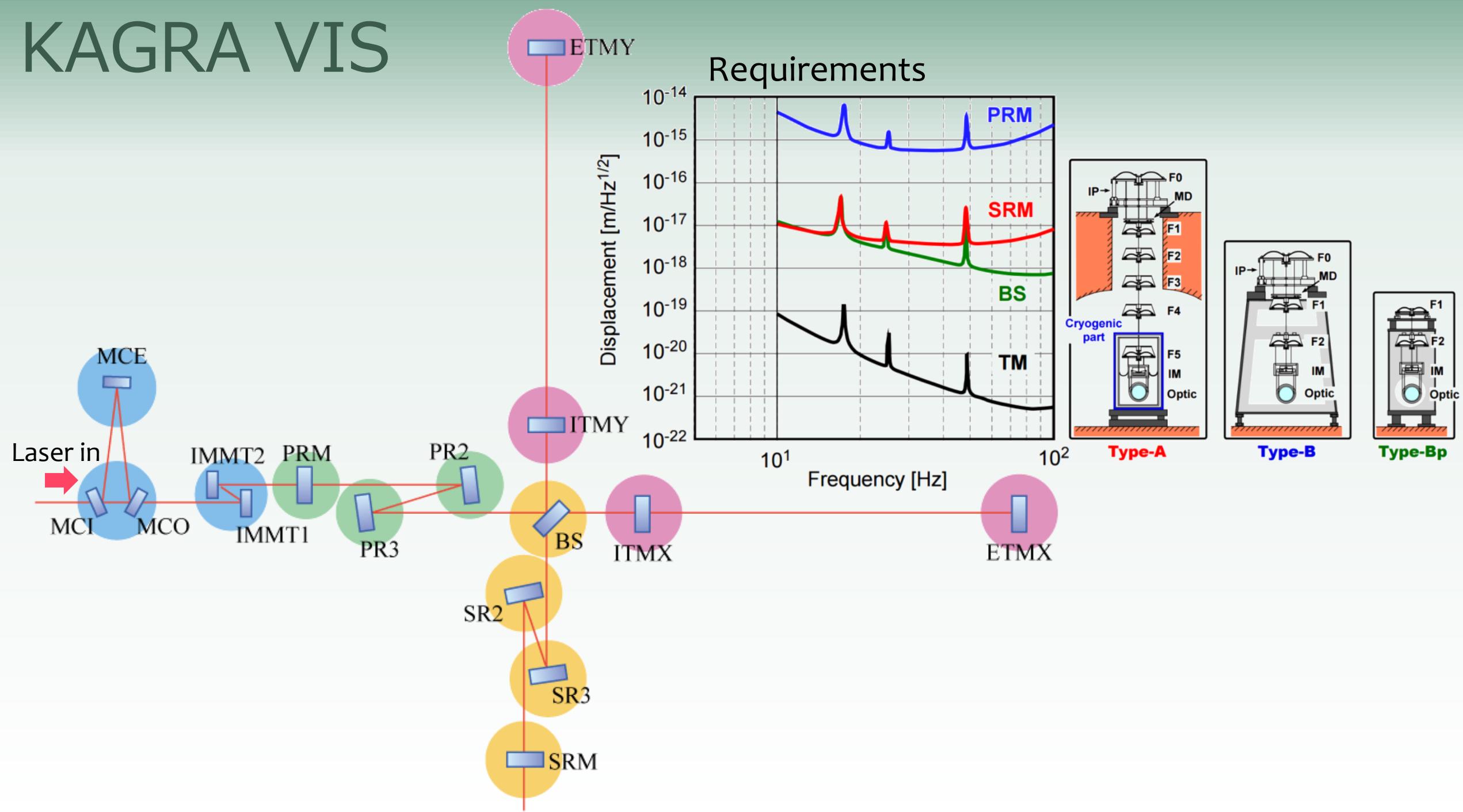


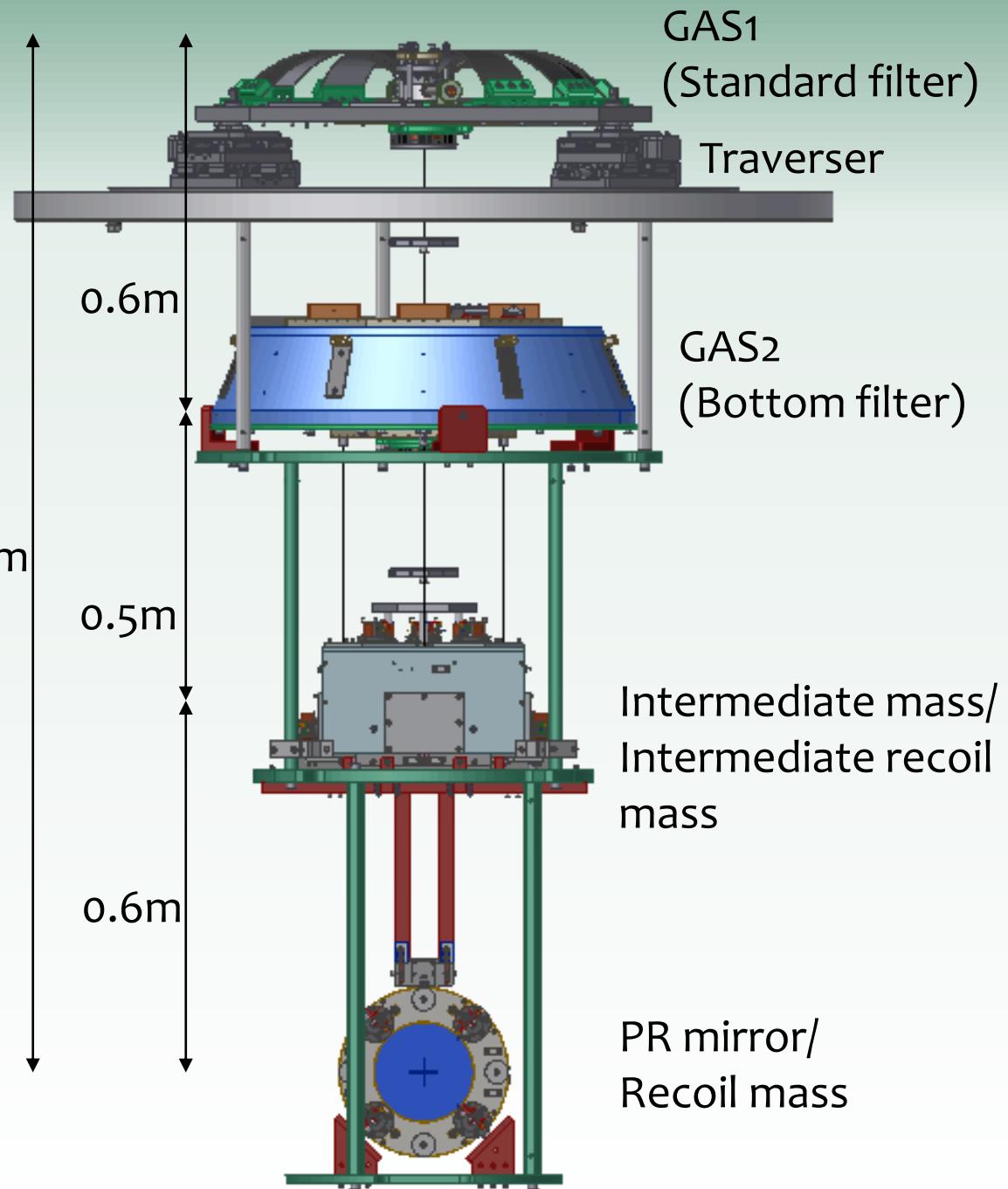
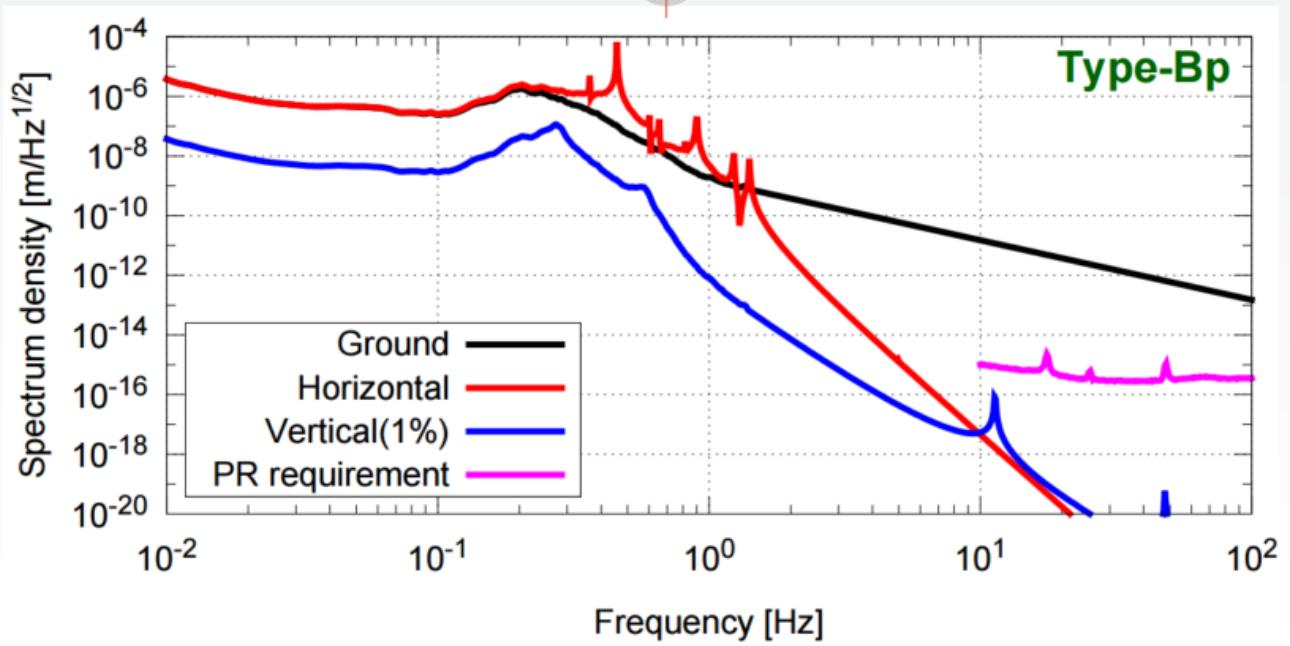
KAGRAにおけるPower Recycling鏡の防振 懸架系システムの開発 III

正田亜八香、KAGRA collaboration

KAGRA VIS

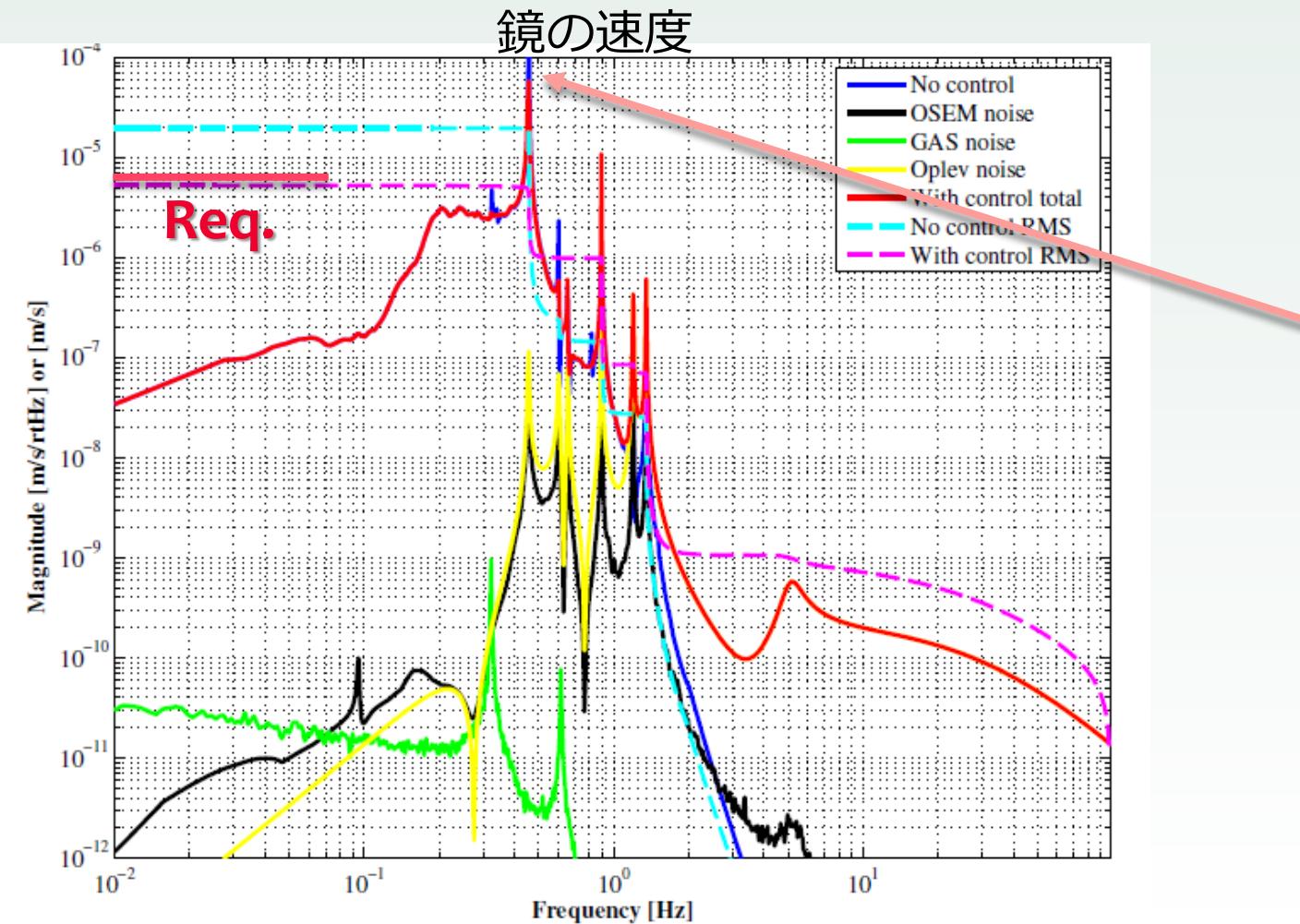


Type-Bp



問題点

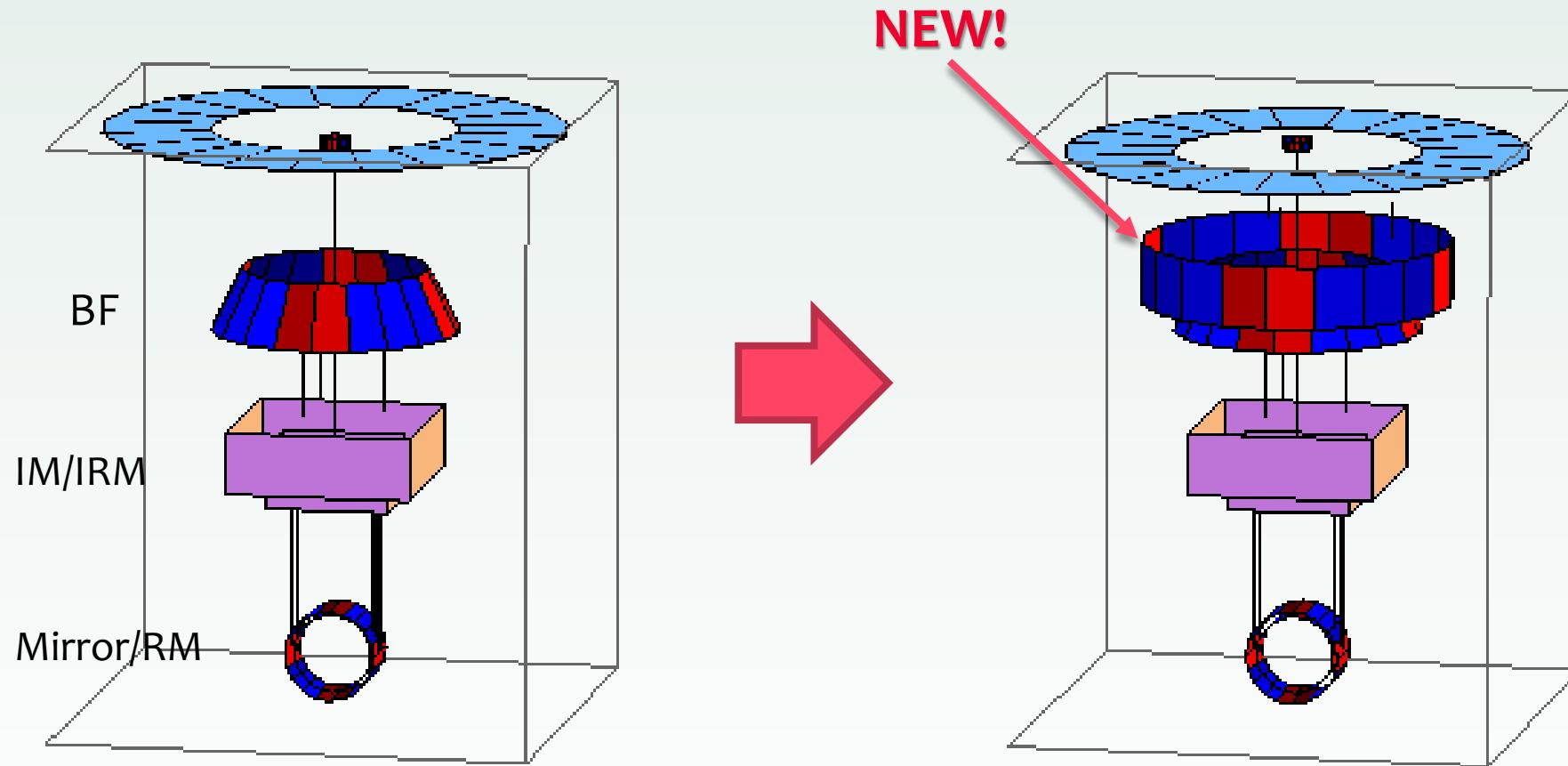
アクティブに減衰させられない共振ピークがある
→全体が揺れすぎていて干渉計を共振状態に引き込めない
励起された後、ロックできるようになるまで時間がかかる



