Summary of iKAGRA Test Run
Apr 11-25, 2016

Yuta Michimura

Department of Physics, University of Tokyo

Quick Facts

- 3 km Michelson, dark fringe lock

- input power to BS ~ 220 mW

- power at detection port (REFL) ~ 4 mW

- duration: Apr 11 9:00 JST - Apr 25 17:00 JST
  (from 1144368017 to 1145606417 in GPS time)

- duty cycle (lock): 90.4 % (IMC was 98.5 %)

- total locked time: 257.7 hours (from Apr 13)

- longest lock: 21.3 hours (typically ~ 2 hours)

- strain sensitivity: ~6e-16 /rtHz @ 100 Hz
  (~??? pc for 1.4Msun-1.4Msun NS-NS inspiral range)

Thanks to inputs from K. Kokeyama, Y. Aso, A. Shoda, M. Nakano, Y. Enomoto, T. Shimoda, K. Hayama, S. Mano, Y. Shikano, etc ......
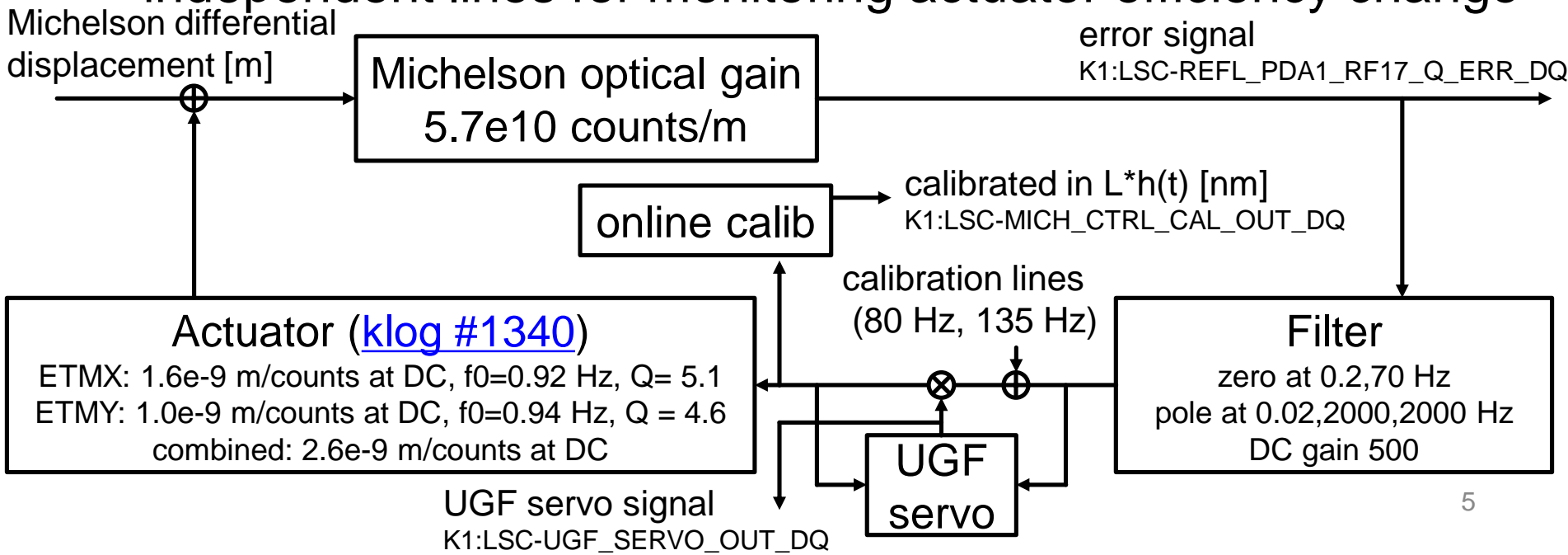
Update from March Run

- RF dark fringe lock instead of DC mid fringe (klog #1388), UGF servo at 94 Hz.

