bKAGRA Phase 1 Overview

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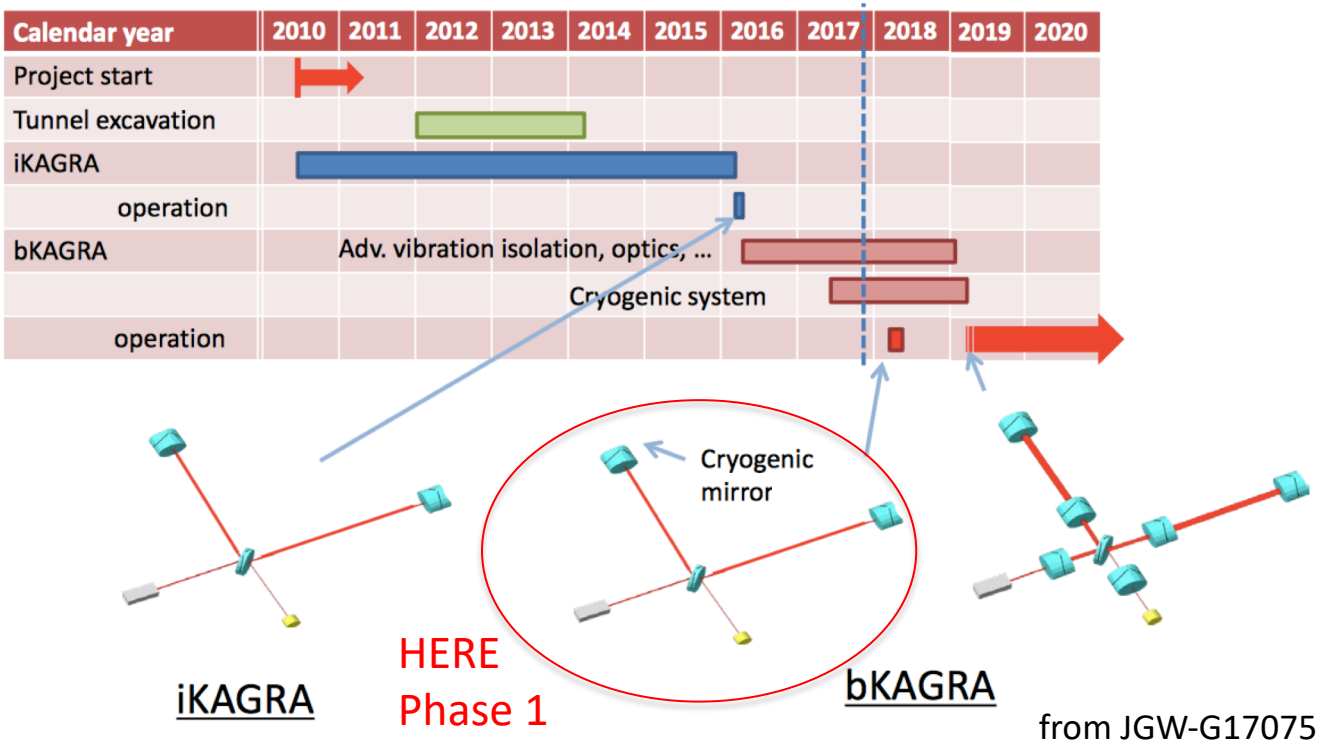
-- bKAGRA Phase 1: Operation of large scale interferometer with a cryogenic mirror, held in Apr 28 – May 6, 2018

-- Aim: Operation and characterization of full KAGRA suspensions including [cryogenic payload]



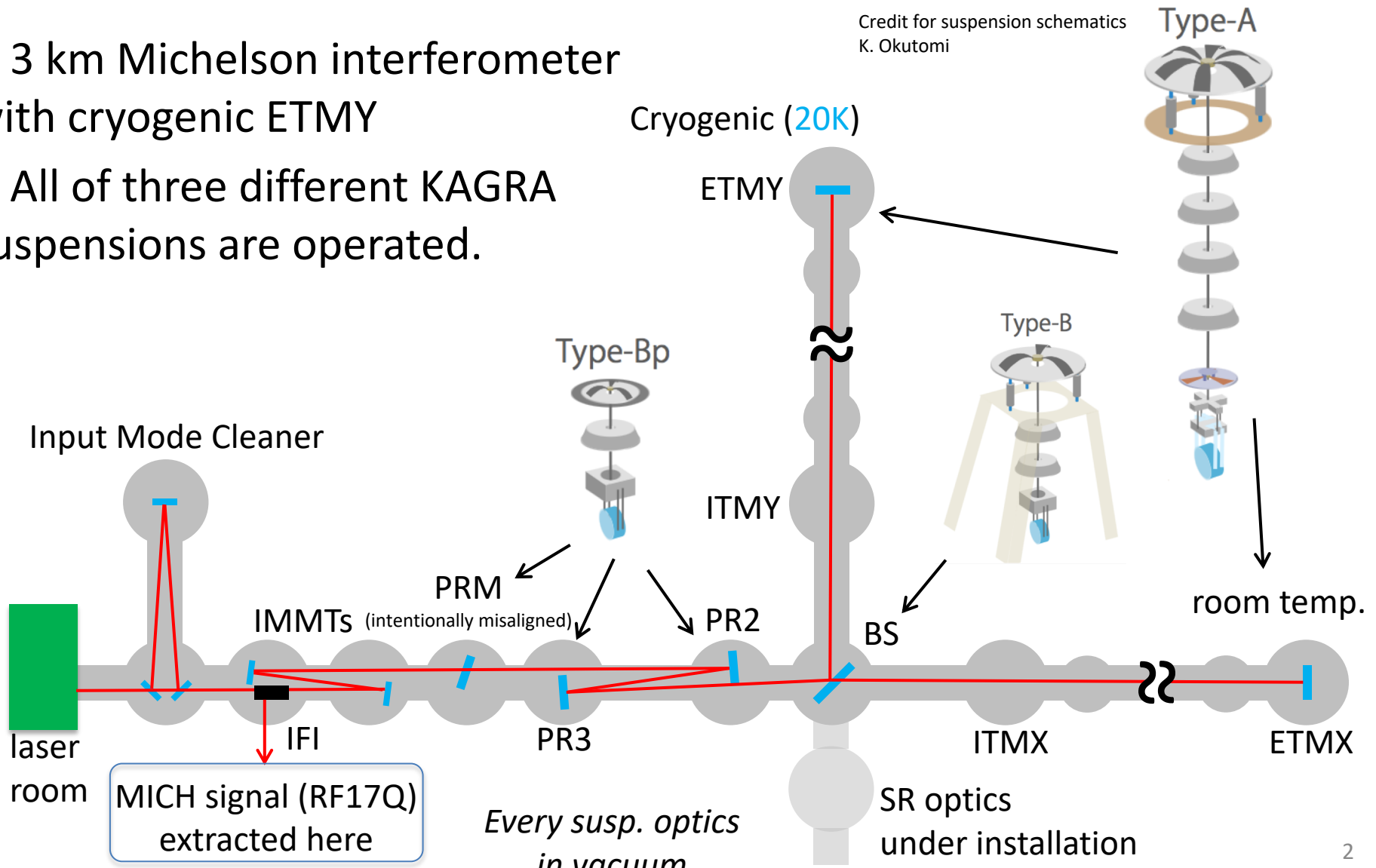
from JGW-G1707532-v1

Phase 1 Overview

Interferometer configuration

-- 3 km Michelson interferometer with cryogenic ETMY

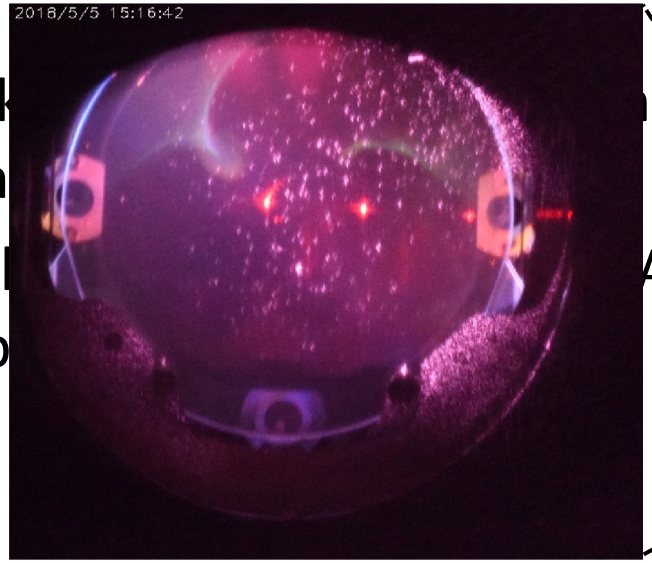
-- All of three different KAGRA suspensions are operated.



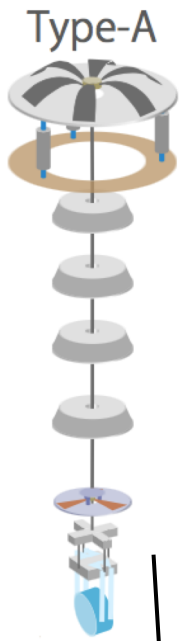
Phase 1 Overview

Interferometer configuration

-- 3 k eter
with
-- All A
susp



Credit for suspension schematics
K. Okutomi



Cryogenic (20K)

ETMY

Type-Bp

Type-B

Input Mode Cleaner

ITMY

PRM

IMMTs (intentionally misaligned)

PR2

BS

room temp.

laser room

IFI

PR3

ITMX

ETMX

MICH signal (RF17Q) extracted here

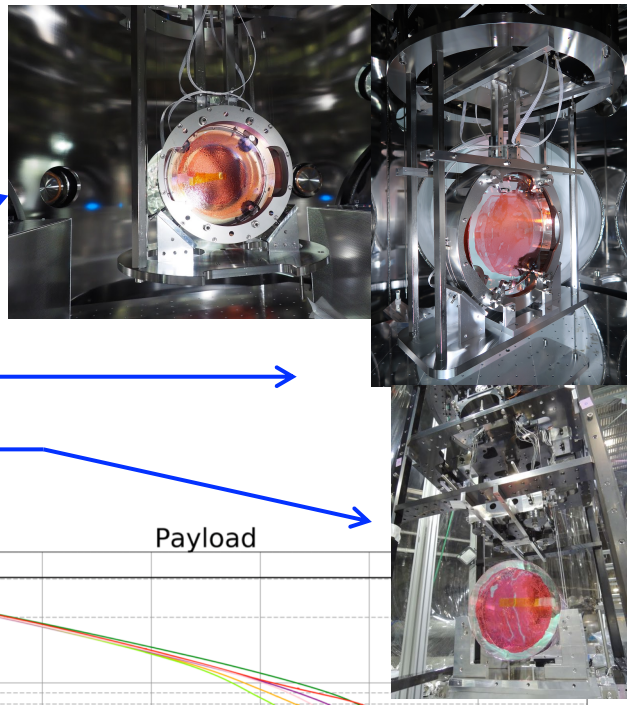
Every susp. optics in vacuum

SR optics under installation

Phase 1 Overview

Milestones

Suspension
Cryogenic
Interferometer



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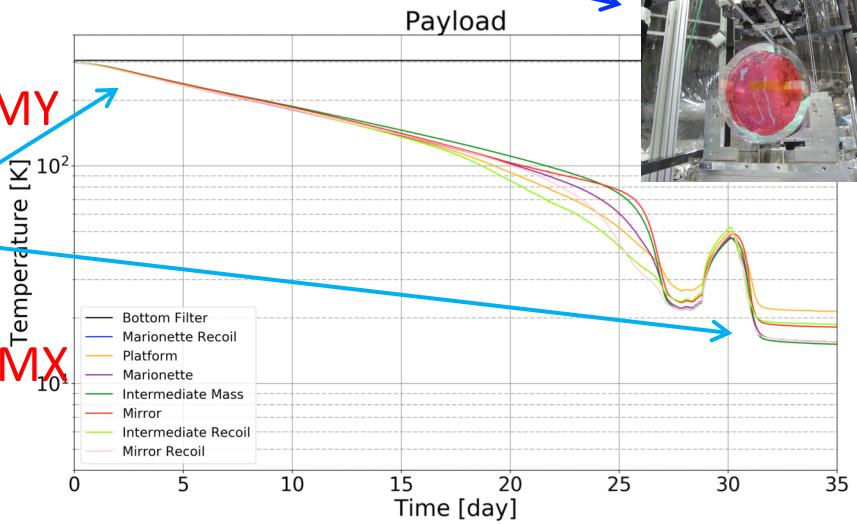
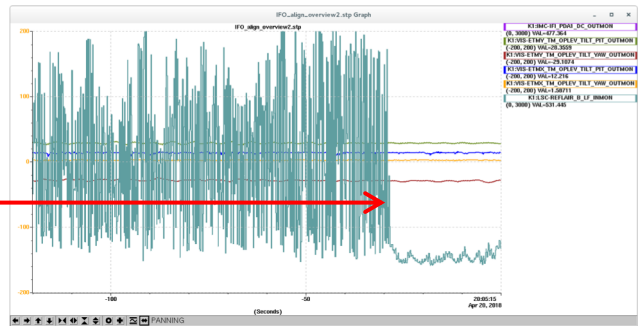
* Apr 20 2018: Michelson locked
* Apr 28 2018: **Phase 1 Operation started**





