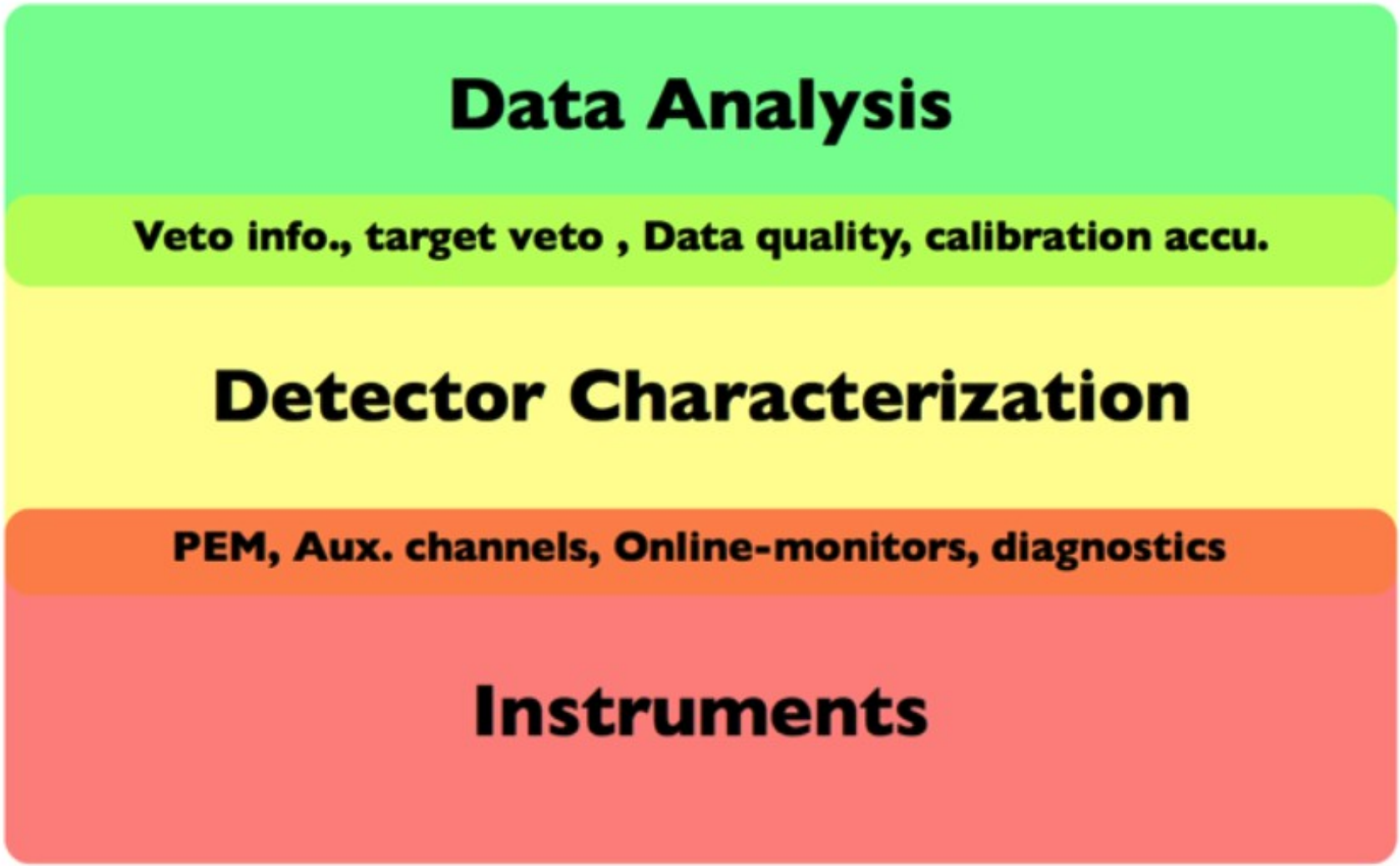
Status of KAGRA detector characterization

Kazuhiro Hayama (ICRR)

On behalf of KAGRA collaboration

Interface


Data Analysis
Veto info., target veto , Data quality, calibration accu.
Detector Characterization
PEM, Aux. channels, Online-monitors, diagnostics
Instruments

Scope

For Detector side

- Development of characterization tools
- Daily summary monitor
- Monitoring Environment around KAGRA

For Data analysis side

- Data quality information
- Veto analysis

Tools for Detector Characterization

KAGRA Detector Characterization

Daily Summary Page

Web-Based Tools

Characterization of GW150914

Powered by HasKAL

DetChar Tools

Non-Stationarity

- Glitch Monitor

Line

- Line Finder
- Line Tracking
- Line Removal

Gaussianity

- Rayleigh Monitor
- Non-Gaussianity Monitor
- RMS Monitor
- Noise Floor Monitor

T.Yamamoto+ PRD (2016)

Time-Series

- Time-Series Monitor

Spectrum

- Spectrum Monitor
- Spectrogram Monitor

GW Range

- Sensitivity Monitor
- Range Monitor
  - Inspiral
  - Inspiral-Merger-Ringdown
  - Ringdown
  - Stochastic

Correlation

- Coherence Finder
- Multiple-channel coherence finder (BruCo)
- Pearson correlation Finder
- NonLinear correlation Finder

User Interface

- Realtime Quick look webpage
- Daily summary webpage
- GUI Interface
- Web-Base Interface
- Command-line Interface

System Health

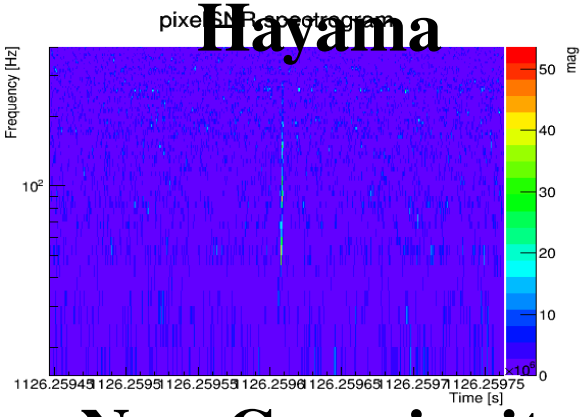
- Health monitor
- File Finder (New)
- Globally Correlated magnetic no
- Violin mode
- Multi-channel analysis
- Newtonian noise
  - Effect of water inside the mountain

Example : GW150914

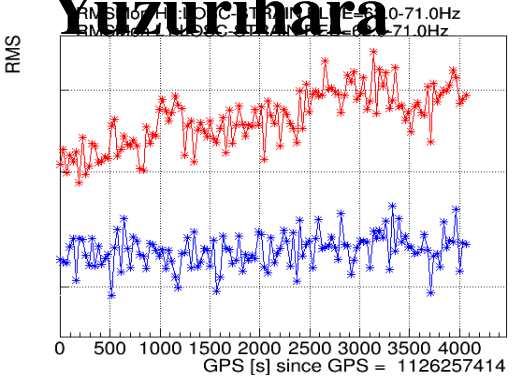
Data Characterization around GW150914

- Seen the signal clearly
- Amp. of Power line(60Hz) fluctuated ～+-5E-21
- Amp. of 500Hz line decreasing
- ＞100Hz, Gaussianity pretty good
- ＜100Hz, non-Gaussian
- 516Gz line: strange behavior.

