Summary of iKAGRA Test Run Mar 25-31, 2016

Yuta Michimura

Department of Physics, University of Tokyo

Quick Facts

- 3 km Michelson, mid-fringe lock
- input power to BS ~ 220 mW
- power at detection port (REFL) ~ 8 mW
- duration: Mar 25 9:00 JST - Mar 31 17:00 JST
  (from 1142899217 to 1143446417 in GPS time)
- duty cycle (lock): 85.2 % (IMC was 94.4 %)
- total locked time: 129.5 hours
- longest lock: 3.6 hours (but typically ~ 30 minutes)
- strain sensitivity: ~3e-15 /rtHz @ 100 Hz
  (~0.77pc for 1.4Msun-1.4Msun NS-NS inspiral range)

Thanks to inputs from Y. Saito, T. Uchiyama, Y. Aso, O. Miyakawa, K. Kokeyama, K. Hayama, Y. Sasaki, M. Nakano, Y. Enomoto, T. Shimoda, etc ……

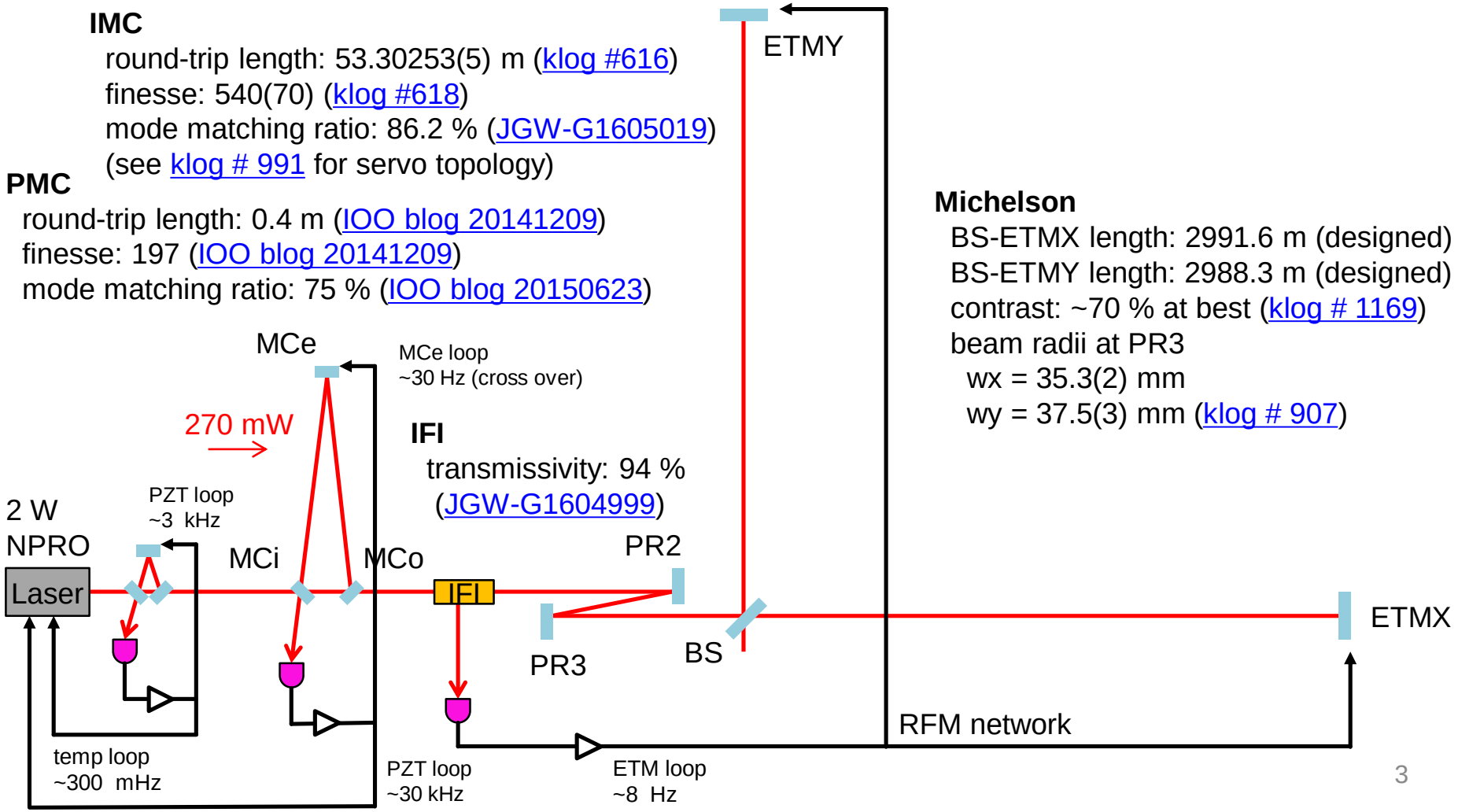
Interferometer Configuration

- 3 km Michelson, mid-fringe lock, UGF ~8 Hz
- suspended mirrors DC alignment controlled with oplevs

IMC
round-trip length: 53.30253(5) m (klog #616)
finesse: 540(70) (klog #618)
mode matching ratio: 86.2 % (JGW-G1605019)
(see klog # 991 for servo topology)

PMC
round-trip length: 0.4 m (IOO blog 20141209)
finesse: 197 (IOO blog 20141209)
mode matching ratio: 75 % (IOO blog 20150623)

Michelson
BS-ETMX length: 2991.6 m (designed)
BS-ETMY length: 2988.3 m (designed)
contrast: ~70 % at best (klog # 1169)
beam radii at PR3
wx = 35.3(2) mm
wy = 37.5(3) mm (klog # 907)