Phase 1 Overview

Milestones

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Cryogenic
Interferometer

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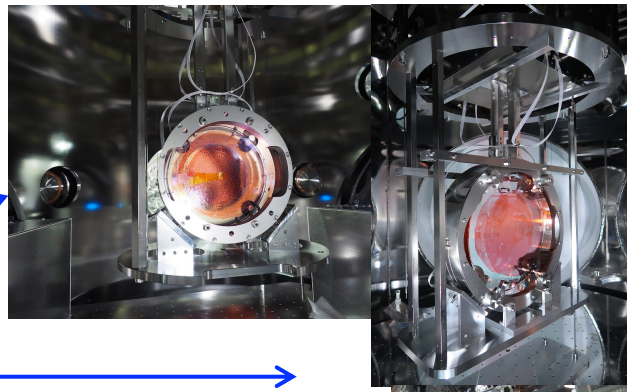
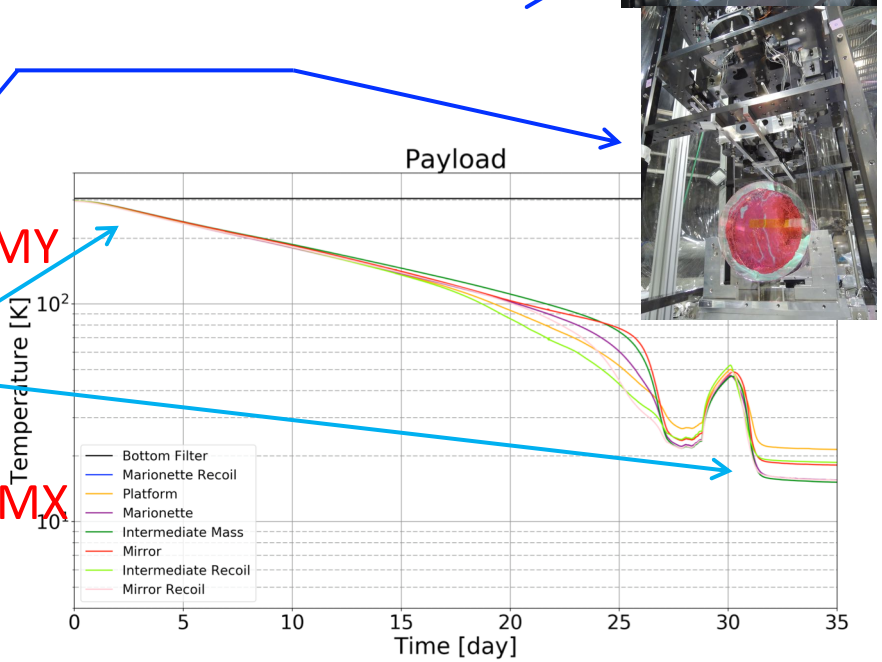
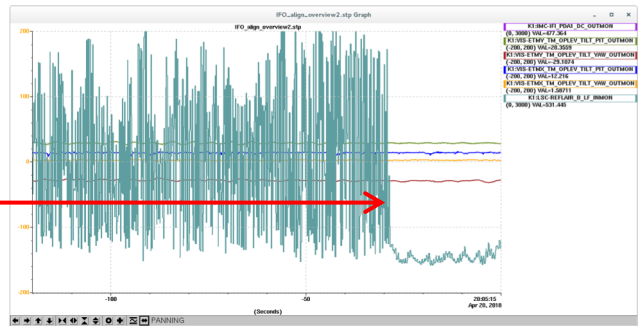






We rushed toward the Operation.

Phase 1 Overview

Cooling down ETMY

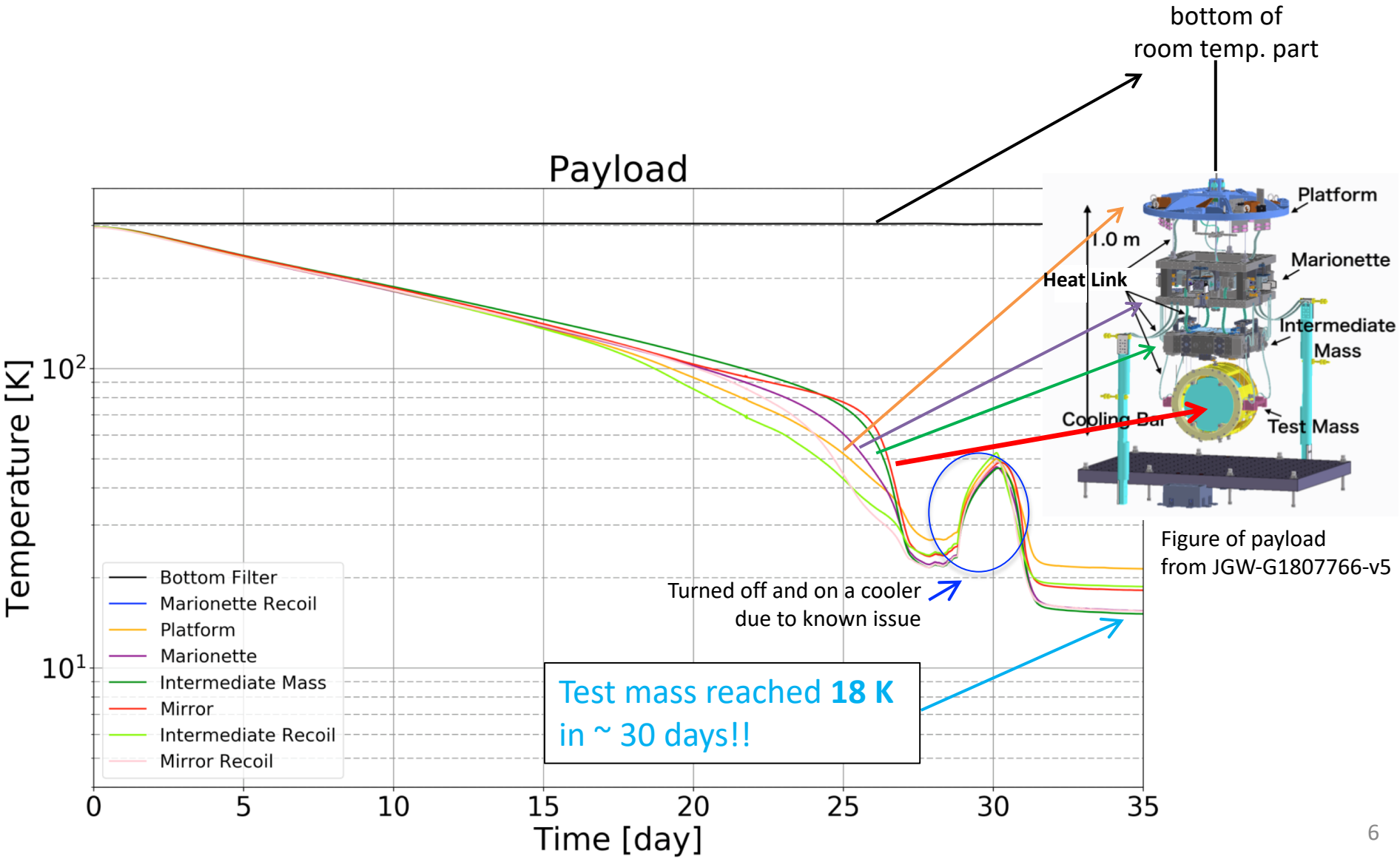
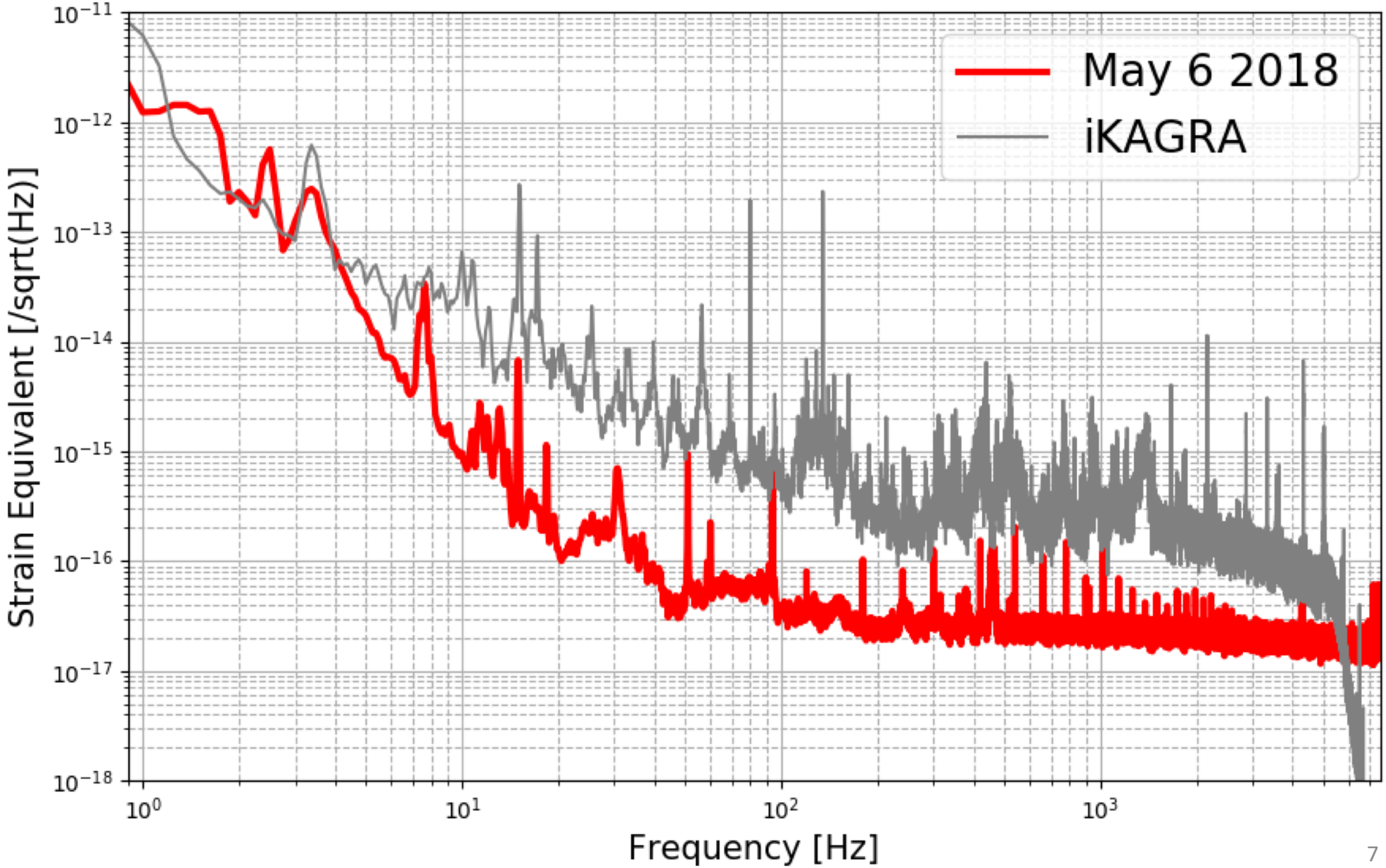