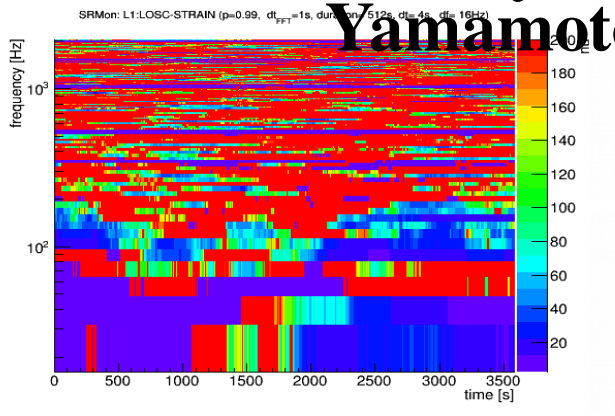
Glitch pipeline
Hayama



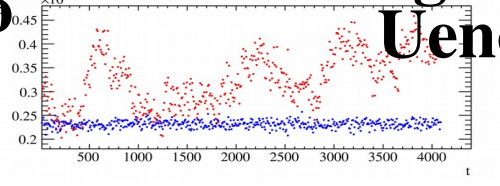
BLRMS (60~70Hz)
Yuzurihara

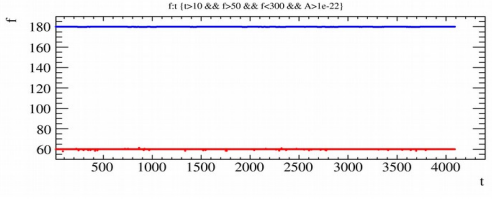


Non-Gaussianity
Yamamoto



Line Tracking
Ueno





Daily Summary Monitors in iKAGRA

General | MIF | VIS | IOO | ENV | Bruco | Web Tools

Calendar

Jun. 2016

Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Su
		1	2	3	4	
6	7	8	9	10	11	1
13	14	15	16	17	18	1
20	21	22	23	24	25	2
27	28	29	30			

May 2016

Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Su
2	3	4	5	6	7	
9	10	11	12	13	14	1
16	17	18	19	20	21	2
23	24	25	26	27	28	2
30	31					

Apr. 2016

Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Su
				1	2	
4	5	6	7	8	9	1
11	12	13	14	15	16	1
18	19	20	21	22	23	2
25	26	27	28	29	30	

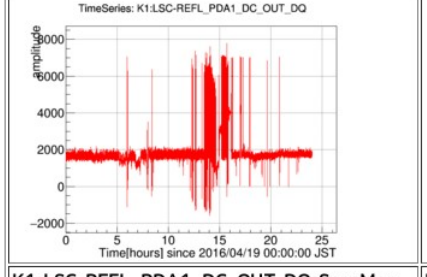
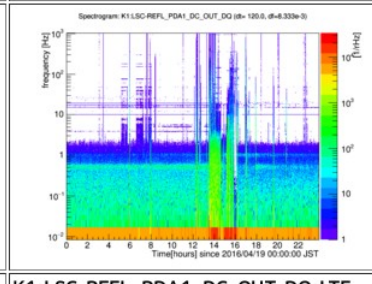
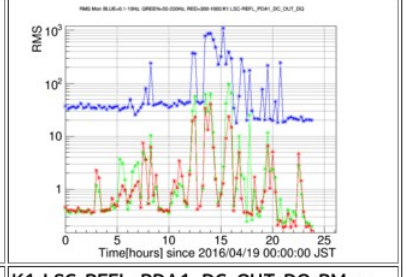
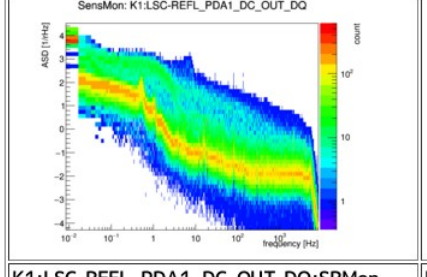
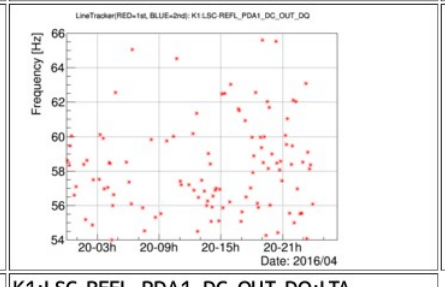
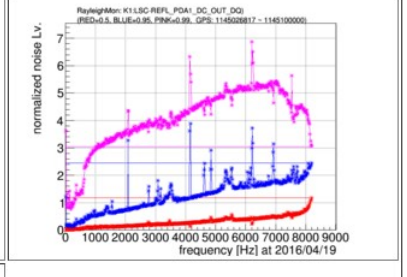
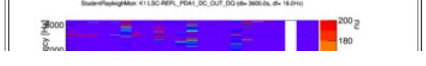
Mar. 2016

Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Su
	1	2	3	4	5	
7	8	9	10	11	12	1
14	15	16	17	18	19	2
21	22	23	24	25	26	2
28	29	30	31			

Feb. 2016

Local Date:
2016-04-19
Layout:
- Channel Order
- Monitor Order

K1:LSC-REFL_PDA1_DC_OUT_DQ

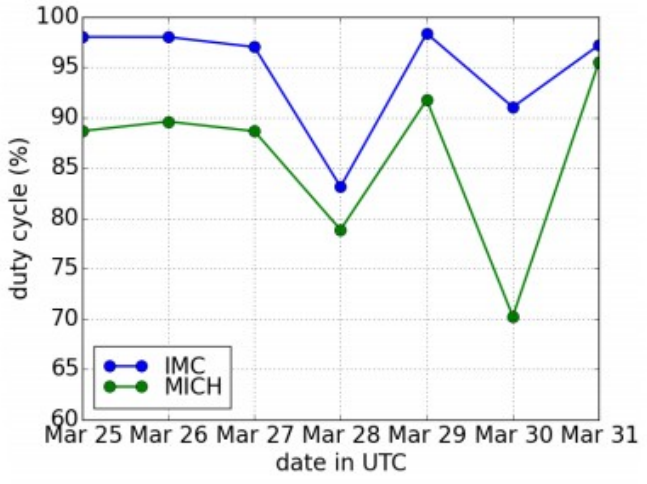
K1:LSC-REFL_PDA1_DC_OUT_DQ:TimeSeries	K1:LSC-REFL_PDA1_DC_OUT_DQ:Spectrogram	K1:LSC-REFL_PDA1_DC_OUT_DQ:RMSMon
		
K1:LSC-REFL_PDA1_DC_OUT_DQ:SensMon	**K1:LSC-REFL_PDA1_DC_OUT_DQ:LTF**	**K1:LSC-REFL_PDA1_DC_OUT_DQ:RMon**
		
K1:LSC-REFL_PDA1_DC_OUT_DQ:SRMon	**K1:LSC-REFL_PDA1_DC_OUT_DQ:LTA**	
		

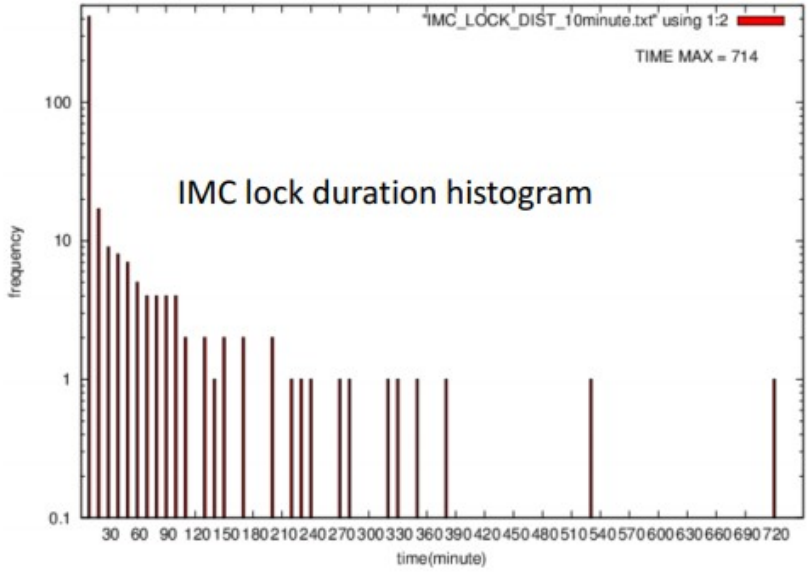
Duty Cycle(Mar.25-Mar.31,2016)

