JGW-G1909593-v2

# *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

# Words from previous KIW

KAGRA Summary

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

- 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 (Concluded)
  - X arm
  - Dual-Recycled Michelson Interfer. (DRMI)
  - Y arm
  - Full interferometer

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

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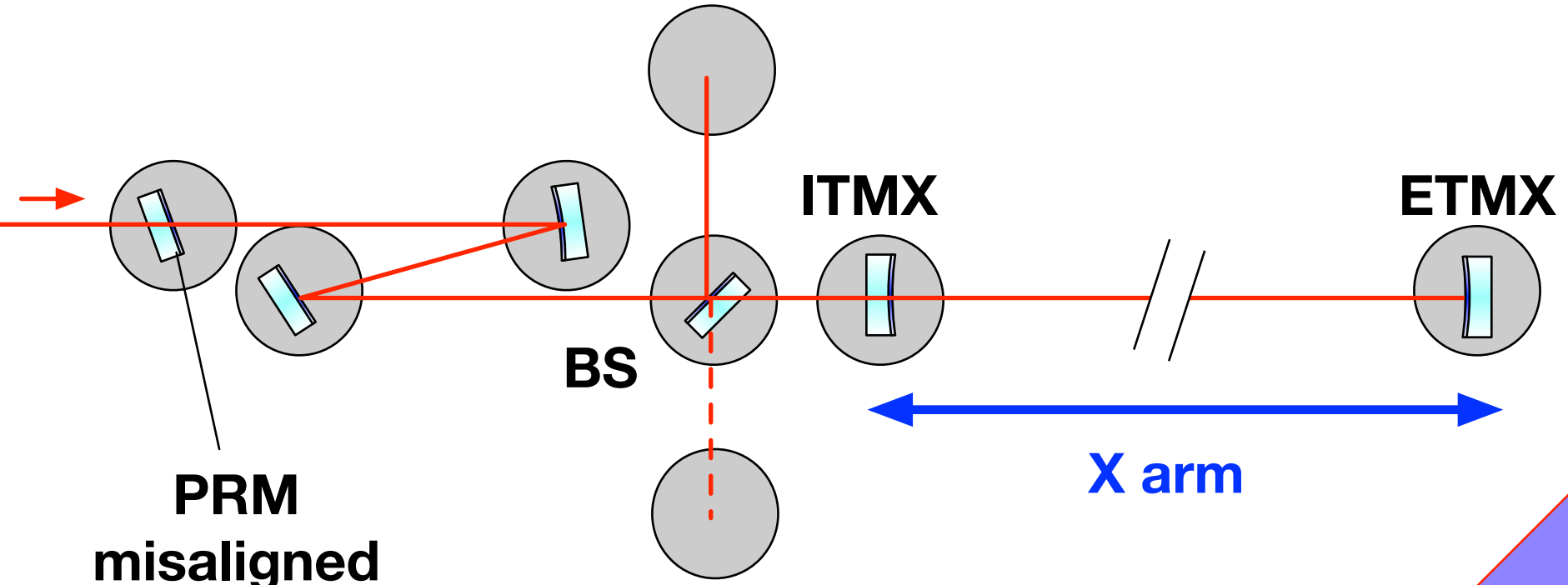
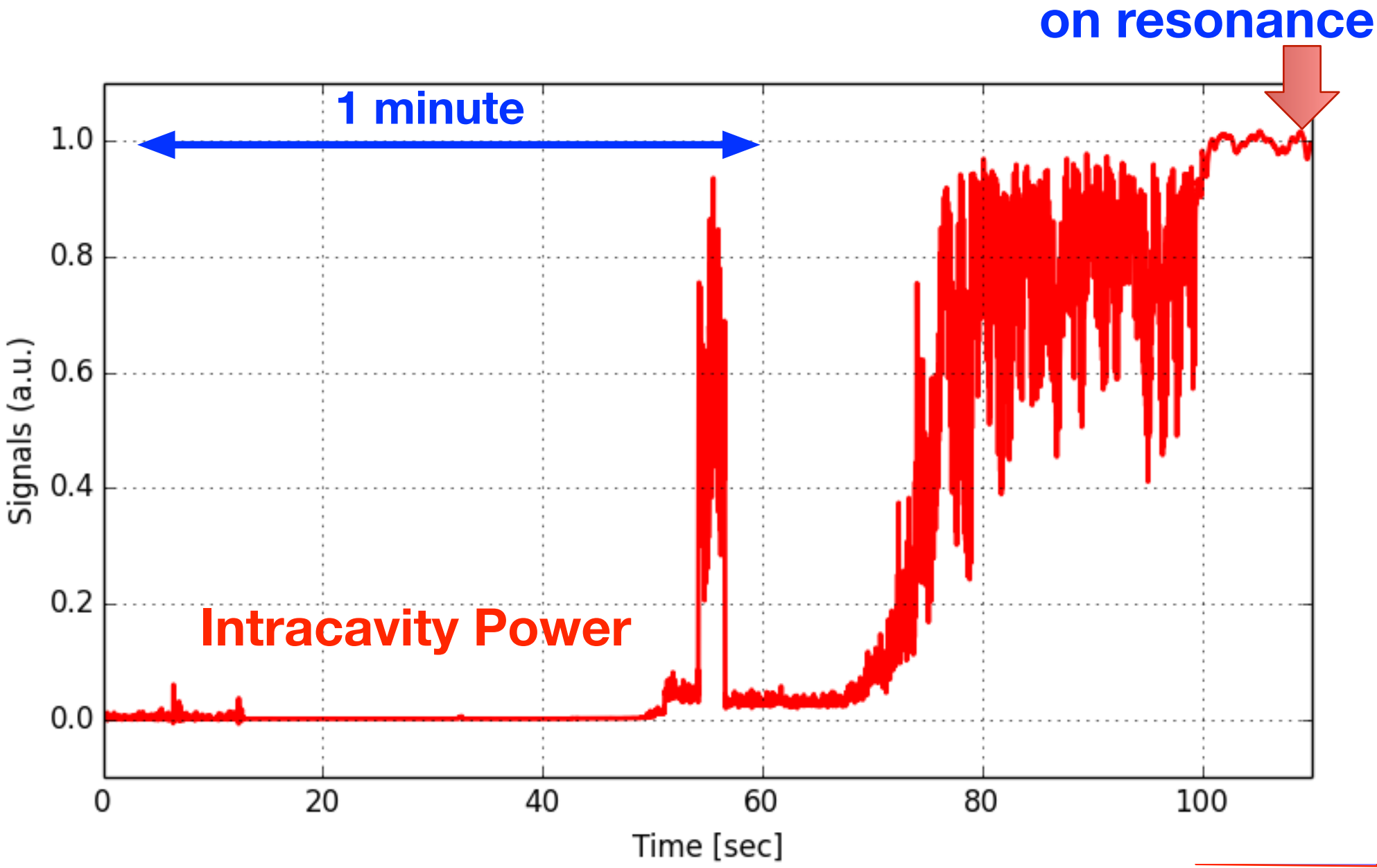
# X arm commissioning

