Commissioning works for KAGRA

KAGRA International Workshop
@Ewha Womans University, Seoul, Korea
2018/6/29(Fri.)

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and KAGRA Collaboration

Commissioning work at KAGRA

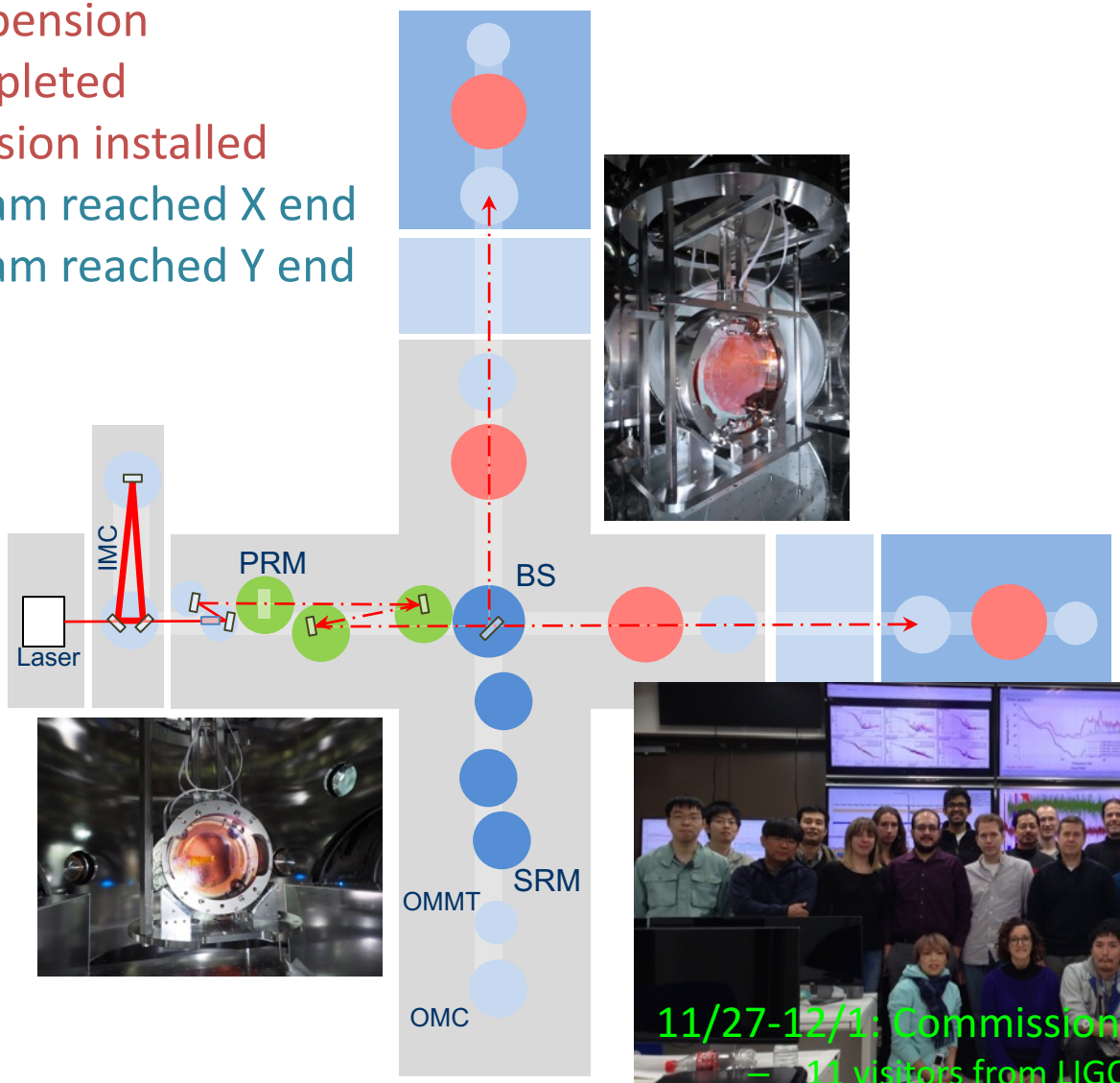
- iKAGRA commissioning: 2016/3~2016/4
  - Simple 3km Michelson interferometer withroom temperature, and no mirrors in vacuum
- bKAGRA commissioning: 2017/9~
  - phase Ⅰ (~2018/5): Michelson with low temperature operation
  - phase Ⅱ (~2019 middle): full configuration
  - phase Ⅲ (2019 middle~): observation

Stages in bKAGRA Phase 1

- Stage 1 (2017/9/25~)
  - Beam alignment to EX and EY area.
- Stage 2 (2017/12/4~)
  - Beam alignment from ETMY to center area
- Stage 3 (2018 March, April)
  - Beam alignment from ETMX to center area
  - Locking of MI with cryogenic ETMY with calibrated sensitivity curve
- ~~Stage 4 (April)~~
  - ~~Locking of MI in vacuum with both cryogenic end~~
  - Operation of IFO

Stage 1: Beam alignment to EX and EY area

- 9/19: All PR suspension installation completed
- 9/21: BS suspension installed
- 10/19: Main beam reached X end
- 10/26: Main beam reached Y end

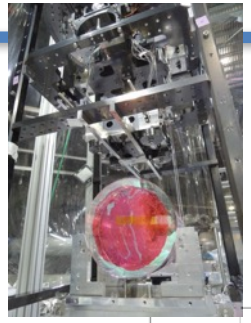


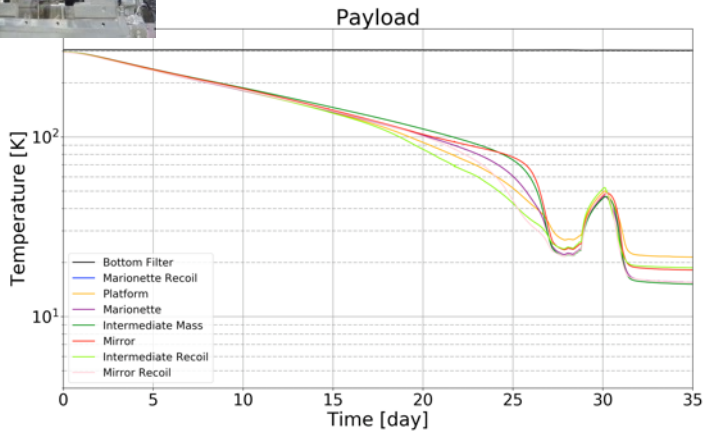
11/27-12/1: Commissioning Work Shop
- 11 visitors from LIGO, VIRGO
- 13 KAGRA members, 3 LOCs

Stage 2: Beam alignment from ETMY to corner area

11/29: Type A and cryostat connected
12/1: ETMY suspension installed
12/19: Main beam returned from ETMY