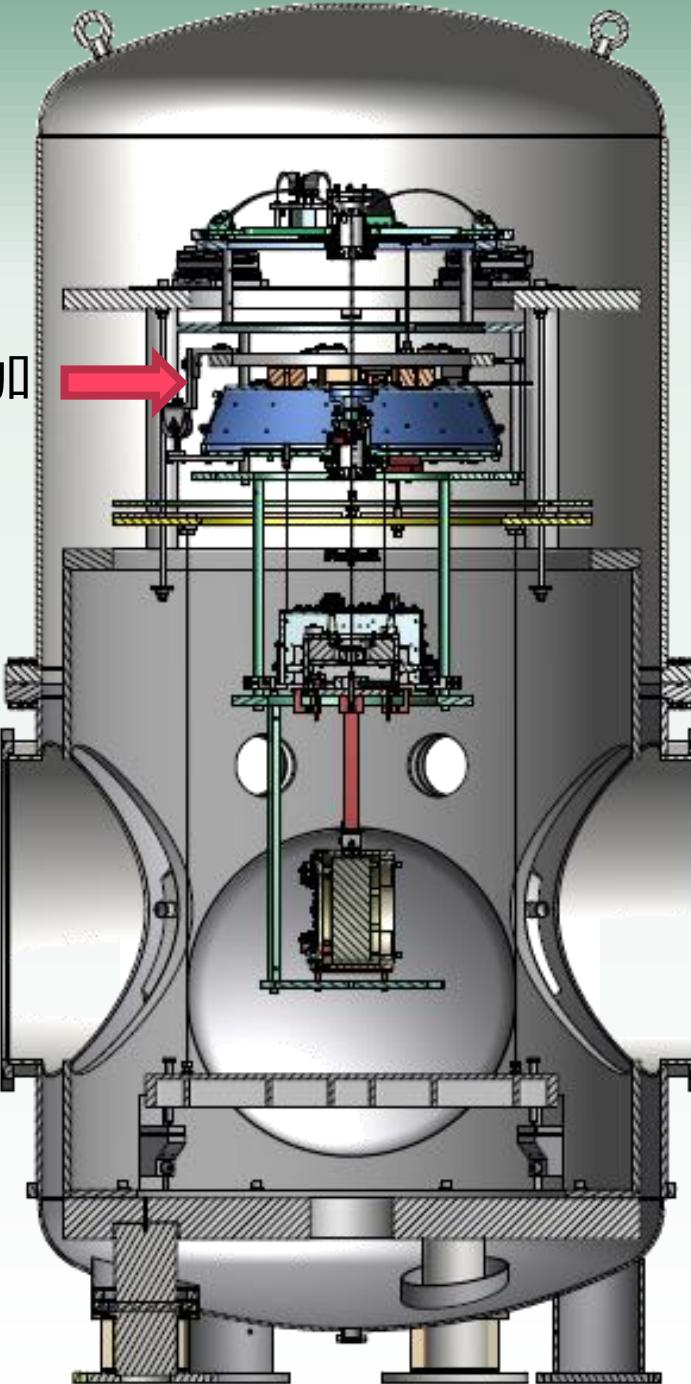
Cannot be damped!



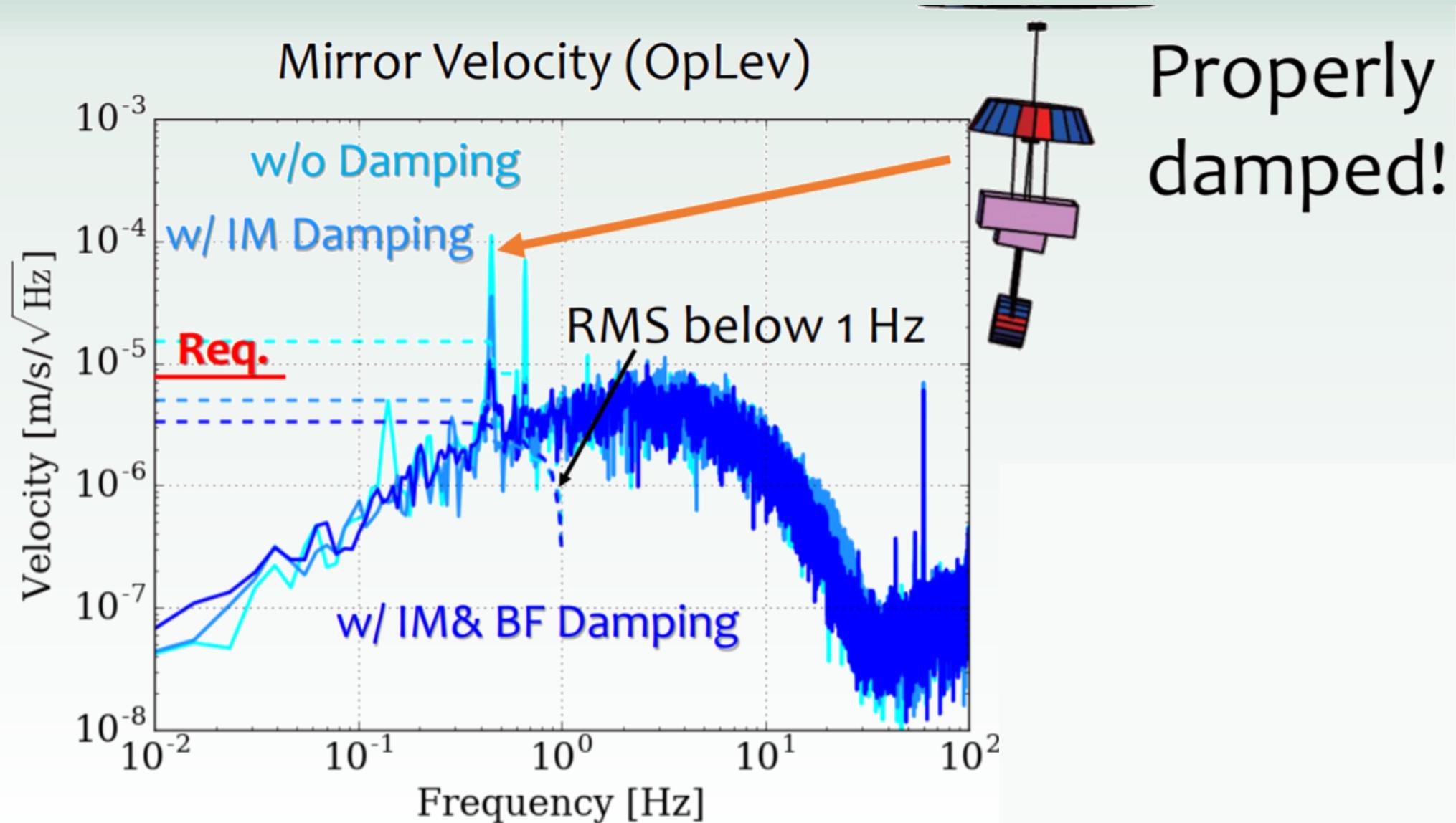
解決策



BFRMの追加



Test Hangingで得られた結果



Achievment

2017/1

2

3

4

5

6

7

8

9

TEST HANGING

PR3

PR2

PRM

前回の物理学会
で発表済み

WHAT'S NEW?

- Optical benchサスペ
ンションの構築
- 経験値の獲得

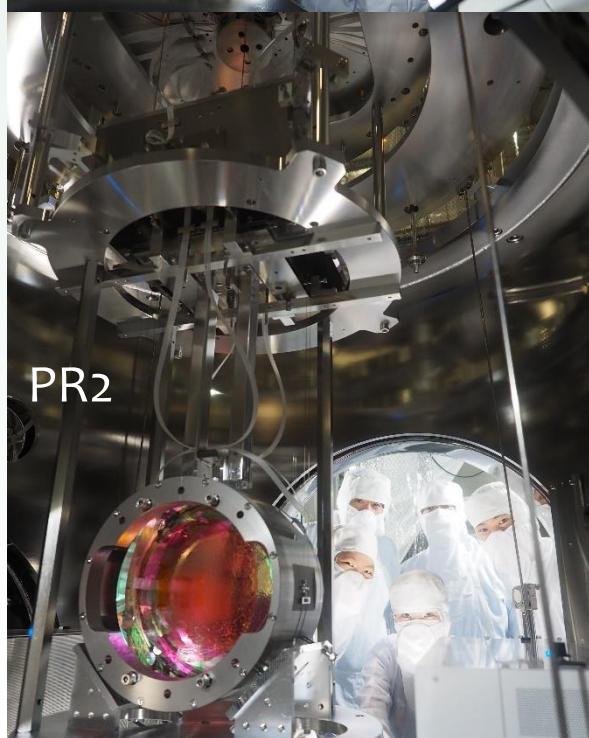
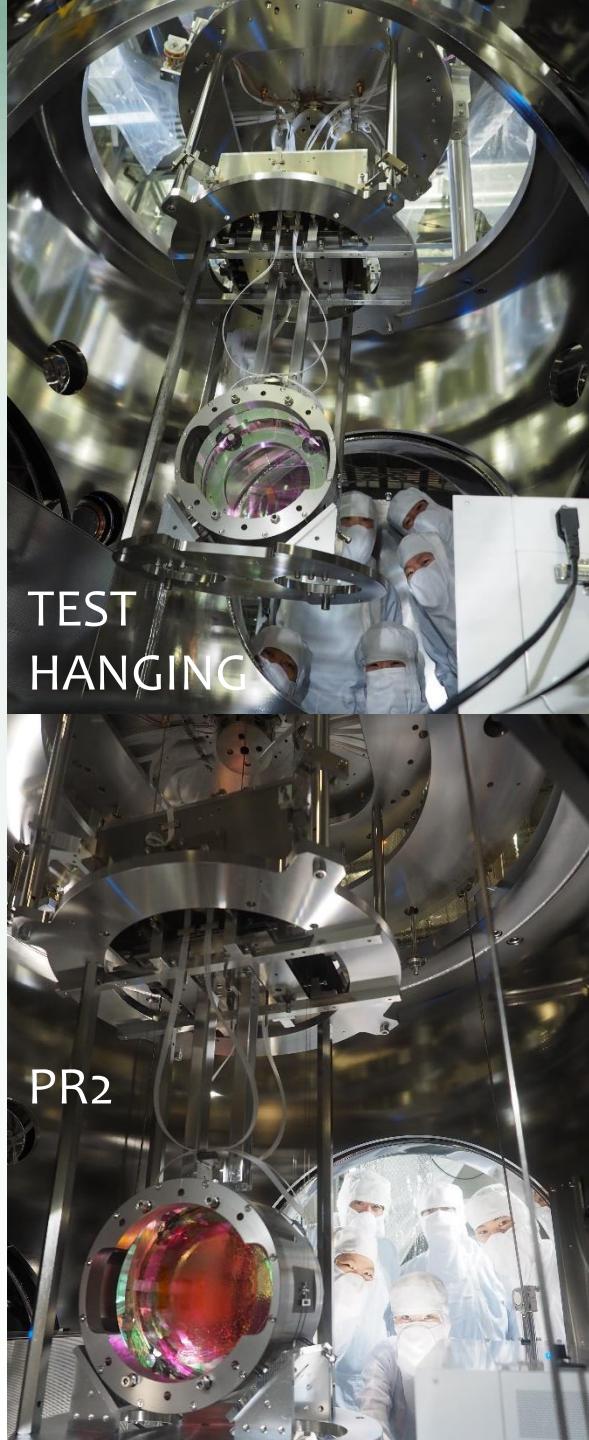
PR2 Mirror
Trouble

PR2ミラーのトラブル中の準備、
test hanging, PR3で獲得した経験
により、アセンブリ完了が加速

アセンブリ完了！
残り：真空槽内への
インストールのみ

Type-Bp インストールチーム

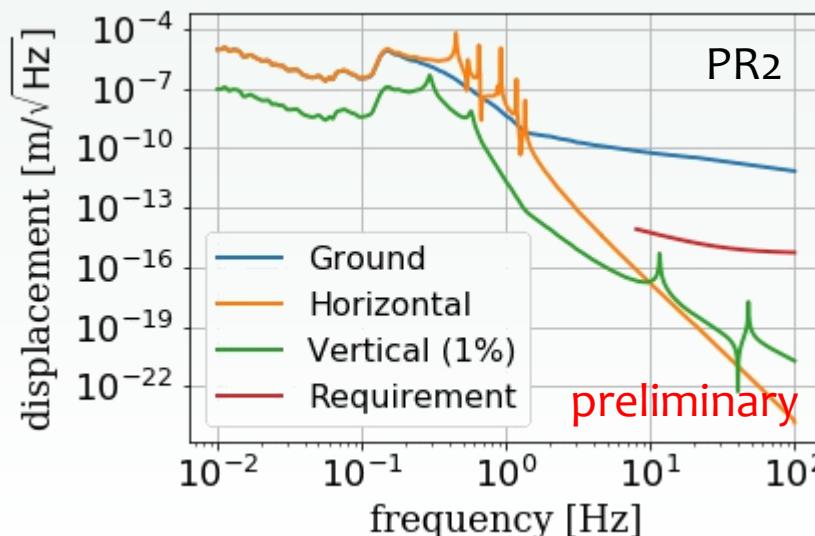
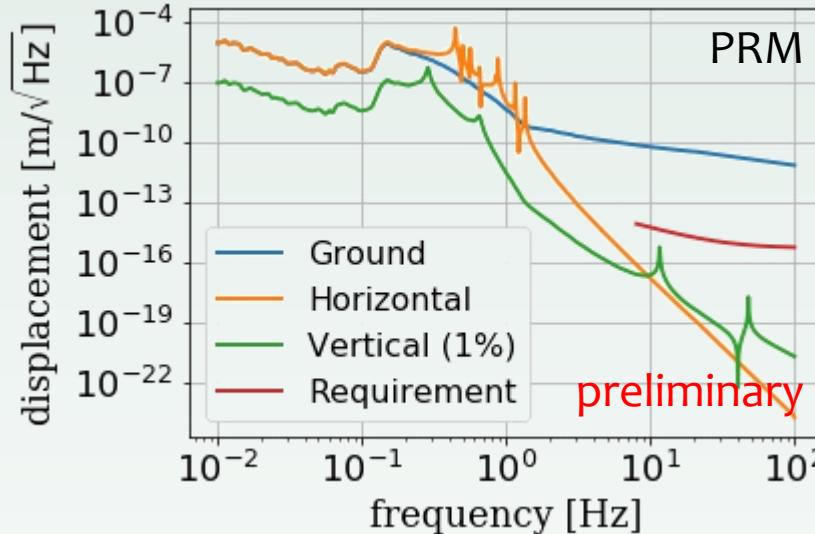
大石奈緒子 (NAOJ), 三代浩世希 (ICRR),
粕谷順子 (東工大), 染谷望 (法政大),
橋本安寿佳 (法政大), 平山哲 (法政大),
関口徹也 (法政大), 藤井善範 (東大/NAOJ),
秋山優太 (法政大), 桐井真 (ICRR),
小森健太郎 (東大), 黒木瞬史 (東大/NAOJ),
新井友也 (ICRR), 吉田涼介 (工学院大)



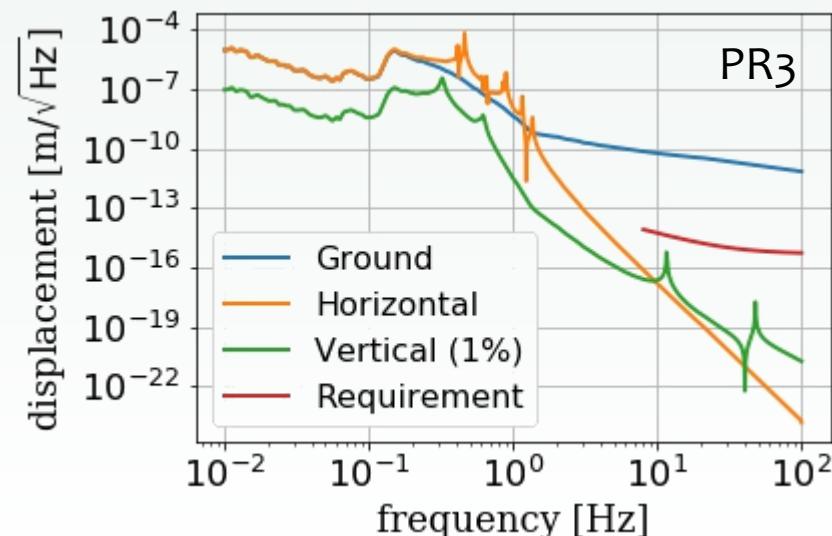
PRM
Coming soon!

