

# Summary of iKAGRA Test Run Mar 25-31, 2016

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# 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:  $\sim 3e-15$  /rtHz @ 100 Hz  
( $\sim 0.77$ pc 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

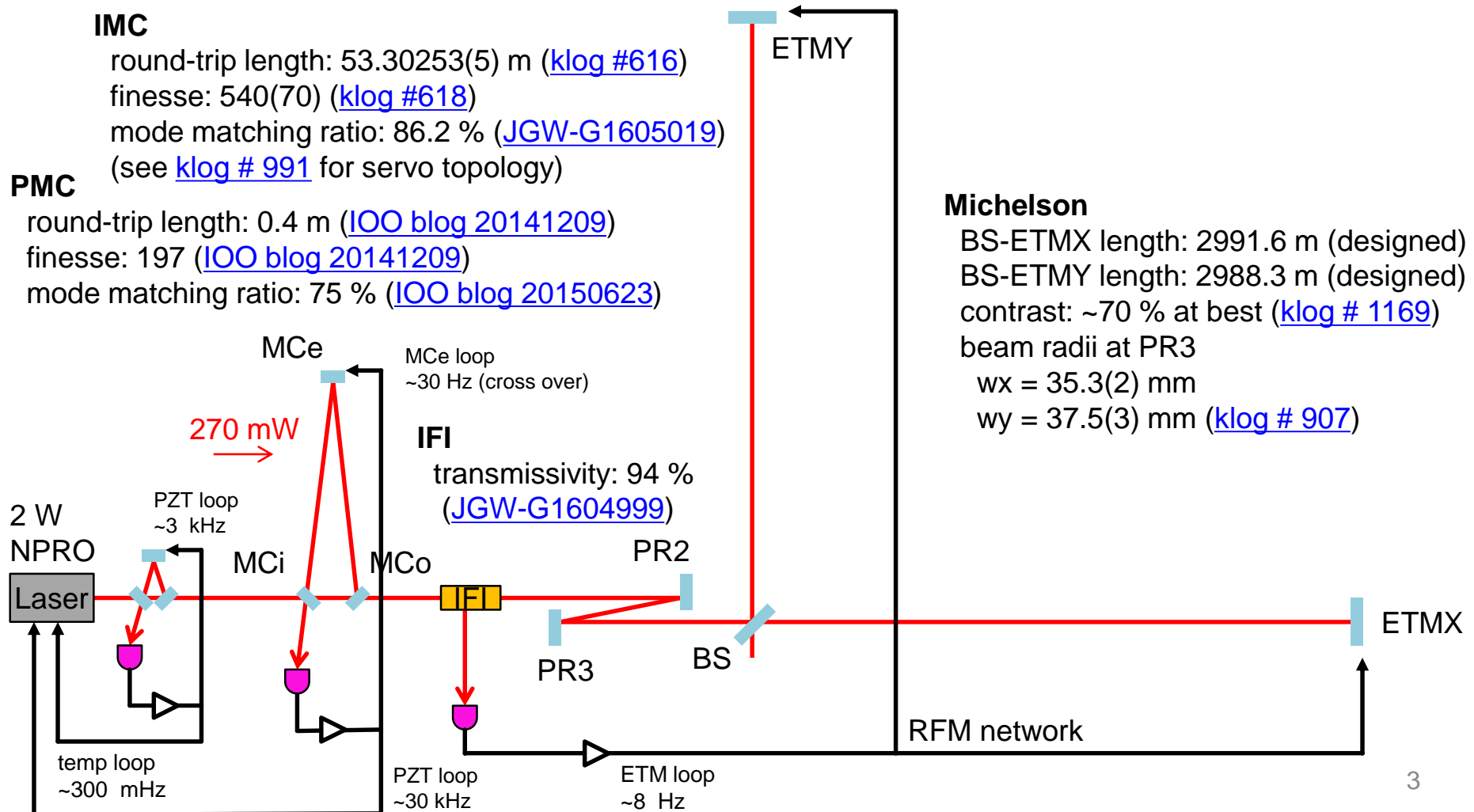
round-trip length: 53.30253(5) m ([klog #616](#))  
 finesse: 540(70) ([klog #618](#))  
 mode matching ratio: 86.2 % ([JGW-G1605019](#))  
 (see [klog # 991](#) for servo topology)

## 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  
 $w_x = 35.3(2)$  mm  
 $w_y = 37.5(3)$  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