Suspensions and Mirrors

- fused silica, room temperature

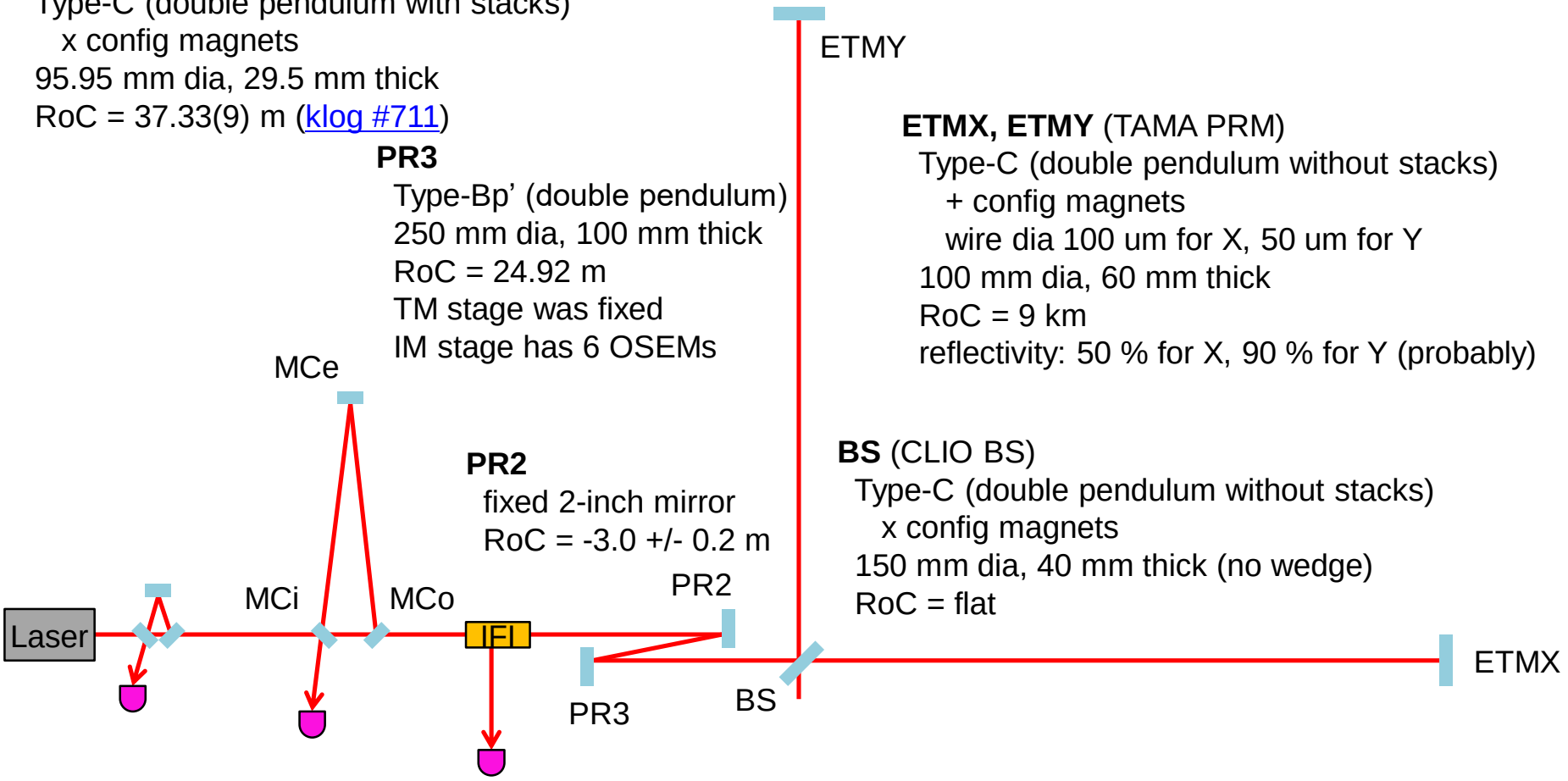
MCi, MCo, MCe
Type-C (double pendulum with stacks)
x config magnets
95.95 mm dia, 29.5 mm thick
RoC = 37.33(9) m (klog #711)

PR3
Type-Bp' (double pendulum)
250 mm dia, 100 mm thick
RoC = 24.92 m
TM stage was fixed
IM stage has 6 OSEMs

ETMX, ETMY (TAMA PRM)
Type-C (double pendulum without stacks)
+ config magnets
wire dia 100 um for X, 50 um for Y
100 mm dia, 60 mm thick
RoC = 9 km
reflectivity: 50 % for X, 90 % for Y (probably)