各サスペンションの性能

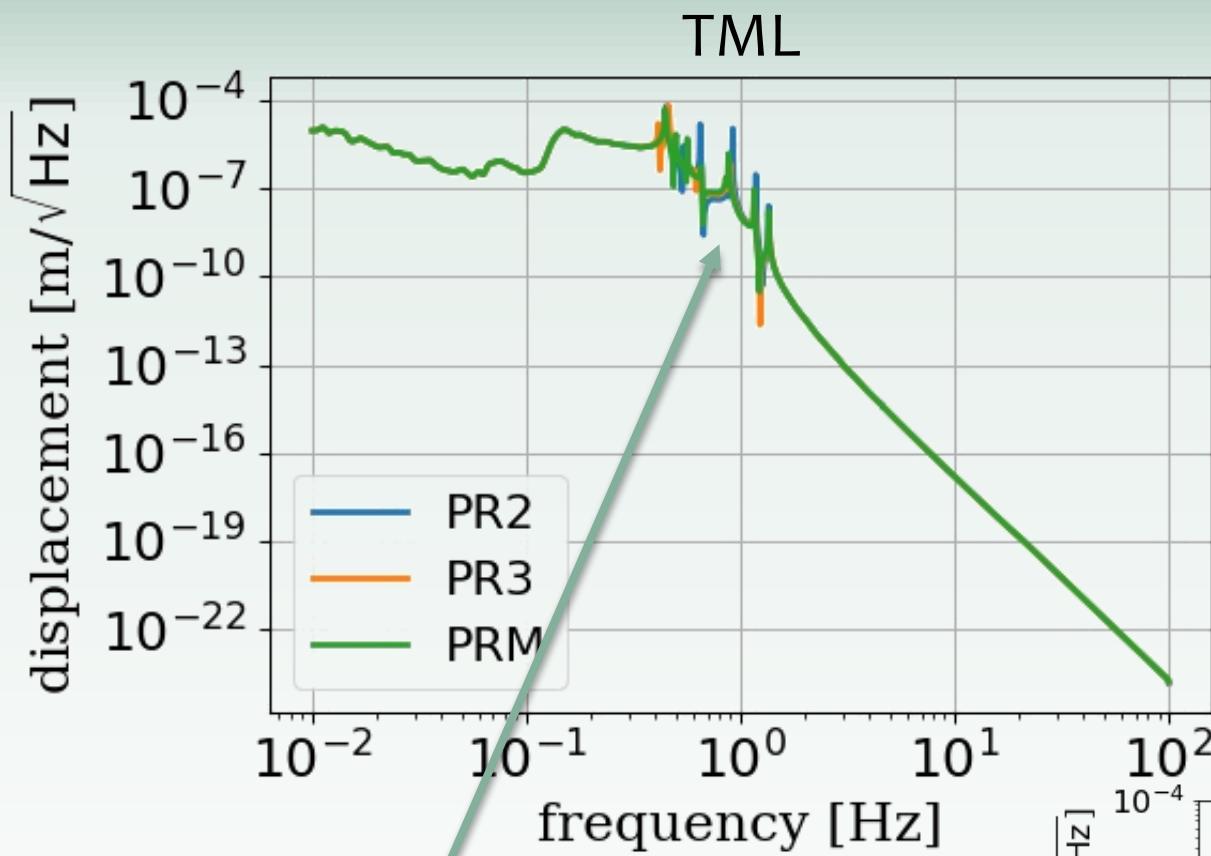
各サスペンションの共振周波数を測定 → 防振性能を計算



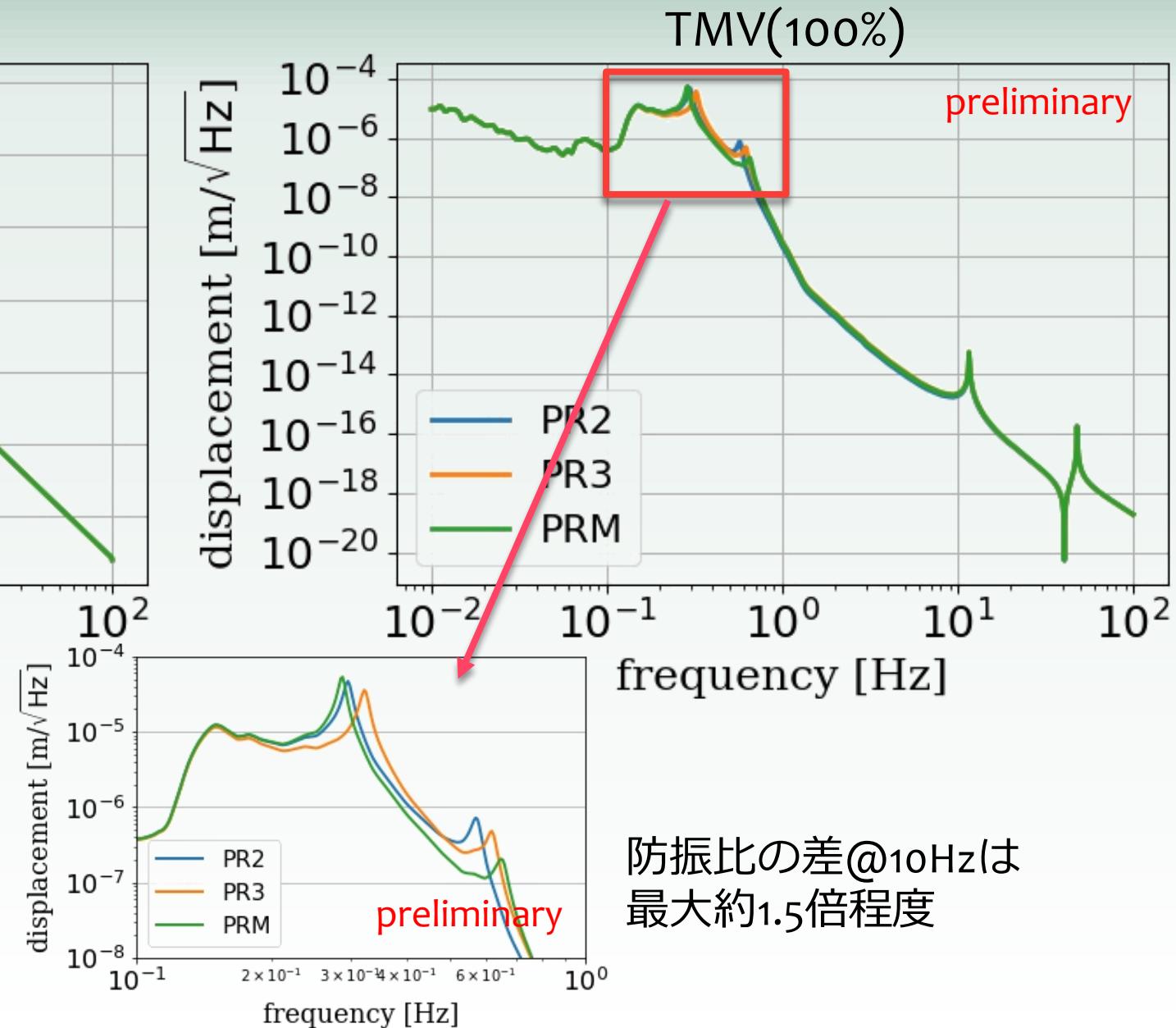
3つのsuspensionでほぼ同じ
性能が得られている



比較



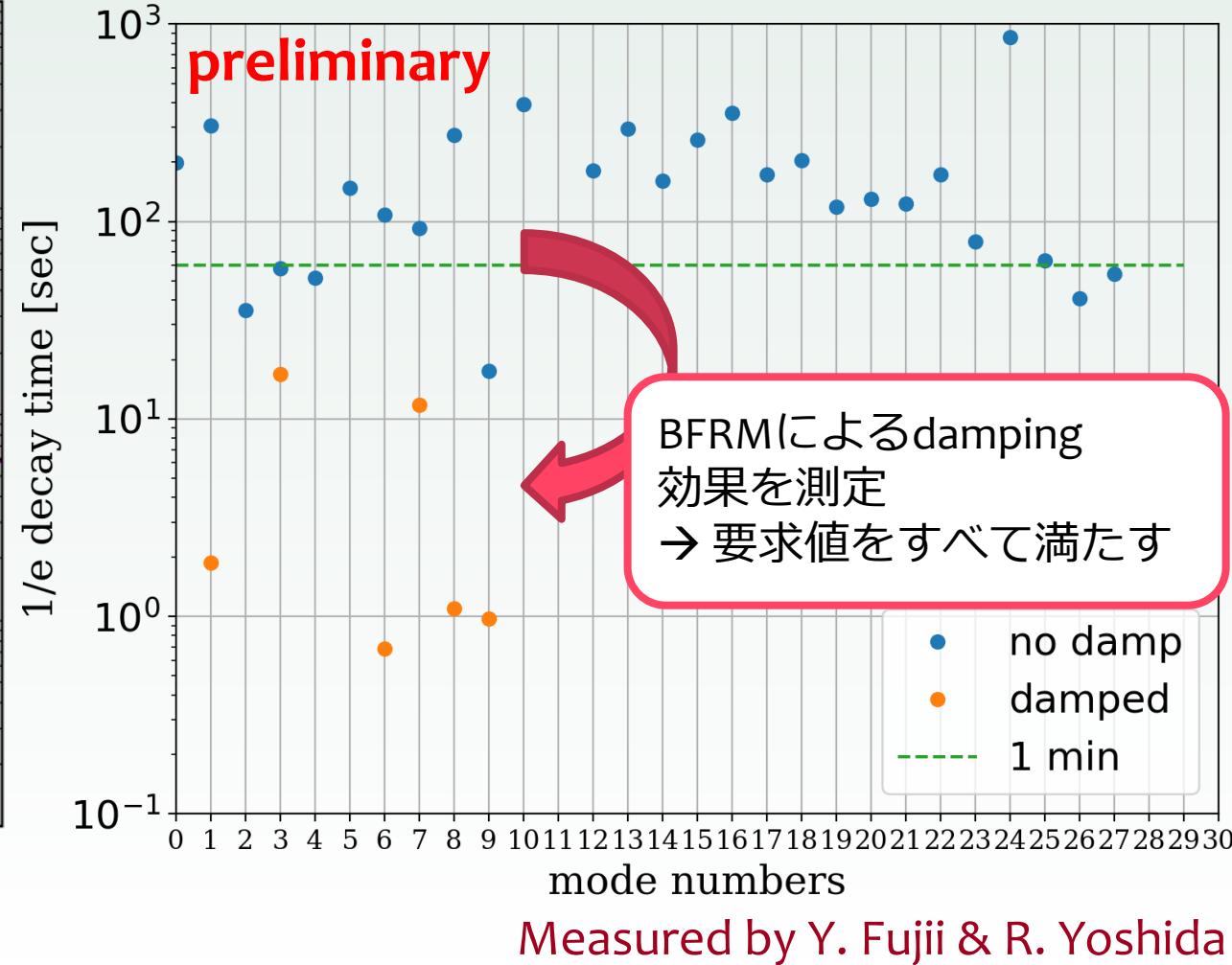
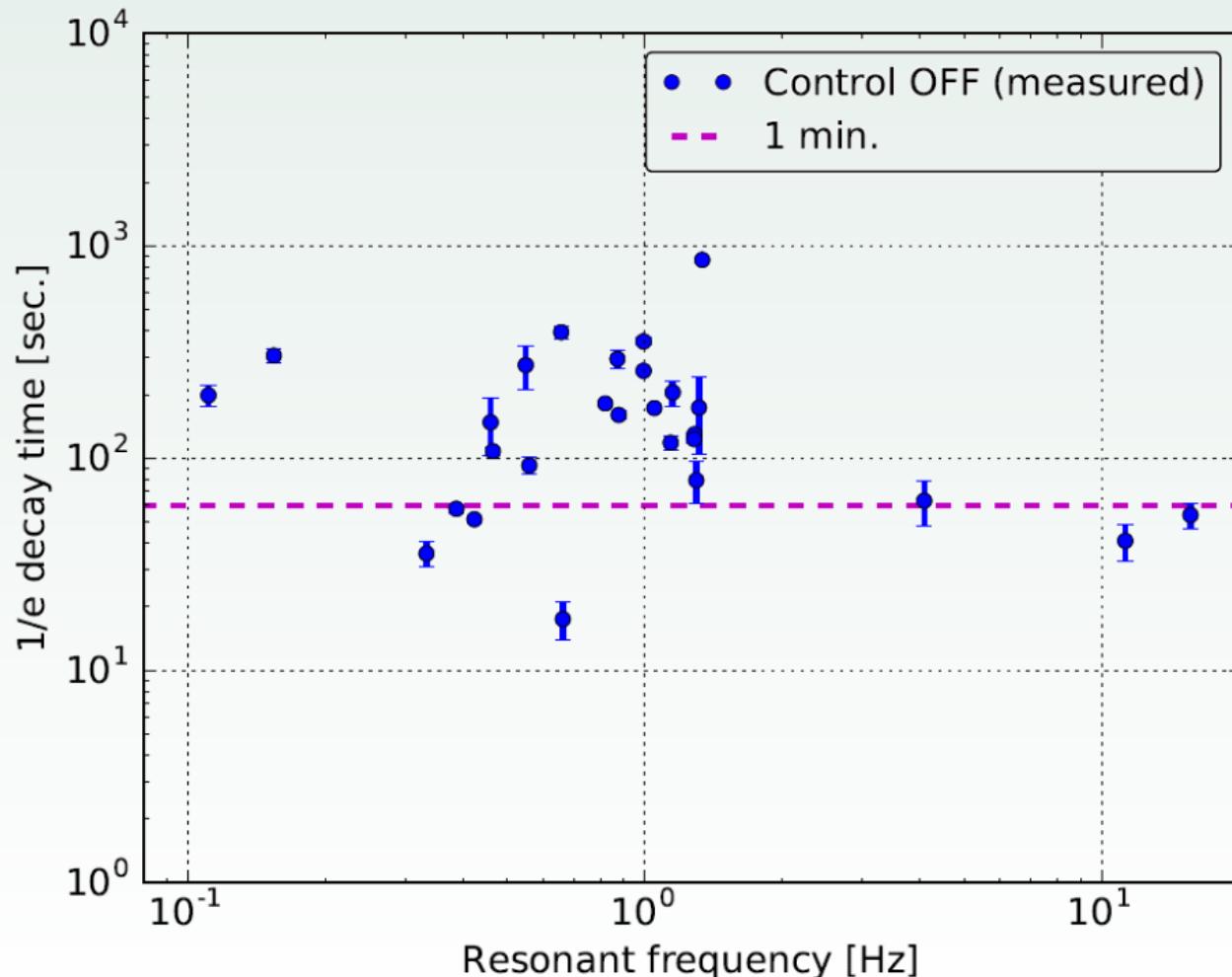
Pitch, rollの共振周波数が
少しずつ違う
(各段のおもりの載せ方など)



防振比の差@10Hzは
最大約1.5倍程度

共振モード減衰時間 (PR3)

各共振モードの減衰時間が1分以下
→ ロックの外れた干渉計を素早く観測モードに戻せる



長期ドリフト

まとめと今後の課題

- KAGRAのパワーリサイクリング鏡用防振装置（Type-Bp）を開発
PR₃, PR₂はインストールまで完了
PRMはアセンブリ完了、インストールを残すのみ
- 各suspensionの防振性能を比較 → ほぼ等しい防振性能が得られた
- 共振モードの減衰時間は、ダンピングにより1分以下を達成できる見込み
- PR₃における長期ドリフト

今後の予定：

- PRMの真空槽内へのインストール
 - 未測定の共振モードの測定
 - Q値（減衰時間）の各suspension間の比較
 - ダンピング制御によるセンサーノイズの評価・最適化
 - コントロール系の自動化
- etc....

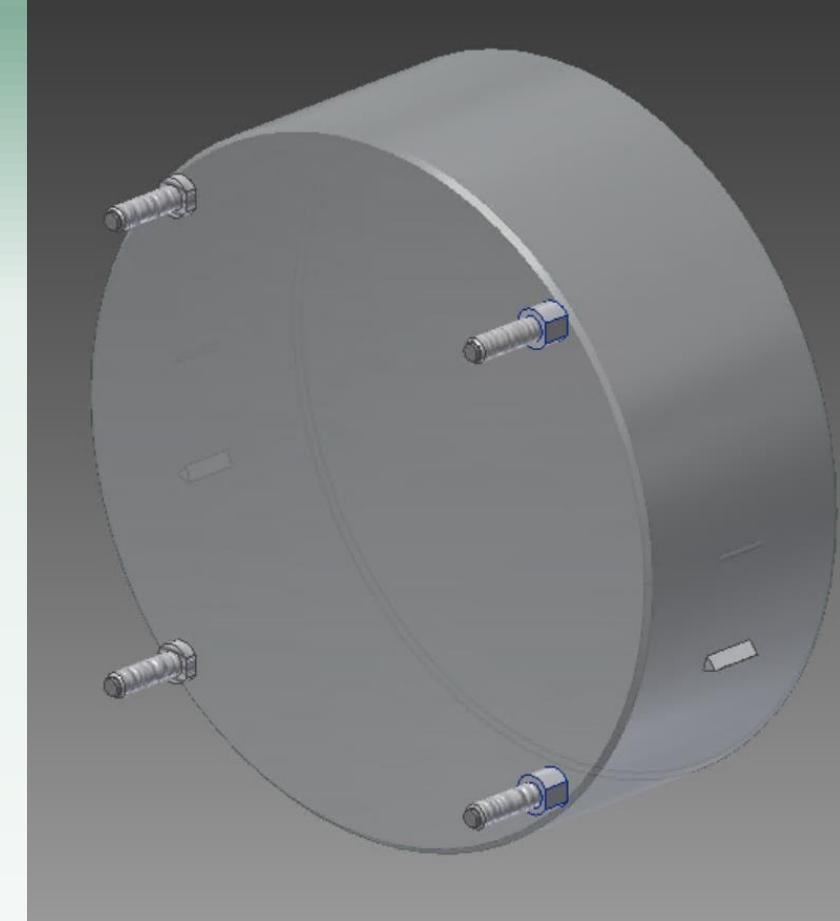
Mirror trouble

1. OSEM flag removing took a long time

The position and dimension of the flags make it difficult to dissolve the glue.

In case of the spare mirror and the iKAGRA PR3, they were removed within a week.

