

→ *Active control*



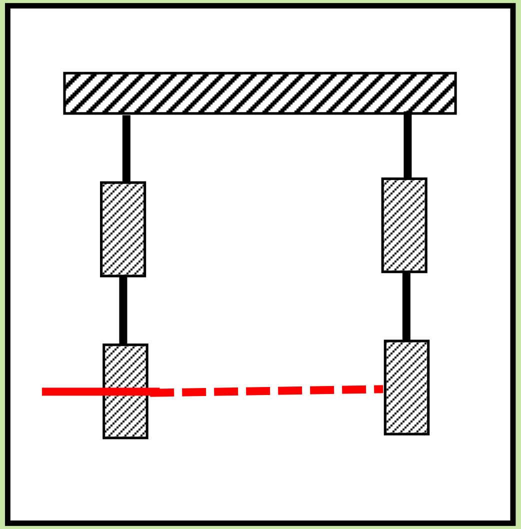
Designing active control system / Control phase

1. Calm-down phase



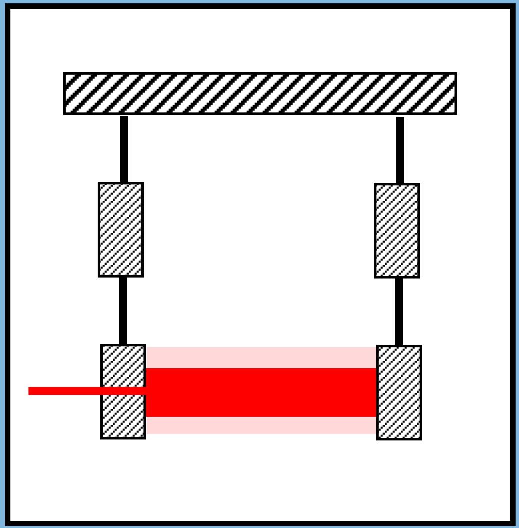
Suppress
large disturbance

2. Lock-acquisition phase



Reduce RMS velocity
RMS angle
(Root-Mean-Square)

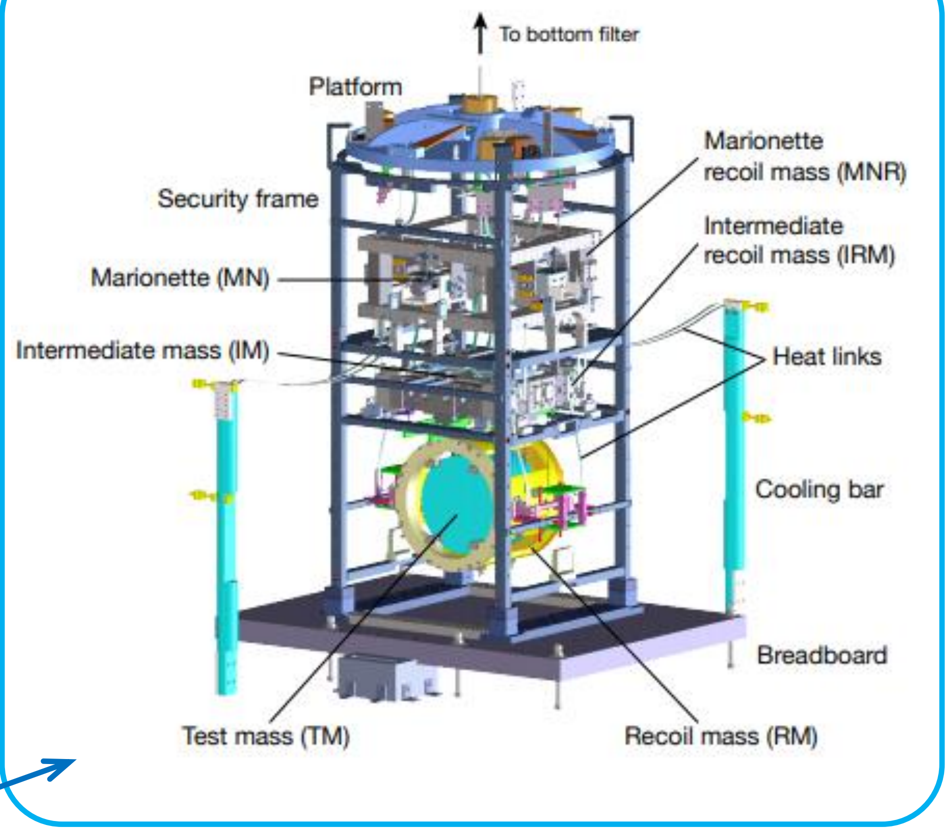
3. Observation phase

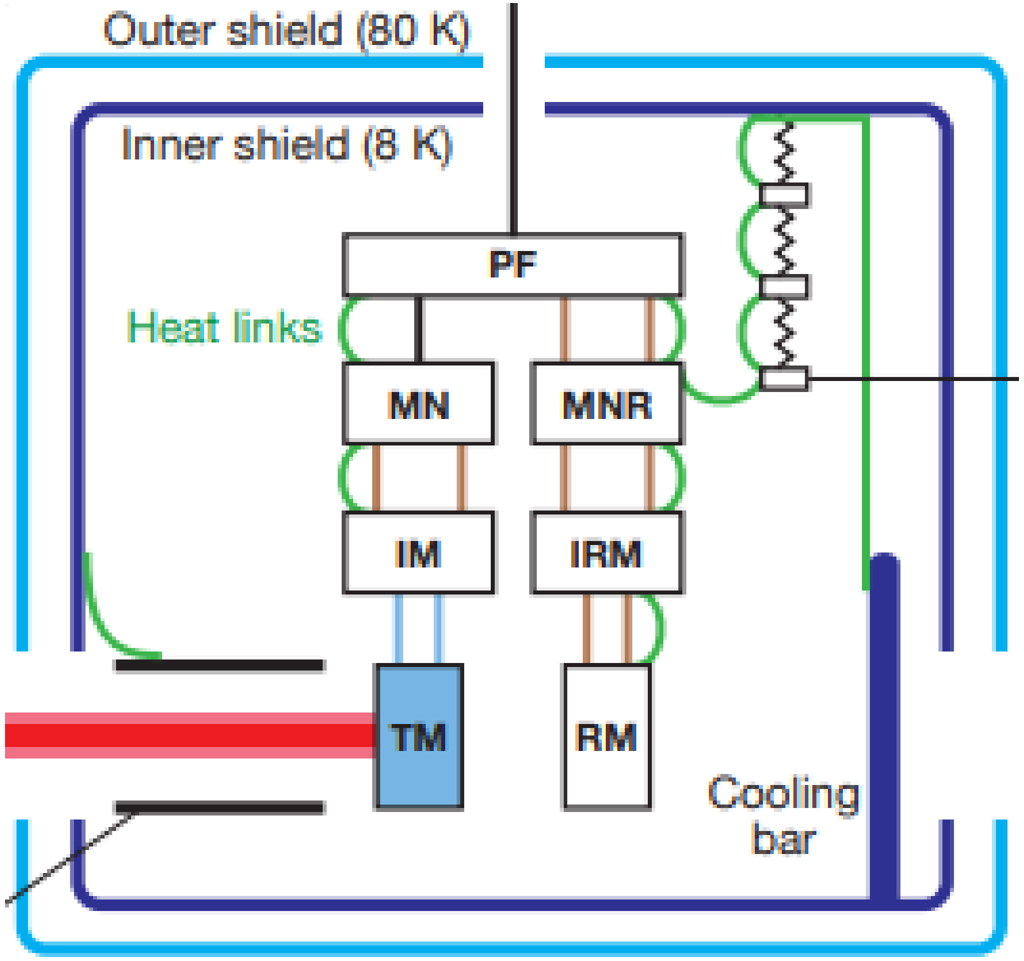


Keep position
with low noise
control

Type-A suspensions?

Inside cryostat





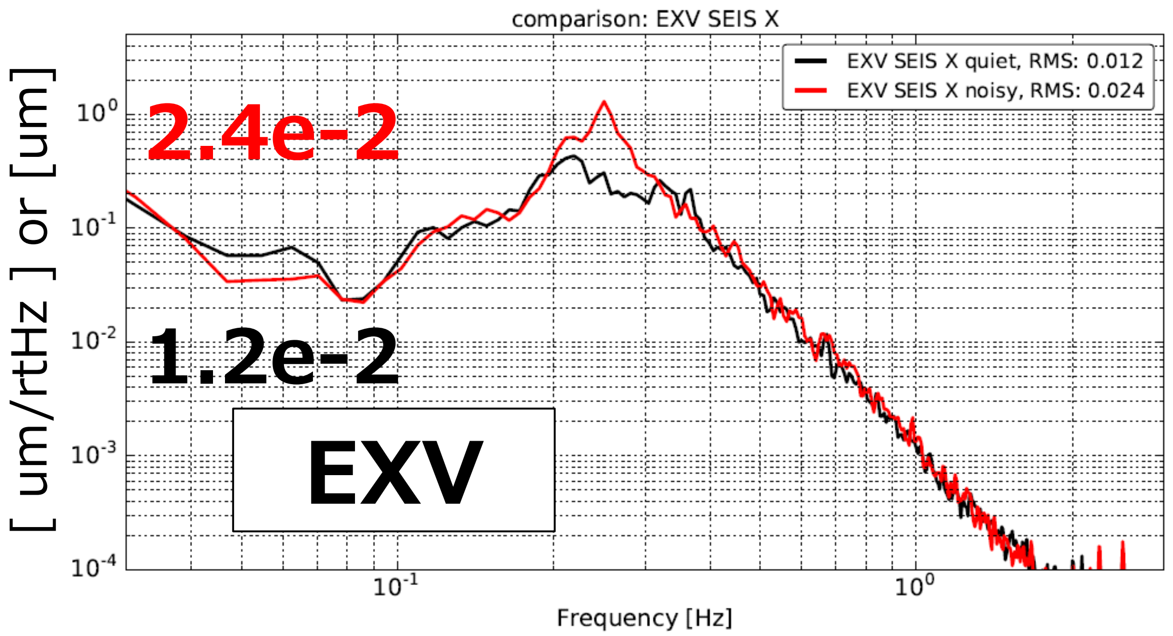
JGW-P1809347

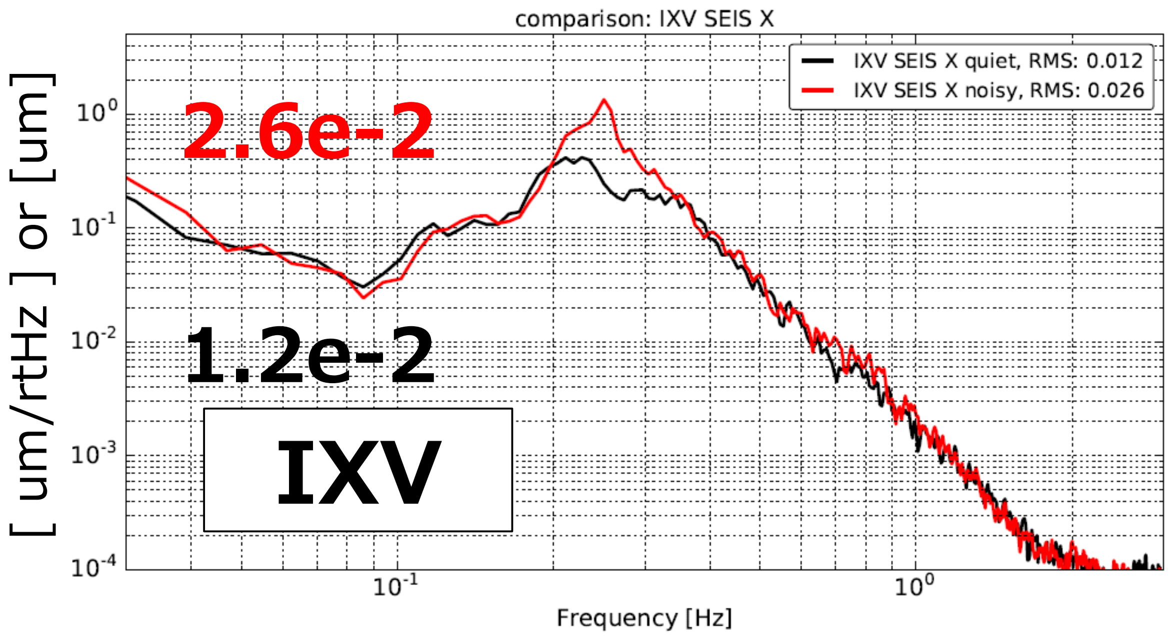
Type-A suspensions?