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

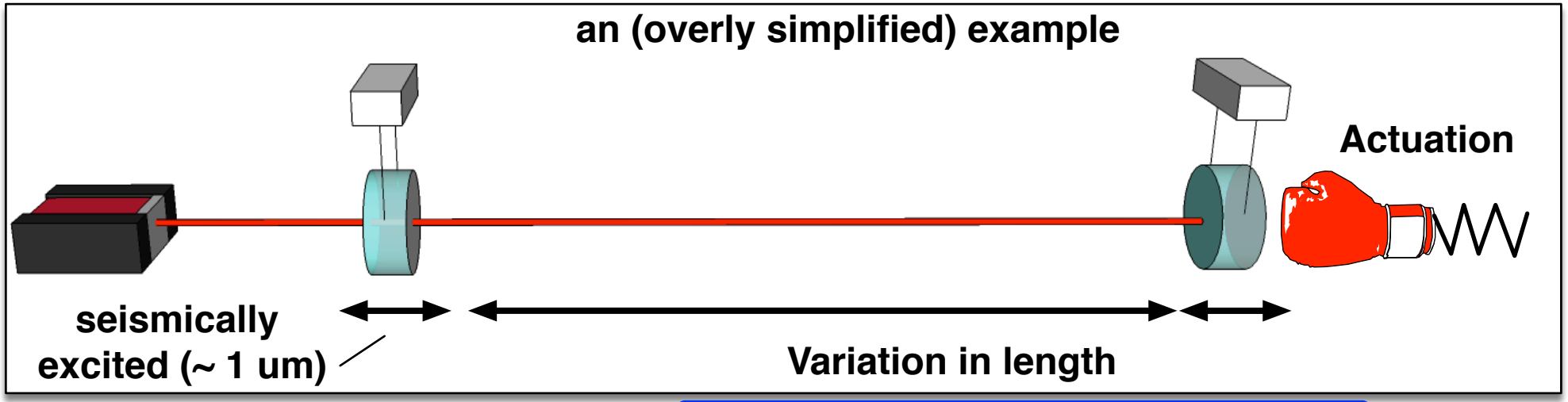


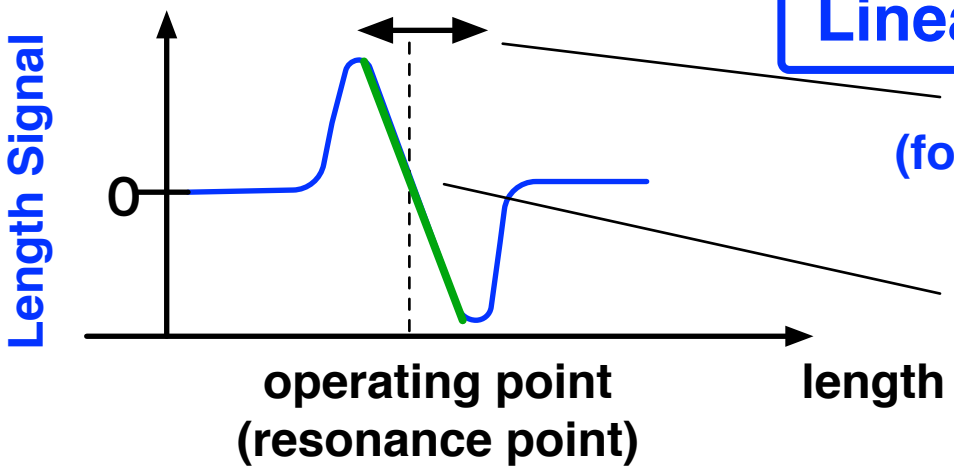
# Highlight


on resonance
1 minute
Intracavity Power
Signals (a.u.)
Time [sec]
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100

# Lock acquisition is not trivial

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




**Linear range is so narrow!**

**~0.4 nm**
**(for 3 km cavity)**

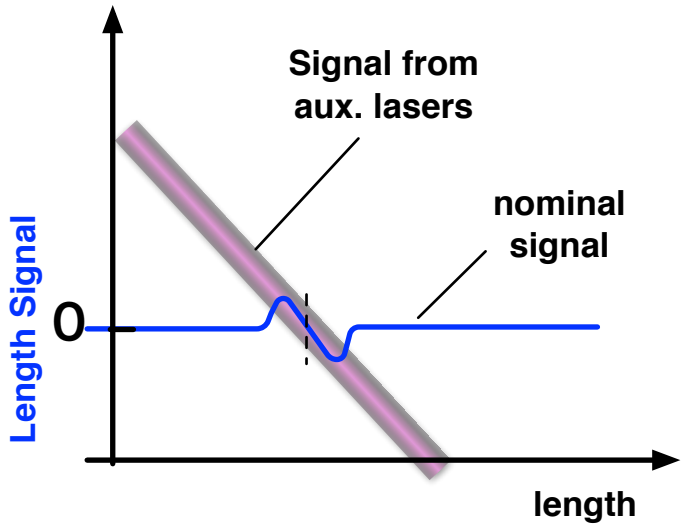
**linear signal**

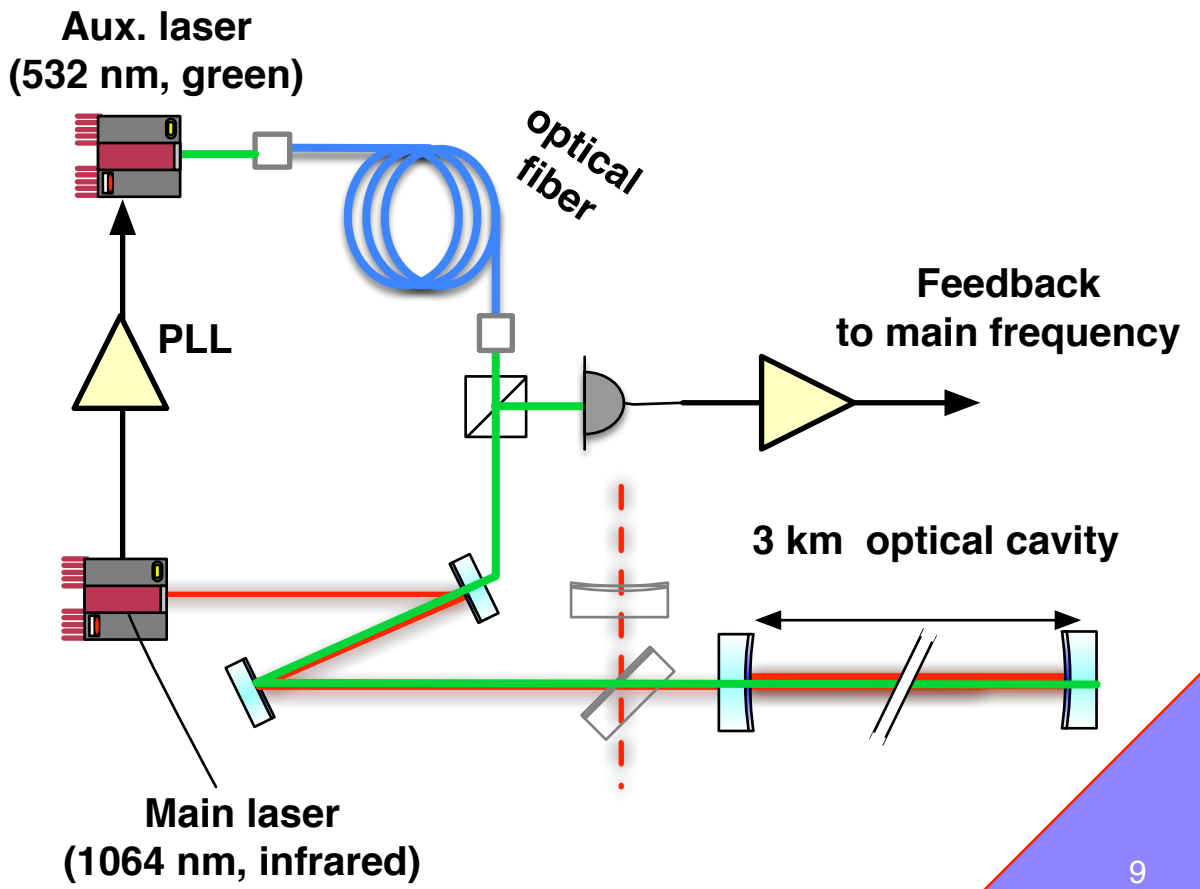
**Need for addressing this issue!**

# A solution: green lock

- Provision of an independent arm-length sensor [1,2]
- A key for the full interferometer operation (e.g. LIGO)
- Reduction of the complexity in the length sensing