This time, two of the flags could not be removed more than 2 weeks.



2. Some of the wire breakers refused to be glued on the mirror for a long time

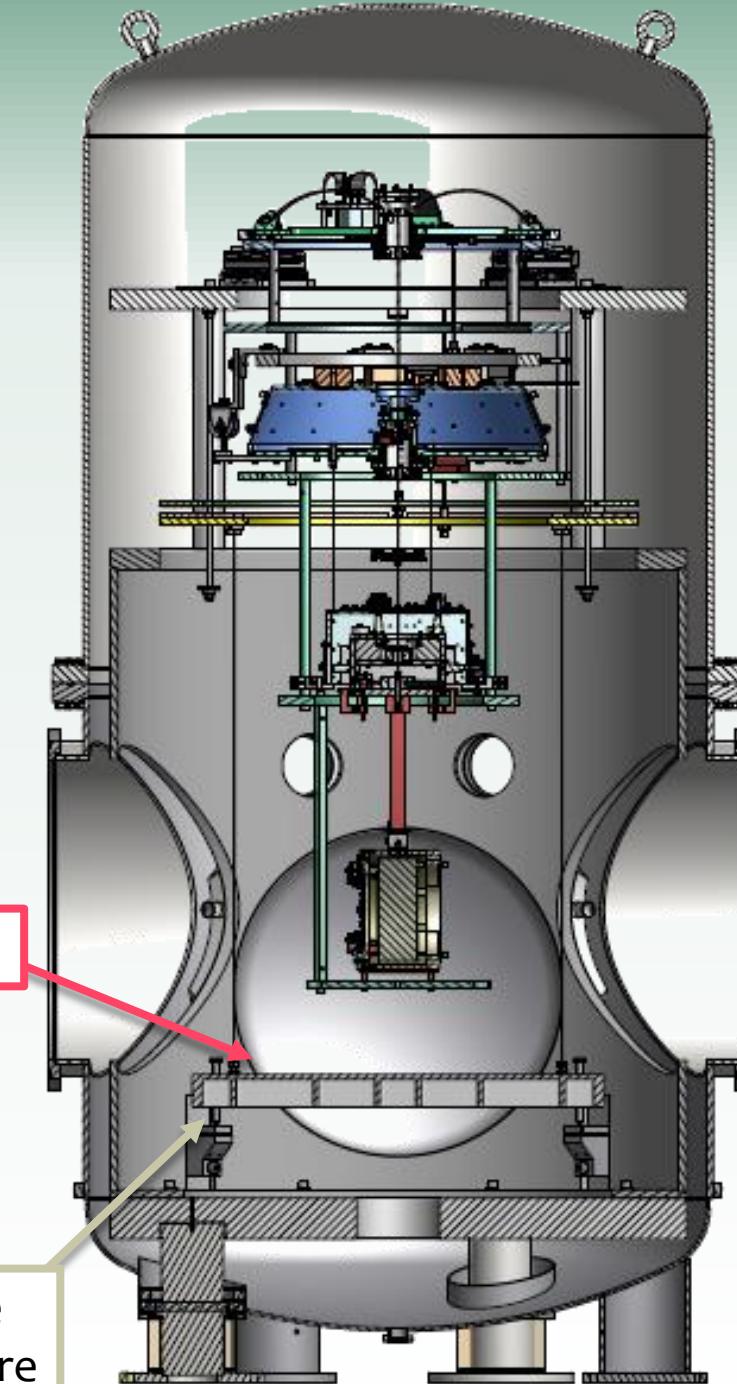
We could attached the wire breakers in iKAGRA phase (but sapphire) once with the same condition, but this time, we failed gluing many times.

We do not know the reason, but they are glued when we changed the gluing jig box (dimension is the same) and with the supervise of experienced person.

Other new topics/troubles

- The tilt of the mirror changed a lot after we fixed the mirror.
The suspension wires around the mirror slipped?
- The PR2 mirror is thinner than design...??
- PRM DGS system and PR3 DGS system cannot be worked at the same time.
Now we are sharing PR3 model with PR3 and PRM.
- We found some screws to be replaced including the PR3 (vent holes required).
- The optical bench is suspended.
The performance is not yet measured.
The height of the optical bench have to be changed from the original design since the spacers in PR2 tank, which were inserted during the iKAGRA phase, cannot be removed.

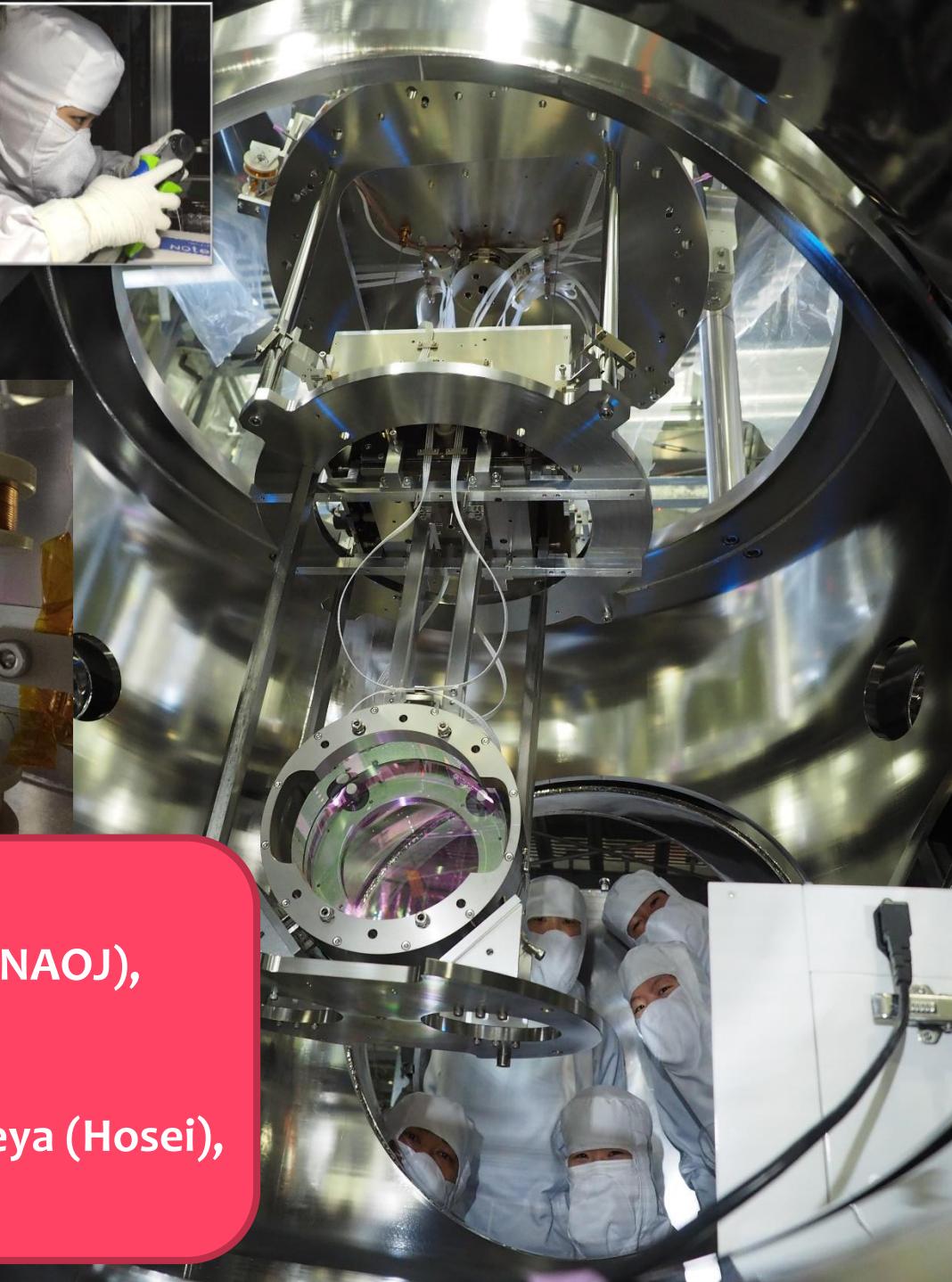
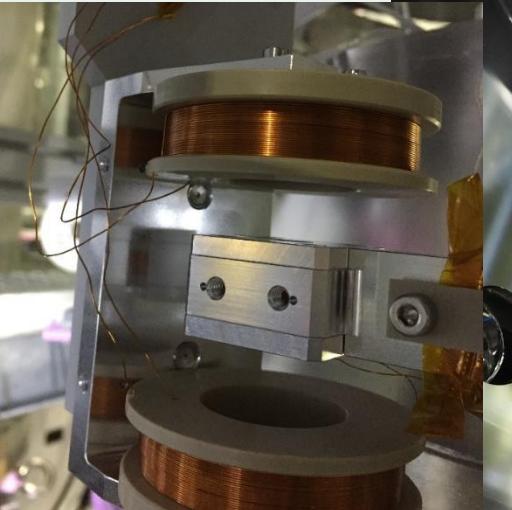
Spacers are
inserted here



Test Hanging

Purpose : Checking assembly procedure
Damping performance evaluation

Period : 2017/1/10 – 2017/3/15



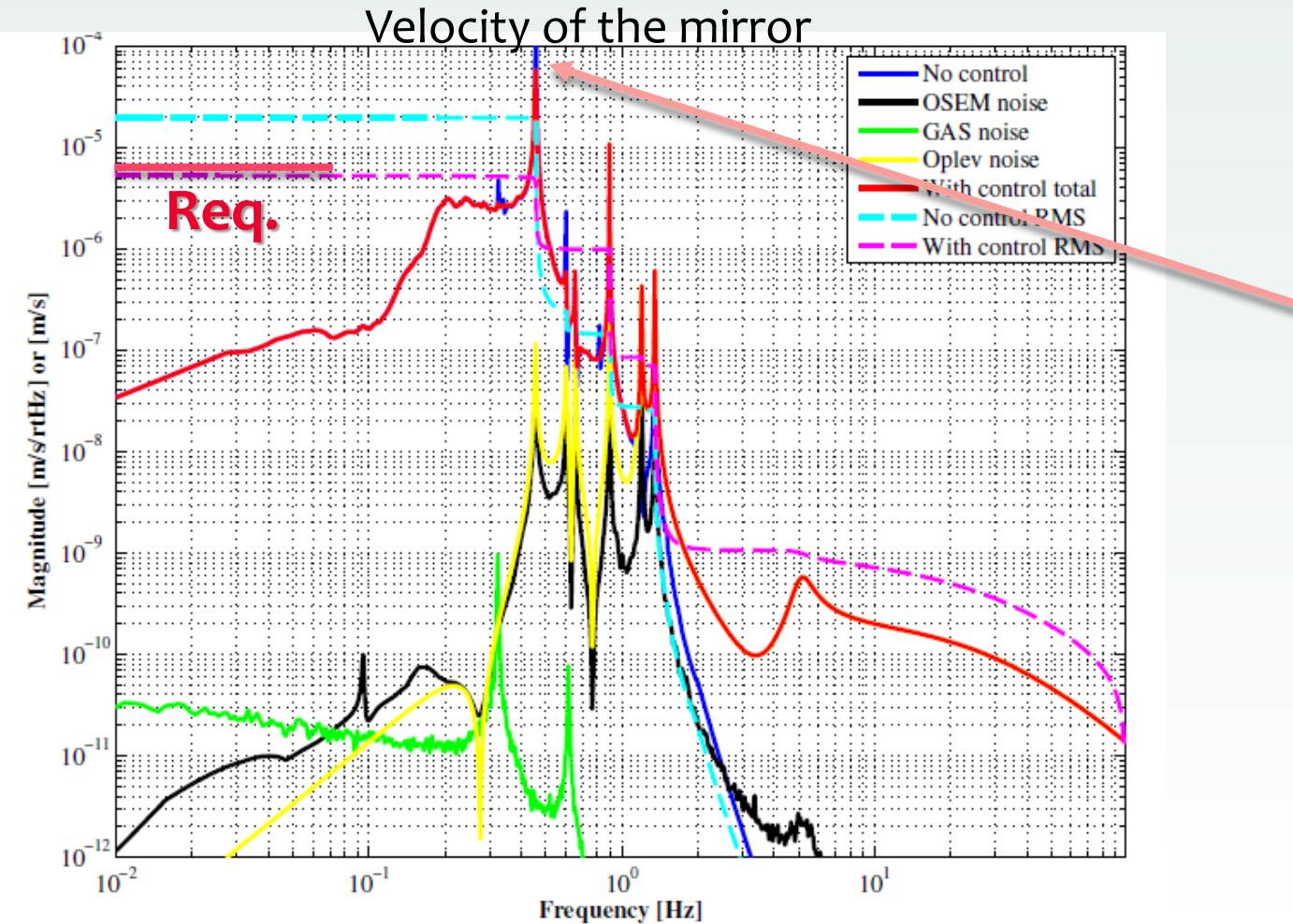
Type-Bp installation team:
**Ayaka Shoda (NAOJ), Naoko Ohishi (NAOJ),
Koseki Miyo (ICRR)**
Many thanks to the shift workers:
**Junko Kasuya (Titech), Nozomi Someya (Hosei),
and Yasuka Hashimoto (Hosei)!!**

Problem

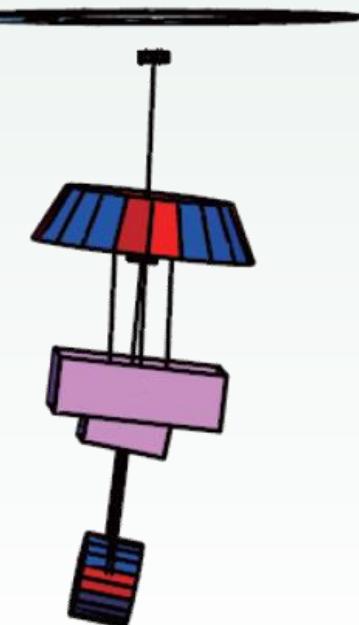
One of the resonance mode cannot be damped properly.

→ Unable to lock the interferometer since the velocity is too large.

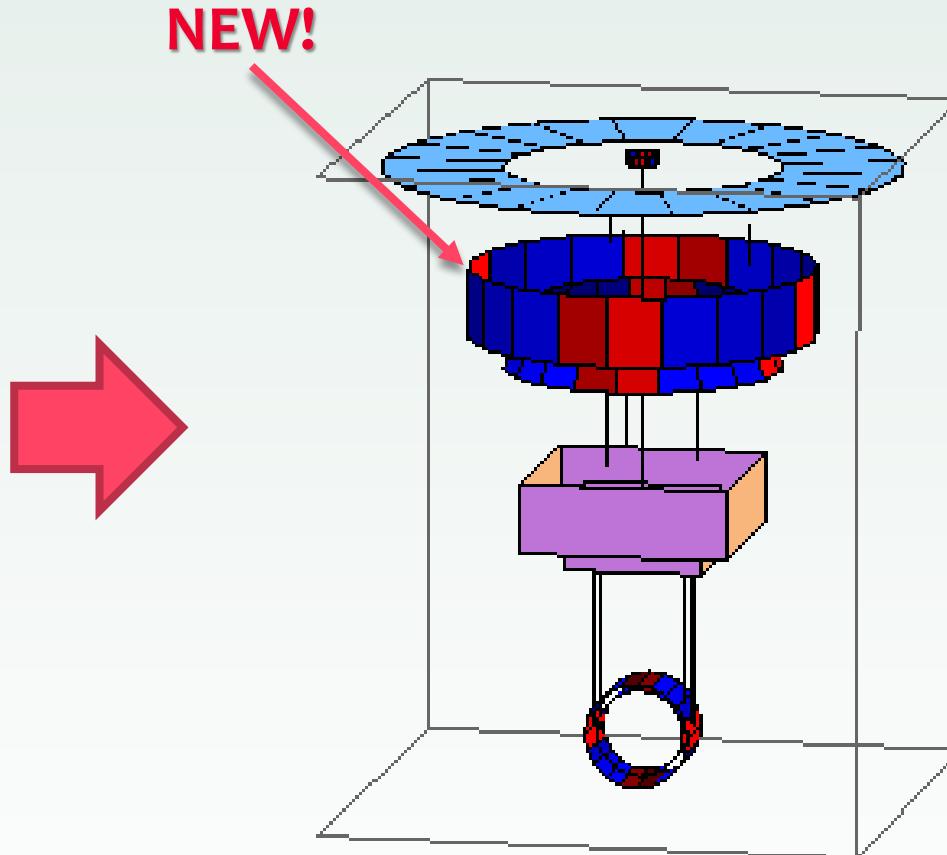
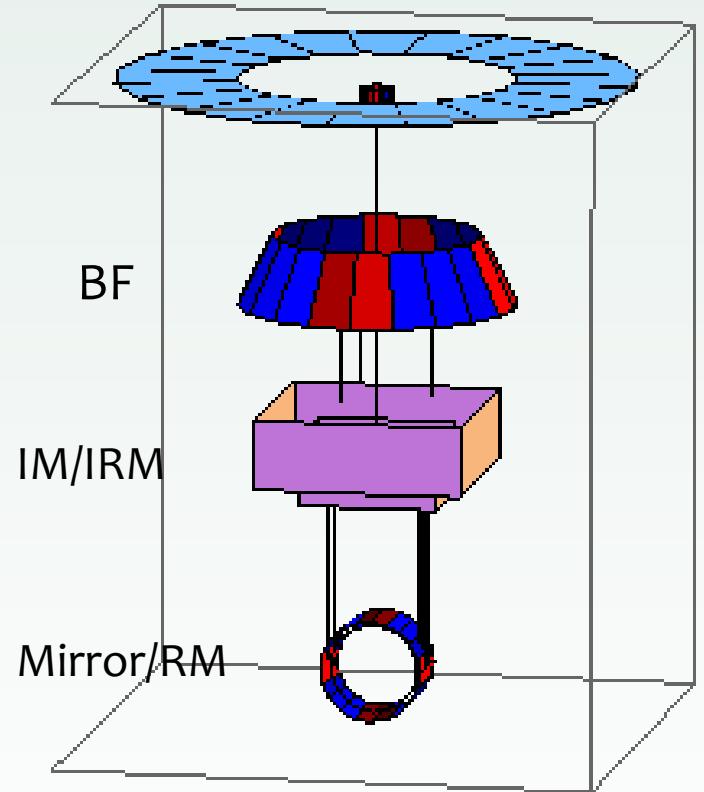
Decrease the duty cycle after the large perturbation such as earthquakes.