JGW-P1809382

With displacement sensors, [residuals] **In bad weather**

Seismic motion when the weather was normal/bad (From page #16)

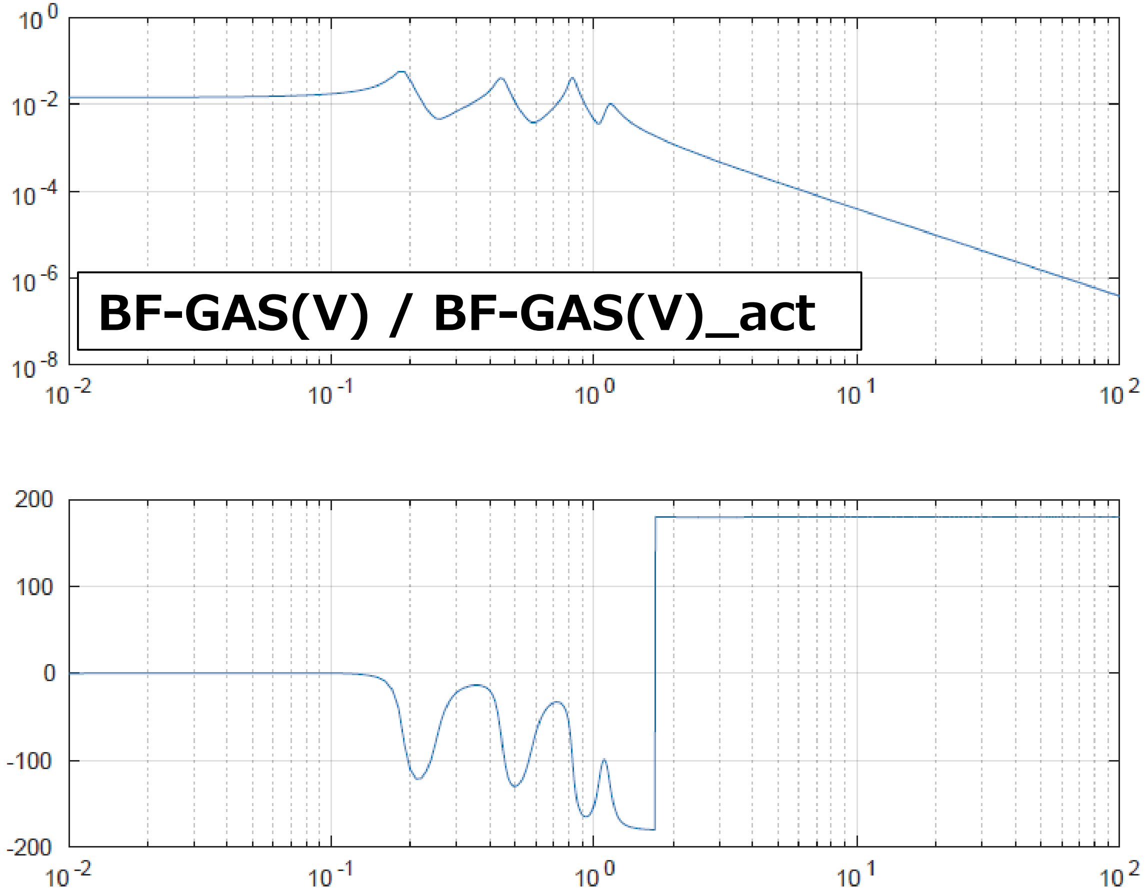




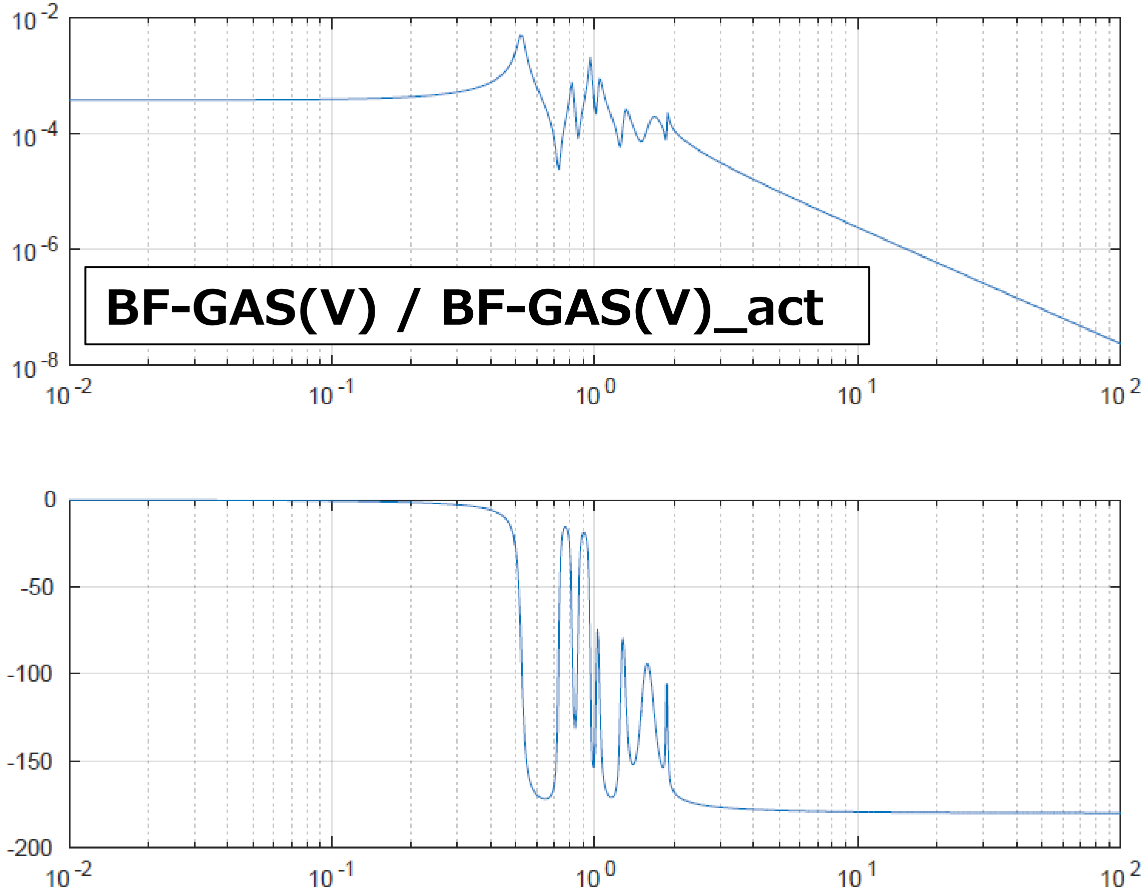
***NOT* locked..**

Vertical transfer functions (fitted)