- Folded oplev for ETMs to reduce length to angle coupling (klog #1355, #1406)

- IMC servo topology changed; crossover frequency 30 Hz to 10 Hz, oplev DC servo turned off, dither alignment installed (klog #1386, #1449, #1484, #1507, #1508)

- PR2-BS duct was connected

- GVs close to IXA/IYA were opened (klog #1338)

- See JGW-T1605101 for basic configurations

- See ChannelList wiki for the channel list and summary of some detailed settings (Suspensions wiki for suspension configuration summary, OplevCalibration wiki for oplev summary)

Apr 12 Commissioning Break

- Test run was stopped during Apr 12 13:00 to Apr 12 16:10 for commissioning works

- Actuator gain monitor was added ([klog #1506](#))

- MCi feedback was added for IMC length loop, and filter setting was modified ([klog #1507](#), [#1508](#))

- PZT loop was modified for IMC length loop

- Also, guardian bug was fixed on Apr 13 ([klog #1506](#)) MICH_LOCK OPERATION state is valid only from the run starting at Apr 13 10:54:30 (JST)

- These changes are summarized in [ChannelList wiki](#)

Calibration

- calibration of error signal (optical gain)
  5.7(1)e10 counts/m (klog #1610; IPython NB)
- calibration of feedback signal (actuator efficiency)
  2.6(1)e-9 m/counts @ DC (klog #1340; IPython NB)
- calibration lines at 80 Hz for UGF servo (UGF controlled at 94 Hz) and at 135 Hz for loop gain monitor, other independent lines for monitoring actuator efficiency change

Michelson differential
displacement [m]

error signal
K1:LSC-REFL_PDA1_RF17_Q_ERR_DQ

Michelson optical gain
5.7e10 counts/m

online calib

calibrated in L*h(t) [nm]
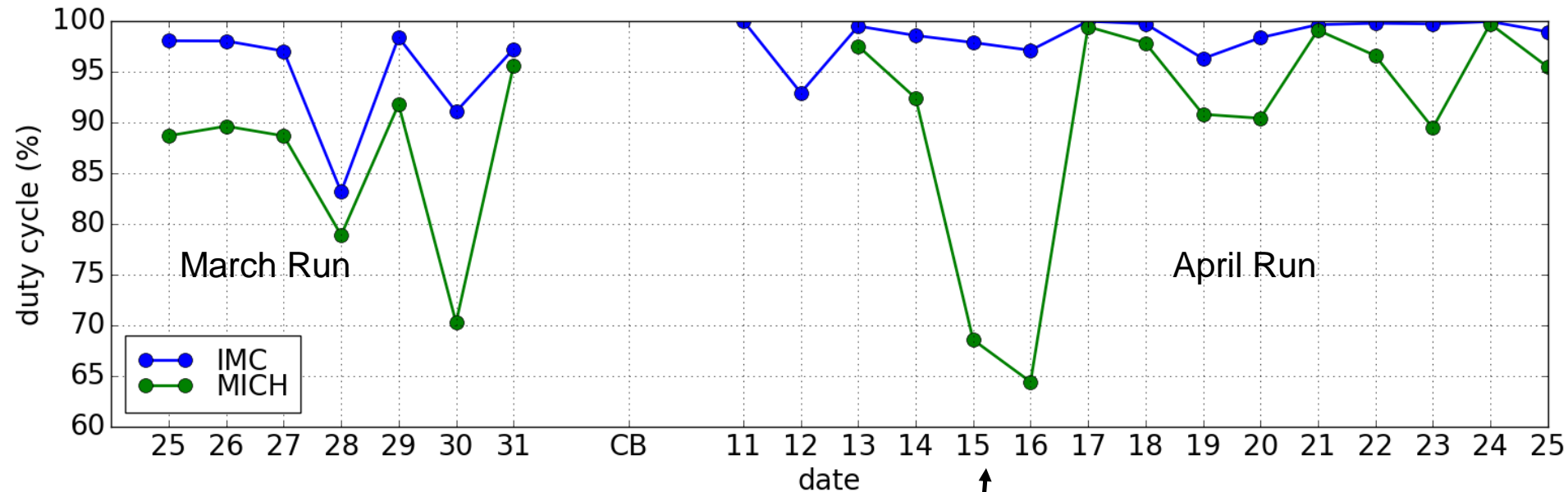K1:LSC-MICH_CTRL_CAL_OUT_DQ

calibration lines
(80 Hz, 135 Hz)

Actuator (klog #1340)
ETMX: 1.6e-9 m/counts at DC, f0=0.92 Hz, Q= 5.1
ETMY: 1.0e-9 m/counts at DC, f0=0.94 Hz, Q = 4.6
combined: 2.6e-9 m/counts at DC

Filter
zero at 0.2,70 Hz
pole at 0.02,2000,2000 Hz
DC gain 500

UGF
servo

UGF servo signal
K1:LSC-UGF_SERVO_OUT_DQ

5

Actuator Gain Monitor

- independent lines; 111 Hz for ETMX, 113 Hz for ETMY, 115 Hz for BS (klog #1506)

