bKAGRA Phase 1 Overview

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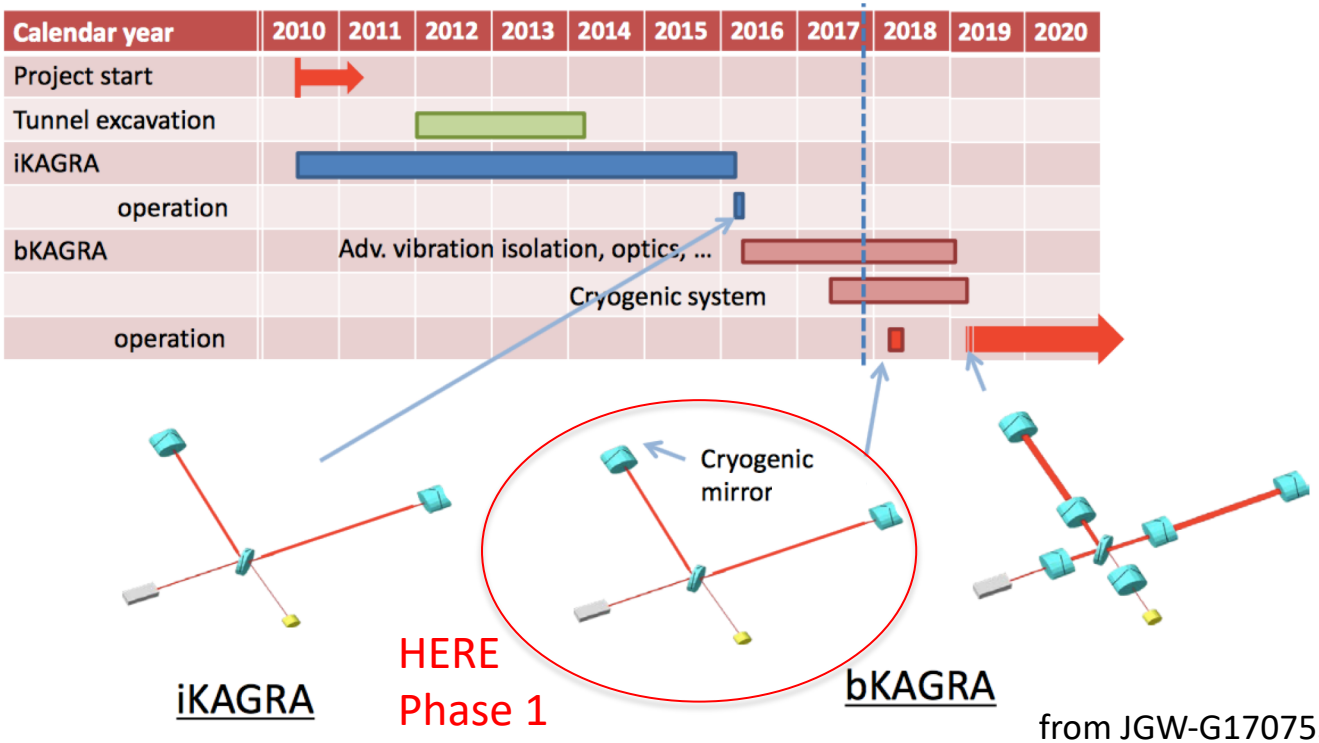
-- bKAGRA Phase 1: Operation of large scale interferometer with a cryogenic mirror, held in Apr 28 – May 6, 2018

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



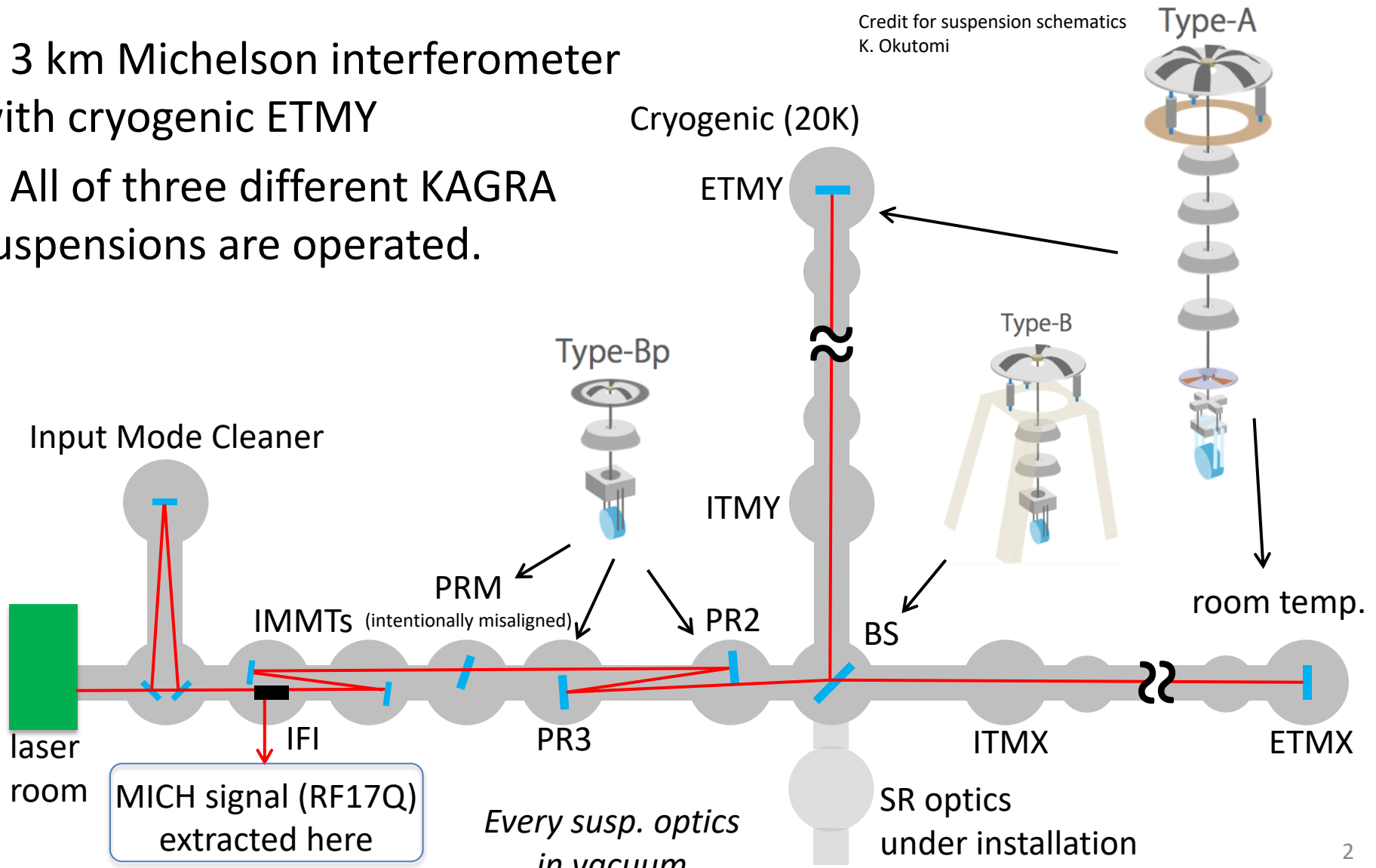
from JGW-G1707532-v1

Phase 1 Overview

Interferometer configuration

-- 3 km Michelson interferometer with cryogenic ETMY

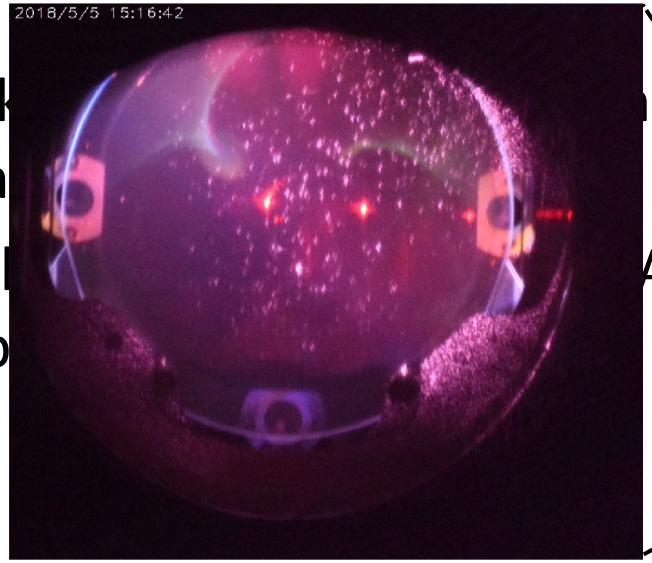
-- All of three different KAGRA suspensions are operated.