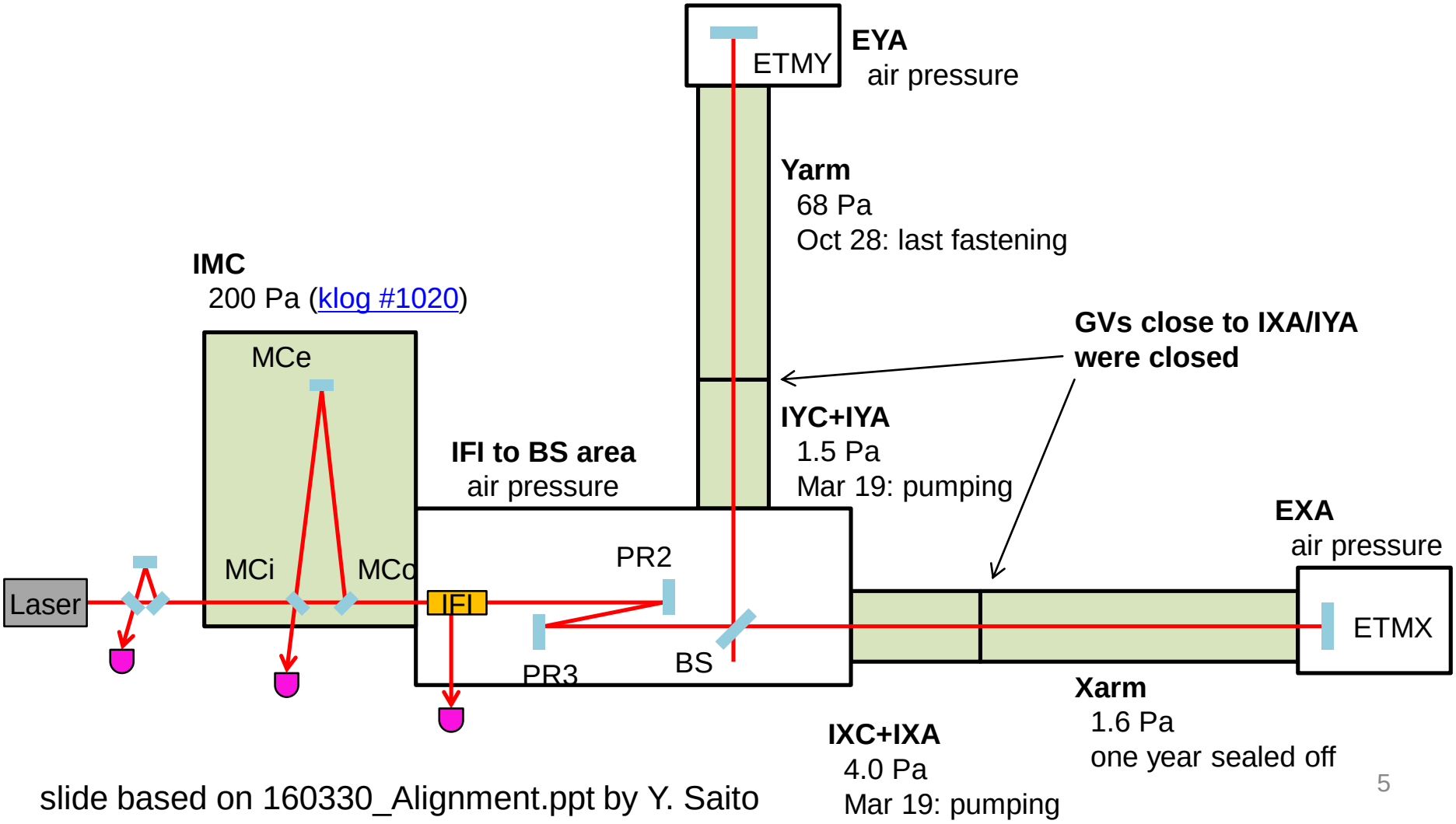
PR2
fixed 2-inch mirror
RoC = -3.0 +/- 0.2 m

BS (CLIO BS)
Type-C (double pendulum without stacks)
x config magnets
150 mm dia, 40 mm thick (no wedge)
RoC = flat



Vacuum

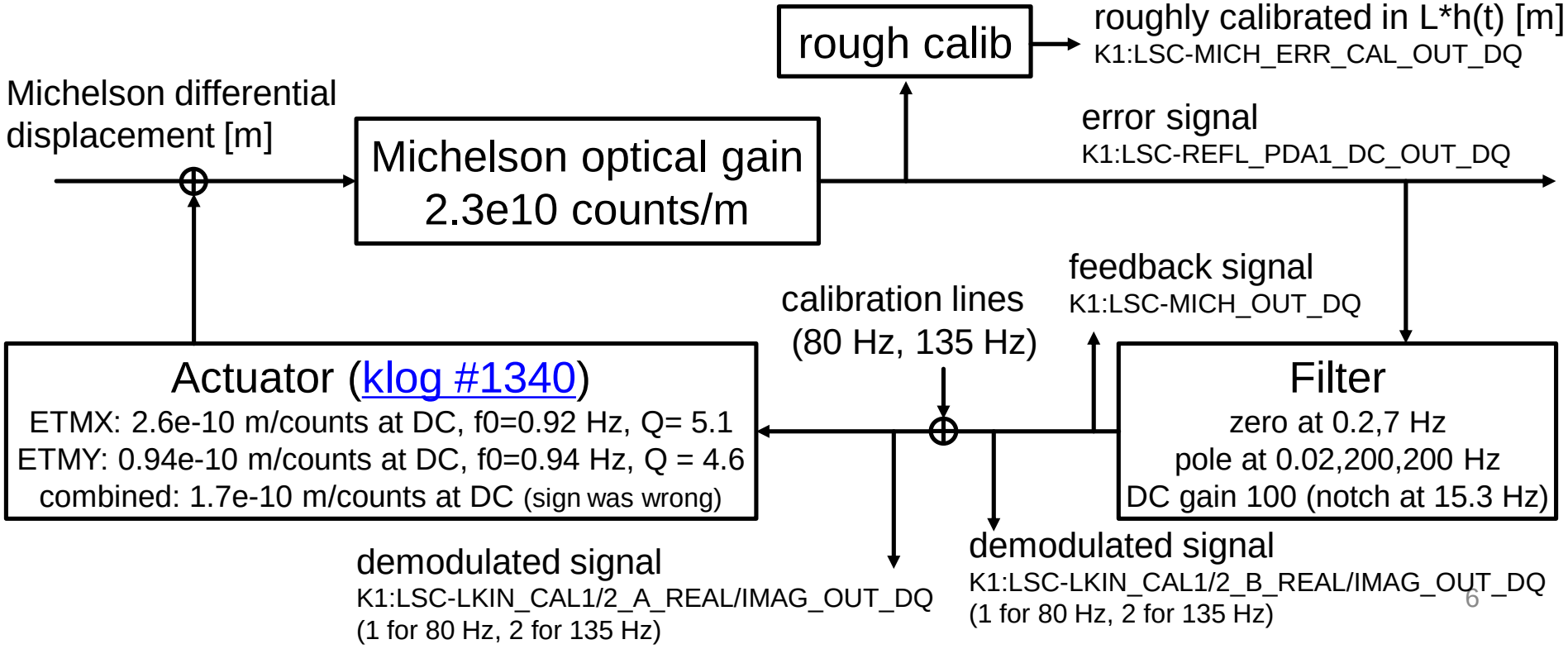
- central part and both ends were at air (PR2-BS was not connected, but covered; klog #1078)