- actuator gain monitor signal is effected by Michelson optical gain change

- available only from Apr 12 16:10

Actuator gain monitor signal
K1:LSC-ACT_DEMOD(1|2|3)_(I|Q)_OUT_DQ
(1 for ETMX, 2 for ETMY, 3 for BS)

Michelson differential
displacement [m]

error signal
K1:LSC-REFL_PDA1_RF17_Q_ERR_DQ

Michelson optical gain
5.7e10 counts/m

calibration lines
(111, 113, 115 Hz)

Actuator (klog #1340)
ETMX: 1.6e-9 m/counts at DC, f0=0.92 Hz, Q= 5.1
ETMY: 1.0e-9 m/counts at DC, f0=0.94 Hz, Q = 4.6
combined: 2.6e-9 m/counts at DC

Filter
zero at 0.2,70 Hz
pole at 0.02,2000,2000 Hz
DC gain 500

6

Duty Cycle

- duty cycle: 90.4 % (98.5 % for IMC)
  was 85.2 (94.4 % for IMC) during March Run

Plot generated using K1:GRD-IMC_LOCK_STATE_N
and K1:GRD-MICH_LOCK_STATE_N.
Duty cycle for MICH on Apr 11 and 12
is not plotted because there was a bug
in guardian state.

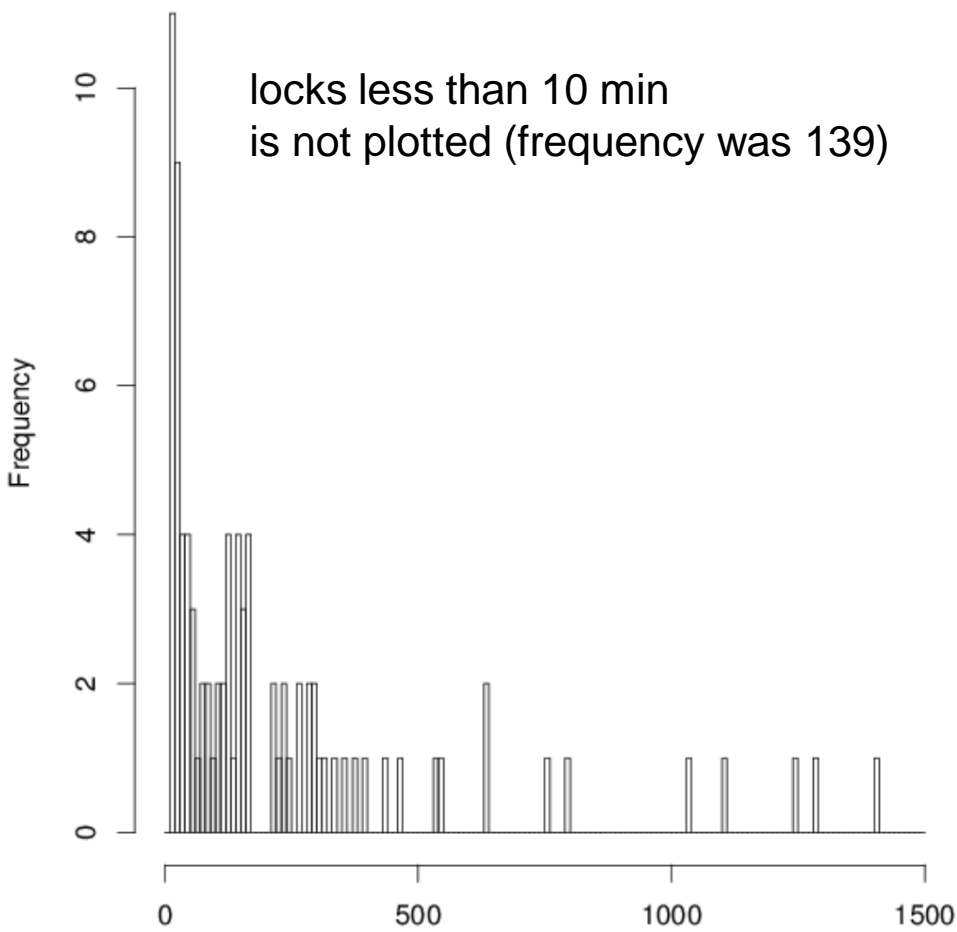Kumamoto Earthquake,
BS went wrong (klog #1550, #1553)

