

Commissioning Status of KAGRA

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for KAGRA collaboration**

**5th KAGRA international workshop @Perugia
Feb. 14th 2019**

Commissioning Goals

☐ Bring the interferometer to the design sensitivity

☐ Automate the global control processes

☐ Deliver the fully locked interferometer

This is what we said at KIW4

JGW-1808425-v2 by O. Miyakawa
(2018 June)

Summary

- Commissioning of bKAGRA phase 1 was successfully done.
 - Cryogenic Michelson was operated.
 - ETMY was cooled down to 20 K.
- We had 1 week operation. We experienced a lot of things and obtained many results.
 - Issues around the payload was identified to some extent.
- Commissioning of bKAGRA Phase 2 started.
 - Installation and preparation for joining late O3 is NOW on-going.
 - High Power Laser will be provided by the end of August.

What we do

- **Conduct series of commissioning experiments by using available parts of the interferometer**

- 3 km Michelson interferometer
- X arm **[New]**
- Y arm
- DRMI
- Full interferometer

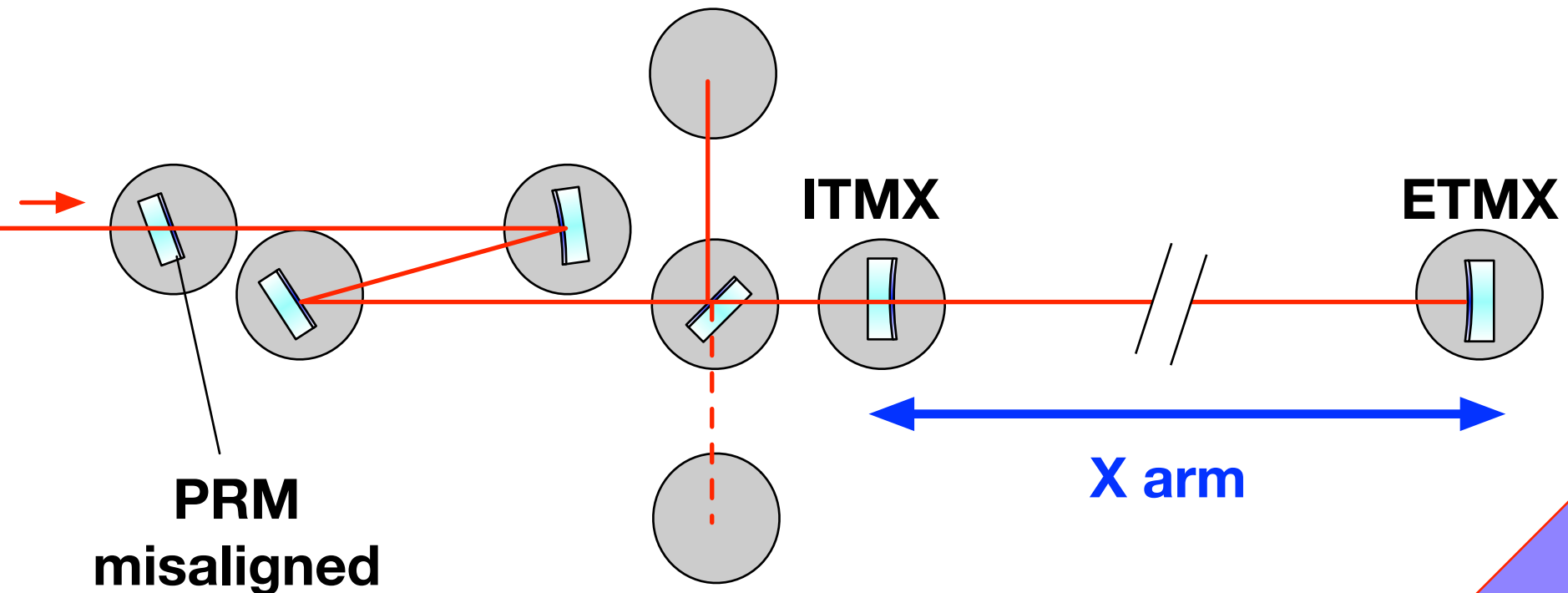
Concluded

Concluded

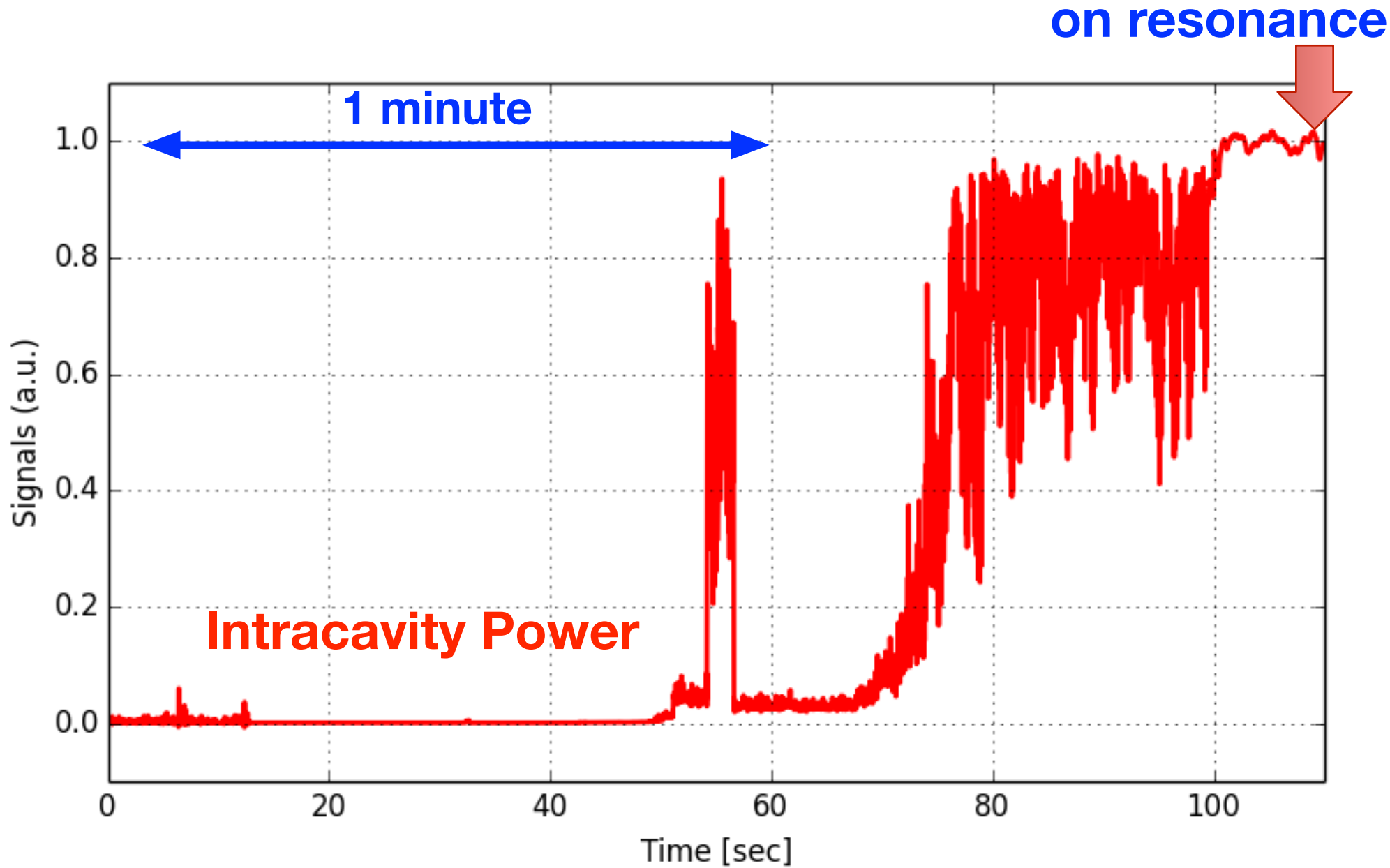
- **Assess the readiness through the experiments**
 - optics, electronics, mechanical parts,

X arm commissioning

- Utilize one of the arms (i.e., X arm)
 - to test key technologies for lock acquisition
 - to assess the readiness of various components
- Test masses at room temperature