slide based on 160330_Alignment.ppt by Y. Saito

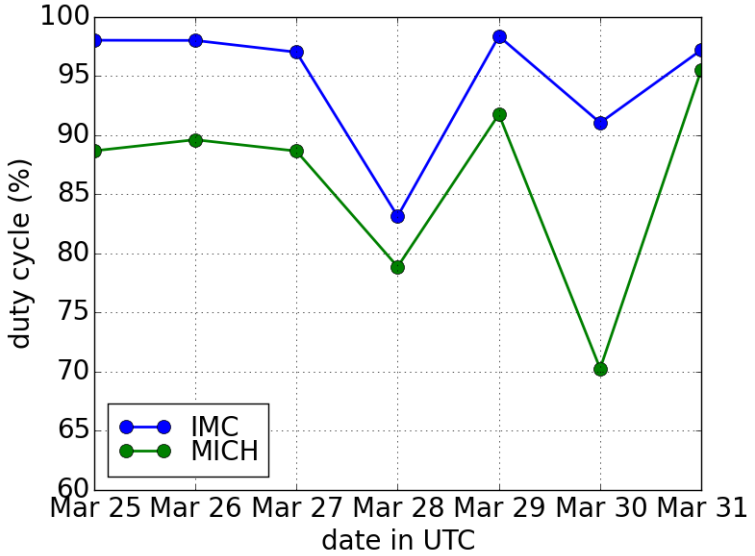
Calibration

- calibration of error signal (optical gain)
  2.3e10 counts/m (klog #1169)
- calibration of feedback signal (actuator efficiency)
  1.8e-14 m/counts @ 80 Hz (klog #1169)
- calibration lines at 80 Hz and 135 Hz to monitor loop gain



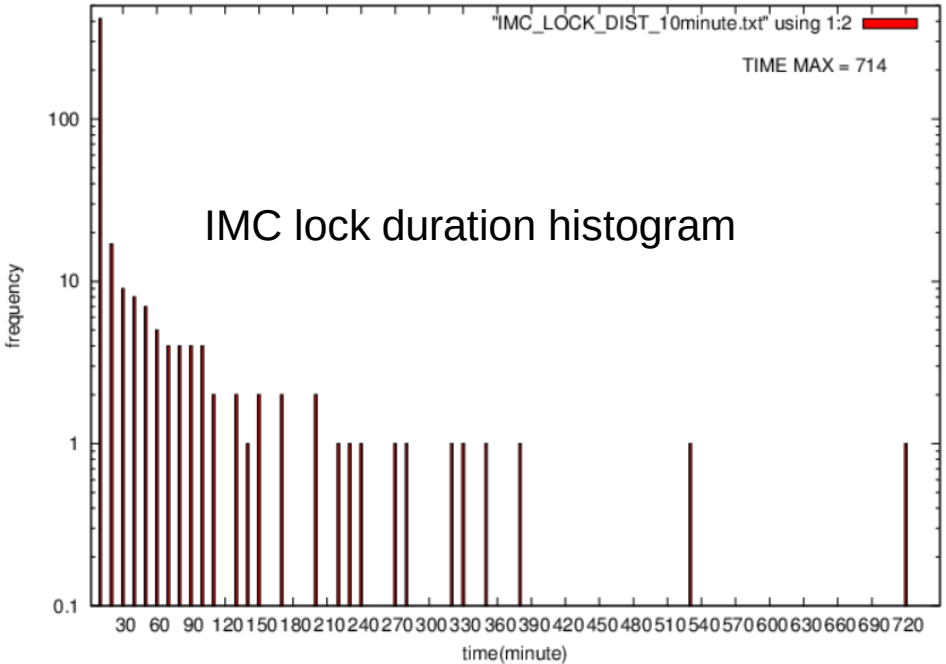
Duty Cycle and Lock Duration

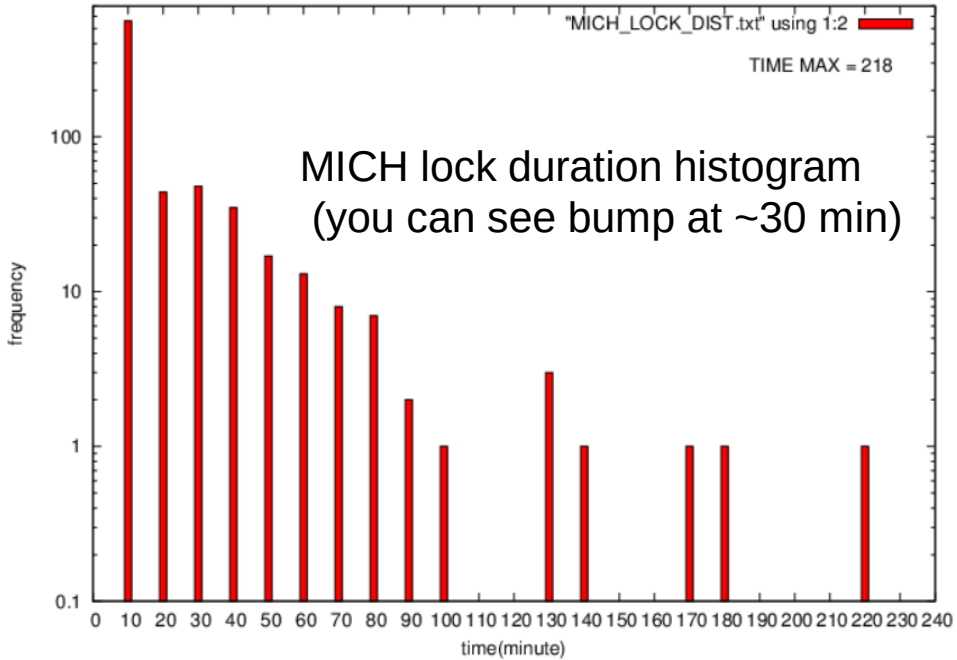
- duty cycle: 85.2 %
  (94.4 % for IMC)



data processing and plot by Y. Sasaki

- longest lock: 3.6 hours
  (12 hours for IMC)