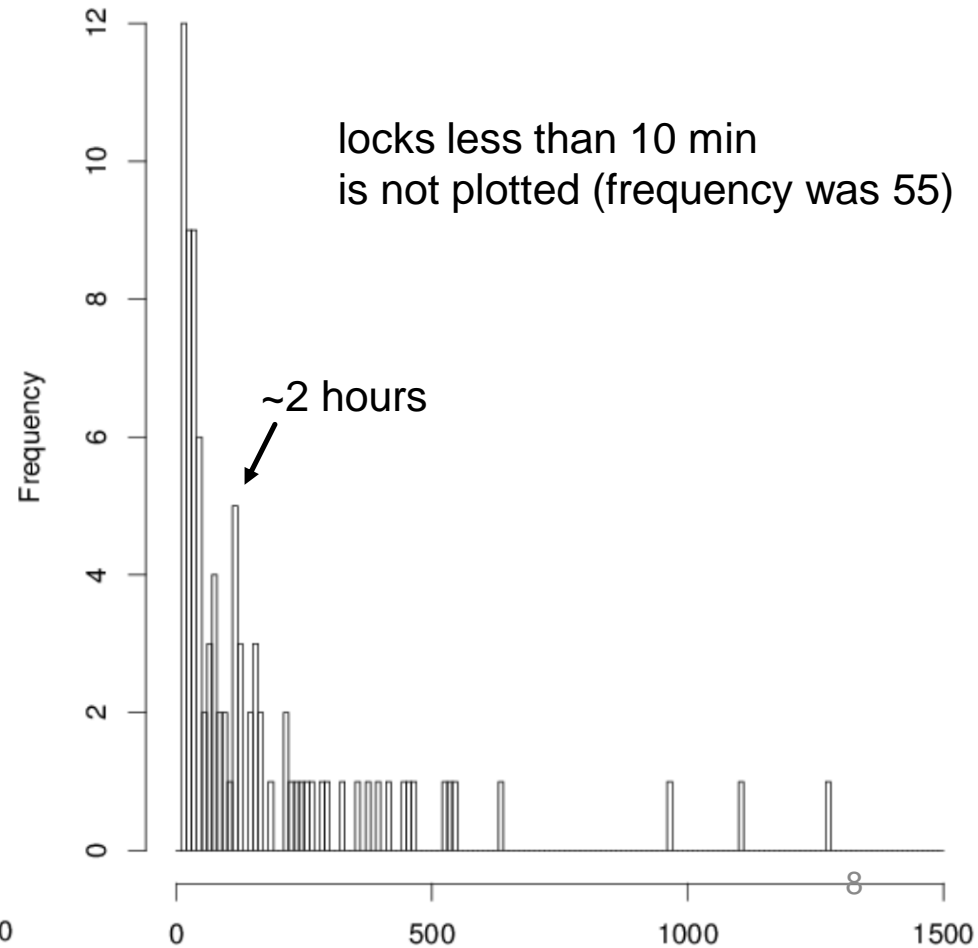data processing by S. Mano
plot by Y. Michimura

Lock Duration

- longest lock: 21.3 hours (23.5 hours for IMC)