**Wider linear range at cost of precision**





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

# Features

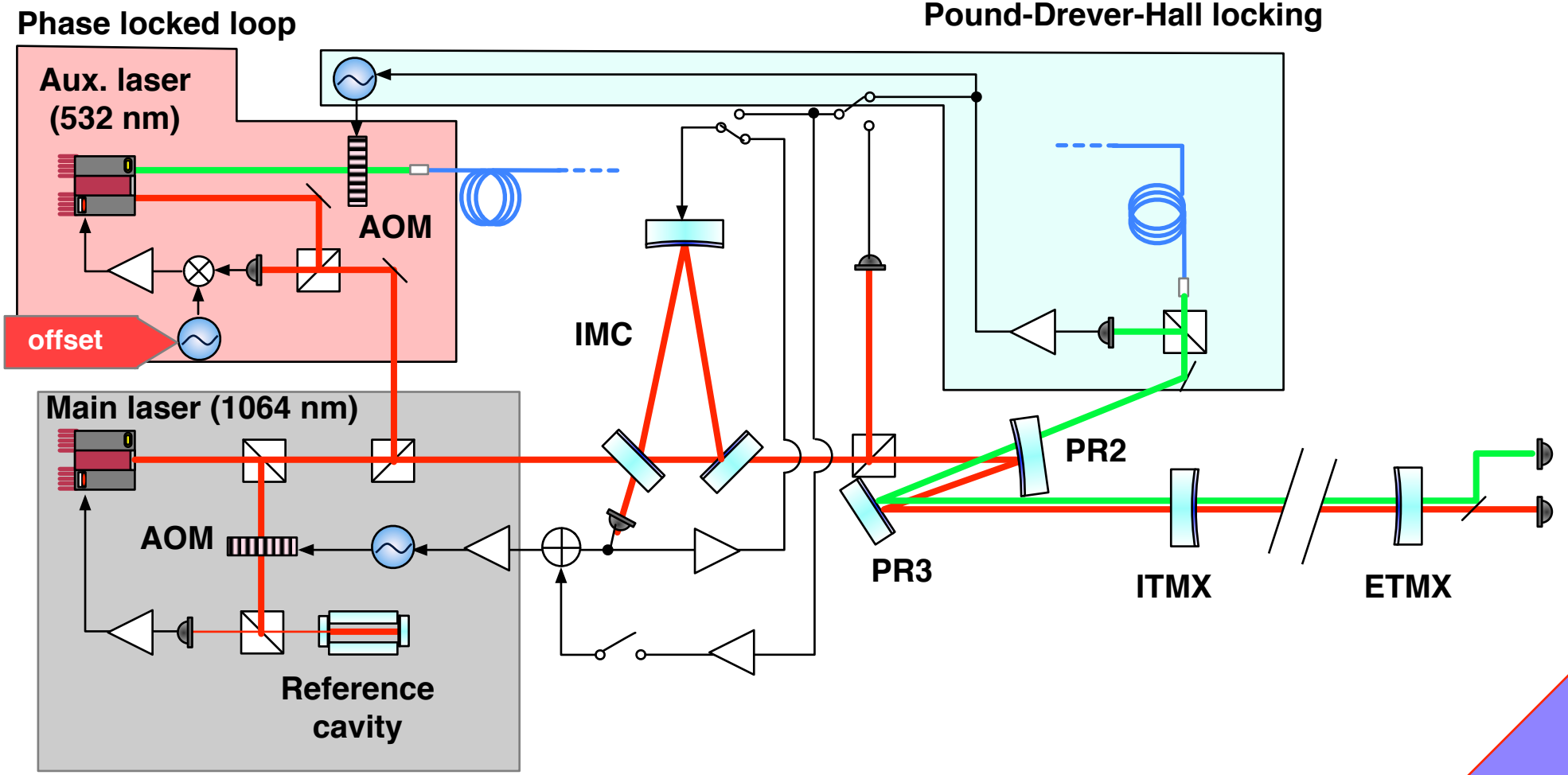
**Major differences from LIGO's system [1]**

- **Injection of green light from the center area (No km-long fibers required!)**
- **Provision of green light through optical fiber**
- **Signals are derived for each arm individually (i.e. X and Y arms)**

**While these features make the system more tractable, careful investigation of noises intrinsic to our setup is necessary.**

[1] A. Staley et al., Class. Quantum Grav. 00, 245010 (2014)