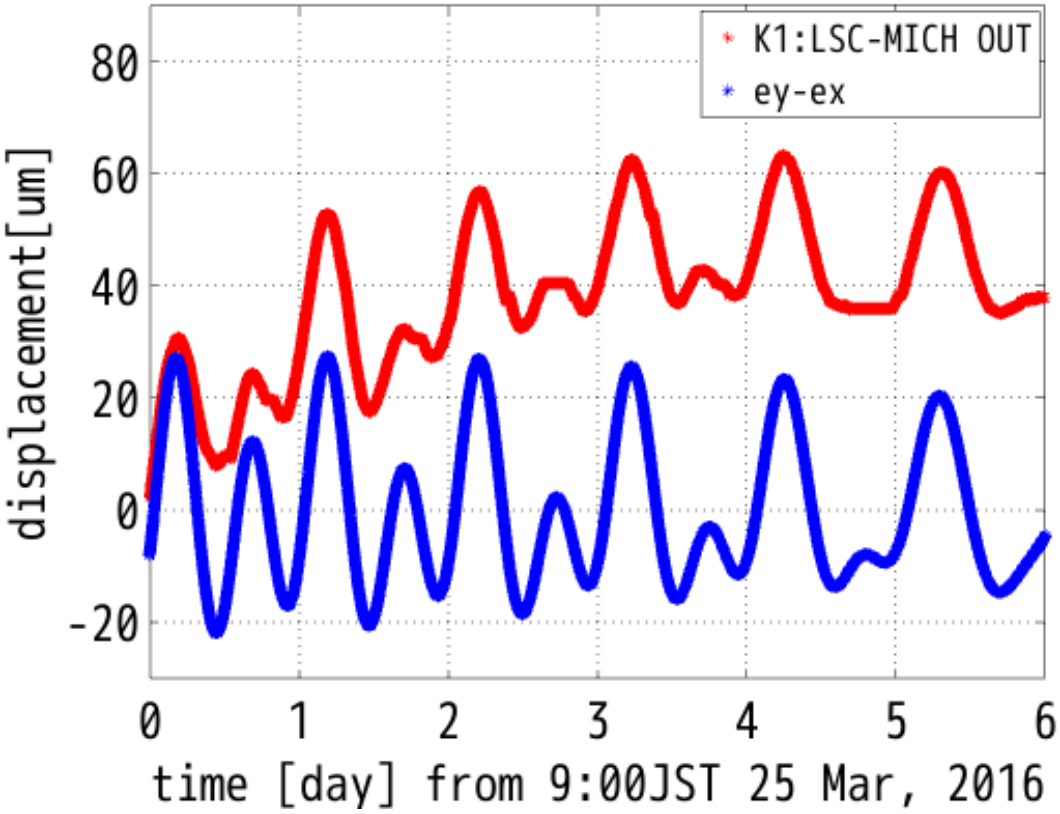




Tidal Drift

- X arm length and Y arm length drifts by ~60 um
- this caused lock loss every ~30 min because of the saturation of the feedback signal

  → needs more actuation range



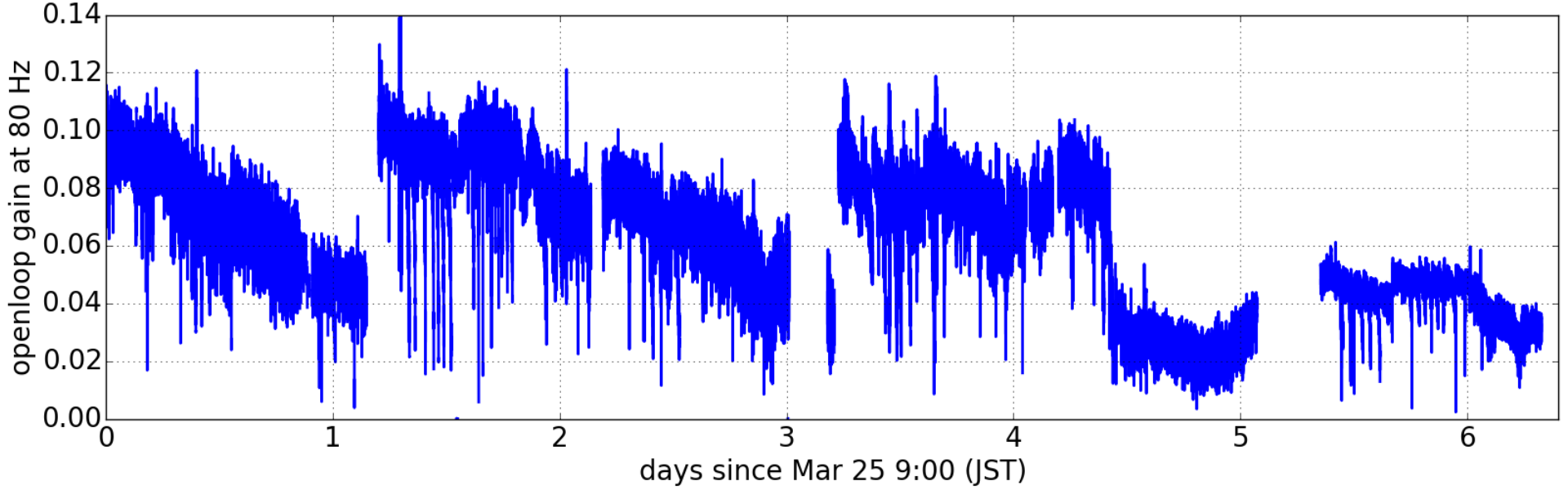
measured with 3-km Michelson

prediction calculated by A. Araya
JGW-E1605098
used GOTIC2 (tidal effect from the Moon and the Sun)

plot by K. Hayama et al. (klog #1418)