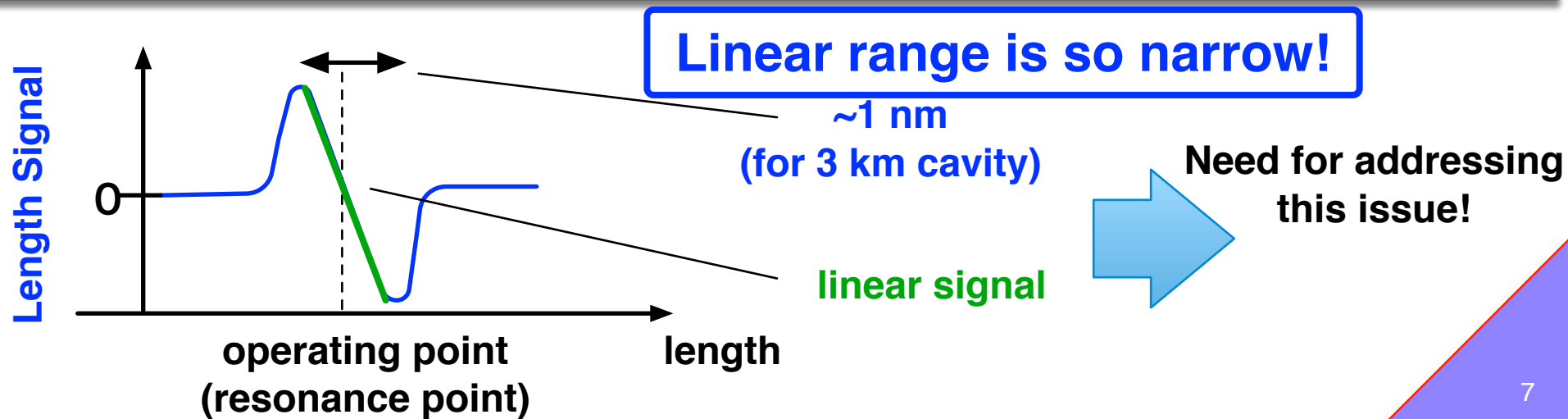
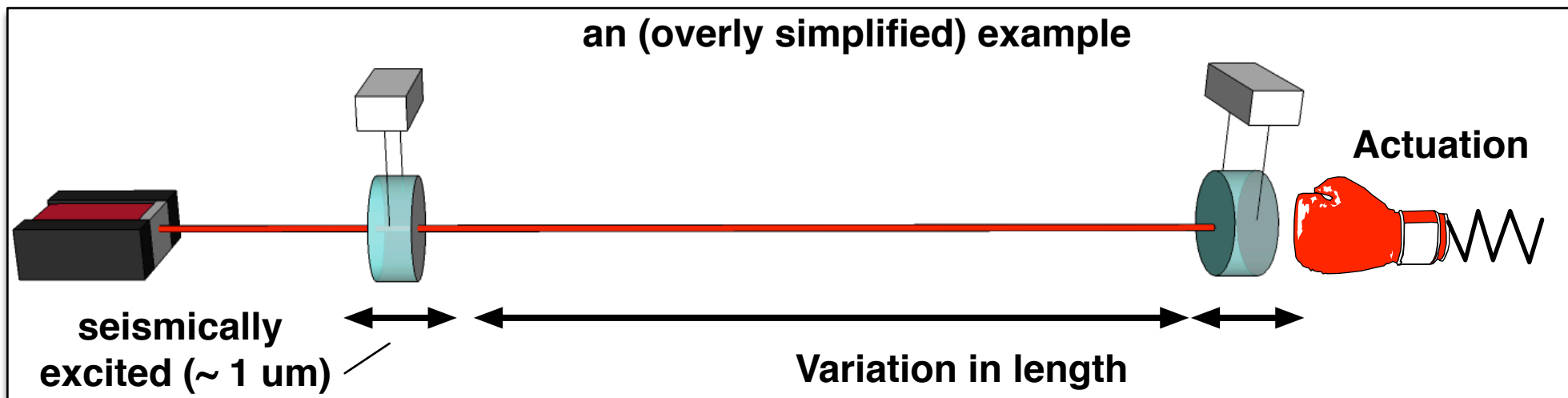


This is the highlight



Lock acquisition is not trivial

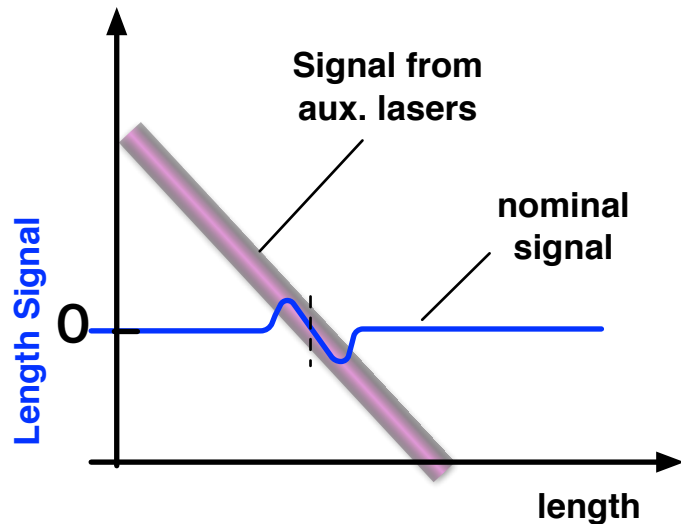
All the optical cavities will need to be locked at a resonance point with an active feedback control



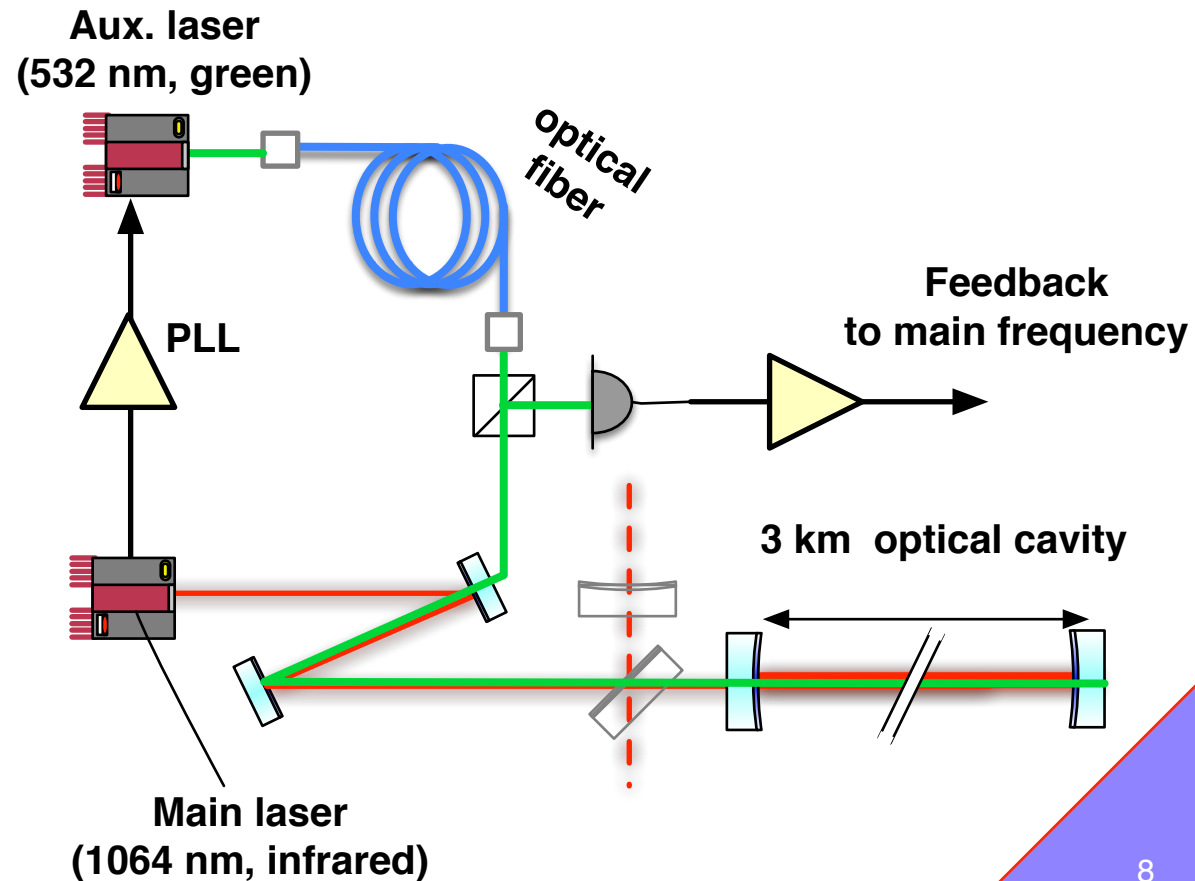
A solution: green lock

- Provision of an independent arm-length sensor [1,2]
- A key for making the full interferometer operational (e.g. LIGO)
- Reduction of the complexity when locking multiple optical cavities
- KAGRA employs an advanced ALS optical topology

Wider linear range!