# Green lock setup



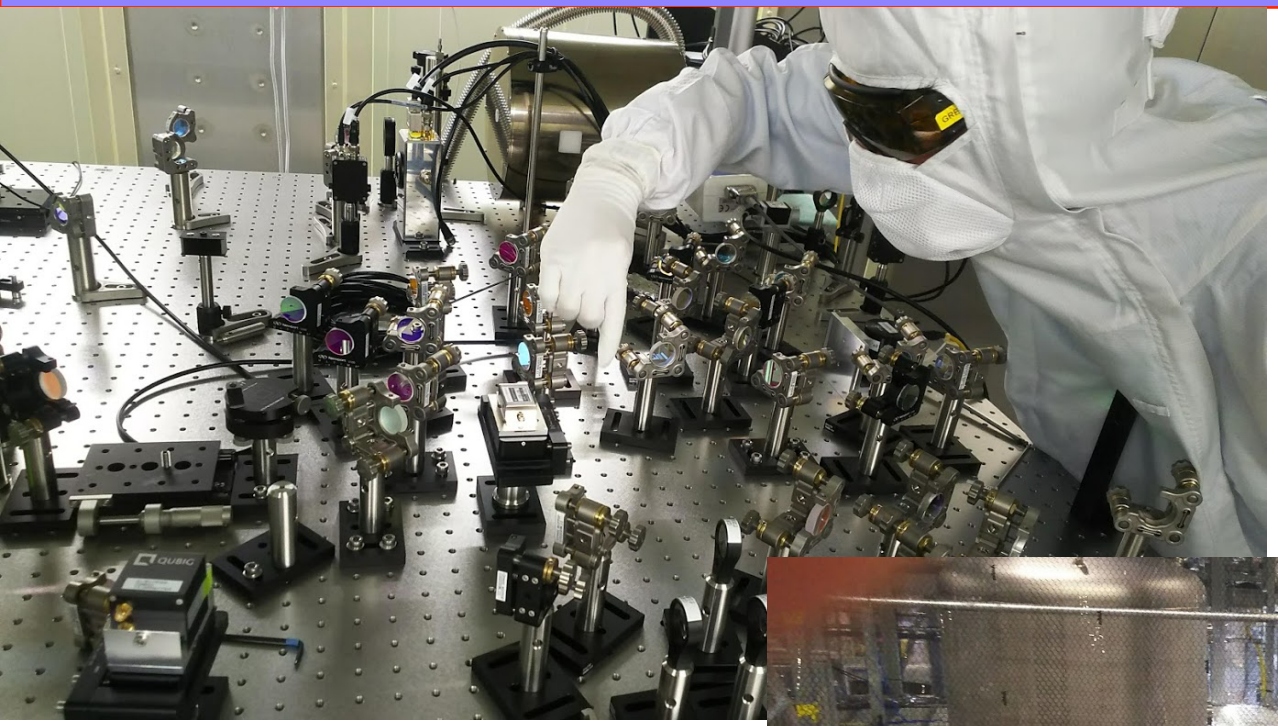

Freq. stabilization

# How it went

**On-site preparation: a few months**
**Experimental period: ~3 months**

- **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**

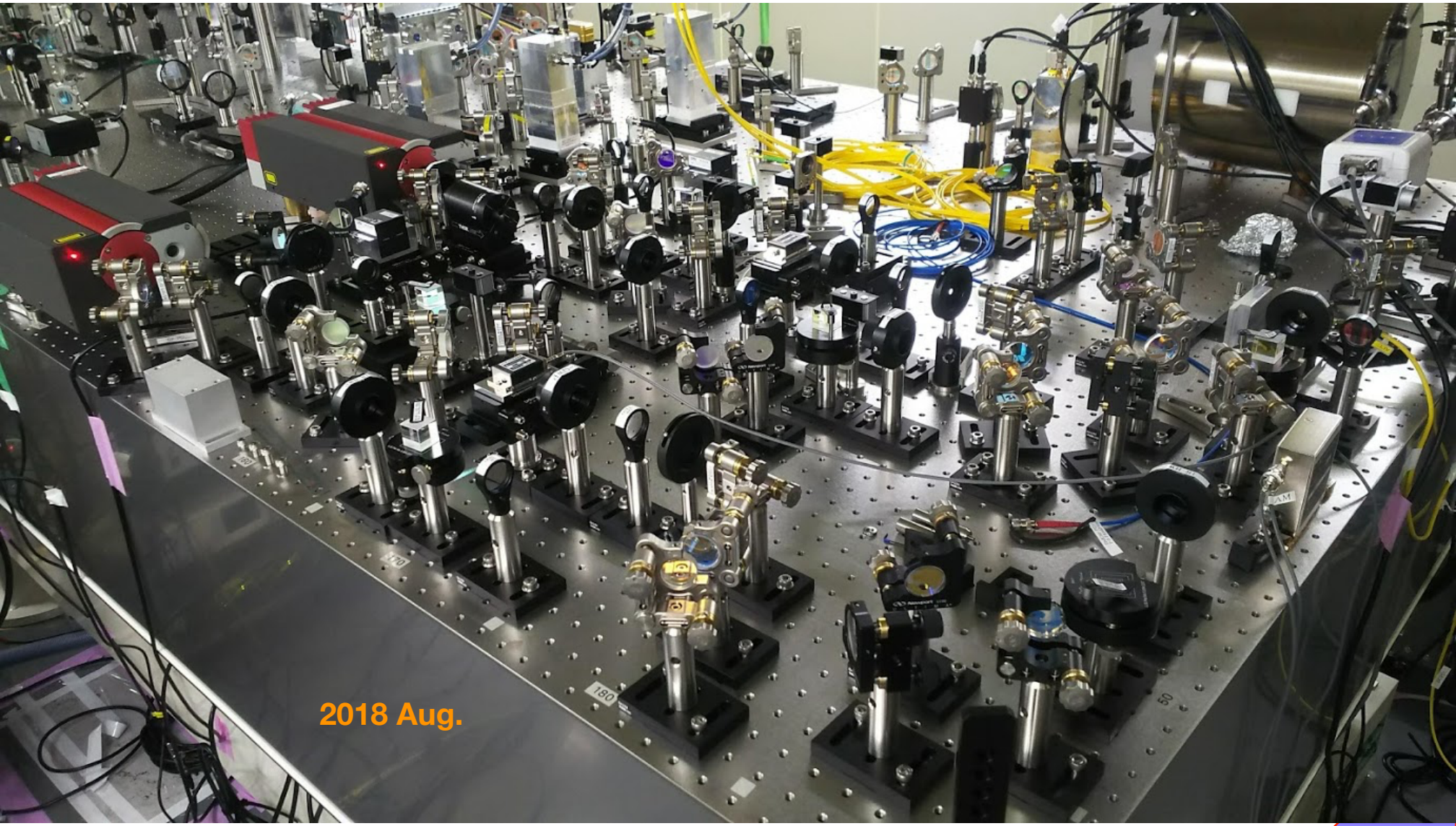
# Hardware installation



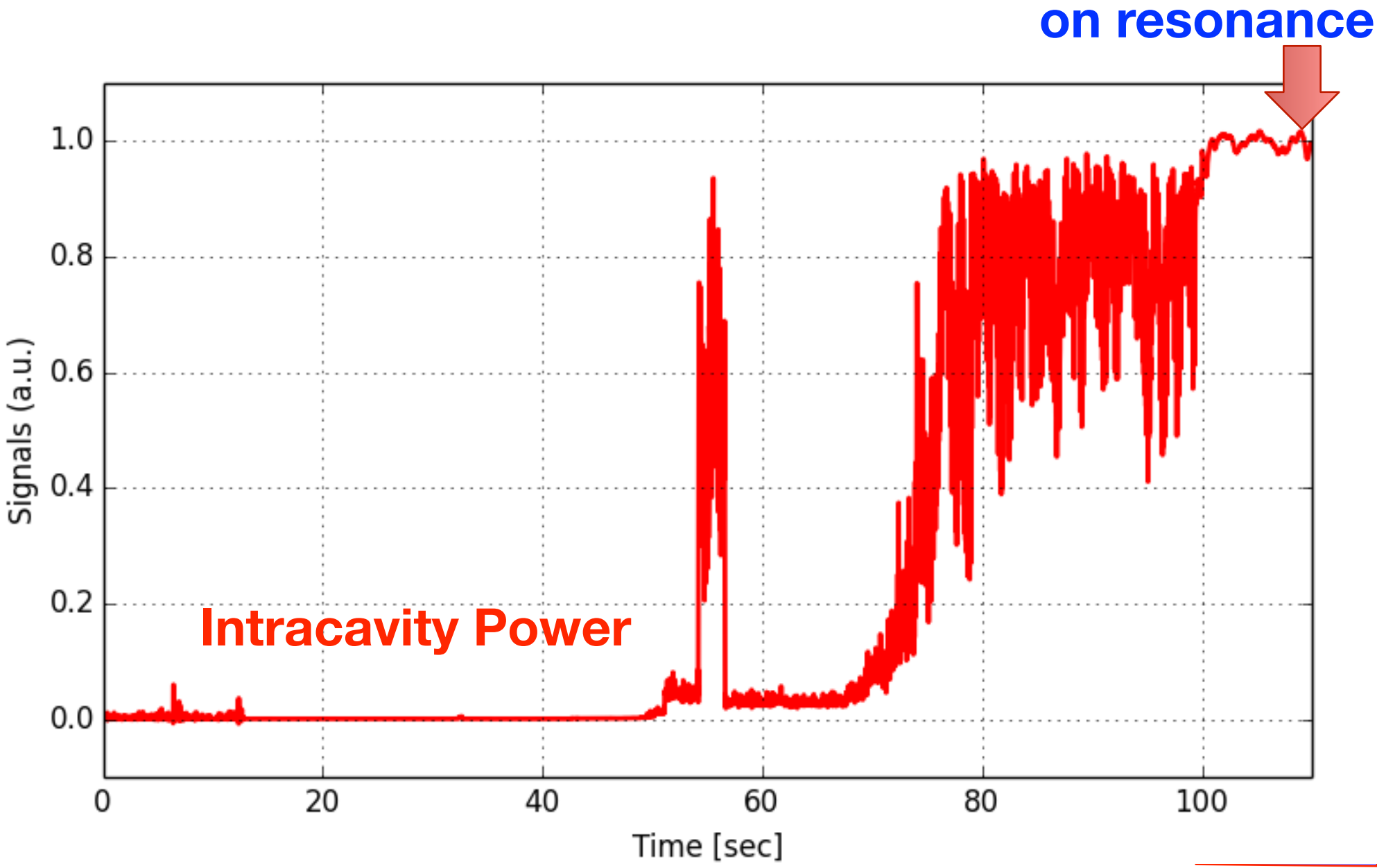
**2018 summer:**
**Installation of optics by**
**K. Yokogawa and R. Sugimoto**
**(Toyama Univ.)**