data processing and plot by S. Mano
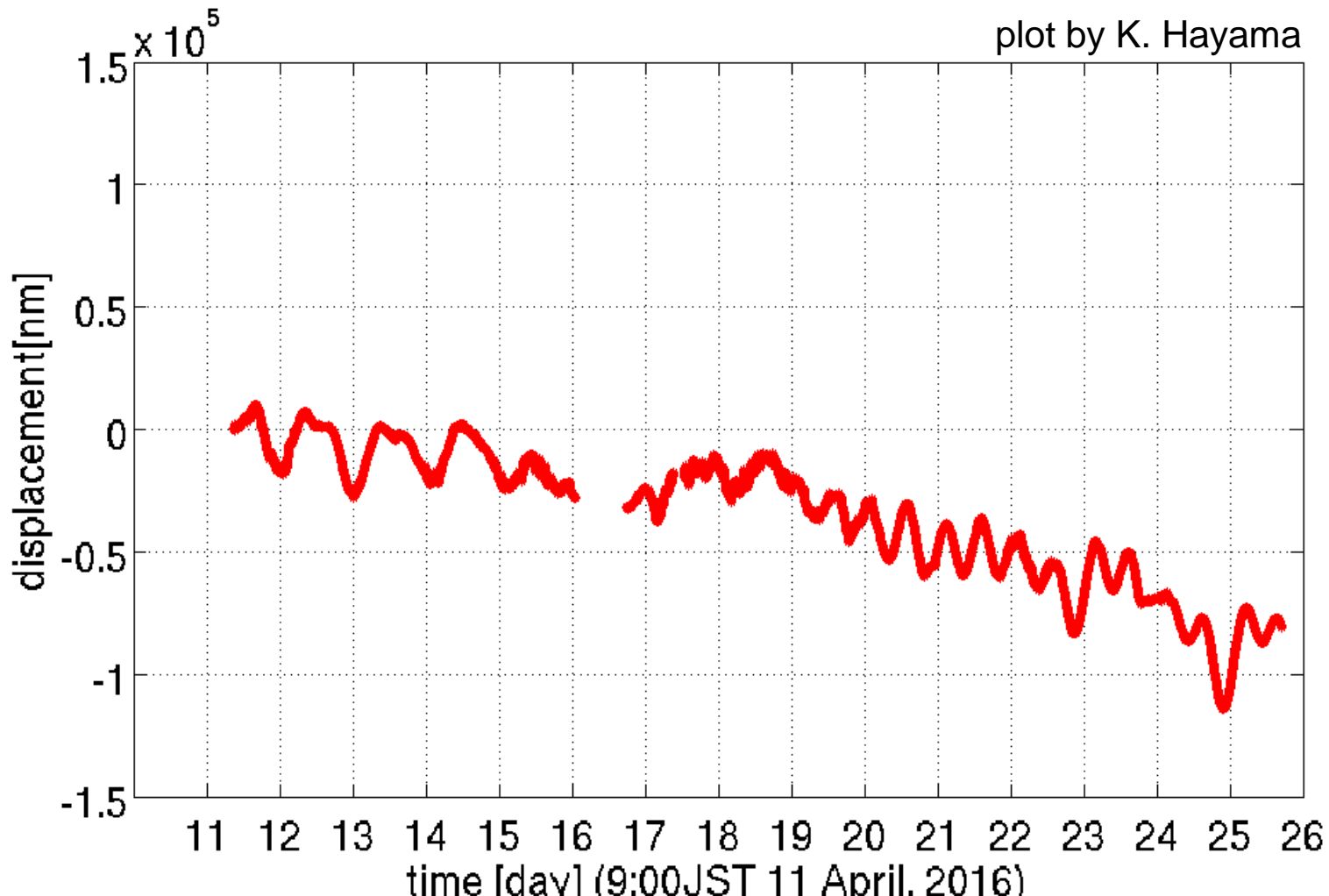
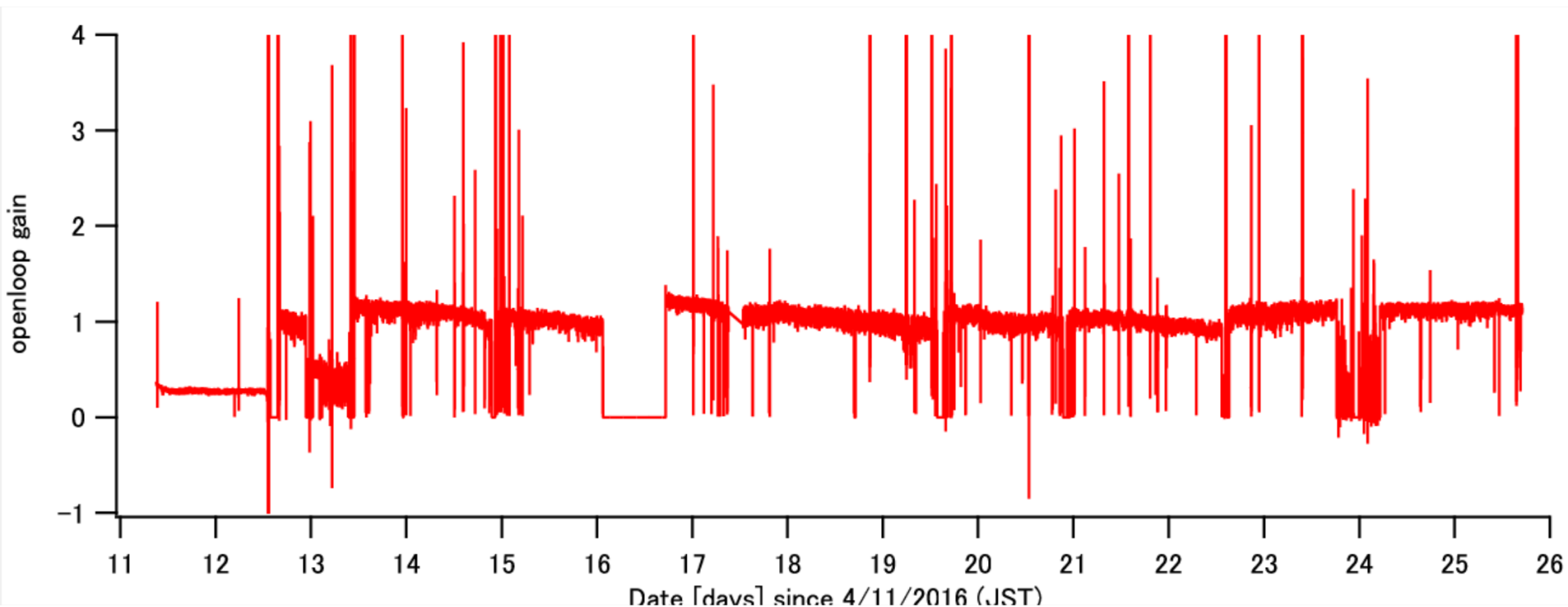**histgram of imc lock (minute)**