[1] A.J. Mullavey et al., Opt. Exp. 20 81 (2012)
[2] KI et al., J.Opt.Soc.Am.A, 29,10,2092 (2012)

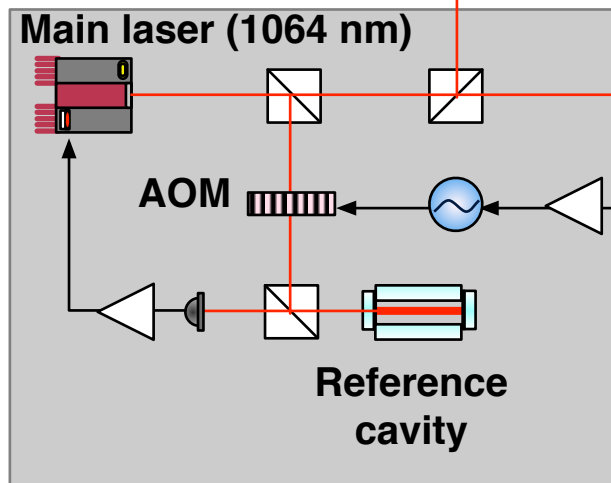
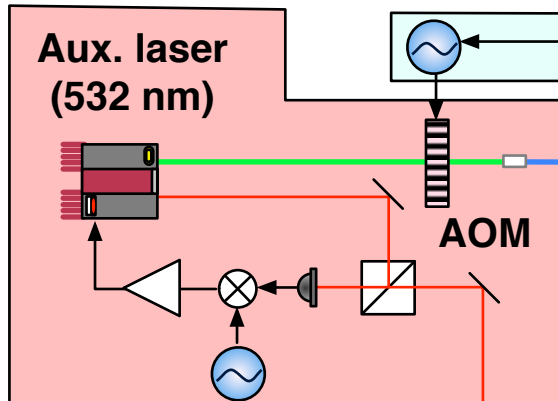


Feature(s)

- **Injection of green light in the center area
(as opposed to injection from end test mass)**
- **Provision of green light through fiber**
- **Electronically decompose two arm degrees of freedom (i.e., DARM and CARM)**

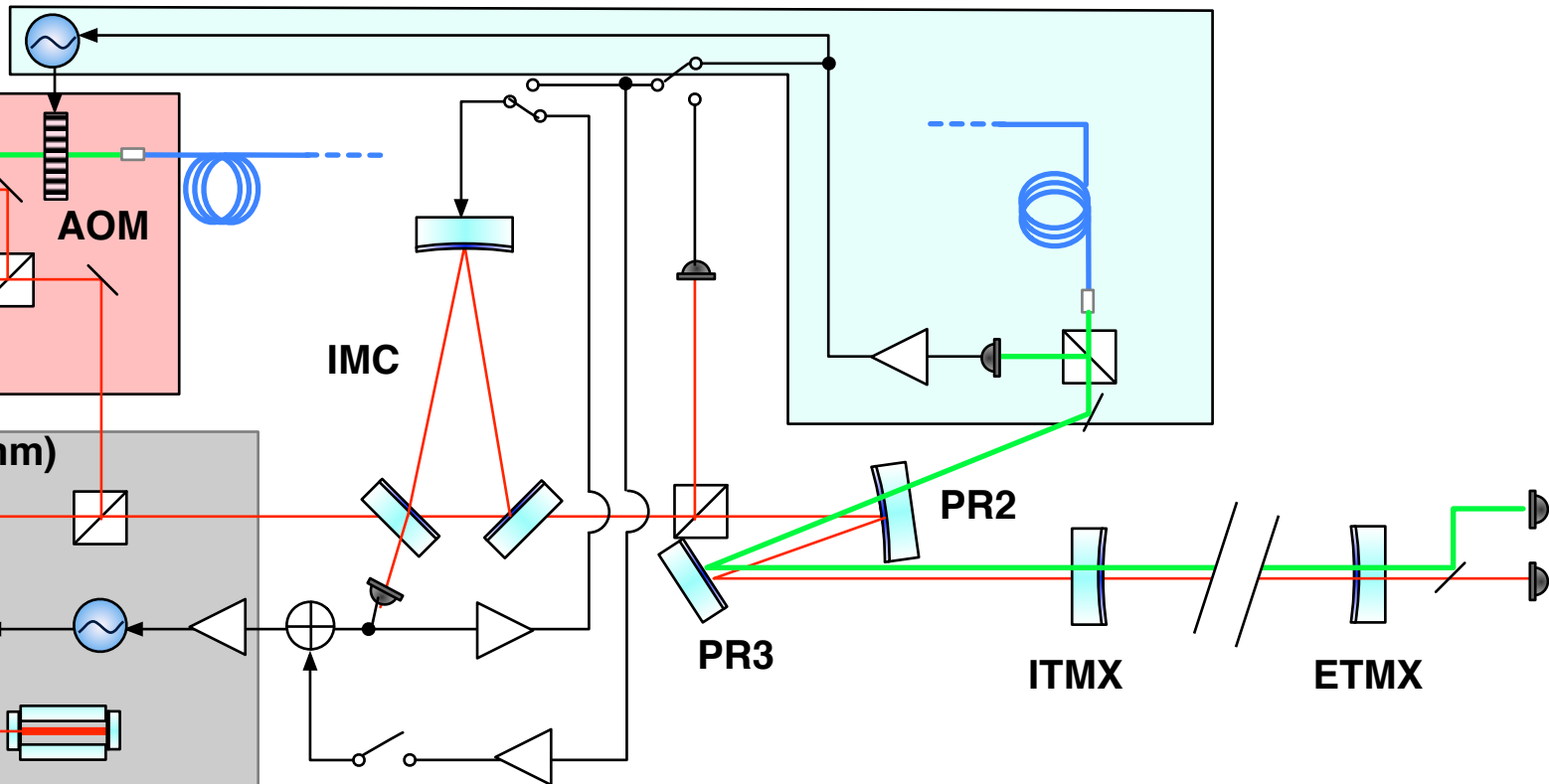
Green lock setup

Phase locked loop



Freq. stabilization

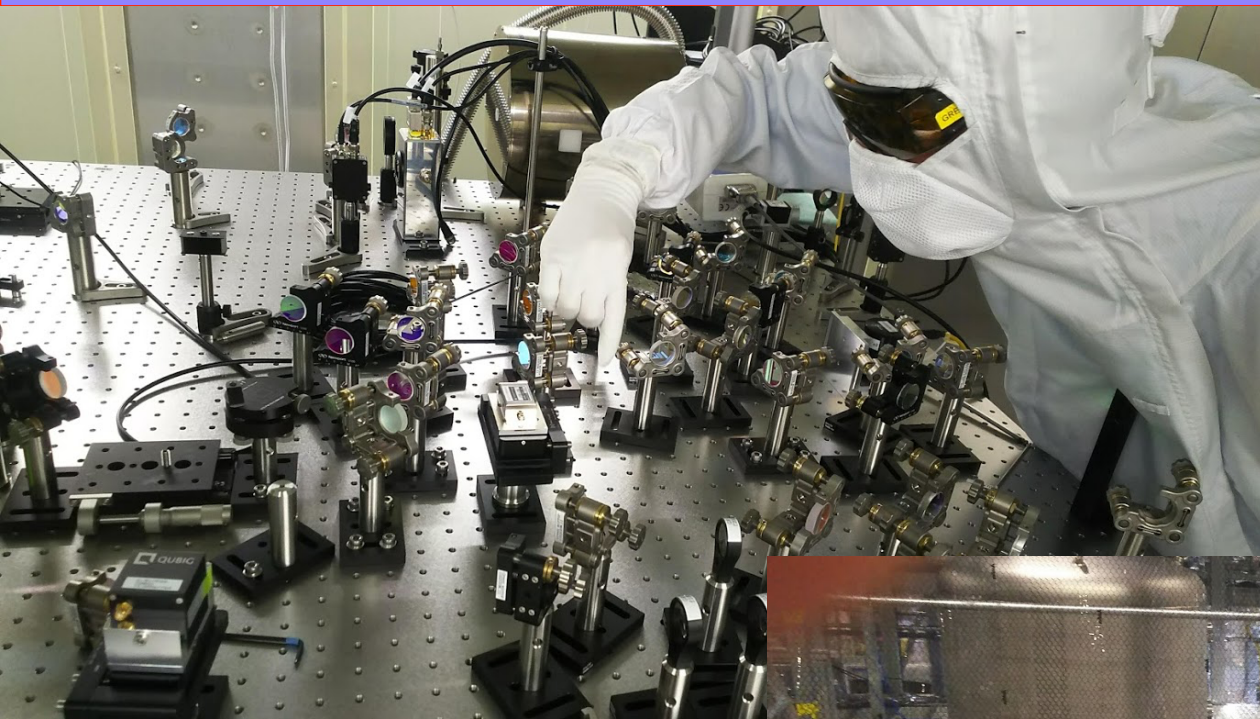
Pound-Drever-Hall locking



How it went

- **August 2018: Installation of in-air optics and optical fibers**
- **September: Interferometer alignment**
- **October: Commissioning period began**
- **Mid. October: Green laser locked to the cavity**
- **November: Handing off to IR succeeded**
- **December: Characterization began**
- **January 2019: Commissioning period ended**