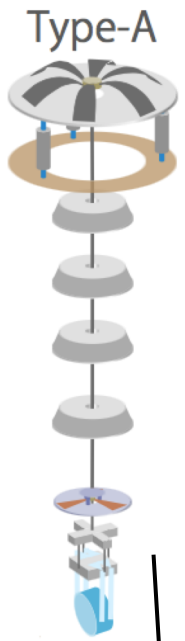
Phase 1 Overview

Interferometer configuration

-- 3 k eter
with
-- Al 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

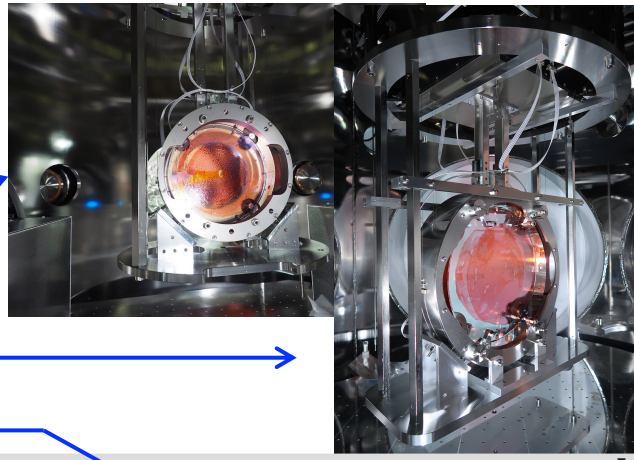
Every susp. optics in vacuum

SR optics under installation

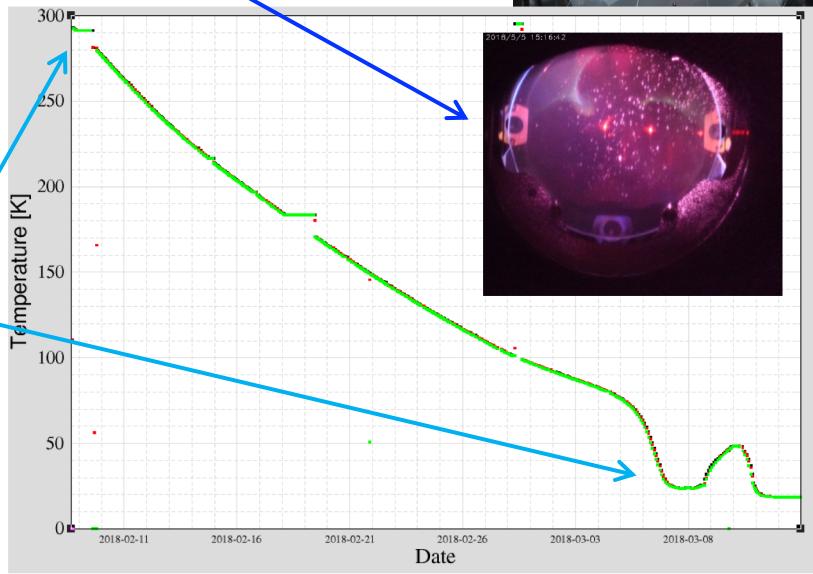
Phase 1 Overview

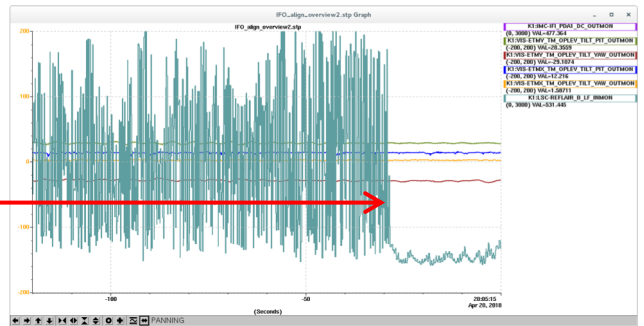
Suspension
Cryogenic
Interferometer

Milestones



* Sept 19 2017: All PR suspension installation completed
* Sept 21 2017: BS suspension installed
* Oct 19 2017: Main beam reached X end
* Oct 26 2017: Main beam reached Y end
* Dec 1 2017: ETMY suspension installed
* Dec 19 2017: Main beam returned from ETMY
* Feb 7 2018: Cooling down of ETMY started
* Mar 11 2018: ETMY reached 20 K
* Mar 23 2018: ETMX suspension installed
* Mar 29 2018: Main beam returned from ETMX
* Apr 10 2018: Michelson fringe observed
* Apr 20 2018: Michelson locked
* Apr 28 2018: **Phase 1 Operation started**





Phase 1 Overview

Milestones

Suspension
Cryogenic
Interferometer

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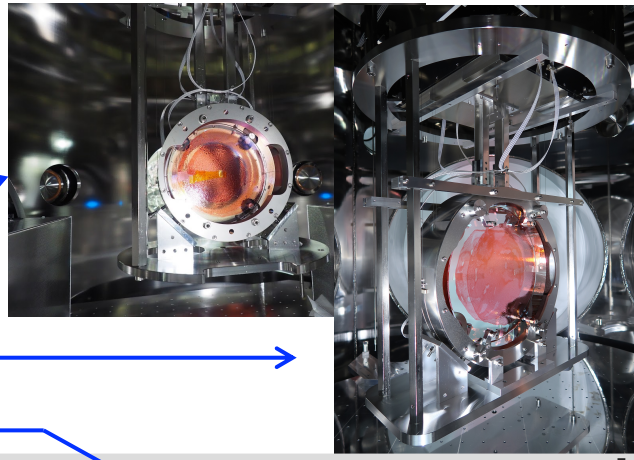
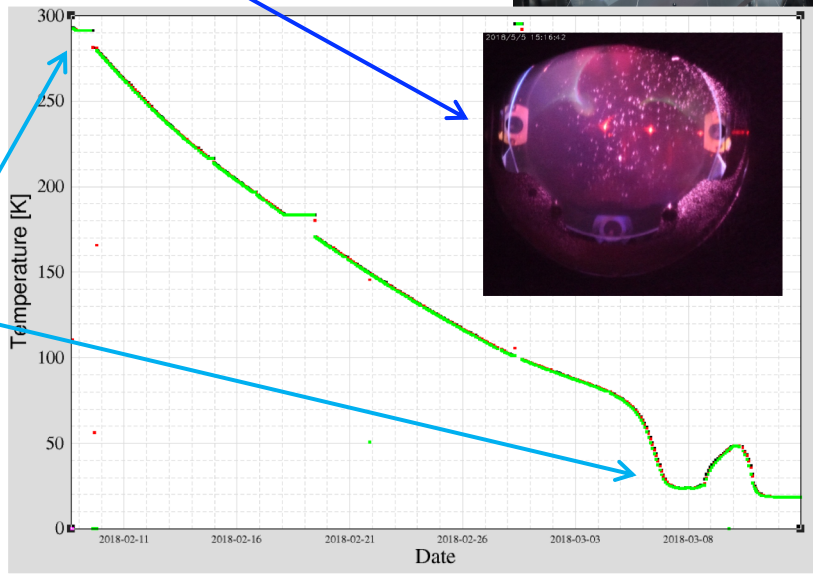
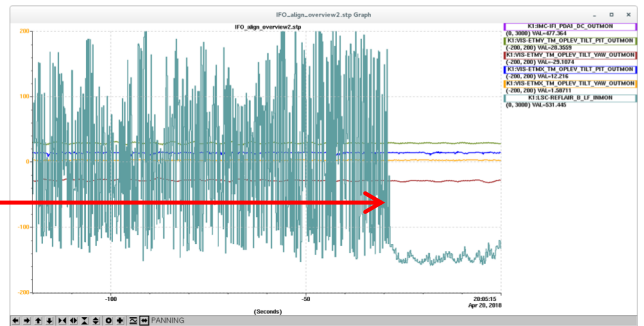


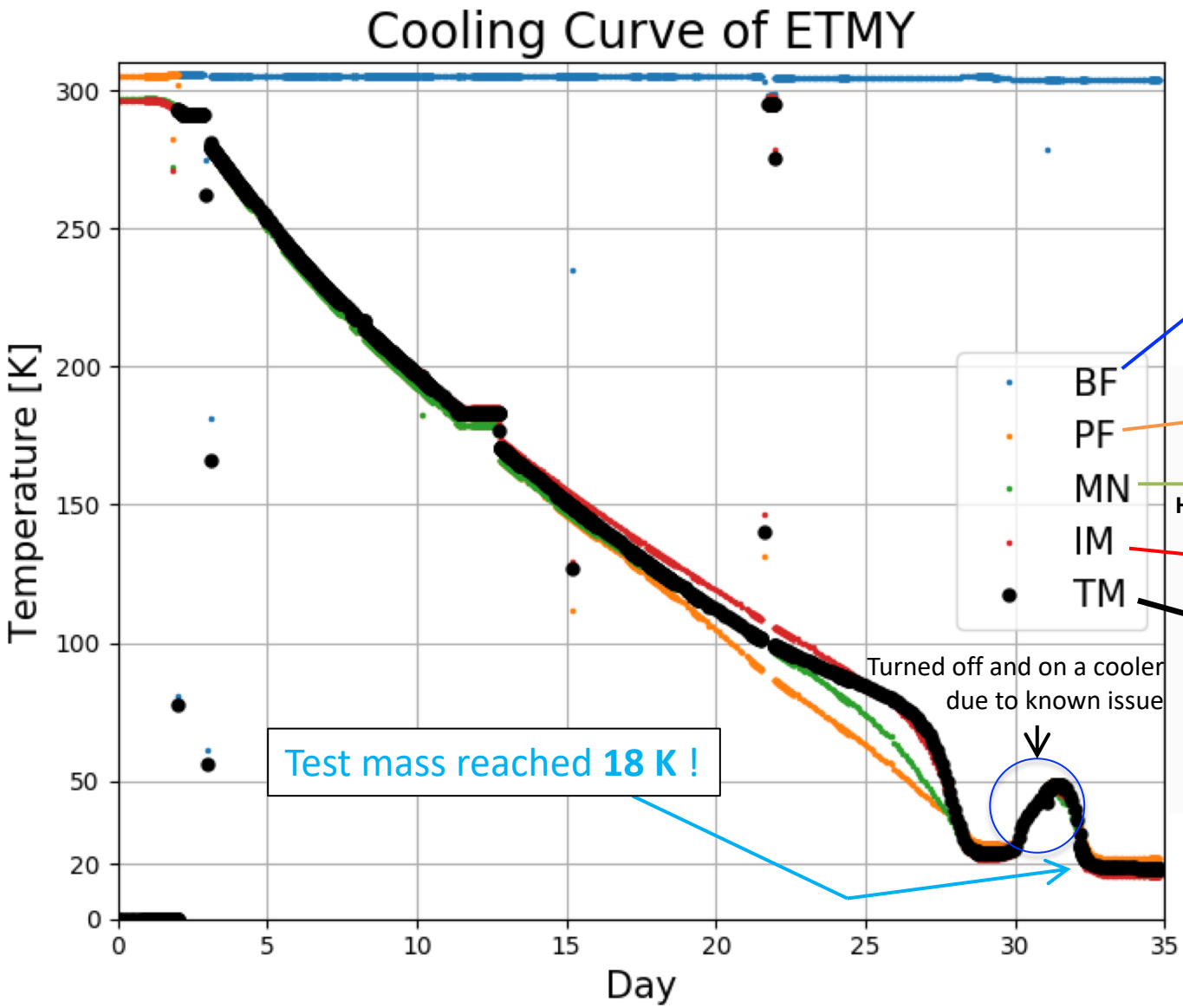




We rushed toward the Operation.