histgram of mich lock (minute)

locks less than 10 min
is not plotted (frequency was 139)

locks less than 10 min
is not plotted (frequency was 55)

~2 hours

Frequency

Frequency

Tidal Drift

- X arm length and Y arm length drifted by ~30 um/day, ~100 um for whole period

plot by K. Hayama

Openloop Gain Drift

- MICH openloop gain drifted by ~20 % (likely by alignment drift)
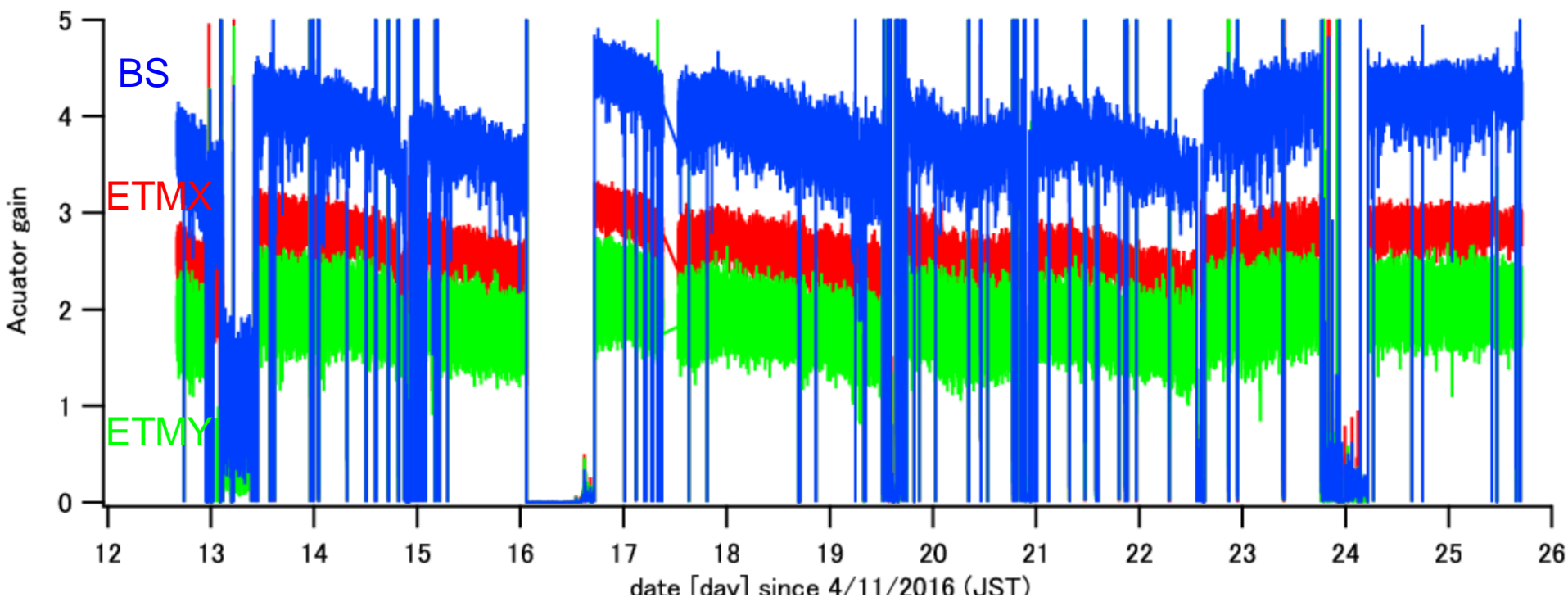
  drift was ~80 % during March Run

time series plot of K1:LSC-UGF_SERVO_OUT16 (openloop gain at 80 Hz)
by Y. Shikano