Figure of payload
from JGW-G1807766-v5

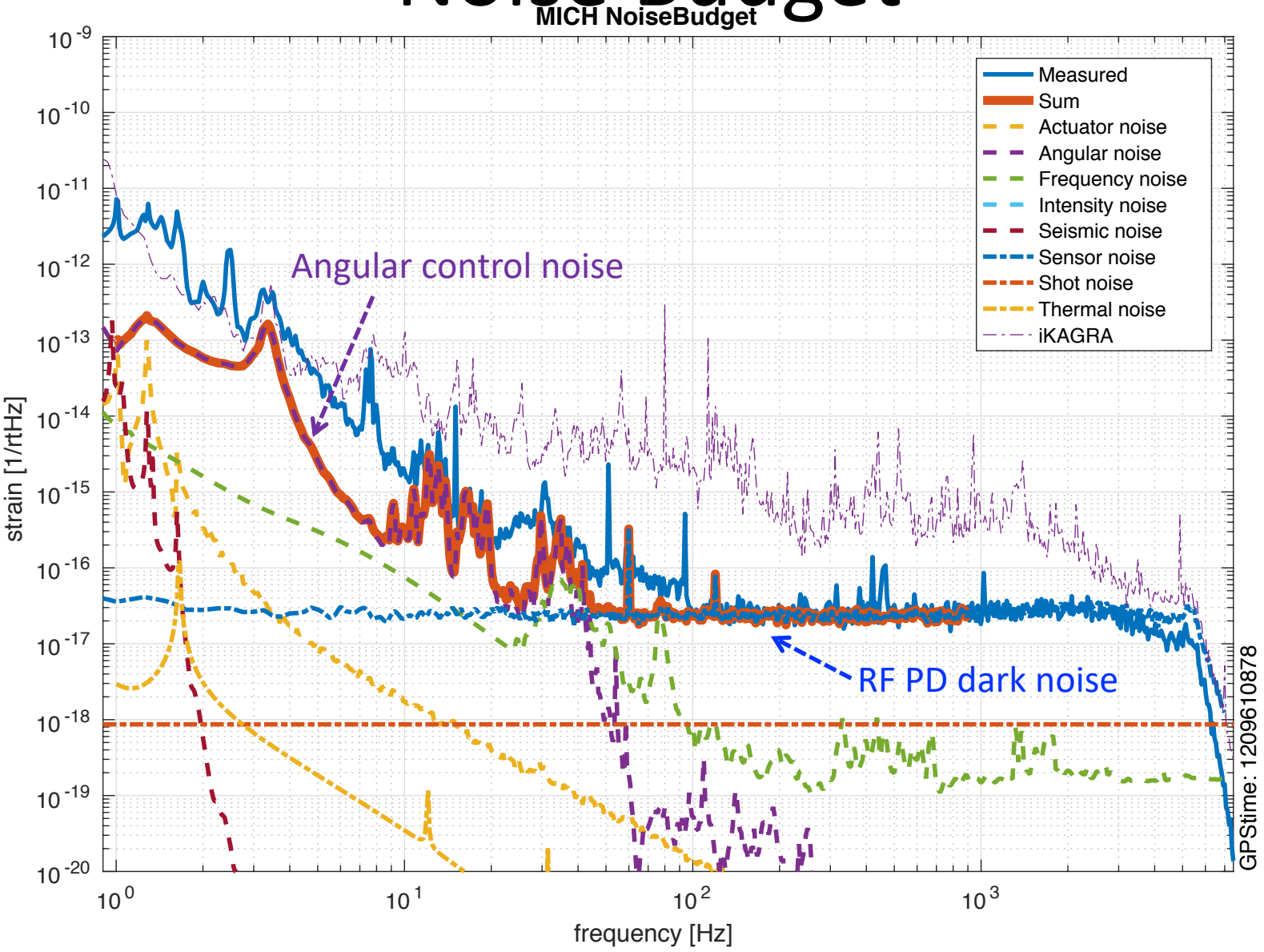
Phase 1 Overview

Sensitivity



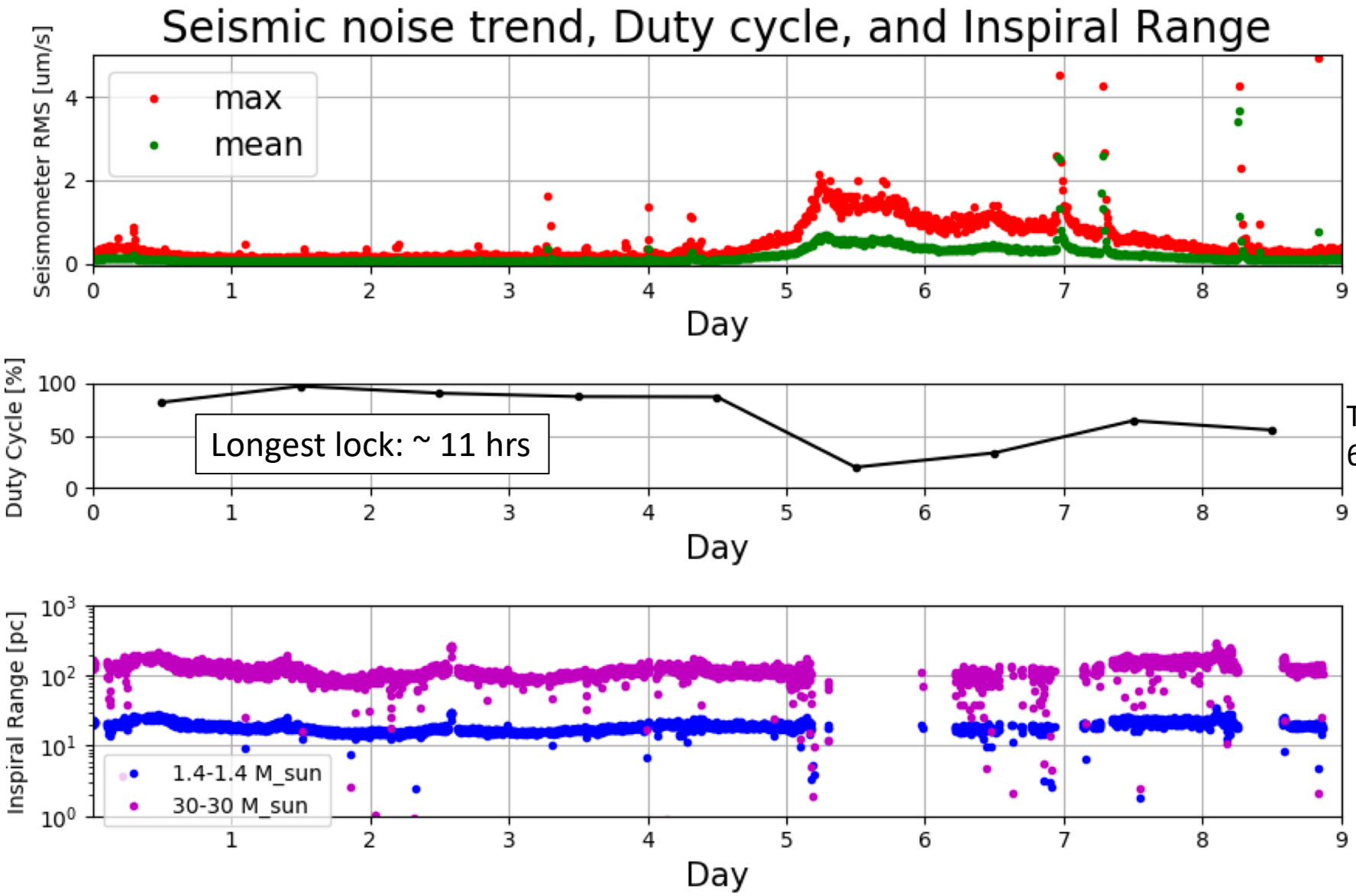
Phase 1 Overview

Noise Budget



Phase 1 Overview

Operation Status



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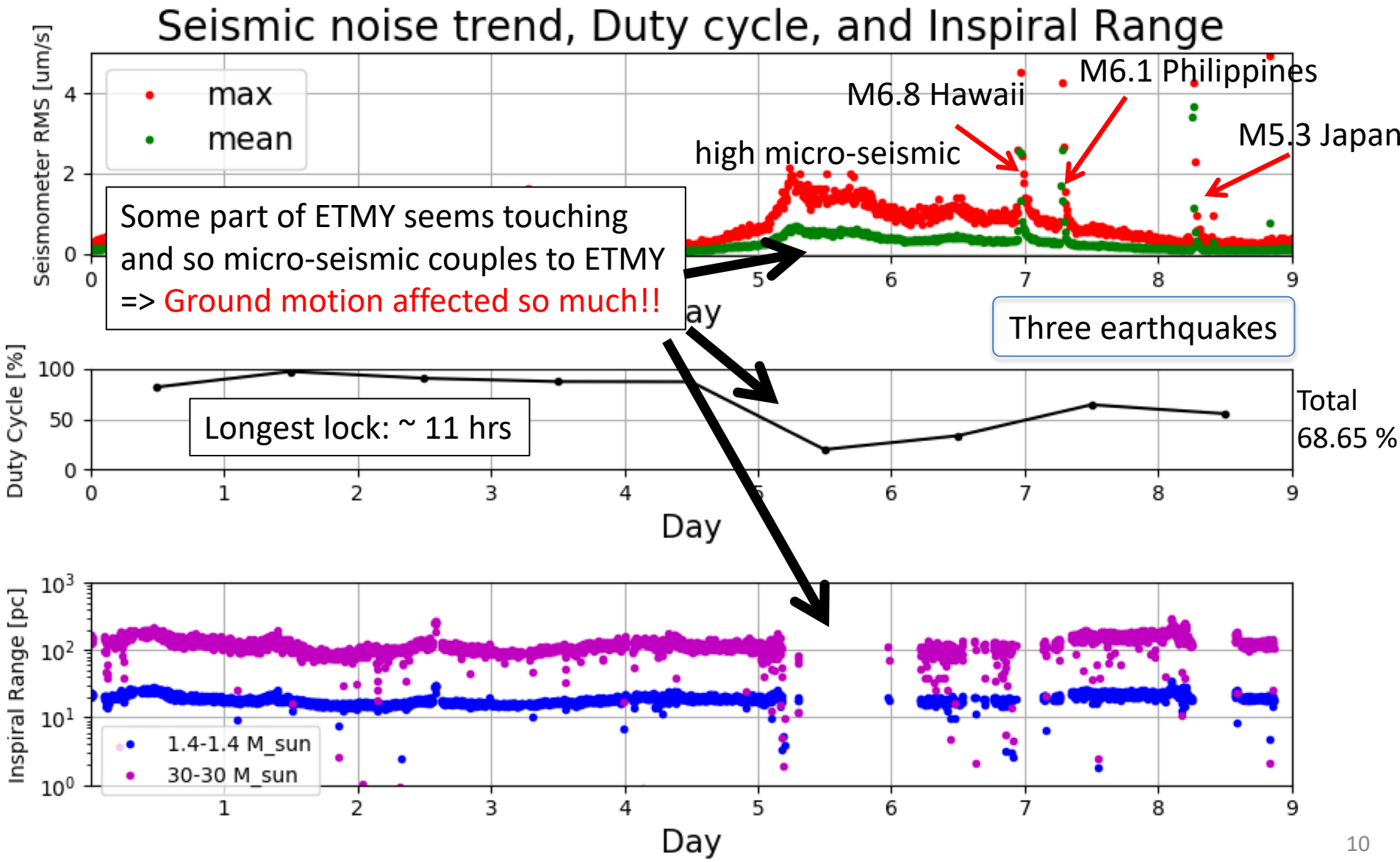