Phase 1 Overview

Cooling down ETMY



bottom of room temp. part

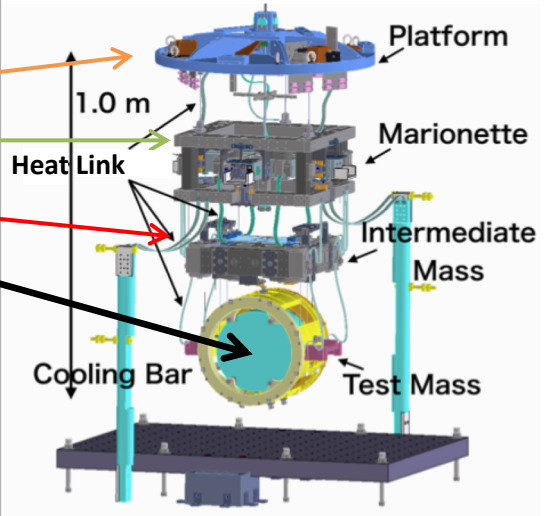
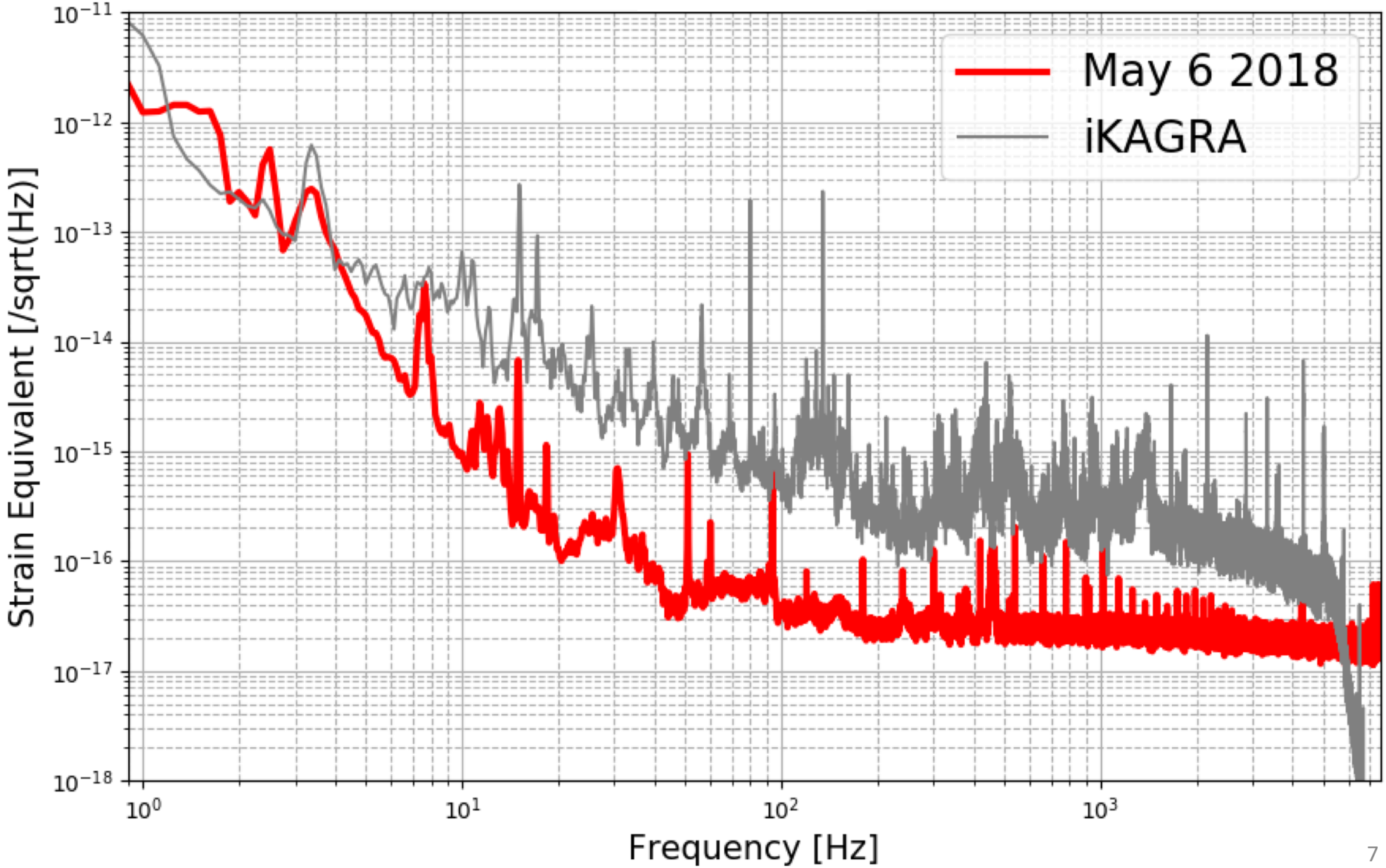