Actuator Gain Monitor

- drift is mostly in common to all the suspensions
  → likely to be MICH optical gain drift (actuator drift was less)
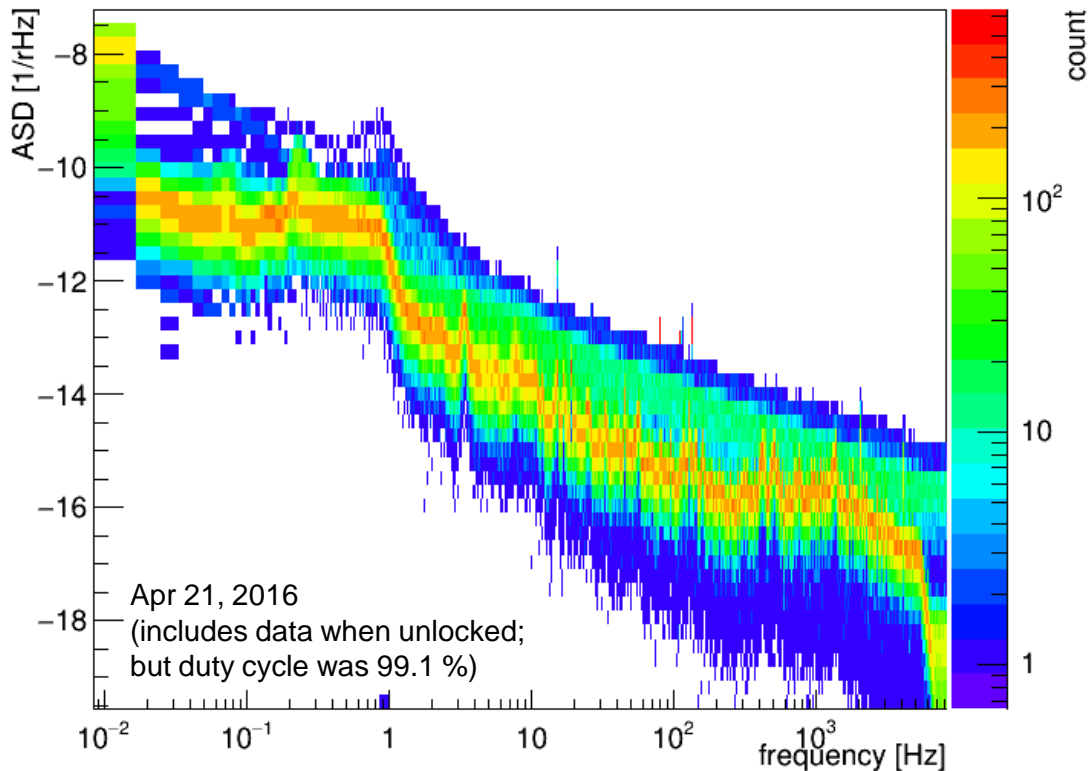- more investigation, calibration needed