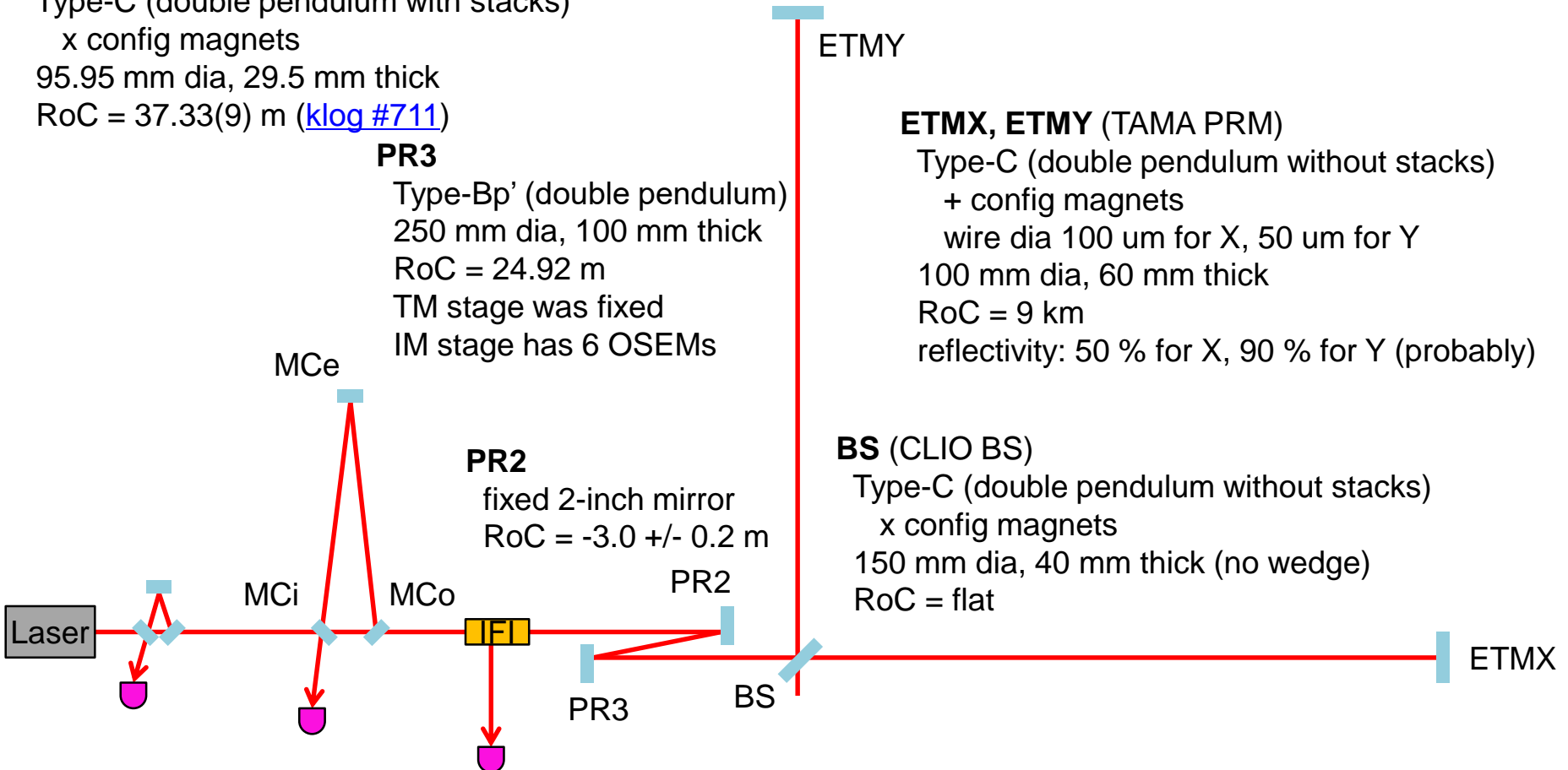
Type-Bp' (double pendulum)  
 250 mm dia, 100 mm thick  
 RoC = 24.92 m  
 TM stage was fixed  
 IM stage has 6 OSEMs

## 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)

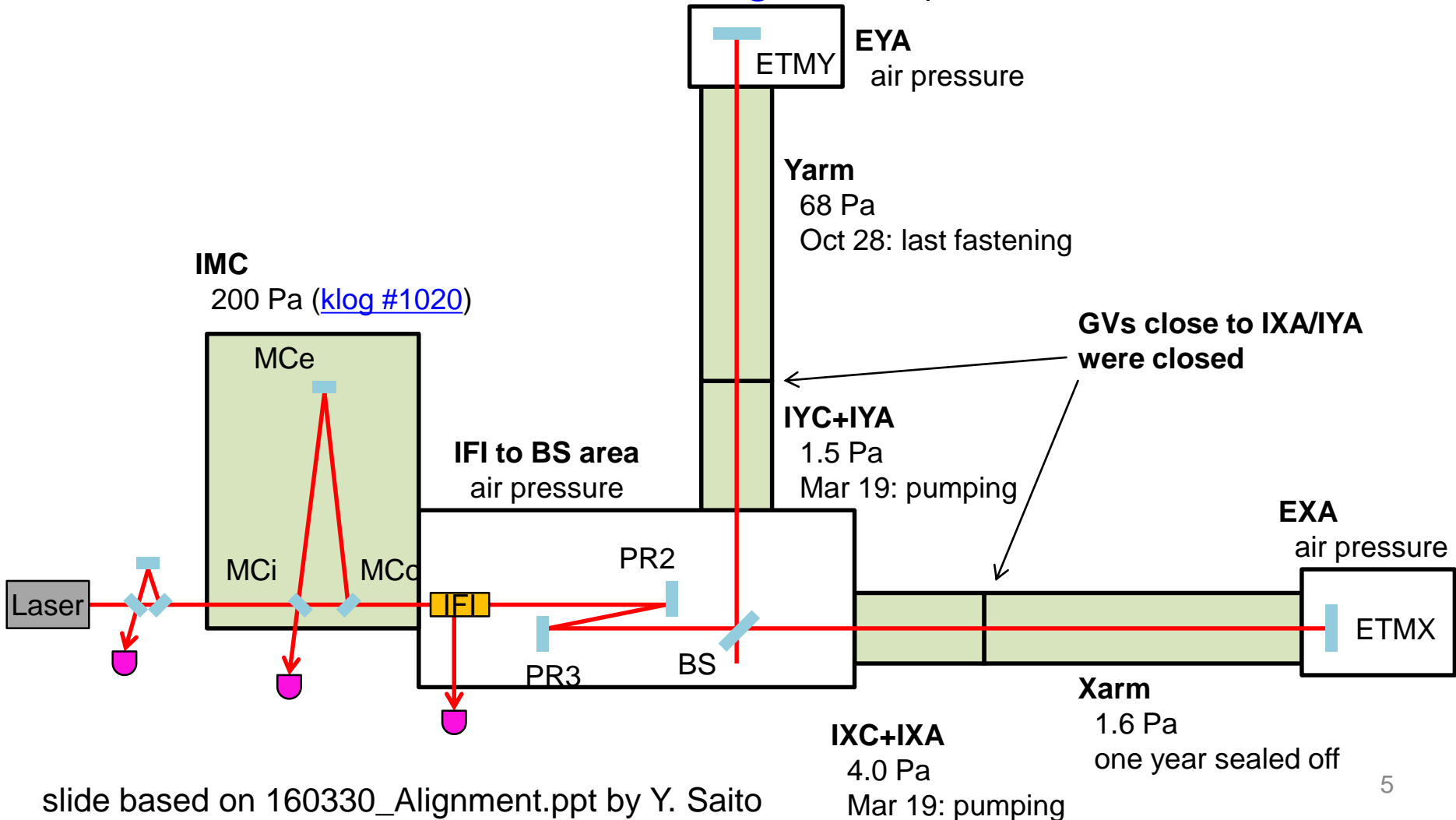
## BS (CLIO BS)