Figure of payload from JGW-G1807766-v5

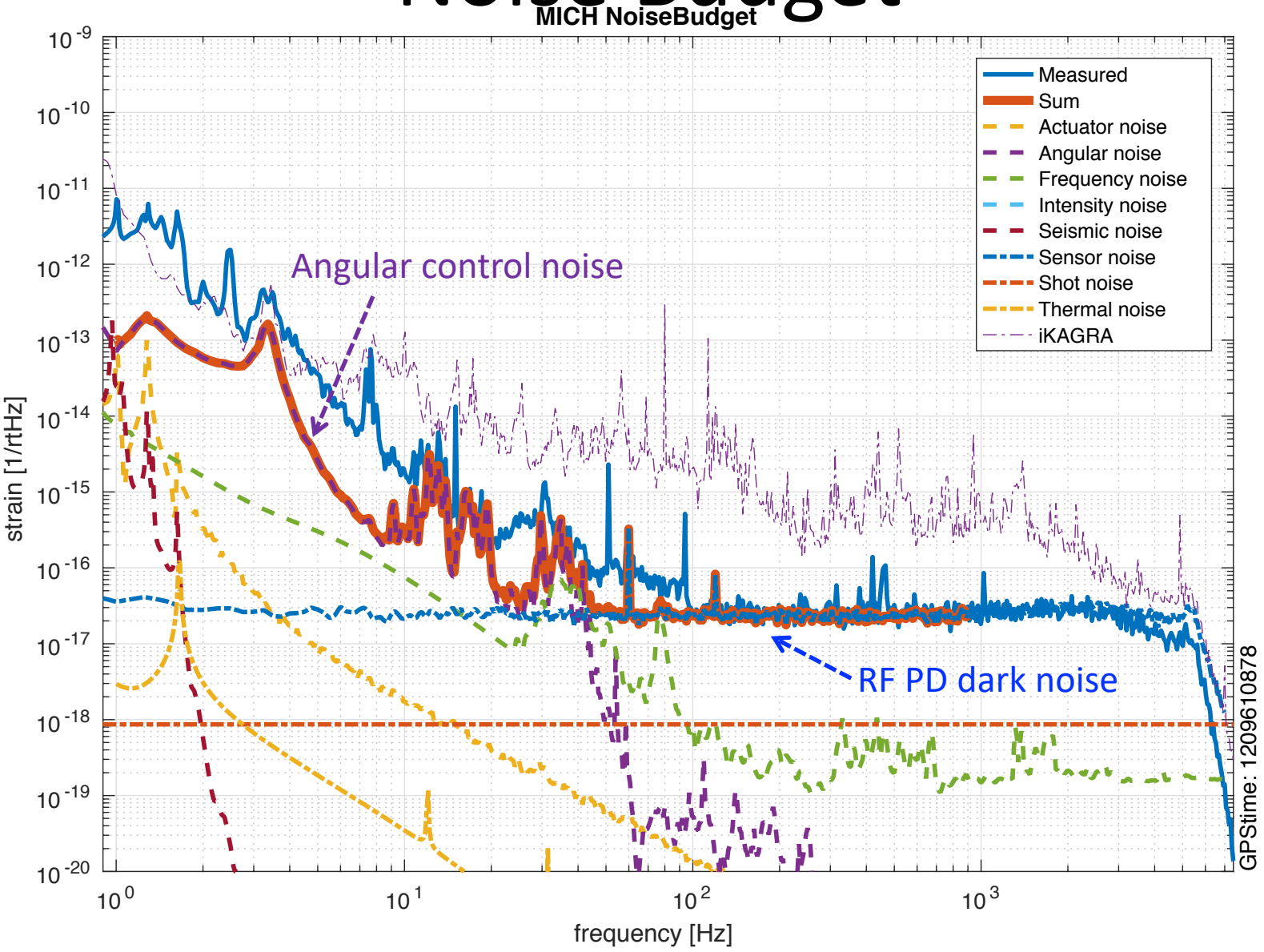
Phase 1 Overview

Sensitivity



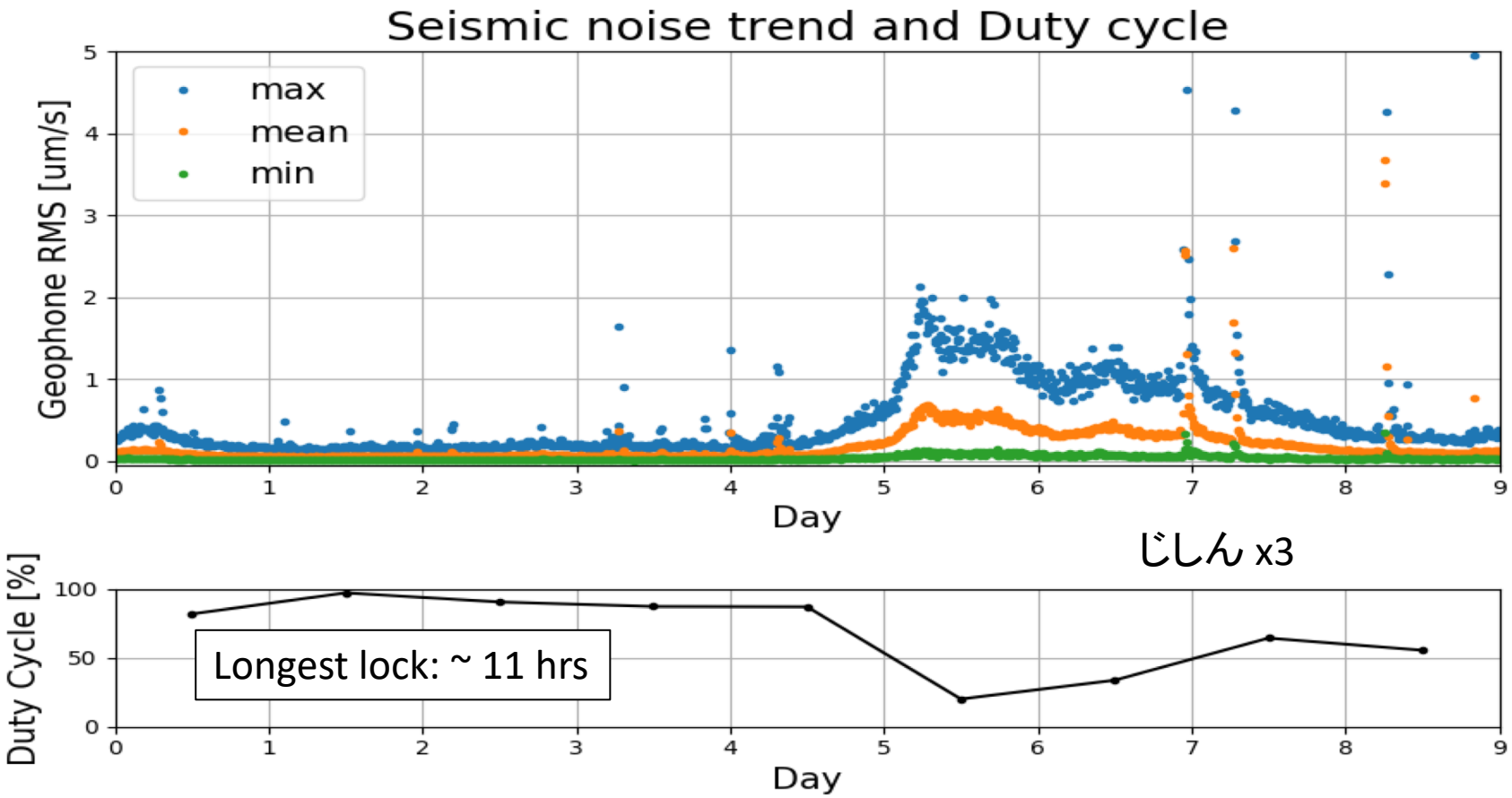
Phase 1 Overview

Noise Budget



Phase 1 Overview

Operation Status

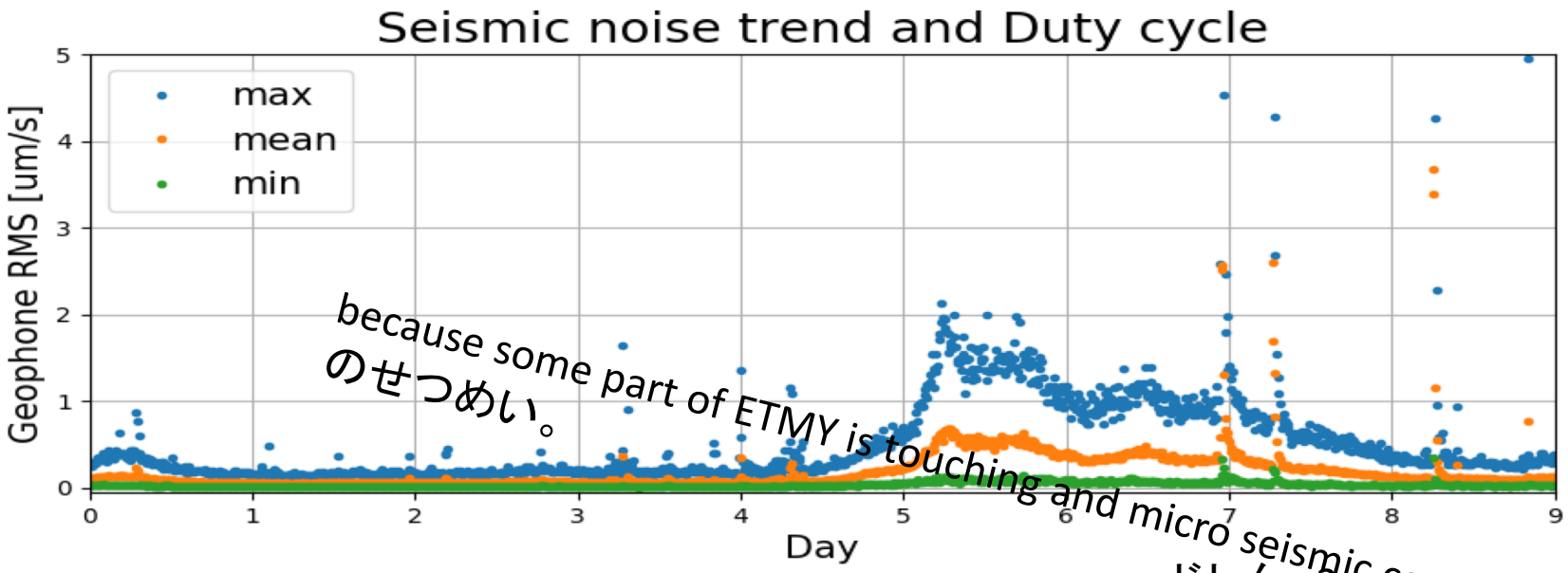


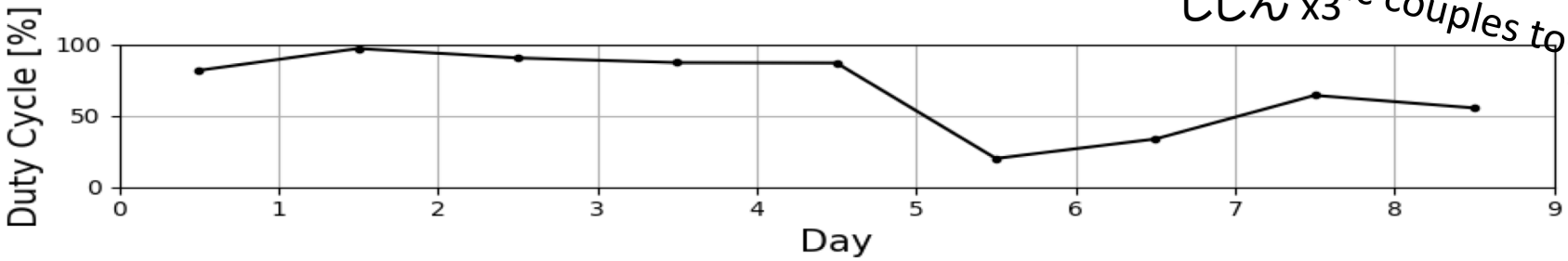
Total
68.65 %

IR のぷろっと

Phase 1 Overview

Operation Status





IR のぷろっと

Characterization

Characterization

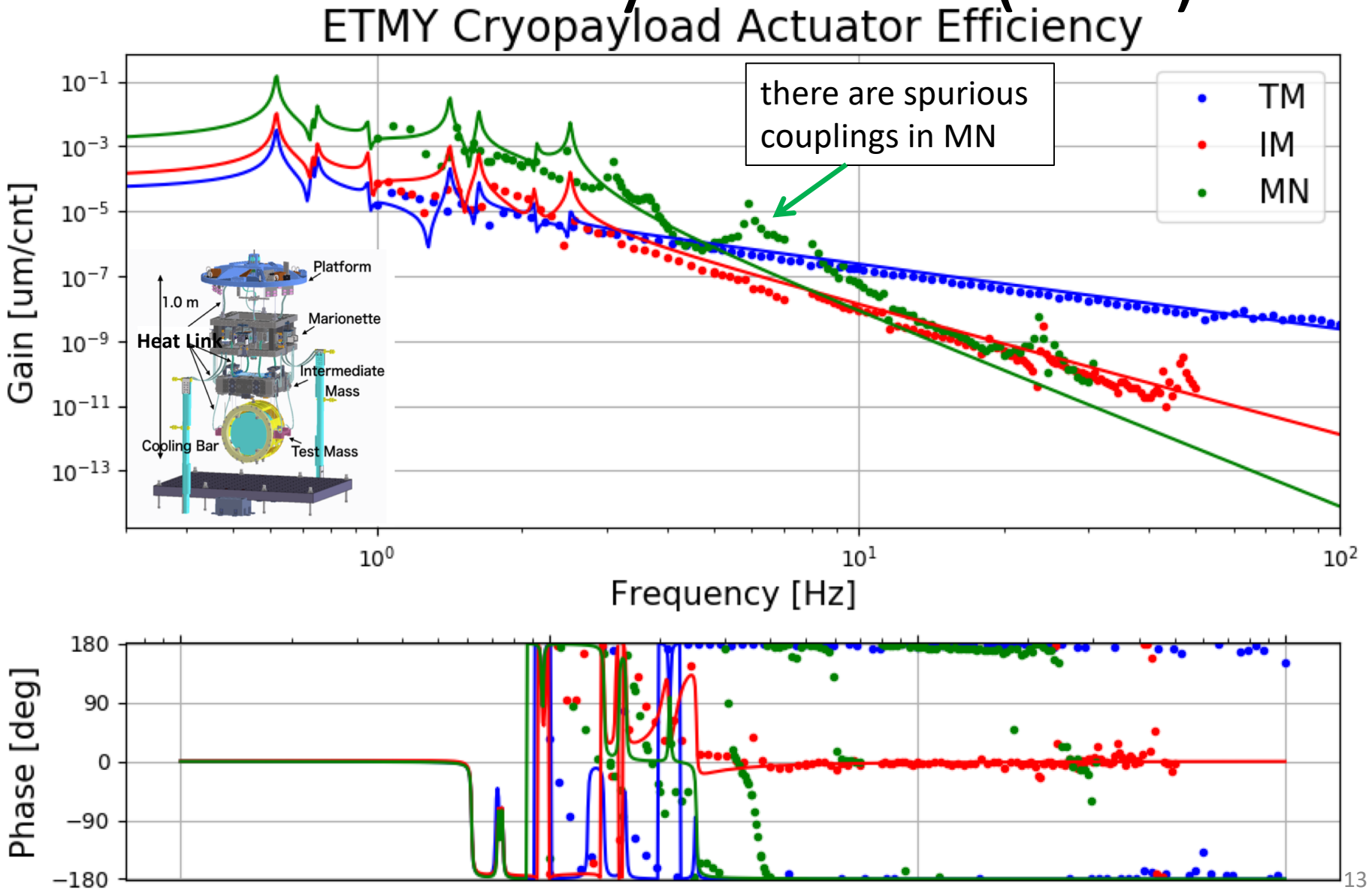
-- During 9 days of Operation, several experiments have been performed, using interferometer signal.

* 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

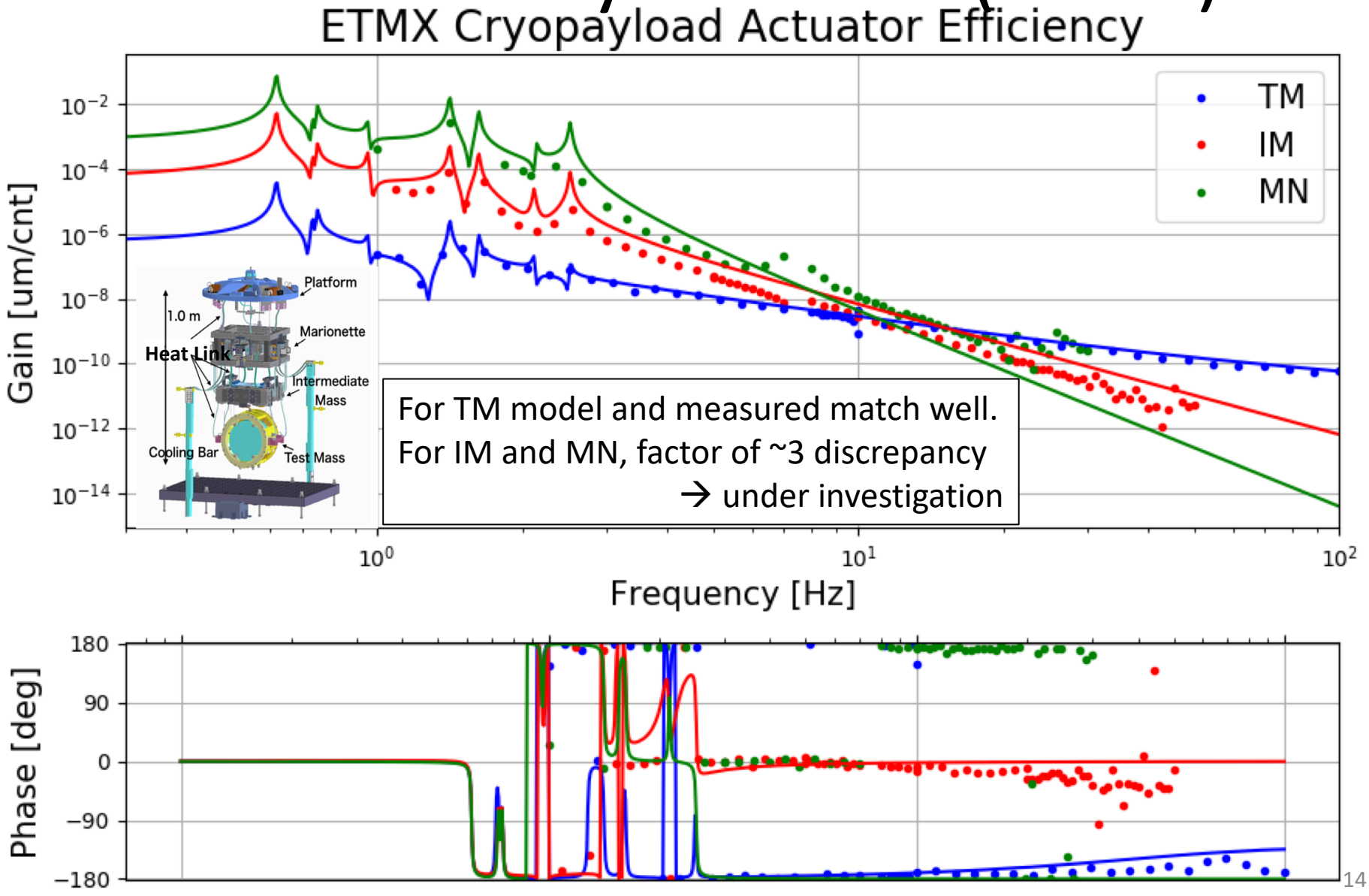
Characterization

Act. Efficiency of EMTY (20 K)