Characterization

Characterization

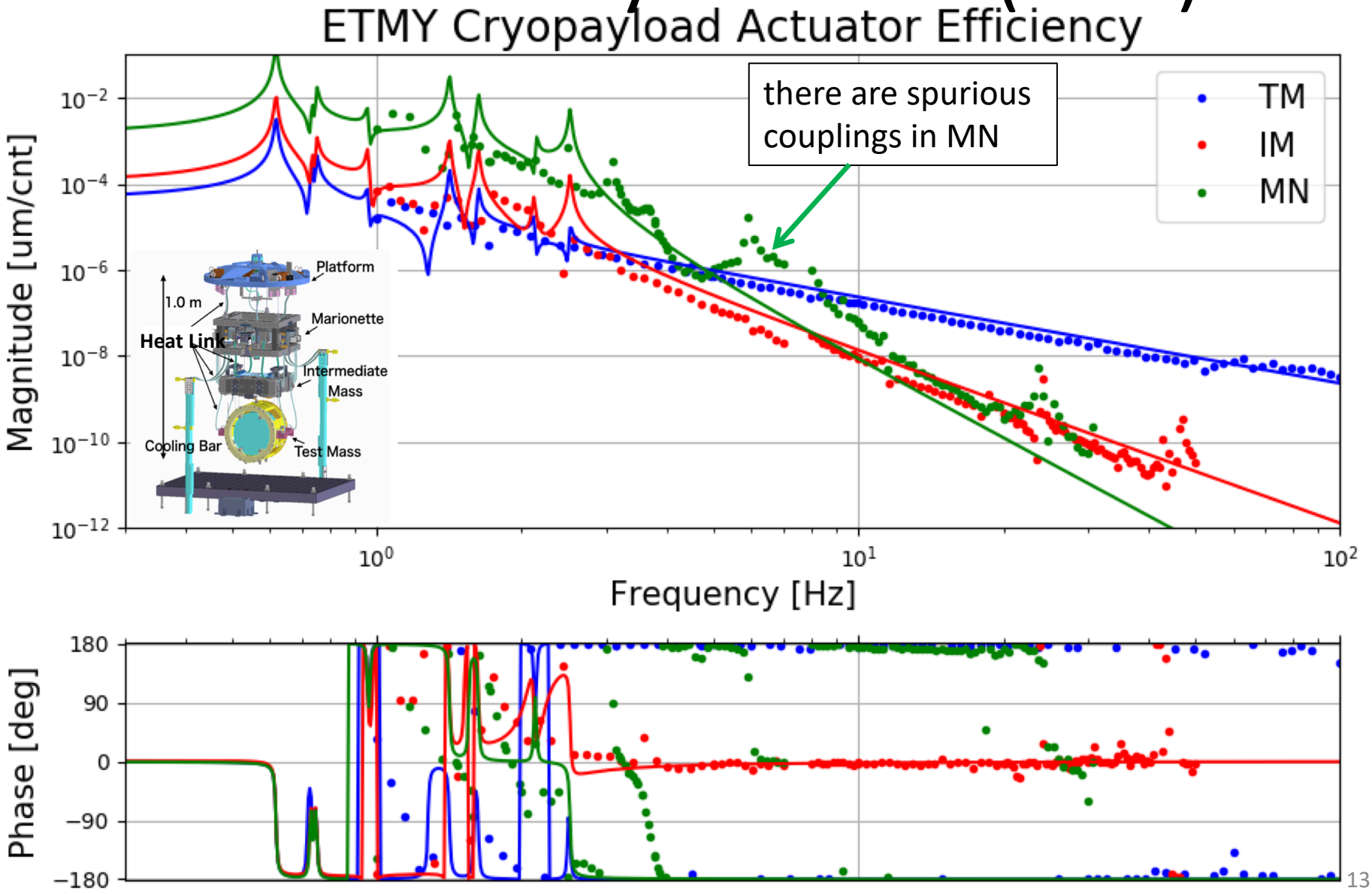
-- During 9 days of Operation, several experiments have been performed, using interferometer signal.

* Actuator efficiency of ETMY (20 K), ETMX (300 K), and BS
* Seismic attenuation factor measurement of ETMX
* Detchar: PEM sensors and Injection test
* Hardware injection test of Compact Binary Coalescence (CBC) and Continuous Wave (CW) signal

→ I am going to briefly explain them

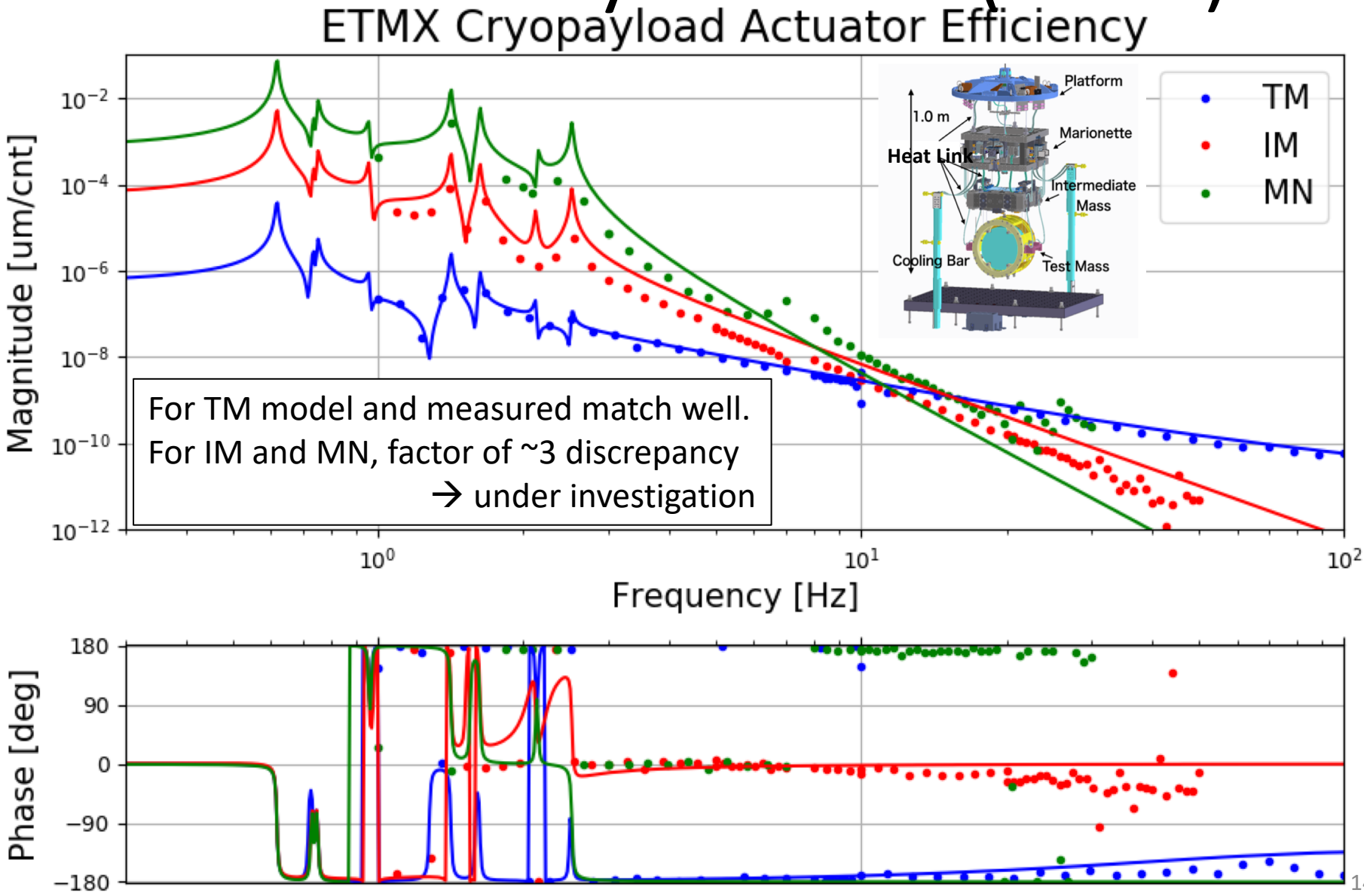
Characterization

Act. Efficiency of EMTY (20 K)



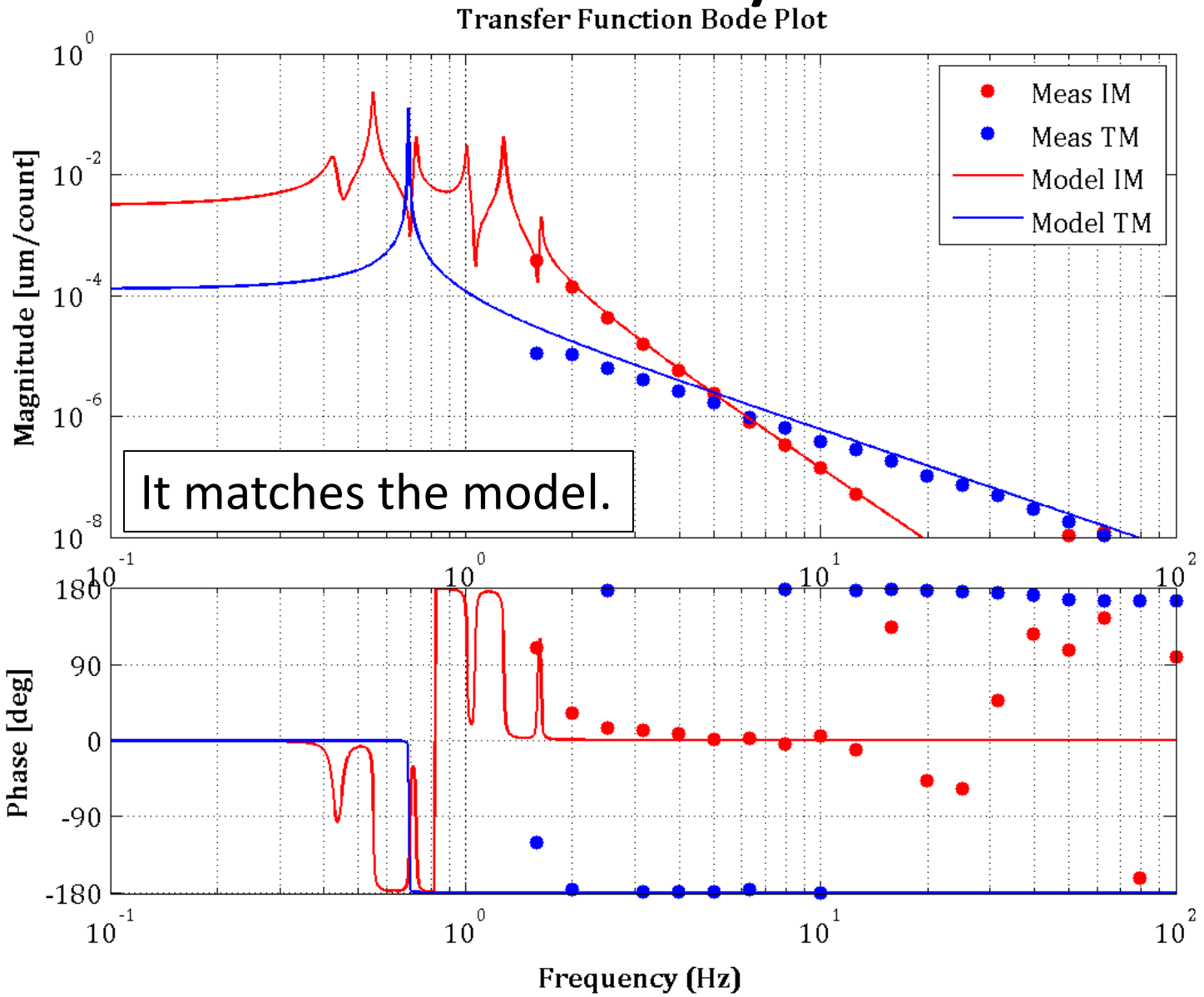
Characterization

Act. Efficiency of EMTX (300 K)