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



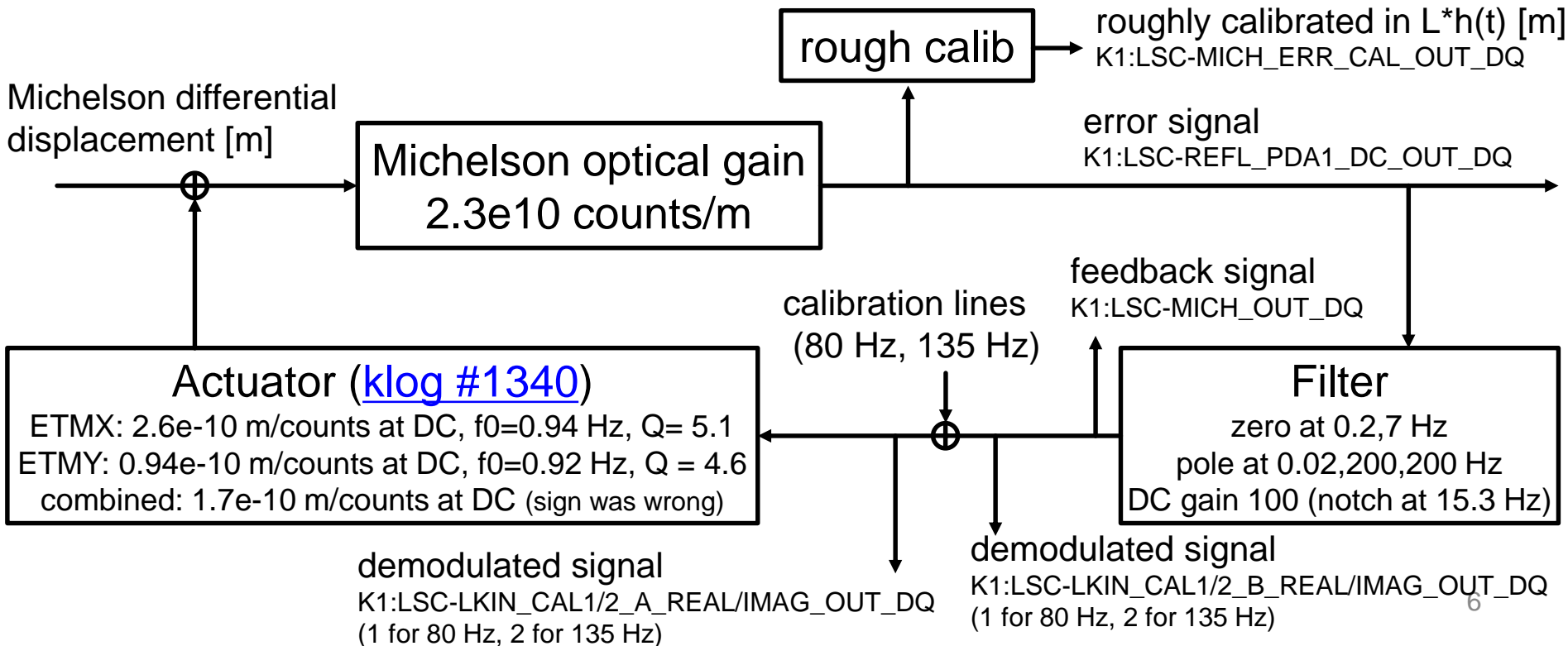
# Vacuum

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