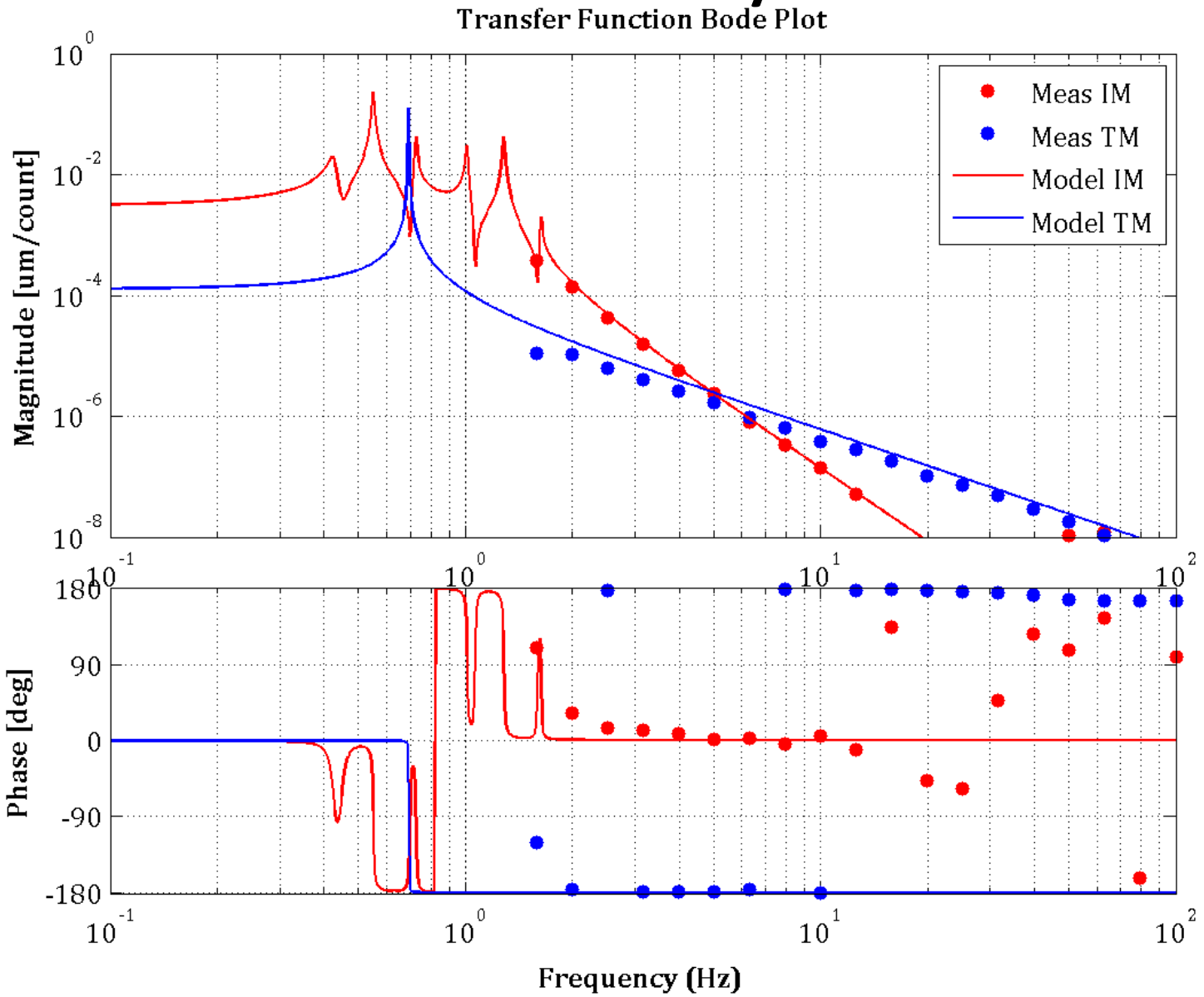
Characterization

Act. Efficiency of EMTX (300 K)