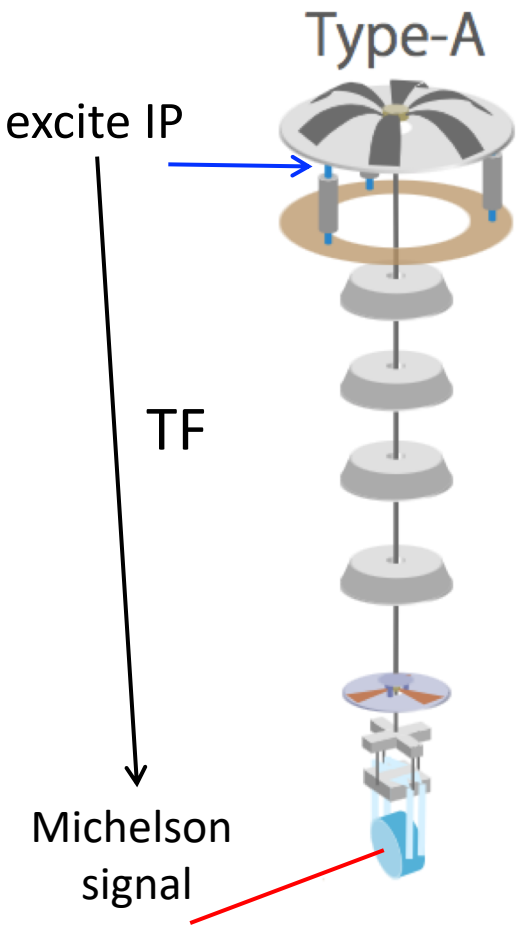
Characterization

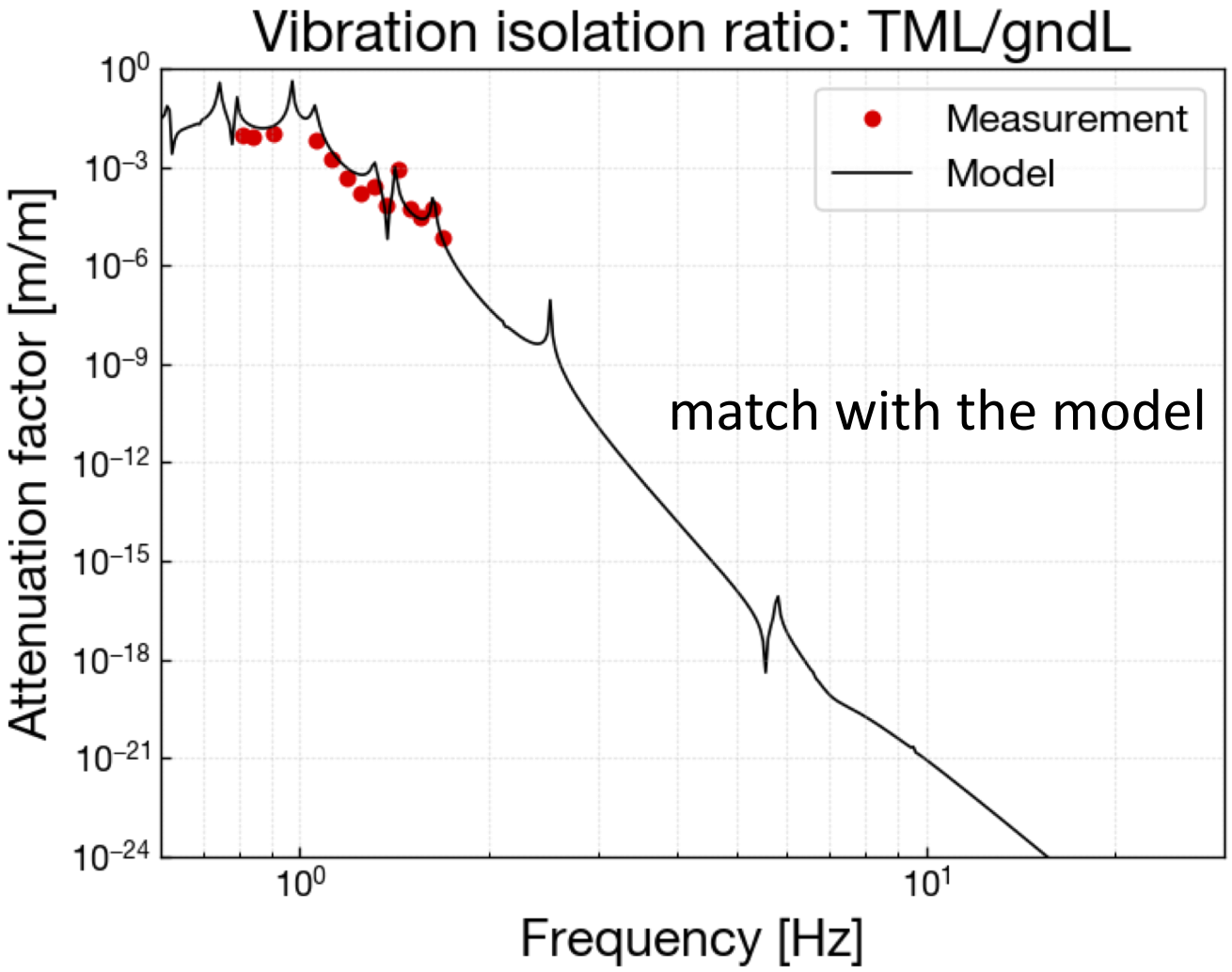
Act. Efficiency of BS



Characterization

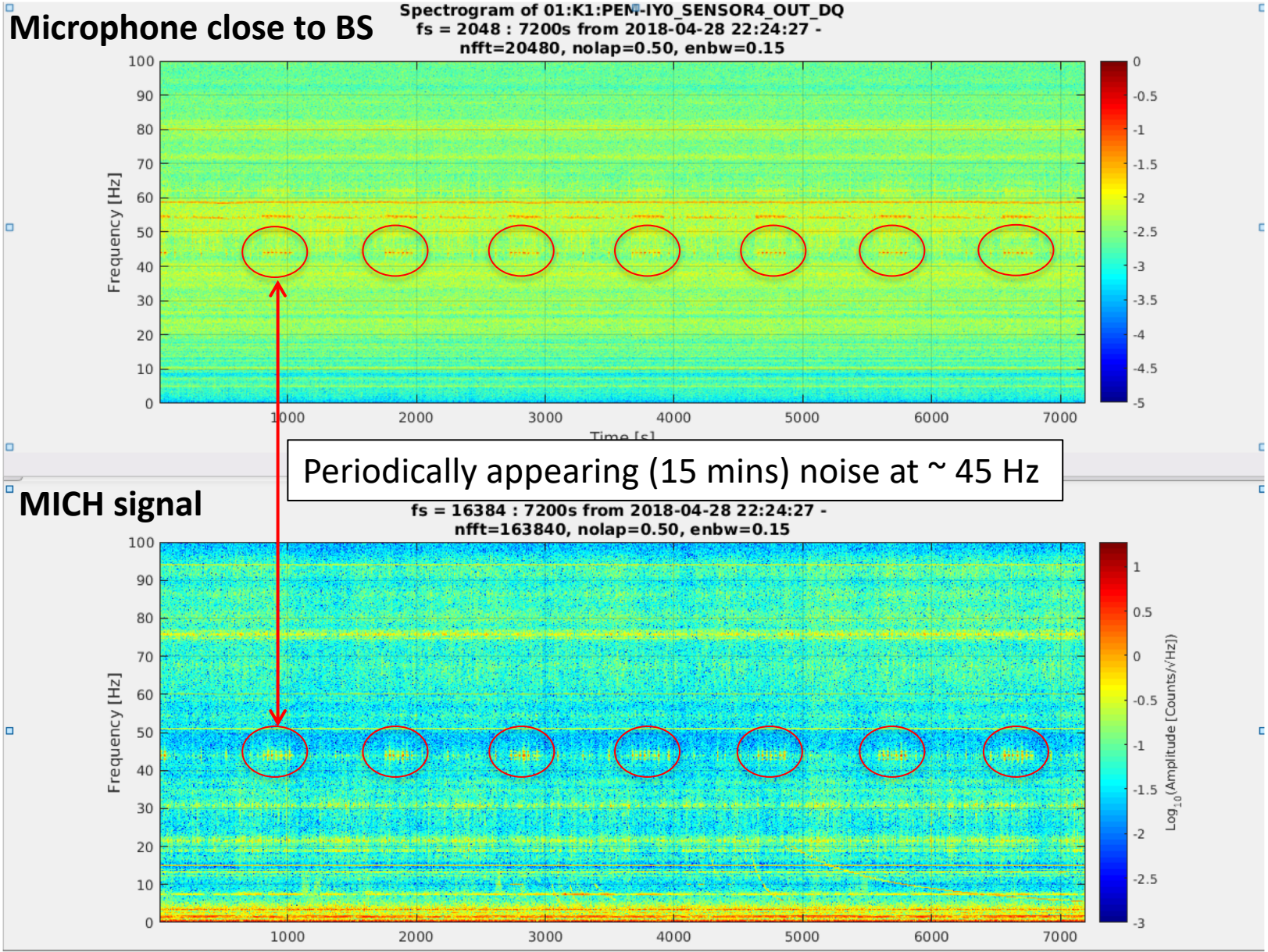
Seismic Attenuation of ETMX





Characterization

PEM related

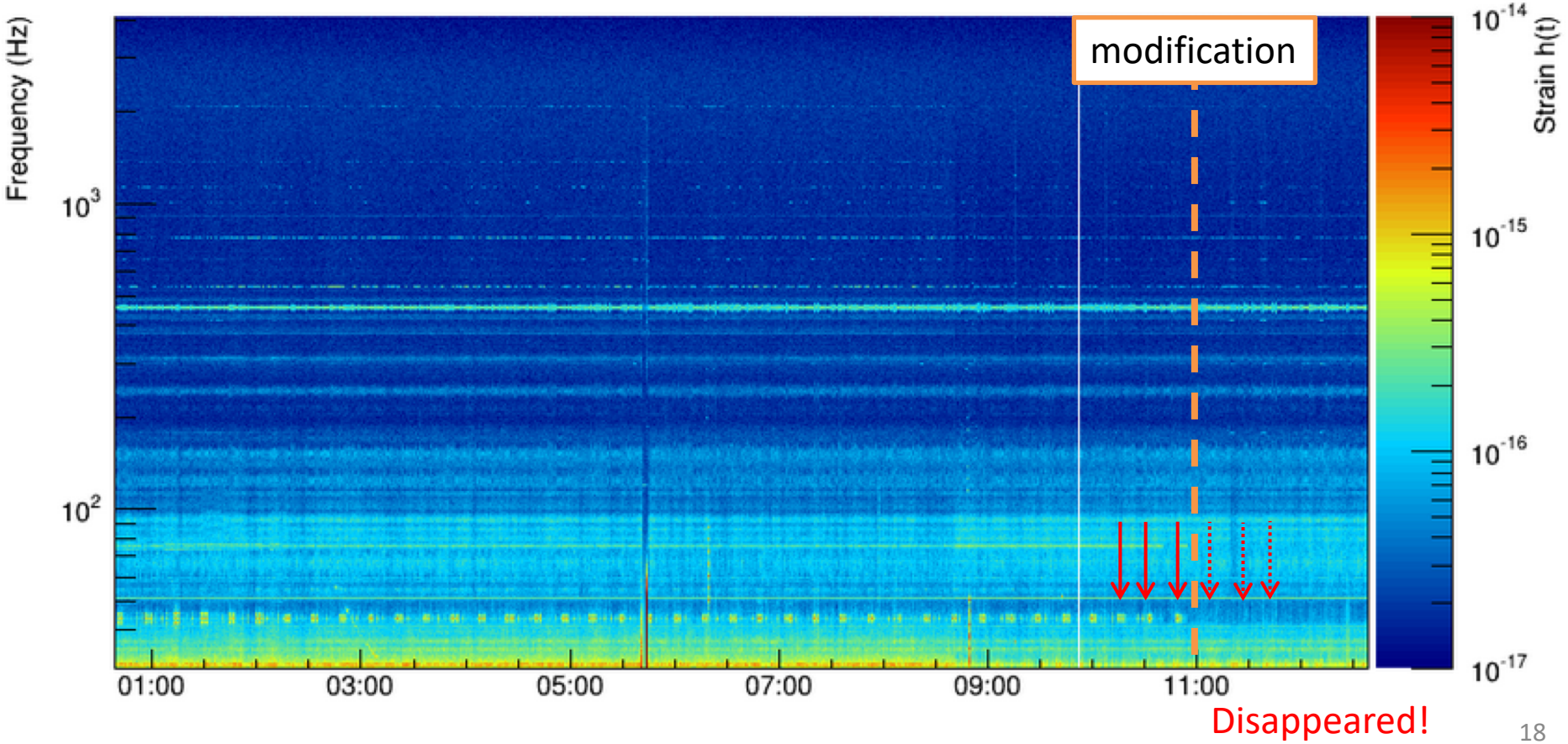


Characterization

PEM related

-- It turned out this noise has coherence with PR2 optical lever signal
=> we modified optical lever control loop of PR2