ETMX

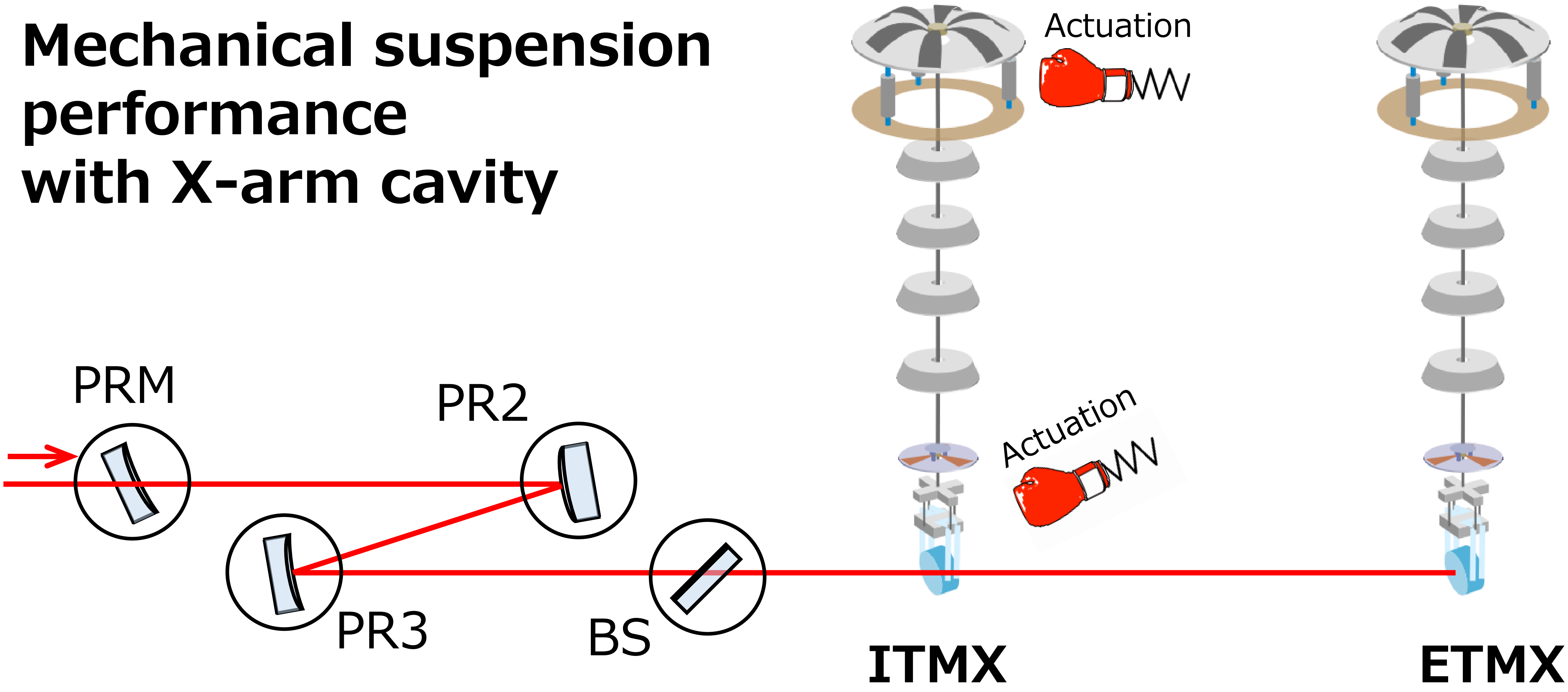


ITMX

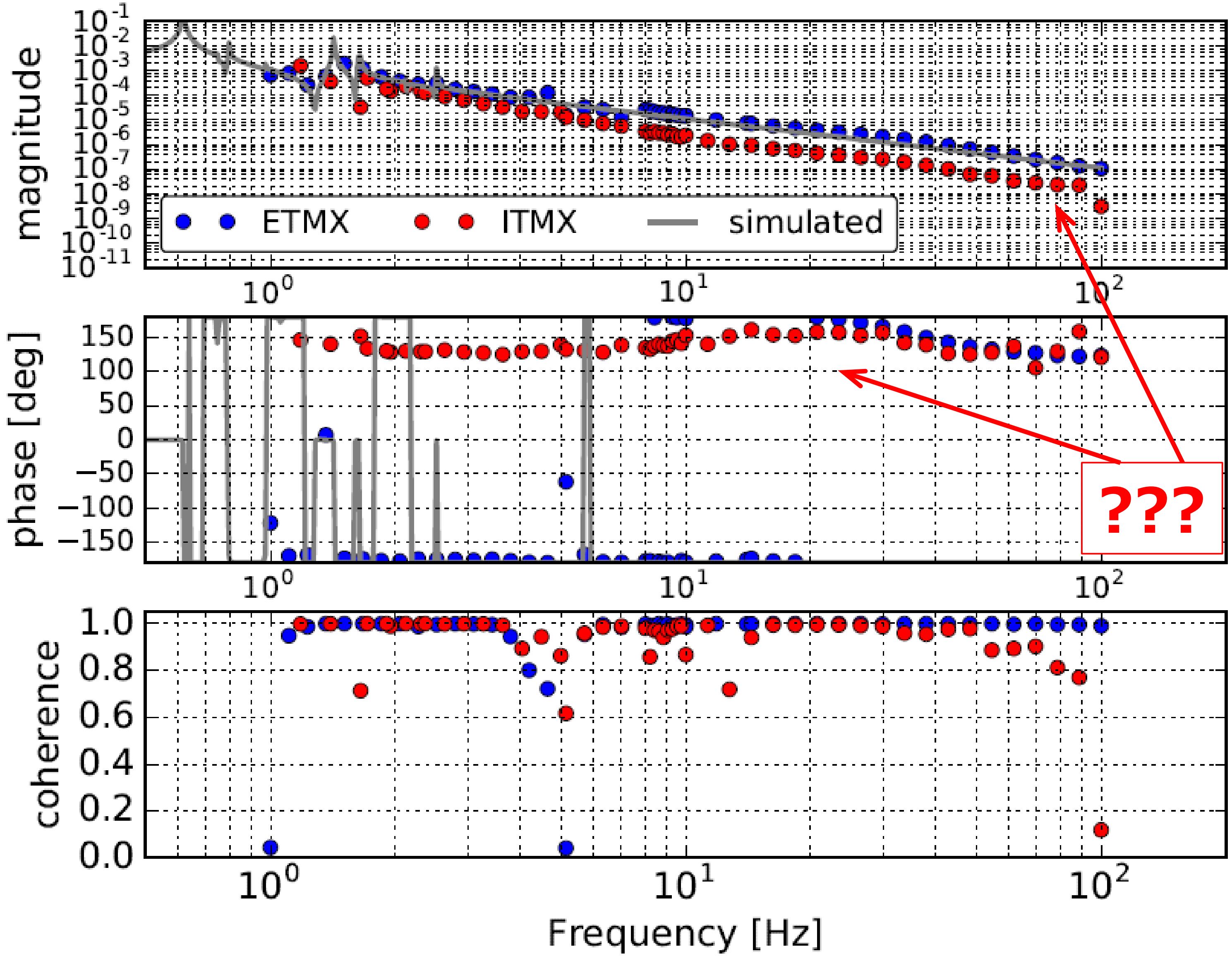


Measurement:

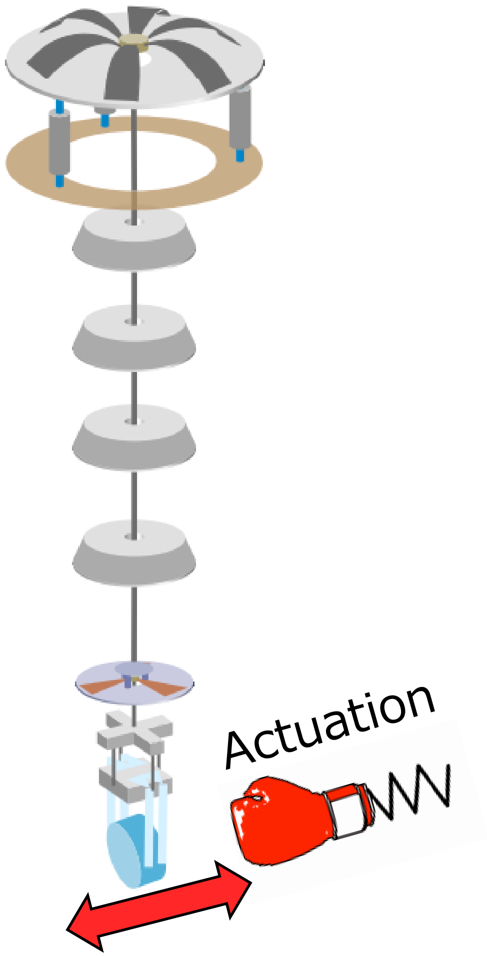
Mechanical suspension performance with X-arm cavity