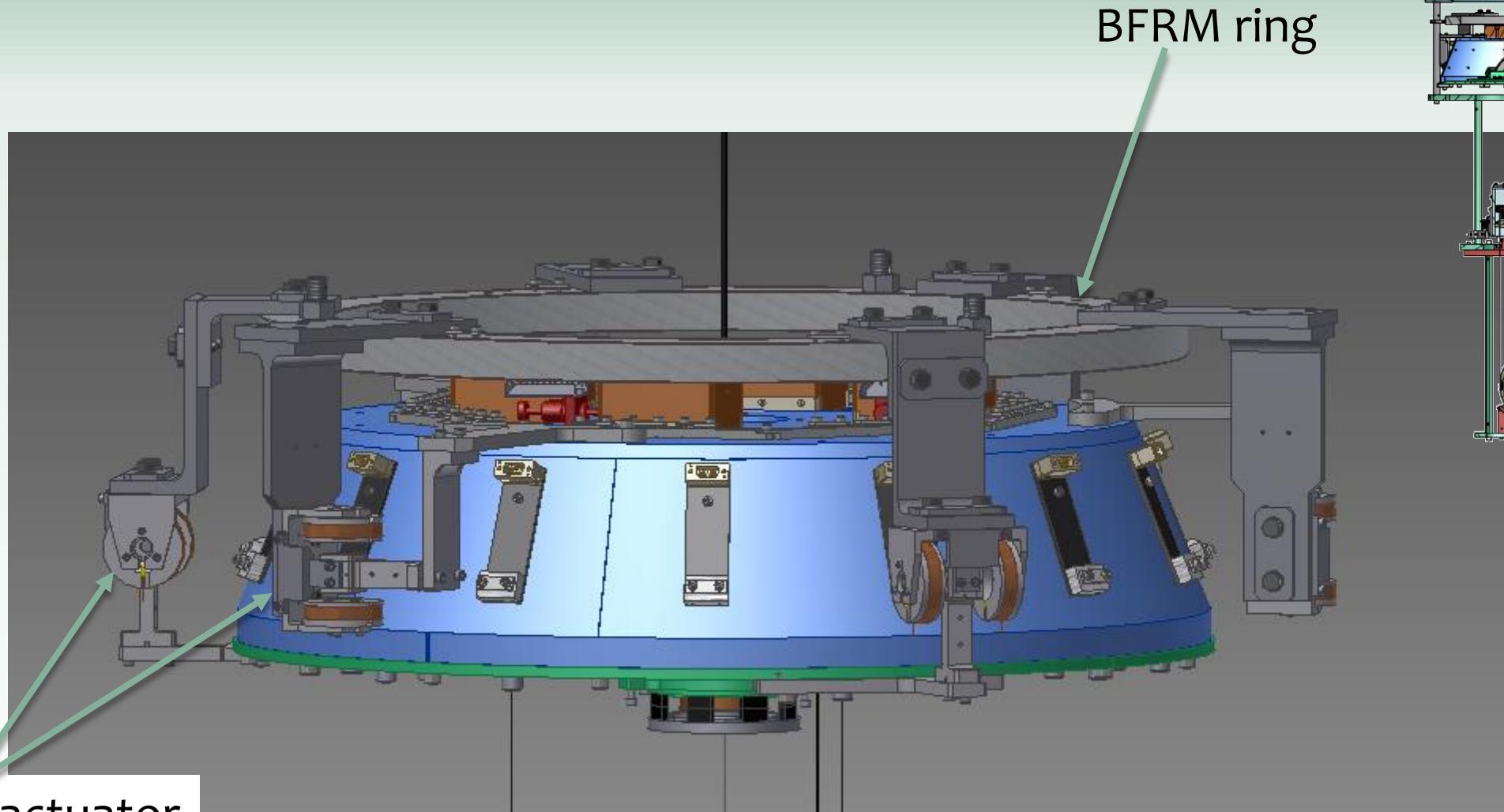
Cannot be damped!



How to solve

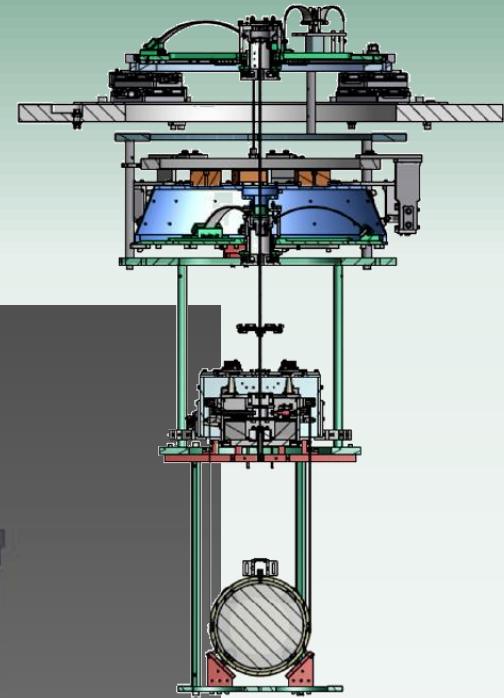


Model



Sensor & actuator

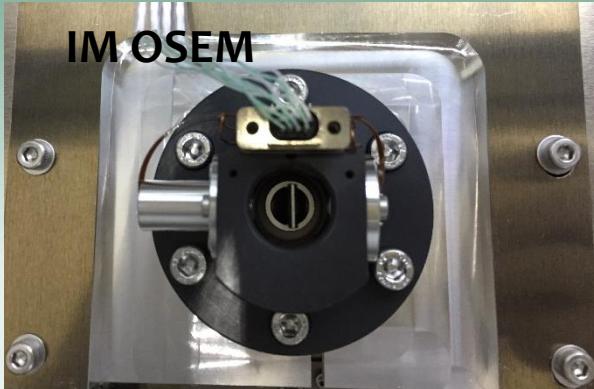
BFRM ring

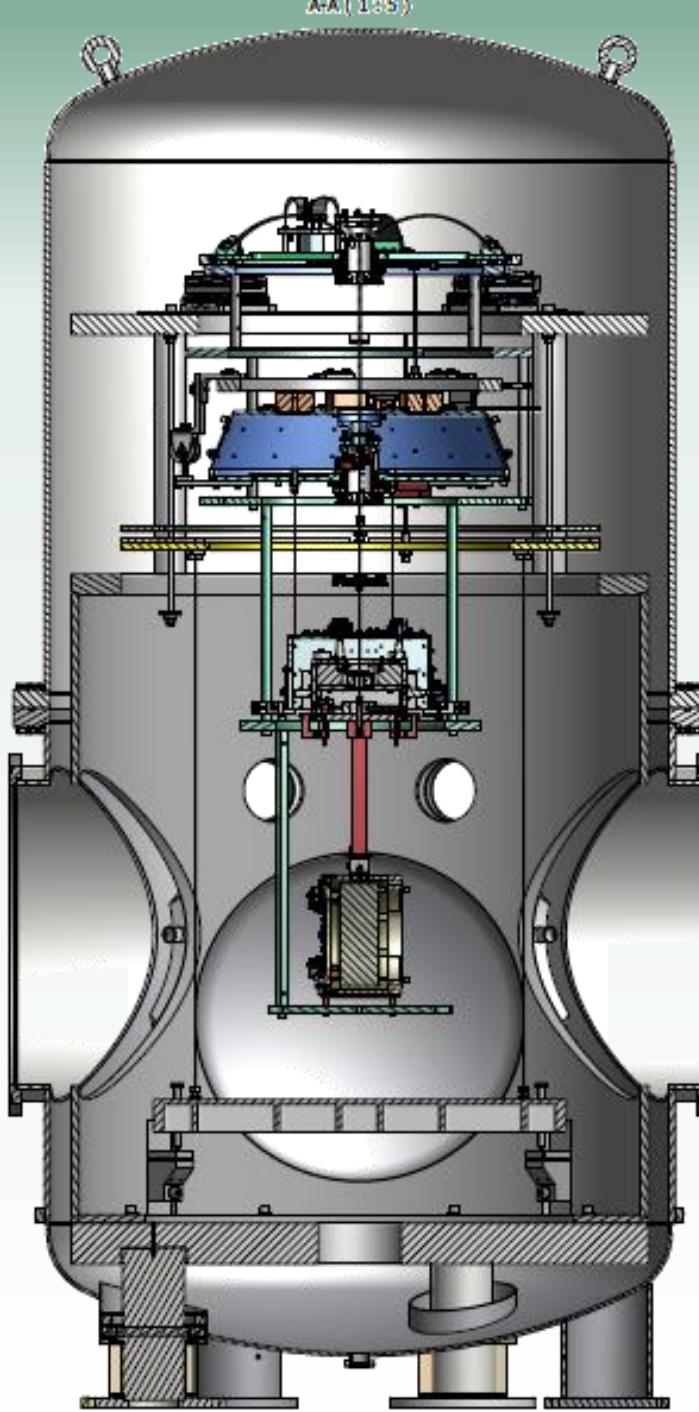


Inspired from Filter 7 damping system in Virgo.
Thanks to R. Passaquieti, V. Dattilo, and F. Paoletti.

New from iKAGRA

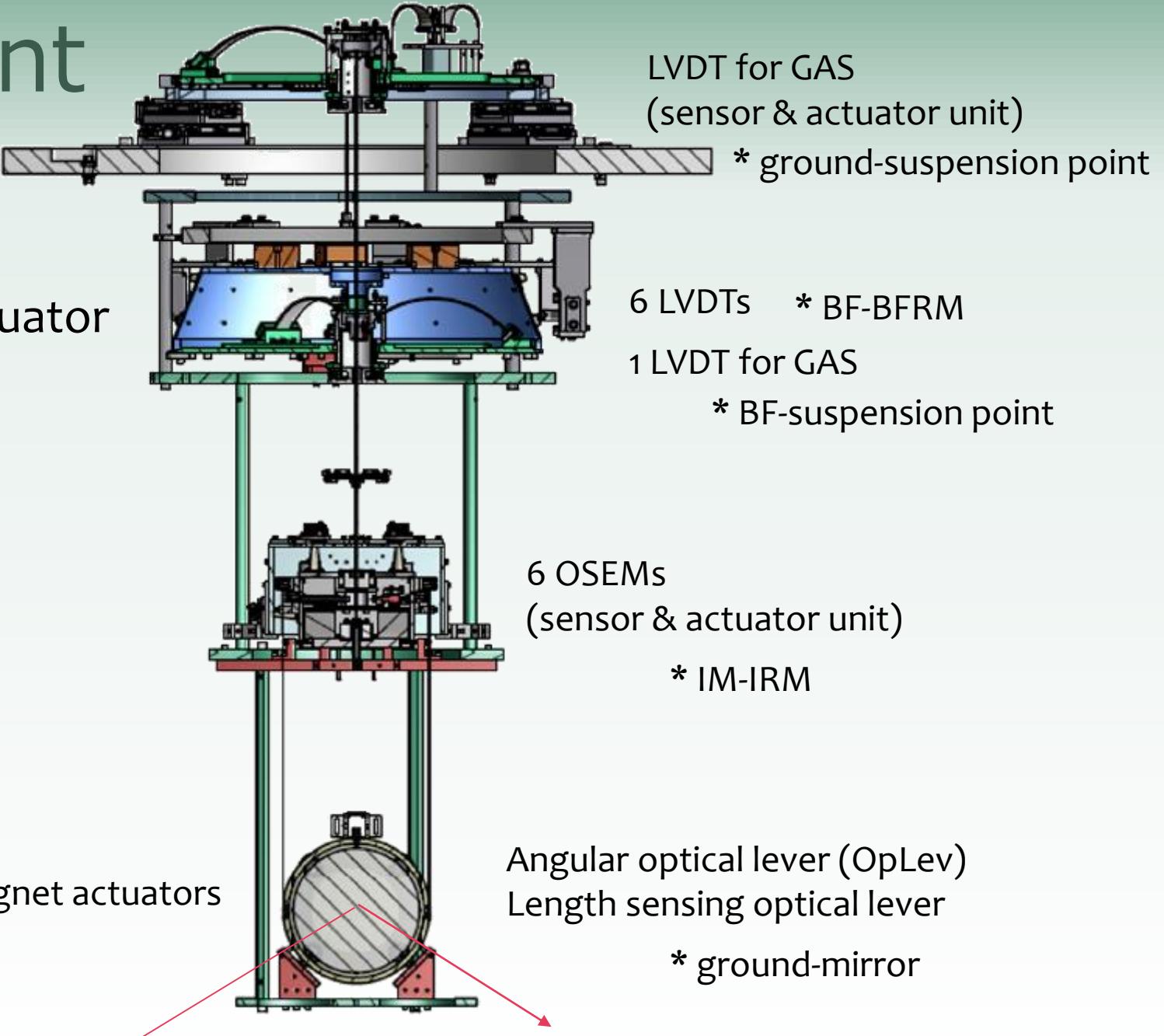
- BF damping system
BF recoil mass
BF LVDT (sensors and actuators)
- 3 stage pendulum + 2 GAS filters
- Wide cavity OSEMs
- Remove sensing function on
the TM OSEMS
→ Length-sensing OpLev
- Design change in the IM OSEM flags
- Changing disassembly procedure



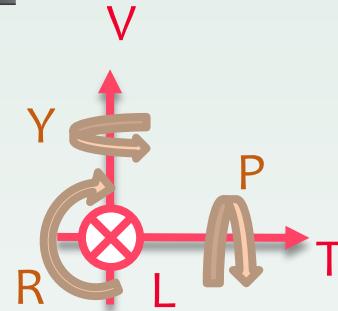
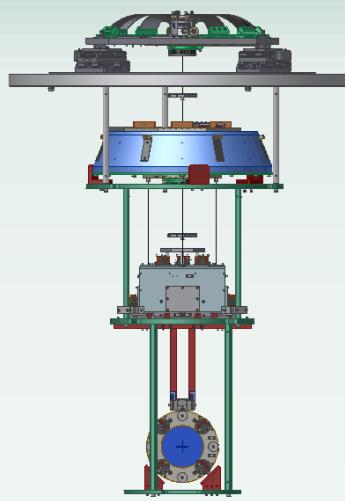


Measurement

Active damping using
the local sensors and actuator
at each stage.