Hardware installation

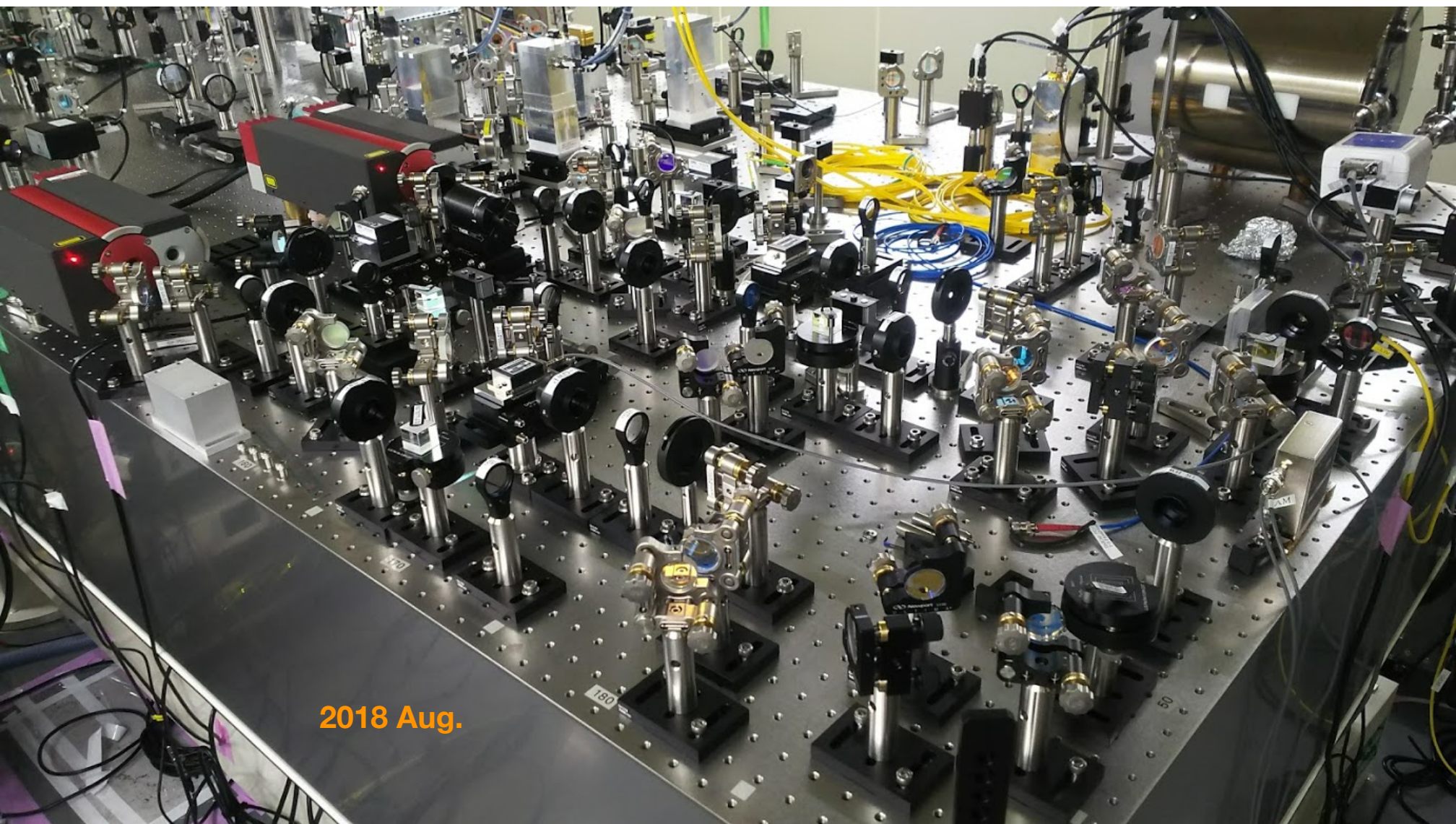


**2018 summer:
Installation of optics by
K. Yokogawa and R. Sugimoto
(Toyama Univ.)**



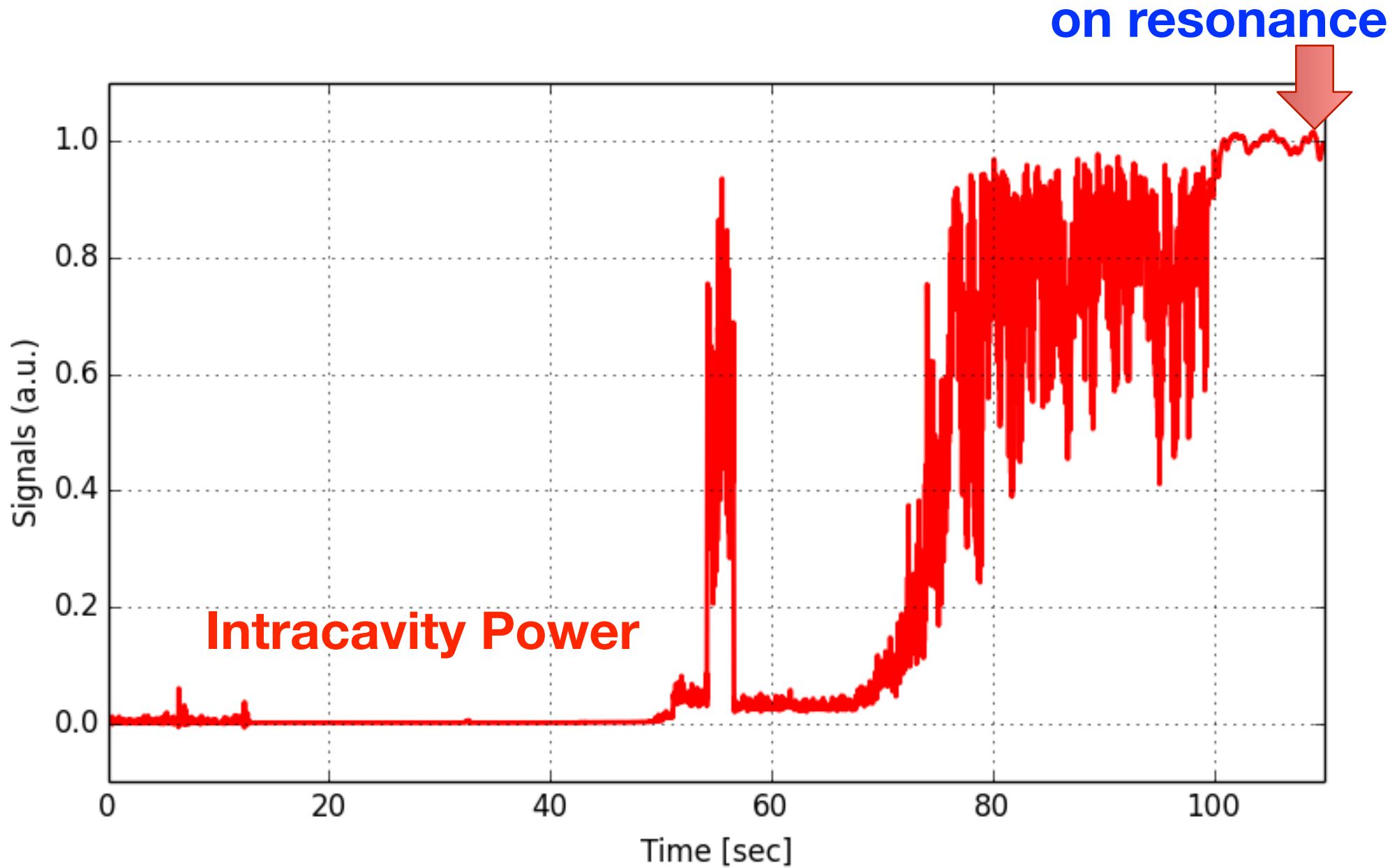
**2018 summer;
Installation of optical fibers
by Fujitsu FSAS**