# 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

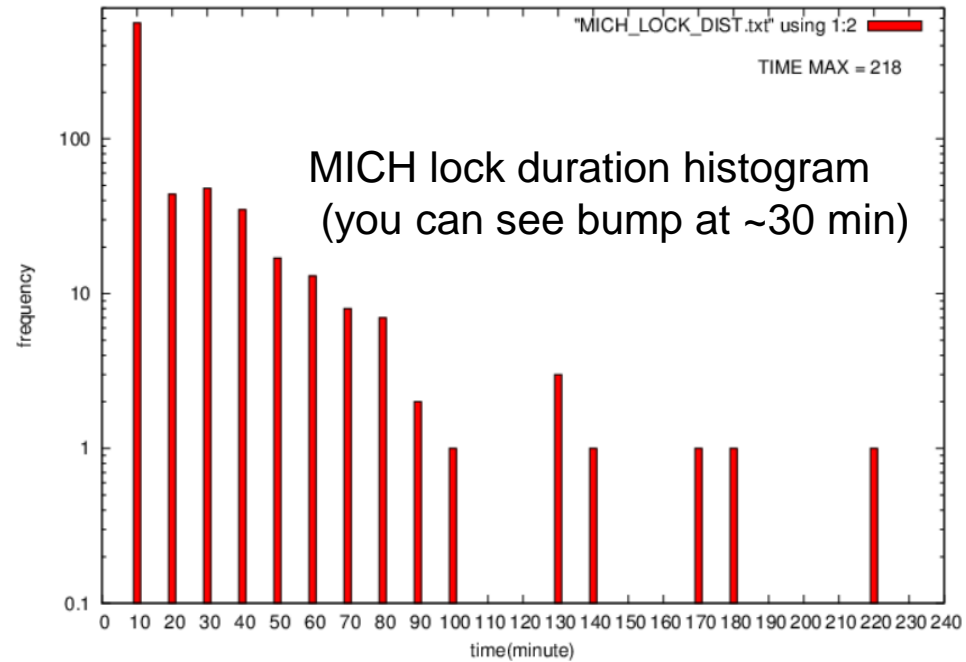
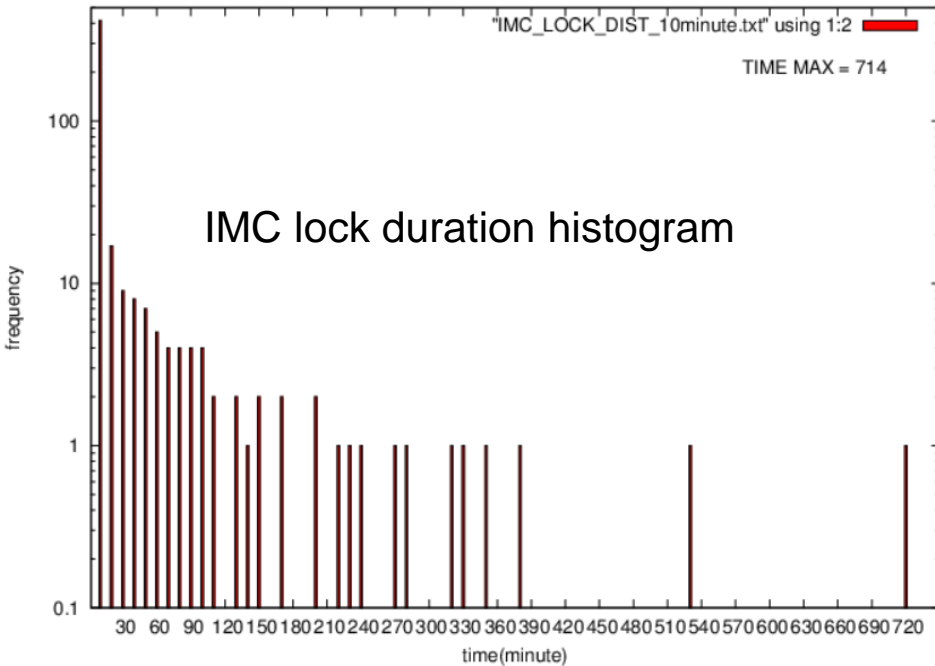
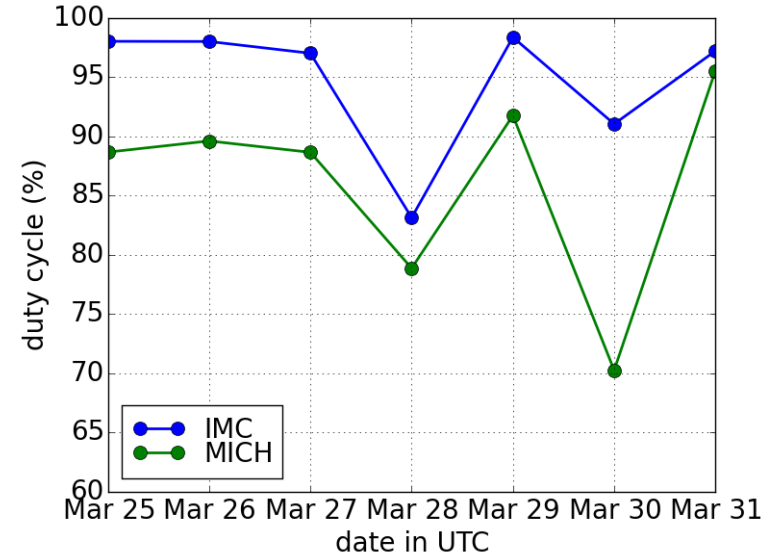