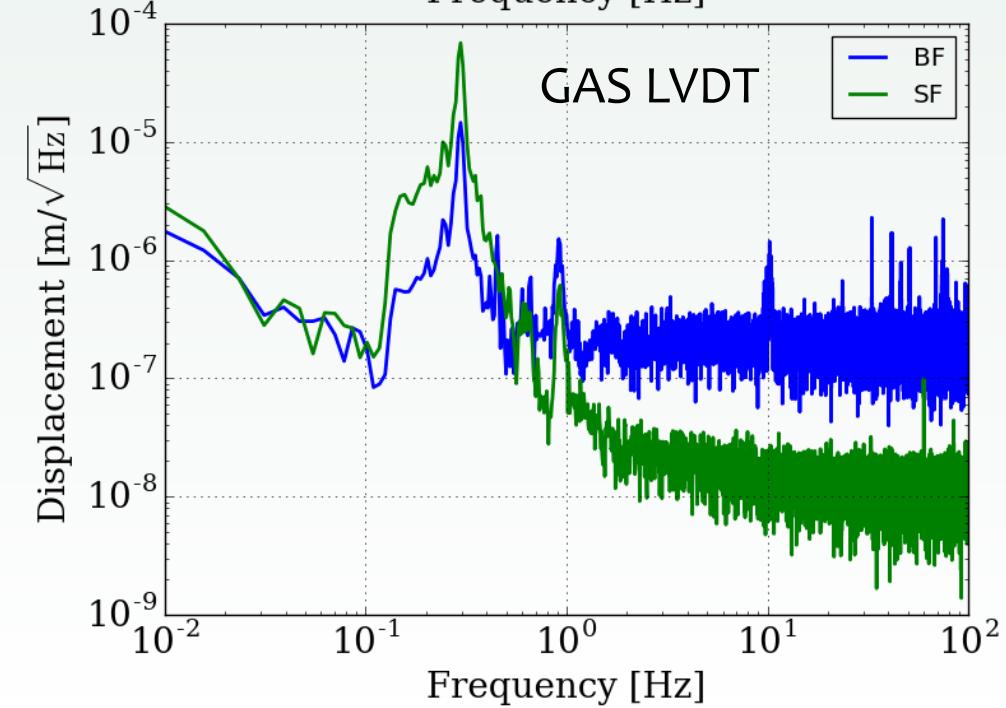
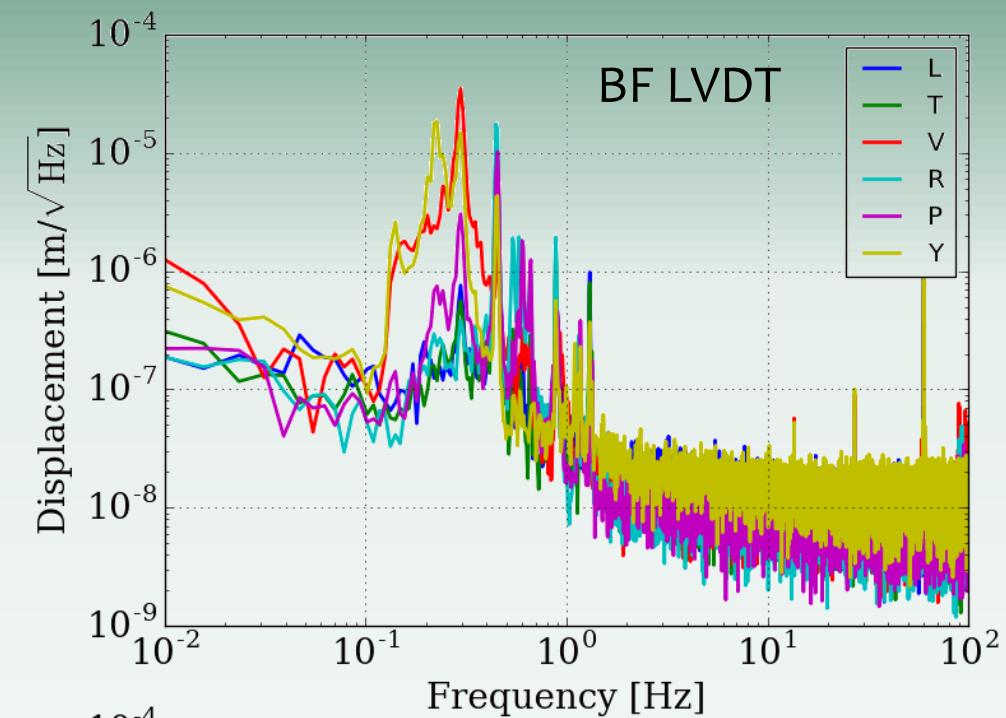
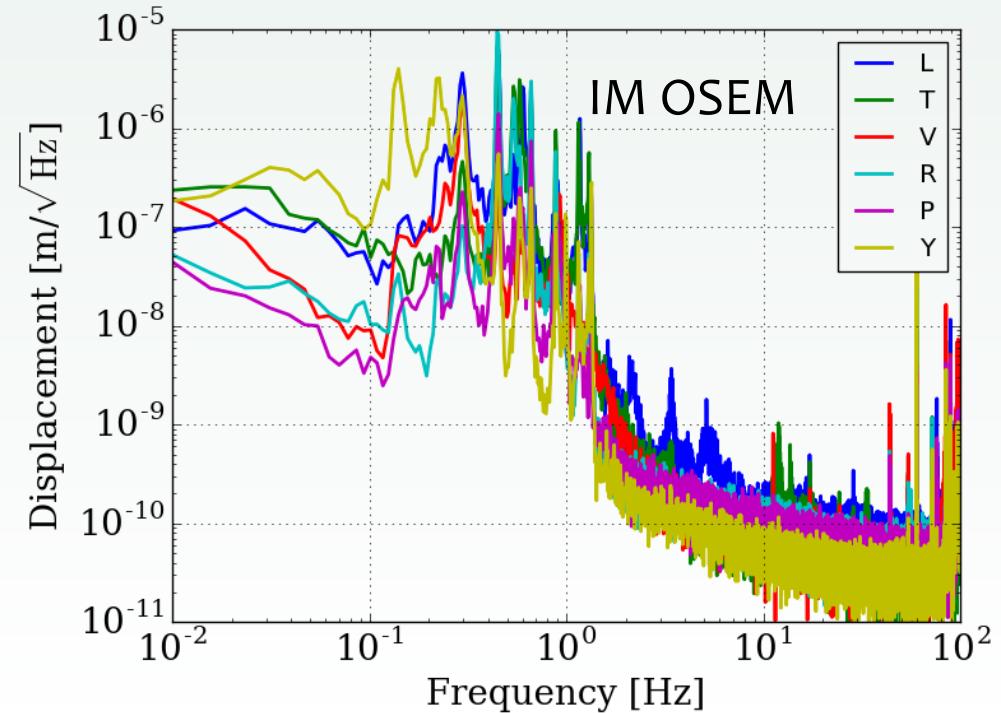


Results

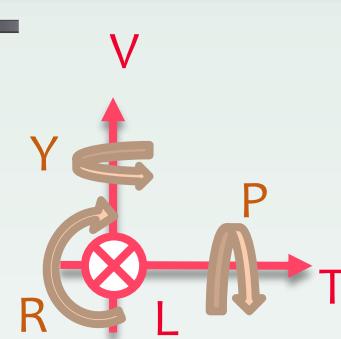
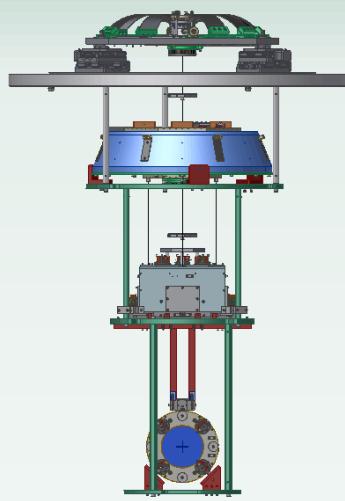


* Calibration factors have large uncertainty for BF LVDT.

w/o damping

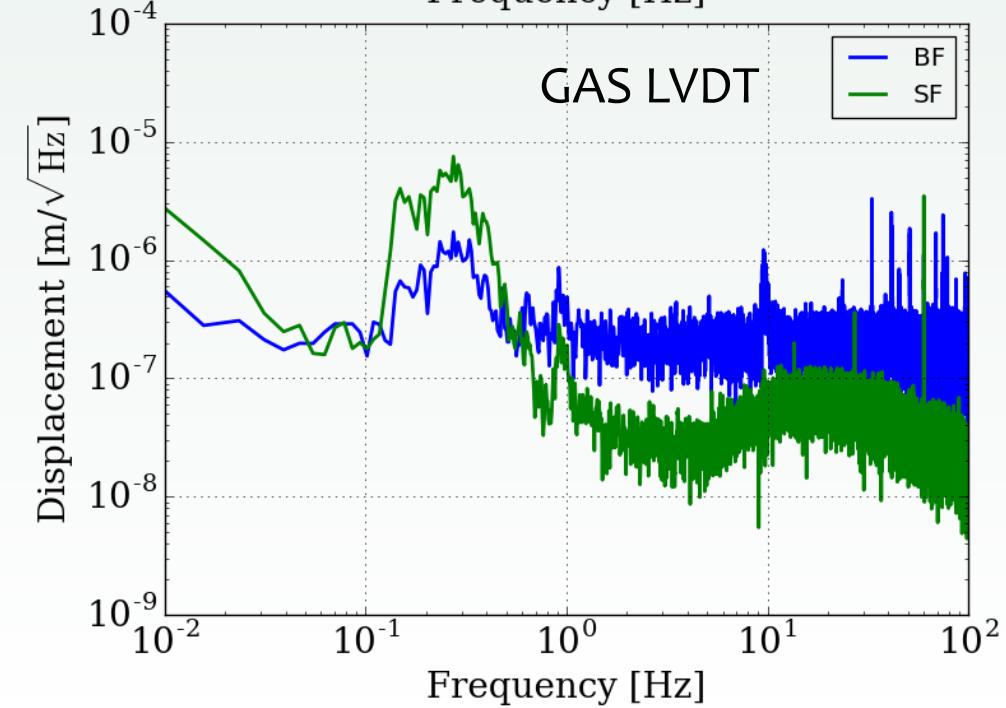
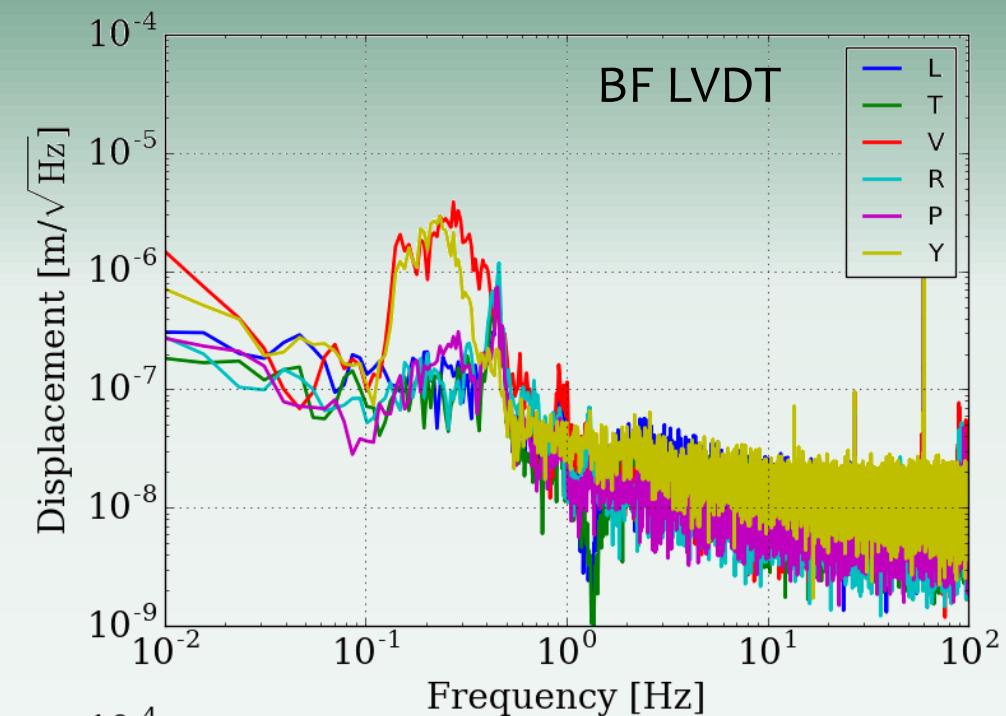
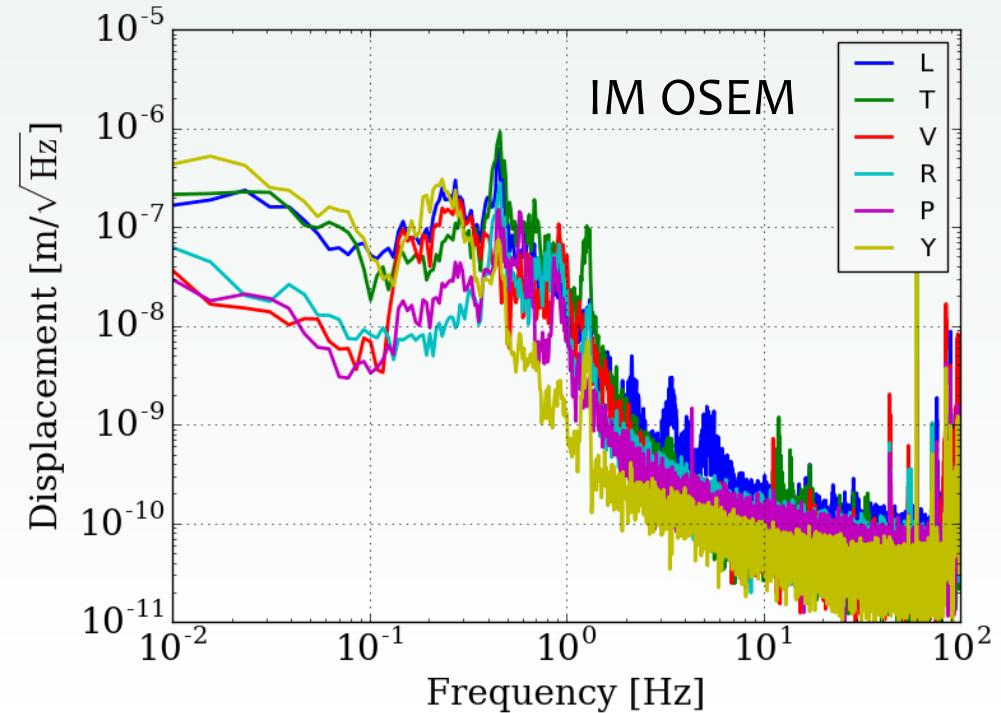


Results



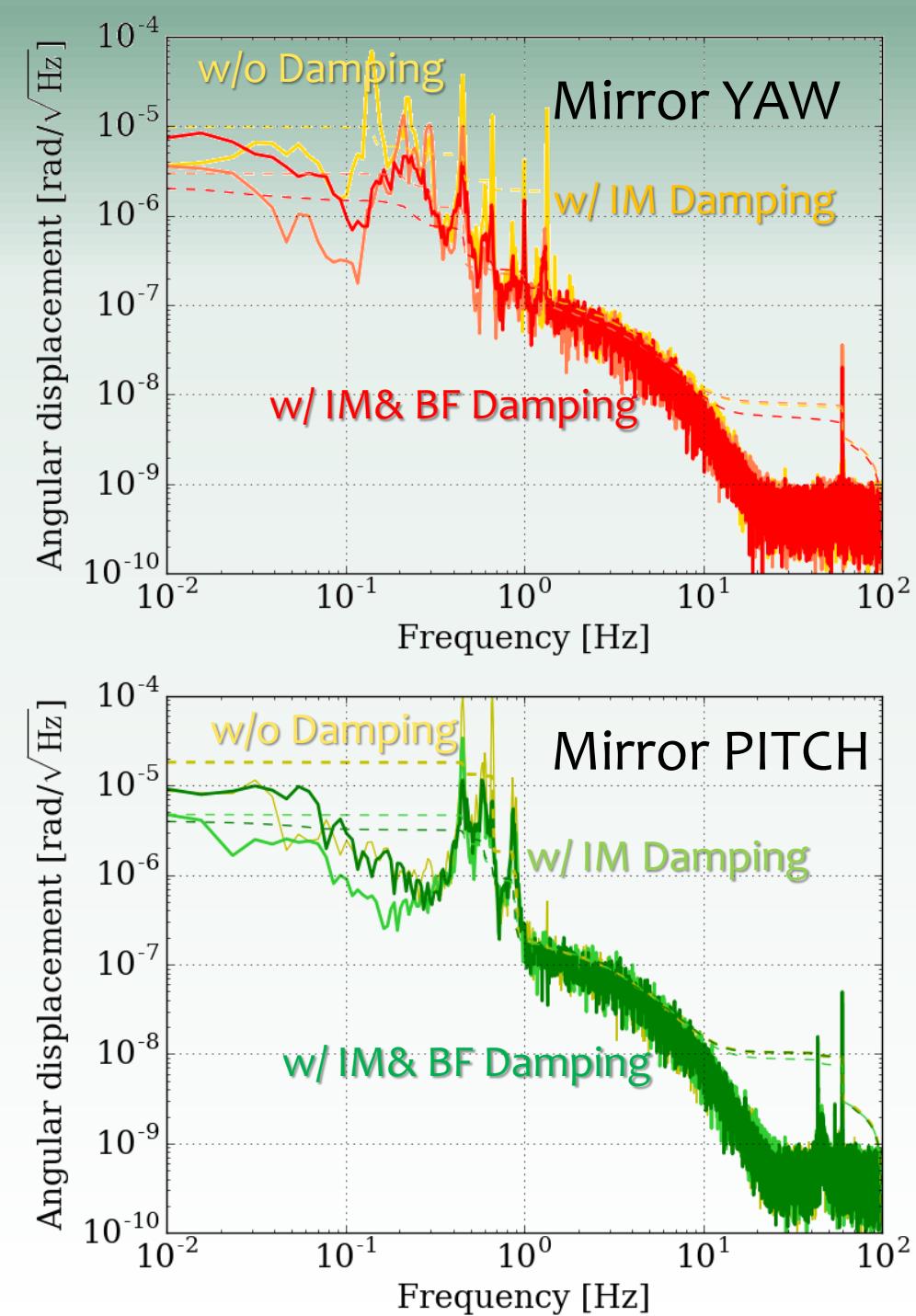
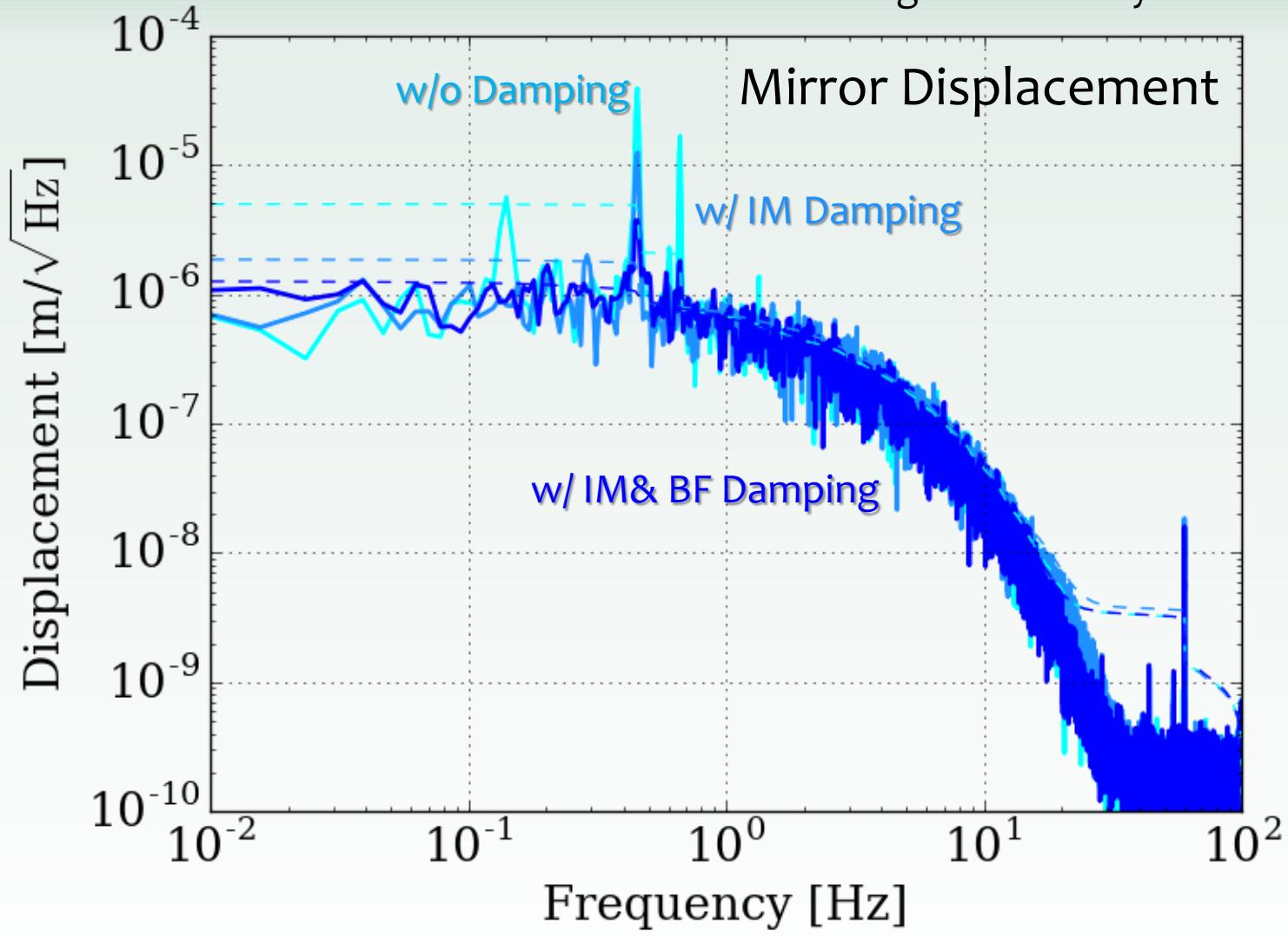
* Calibration factors have large uncertainty for BF LVDT.