Hardware installed



2018 Aug.

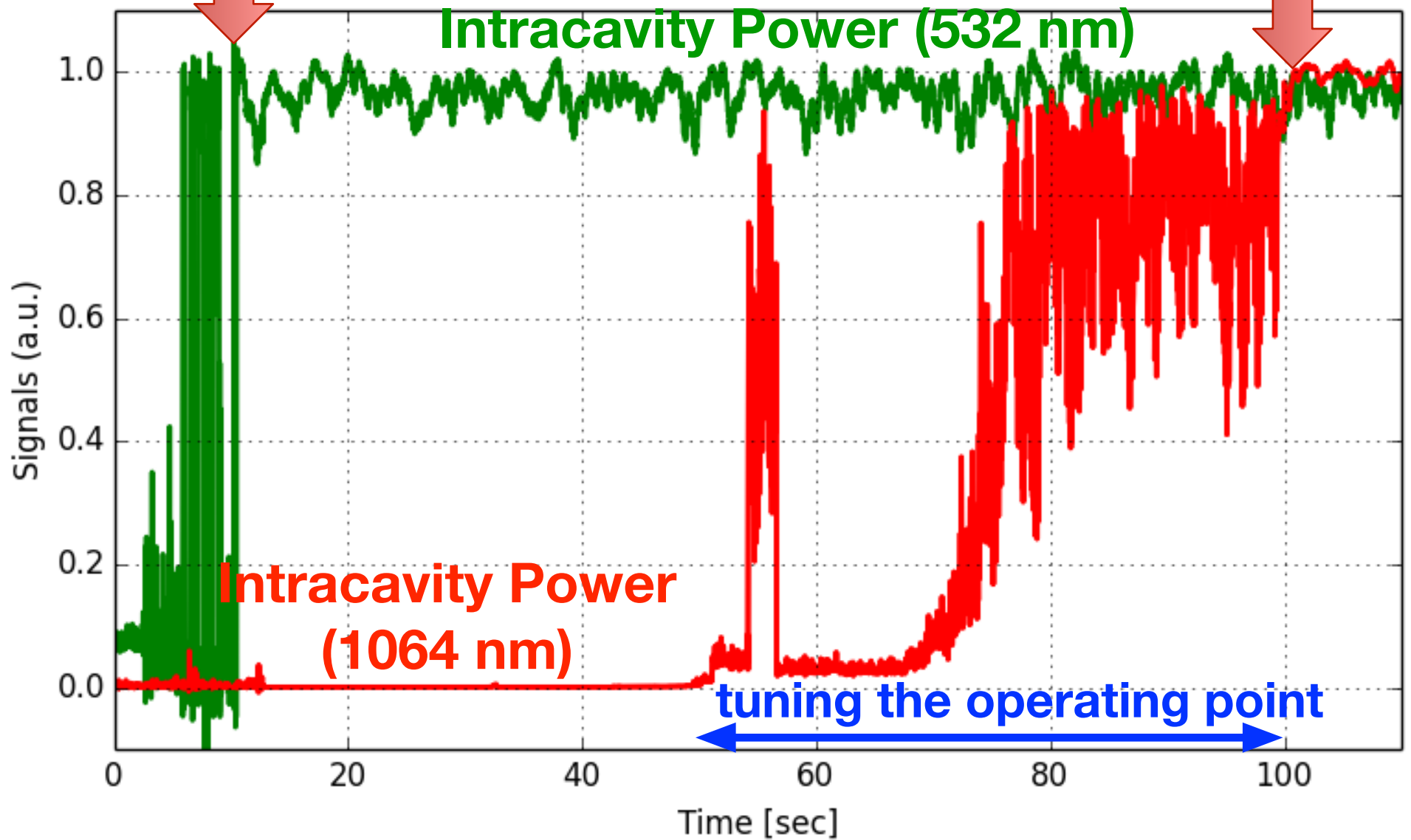
Hand-over success!



Hand-over success!