# Duty Cycle and Lock Duration

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

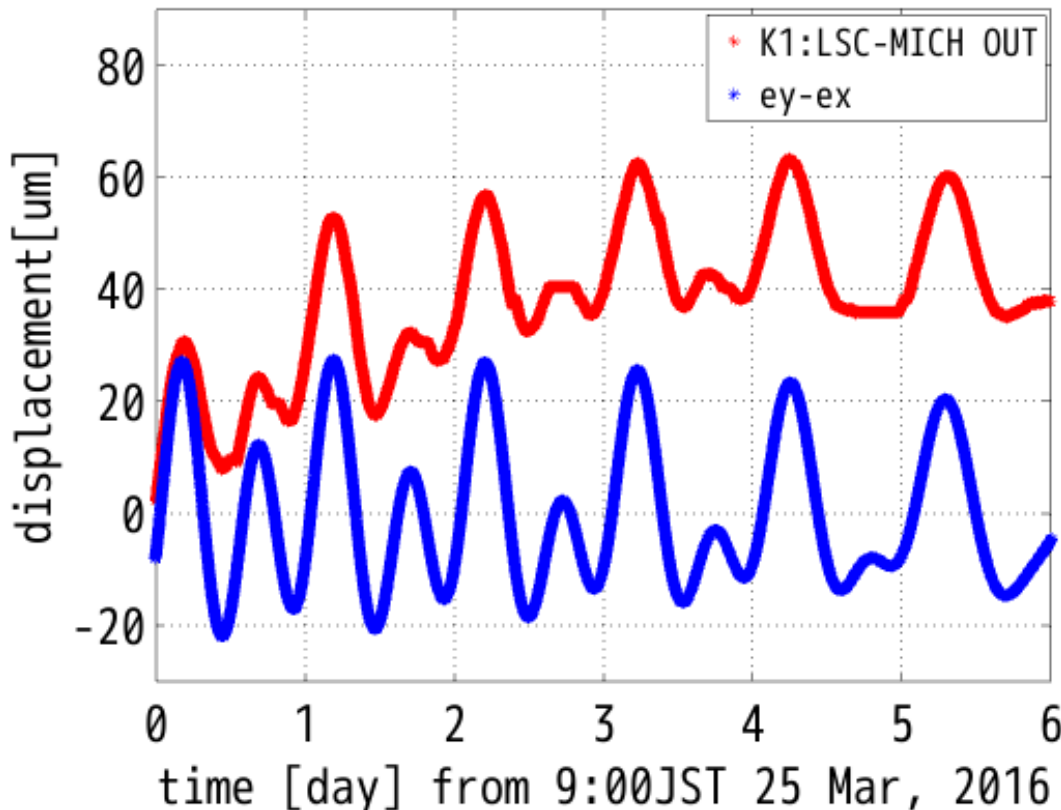
data processing and plot by Y. Sasaki

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



# Tidal Drift

- X arm length and Y arm length drifts by  $\sim 60$   $\mu\text{m}$
- this caused lock loss every  $\sim 30$  min because of the saturation of the feedback signal  
→ needs more actuation range