Openloop Gain Drift

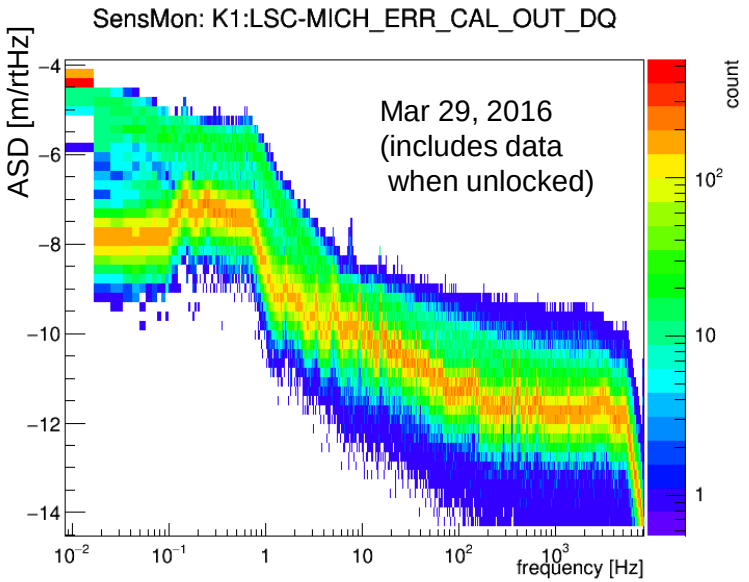
- MICH openloop gain degraded by almost 80 % (likely by alignment drift)
  → needs UGF servo (and online calibration)

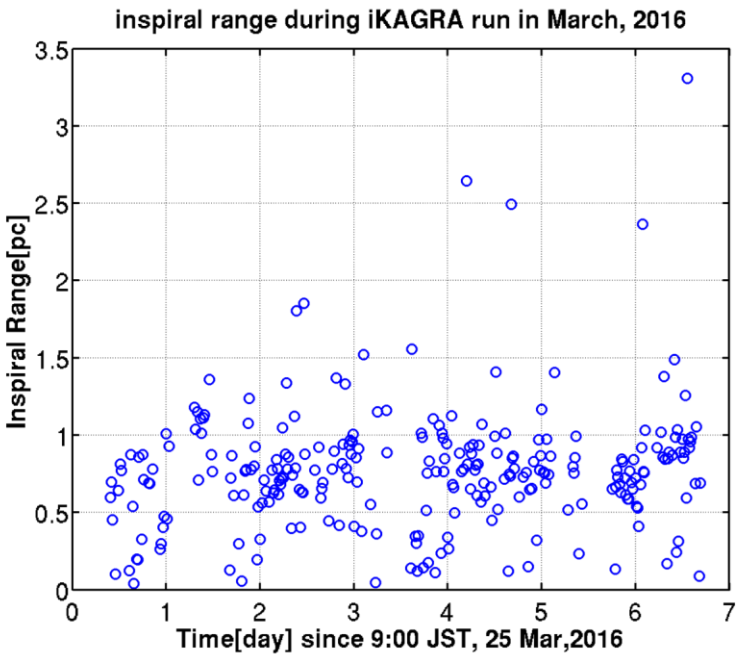


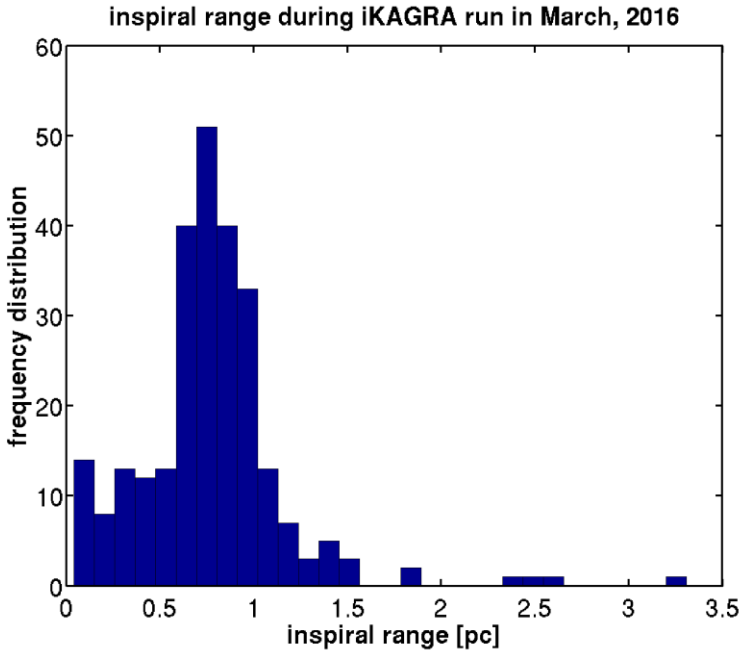
calculation done using K1:LSC-LKIN_CAL1_A/B_REAL/IMAG_OUT_DQ
by Y. Sasaki & Y. Michimura

Inspiral Range

- average: 0.77 pc
  standard deviation: 0.39 pc
  for 1.4Msun-1.4Msun NS-NS
- rough strain sensitivity fluctuated by roughly 1 order of magnitude