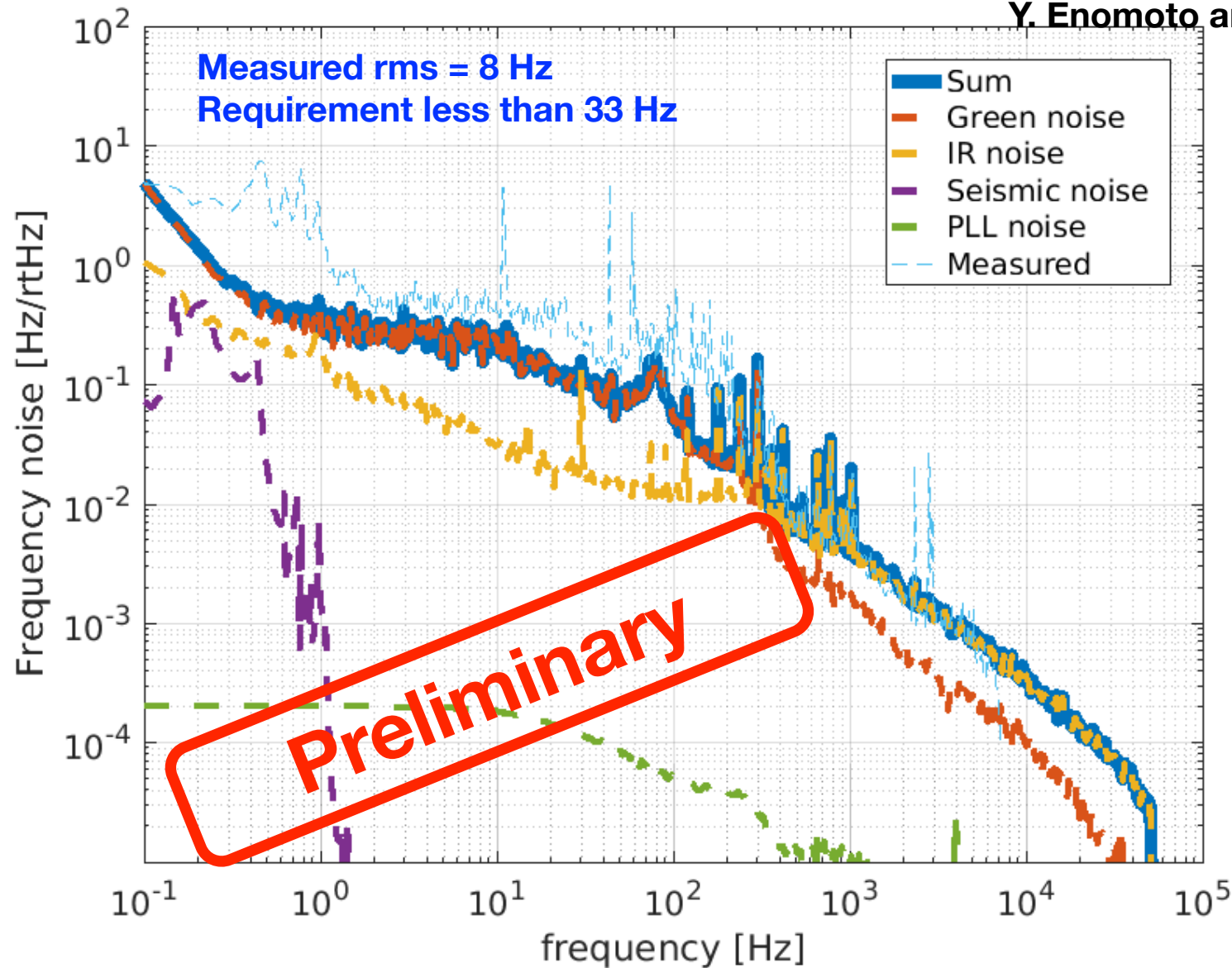
Green laser locked

Sensor switched

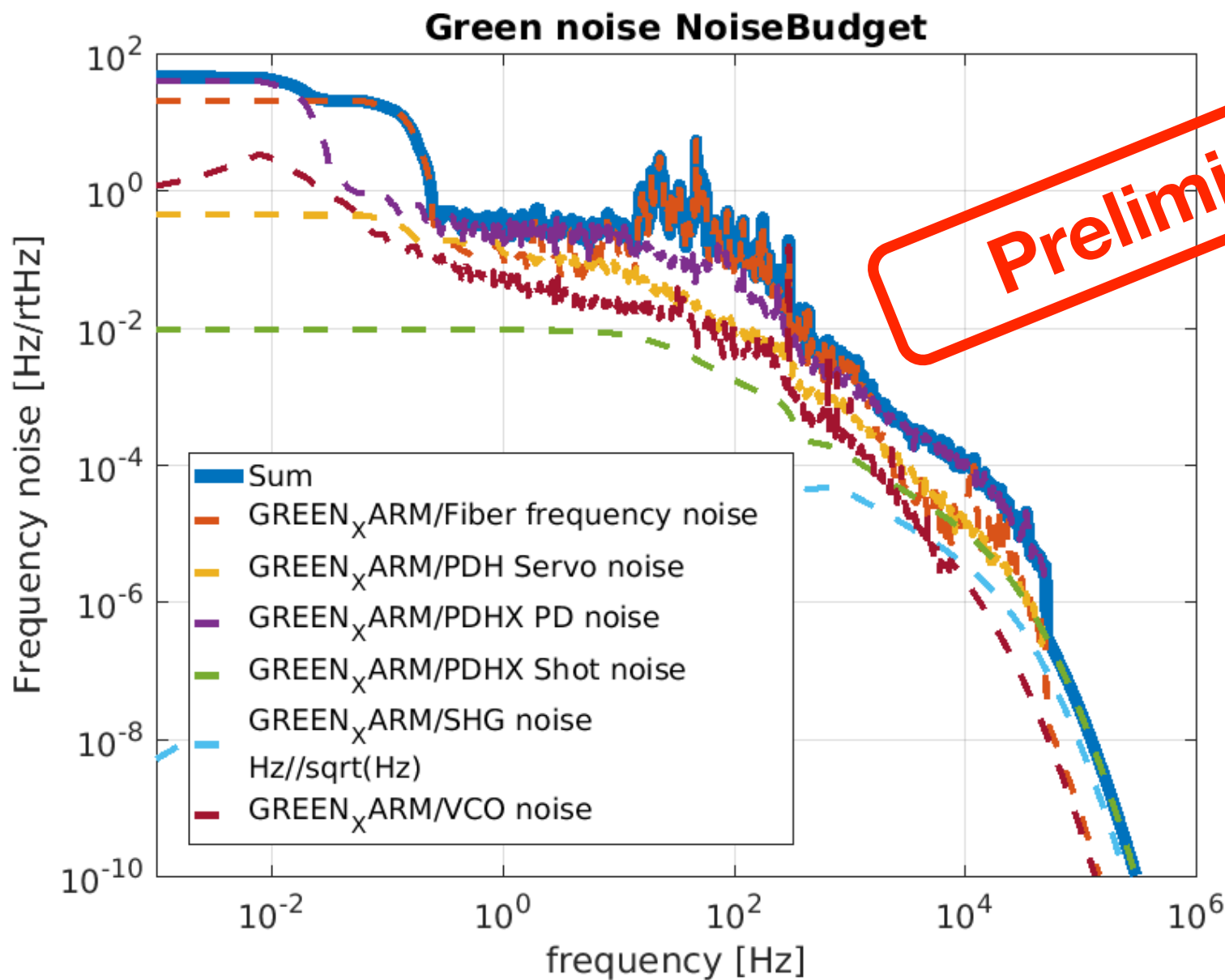


Required stability achieved

Calculation/measurement by
Y. Enomoto and K. Yokogawa

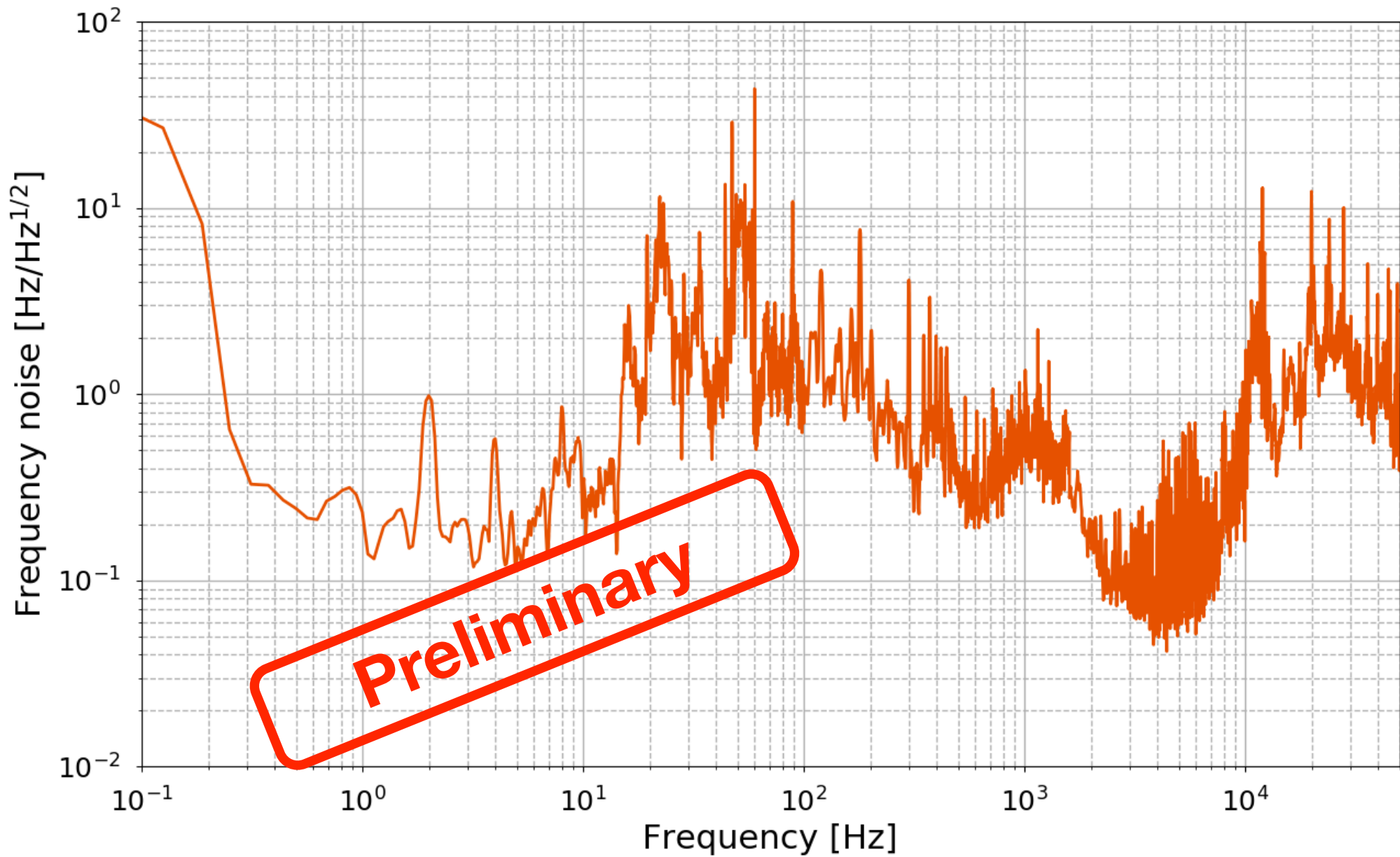


Noise from green lock system



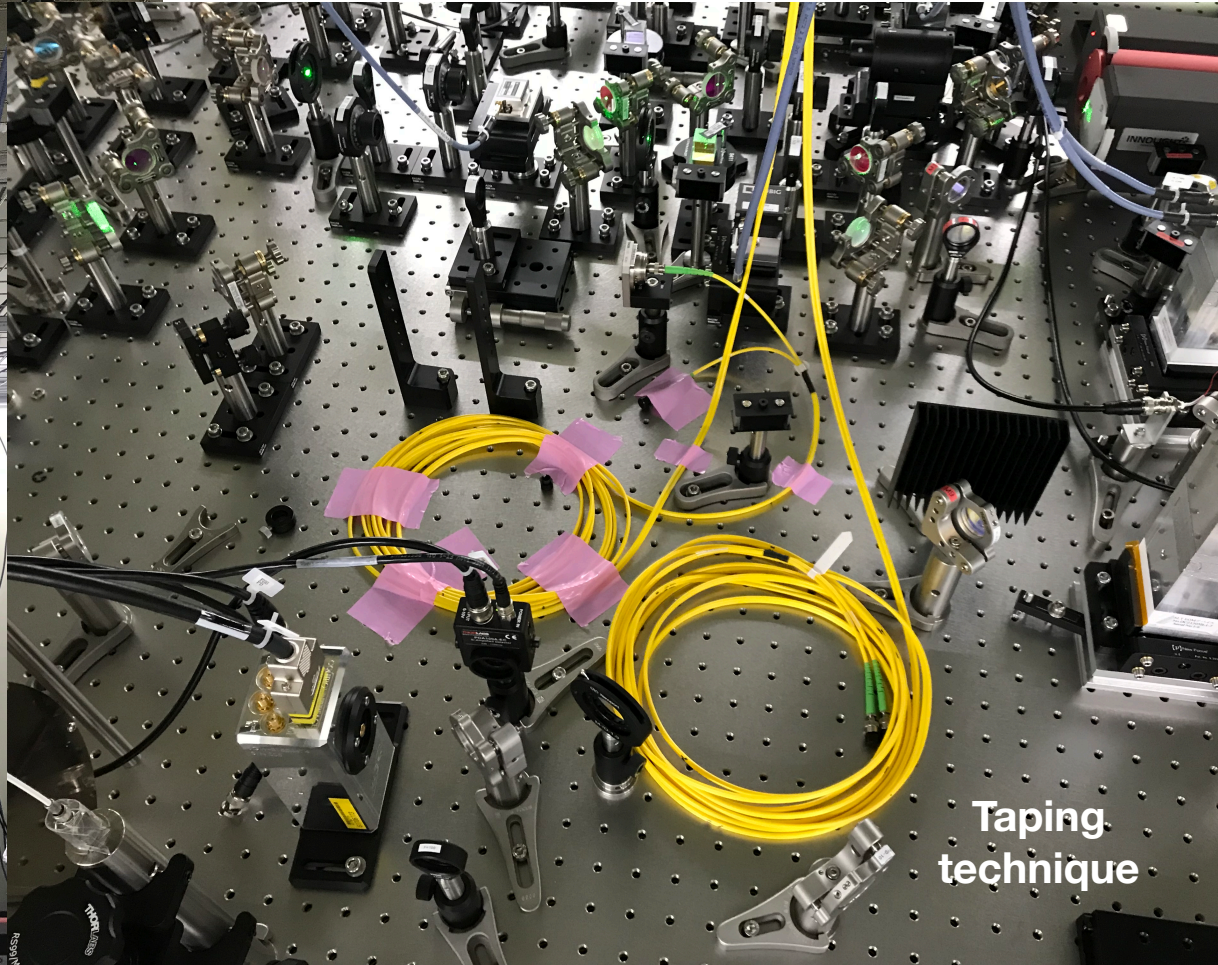