w/ damping



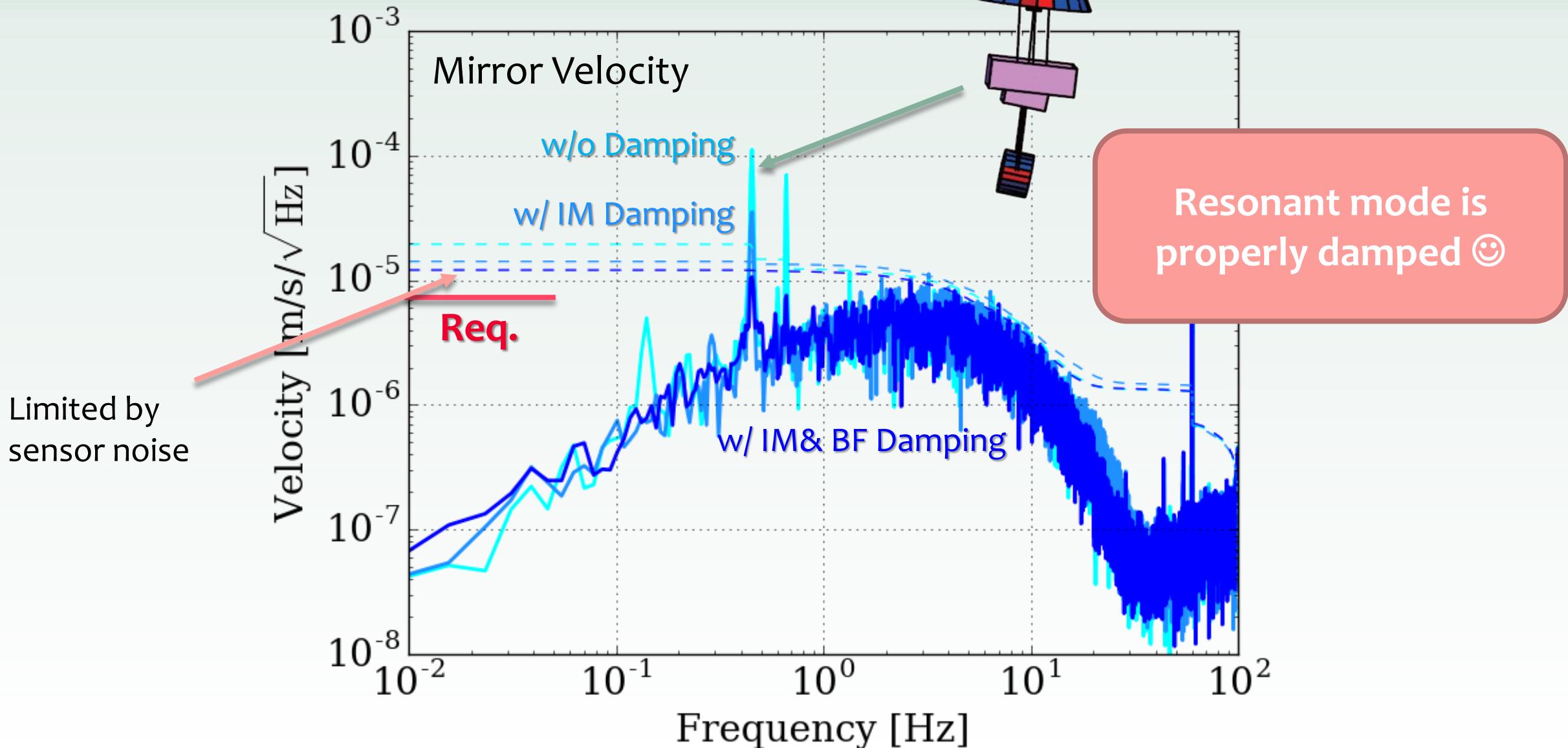
Result

* Calibration factors have large uncertainty.

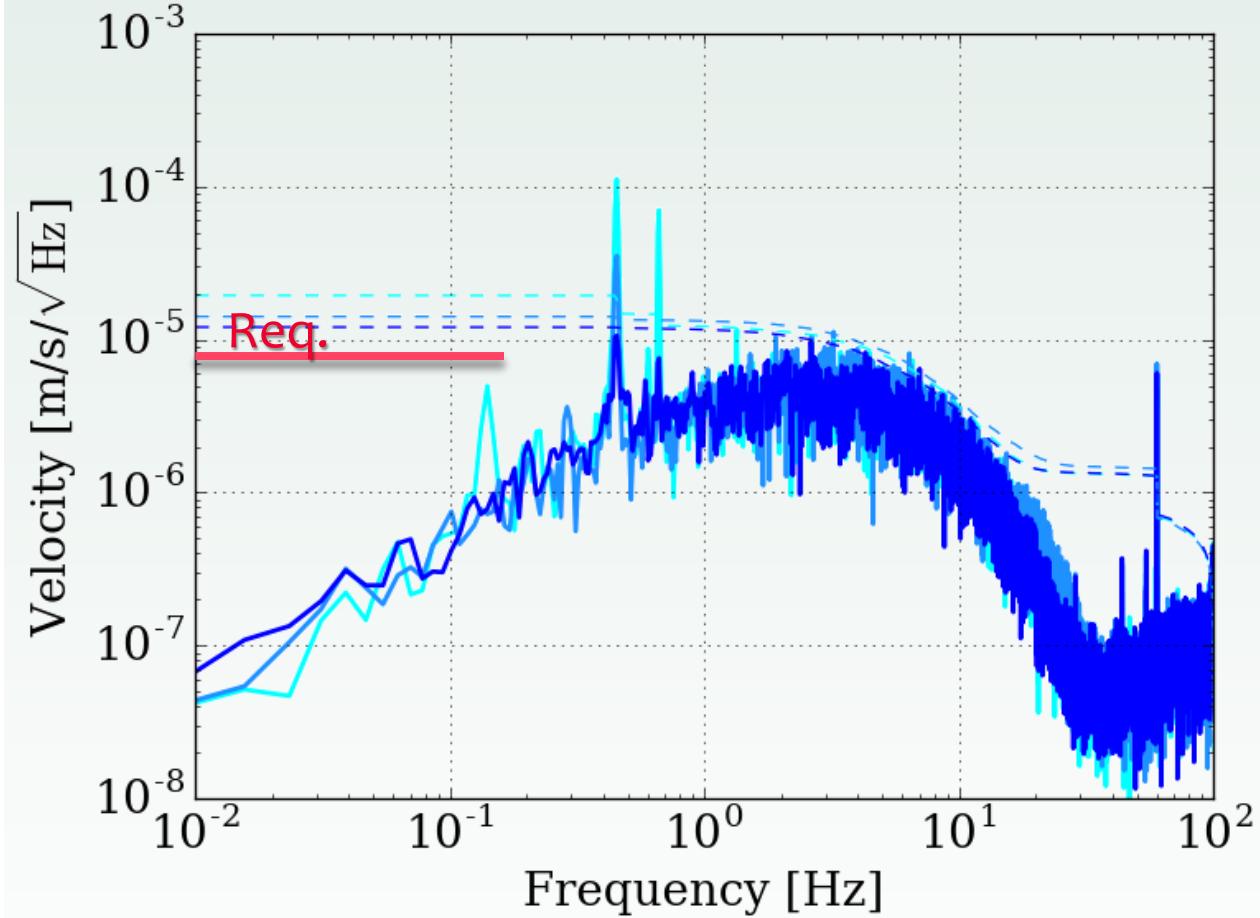
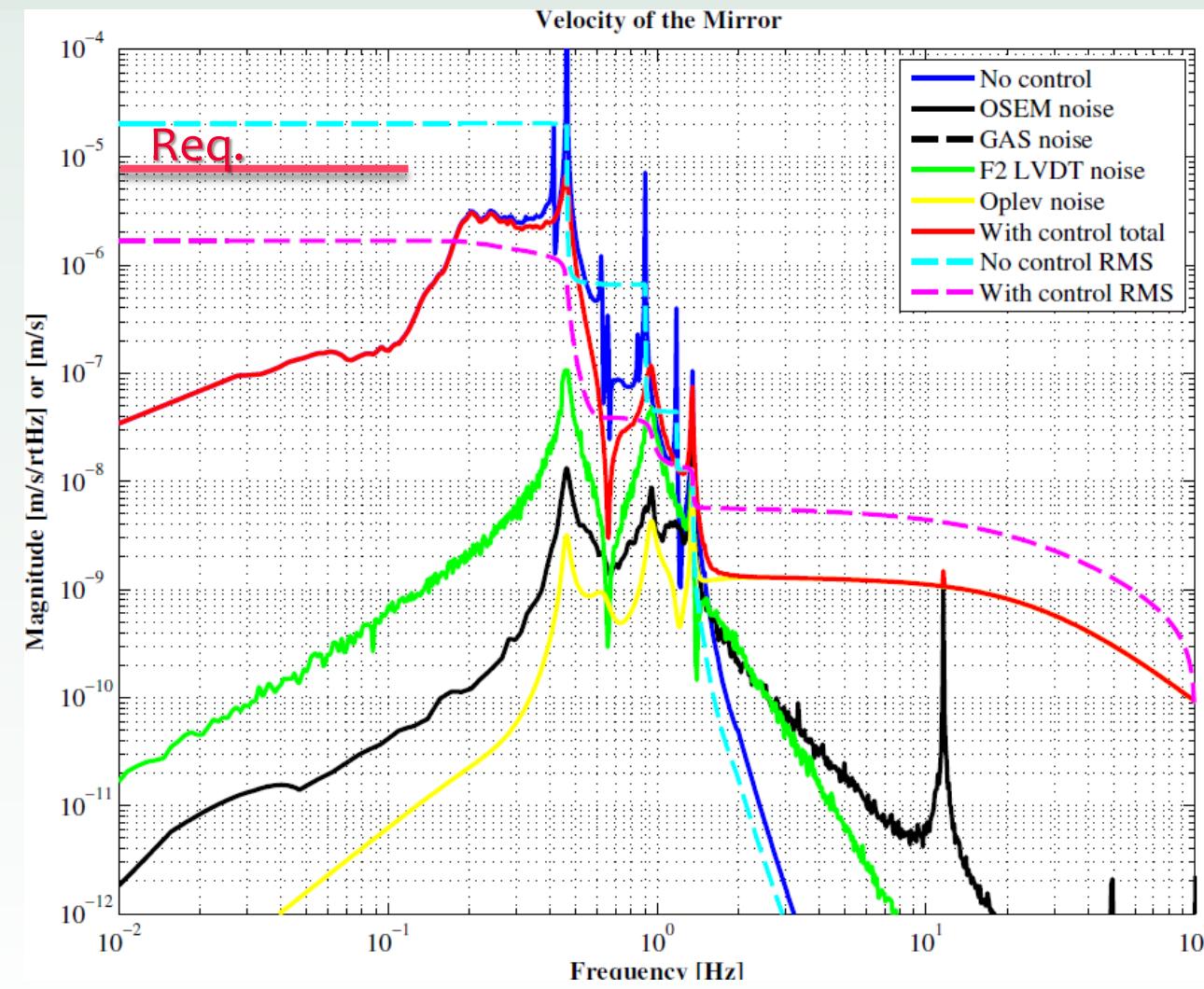


Result

* Calibration factors have large uncertainty.



Compare with the simulation



Schedule

One month delay from the first plan.

- Lost 2 weeks since gluing tools are missing.
The handover was not proper.
- Lost 1 week because the mirror hanging
was failed once (not a big accident).
- Lost 1 week because of fixing the fragile
cables again and again.
Cabling work was a lot more time
consuming than expected.

How to speed up?

- This should not happen again.
(We did almost everything during
the test hanging.)
- This kind of accident can be happen
again. We have to take them into
account in our schedule.
- We will outsource this work to a
company.

Tasks remained

- Improve the efficiency of the time consuming work
Improve the safety
(ex. outsourcing the cable assembly, prepare more steps on the 2nd floor)
- Calibrate each sensors & actuators
- Optimize the control loop
→ Decrease noise coupling
- De-coupling of the length-sensing OpLev
- Measurement of Q-values
- Optical bench suspension

Future plan

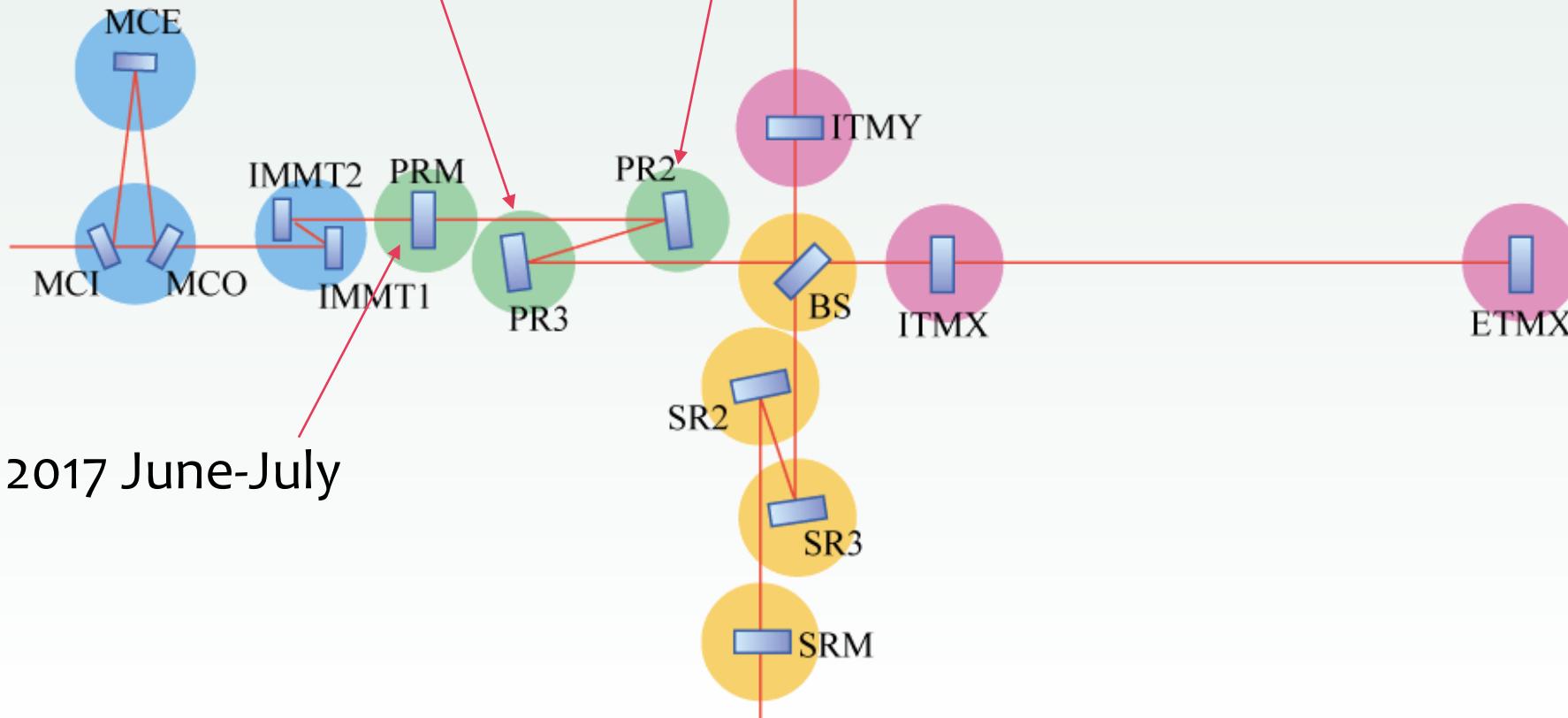
2017 April-May

PR3 mirror is ready to be shipped to Kamioka on 3rd April.

ETMY

Other shift workers from Hosei Univ. will join!!