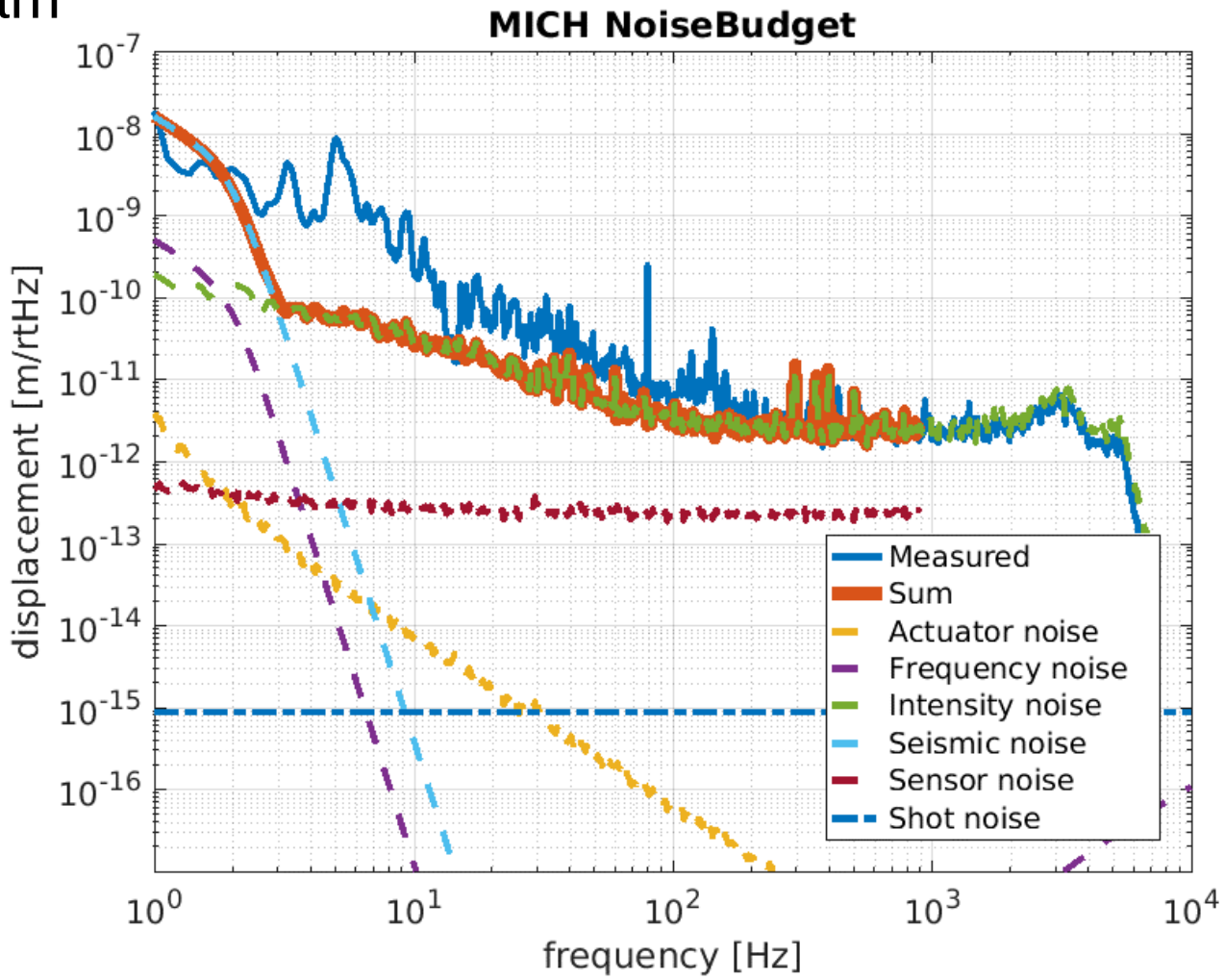




plot by K. Hayama

Noise Budget

- likely to be limited by intensity noise of the IMC transmitted beam



plot generated with Simulink NoiseBudget by Y. Michimura (klog #1323)

Issues in March Test Run

- Michelson lock was lost every ~30 minutes

- Alignment was adjusted manually ~ once per day

- Calibration was done offline

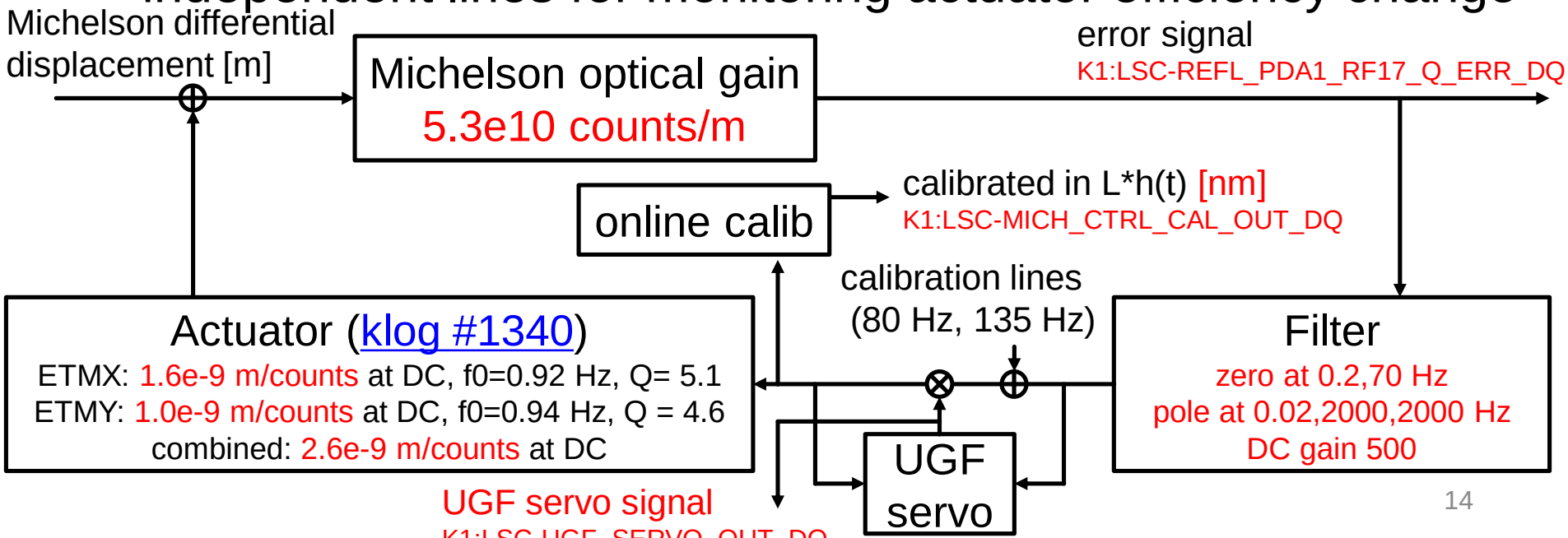
- PMC was re-locked manually
- GVs close to IXA/IYA was closed
- PR2-BS duct was not connected
- Some unsafe issues left unaddressed