2018
2/7: Cooling down of ETMY started
3/11: ETMY reached 20 K



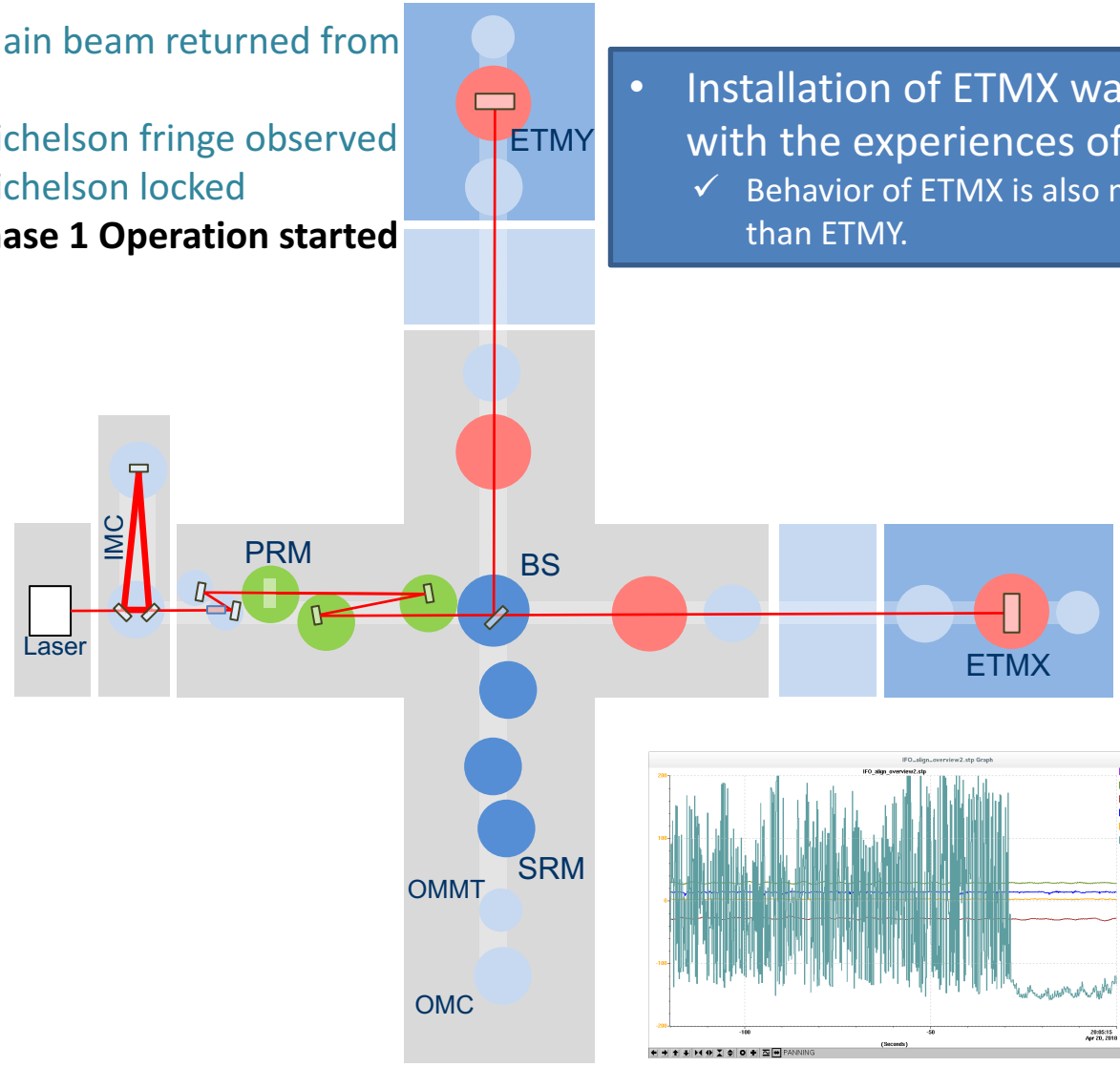


- It took ~2months from connection Type A and Cryostat to start cooling down. Is it possible shrink time for the next mirrors?
  - ✓ Some troubles happened for the first time work, but it can be avoided in the next time.

Stage 3:Installation of ETMX, locking Michelson interferometer

* 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**

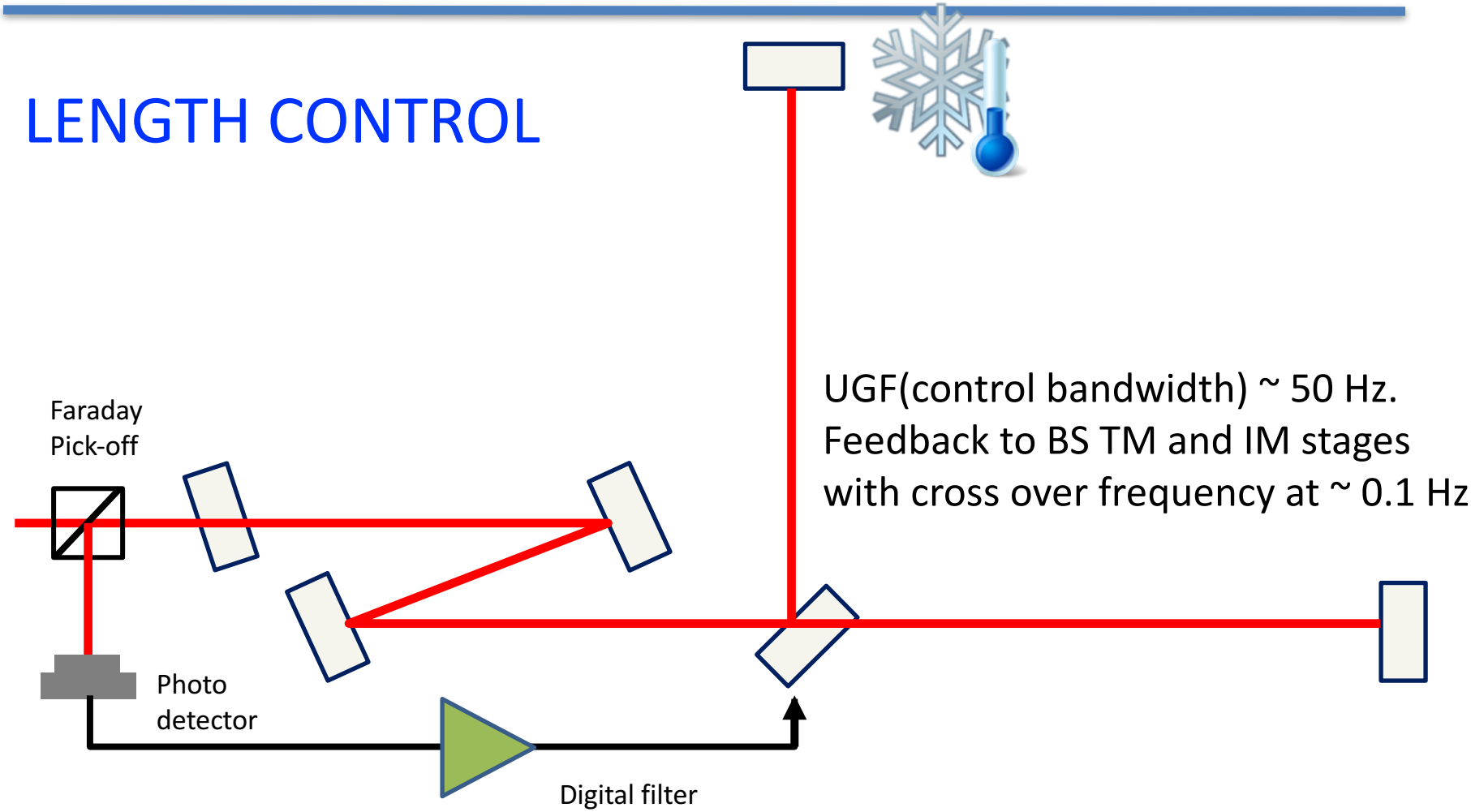
- Installation of ETMX was much faster with the experiences of ETMY.
  - ✓ Behavior of ETMX is also much smoother than ETMY.