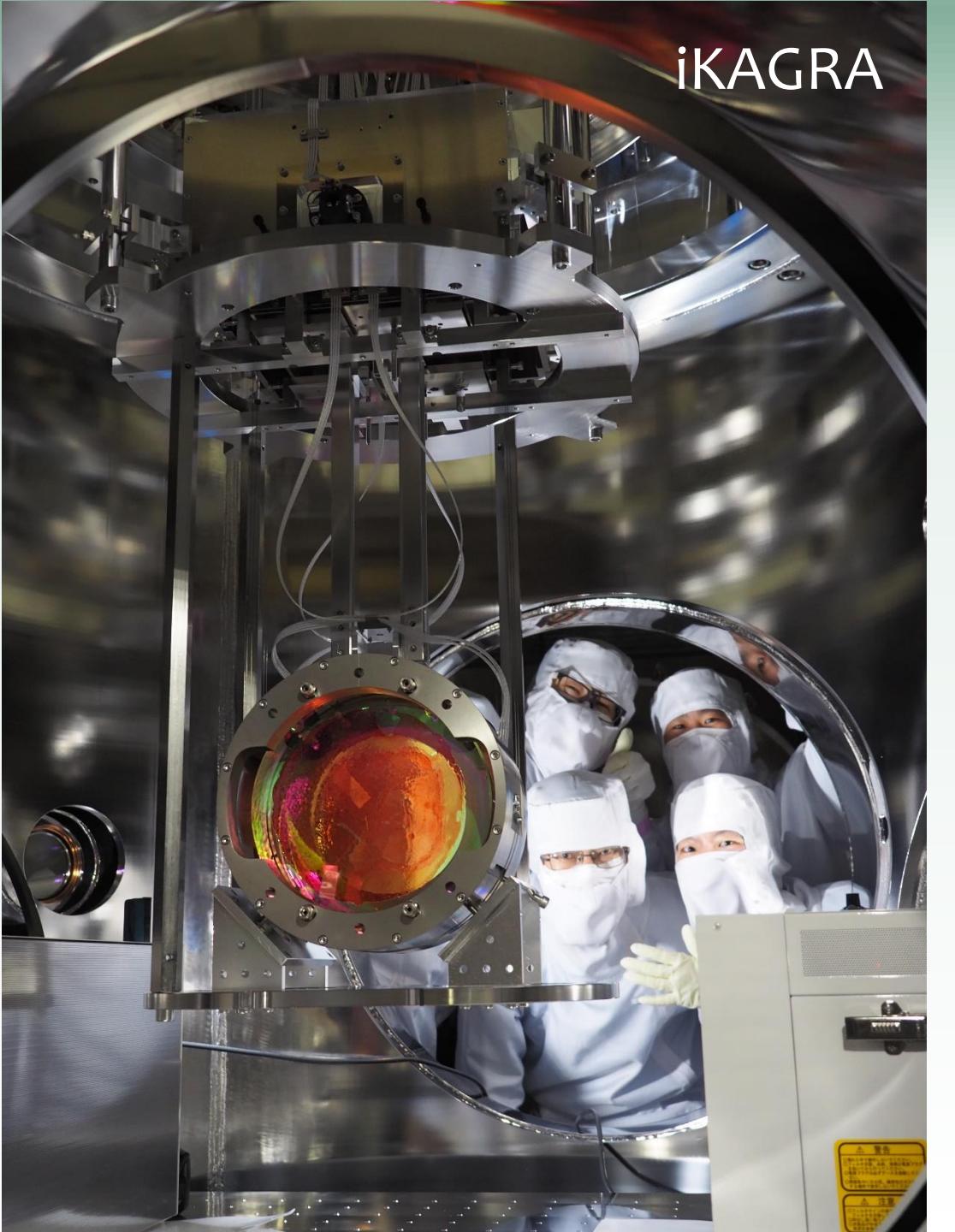
2017 May-June



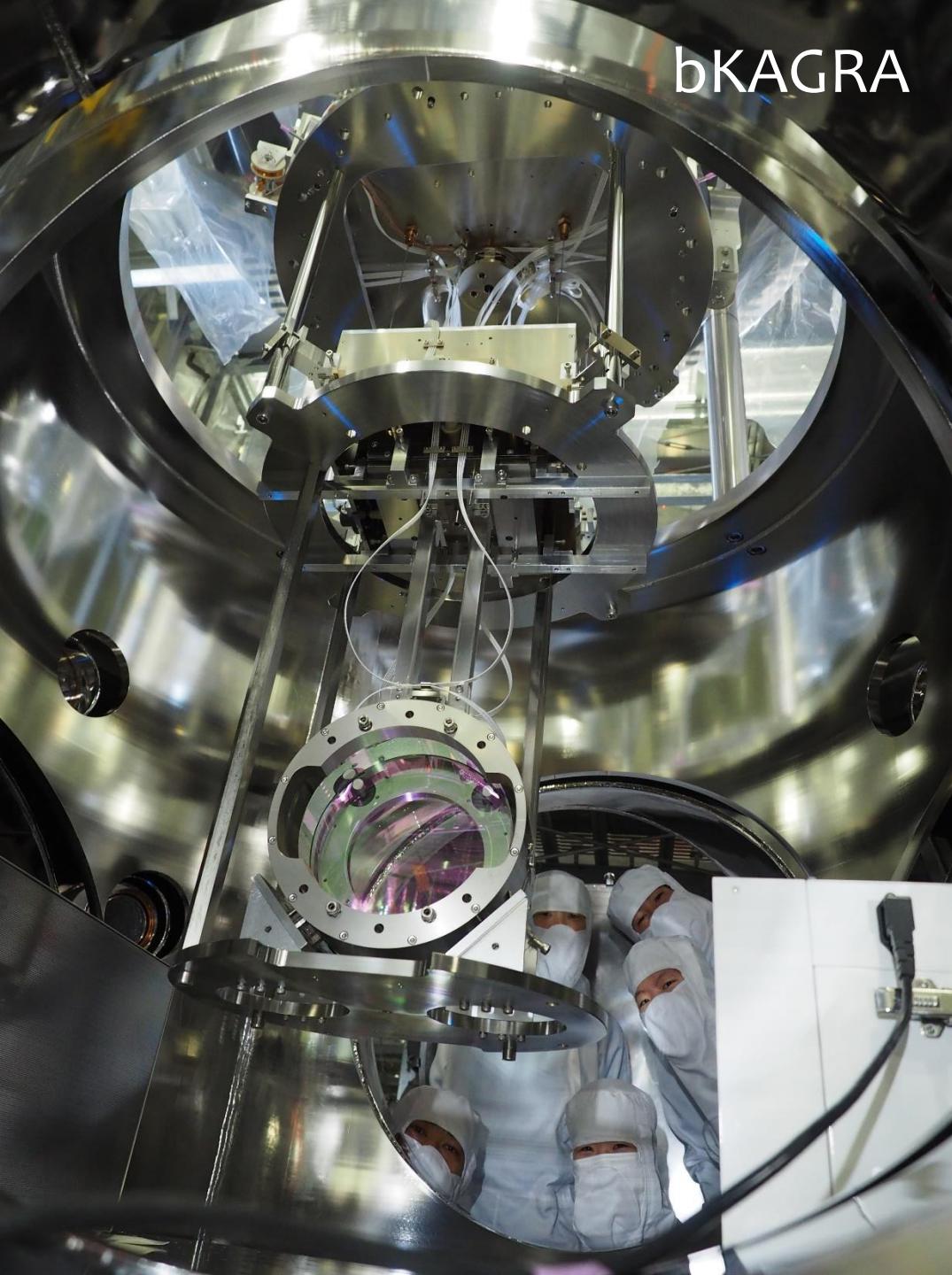
Summary

- Upgrade Type-Bp suspension from iKAGRA
→ All the resonant modes are damped
- Test Hanging is done
→ Checked the damping
- PR3 mirror suspension will be assembled from April.
PR installation will be completed in this summer.

iKAGRA



bKAGRA



JANUARY 2017

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1	2	3	4	5	6	7
8	9	10 Gluing	11 Gluing	12 Mirror hanging	13 Mirror hanging	14
15	16 Winch inspection	17 Mirror hanging (2 nd try)	18 Mirror alignment	19 RM hanging	20 RM alignment	21
22	23 DGS trouble	24 EQ stop assembling	25 Spectra measurement BF preparation	26 TF measurement BF setting	27 Parts inspection OSEM flag assembly	28
29	30 IM hanging	31 IRM assembly				

FEBRUARY 2017

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1 IM TF measurement	2	3 BFRM test assembly @Mitaka	4
5	6 Set IM damping	7 Picomotor check Parts preparation	8 LVDT calibration BF assembly	9 BFRM assembled	10 OB suspension parts checked	11
12	13 OB suspension parts checked	14 Top plate SF assembly	15 Cabling	16 BFRM test assembly @Mitaka	17	18
19	20 BF hanging	21 Ballast mass setting	22 Cabling	23 Cabling	24 BF balancing	25
26	27 BF balancing BFRM coil assembly	28 Signal check IM OSEM alignment				

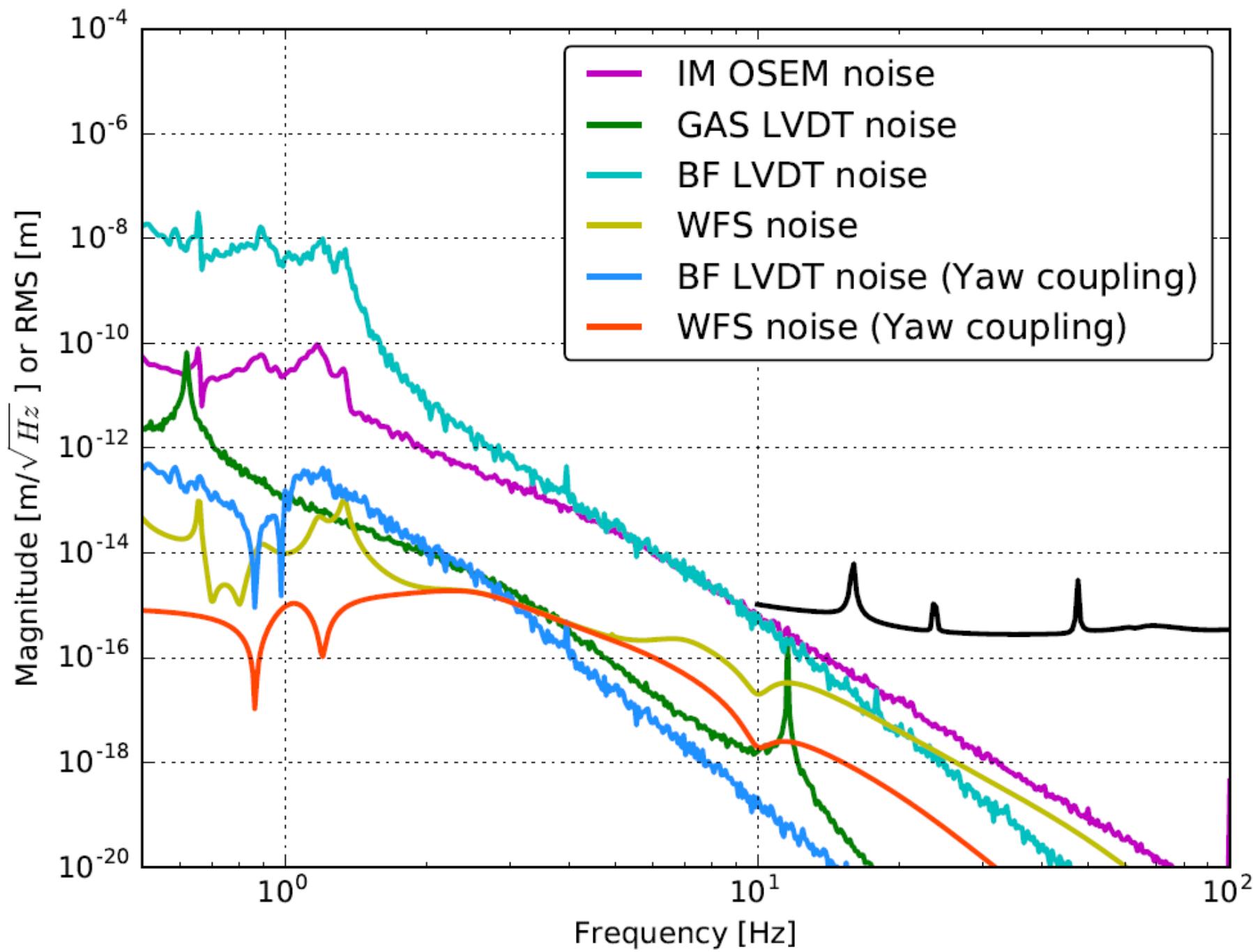
MARCH 2017

24calendars.com

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1 Signal check	2	3	4
5	6 Installation preparation BF signal check	7	8 Installation	9 Cabling Oplev setting	10	11
12	13 Signal check	14 Signal check	15 Measurement	16 Remove SUS from chamber	17	18
19	20 Disassembly	21 Chamber moving Calibration	22 Chamber moving	23 Chamber moving	24	25
26	27	28	29	30	31	

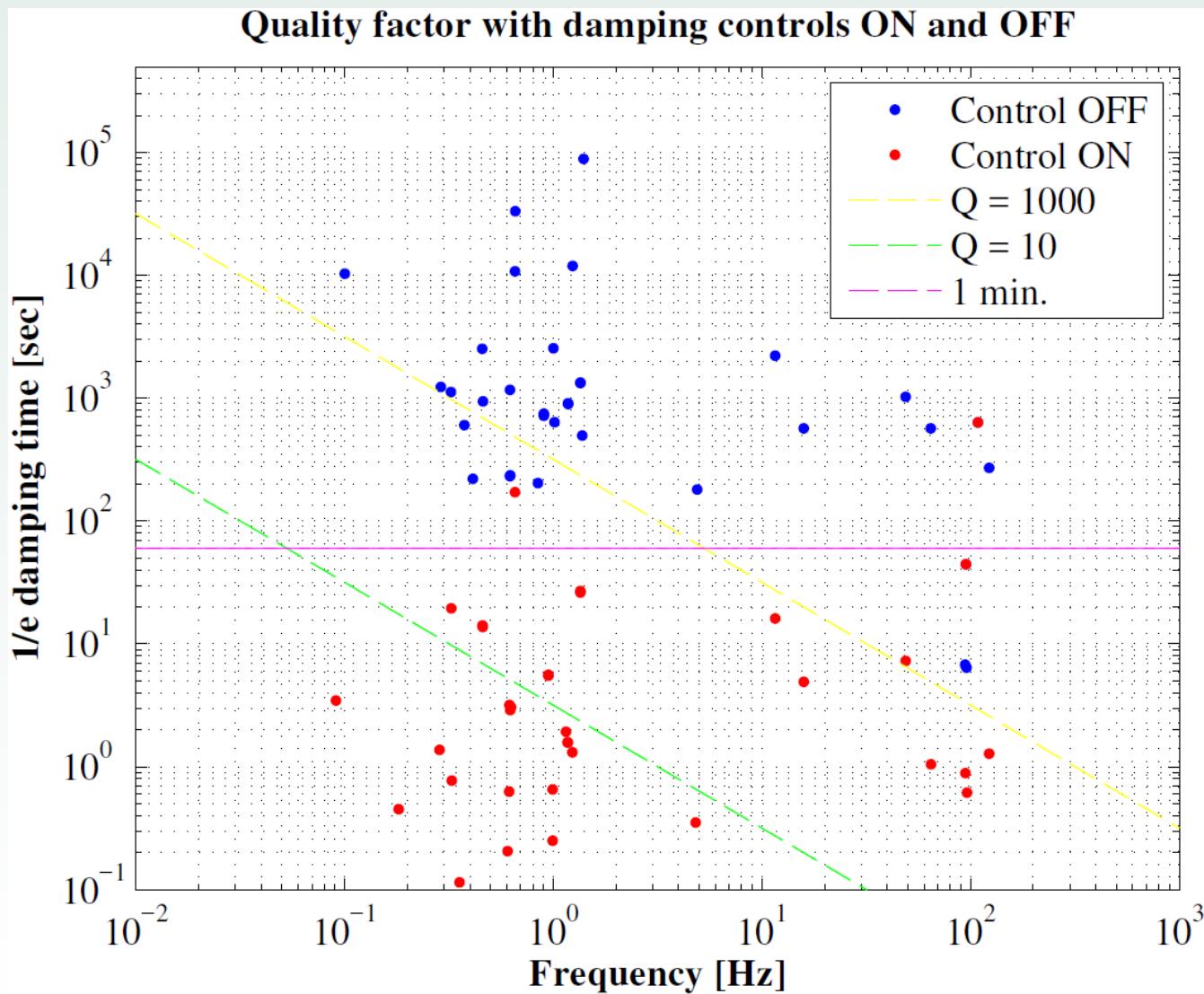
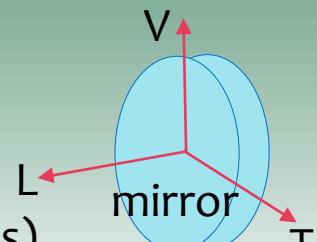
APRIL 2017

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
						1
2	3 Mirror hanging	4 Mirror alignment	5 RM hanging	6 RM alignment	7 EQ stop assembling	8
9	10 Spectra measurement BF preparation	11 TF measurement BF setting	12	13 IM hanging IRM assembly	14 IM TF measurement	15
16	17 Set IM damping Picomotor check	18 LVDT calibration BF assembly	19 BFRM assembled	20 Top plate SF assembly	21 Cabling	22
23	24 BF hanging	25 Ballast mass setting	26 Cabling	27 BF balancing	28 BF balancing BFRM coil assembly	29
30	Signal check Installation preparation		Installation			



Damping time simulation

※controlled only in L,T,Y at BF



TM T, RM -T