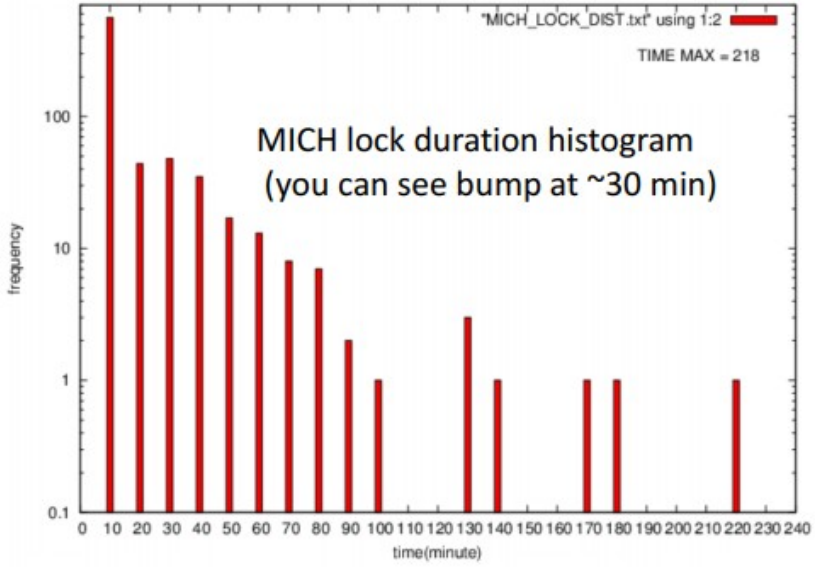
- **Duty factor: 85.2 %**
  (94.4 % for IMC)

data processing and plot by Y. Sasaki

- **Longest lock: 3.6 hours**
  (12 hours for IMC)

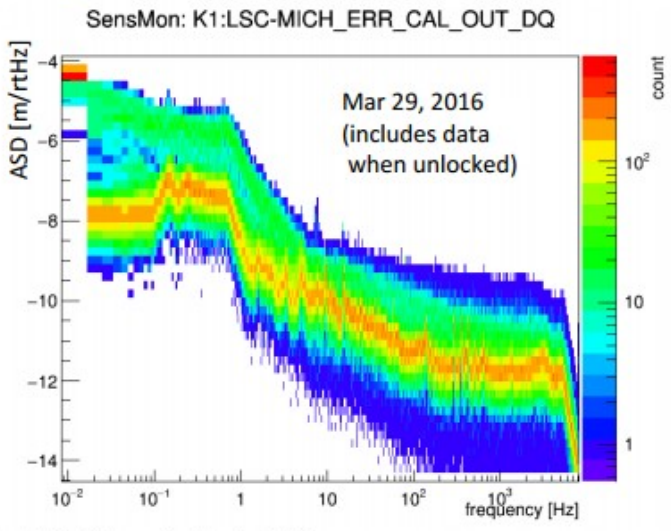


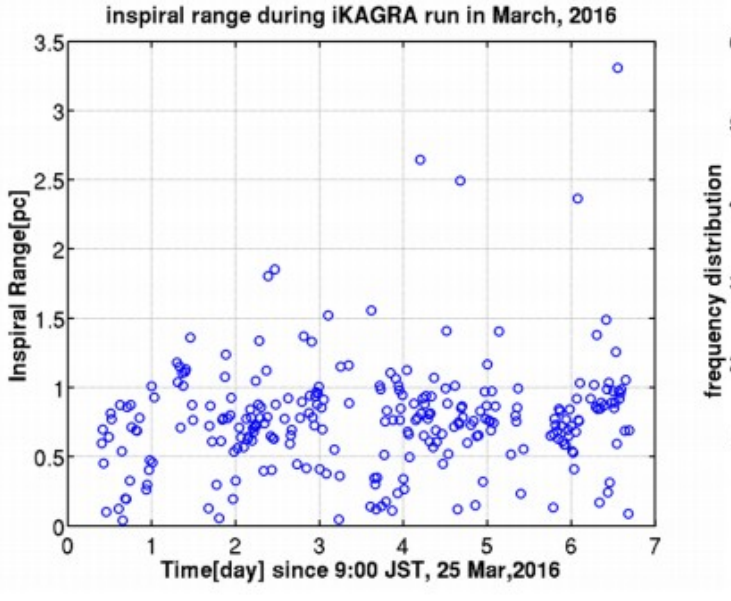


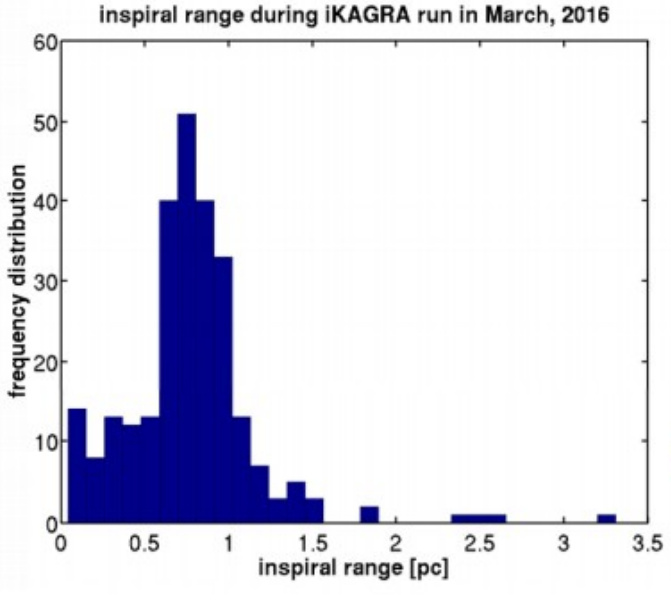


Inspiral Range

- 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



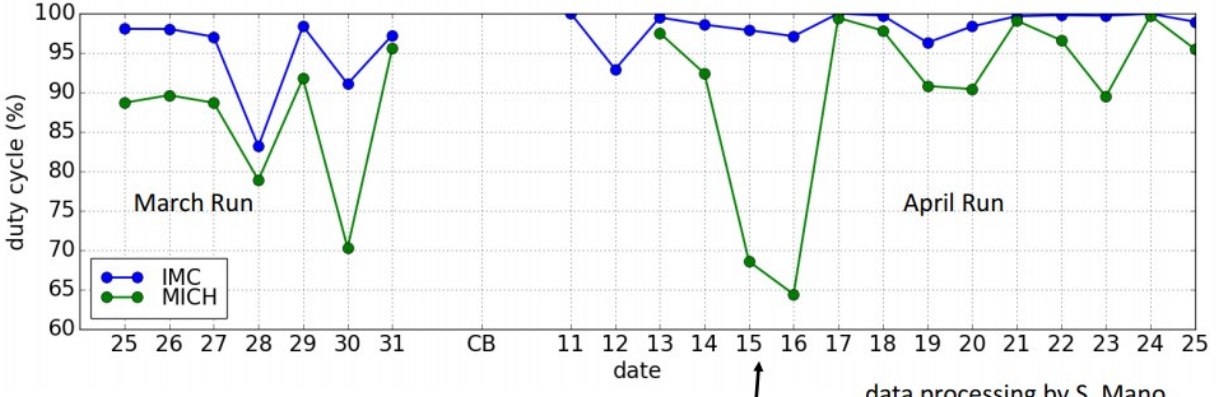




plot by K. Hayama

Duty cycle(April11-April25,2016)

- **duty factor: 90.4 % (98.5 % for IMC)**
  was 85.2 (94.4 % for IMC) during 1st 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.