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

# Hardware installed



# Hand-over success!



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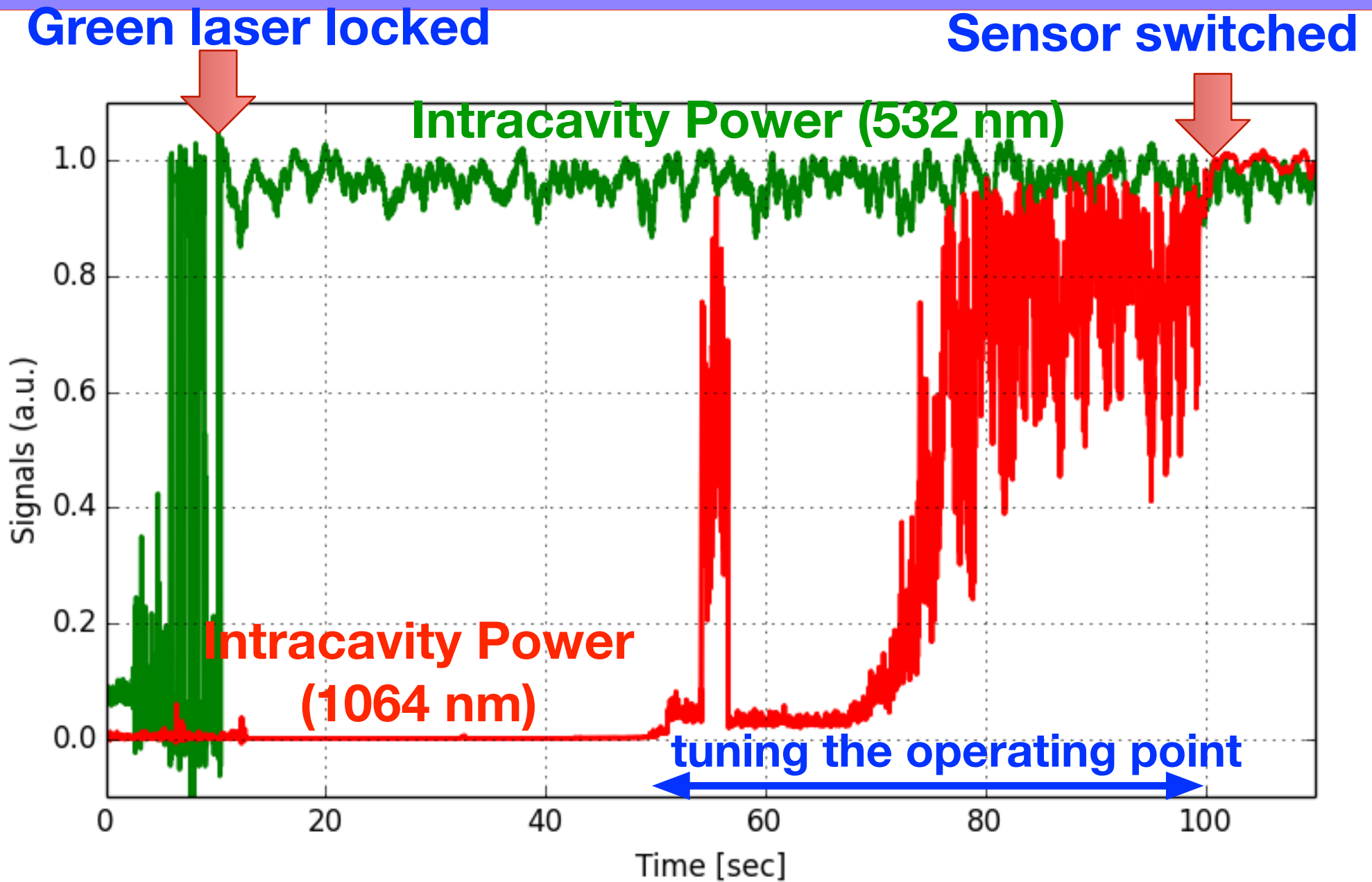
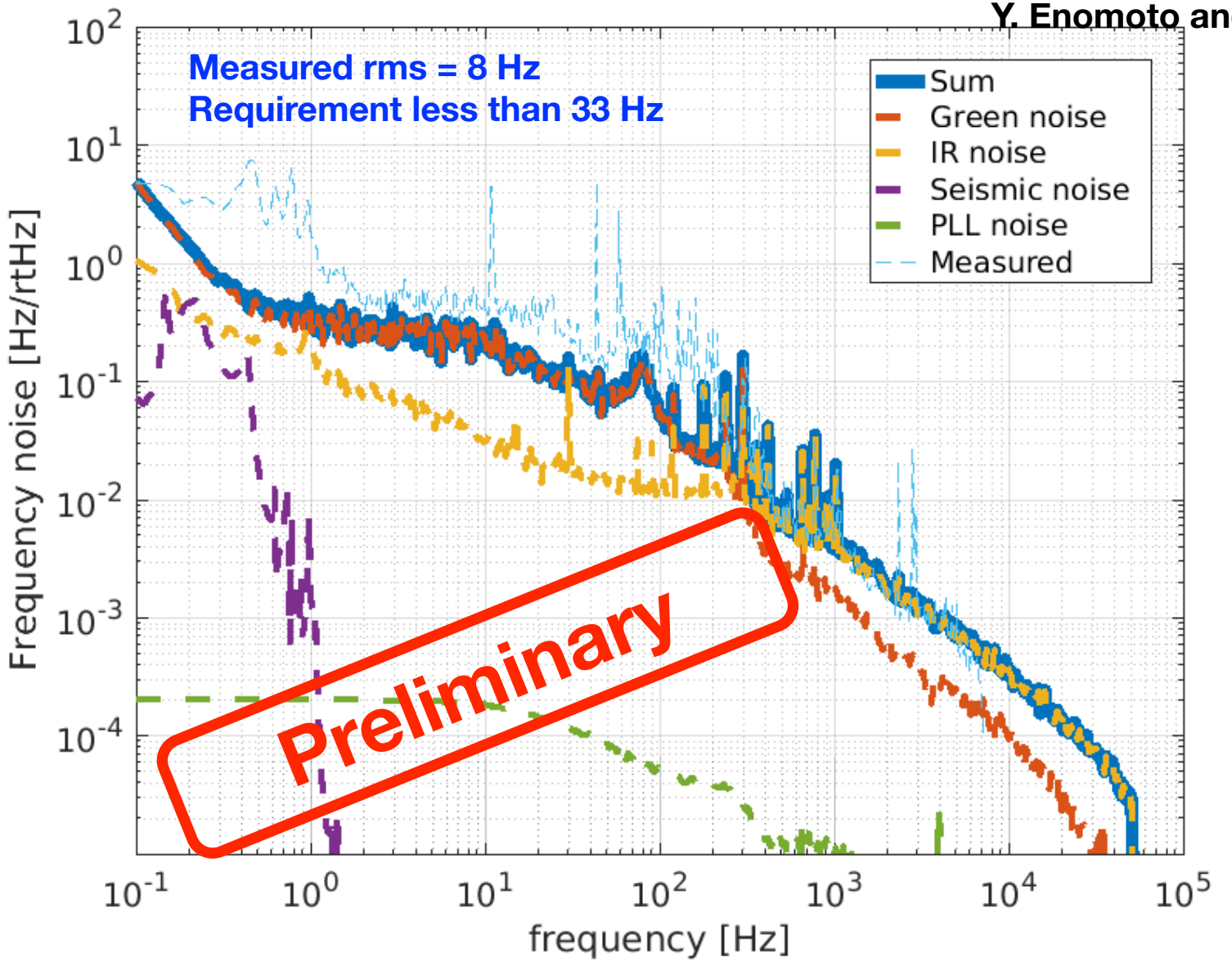
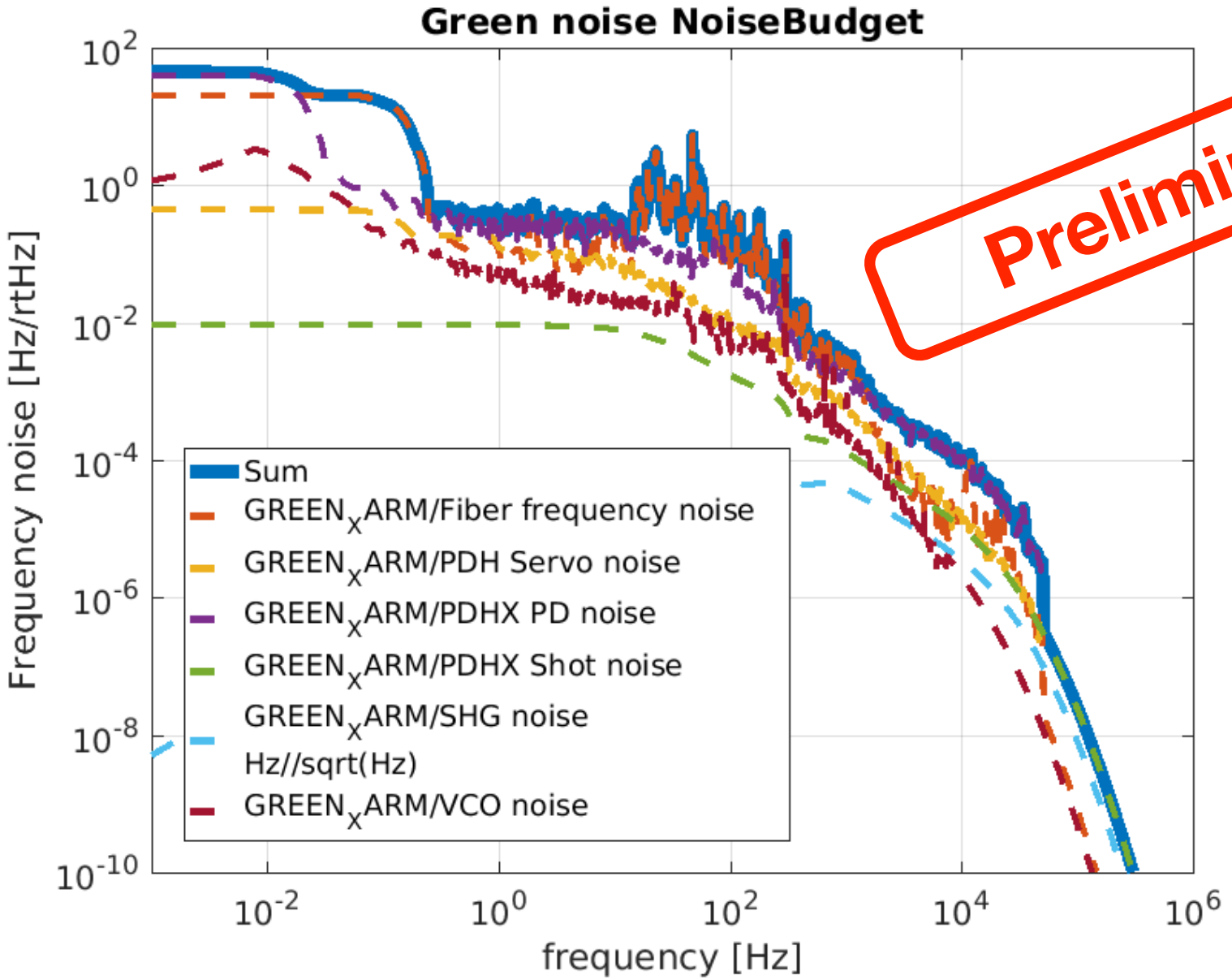