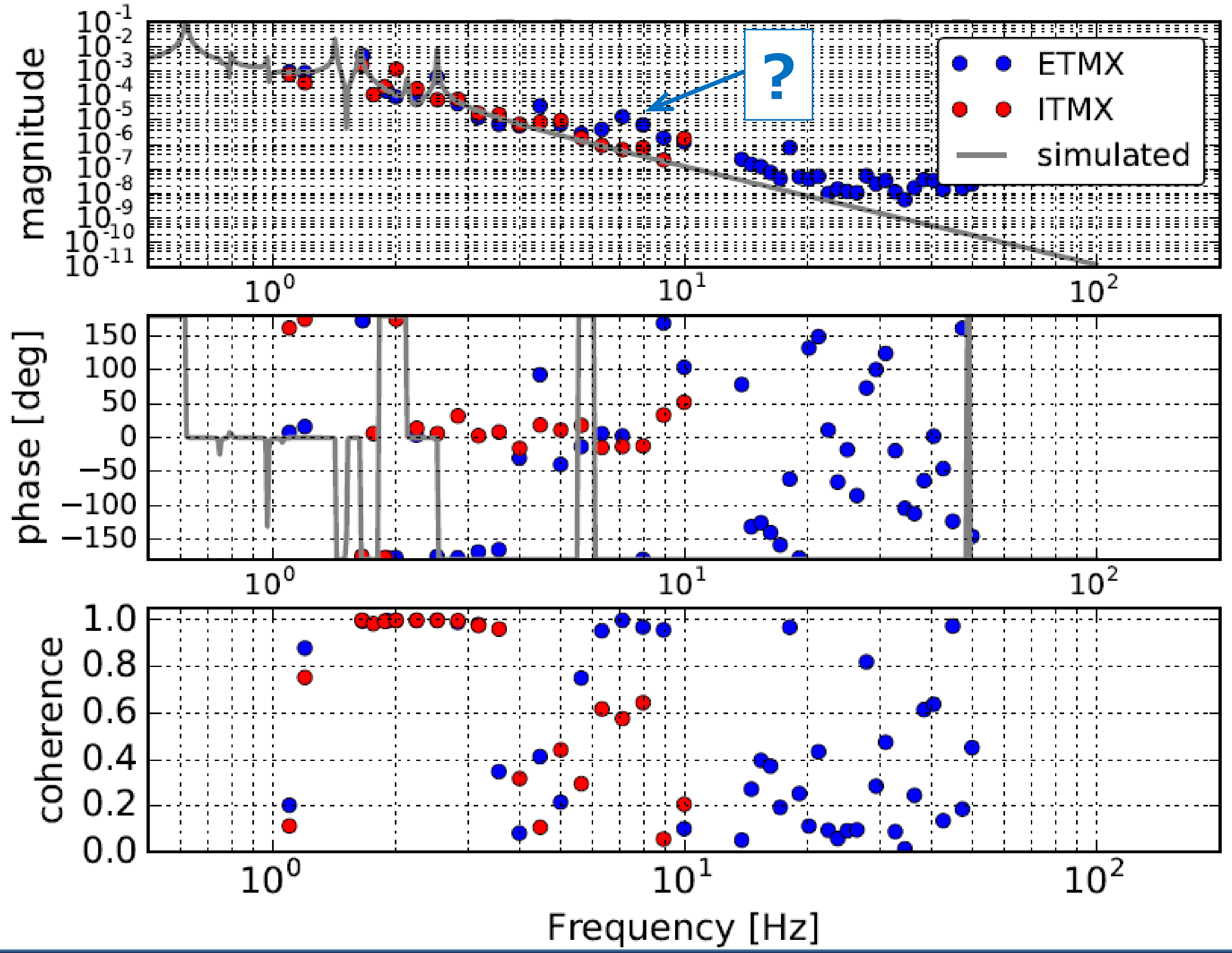
Force transfer functions



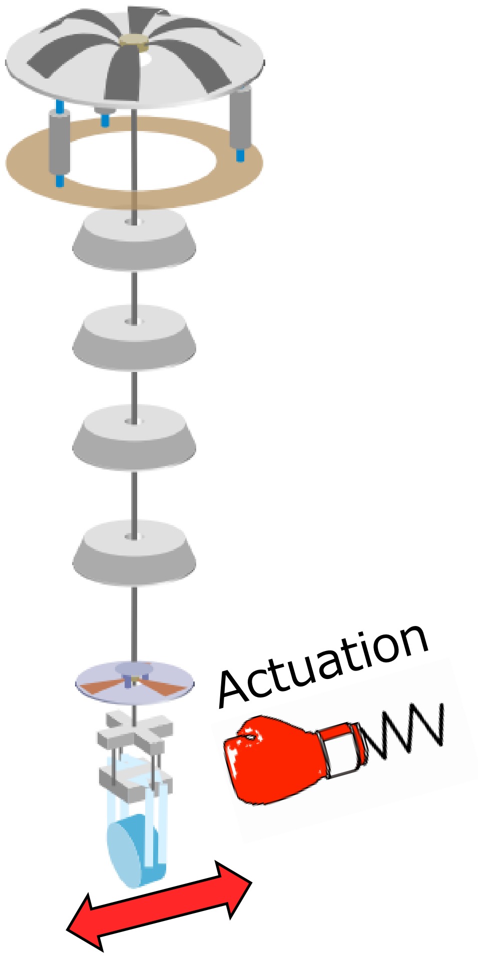
From (TM-RM)-act to TM



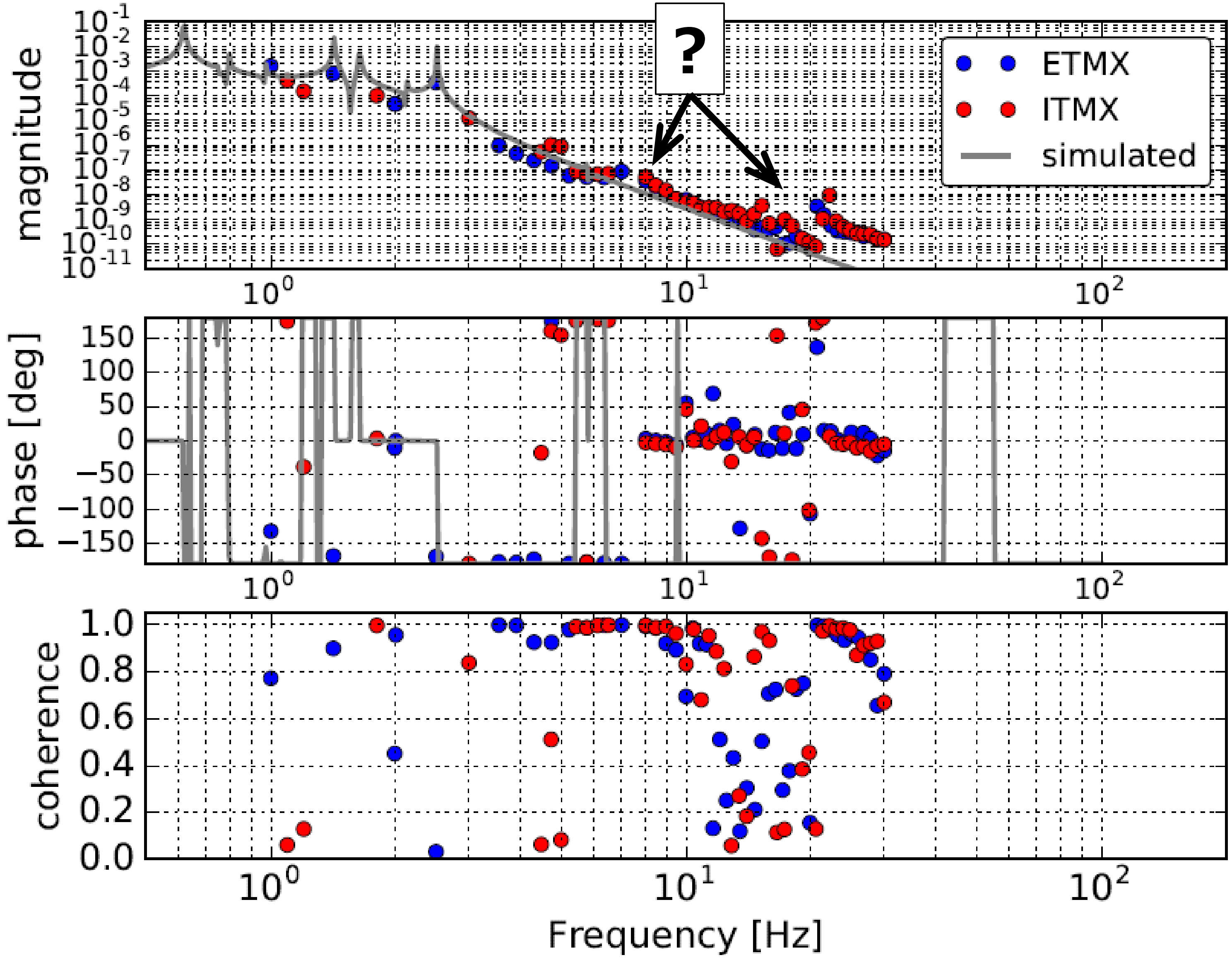
Force transfer functions



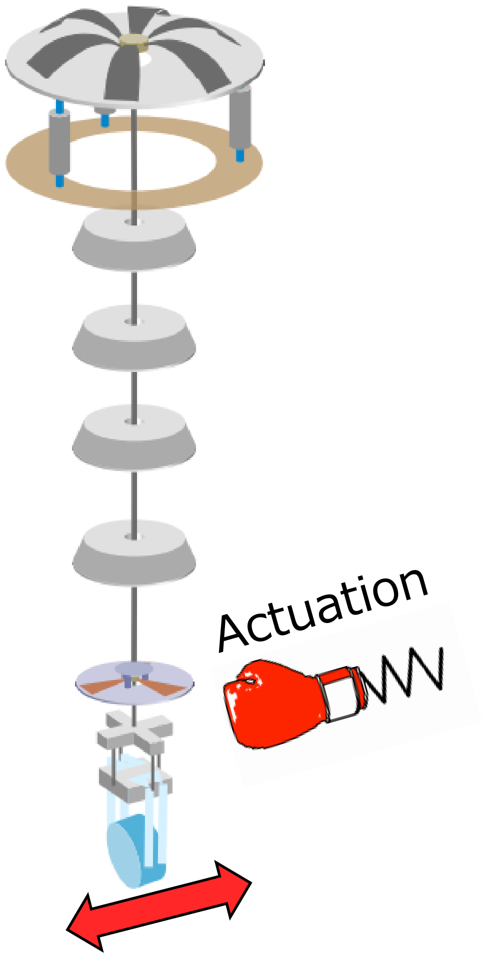
From (IM-IMR)-act to TM



Force transfer functions



From (MN-MNR)-act to TM



Note: Measurement of mechanical suspension performance with X-arm cavity

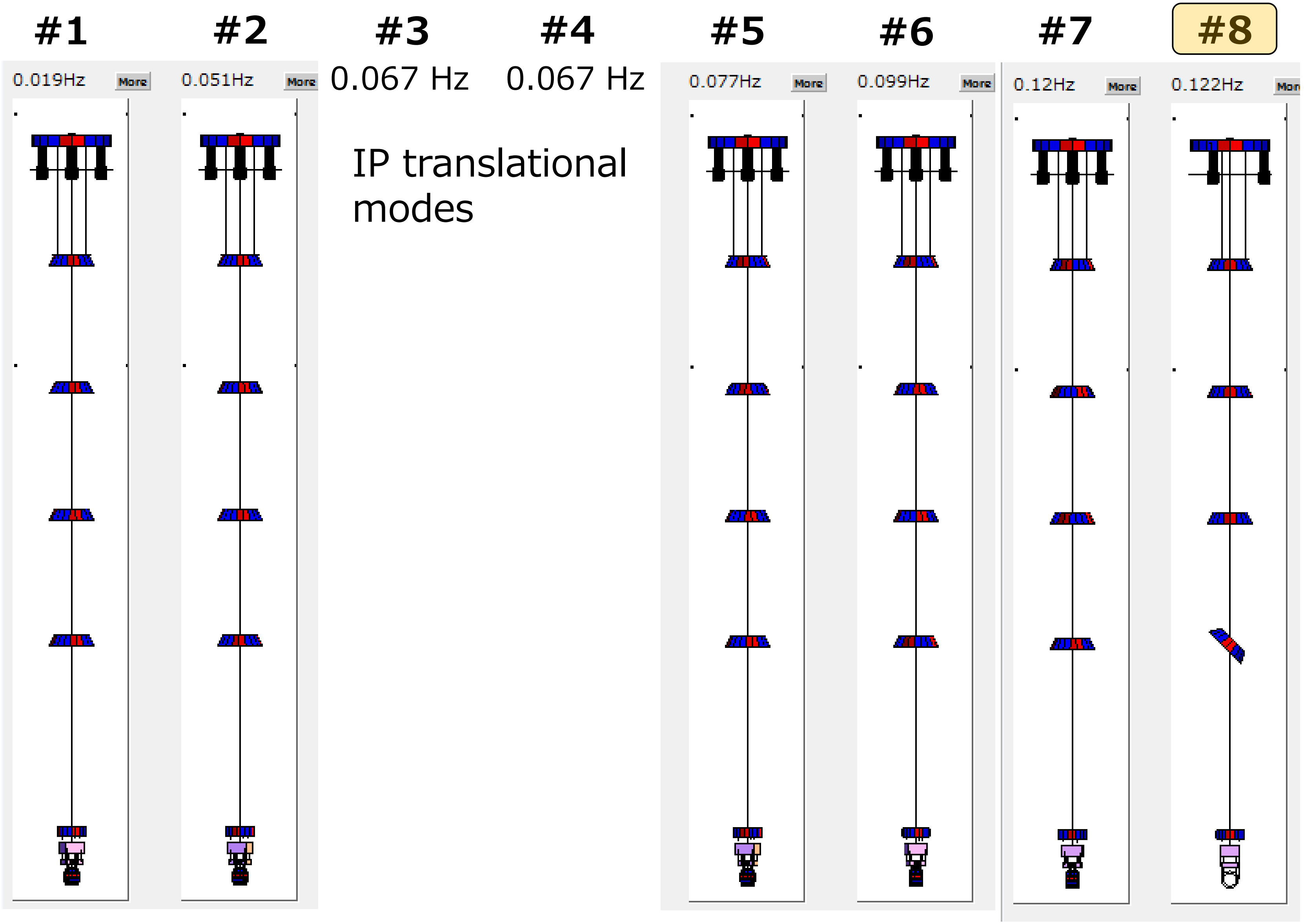
Excitation point:

Excited stage name	Degree of freedom
TM	L
	P
IM	L
	V
MN	L
BF	GAS
	(L)
IP	L

Sensing point:

All the local sensors
for ETMX and ITMX

(*1) Some resonances have to be identified, as shown in the above.
(*2) measurement files are stored under */users/VISsvn/* though, Not much organized well now..
please let me know if you want to have them ASAP.