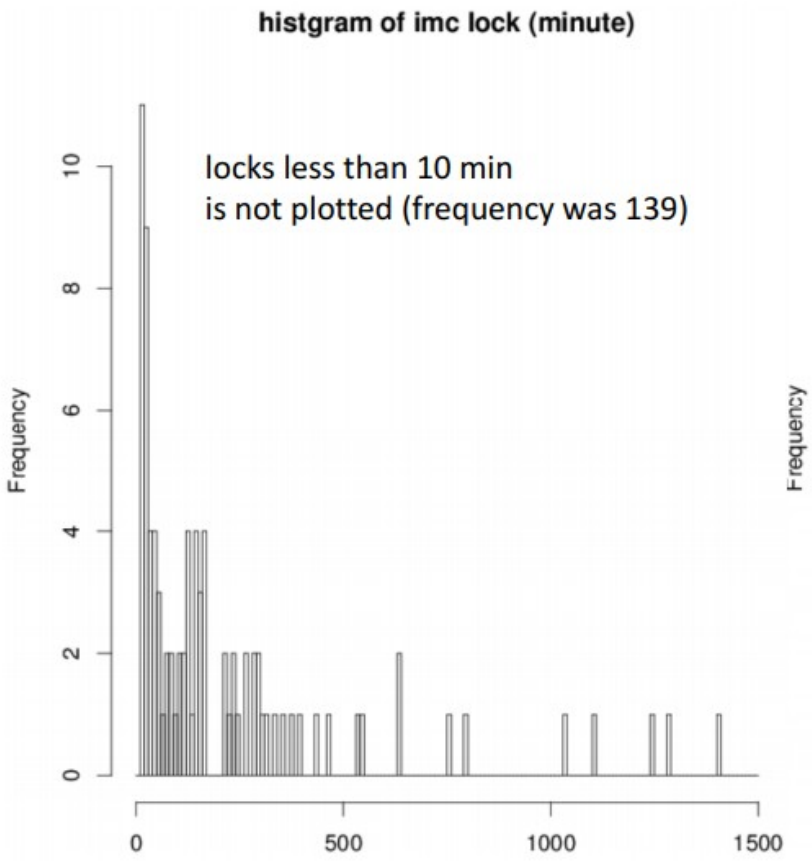
Kumamoto Earthquake, BS went wrong

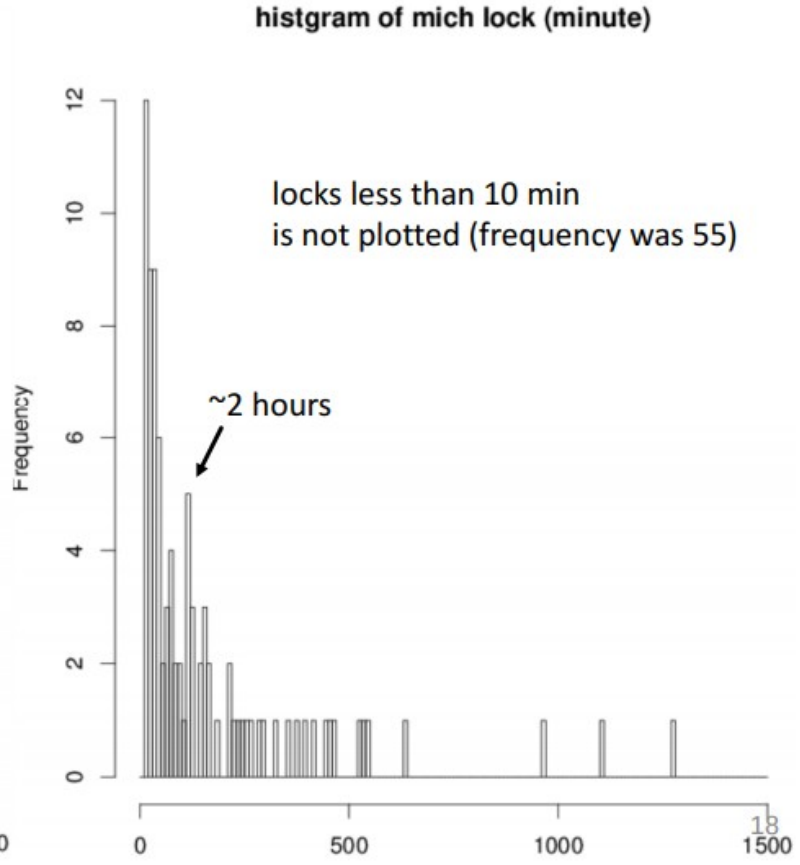
data processing by S. Mano
plot by Y. Michimura

Lock Duration(April11-April25)

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

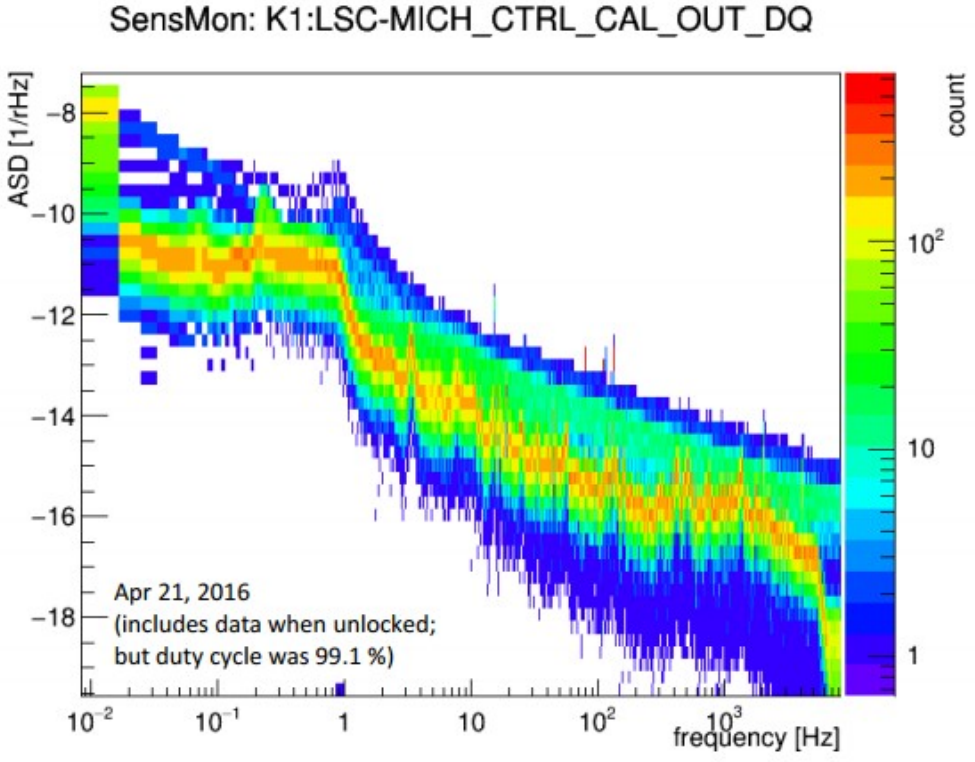
data processing and plot by S. Mano





Inspiral Range

- **~4.2 pc for 1.4Msun-1.4Msun NS-NS (average value on Apr 21) was 0.77 +/- 0.39 pc during March Run**
- **strain sensitivity fluctuated by roughly 1 order of magnitude**