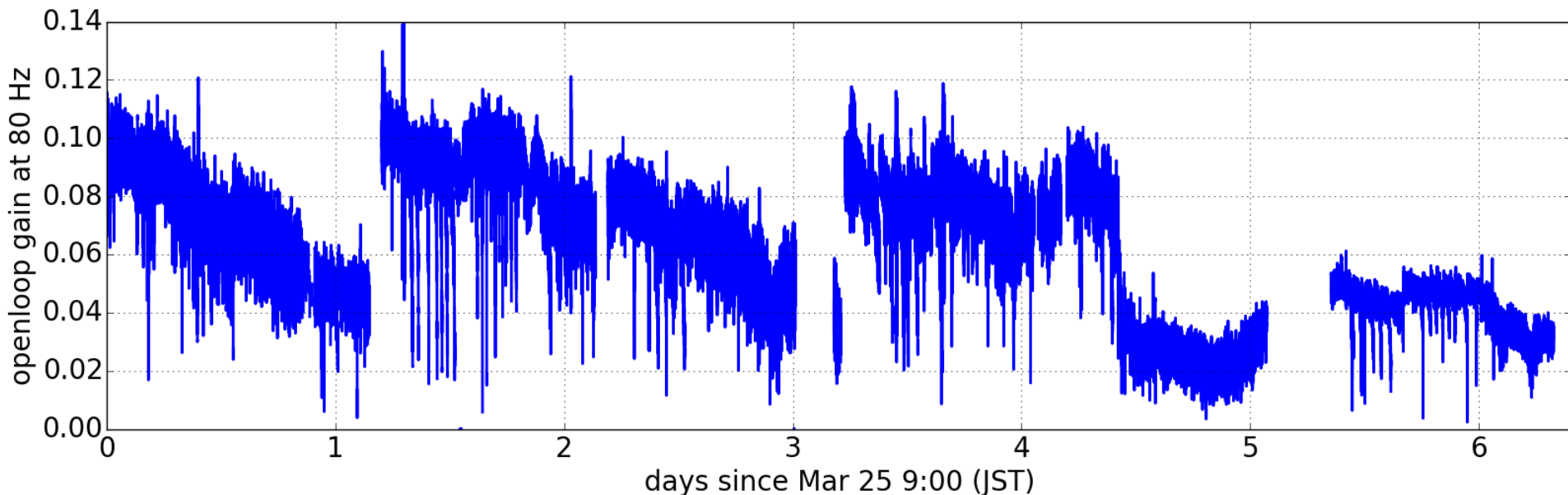
measured with 3-km Michelson

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



# Openloop Gain Drift

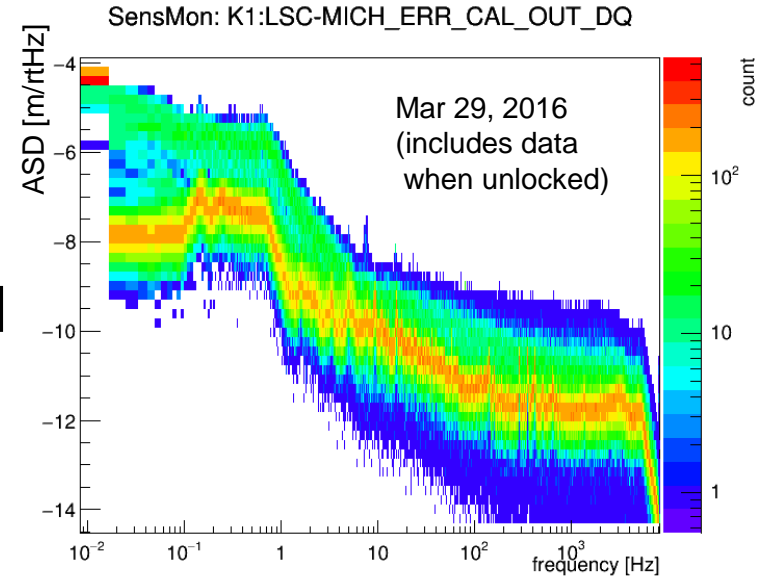
- MICH openloop gain degraded by almost 80 % (likely by alignment drift)  
→ needs UGF servo (and online calibration)



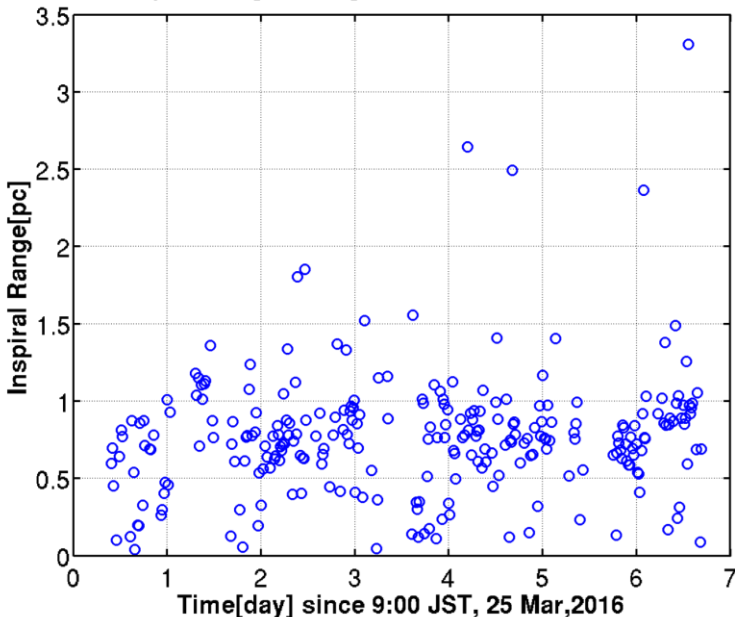
calculation done using K1:LSC-LKIN\_CAL1\_A/B\_REAL/IMAG\_OUT\_DQ  
by Y. Sasaki & Y. Michimura

# Inspiral Range

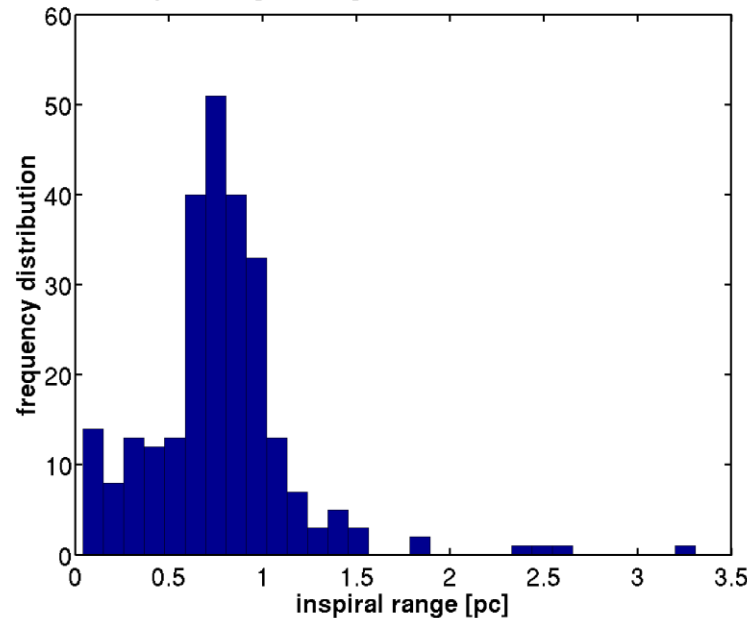
- average: 0.77 pc  
standard deviation: 0.39 pc  
for 1.4Msun-1.4Msun NS-NS
- rough strain sensitivity fluctuated  
by roughly 1 order of magnitude