MICH spectrogram



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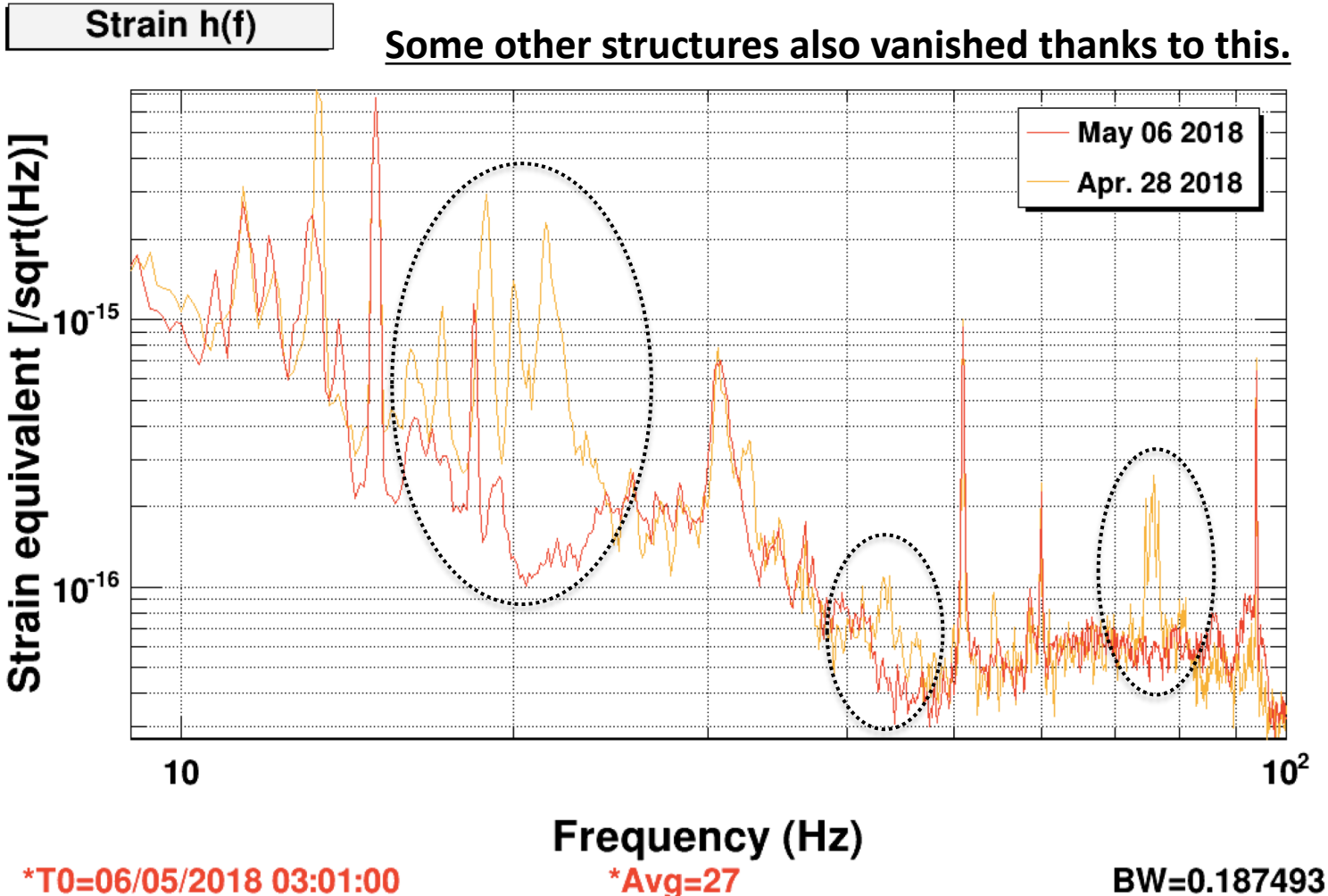
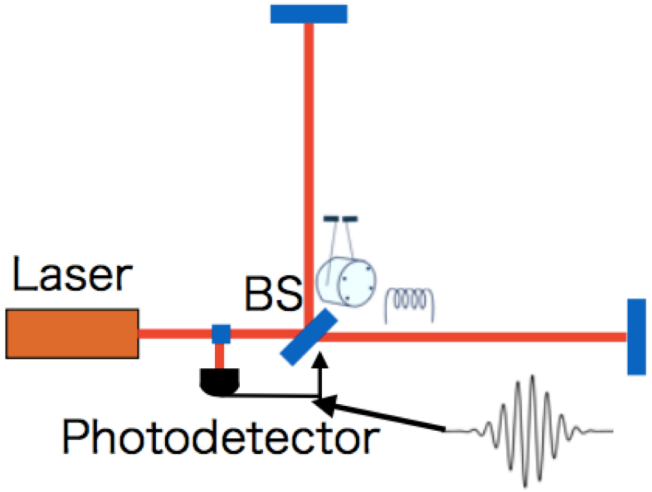


Characterization

Hardware Injection Test

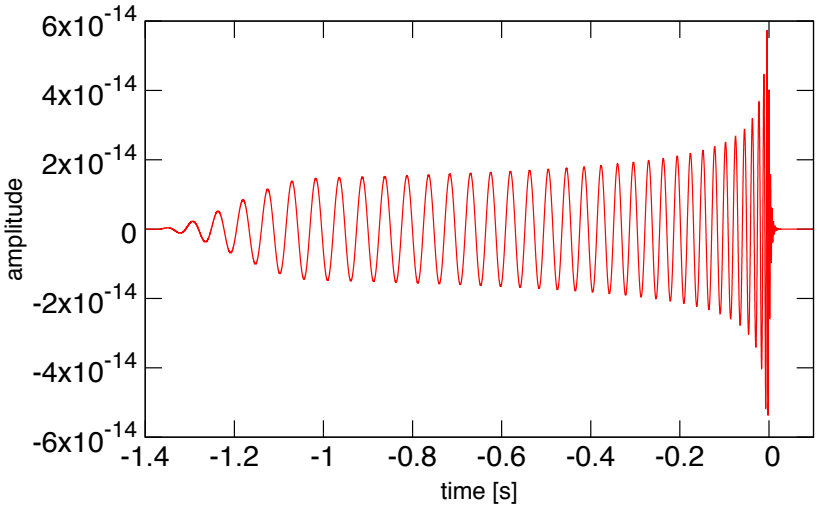
-- Rehearsal for near future observation.

-- Two types of waveforms were injected into feedback signal



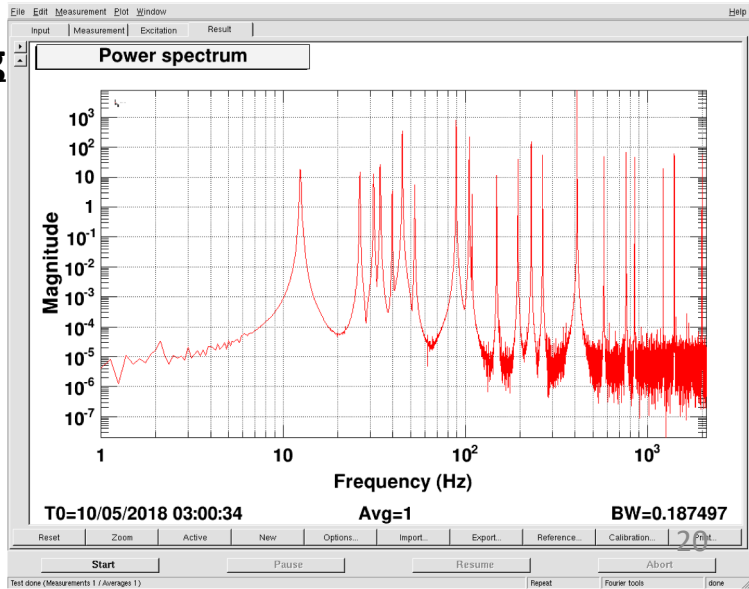
* BBH CBC injection

=> evaluate the effect of bias of detector response and calibration error on parameter estimation.



Analysis on going

* Continuous Wave injection



Summary

-- We recently had a so-called Phase 1 Operation.
→ Cryogenic Michelson was operated.
-- ETMY was successfully **cooled down to 20 K**

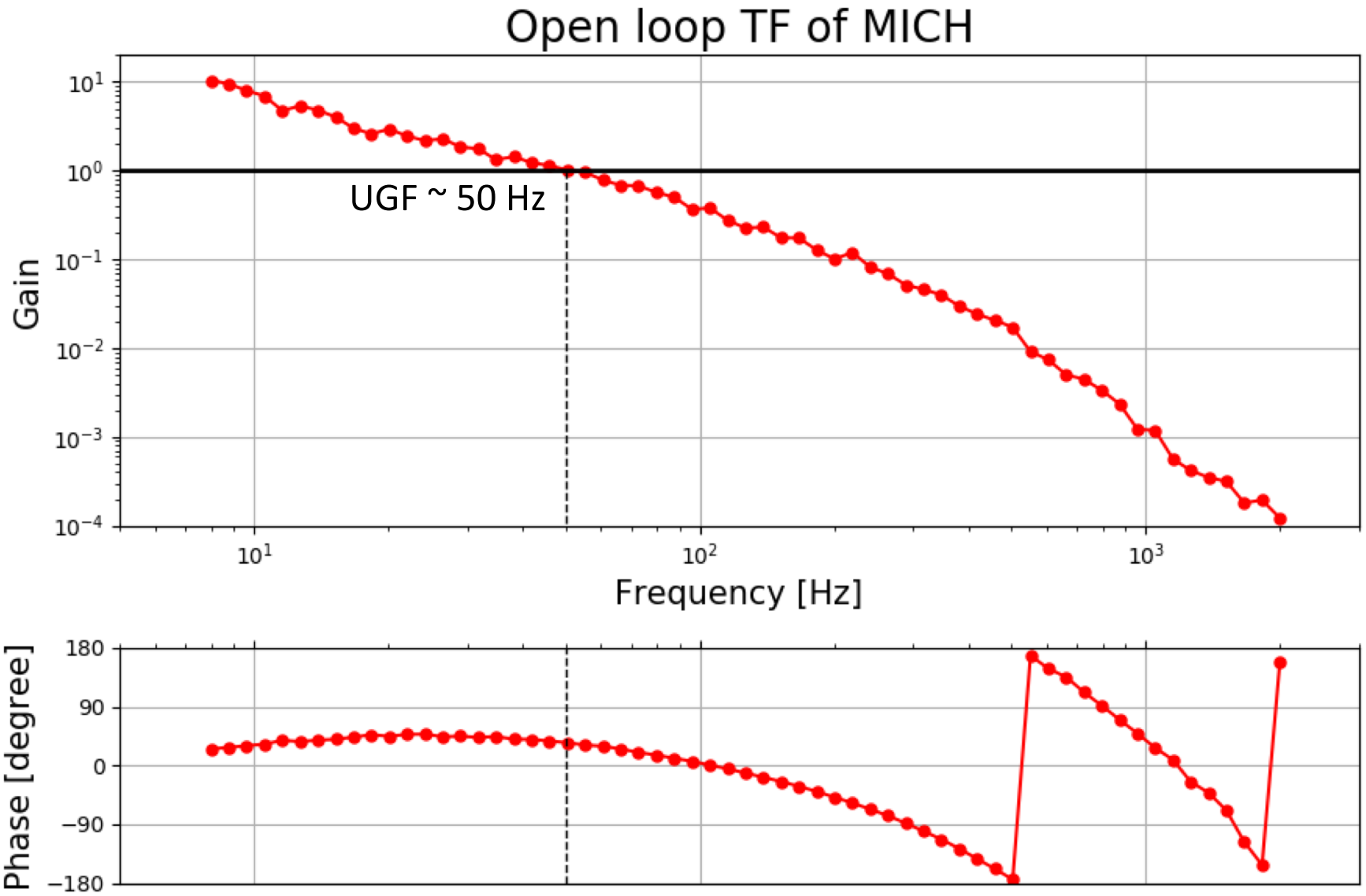
-- Cryogenic payload (test mass) was successfully actuated at cryogenic temperatures.
Issues around the payload was identified to some extent.
→ Identification and fixing are on-going toward the next step

-- Phase 1 has finished.
Installation and preparation for joining late O3 is NOW on-going.

Thank you!