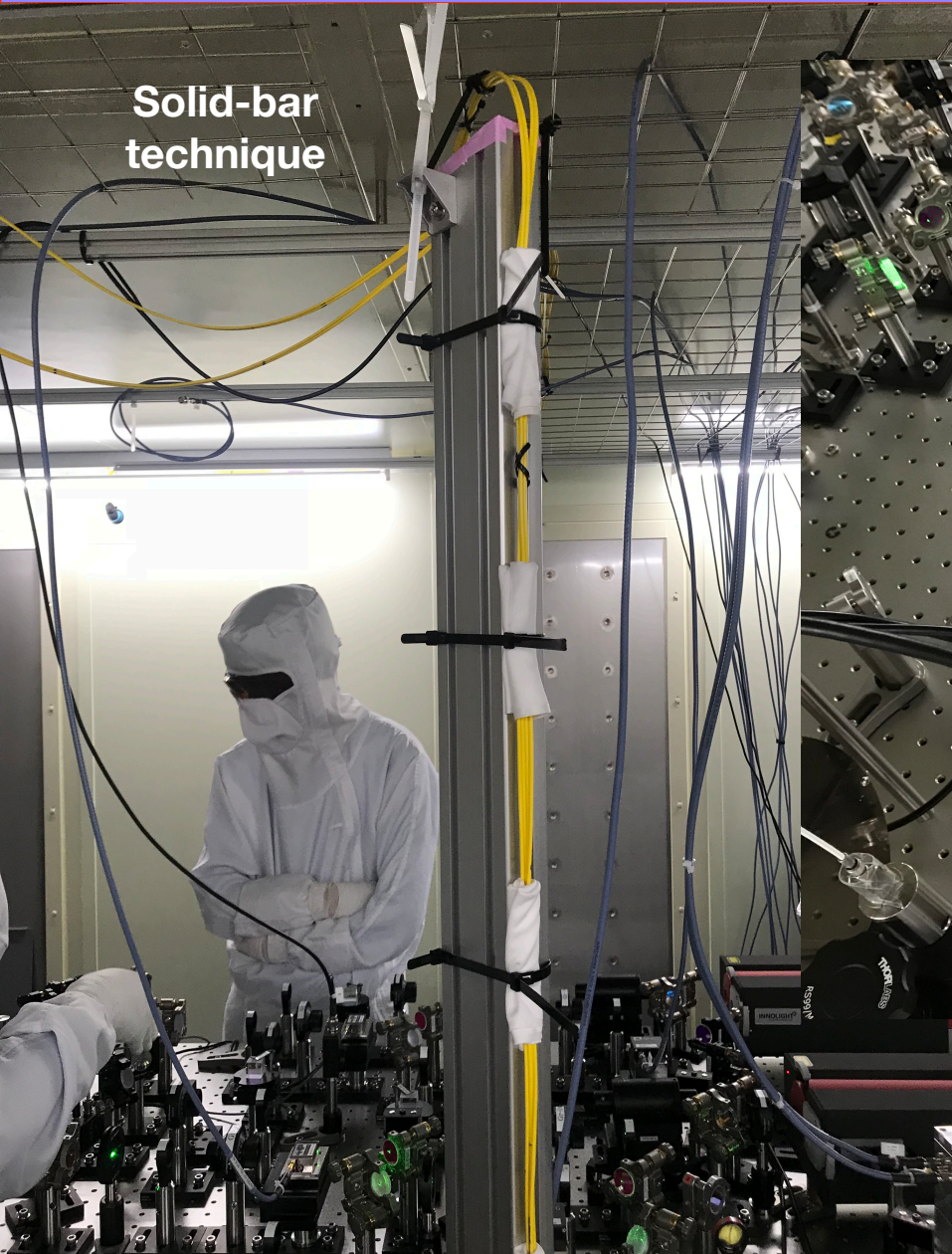
Preliminary

Fiber noise



Fiber noise reduction (temporary)

Solid-bar technique



Taping technique

Also, reducing air current helped significantly.

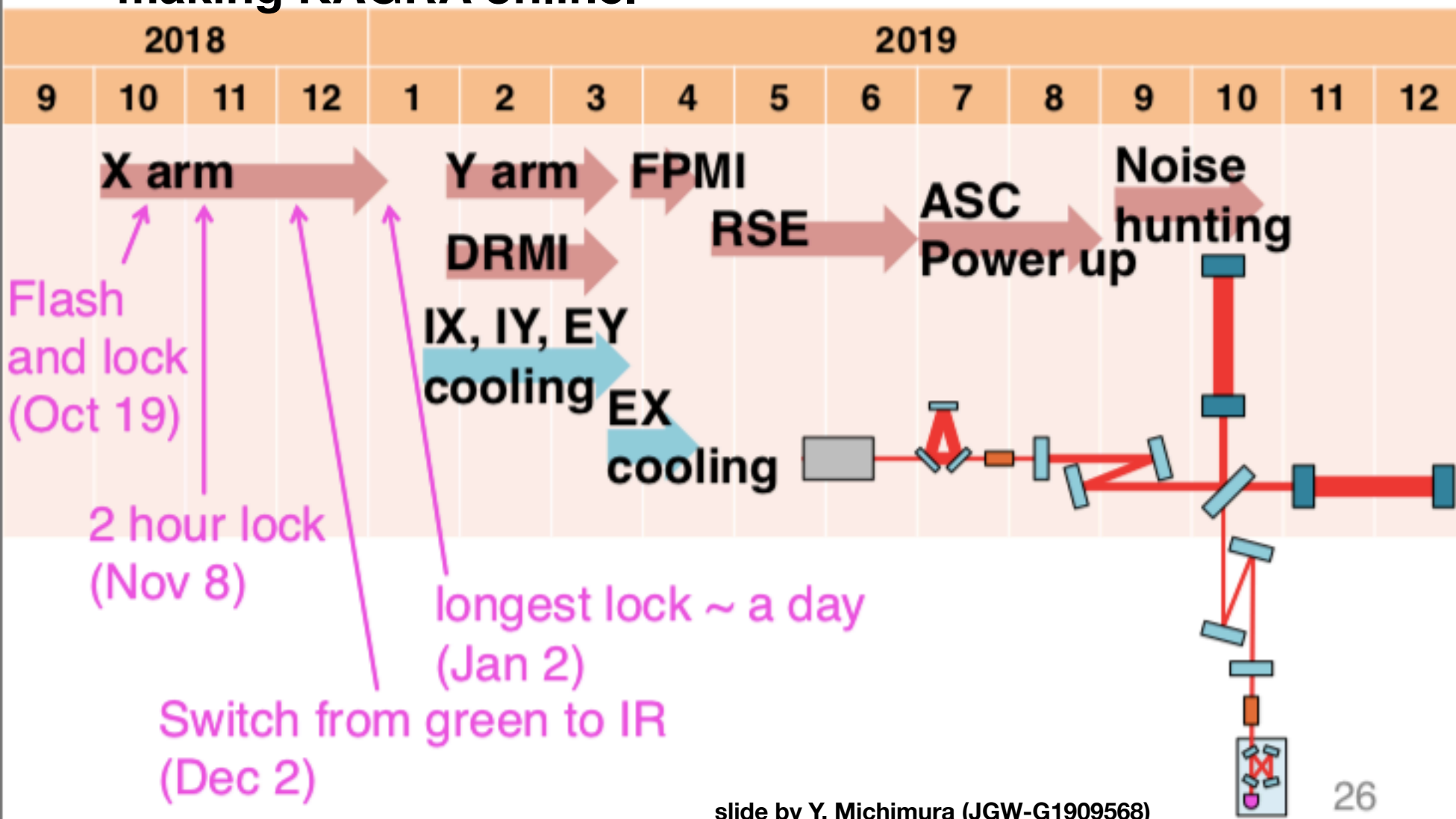
Most of the goals achieved

List of goals will be here.