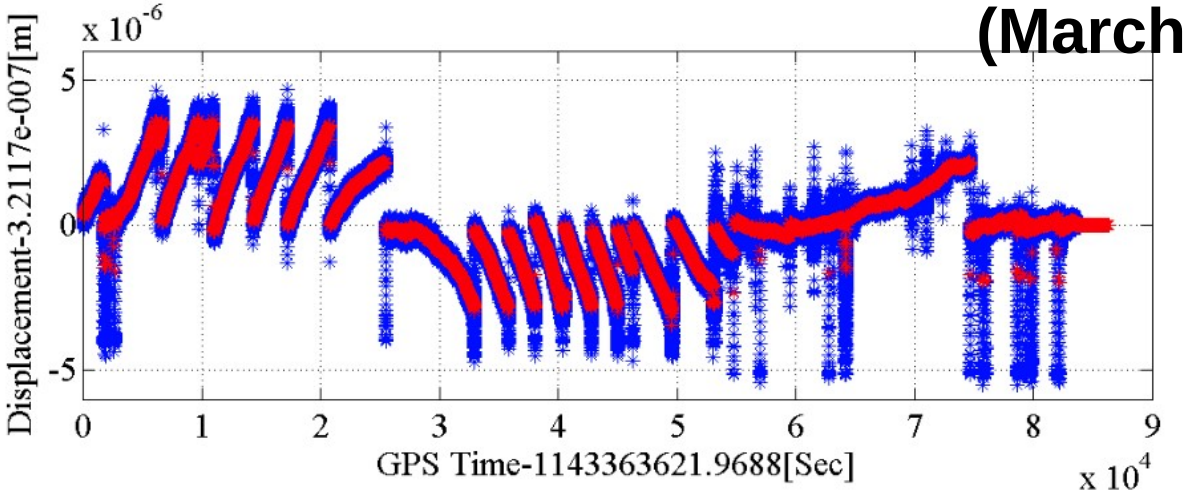


plot by K. Hayama

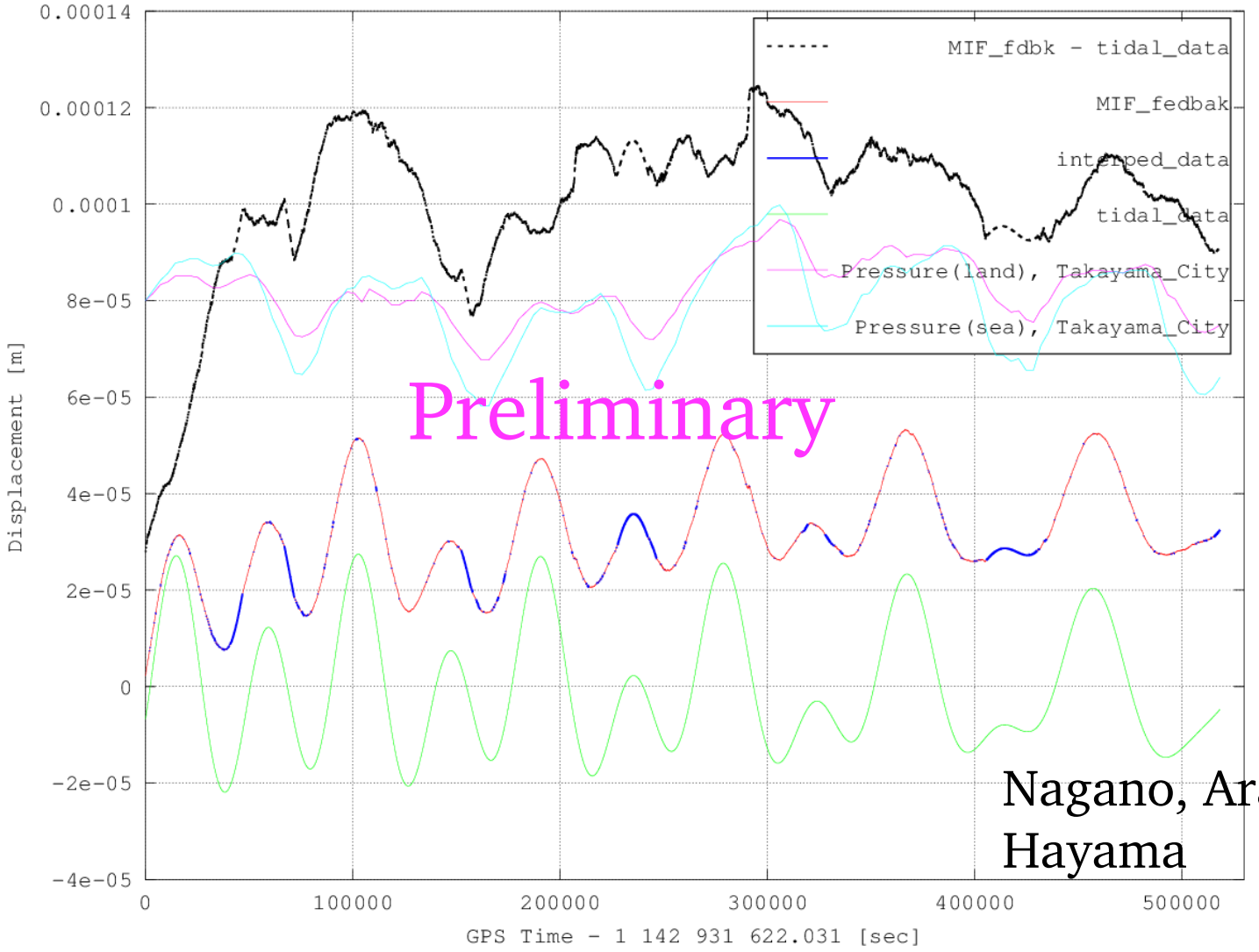
Differential of the X and Y arms

- During March test run, lock lost every 30min because feedback signals were saturated.
- We need more actuator range
- How large?

1day plot (March30-31)

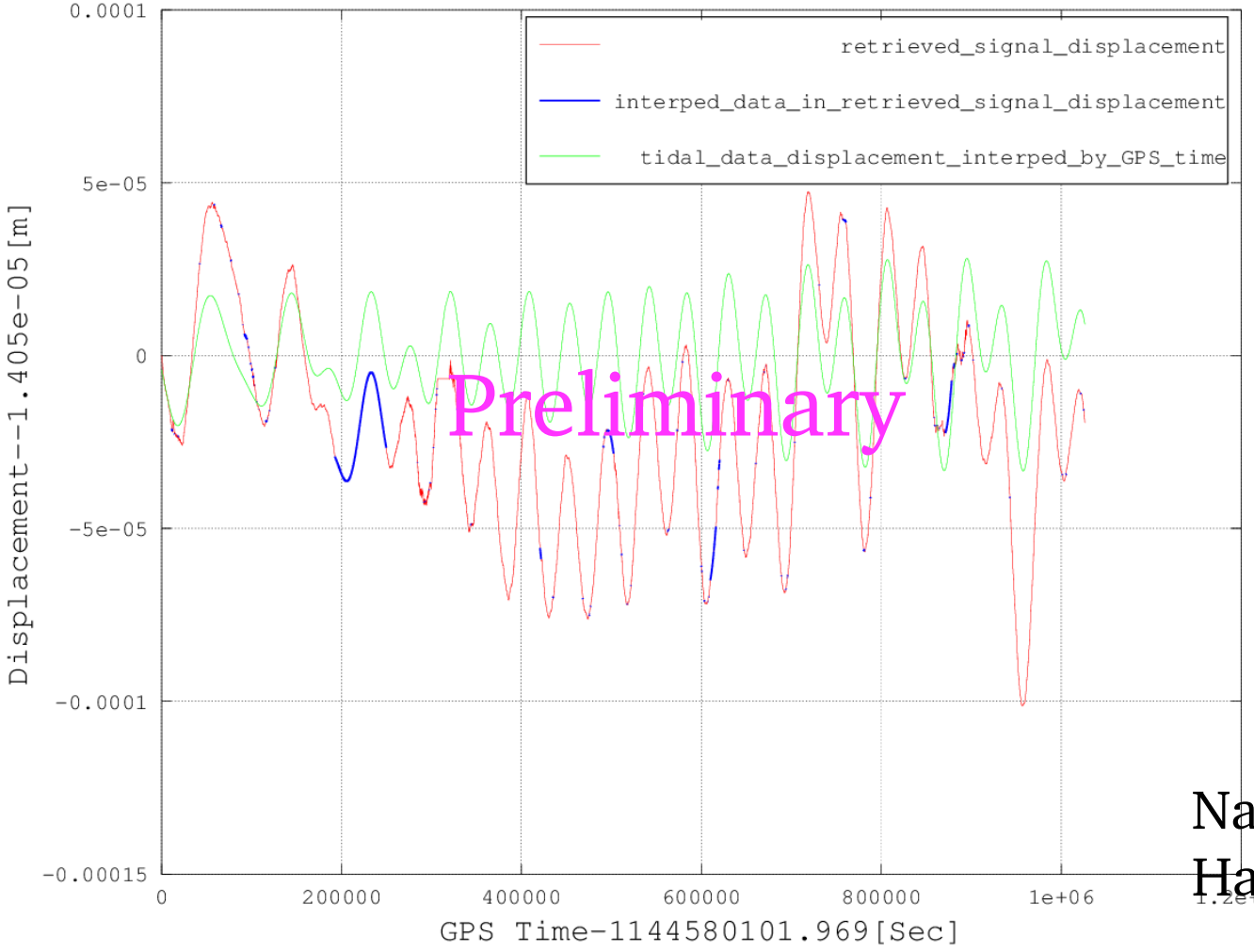


Tidal Distortion(Mar.25-Mar.31)