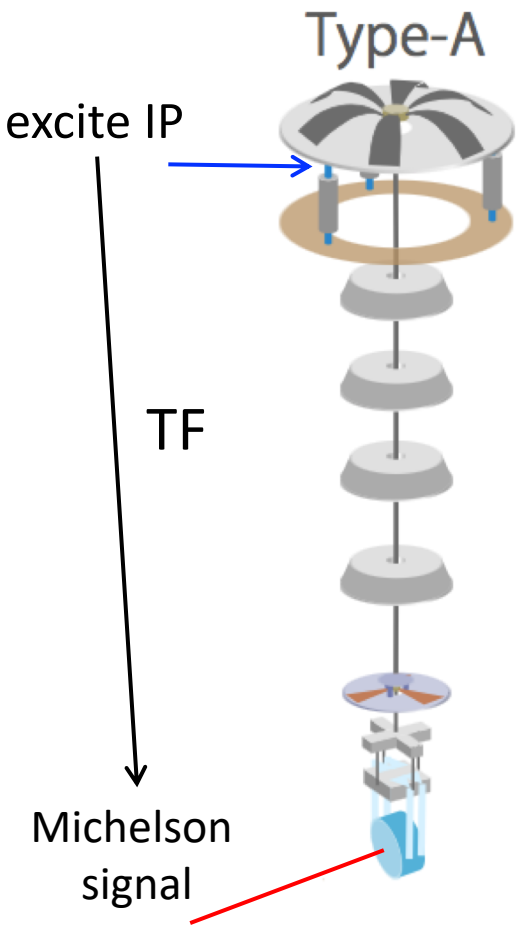
Characterization

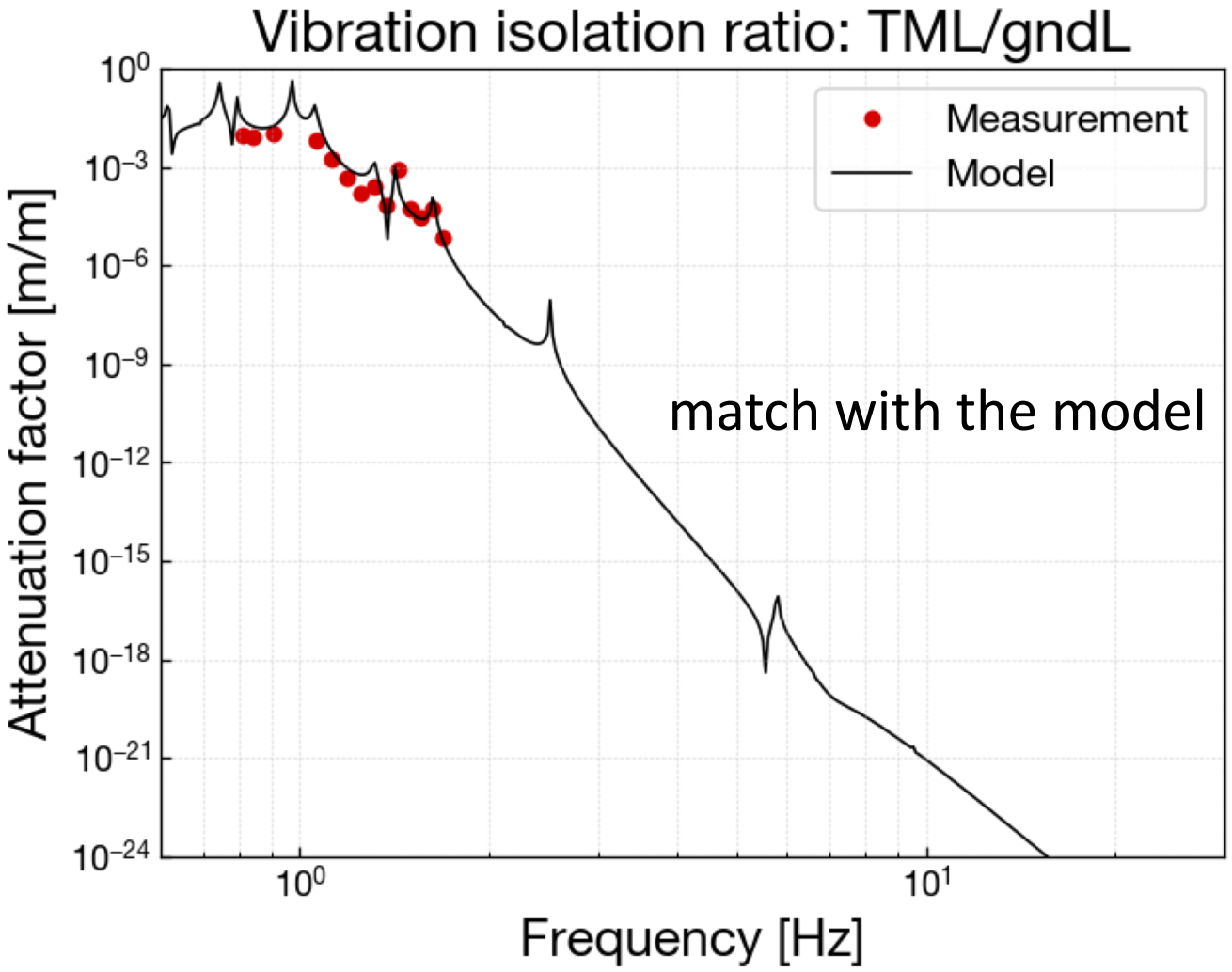
Act. Efficiency of BS



Characterization

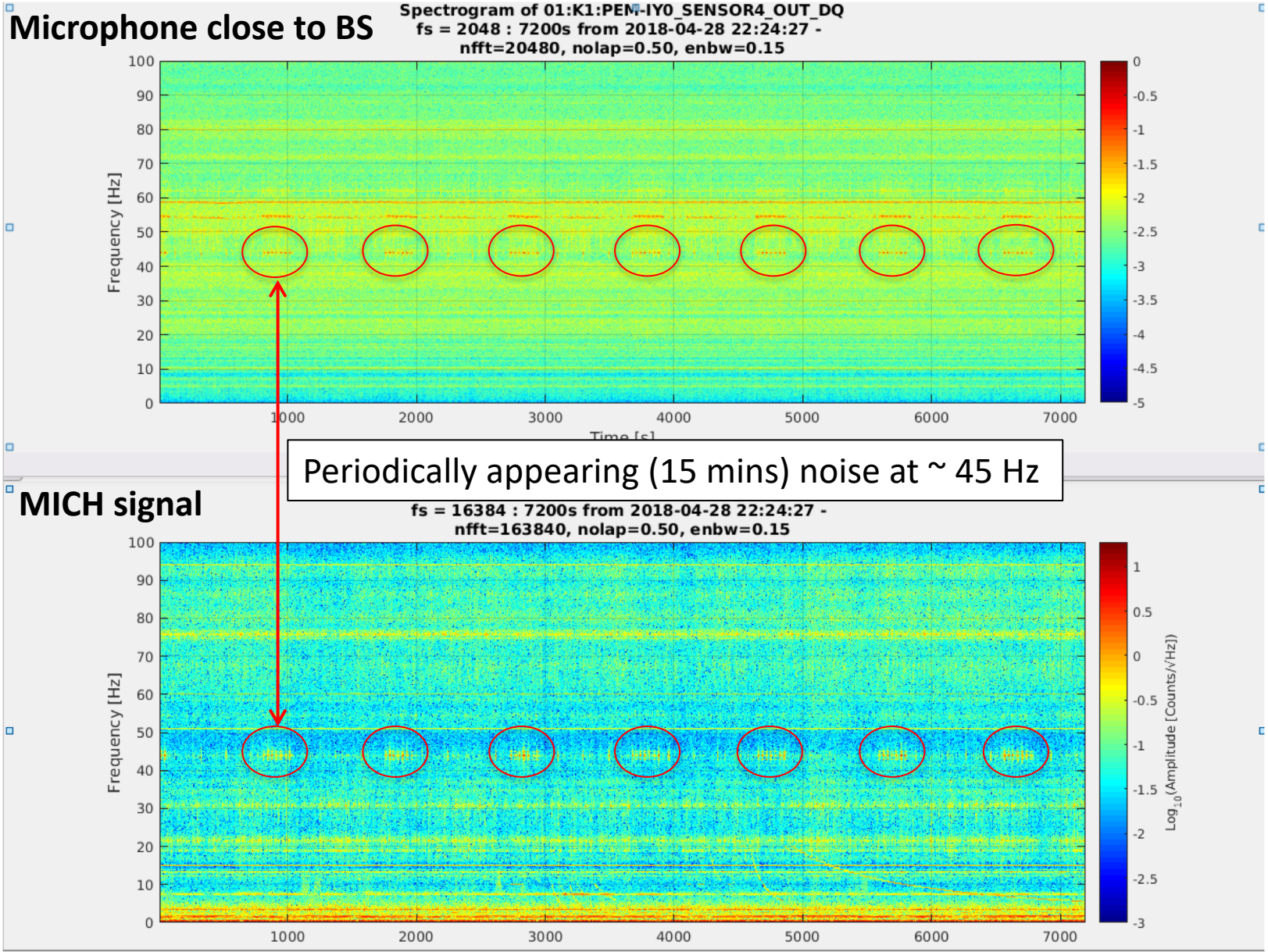
Seismic Attenuation of ETMX





Characterization

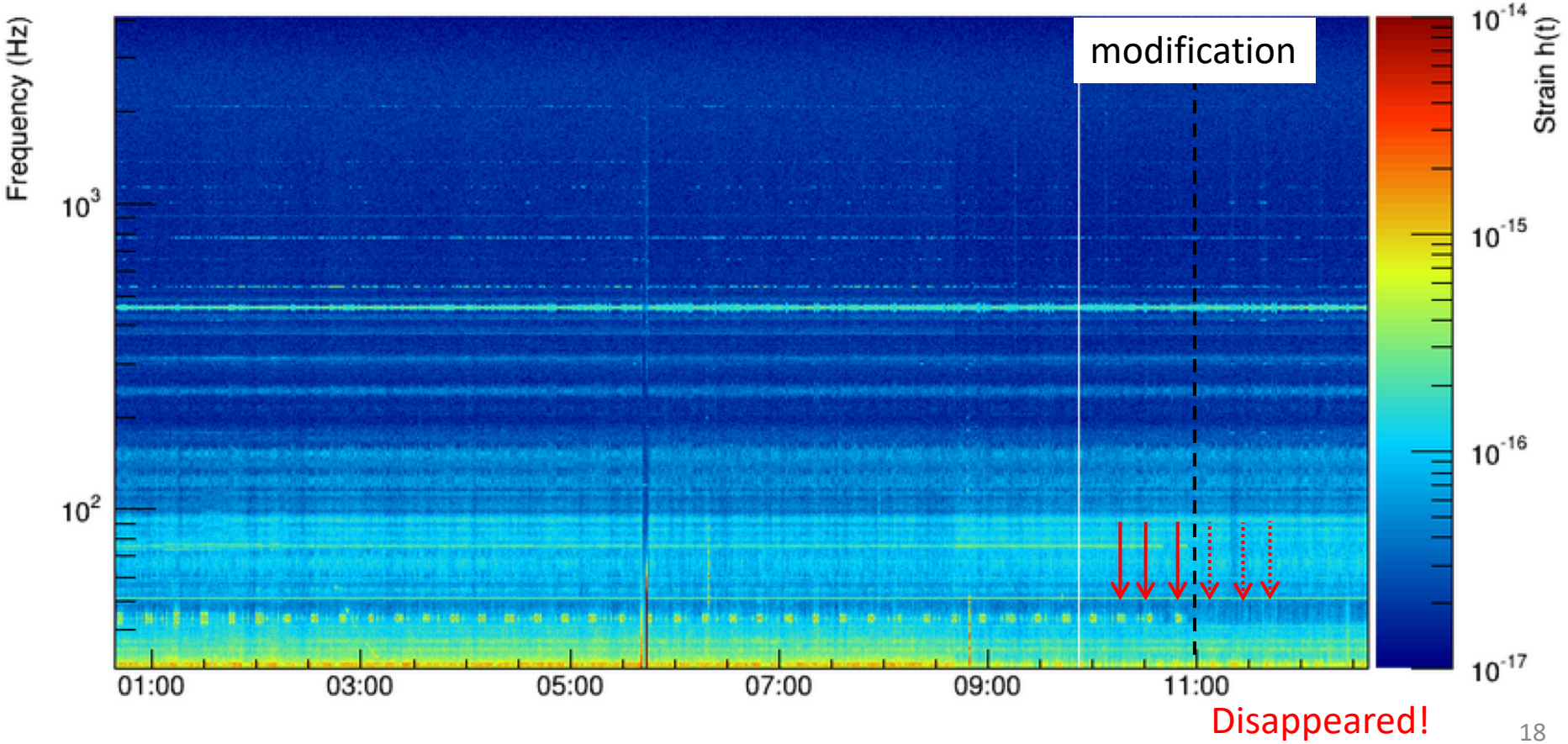
PEM related



PEM related

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

MICH spectrogram



Disappeared!

PEM related

-- It turned out this noise has coherence with PR2 optical lever signal
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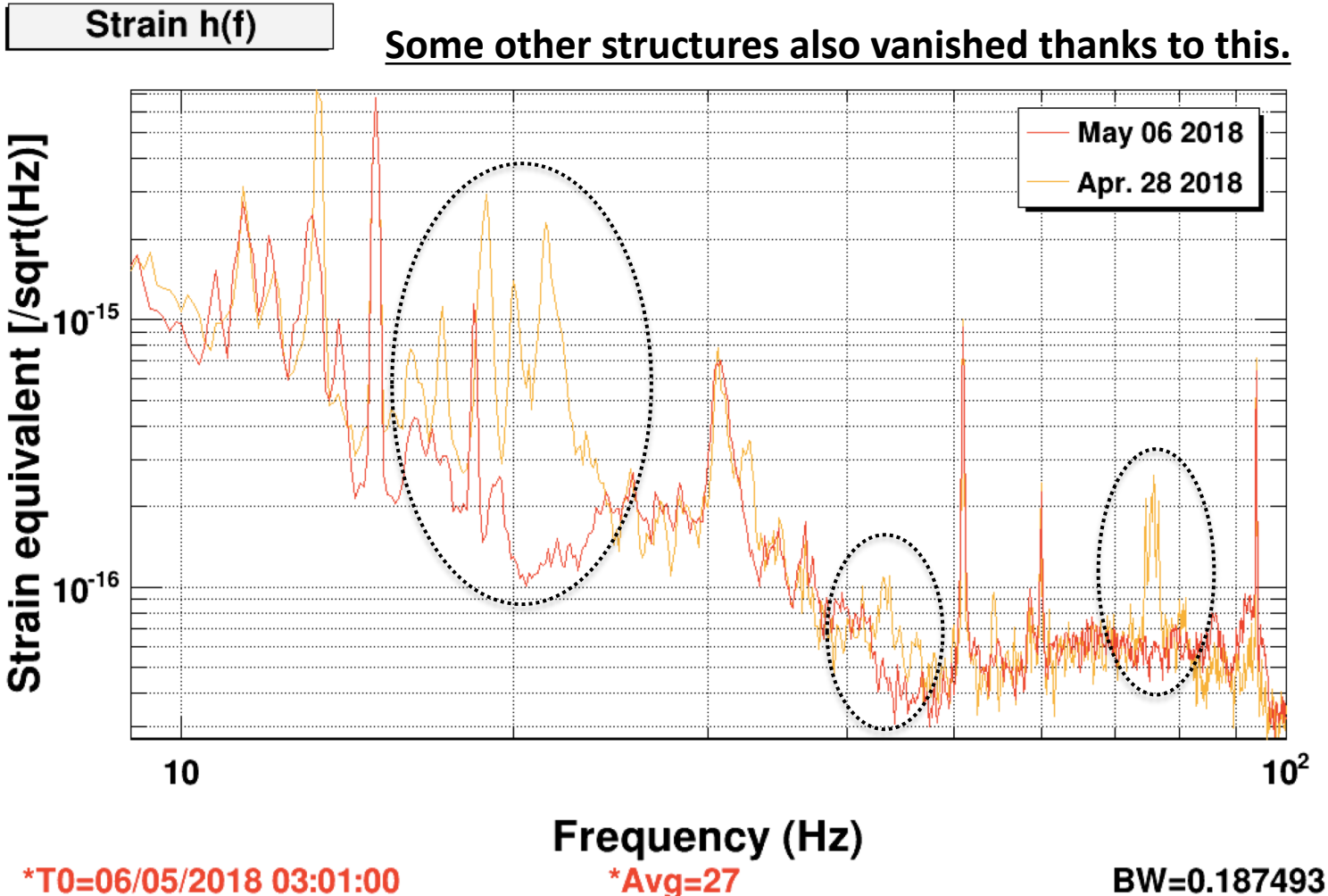