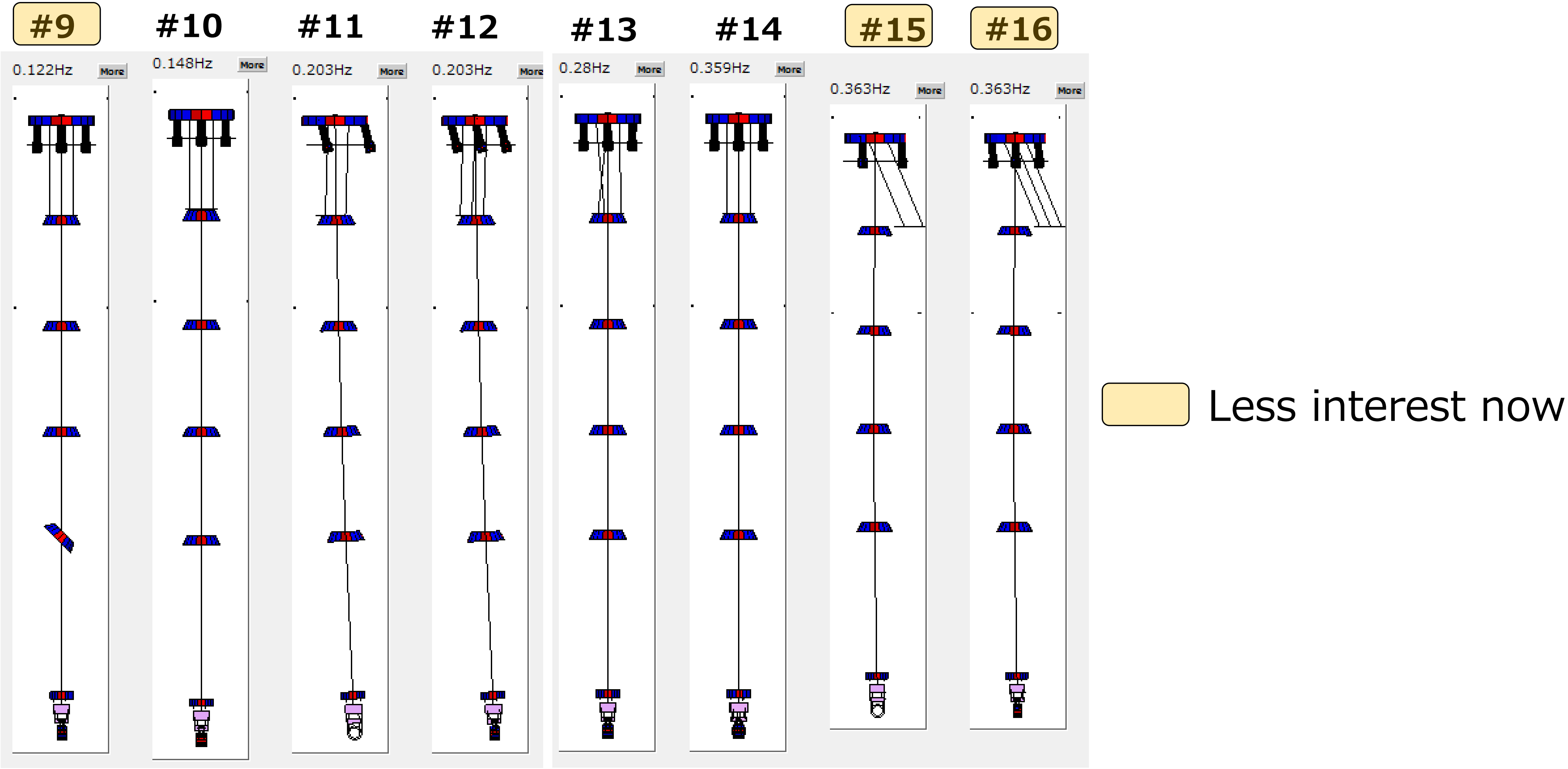


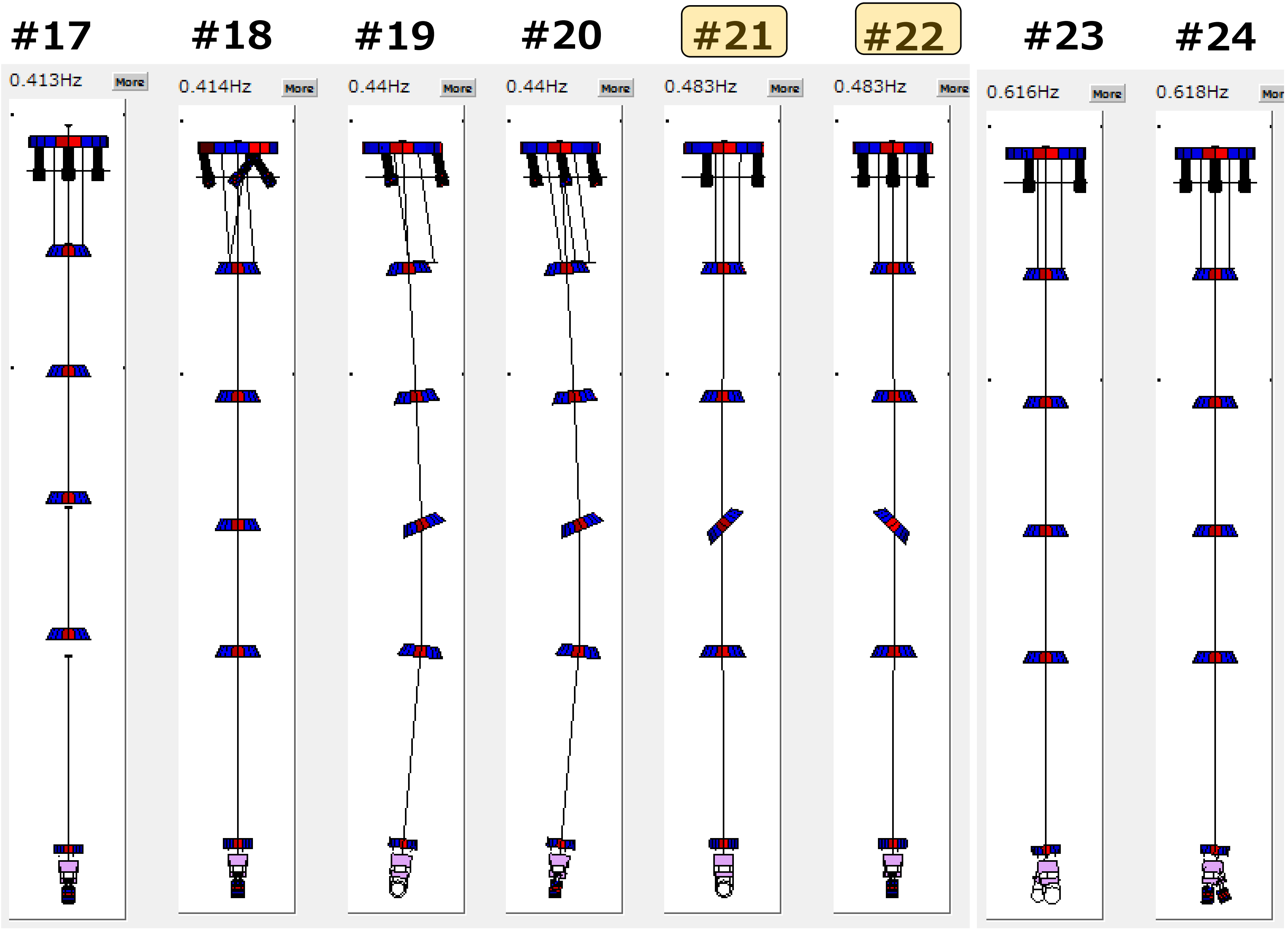
Type-A SAS,

'TyrpeA180429_20K'