Nagano, Araya, Hayama

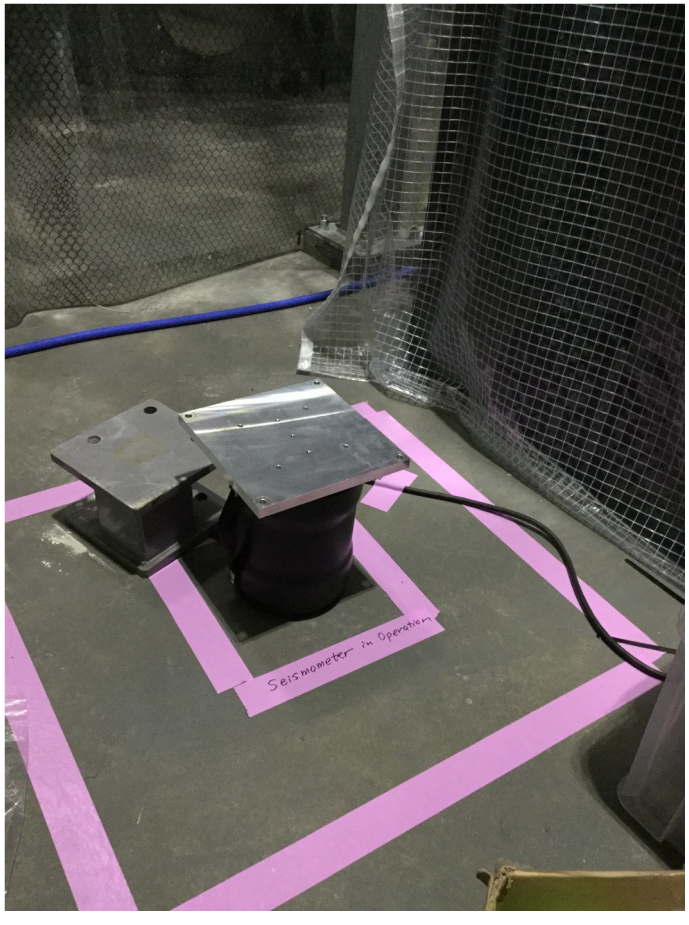
Tidal Distortion(April11-April25)

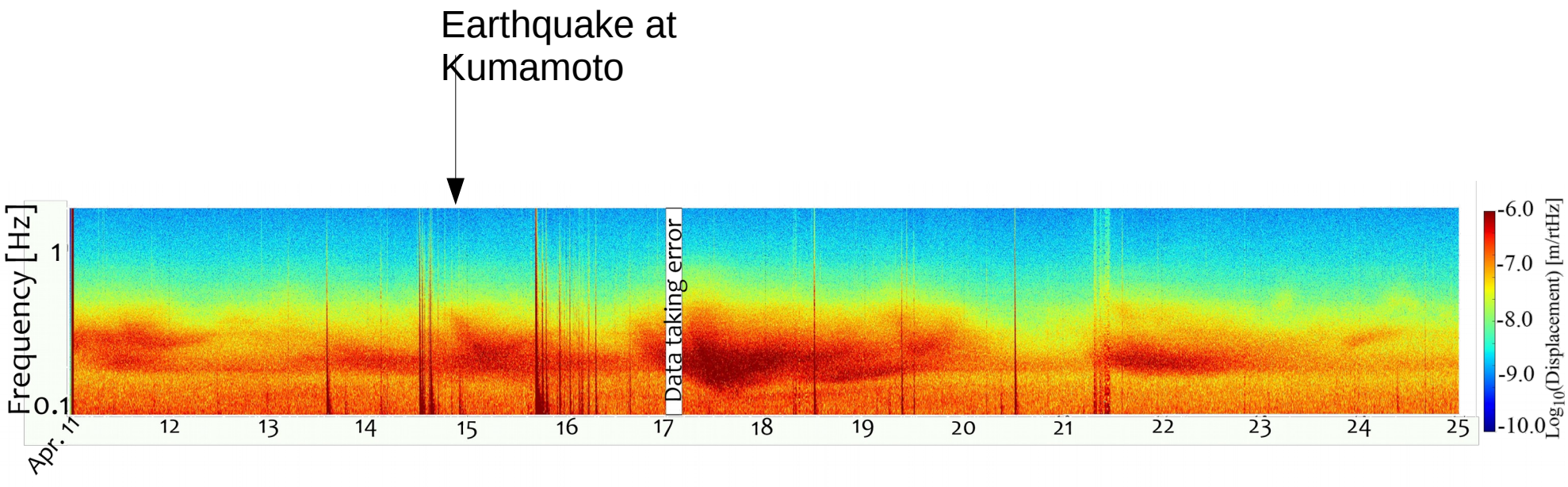


Nagano, Araya, Hayama

Environmental Monitors in iKAGRA

- **Seismoneters at Center, X-end,Y-end**




Earthquake at
Kumamoto
Frequency [Hz]
1
0.1
Data taking error
Apr. 11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
-6.0
-7.0
-8.0
-9.0
-10.0
Log10(Displacement) [m/rtHz]

A. Shoda (NAOJ)

Gravity Gradient Noise Produced by Water

Hayama, Shikano, Kataoka, Furuta, Uchiyama, Somiya, Shoda, Miyoki, Ohashi, Saito

- **Water flow generates gravity gradient noise**
- **Since the KAGRA site has large amount of water flow, we need to estimate the gravity gradient noise due to the water flow**
- **Right before the April test run, we started to measure the water flow.**