inspiral range during iKAGRA run in March, 2016



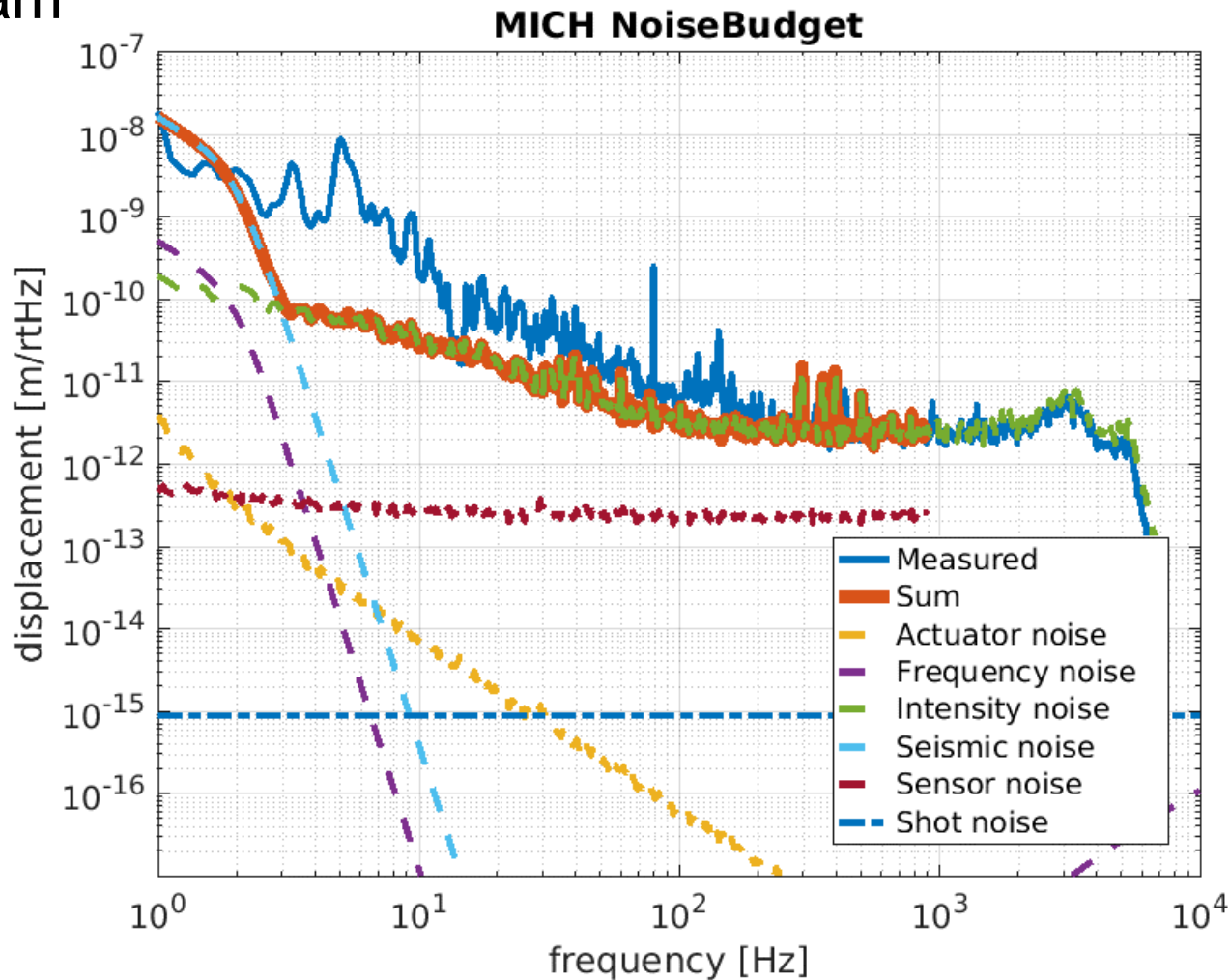
inspiral range during iKAGRA run in March, 2016



plot by K. Hayama

# Noise Budget

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



# Issues in March Test Run

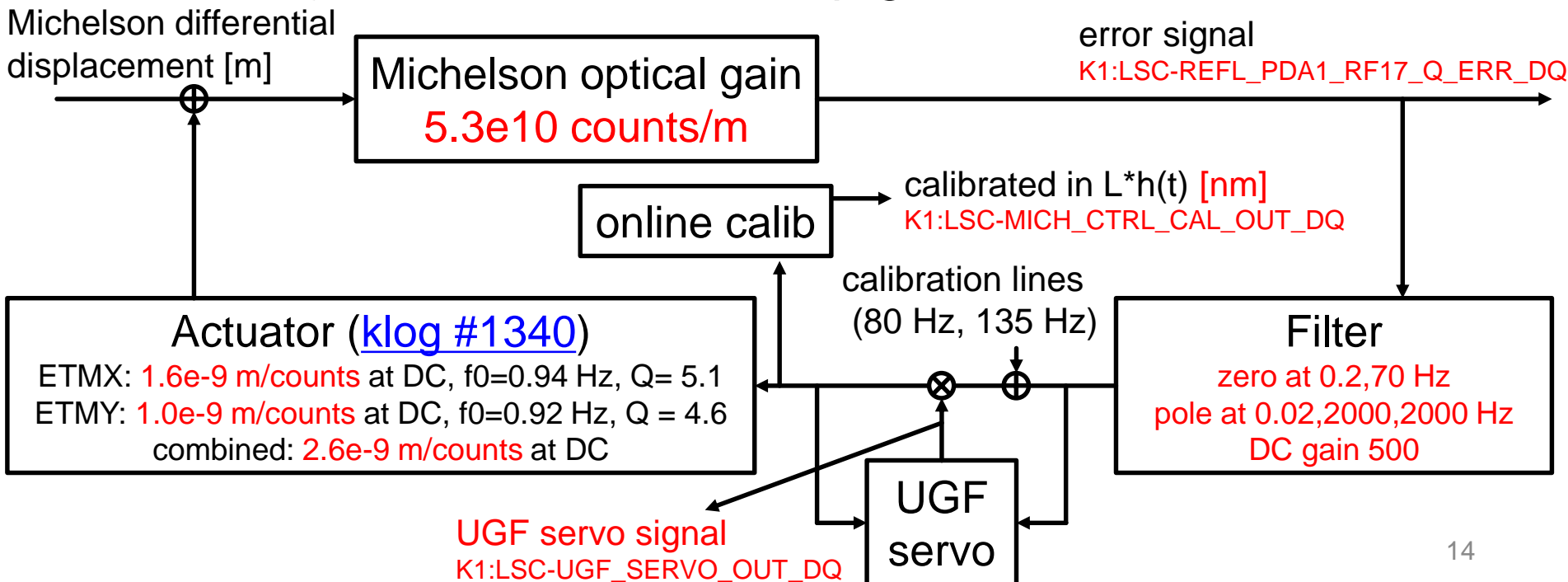
- Michelson lock was lost every ~30 minutes
- Alignment was adjusted manually ~ once per day
- Calibration was done offline
- PMC was re-locked manually
- GVs close to IXA/IYA was closed
- PR2-BS duct was not connected
- Some unsafe issues left unaddressed