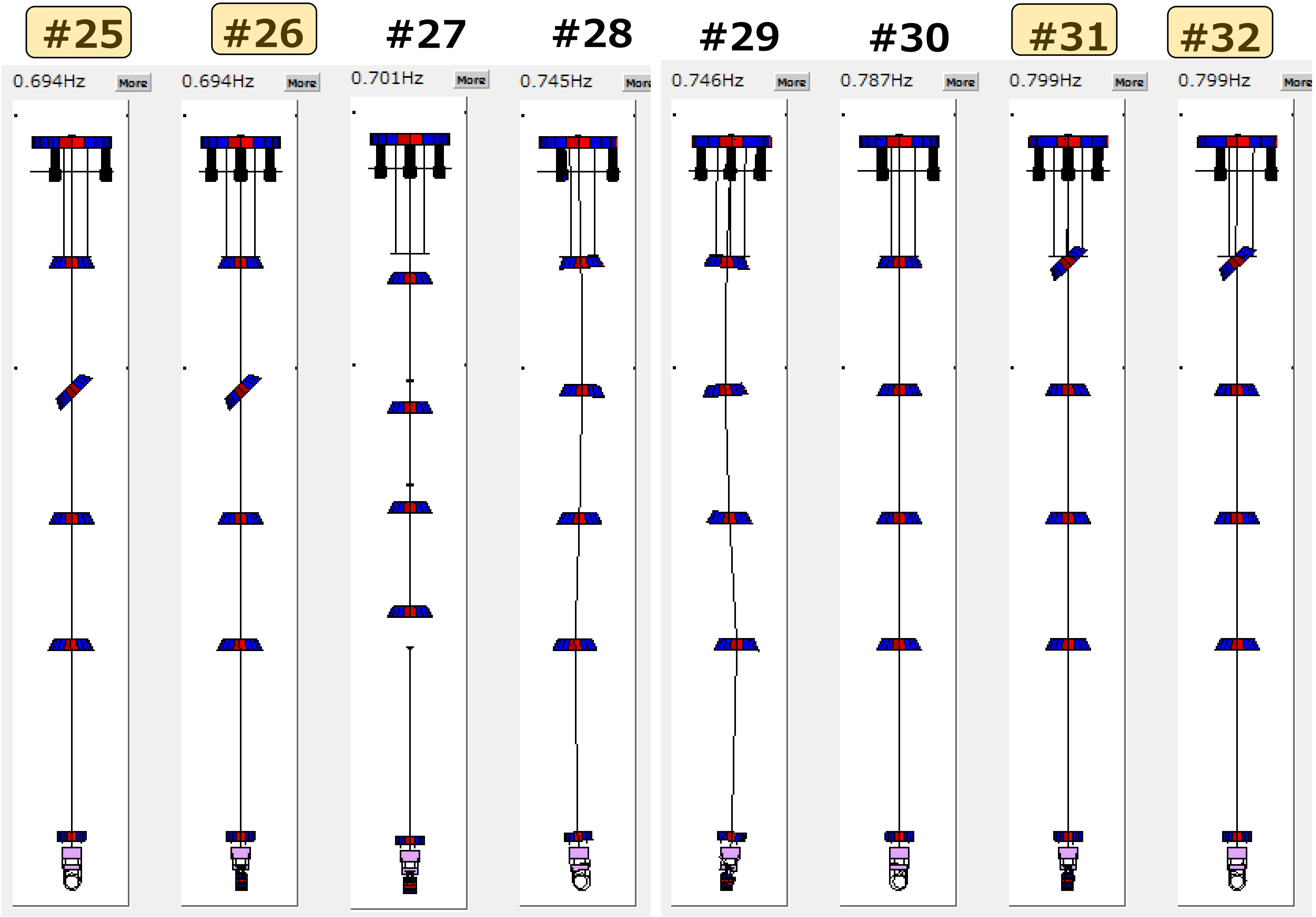
Eigen mode: 75 modes

Less interest now

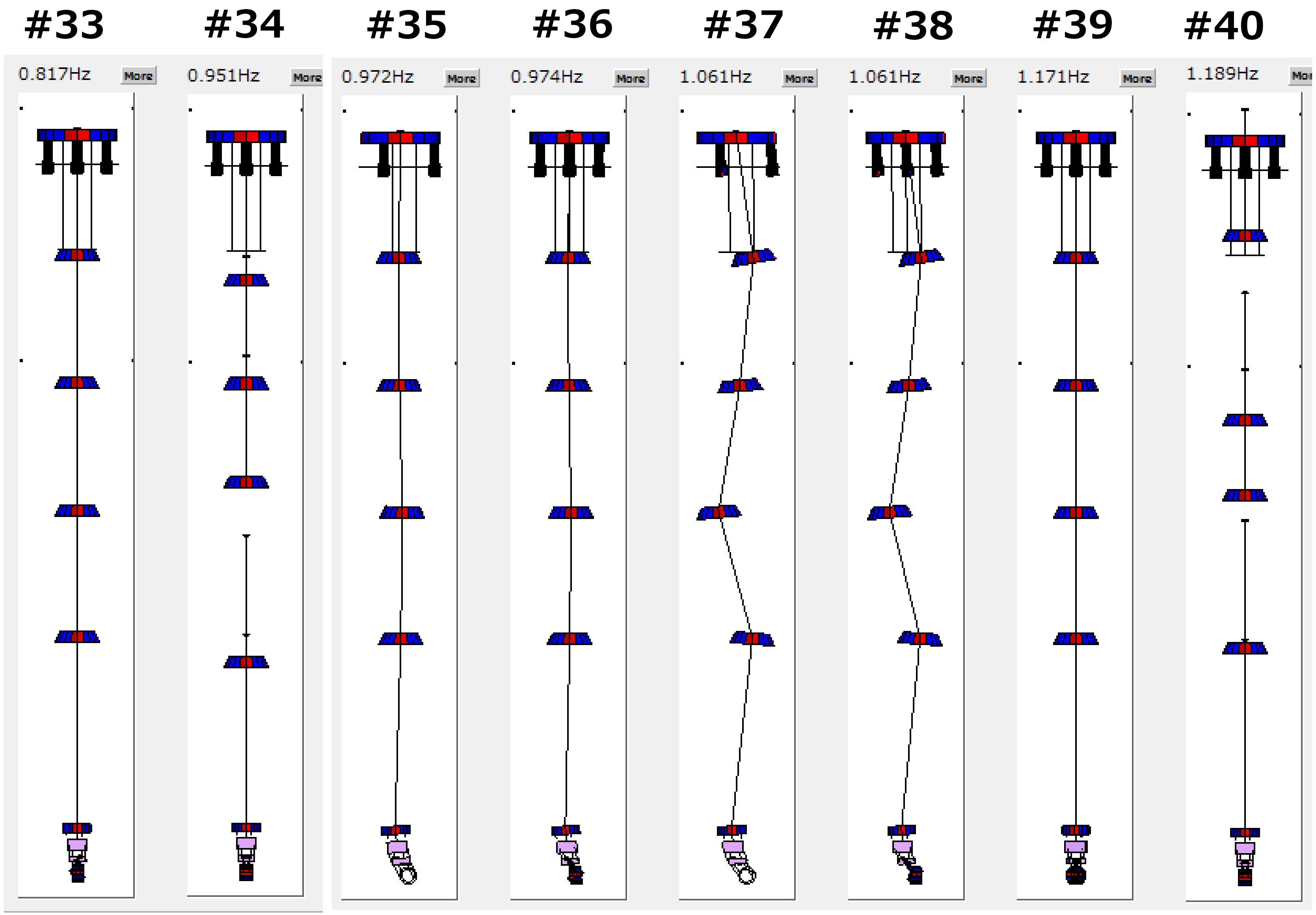

#9
#10
#11
#12
#13
#14
#15
#16
0.122Hz
0.148Hz
0.203Hz
0.203Hz
0.28Hz
0.359Hz
0.363Hz
0.363Hz
More
Less interest now