# Required stability achieved

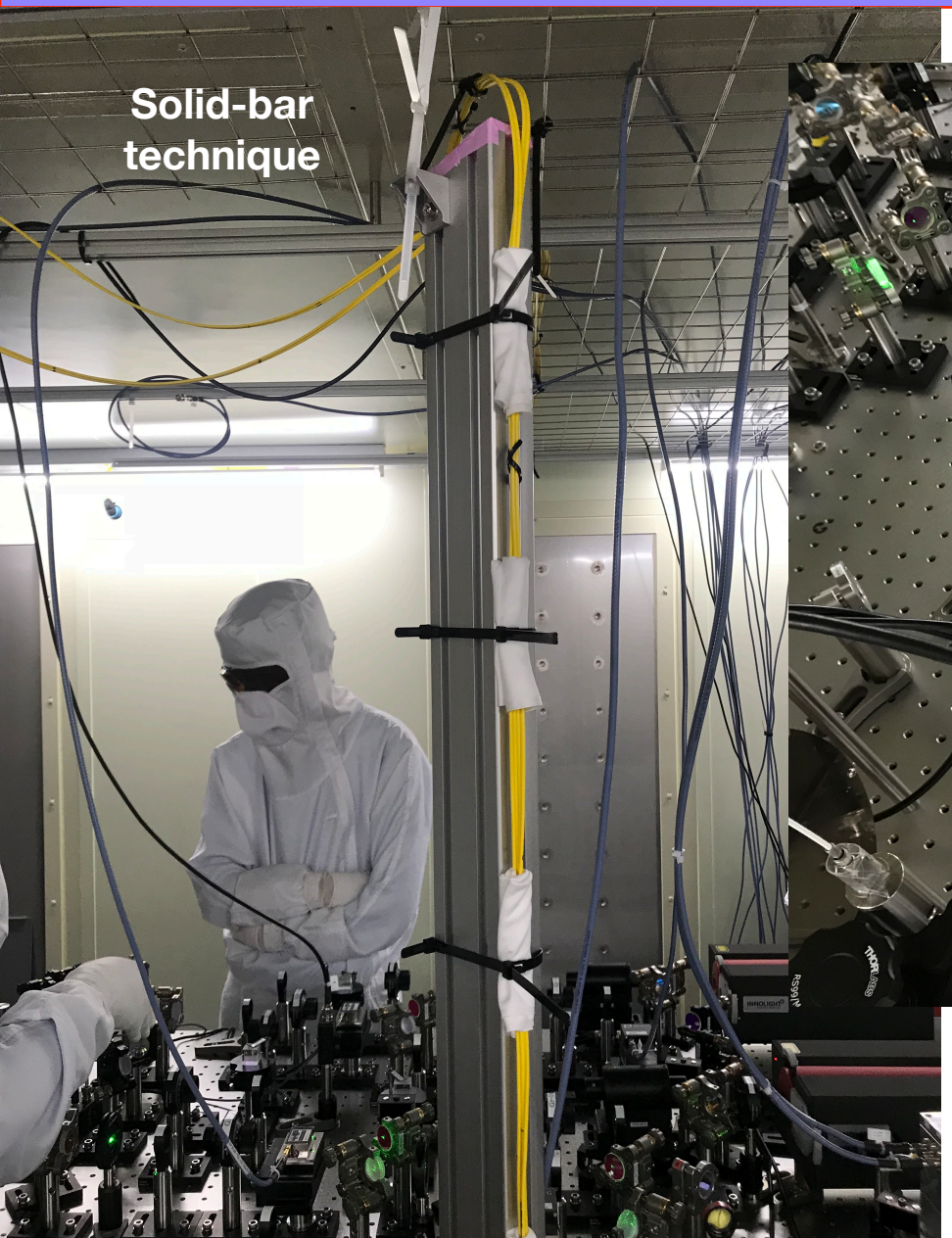
**Calculation/measurement by Y. Enomoto and K. Yokogawa**

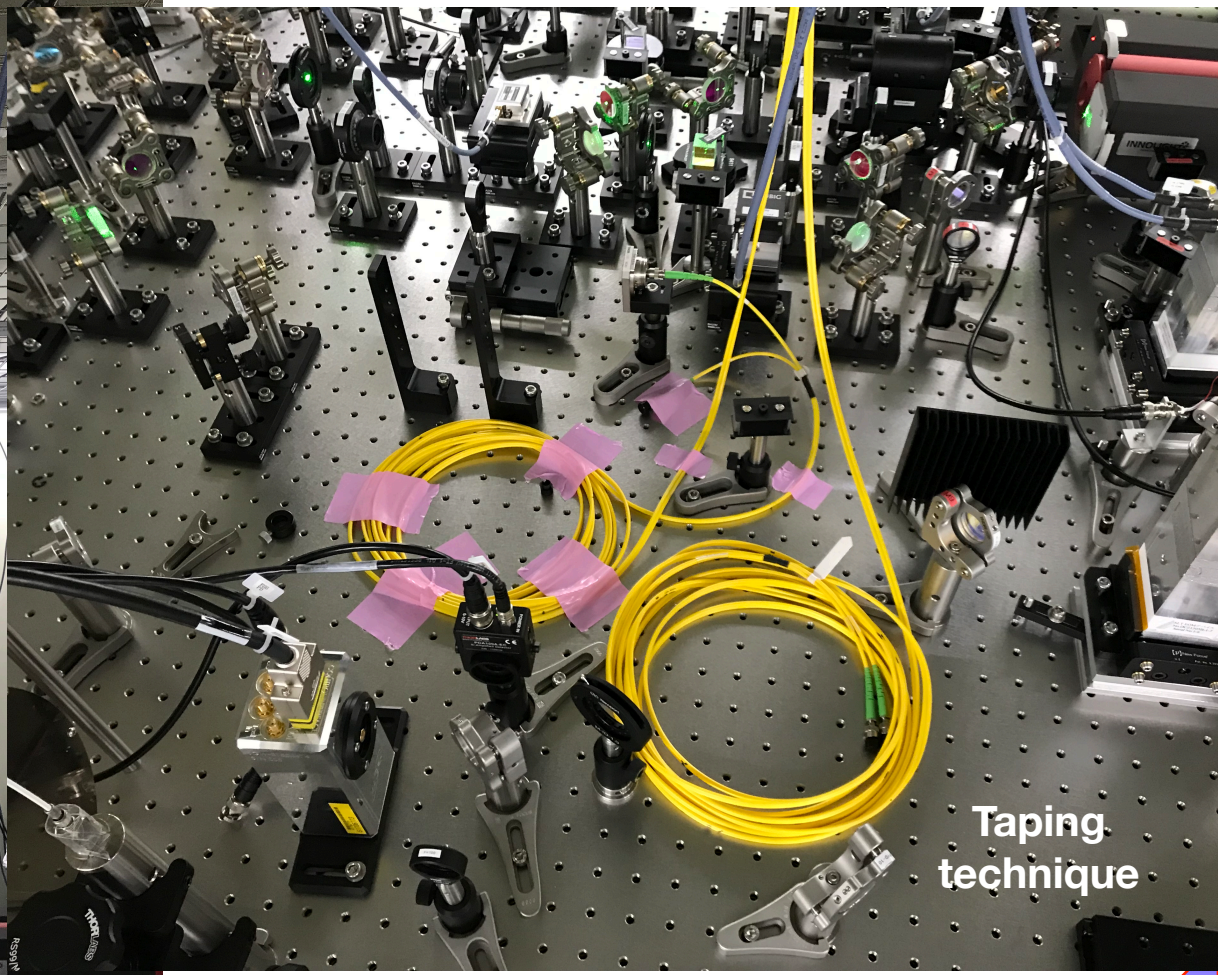


# Noise from green lock system



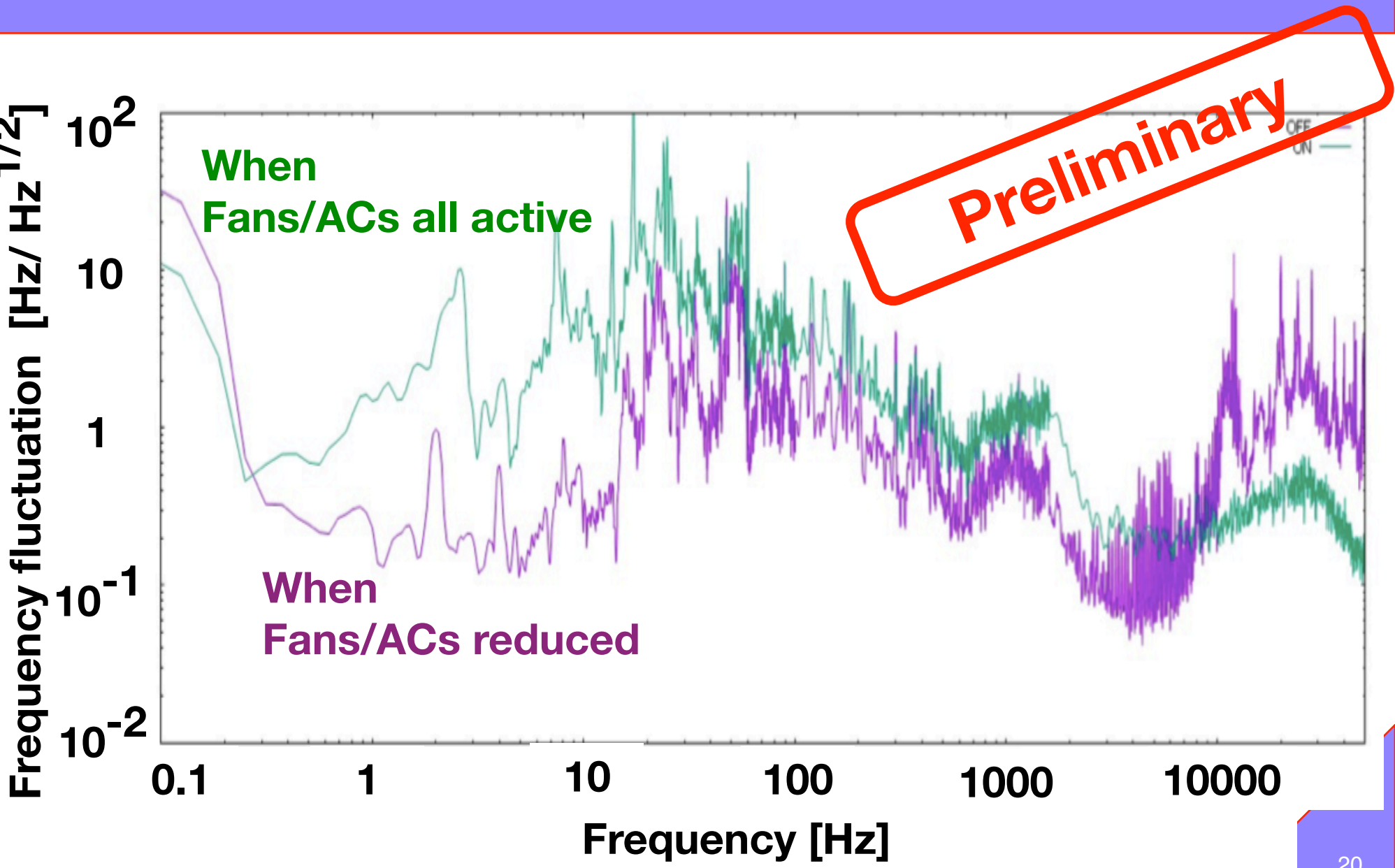
# Fiber noise reduction (temporary)