What's New in April Test Run

- Michelson lock was lost every ~30 minutes
  → improved to > ~5 hours (limited by IMC; tidal won't be a problem this time klog #1446)
  new actuation efficiency (ETM differential): 2.6e-9 m/C at DC(klog #1340), higher UGF (klog #1344), RF lock instead of DC lock (klog #1388), x10 sensitivity (klog #1389), folded oplev for ETMs to reduce L2A (klog #1355)
  more stable IMC (less feedback to mirrors klog #1386, oplev DC servo turned off klog #1449)
- Alignment was adjusted manually ~ once per day
  → dither alignment installed for IMC (working perfectly; klog #1484, #1492)
- Calibration was done offline
  → UGF servo (klog #1425) and online calibration (klog #1456)
- PMC ~~was re-locked manually~~ remote control restored (klog #1351)
- GVs close to IXA/IYA was ~~closed~~ opened (klog #1338)
- PR2-BS duct was ~~not connected~~ connected
- Some unsafe issues ~~left unaddressed~~ partially addressed

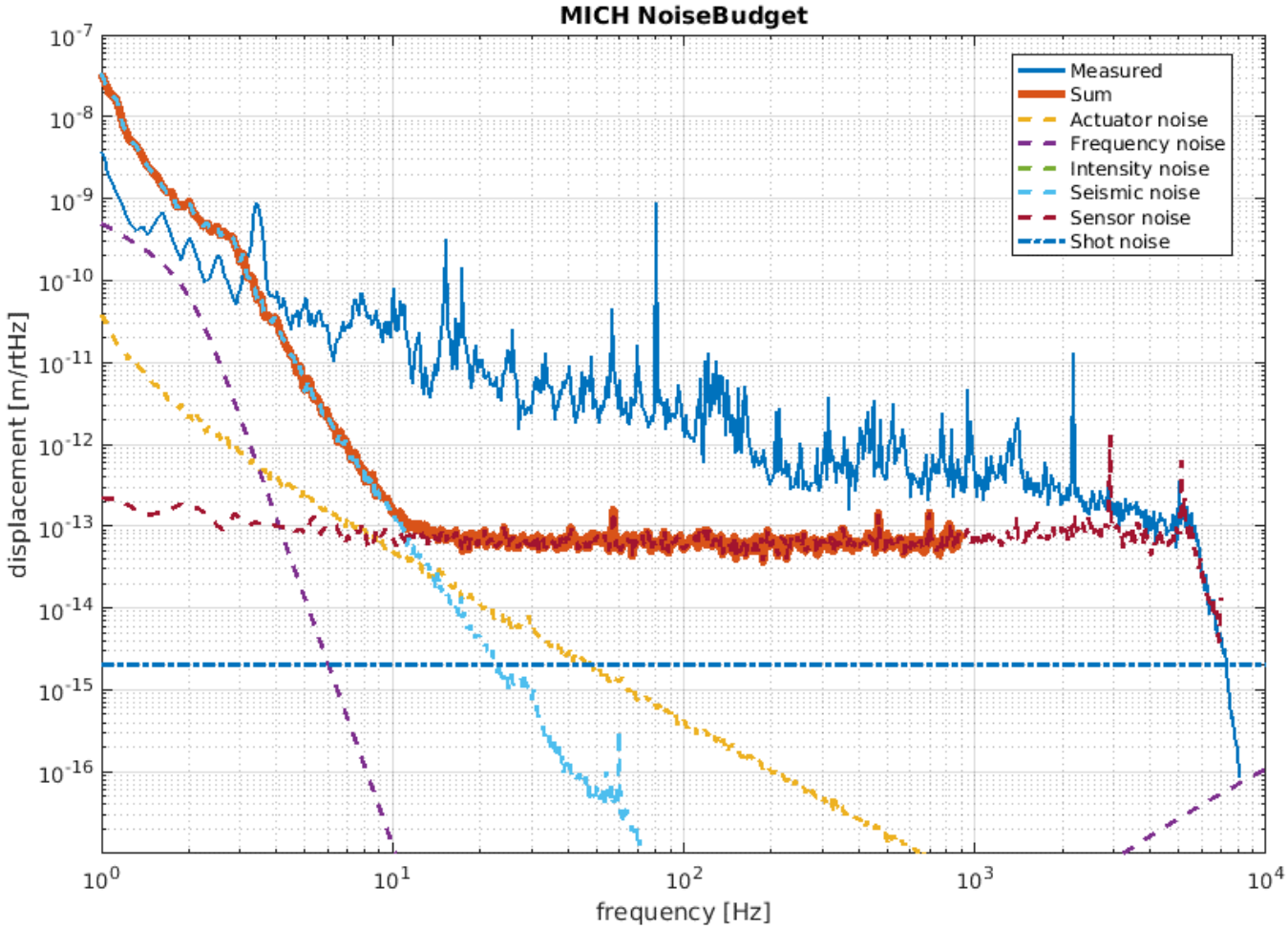
Calibration for April Test Run

- calibration of error signal (optical gain)
  5.3e10 counts/m (klog #1455)
- calibration of feedback signal (actuator efficiency)
  2.6(1)e-9 m/counts @ DC (klog #1340)
- calibration lines at 80 Hz for UGF servo (UGF controlled at 100 Hz) and at 135 Hz for loop gain monitor, other independent lines for monitoring actuator efficiency change



Updated Noise Budget

- not limited by intensity noise of the IMC transmitted beam
- could be BS angular noise coupling?



plot generated with Simulink NoiseBudget by T. Shimoda (klog #1478)

What To Do After April Test Run

- evacuate central part and both ends
  to open all GVs and see optical axis change
  to investigate alignment change during evacuation
- PR3 height check
- oplev stability, noise measurements with fixed mirror
- investigate scattering noise from vibration of ducts
- investigate why measured ETMX/Y actuator efficiency don’t match calculation from coil efficiency
- what else?