Phase 1 overview

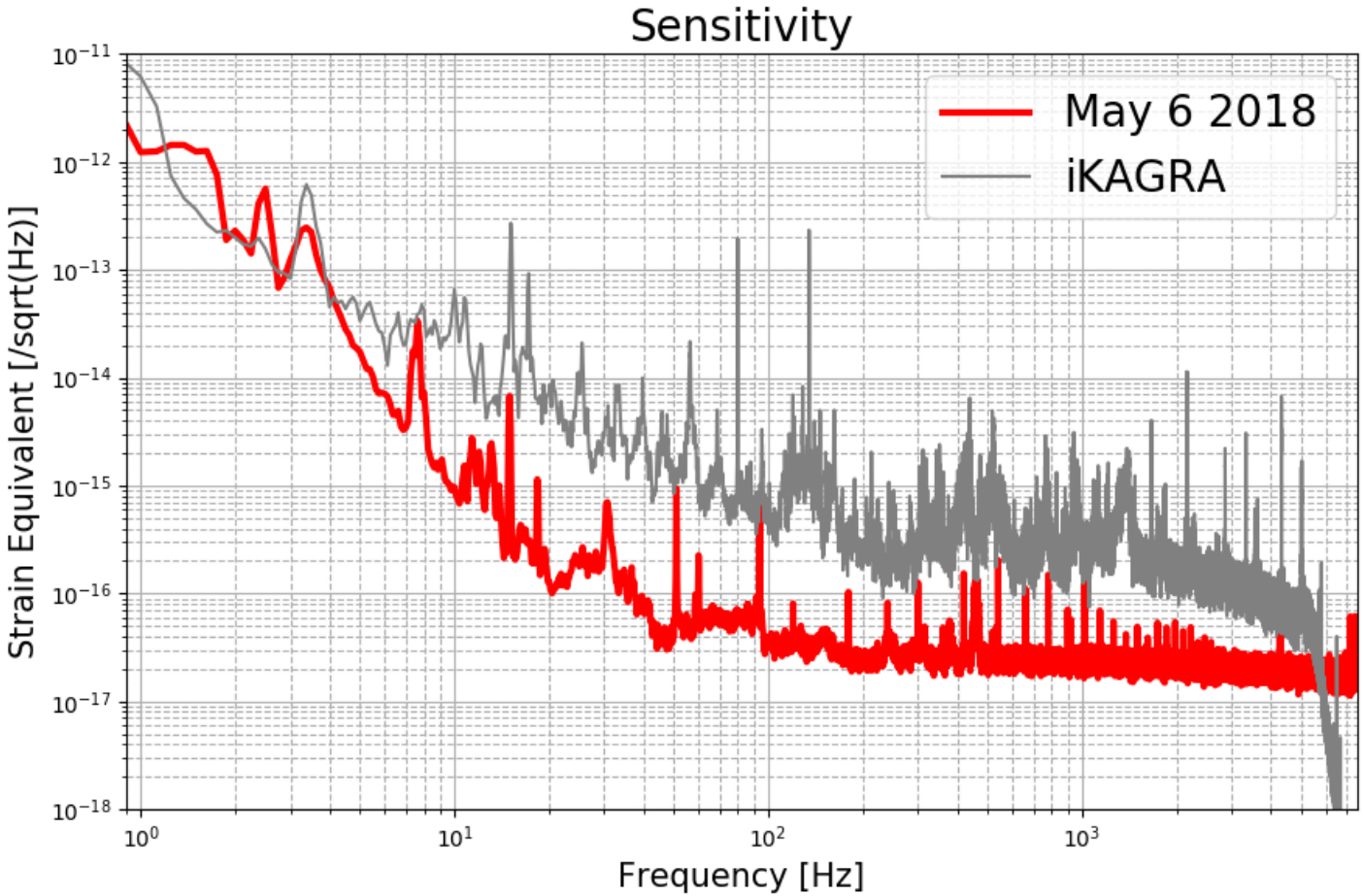
- Infrastructure
  - PRs, BS, ETMs are implemented and worked.
  - All mirrors in vacuum: 3km arms, X-end, Y-end and central area.
  - Cooled ETMY with a spare mirror.
  - Room temperature ETMX with a real mirror.
- IFO
  - 3km Michelson lock: ~10hours (longest).
  - Sensitivity: 2~3e-17/rHz
  - 9 days operation.

LENGTH CONTROL



UGF(control bandwidth) ~ 50 Hz.
Feedback to BS TM and IM stages
with cross over frequency at ~ 0.1 Hz