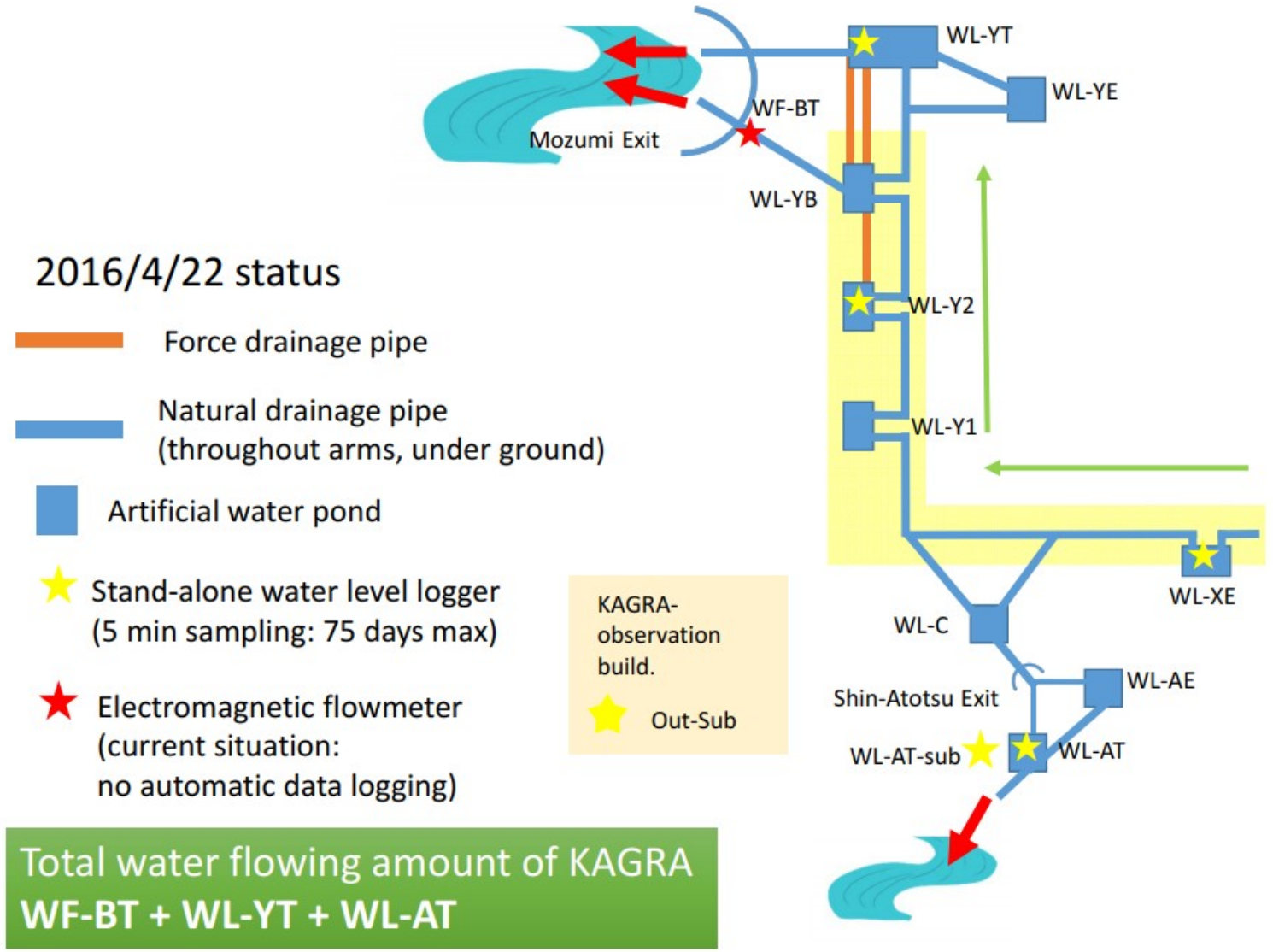
Stand-alone water level logger

http://www.weather.co.jp/catalog_html/hobo/U20.htm

- CO-U20-001-04 (Onset)

Part number	U20-001-04/ U20-001-04-Ti	U20-001-01/ U20-001-01-Ti	U20-001-02/ U20-001-02-Ti	U20-001-03/ U20-001-03-Ti
	HOBO Water Level Specifications			
Range	0-4 m (0-13 ft) 0-145 kPa (0-21 psia)	0-9 m (0-30 ft) 0-207 kPa (0-30 psia)	0-30 m (0-100 ft) 0-400 kPa (0-58 psia)	0-76 m (0-250 ft) 0-850 kPa (0-123 psia)
Factory Calibrated Range (0° to 40°C; 32° to 104°F)	69 to 145 kPa (10-21 psia)	69 to 207 kPa (10-30 psia)	69 to 400 kPa (10-58 psia)	69 to 850 kPa (10-123 psia)
Water Level Accuracy (Typical Error)	± 0.3 cm (0.01 ft) (± 0.075% FS)	± 0.5 cm (0.015 ft) (± 0.05% FS)	± 1.5 cm (0.05 ft) (± 0.05% FS)	± 3.8 cm (0.125 ft) (± 0.05% FS)
Resolution	0.14 cm (0.005 ft)	0.21 cm (0.007 ft)	0.41 cm (0.013 ft)	0.87 cm (0.028 ft)
Burst Pressure	310 kPa (45 psia) 18 m (60 ft) depth		500 kPa (72.5 psia) 40.8 m (134 ft) depth	1200 kPa (174 psia) 112 m (368 ft) depth
	Temperature Specifications (all models)			
Range	-20° to 50°C (-4° to 122°F)			
Accuracy	± 0.37° @ 20°C (± 0.67° @ 68°F) ± 0.44° from 0° to 50°C (± 0.79° from 32° to 122°F)			
Resolution (10 bit)	0.1° @ 20°C (0.18° @ 68°F)			
Response time	5 minutes (to 90% in water)			
Dimensions	2.46 cm diameter x 15 cm (0.97 x 5.9 in) hole in mounting bail 6.3 mm (0.25 in)			
CE compliant	Yes			