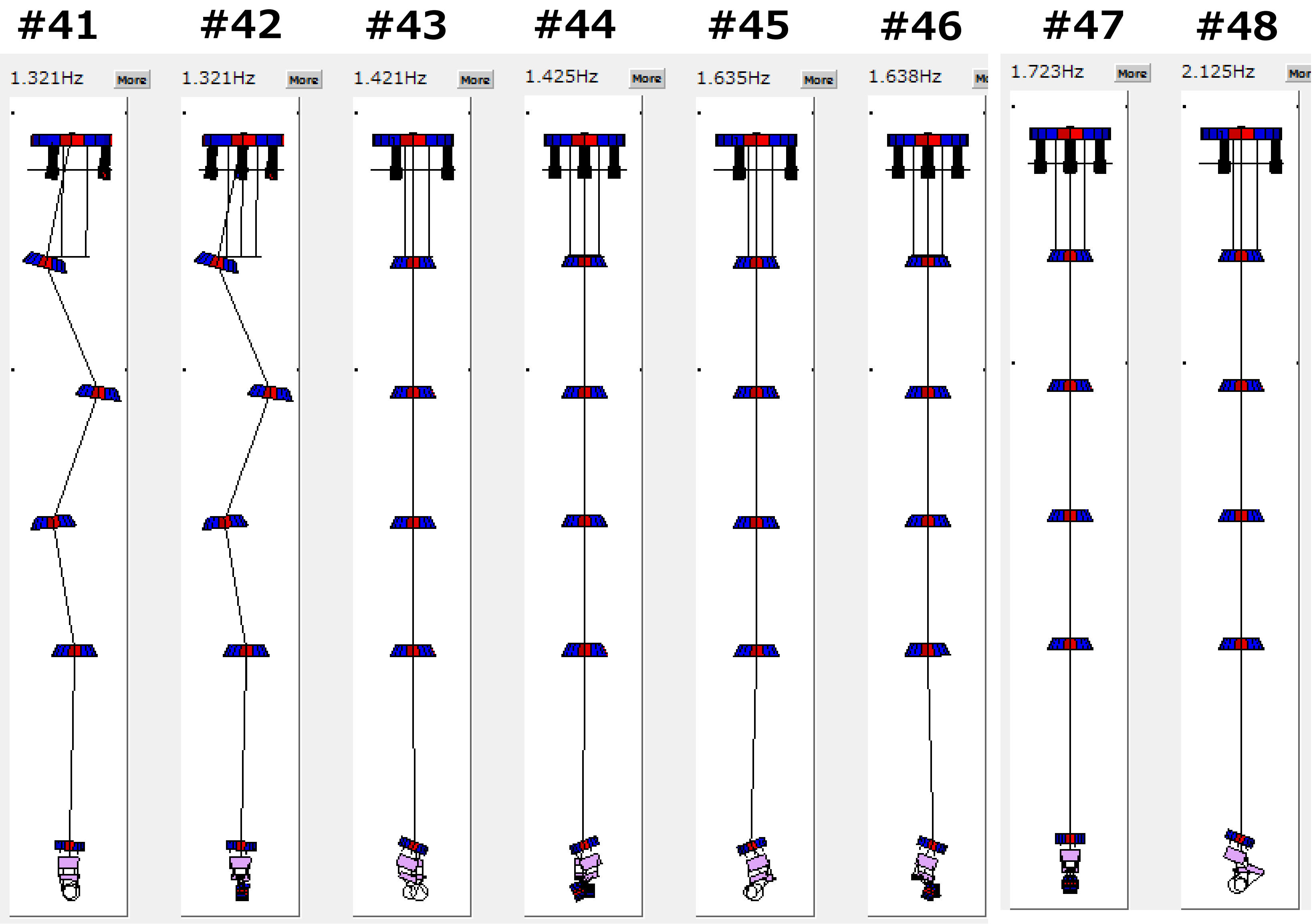
Less interest now



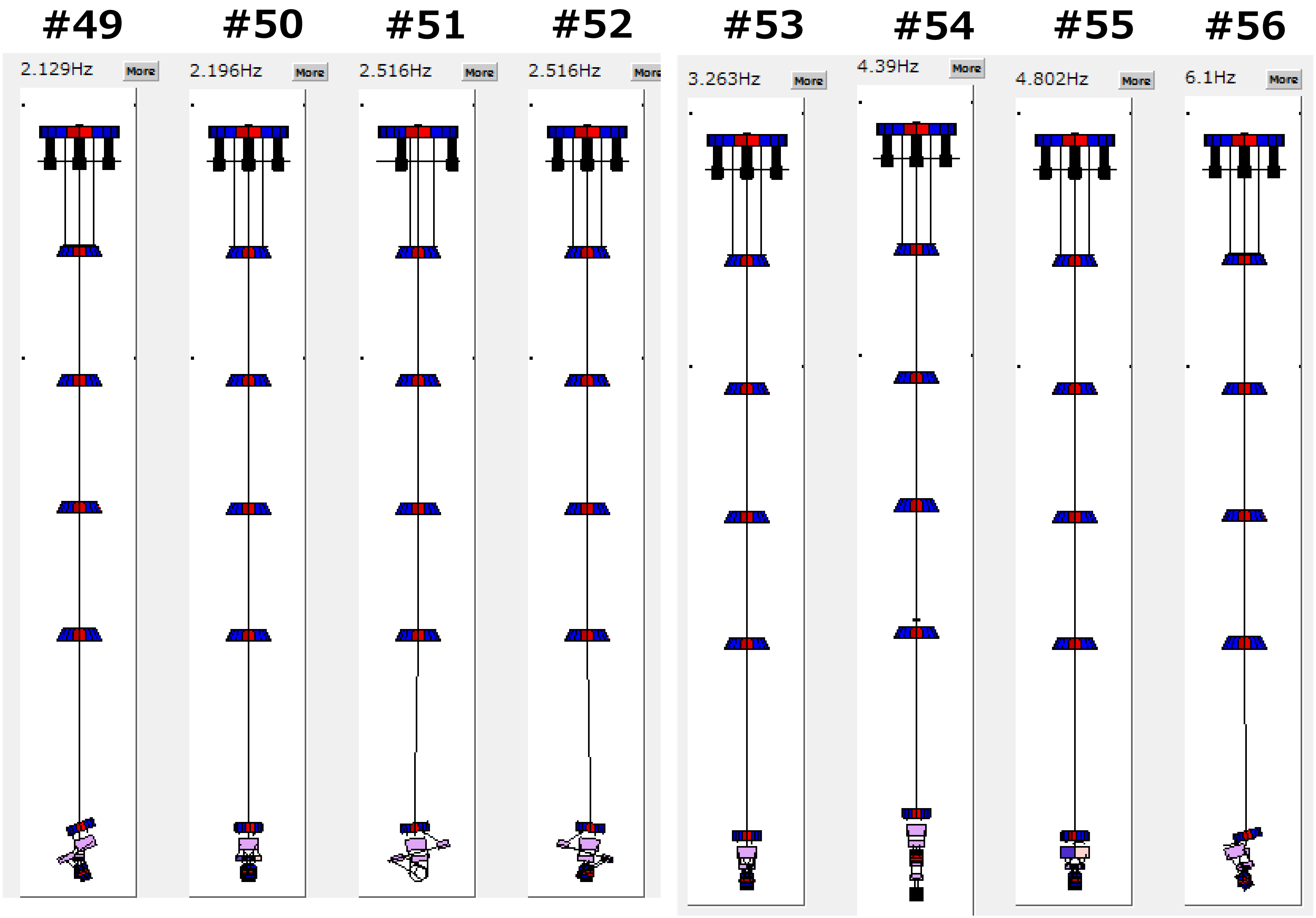
Less interest now



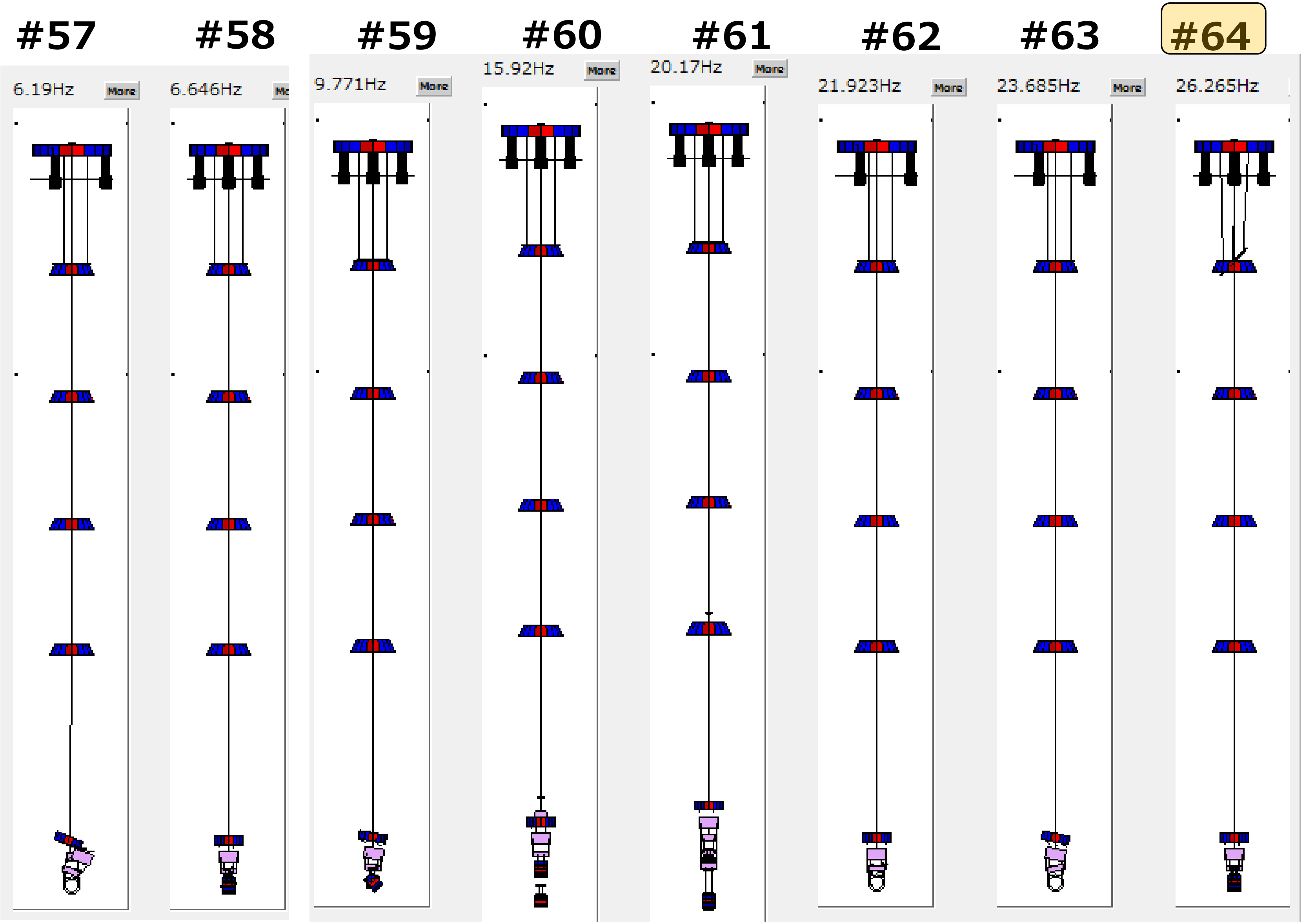
Less interest now



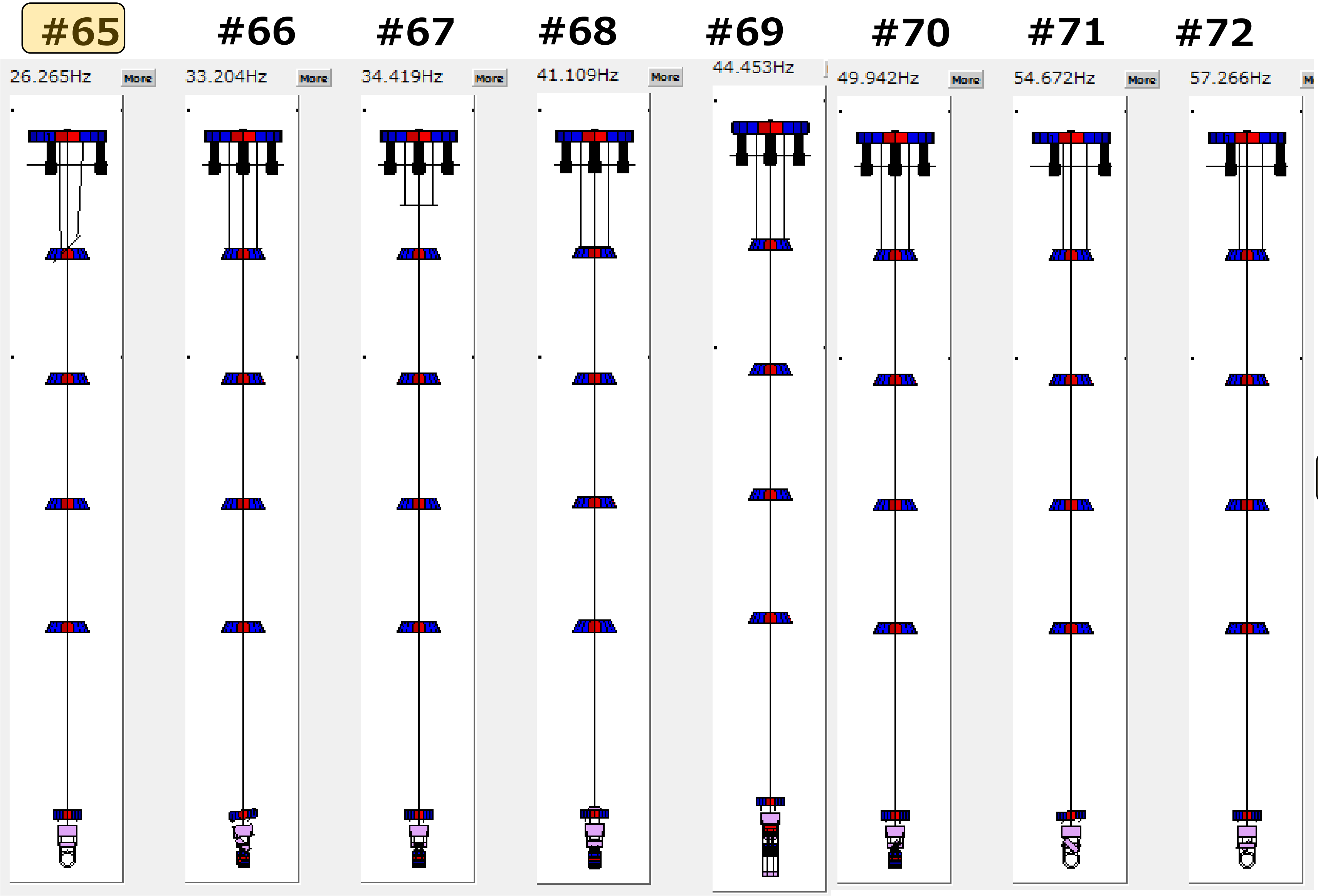
Less interest now



Less interest now

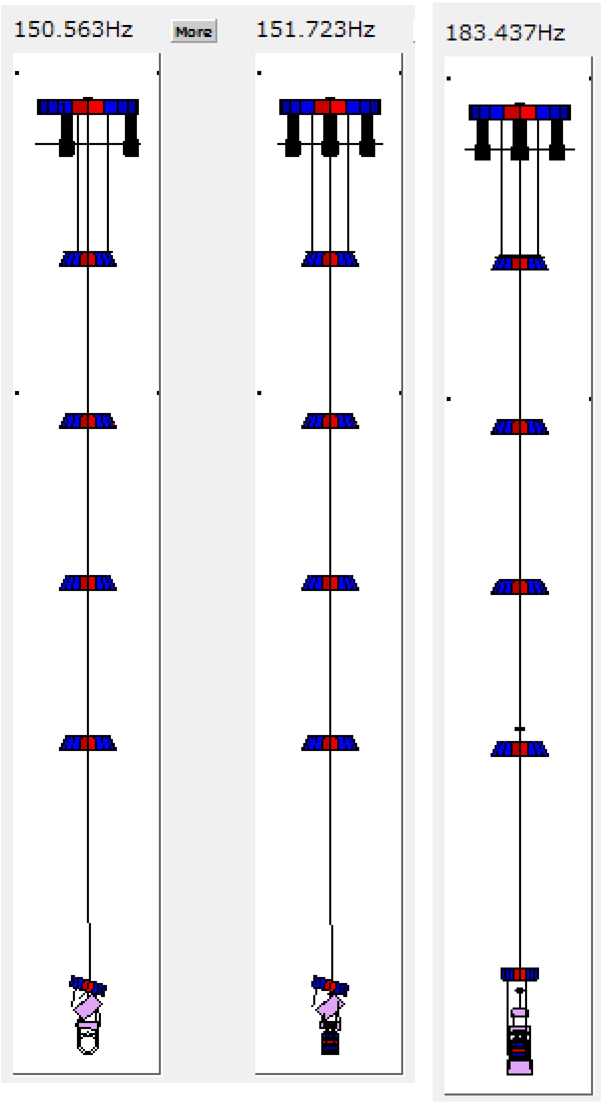


Less interest now



Less interest now

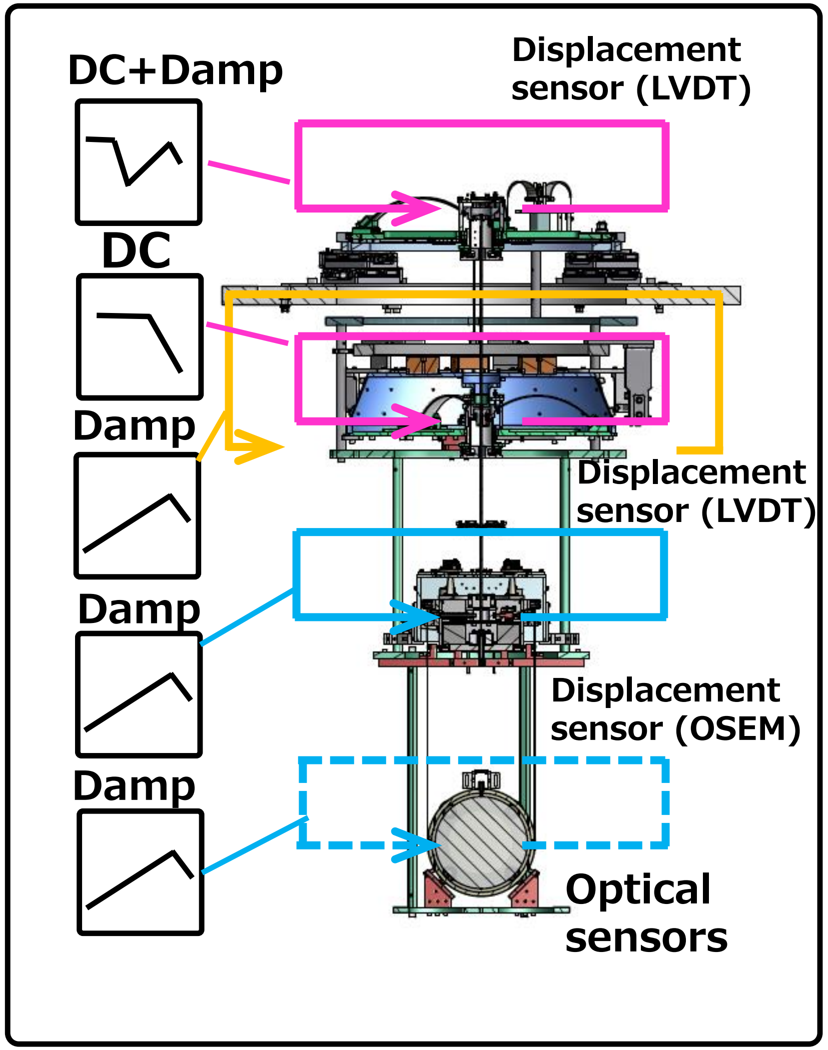
#73 #74 #75



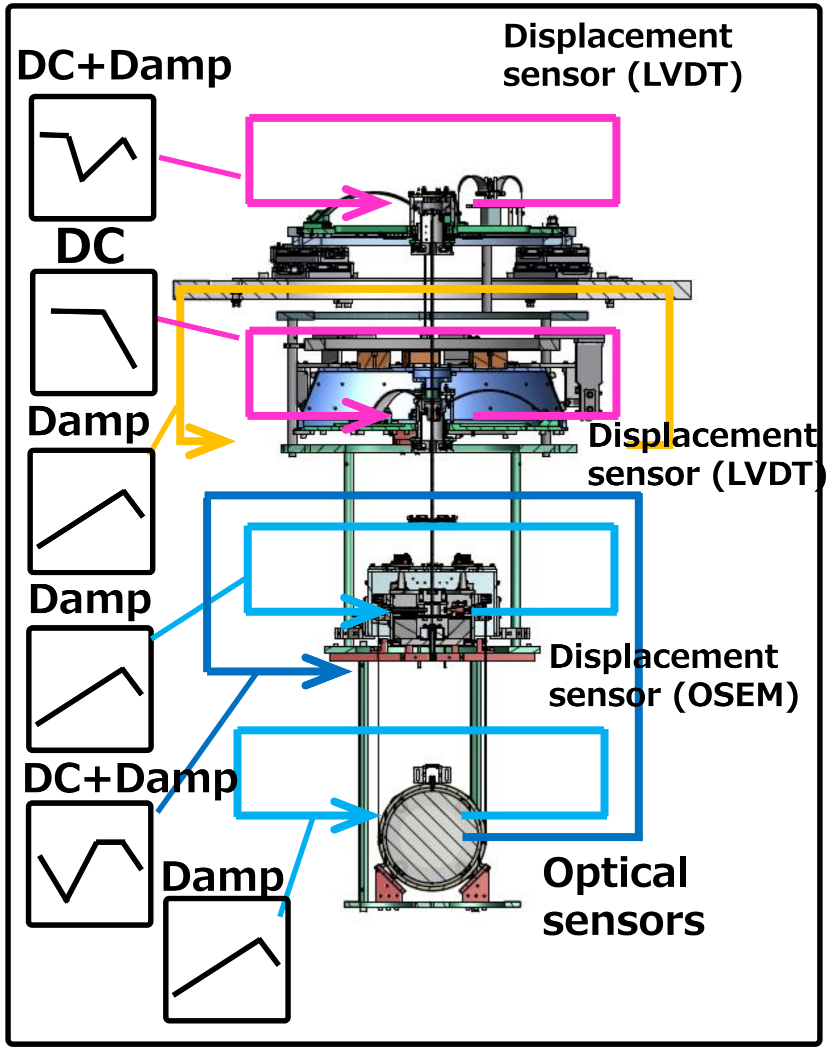
Less interest now

Designing active control system / ex. Type-Bp SAS