Noise spectrum

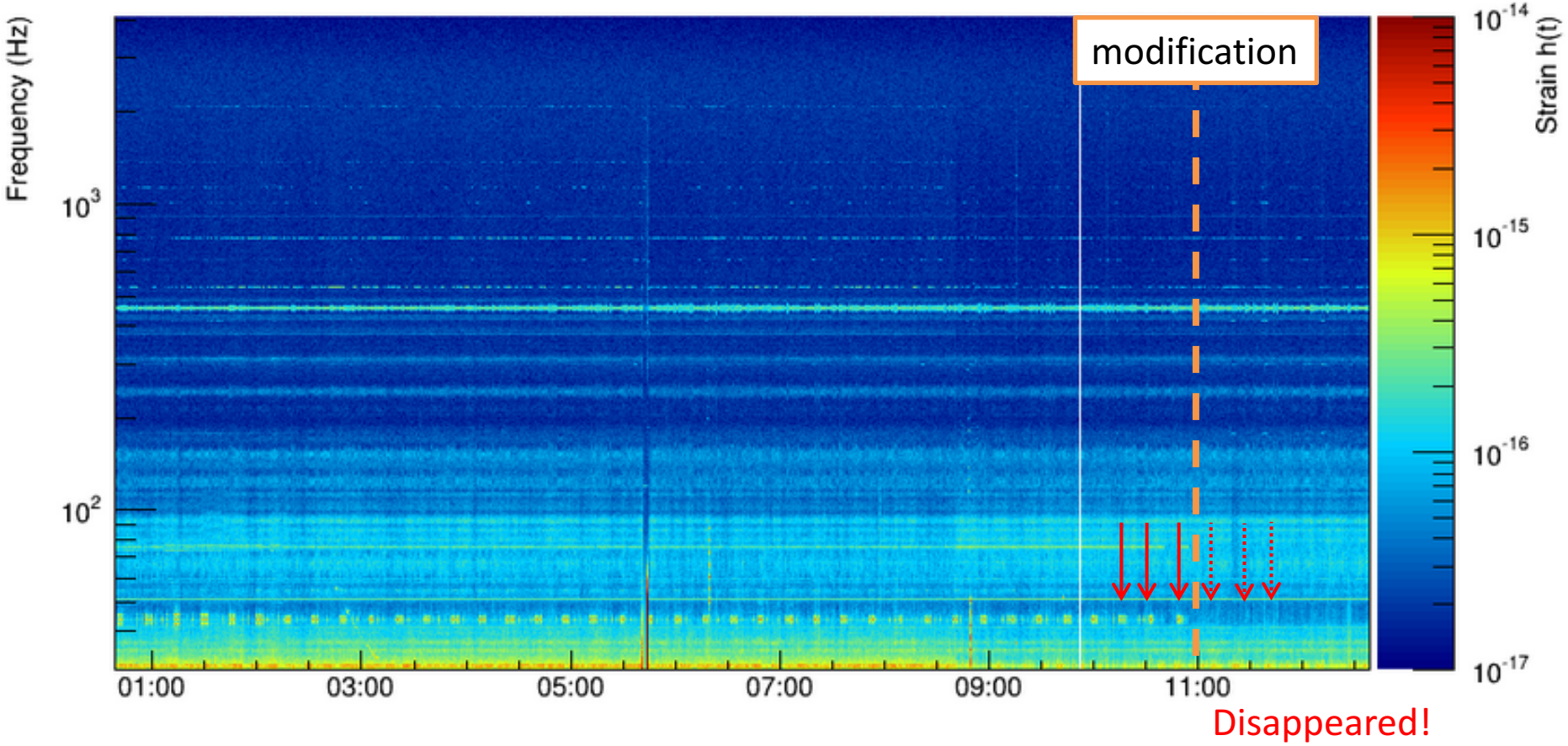


- Sensitivity was improved 1~1.5 order from iKAGRA in almost frequency.
- This is mainly because all the mirrors were in vacuum, and acoustic noise was reduced.