KAGRA Water Flow



-Y2

Pic6

Pic7

lone water lev
sampling: 75 d

magnetic flow
t situation:
omatic data log

er flowing a
WL-YT + WL

WL-AT

pic1

Pic2

WL-WT

pic3

pic4

pic5

WL-XE

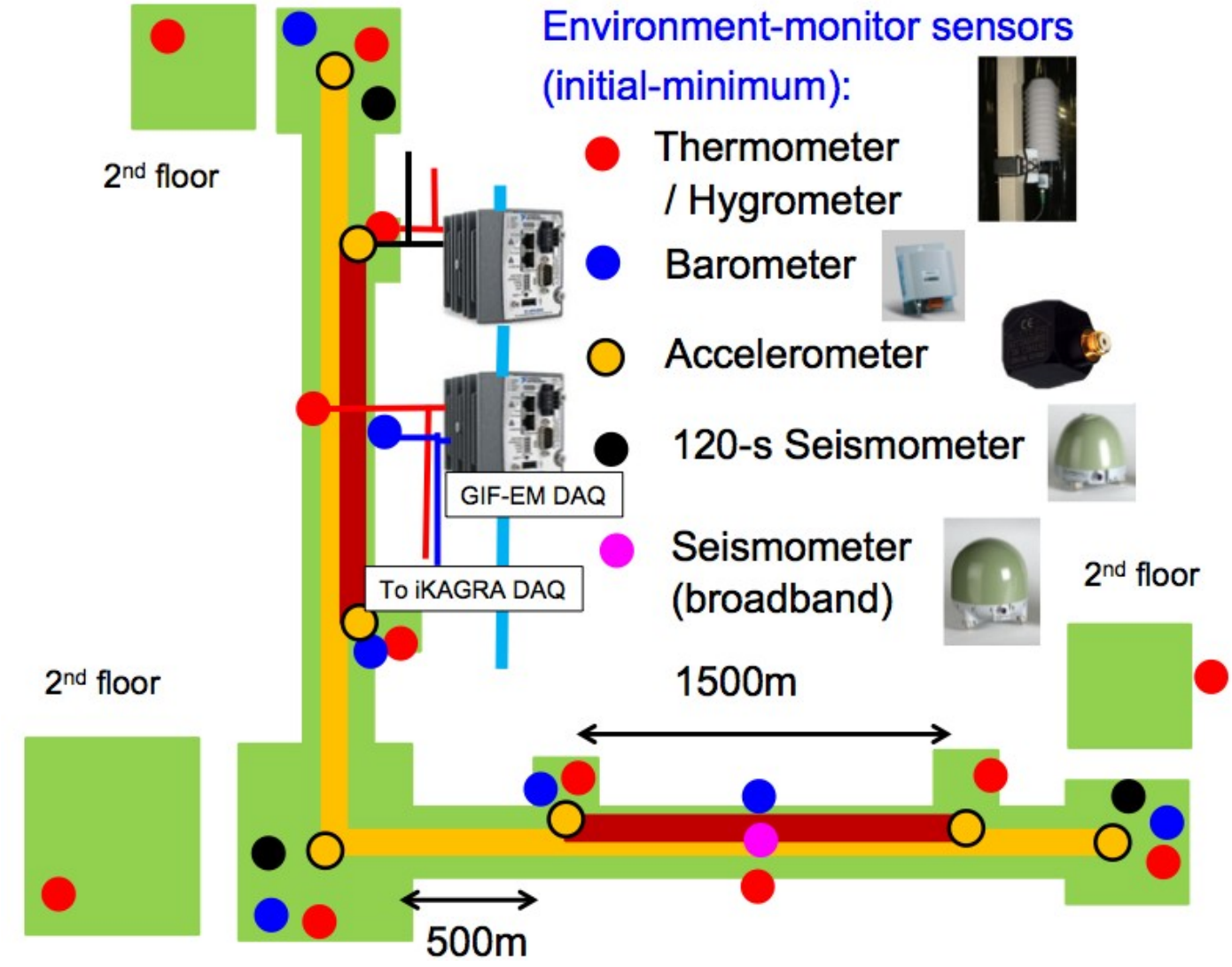
Pic8

Toward observation of water GGN

Y. Shikano (IMS)

- At IMS Shikano group,
  - Simulation by Finite Element Method (COMSOL)
    - CAD drawing started in iKAGRA situation and bKAGRA situation
    - Precise information of current mirror in iKAGRA position is needed.
    - 30 days trial package is needed (Subsurface Flow Module)
    - Amount of water level and water flowing mechanism
    - Evaluating GGN of water (roughly)
- Additional monitoring system development
  - High-speed data sending system?
  - Strategical planning to measure the water flowing by the bKAGRA? Engineering run at bKAGRA?

Schedule for Environmental Monitors



KGWG DetChar Activities in KAGRA

John Oh
on behalf of KGWG detchar group

- Channel Safety Study of iKAGRA Data

  * Using H/W Injection signal, unsafe channels (strongly involved to GW channels) should be identified by timing coincidence, significance, and correlation index

- Omicron Trigger Generation of iKAGRA Data

- EtaGen Trigger Generation of iKAGRA Data

- Glitch Classification of iKAGRA Data using Artificial Neural Networks

- Nonlinear correlated glitch trigger study by MIC

Omicron Trigger Generation for iKAGRA

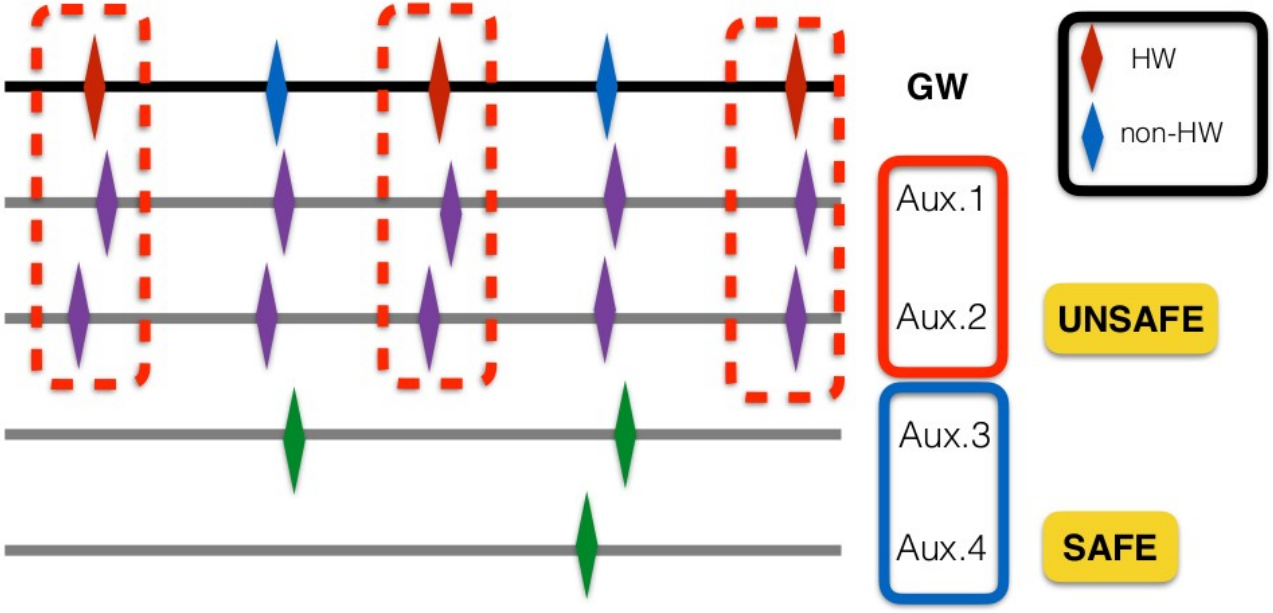
Young-Min Kim (SNU)

- Omicron algorithm (http://virgo.in2p3.fr/GWOLLUM/v2r1/index.html?Friends/omicron.html)
  - Burst-type search based on Q-transform (CQG 21, S1809 (2004))
  - It is used currently for LIGO/Virgo Detector Characterization.
  - Omicron triggers can be used for detector characterization of iKAGRA
- Installation on KISTI cluster
  - ldg-ui.sdfarm.kr:/data/ligo/home/detchar/opt/virgosoft/
  - Requirements: CMT architecture, Virgo packages, ROOT, GSL, FFTW. (Ask to Florent Robinet:robinet@lal.in2p3.fr)
- How to generate Omicron triggers and scans
  - source /data/ligo/home/detchar/opt/virgosoft/environment.v2r1.sh
  - omicron [segments.txt] [parameters_0.txt]
    - [segments.txt] —> [GPS start time] [GPS end time] or [GPS time]

Safe Channel Study

Young-Min Kim (SNU)

- The safety of a veto is important for veto criteria not to remove accidentally a true gravitational wave signal.
  - ***unsafe*** channels : Auxiliary channels with non-negligible couplings from GW channel. A corresponding response to HW injections is greater than expected by chance.
  - ***safe*** channels : it can be used as a veto or to study glitches in h(t).

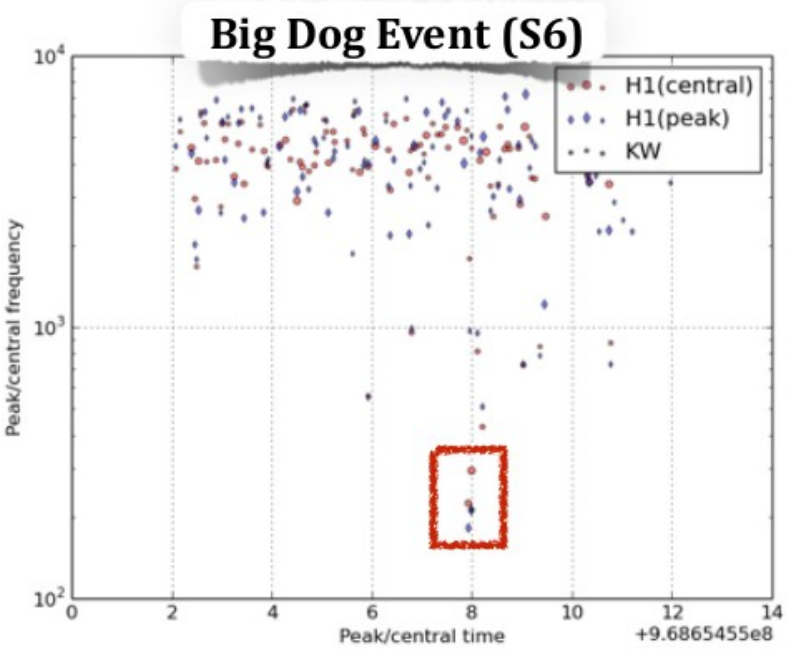


EtaGen (η-Gen):

An ETG candidate for KAGRA

E. Son (NIMS)

- EtaGen is an event trigger generator based on Hilbert-Huang Transform.



- The efficiency of EtaGen finding simulated sine-Gaussian and white noise burst signals are over 90%.
- Triggers generated near the injection times will be used in the further analyses, e.g., finding safe/unsafe auxiliary channels.

END

Channel ↔ Audio Transform