Hardware Injection Test

Summary

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

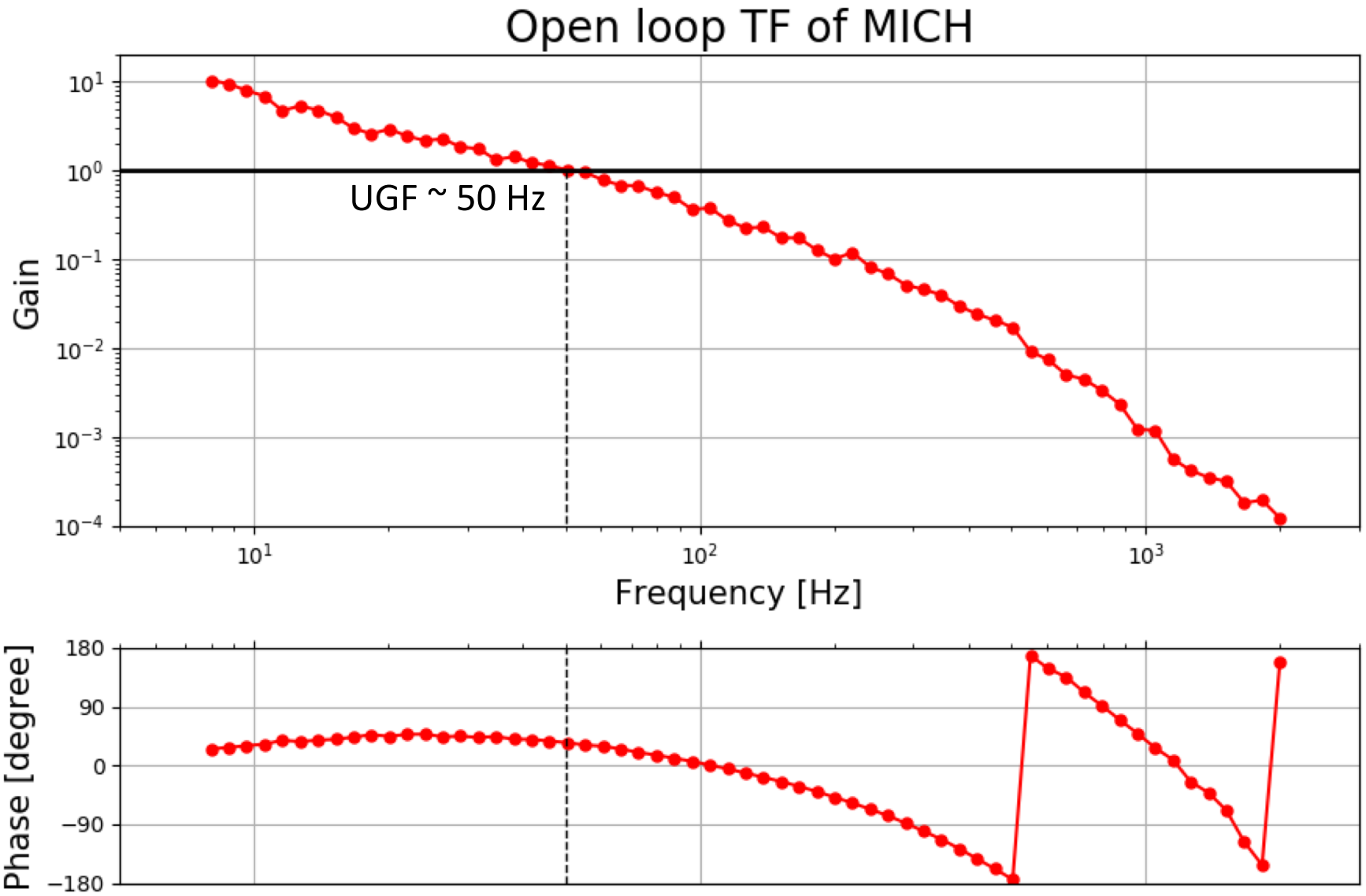
-- Cryogenic payload (test mass) was successfully actuated at cryogenic temperatures.
Issues around the payload was identified to some extent.
→ Identification and fixing are on-going toward the next step

-- summary as a whole (incl. near future)

Thank you!

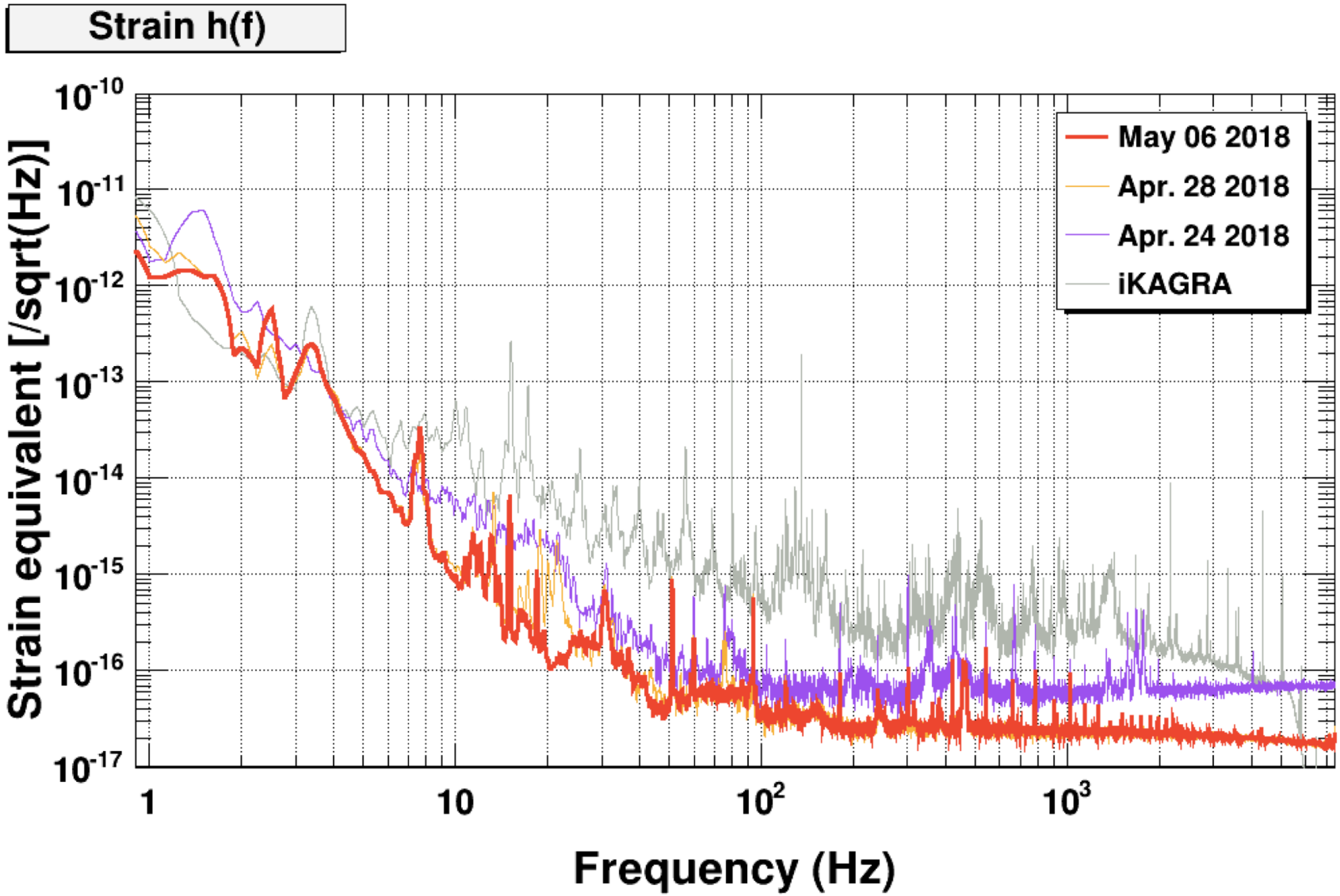
Phase 1 Overview

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

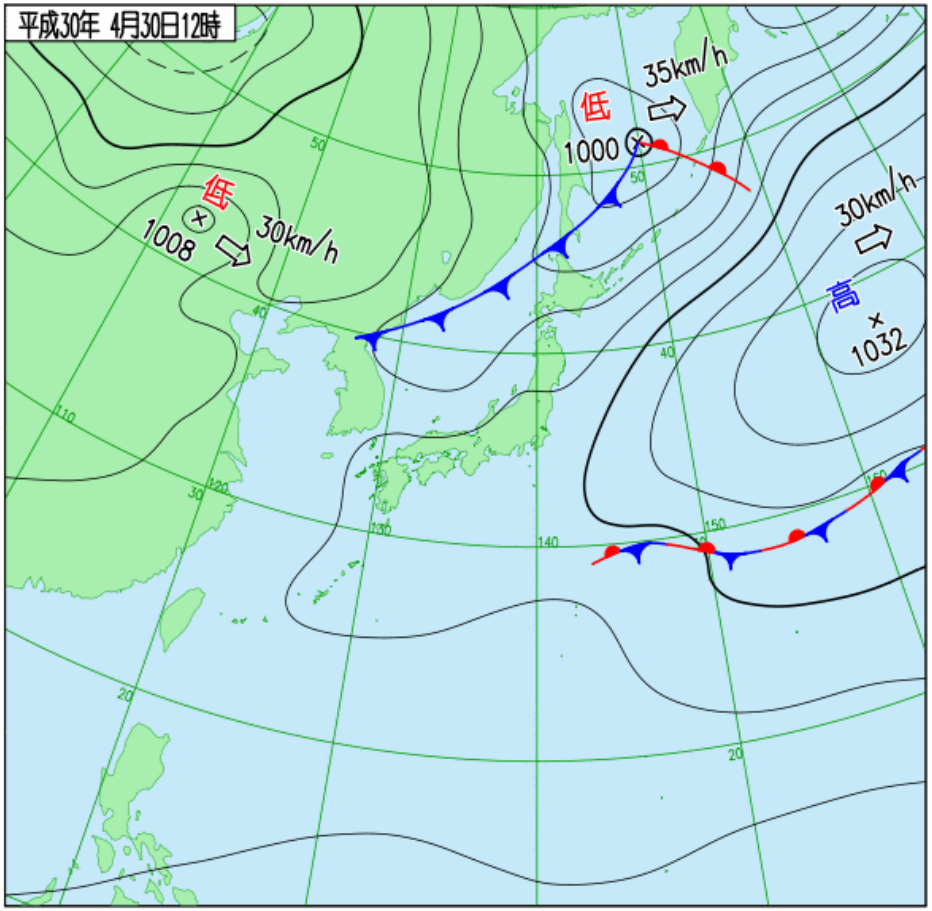
Results: 3.4(5) m, 4.5(7) m, 3.9(6) m (Design: 3.3298 m)