# 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 #1389](#)), x10 sensitivity ([klog #1389](#)), folded oplev for ETMs to reduce L2A ([klog #1355](#))
  - more stable IMC (less feedback to mirrors [klog #1388](#), oplev damping 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

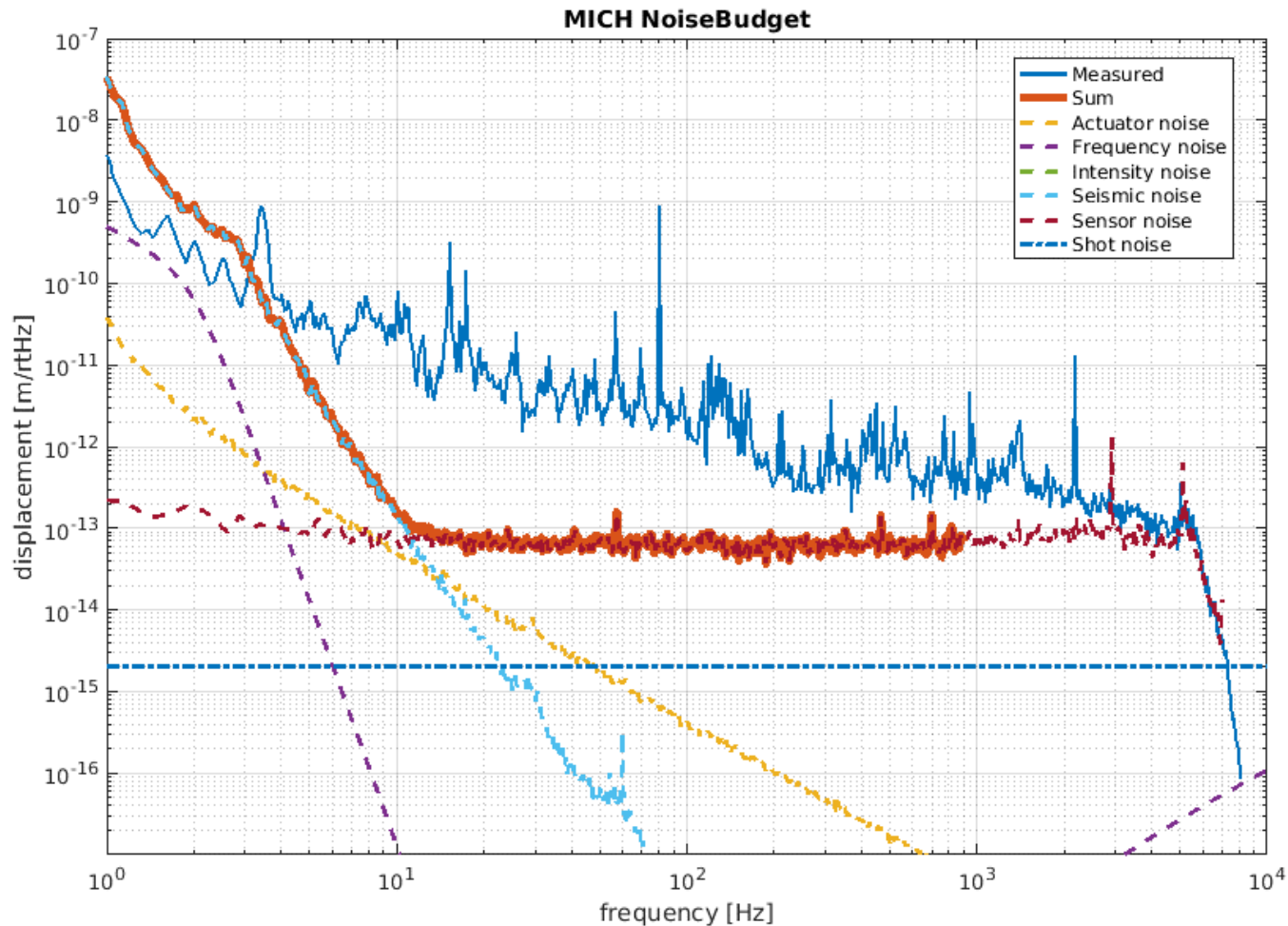
# Calibration for April Test Run

- 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



# Updated Noise Budget

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



# 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
- what else?