**Also, reducing air current helped significantly.**

# Measured fiber noise

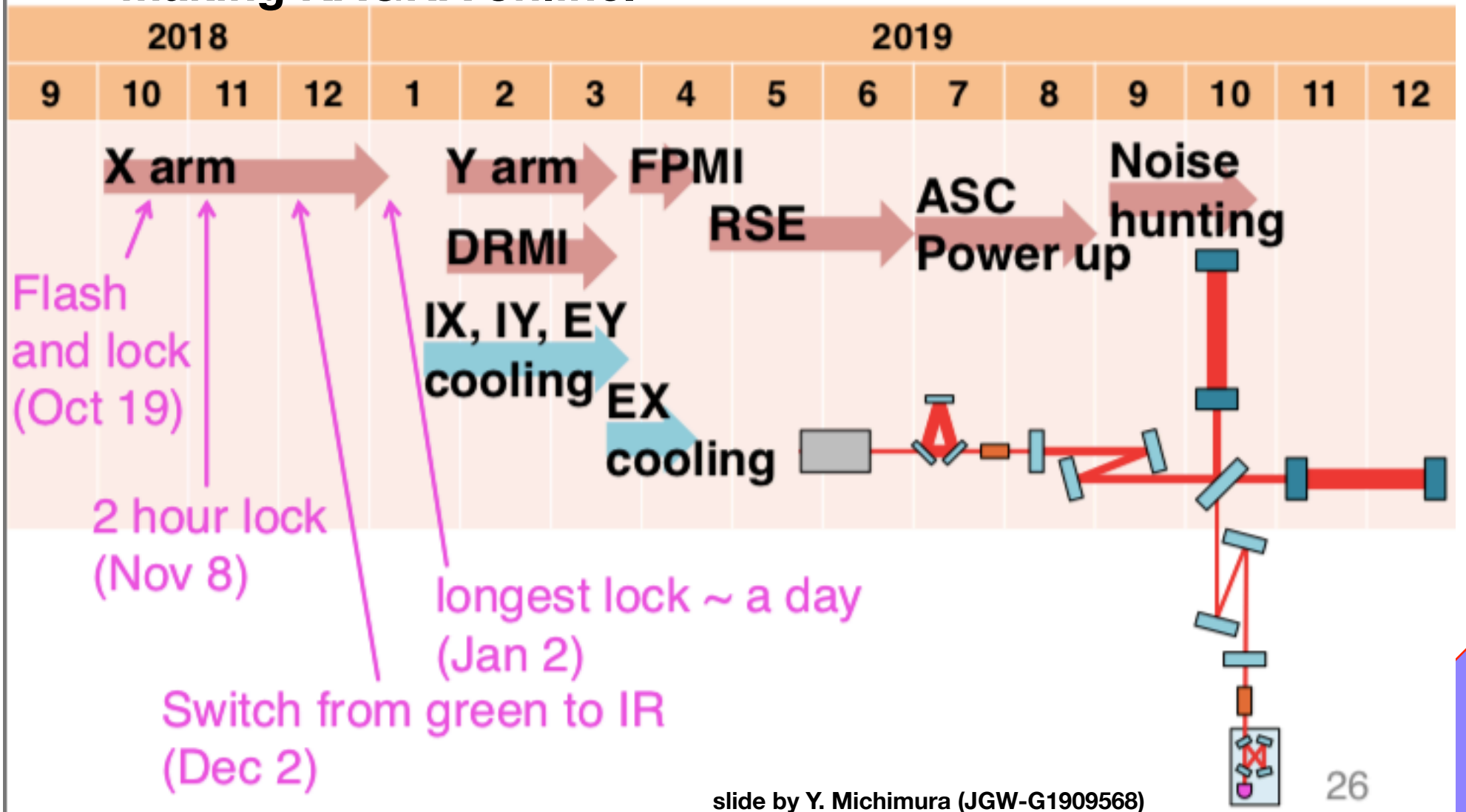


# Most of the goals achieved

- Residual length noise below 0.38 nm in RMS [Achieved]
- Test mass angular fluctuation below 0.88 nm in RMS [Achieved]
- A lock stretch longer than 2 hours [Achieved]
- Demonstration of hand-over to a infrared sensor [Achieved]
- Establishment of initial alignment procedure 30% done
- Direct lock of the laser frequency without green lock [Achieved]
- Angular fluctuation below 10 nrad with wavefront sensors Postponed
- Full automation of the green lock system [Achieved]

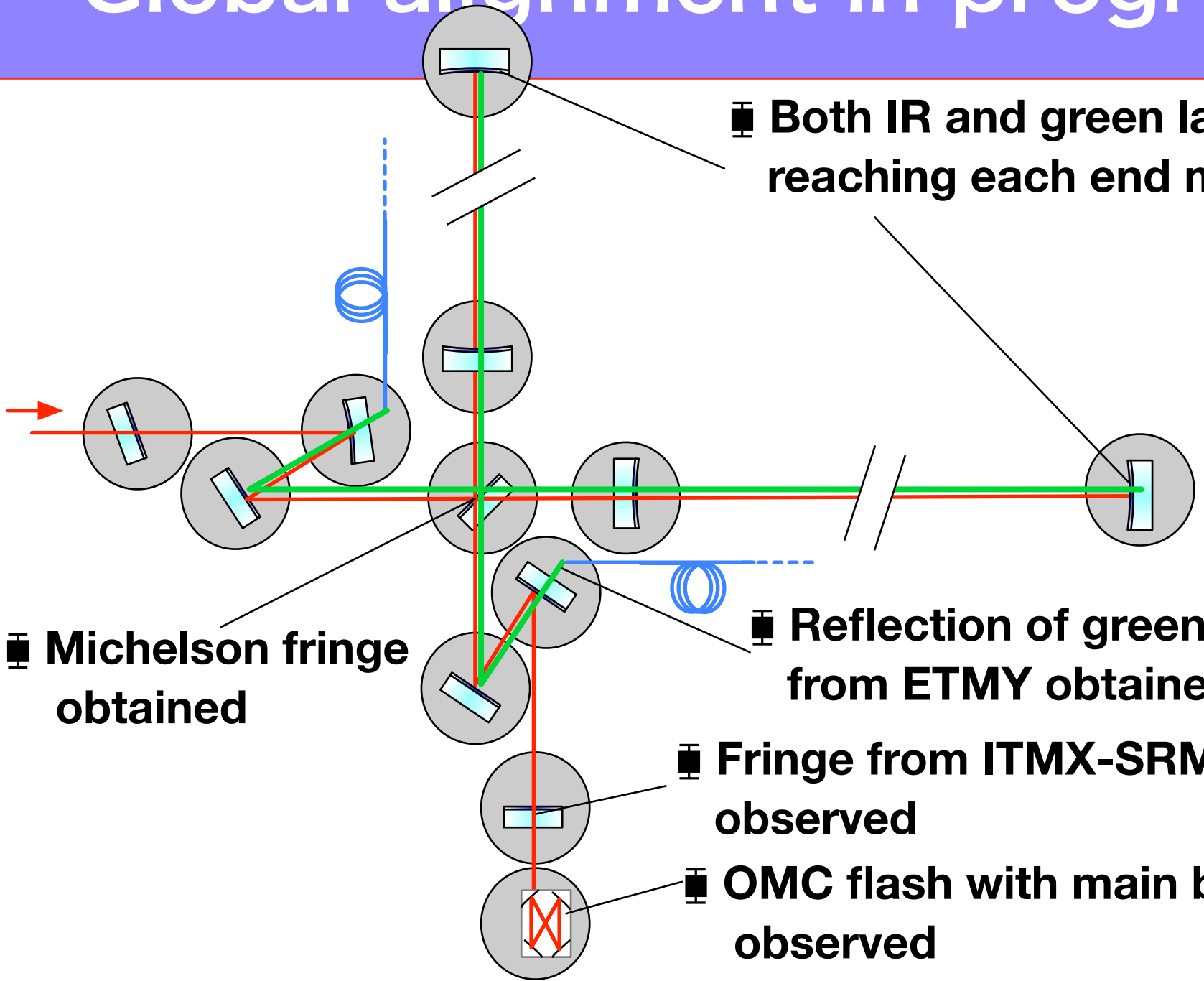
# Into O3

- Several more commissioning experiments before making KAGRA online.