PEM results

-- 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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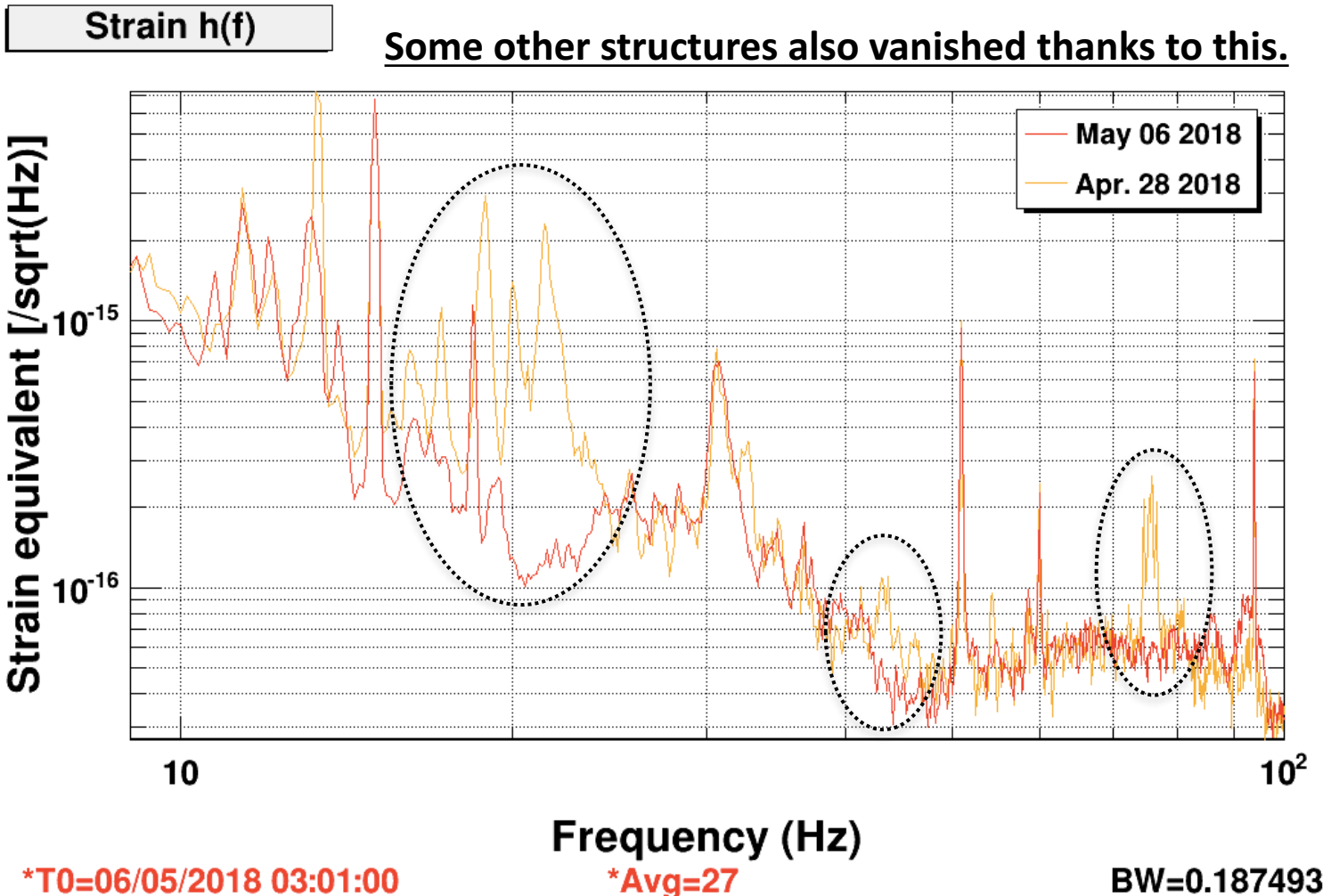
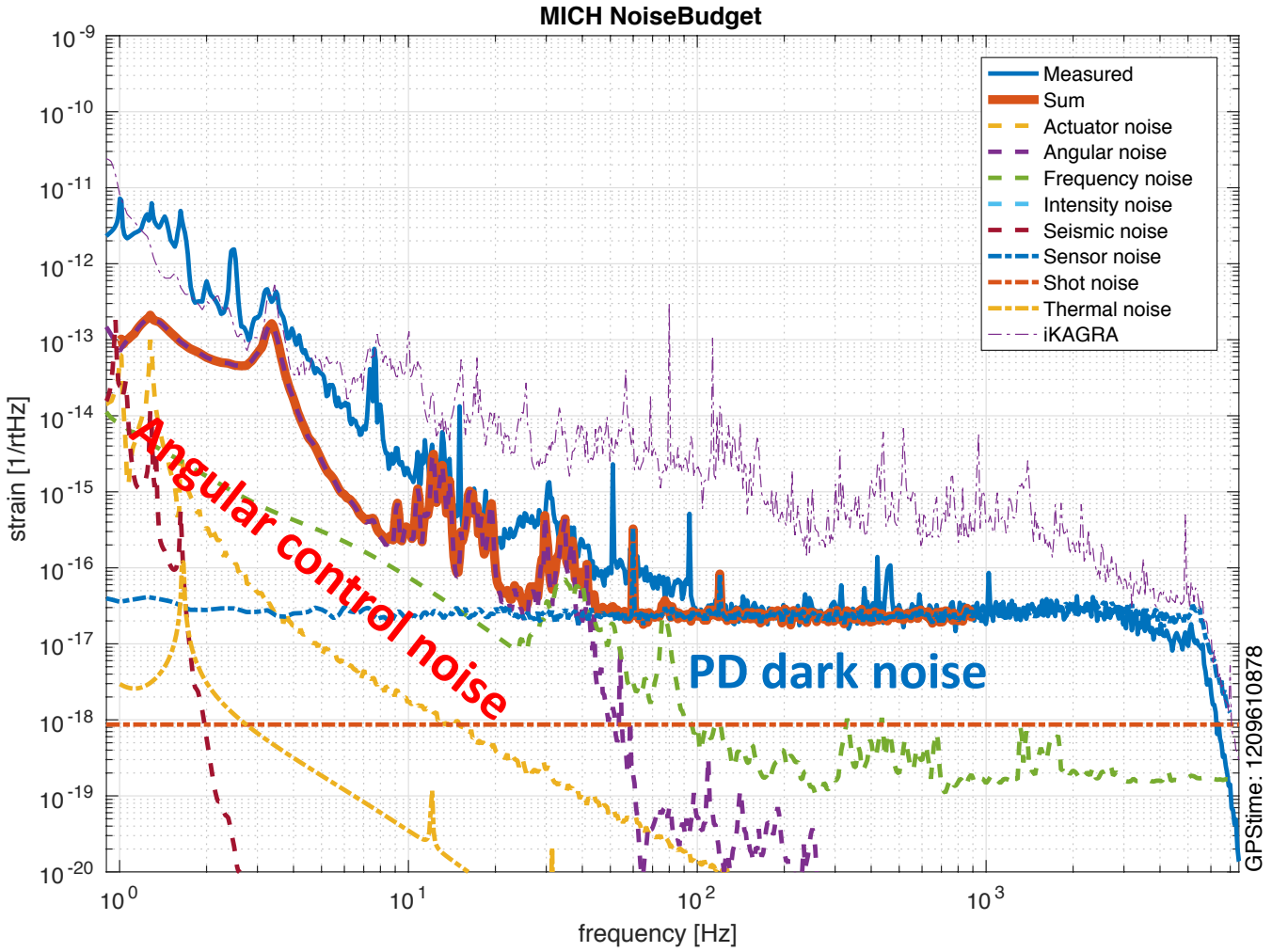
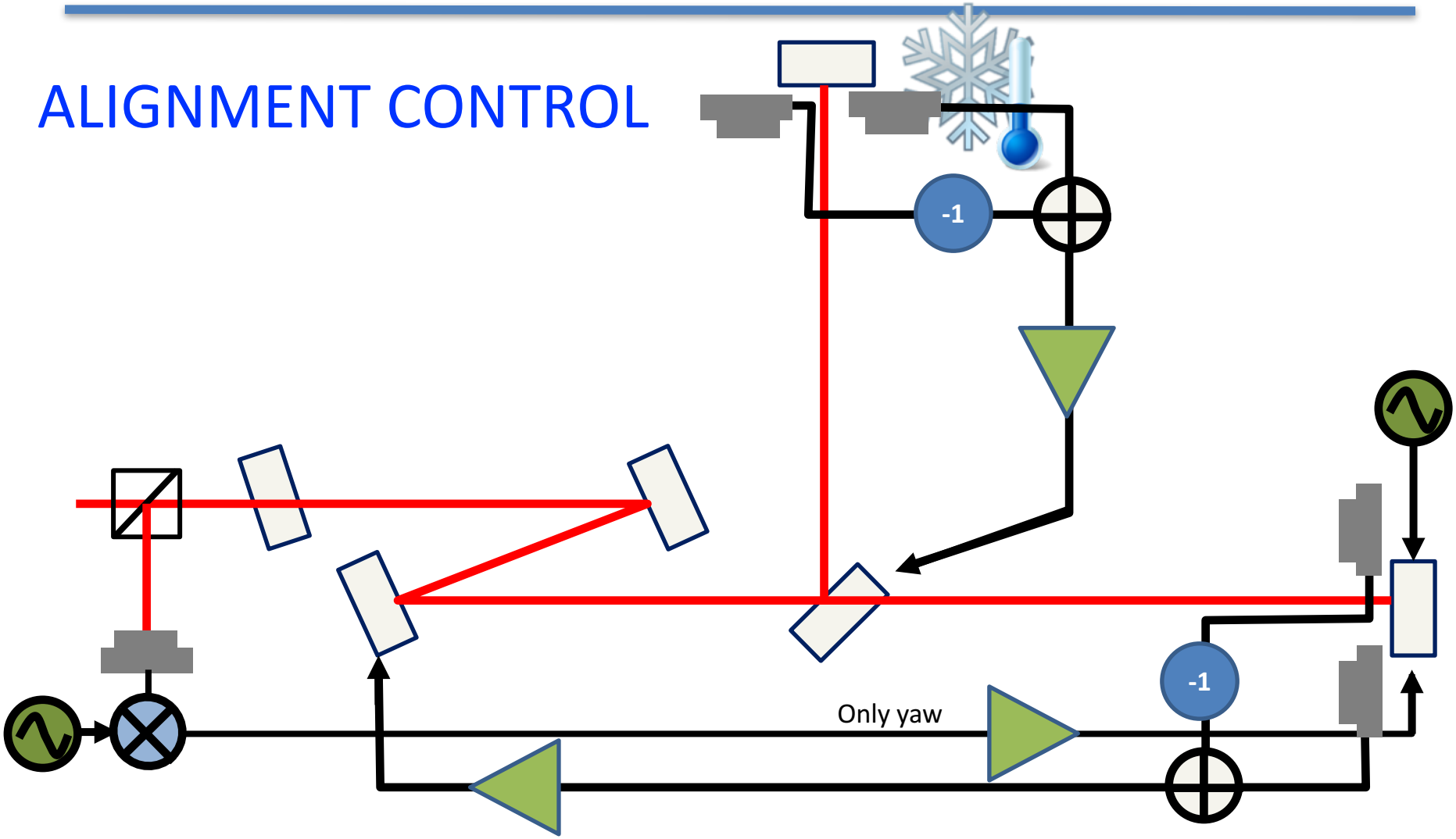