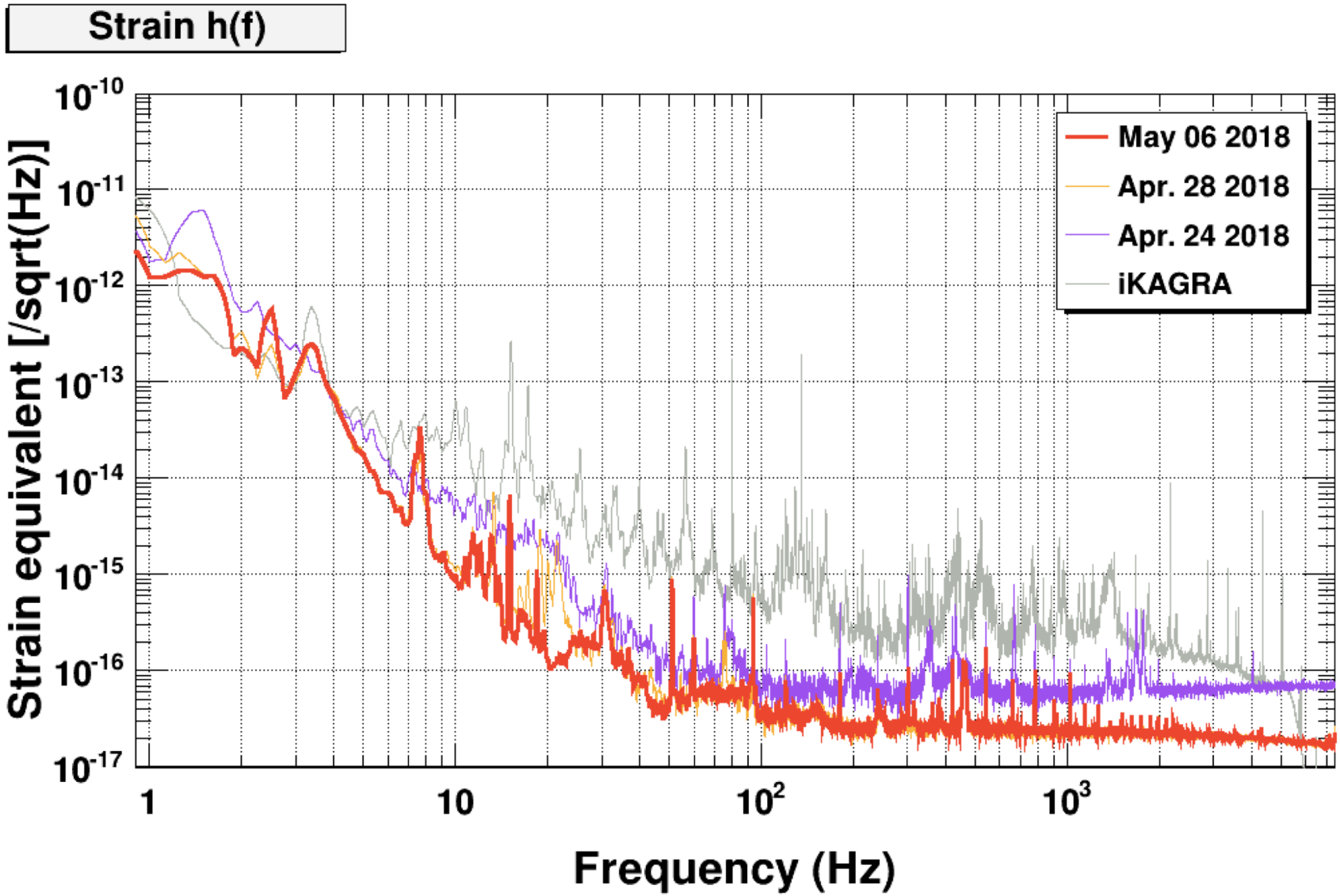
Phase 1 Overview

Open loop TF



Phase 1 Overview

Noise curves



Schnupp Asymmetry

→ intentional asymmetry in length of two arms of Michelson

-- I worked on this measurement as a main worker.

-- RF signal at REFL port of Michelson is:

$$P_{\omega_\mathrm{m}} = \beta \sin\left[\omega_\mathrm{m}(L_x - L_y)/c\right] \sin\left[2\omega_\mathrm{laser}(L_x - L_y)/c\right] \times \cos\omega_\mathrm{m} t$$

If you modulate the frequency,

$$\left.\frac{\partial P_{\omega_\mathrm{m}}}{\partial \omega_\mathrm{laser}}\right|_\mathrm{dark} = \beta \sin\left[\omega_\mathrm{m}(L_x - L_y)/c\right] \frac{2(L_x - L_y)}{c} \times \cos\omega_\mathrm{m} t$$

-- We swinged IMC length to modulate laser frequency, and looked at MICH signal.

-- We repeated the measurement three times

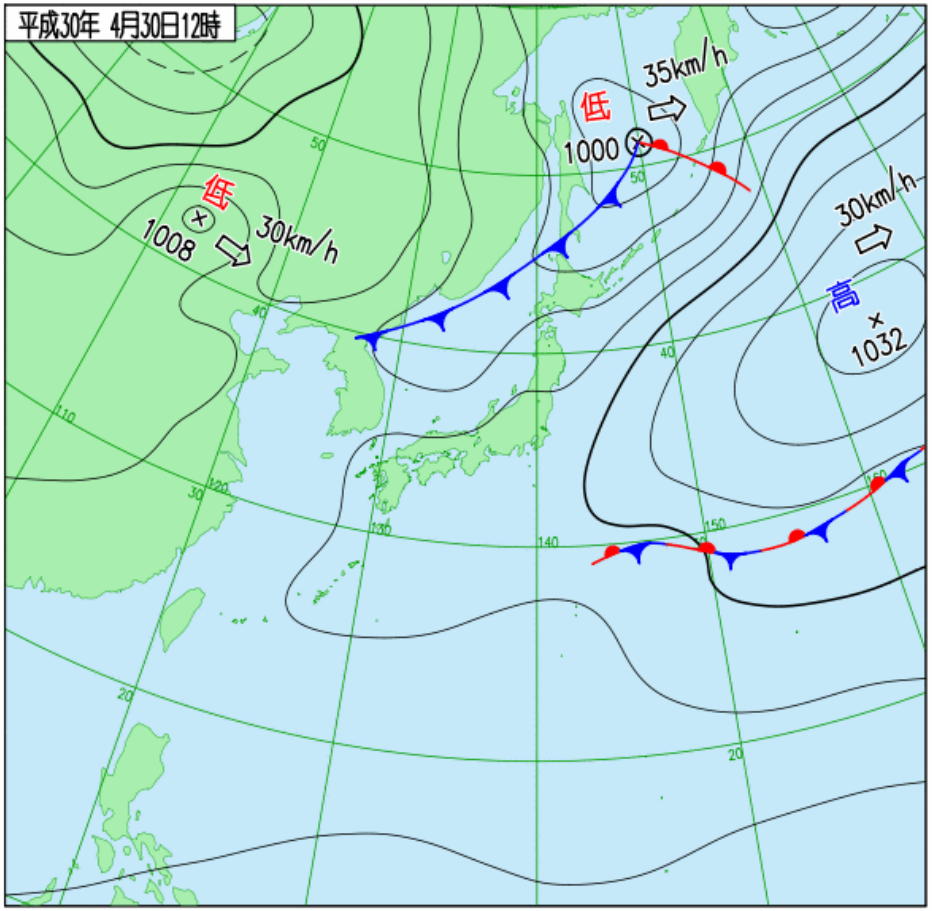
Results: 3.4(5) m, 4.5(7) m, 3.9(6) m (Design: 3.3298 m)

=> not very successful…

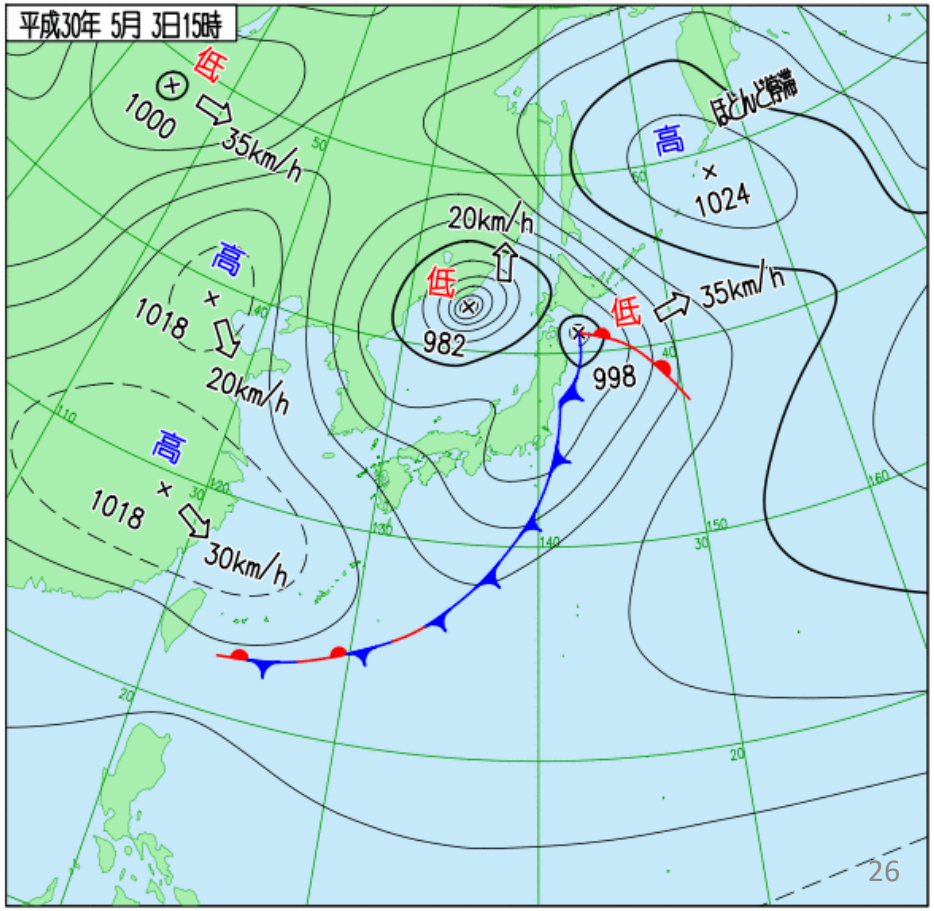
What I Learned

Micro-Seismic Noise

Quiet case



Noisy case



Phase 1 Overview

Interferometer configuration

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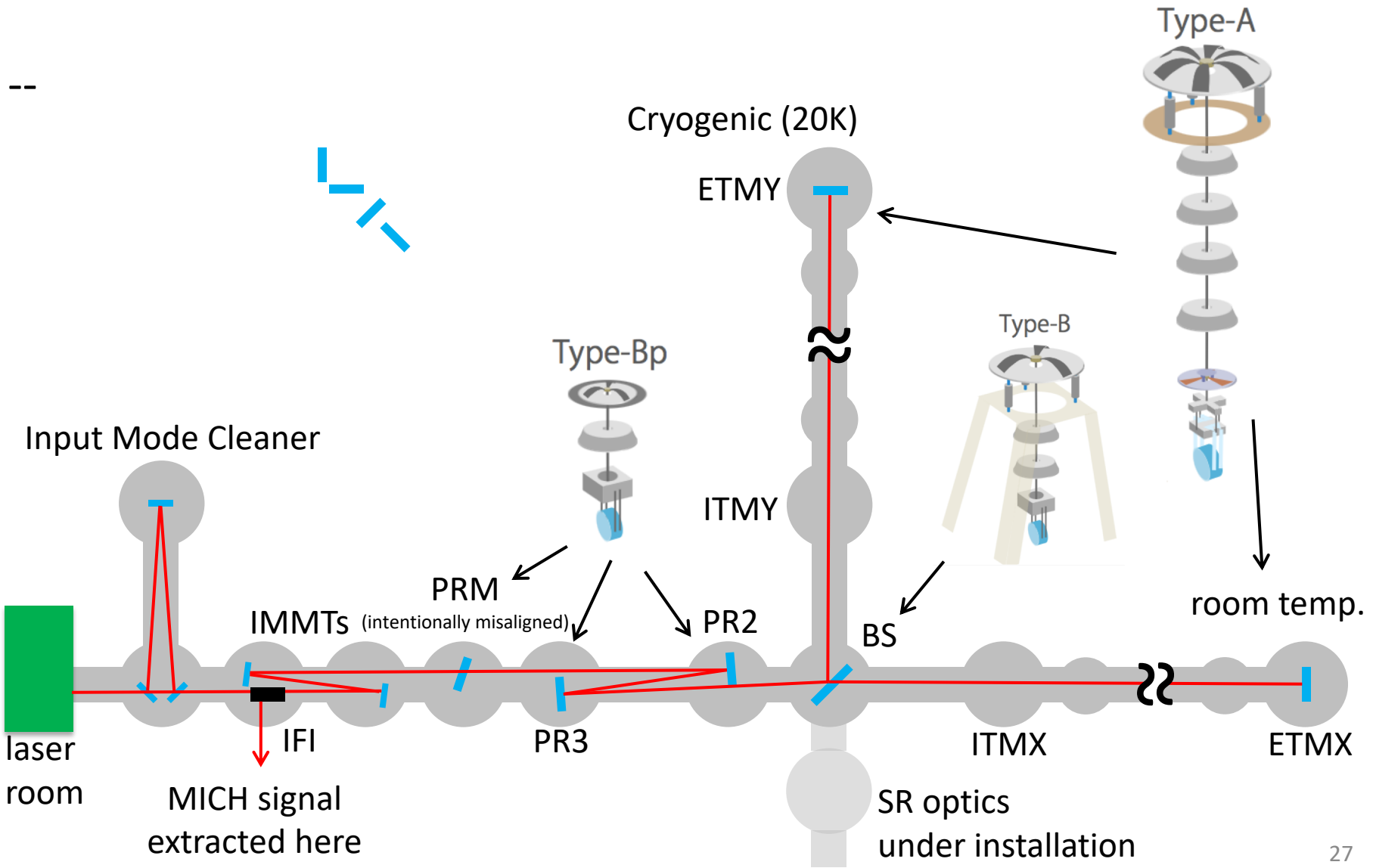