List of measured parameters are here.

Into O3

Several more commissioning experiments before making KAGRA online.



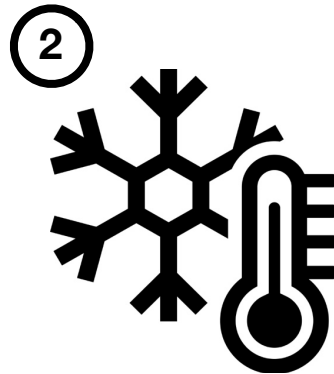
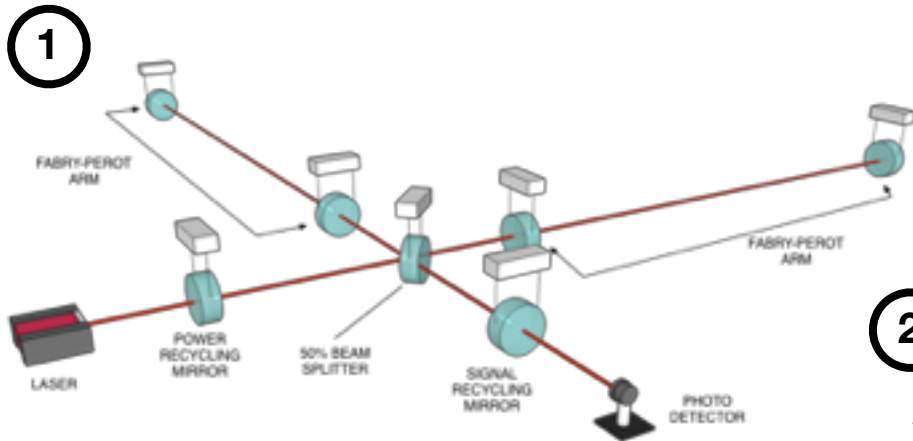
Global alignment in progress

Some cool picture for interferometer alignment will be here.

Summary

- ▣ **The X arm commissioning has concluded with success.**
- ▣ **One critical finding: green lock suffers from fiber noise.**
- ▣ **The DRMI commissioning experiments will start in the middle of this month (February).**
- ▣ **Several more commissioning experiments are foreseen before becoming a part of the world-wide detector network.**

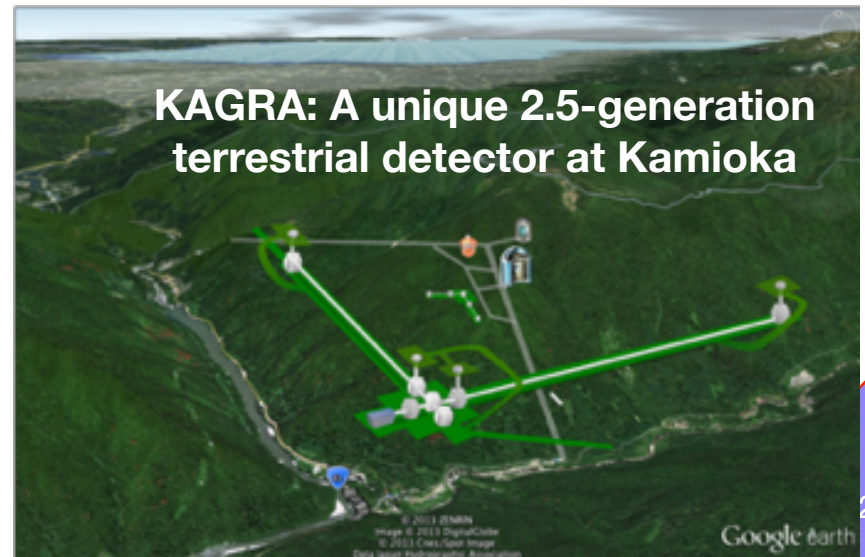
KAGRA



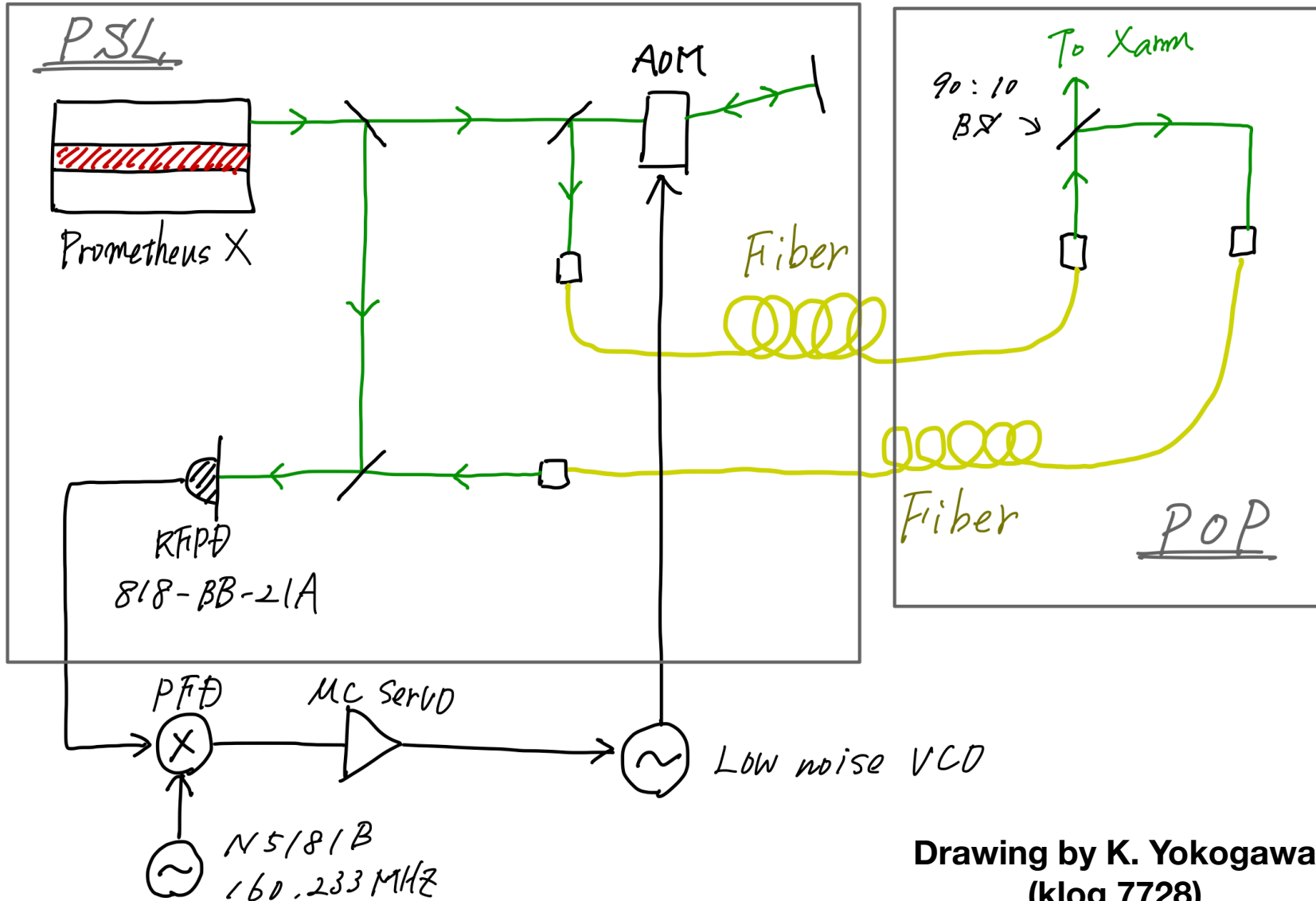
① A 3-km Dual-recycled Fabry-Perot Michelson laser interferometer

② Cryogenic mirrors
[KAGRA only]

③ Underground
[KAGRA only]



Fiber Noise Measurement



Drawing by K. Yokogawa
(klog 7728)