Noise budget



ALIGNMENT CONTROL

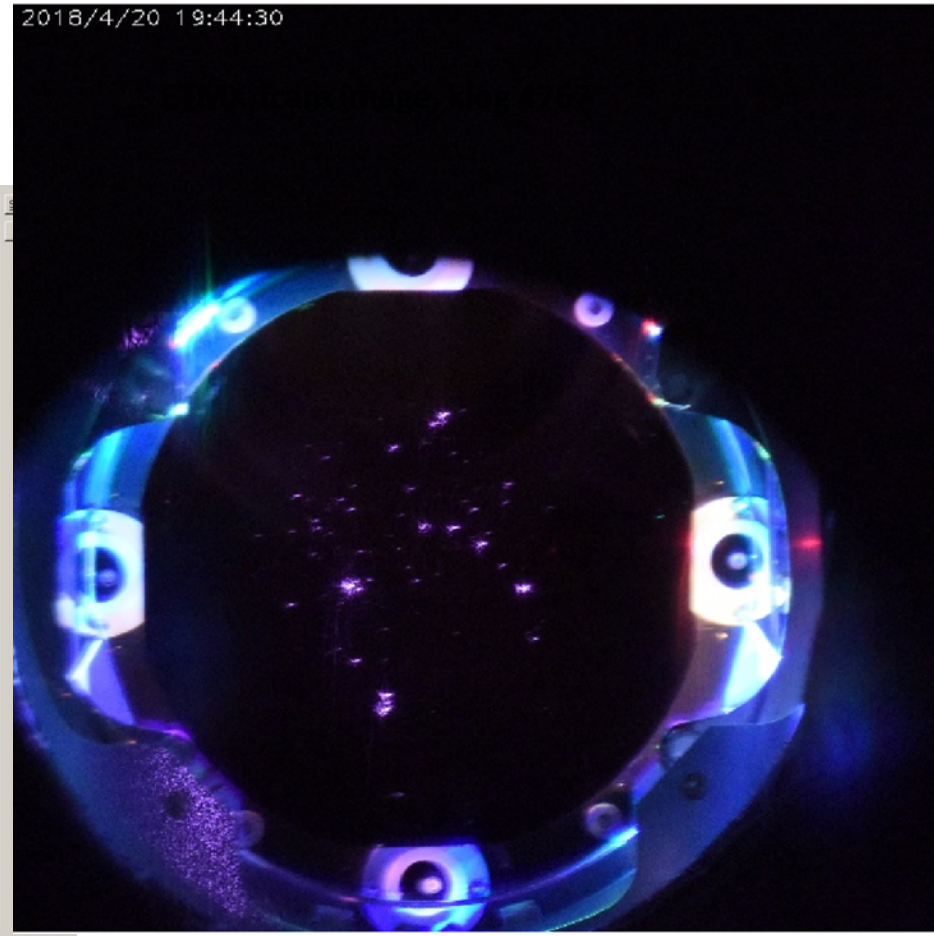


ALIGNMENT CONTROL (contn'd)

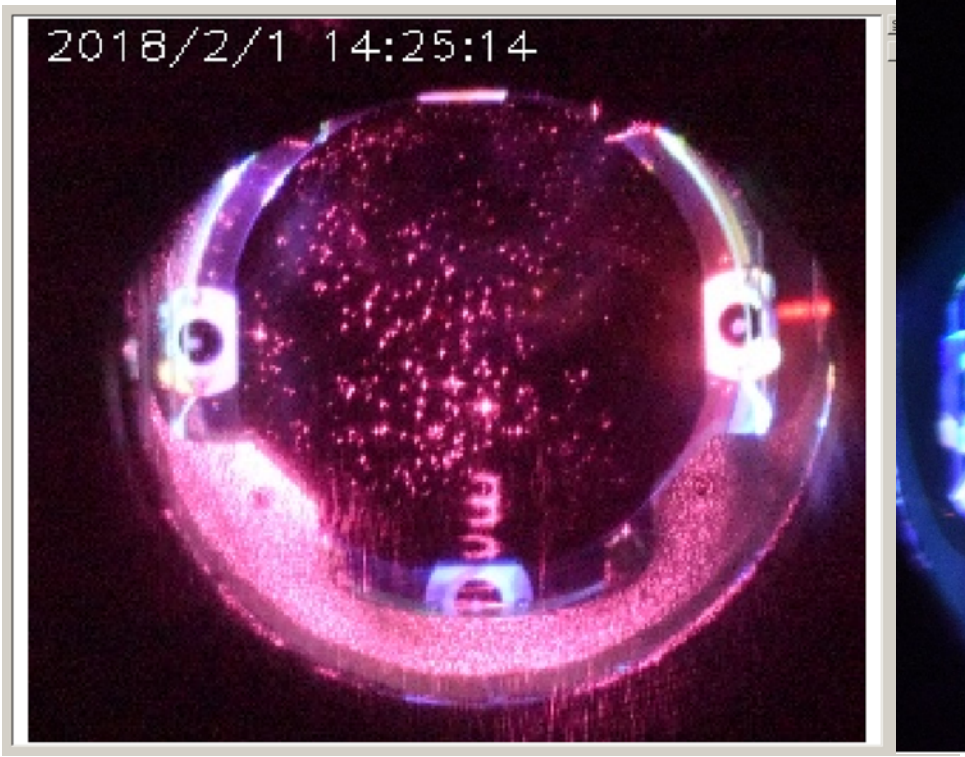
- Manual fine adjustment ~ every half a day
- No global control on ETMY angle
  - Optical lever local control was good enough
- ETMX needed a global control
  - Servoing to optical lever had a long term drift issue (~ a day)
  - Global control lets ETMX follow ETMY
  - Seemingly worked fine