=> not very successful…

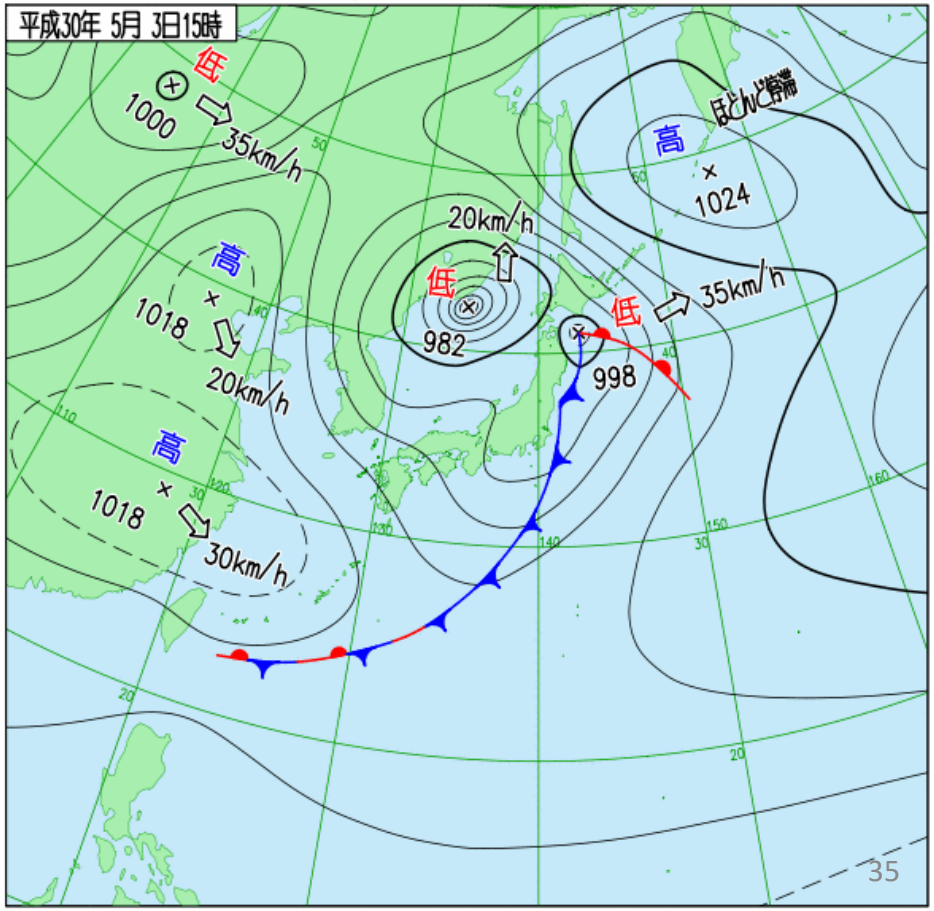
What I Learned

Micro-Seismic Noise

Quiet case



Noisy case

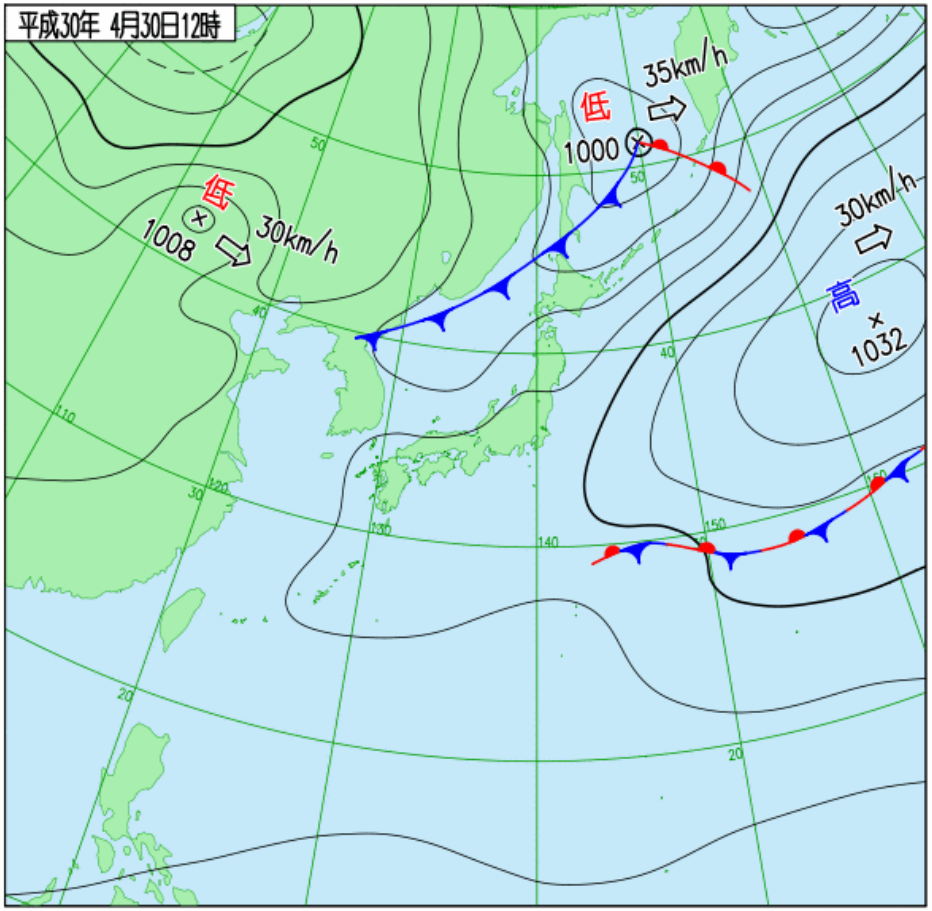


What I Learned

Micro-Seismic Noise

For our experiments:
Check the weather forecast and decide which day to take champion data

Quiet case



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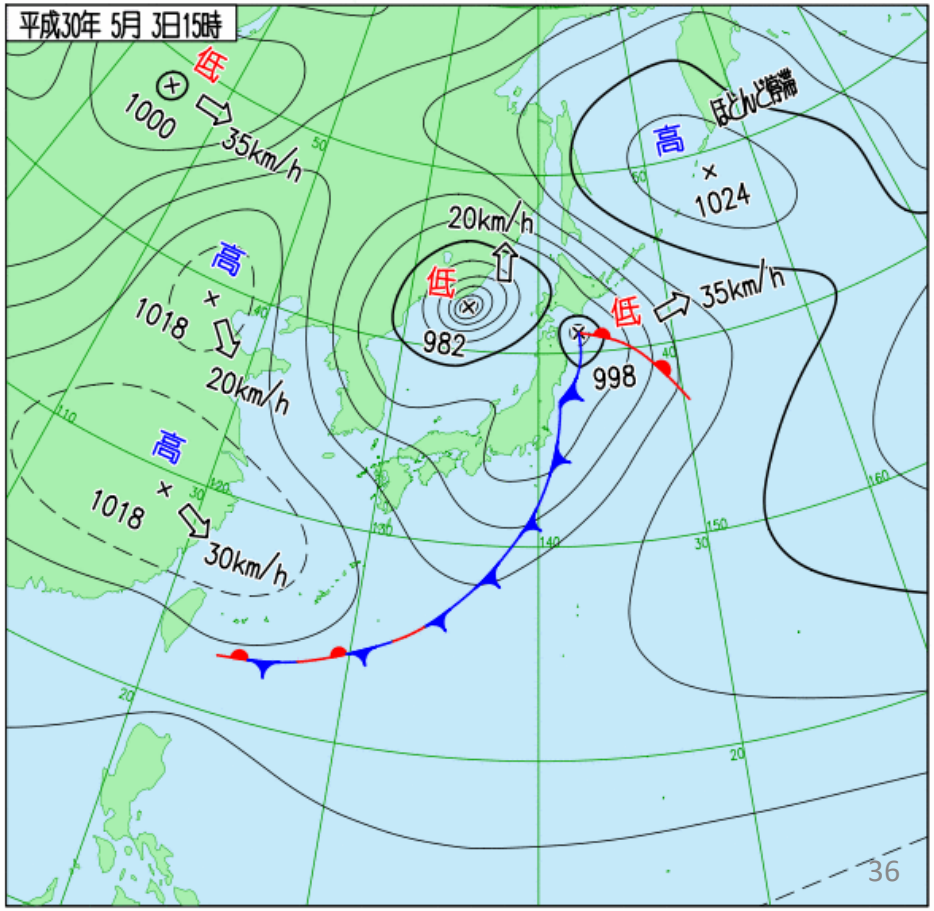
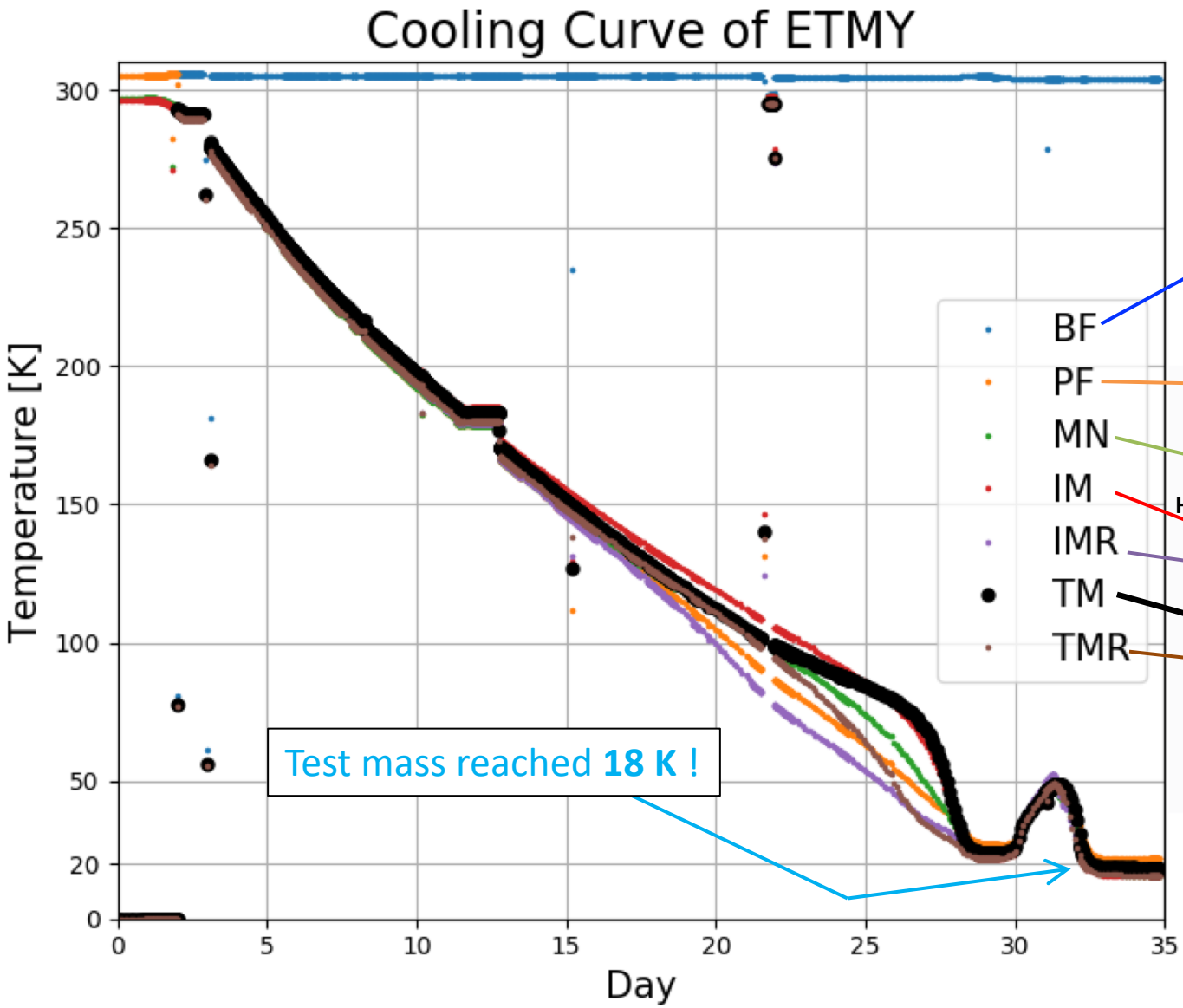


Phase 1 Overview

Cooling down ETMY



bottom of room temp. part

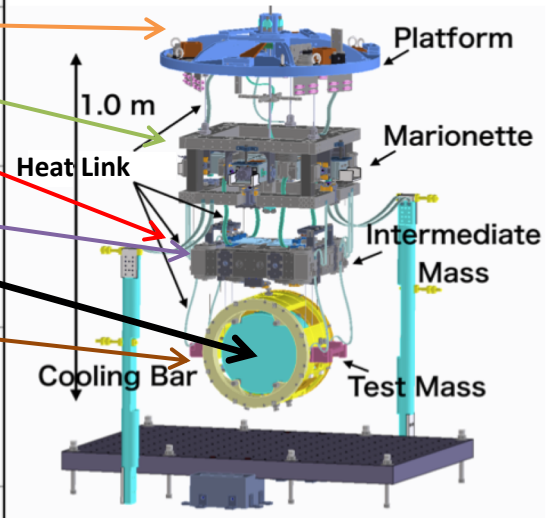


Figure of payload from JGW-G1807766-v5

Phase 1 Overview

Operation Status