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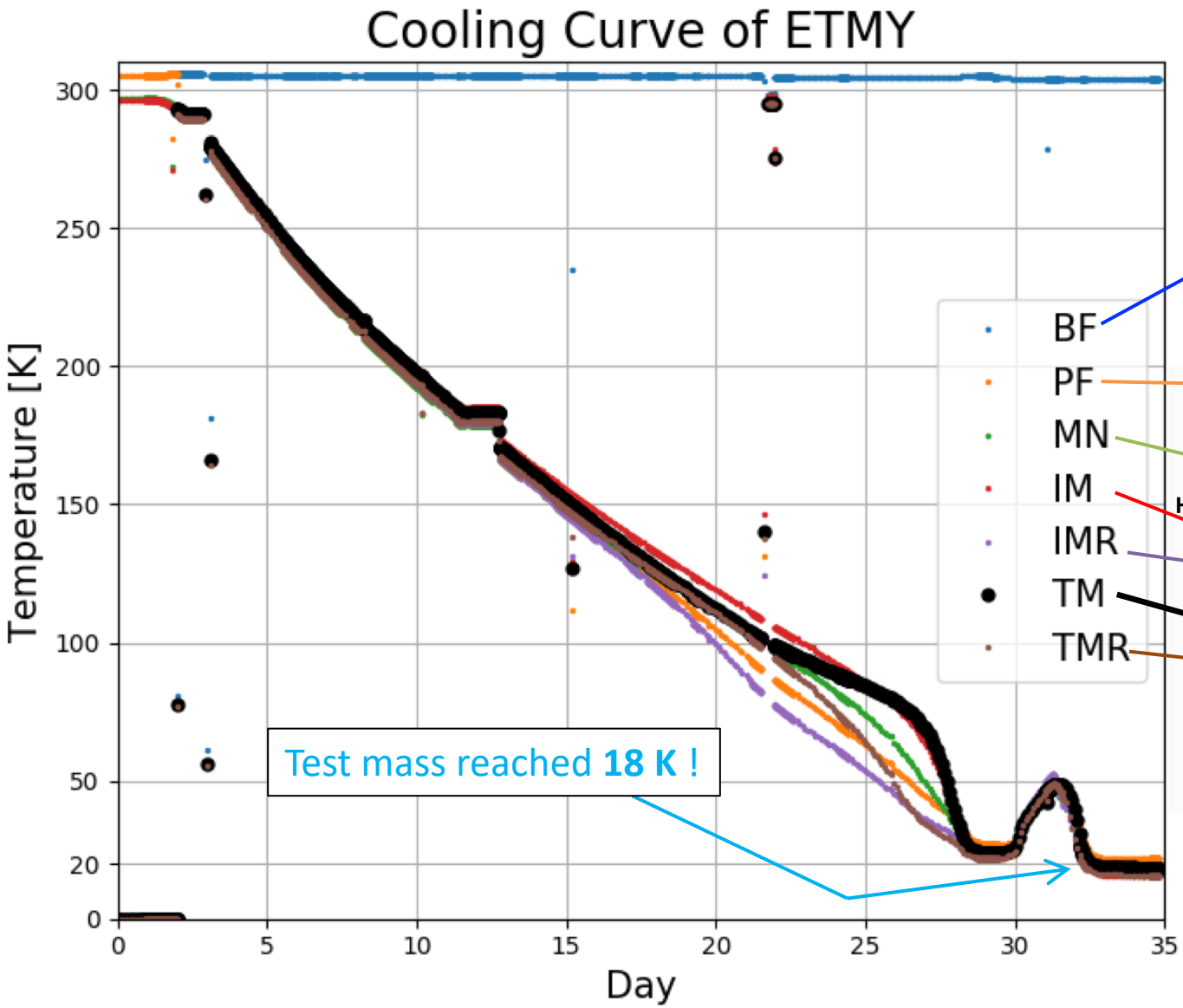
Cooling down ETMY



bottom of room temp. part

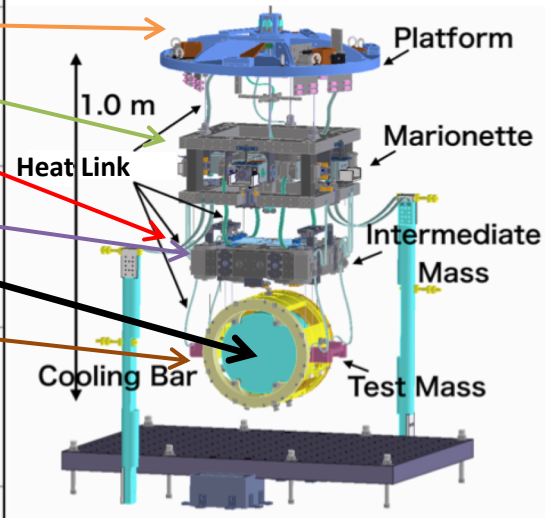
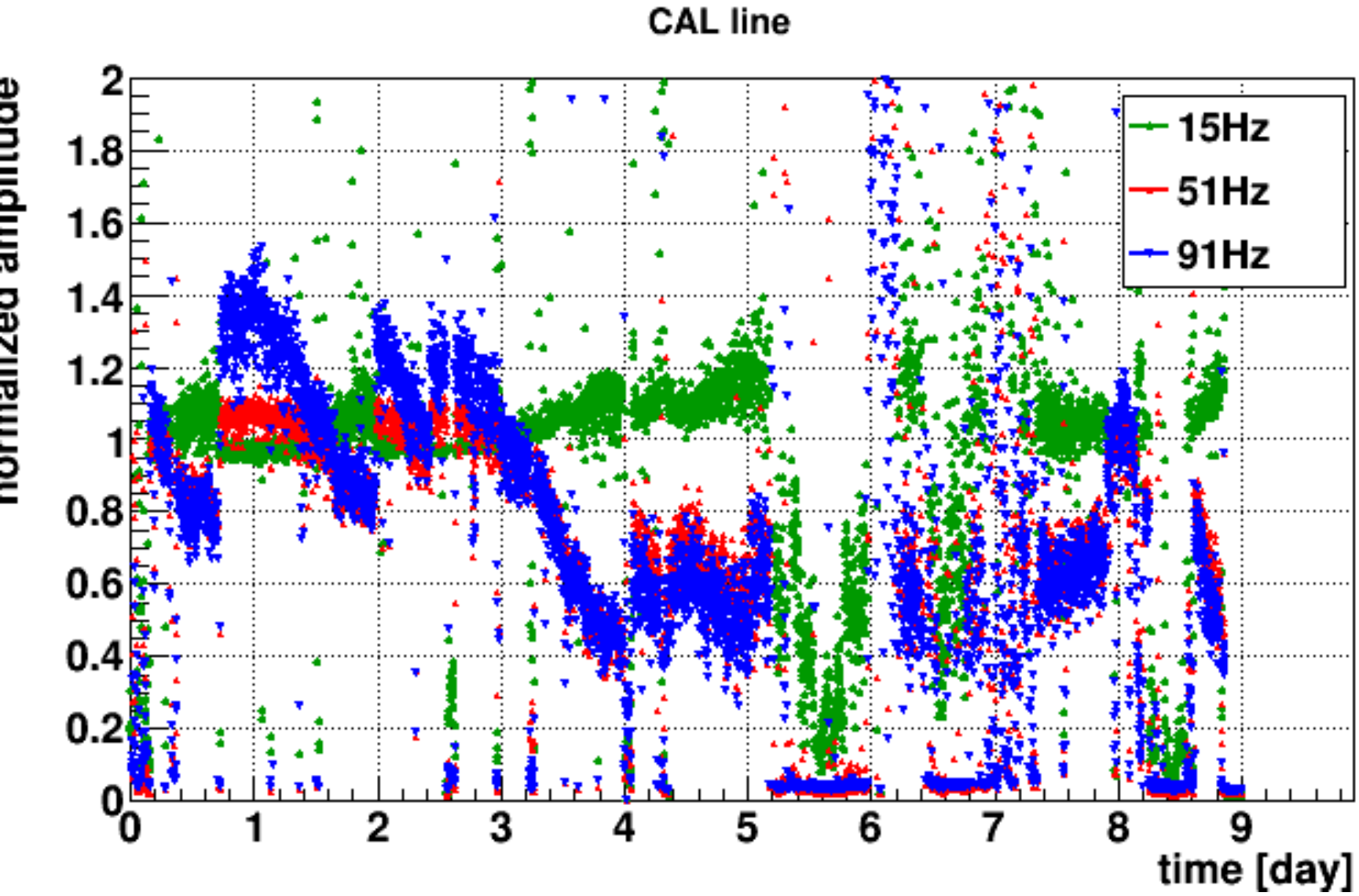


Figure of payload from JGW-G1807766-v5

Phase 1 Overview

Operation Status



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Cryogenic
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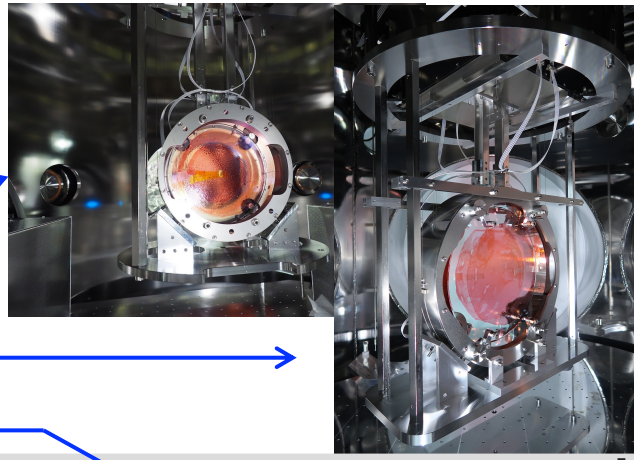

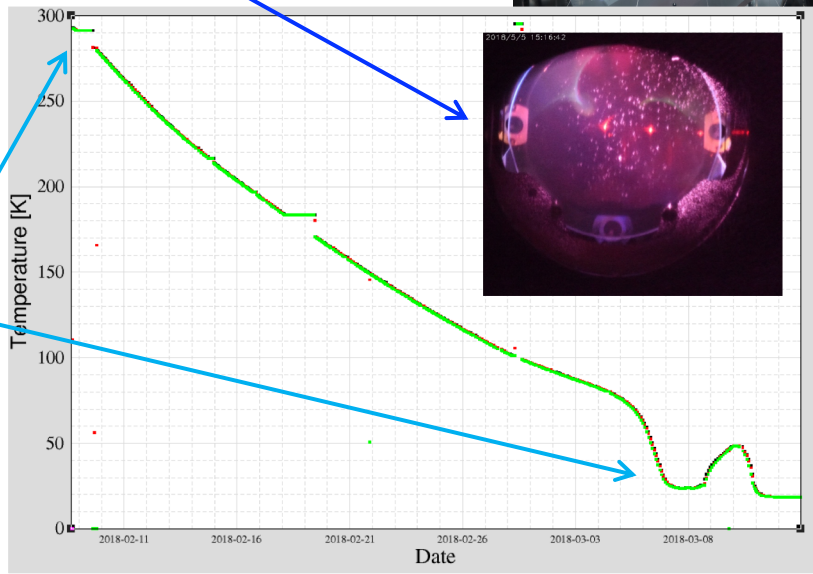

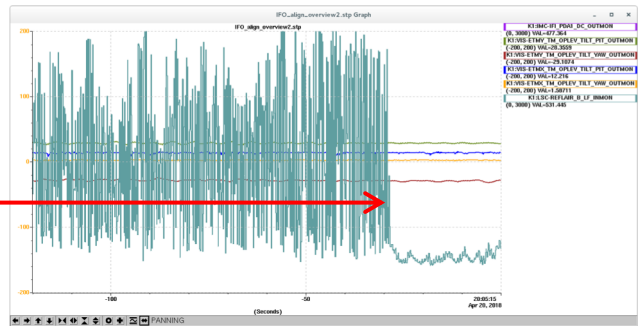

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