Bright spots

ETMX Tcam image: real mirror

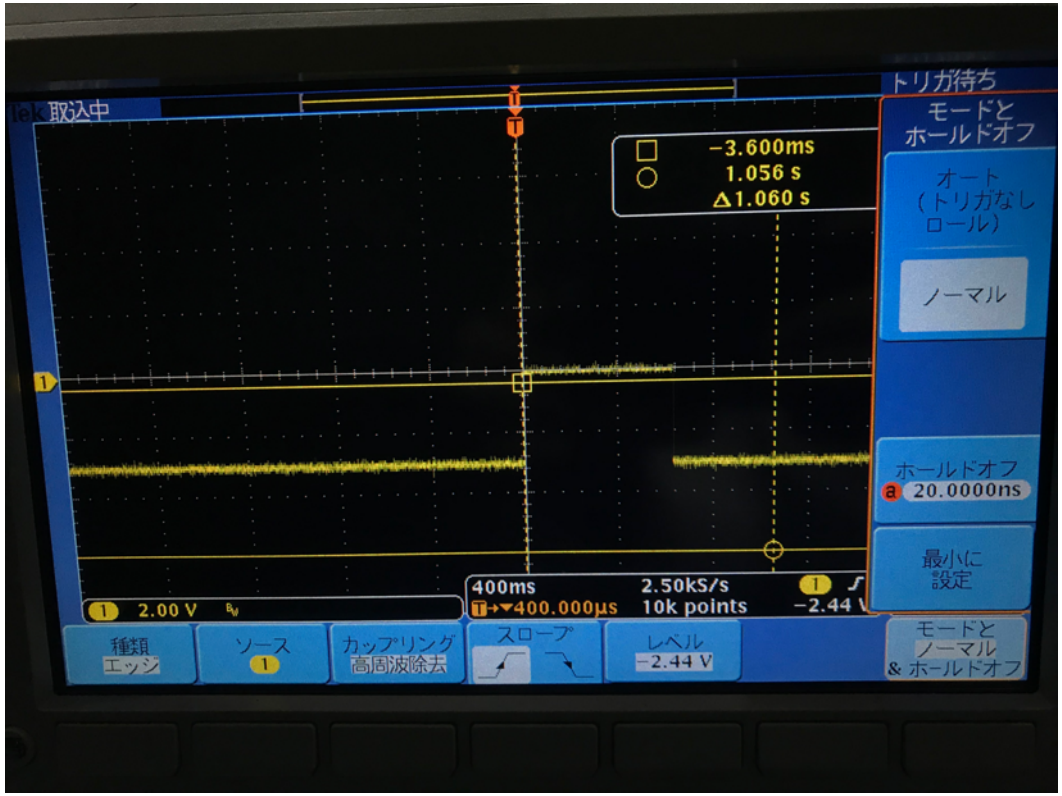


ETMY Tcam image: spare mirror



DAC glitches

- Observed in ETMY, PRs 2 and 3, and BS controllers.



Klog 4254

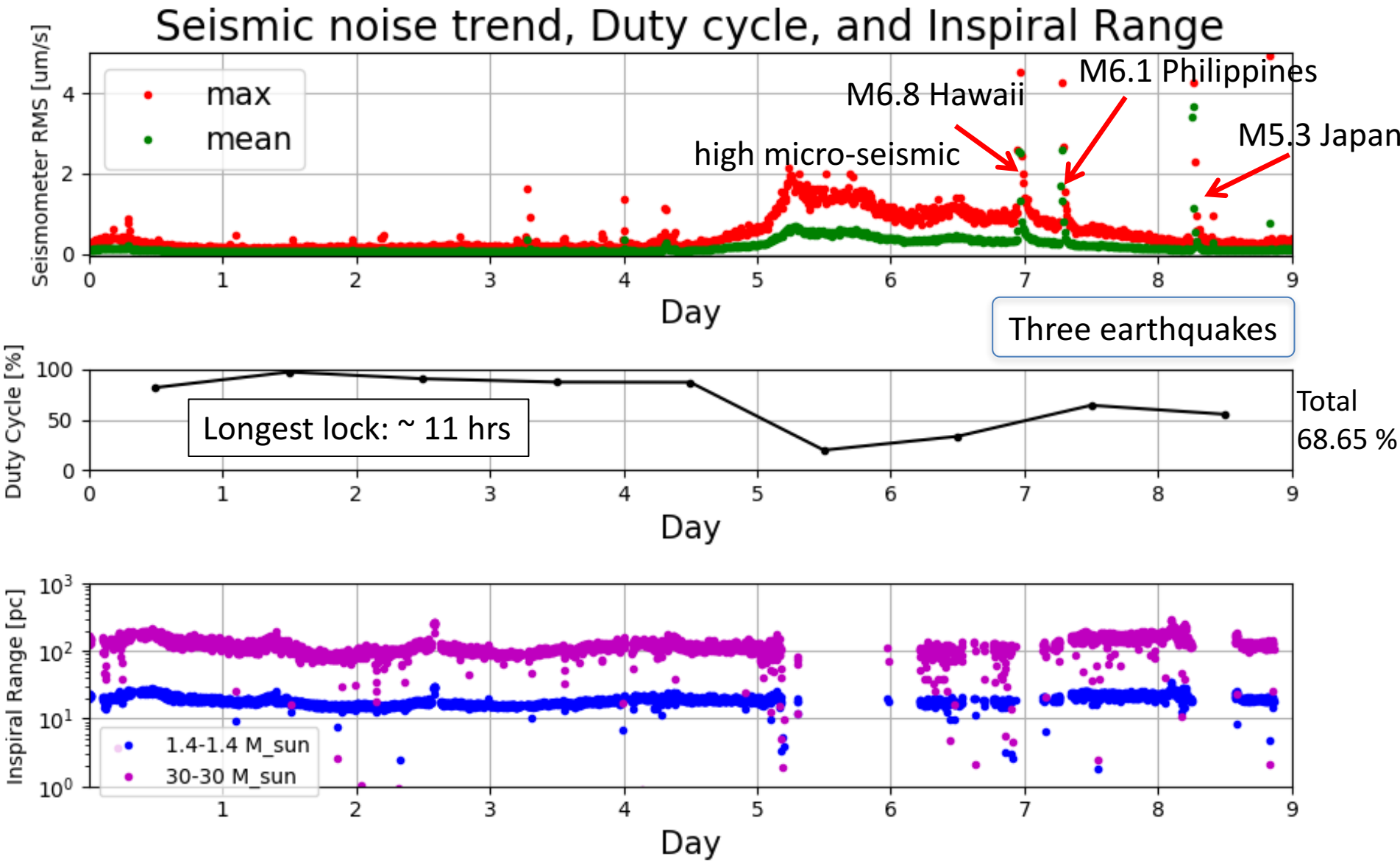
- This is because of too much load on CPU for real-time control PC.
- Reducing the sampling rate (16 -> 2 kHz) reduced the glitch rate to an OK-level.