calculation done using K1:LSC-ACT_DEMOD(1|2|3)_(I|Q)_OUT_DQ
by Y. Shikano

Inspiral Range

- average: ??? pc
  standard deviation: ??? pc
  for 1.4Msun-1.4Msun NS-NS

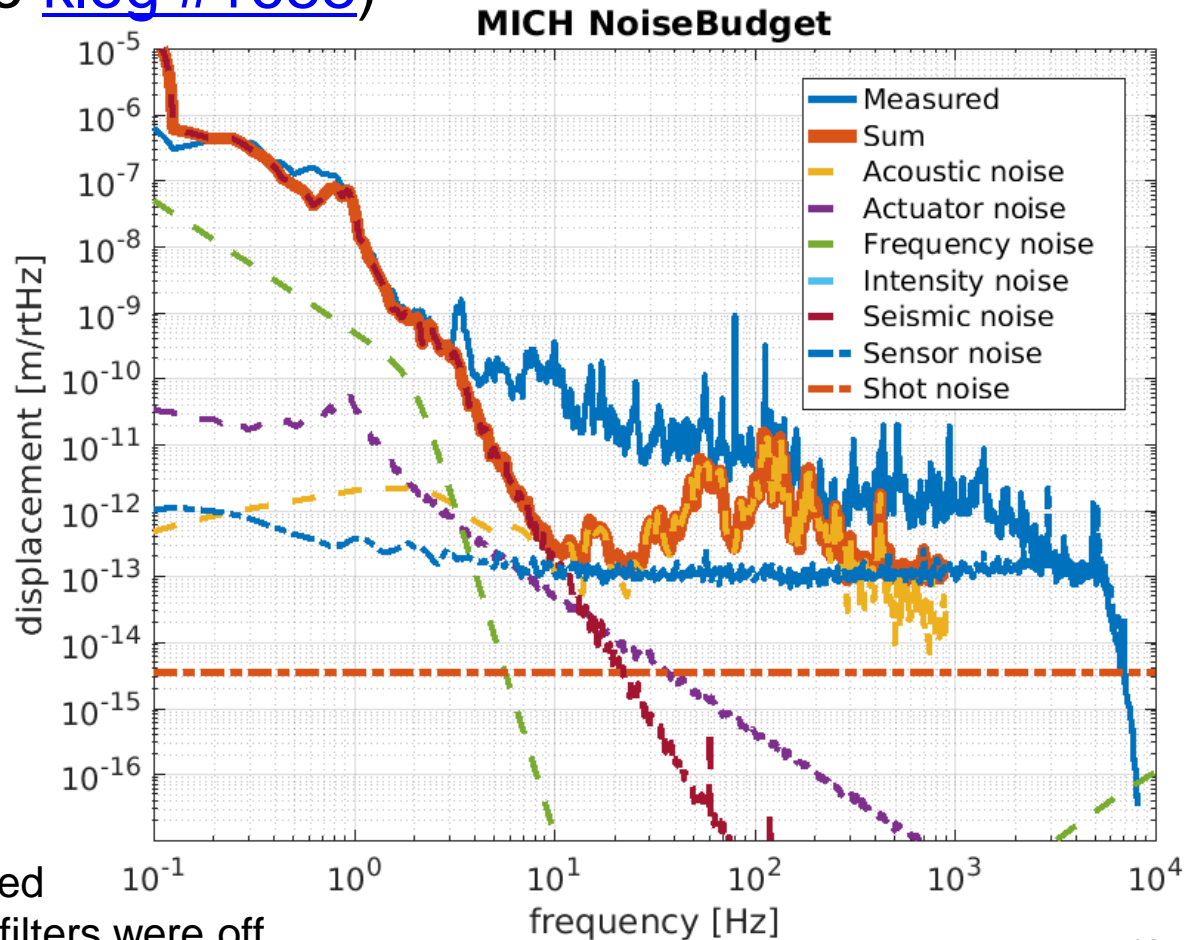- strain sensitivity fluctuated by roughly 1 order of magnitude

SensMon: K1:LSC-MICH_CTRL_CAL_OUT_DQ

Apr 21, 2016
(includes data when unlocked;
but duty cycle was 99.1 %)

plot by K. Hayama

Noise Budget

- limited by seismic noise below ~4 Hz, acoustic/fan noise at around 100 Hz (see also klog #1715), ADC noise above ~3 kHz (see also klog #1688)

- unknown noise at around 10 Hz

MICH NoiseBudget

Legend:
- Measured
- Sum
- Acoustic noise
- Actuator noise
- Frequency noise
- Intensity noise
- Seismic noise
- Sensor noise
- Shot noise

Y-axis: displacement [m/rtHz]
X-axis: frequency [Hz]

above NoiseBudget is generated when fans were on, whitening filters were off
plot generated with Simulink NoiseBudget by T. Shimoda, M. Nakano (klog #1568, #1705)

Some Issues to Remember

- Unknown 550 Hz LPF in MICH loop (klog #1645)
  also, DGS delay in 3km arm is not measured yet (?)
  so, phase delay in OLTF is not fully understood

- Unknown sensitivity improvement over 2 kHz after Apr 12 commissioning break (klog #1531)

- Oplev calibration for IMC mirrors might be wrong and need to be checked (OplevCalibration wiki)

- Why there are no 60 Hz line noise?