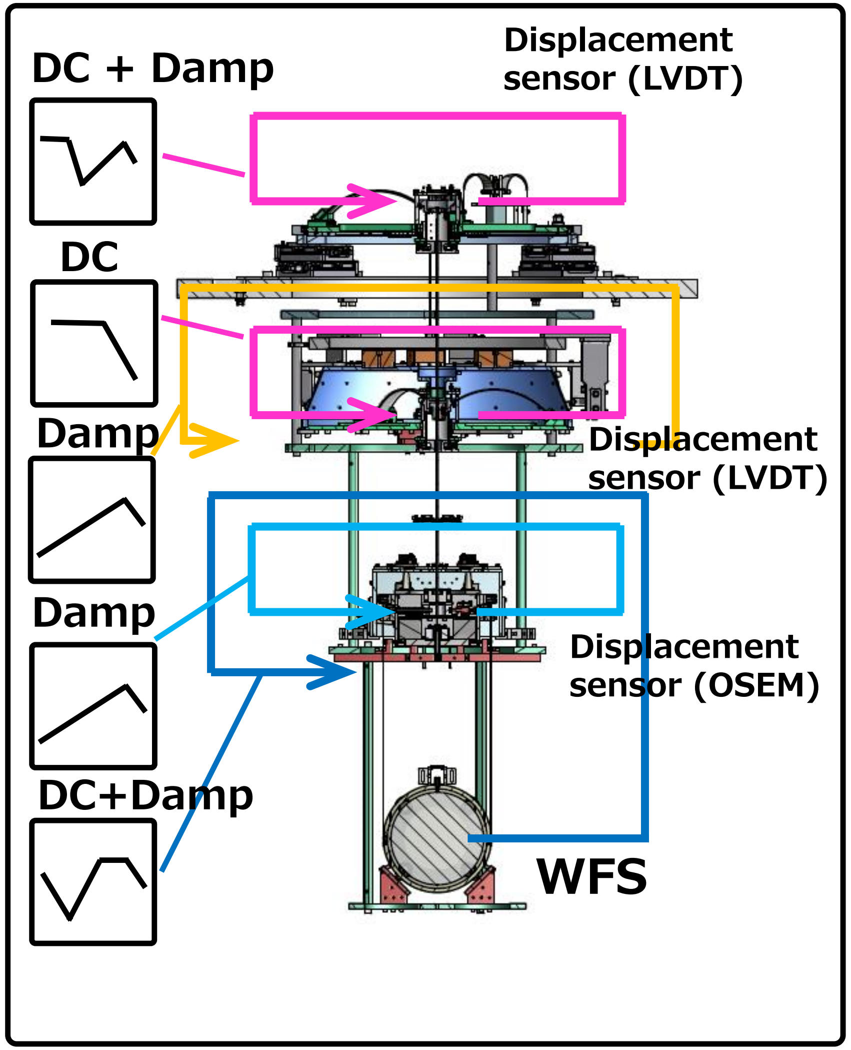
1. Calm-down phase



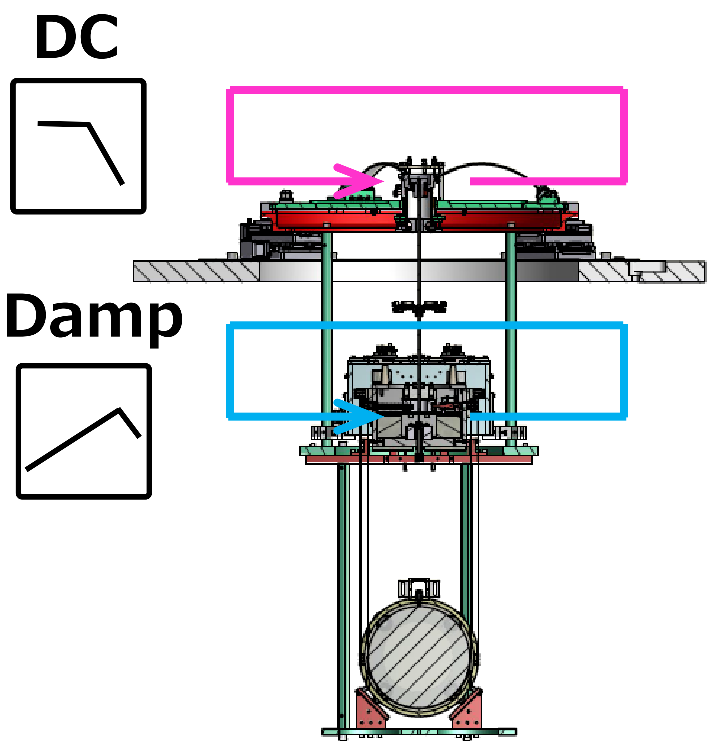
2. Lock-acquisition phase



3. Observation phase

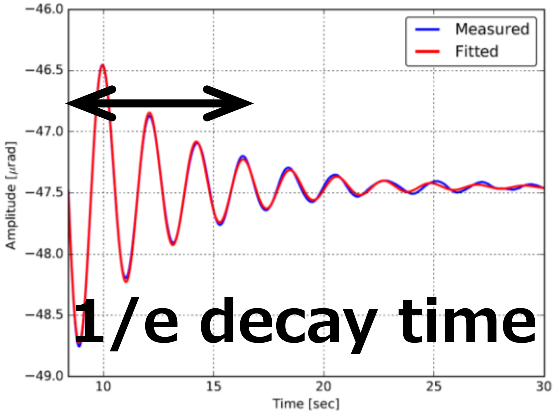


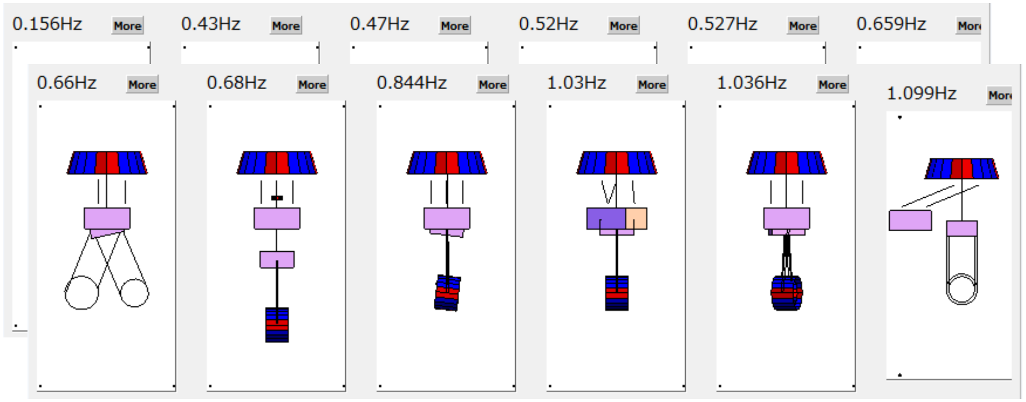
2. Decay time measurement



(Example)

For damping resonances





For the resonant modes which disturb the lock acquisition.

→ We have to measure the decay time constants w/ and w/o damping controls, in order to verify the damping control performance, FOR ALL THE TYPE-A/B/Bp SUSPENSIONS.