bKAGRA phase1 operation schedule

	4/28	4/29	4/30	5/1	5/2	5/3	5/4	5/5	5/6	5/7
Day (9:00-17:00)	OLG measurements	Type-A Yend TRF	BS TRF	Type-A Xend TRF	Noise injection Center	Noise injection YEND	Schnupp Assymmetry & IFO noise budget	Noise injection XEND	CRY Extra EXP. 1 & 2	Phase 2
Night (17:00-9:00)	OLG measurements	Type-A Yend TRF	CW injection	Type-A Xend TRF	CBC injection	CBC injection	Schnupp Assymmetry & IFO noise budget	OLG measurements	CRY Extra EXP. 1 & 2	
Parallel	Data transfer, Pipeline tests, GIF									

- Originally this was planned that 4/23(Mon) started.
- Actual starting date was 4/28(Sat), that was 5days delay due to vacuum leakages.
- IFO was also helped by this delay. The first lock was 4/20. We needed some days for tuning interferomter.
- Some of results of this operation will be talked in this workshop.

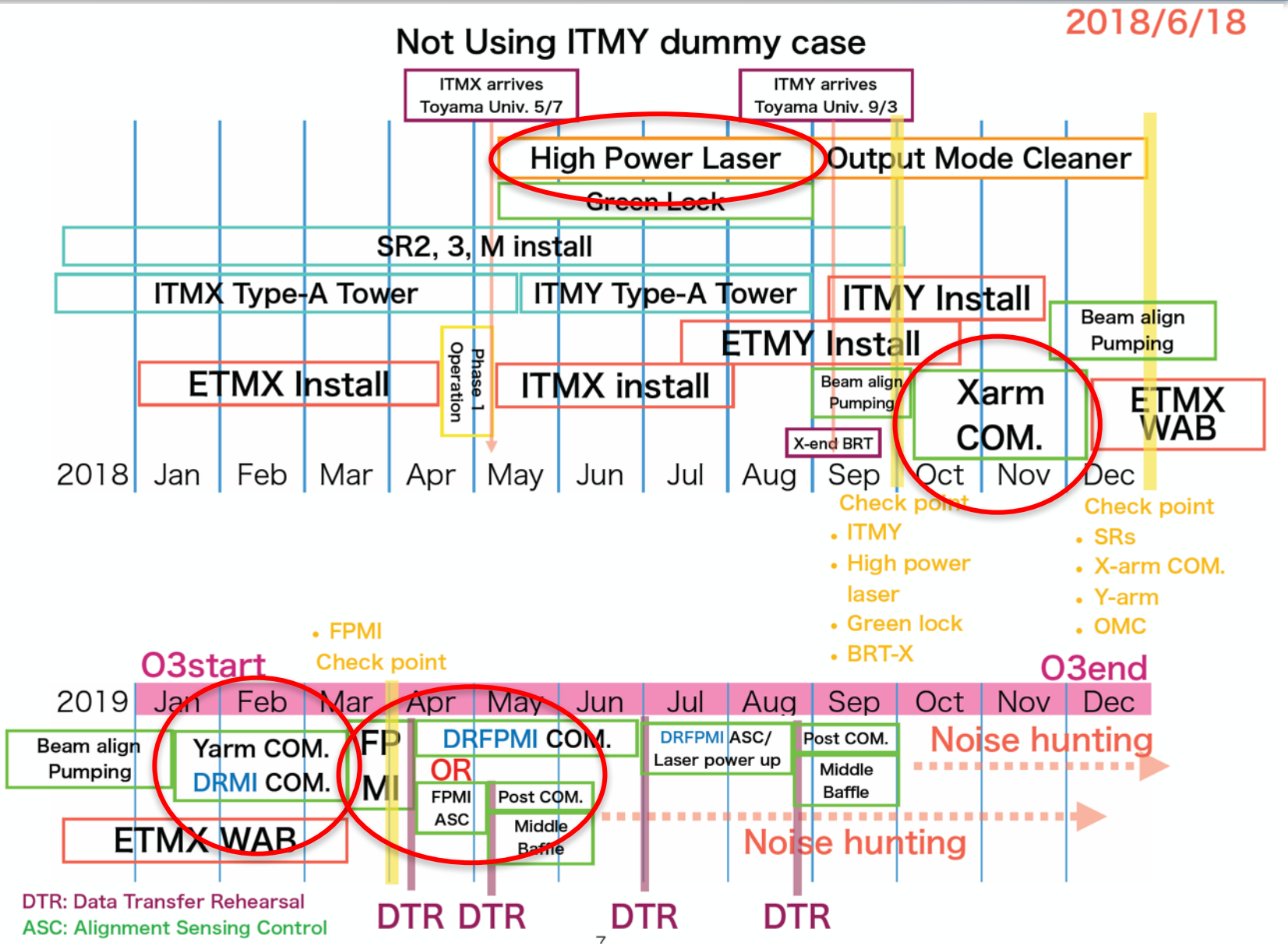
Operation Status



Stages in Phase II

- Proposing several days engineering run after each step.
  - HPL stage: for High Power Laser
  - XA stage: 1 day engineering run for X Arm lock.
  - YA stage: 3 day engineering run for Y Arm lock.
  - FPM stage: 1week engineering run for Fabry Perot Michelson lock.
  - RSE stage: 1week engineering run for RSE lock.
- Additional run.
  - 2 weeks run IFO with some sensitivity. This will be a good training for O3.

Schedule


2018/6/18
Not Using ITMY dummy case
ITMX arrives Toyama Univ. 5/7
ITMY arrives Toyama Univ. 9/3
High Power Laser
Output Mode Cleaner
Green Lock
SR2, 3, M install
ITMX Type-A Tower
ITMY Type-A Tower
ITMY Install
ETMY Install
Beam align Pumping
ETMX Install
Operation Phase 1
ITMX install
Beam align Pumping
Xarm COM.
ETMX WAB
X-end BRT
2018 Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Check point
• ITMY
• High power laser
• Green lock
• BRT-X
Check point
• SRs
• X-arm COM.
• Y-arm
• OMC
• FPMI Check point
O3start
O3end
2019 Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Beam align Pumping
Yarm COM.
DRMI COM.
FPMI
DRFPMI COM.
OR
FPMI ASC
Post COM.
Middle Baffle
DRFPMI ASC/ Laser power up
Post COM.
Middle Baffle
Noise hunting
ETMX WAB
Noise hunting
DTR: Data Transfer Rehearsal
ASC: Alignment Sensing Control
DTR DTR DTR DTR

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.