slide by Y. Michimura (JGW-G1909568)

# Global alignment in progress

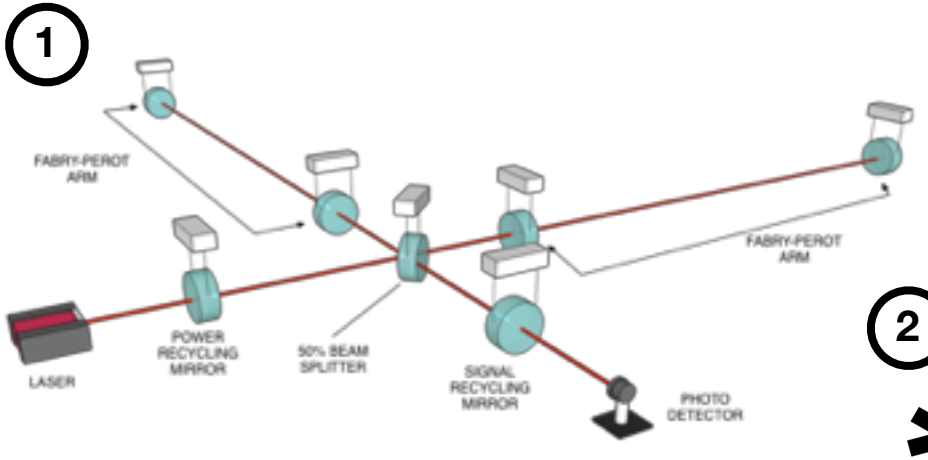


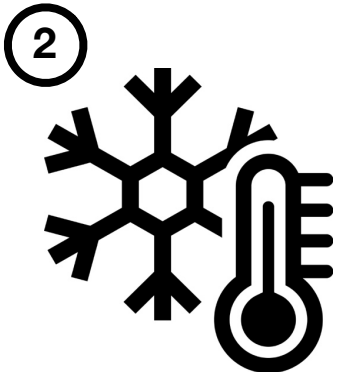
- Both IR and green lasers reaching each end mirror
- Michelson fringe obtained
- Reflection of green laser from ETMY obtained
- Fringe from ITMX-SRM cavity observed
- OMC flash with main beam observed

# Summary

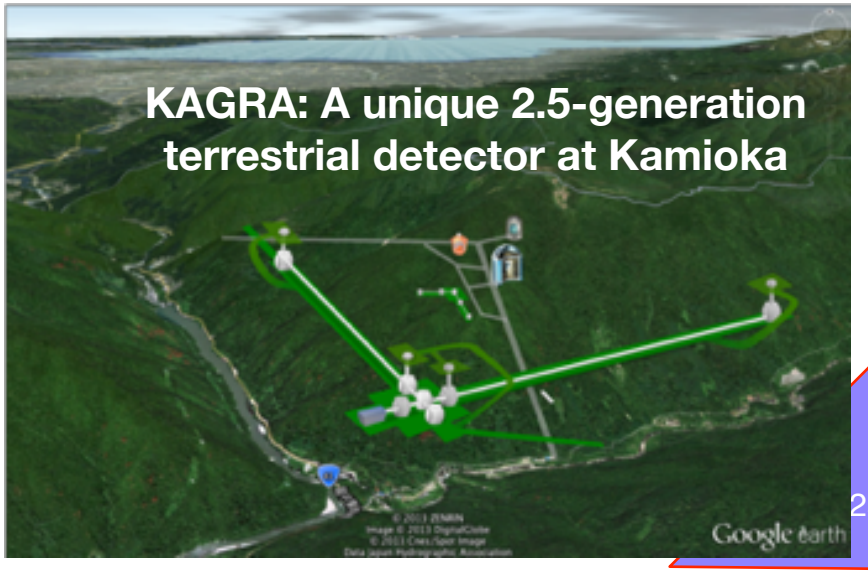
- The X arm commissioning has concluded with success.
- One critical finding: green lock suffers from fiber noise.
  Temporarily addressed.
- The DRMI commissioning experiment will start
  in the middle of this month (February).
- A few more commissioning experiments are foreseen
  before becoming a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

# KAGRA

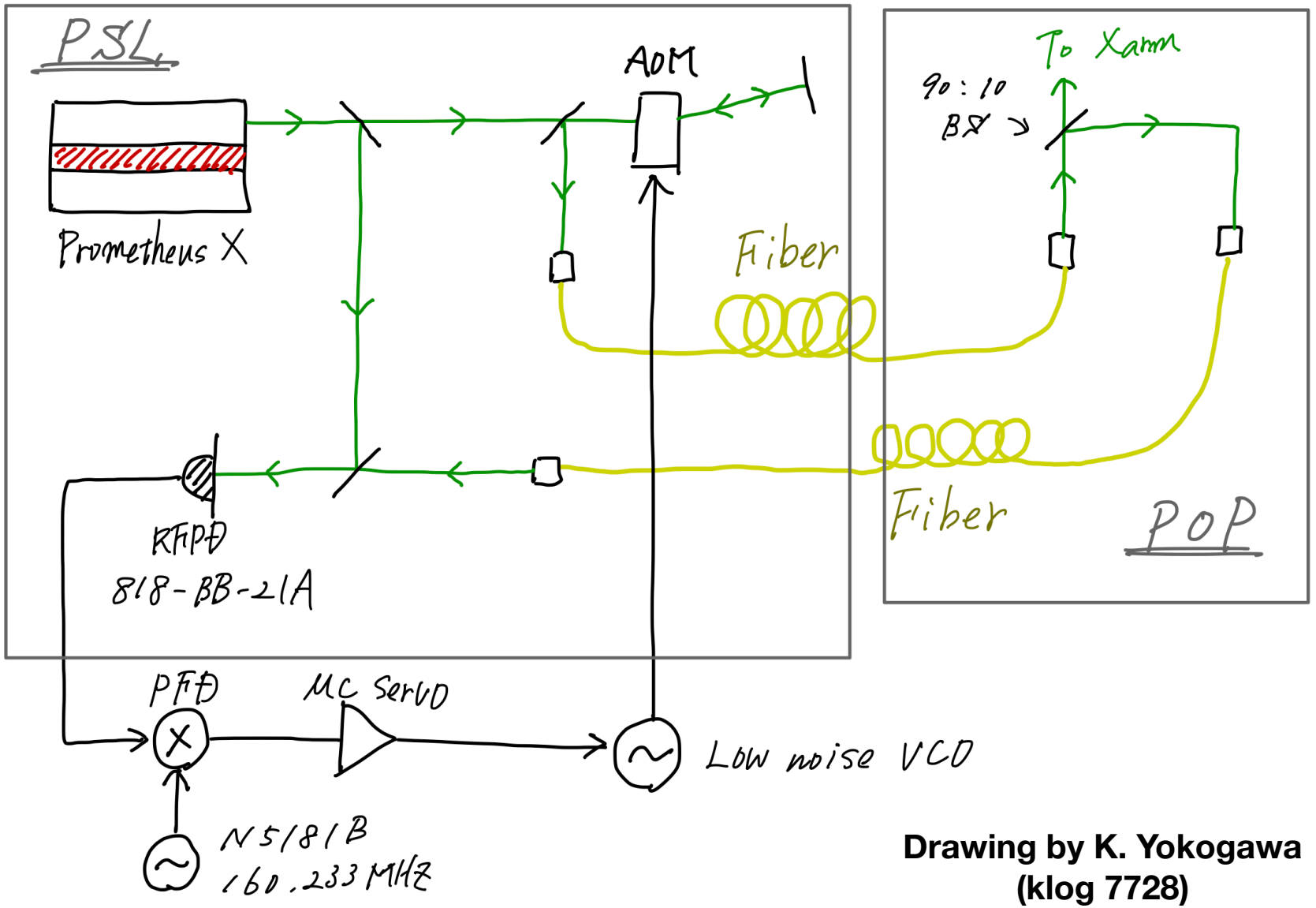



1. **A 3-km Dual-recycled Fabry-Perot Michelson laser interferometer**
2. **Cryogenic mirrors [KAGRA only]**
3. **Underground [KAGRA only]**



# Fiber Noise Measurement




**Drawing by K. Yokogawa (klog 7728)**